

**Summary of Aquatic Organism Passage Surveys on the
Apalachicola National Forest, Florida, 2017-2019**



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January 2020

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Project Type

Effect of roads on hydrology and aquatic organism passage.

Goal

Assess the impacts of the forest road system on hydrology and aquatic organism passage.

Objective

Complete inventory and assessment of drainage structures beneath forest roads, then assess fish passage at priority crossings.

Approach

Forest identifies roads within the Apalachicola Regional Restoration Initiative area in need of assessment. CATT and Forest work together to develop drainage structure inventory methods. CATT field team collects and submits data for Forest. Forest uses data to identify areas in need of restoration or maintenance.

Accomplishments

2017/2018: Completed 840 miles of road assessments and identified and assessed 659 crossdrain structures, 1,201 waterbody crossing structures, and 1,771 miscellaneous features.

2019: Completed 182 miles of roads assessments and identified and assessed 40 crossdrain structures, 258 waterbody crossing structures, and 504 miscellaneous features; completed AOP assessments at 23 crossings

Partners and Contacts

Forest Contacts: Jason Drake, Forest Ecologist; Paul Medley, GIS Program Manager; Jorge Guevara, Hydrologist; Jordan Nickle, GIS Analyst; John Dunlap, Forest Wildlife Biologist

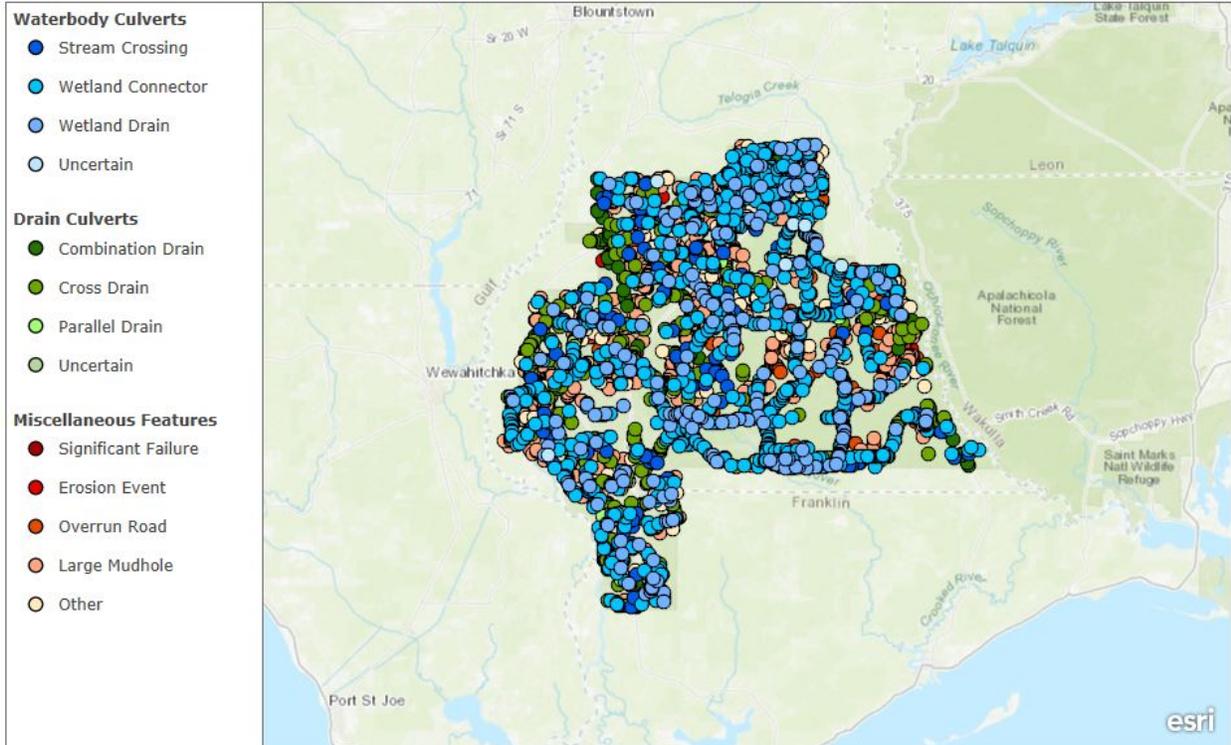
Project Summary

Determining the direction of water flow across extremely flat landscapes such as coastal plains can be very difficult. The Apalachicola NF has a need to delineate and map watersheds across the Apalachicola Regional Restoration Initiative area but is hampered by a lack of accurate drainage and flow network information. A critical component in the mapping effort is locating where water flow is impeded or modified by roads and trails; the only way to identify these 'crossdrains' is through an intensive search and mapping effort on the 800+ miles of roads in the project area. In 2017-2019, the Apalachicola NF partnered with the CATT to deploy field crews to inventory crossdrain structure (pipes, etc.) and assess aquatic organism passage at road crossings. Project results will be used to complete watershed drainage maps, locate stream and wetland diversions, identify maintenance problems, and opportunities for remediation projects.

Field Methods

Appendix A: Guide to Drainage Structure Characterization on the Apalachicola National Forest, FL
Appendix B: SARP Stream Crossing Survey Data Form Instruction Guide

Apalachicola NF Cross Drain Data Collection



Working field map for cross-drain data collection on the Apalachicola National Forest, Apalachicola Ranger District.

Appendix A:

Guide to Drainage Structure Characterization on the Apalachicola National Forest, FL

Guide to Drainage Structure Characterization on the Apalachicola National Forest, FL



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November 2014**

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Introduction

Determining the direction of water flow across extremely flat landscapes such as coastal plains can be very difficult. Lack of accurate drainage and flow network maps presents challenges for managing streams and wetlands on the Apalachicola NF. The Apalachicola NF is currently using high resolution imagery to map drainages and streams across the entire National Forest. A critical component in the mapping effort is finding the structures that connect streams or wetlands beneath road beds. The only way to identify these structures is through an intensive structure inventory on roads within the boundary of the Forest. In 2014, the USDA Forest Service, Southern Research Station, Center for Aquatic Technology Transfer partnered with the Francis Marion NF to develop and test methods capable of locating pipes buried beneath road fill. In 2017-2018, we will deploy field teams to inventory drainage structures on the Apalachicola NF. The results of the project will be used to develop accurate, precise flow maps for the entire Forest as well as to identify stream and wetland diversions, maintenance problems, and other as yet unknown issues related to the drainage network.

Safety Protocols

- Perform daily ‘check in/check out’ procedure
- Have radio, cell phone, and SPOT unit with you when in field
- All survey team members must wear a safety vest and hardhat when performing surveys
- Wading boots with appropriate traction (felt or non-slip rubber soles) are required for all stream work; otherwise hiking boots (must cover ankle) are required
- Know the hazards in and around the stream channel (slick rocks, snakes, glass, etc.)
- Be aware of cars, ditches, and other road hazards
- Hold weekly ‘tailgate safety’ meetings to discuss and remind team of hazards

Outline of Inventory

1. Follow ‘check out’ procedure when leaving for field
2. Navigate to road where inventory will be conducted
3. Wearing proper PPE, walk and scan road with detector to locate structures
4. When structure is found, complete data-form on electronic data recorder
5. Follow ‘check-in’ procedure when returning from field
6. Backup data and photos at the end of each fieldwork day

The following sections describe the inventory in detail:

Section 1: Getting Started – equipment, starting the inventory

Section 2: Attributes – definitions, how to measure, what to record

Section 3: Wrapping Up – what to do when the inventory is completed

Section 1: Getting Started

Equipment List

- | | |
|-------------------------------------------------|-------------------------------------------------------------------|
| <input type="checkbox"/> Check truck fuel level | <input type="checkbox"/> BAK Tablet – check charge, reception |
| <input type="checkbox"/> Spare key for truck | <input type="checkbox"/> Backup Camera – check charge, SD card |
| <input type="checkbox"/> Truck gas card | <input type="checkbox"/> Metal detector – check charge, calibrate |
| <input type="checkbox"/> Water cooler | <input type="checkbox"/> Batteries for metal detector |
| <input type="checkbox"/> Bug spray | <input type="checkbox"/> Bad Elf GPS – check charge, reception |
| <input type="checkbox"/> Sunscreen | <input type="checkbox"/> SPOT unit (w/ extra batteries) |
| <input type="checkbox"/> Wasp killer | <input type="checkbox"/> Waterproof notebook |
| <input type="checkbox"/> Bow saw | <input type="checkbox"/> Pencils |
| <input type="checkbox"/> Cell Phone | <input type="checkbox"/> Flagging |
| <input type="checkbox"/> Radio | <input type="checkbox"/> Markers |
| <input type="checkbox"/> Hard hat | <input type="checkbox"/> Maps |
| <input type="checkbox"/> Hi viz safety vests | <input type="checkbox"/> Flashlight |
| <input type="checkbox"/> Wading boots | <input type="checkbox"/> Tape measure |
| <input type="checkbox"/> Waders | <input type="checkbox"/> Stadia rod |
| <input type="checkbox"/> Hiking boots | <input type="checkbox"/> Tecnu |
| <input type="checkbox"/> Toilet paper | <input type="checkbox"/> Probing rod |
| <input type="checkbox"/> First aid kit | <input type="checkbox"/> Compass |
| <input type="checkbox"/> _____ | <input type="checkbox"/> _____ |
| <input type="checkbox"/> _____ | <input type="checkbox"/> _____ |

Starting the Inventory

Determine the starting point for your inventory, typically an intersection of two roads. One team member exits the vehicle, tunes the metal detector, and begins walking the road, scanning the road bed, ditch lines, and turnouts for crossdrains and searching for stream crossings. Upon locating a crossdrain or culvert the team member records a GPS point and appropriate attributes (see next section). The second team member drives the vehicle a safe distance behind the first team member, with vehicle hazard lights on and provides support once a drainage structure has been located.

Section 2: Attributes

Purpose

Definition:

Function the structure is providing for the road system.

Connecting water bodies:

- Stream Crossing – defined stream channel upstream and downstream of crossing; may be targeted for additional fish passage assessment
- Wetland Connector – wetland on both sides of road
- Wetland Drain – wetland on one side of road drains to stream channel on other side

Connecting ditch lines:

- Cross Drain – perpendicular to road; connects ditch lines on opposite sides of road
- Parallel Drain – parallel to road; provides continuous ditch line under pullout or driveway
- Combination Drain – perpendicular to one road, parallel to another; found at intersections
- Uncertain – purpose not clear; comment describing the site is required

How to measure or estimate:

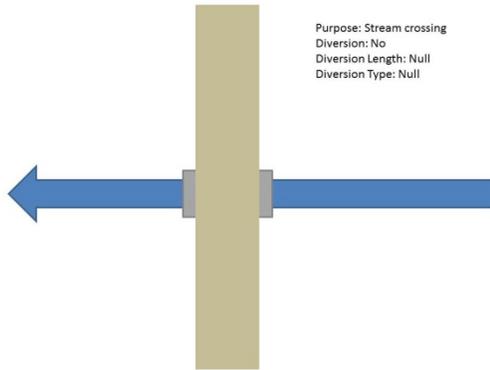
Visually assess the function of the structure. Look carefully at the landscape and road system around the structure. Refer to maps or imagery on the tablet if needed. If the function is not clear then describe the structure and the drainage pattern in the comments section.

When to record:

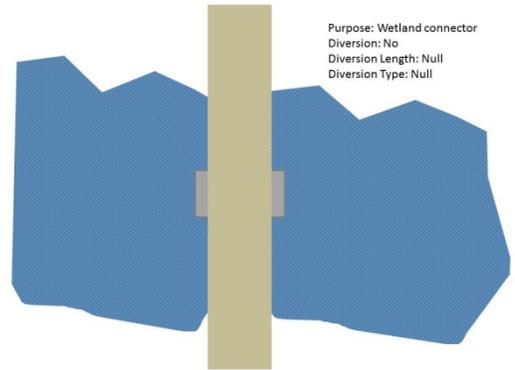
Required for all structures

Purpose Examples:

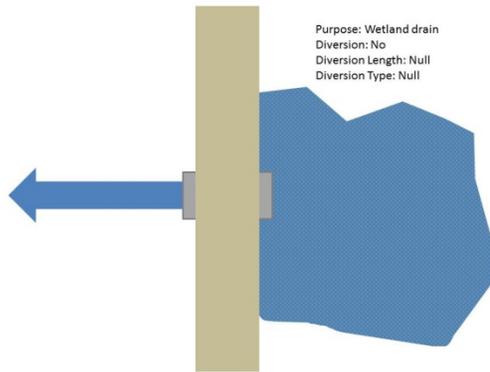
Stream Crossing



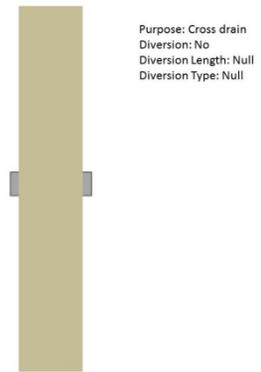
Wetland Connector



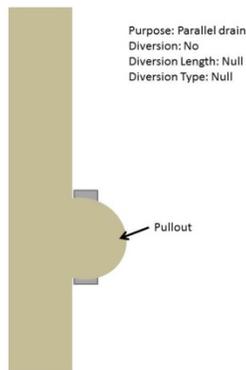
Wetland Drain



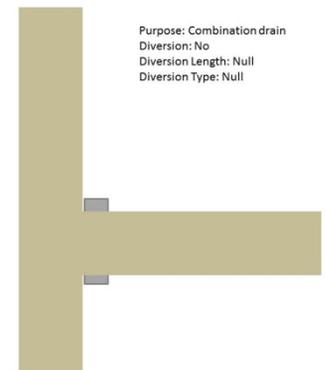
Cross Drain



Parallel Drain



Combination Drain



Diversion

Definition:

Water from stream channel or wetland flowing in ditch line on upstream (inlet) or downstream (outlet) side of structure.

- No – wetland or stream channel does not flow in ditch line
- Inlet – water flows in ditch on upstream side of road before going through structure
- Outlet – water flows in ditch on downstream side of road after exiting structure
- Both – water flows in ditch on upstream and downstream side of road

How to measure or estimate:

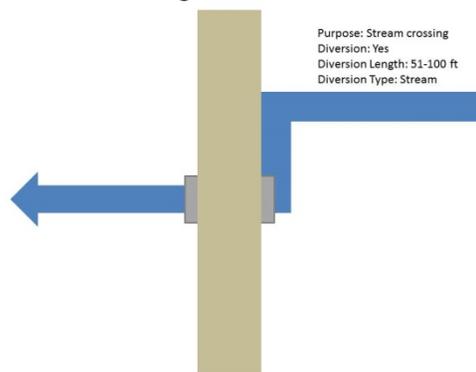
Inspect the ditch line for diversion of stream channels or channelization of wetlands prior to flowing through or after exiting the structure

When to record:

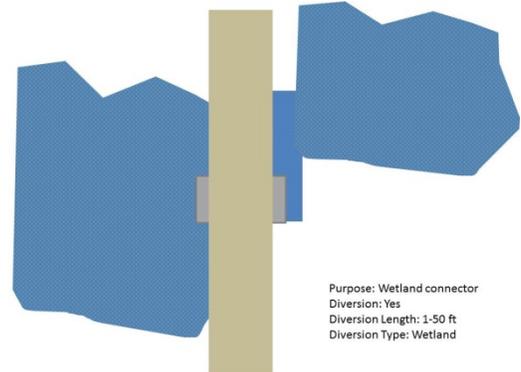
Record for structures connecting water bodies; stream crossing, wetland connector, wetland drain

Diversion Examples:

Stream Crossing with Inlet Diversion



Wetland Connector with Inlet Diversion



Diversion Length (inlet and outlet)

Definition:

Distance water flows in the ditch prior to going through or after exiting the structure

- 1-50 ft
- 51-100 ft
- 100+ ft

How to measure or estimate:

Measure diversion length with a tape measure to determine diversion length category

When to record:

Only where diversions are present

Diversion Type (inlet and outlet)

Definition:

Wetlands and streams can both be diverted

- Stream - stream channel intersects a road bed and water flows in the ditch line before returning to the stream channel
- Wetland - wetland has been channelized and water from the wetland is flowing in the ditch

How to measure or estimate:

Determine if the structure is connecting a stream channel or a wetland

When to record:

Only where diversions are present

Is Culvert Visible?

Definition:

Some structures are completely hidden from view due to dense vegetation or because they were buried during road maintenance operations; these structures can only be detected using the metal detector

- Yes – can see any part of the structure without digging or trimming vegetation
- No – cannot see any part of the structure without digging or trimming vegetation

How to measure or estimate:

Determine if any part of the structure is visible without digging or trimming vegetation
****DO NOT reach into dense vegetation to uncover a crossing; snakes may be present****

When to record:

Required for all structures

End Treatments

Definition:

Type of erosion protection structure at the ends of culverts, usually made out of cement; aka footers, endwalls, or end sections

- No – no end treatments are present on either side of the structure
- Inlet – end treatments present on the inlet side
- Outlet – end treatments present on the outlet side
- Both – end treatments are present on both the inlet and outlet side of the structure

How to measure or estimate:

While checking if it's visible, inspect the top and sides of structure

When to record:

Required for all structures

Shape

Definition:

Cross-sectional shape of the structure.

Shapes include:

- Circular – a circle, can be a wide variety of materials
- Box – a square or rectangle, typically made of concrete
- Pipe Arch – arch with a bottom, also called a squashed pipe; typically corrugated metal
- Ford – concrete slabs or other material with water flowing over top
- Vented Ford – concrete or other material with pipes or boxes venting the slab
- Natural Ford – road crosses stream with no structure, just natural substrate
- Bridge – spans channel with only pillars, no bottom to structure
- Open Bottom Arch – arch with no bottom, only concrete footers at stream banks
- Unknown – cannot see structure or enough of structure to determine shape

How to measure or estimate:

Visual inspection

When to record:

Required for all visible structures

Shape Examples:

Open Bottomed Arch -

structure is not continuous beneath the substrate (in contrast to circular or pipe arch, which are closed loops); natural stream bed forms the bottom of the structure; cement footers at stream edge indicate an open bottom arch



Circular -

height and width of pipe are equal



Box -

square or rectangular shaped



Pipe Arch -

similar to circular pipe but height and width are not equal



Shape Examples, continued:

Ford -

can be constructed in various manners including slated (often concrete or wooden), paved, or any method that alters the natural substrate



Vented Ford -

ford surface with any pipe or culvert underneath



Natural Ford -

no structure present and natural substrate throughout entire crossing



Material

Definition:

Structures can be constructed of a variety of materials, including:

- Cement
- Corrugated Metal
- Smooth Metal
- Plastic (corrugated)
- Plastic (Smooth)
- Wood
- Other – this includes structures with a combination of materials; describe in comments
- Unknown – only when structure is not visible

How to measure or estimate:

Visual inspection

When to record:

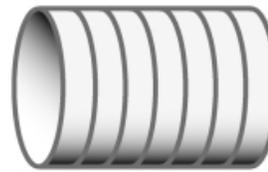
Required for all visible structures

Material Examples:



Corrugated Metal -
can have helical or concentric
corrugations; may or may not have rust
line, may be made a single piece or
multiple plates bolted together

Corrugation Patterns



Circumferential
(Annular)



Helical
(Spiral)



Cement -
used in many box and some circular
and arch culverts



Material Examples, continued:

Plastic -

made of plastic (PVC or HDPE), may or may not have corrugations



Smooth Metal -

metal pipe with no corrugations



Wood -

wood and logs are used to make log stringers, log box culverts, and circular culverts



Other -

an unknown material or one not listed above; make a note in the comments field about the pipe material

Width

Definition:

The maximum inside width or diameter of a structure

How to measure or estimate:

Measured with a tape measure or rod in feet and tenths of feet

When to record:

Required for all visible structures

****DO NOT reach into dense vegetation to uncover a crossing; snakes may be present****

Height

Definition:

Maximum internal height or diameter of a structure

How to measure or estimate:

Measured with a tape measure or rod in feet and tenths of feet

When to record:

Required for all visible structures

****DO NOT reach into dense vegetation to uncover a crossing; snakes may be present****

Width and Height Example:

Pipe Width and Height (ft) -
the inside height and width of each pipe is measured using a stadia rod or tape measure; measure at the widest and highest point of the pipe; dig down through substrate to pipe if necessary



Perch

Definition:

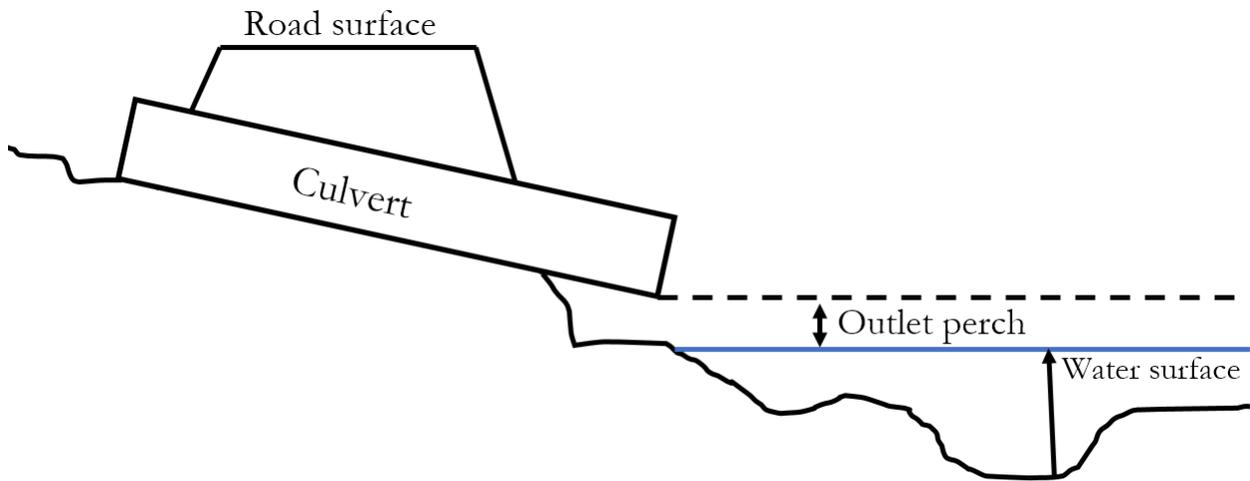
Distance from the surface of the water to the bottom of the structure outlet; when structure is installed with its bottom at or below stream grade the perch is 0

How to measure or estimate:

Measure with a rod or tape; record in feet and tenths of feet

When to record:

Record for structures connecting water bodies; stream crossing, wetland connector, wetland drain (if dry, leave null value)



Backwatered

Definition:

Pool habitat starts downstream of the structure, extends through the entire length of the structure, and continues upstream of the structure

- Yes
- No
- Dry – if channel is dry, backwatered cannot be assessed

How to measure or estimate:

Visual assessment of habitat type in and around structure

When to record:

Record for structures connecting water bodies; stream crossing, wetland connector, wetland drain

Natural Substrate

Definition:

Degree to which substrate in the natural channel extends through the structure

- None – no substrate in the structure
- Partial – substrate extends through only a portion of the structure or does not match substrate in the channel
- Full – substrate in the structure matches the stream channel and extends through the entire structure
- Unknown – cannot see into structure well enough to assess substrate

How to measure or estimate:

Visually assess the status of substrate in the structure

When to record:

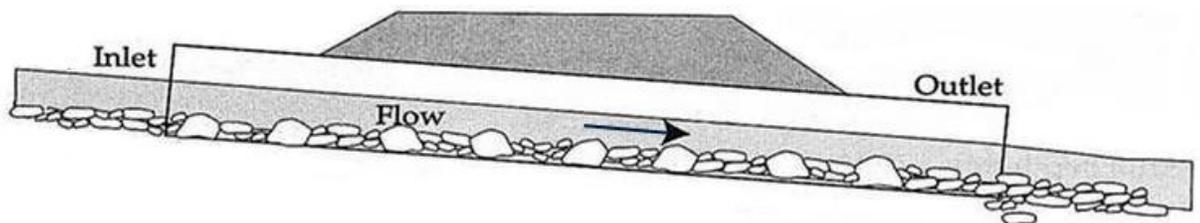
Record for structures connecting water bodies; stream crossing, wetland connector, wetland drain

Natural Substrate Example:

Natural Substrate -

each pipe needs to be checked for continuous substrate; the substrate must fully run the length of the culvert, be wide enough to provide a natural substrate for fish; and be representative of the stream bed

Note: if pipe is full of gravel to the point where it is somewhat plugged (i.e. blocking flow & restricting fish passage) it is NOT considered continuous substrate; in this case make a note in the comments



Coating (interior)

Definition:

Metal pipes are sometimes coated with a black tar on the inside to prevent corrosion

- None – no tar coating
- Full – entirely coated
- Partial – coating is weathered and no longer coats entire pipe
- Unknown – unable to assess coating inside pipe

How to measure or estimate:

Visually assess the status of coating on the inside of the structure

When to record:

Required for all visible structures

Condition and Condition Comment

Definition:

Structures often become damaged by high flows, road maintenance, and corrosion

- Good – no corrosion or damage to structure
- Fair – surface corrosion; light damage to structure
- Poor – heavy corrosion with holes; inlet or outlet broken or bent potentially disrupting proper function

How to measure or estimate:

Visually assess condition of structure; if condition is poor a comment is required describing condition

When to record:

Required for all visible structures

Is Culvert Functioning?

Definition:

Inlet or outlet may become plugged or crushed by debris due to high flows or road maintenance

- Yes – inlet **AND** outlet are **BOTH** less than 50% plugged with debris and are not crushed to less than 50% of original capacity
- No – inlet **OR** outlet are 50% or more plugged with debris or are crushed to less than 50% of original capacity; comment regarding condition is required
- Yes, but - inlet **OR** outlet are 50% or more plugged with debris or are crushed to less than 50% of original capacity, however, flow is still being maintained; comment regarding condition required

How to measure or estimate:

Visually assess the degree to which inlet and outlet are plugged or crushed

When to record:

Required for all visible structures

Flow

Definition:

Amount of water moving through a stream channel

- Wet – water flowing through riffles; no dry reaches
- Isolated Pools – riffles between pools are dry
- Dry – no water in stream channel

How to measure or estimate:

Visually assesses the flow status

When to record:

Record for structures connecting water bodies; stream crossing, wetland connector, wetland drain

Flow Condition Examples:

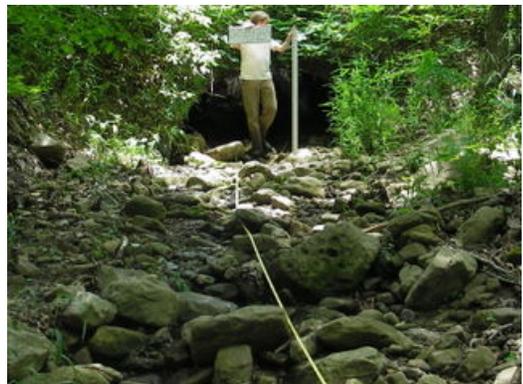
Wet -
pools full and continuous flow through riffles



Isolated pools -
discontinuous flow; pools have water but riffles dry or with sub-surface flow



Dry -
no water in pool or riffles



Flow Azimuth

Definition:

Direction of stream flow

- 0-359 degrees

How to measure or estimate:

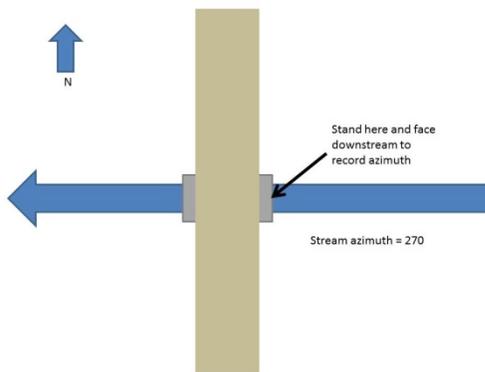
Stand on upstream end of structure and site down the length of the structure with a compass. Rotate the compass dial to line up red arrow with North. Record the number at the top of the compass dial

When to record:

Record for structures connecting water bodies; stream crossing, wetland connector, wetland drain

Flow Azimuth Example:

Standing at upstream end of pipe facing downstream; azimuth = 270 degrees



Posted

Definition:

A posted structure is marked with a post or sign

- Yes
- No

How to measure or estimate:

Look for a post or sign at the inlet or outlet of crossing

When to record:

Required for all structures

Posted Example:

Posted -
post or sign marking structure location



Photograph (inlet and outlet)

Definition:

Picture from camera

How to measure or estimate:

These fields act as reminders to take photos for both the inlet and outlet; can be used to leave comments relating to the respective photo. Taken with one team member standing by drainage structure, with pocket rod or stadia rod for scale set on the structure's bottom lip. Shot in landscape orientation, from a far enough distance so channel bankfull is visible in picture

When to record:

Required for structures connecting water bodies (stream crossing, wetland connector, wetland drain). Optional at all other sites and bridges; use photos when written descriptions won't tell the whole story at a site

Photo Number or Description (inlet and outlet)

Definition:

Picture number from the digital camera (record when tablet's integrated camera is not functional)

- 3 digit ID #

How to measure or estimate:

Push the play button on the camera. Record the last 3 digits of the picture number

When to record:

Required when photograph was not taken using tablet's integrated camera for structures connecting water bodies (stream crossing, wetland connector, wetland drain). Optional at all other sites and bridges; use photos when written descriptions won't tell the whole story at a site

Comments

Definition:

Remarks needed to expand upon or clarify data collected at a structure

How to measure or estimate:

NA

When to record:

Record comments any time you feel that the data recorded does not fully capture the status of or conditions of a structure. Comments may be required when certain responses are recorded for attributes. Comments are a welcome addition at any structure

Miscellaneous Features – New Point Feature

Definition:

Potential features of interest that are not covered in the drain/waterbody layers

How to measure or estimate:

Visual inspection along road, metal detection survey

When to record:

Whenever you come across a large culvert failure, area overrun by water that needs a culvert, or obvious drift lines with no surrounding culvert

- Type – Open text field; these are suggested categories but it's understood that there may be other scenarios you encounter
 - Erosion Event
 - Significant Failure
 - Large Mudhole
 - Overrun Road
 - End of Road
 - Other
- Comments – Any information that can be addressed
- Picture – Open text field; additional description of area
- Attachments – Take a photo of the whole area; can add multiple pictures if necessary. Photos not required for large mudholes, unless they are significant enough to warrant one.

Miscellaneous Features Examples:

Erosion event –
areas with visible signs of erosion present,



Significant failure -
nonfunctioning culvert in need of
immediate replacement or repair



Overrun road -
are overrun or overtopped by water that
does not have a culvert but needs one



Large mudhole -
low areas in the roadway that can fill with
water



Section 3: Wrapping Up

When you return to home base:

- Send a check in message to appropriate person(s)
- Turn in the data recorder and camera to the team leader
- Team leader backs up data and sends “Updates Pushed” email
- Other team members prepare equipment for next day
- Team leader develops logistical plan for next day and communicates in to the team

Appendix 1 – Field Troubleshooting

There may be some issues you run into while out in the field. Below are a few scenarios and troubleshooting tips to help mitigate these issues.

Syncing Issues

- Verify devices are connected before beginning a survey. The Bad Elf should show that it's connected to one (1) device and the iPad should indicate the serial number of the GPS it's connected to.
- Occasionally, both devices will show they're connected, but a point won't collect. This is a quirk of Collector, but hopefully shouldn't happen too often. To verify that Collector is receiving the coordinates, double check the box in the lower left hand corner of the app, it should show the location accuracy. If “-” is present, Collector will not take a point. Try closing out the app and restarting it.

Thrown Point Protocol

- Thrown points happen when a point is successfully collected in Collector and then there's an attempt to navigate within the map. Wherever the map is initially contacted, it will move the point to that spot. This is another quirk of Collector, so please be aware. If thrown point is recognized in the field, simply press the button that looks like the outline of a person with a circle in it. This will move the point to your existing location. For waterbody and drain culverts, it is easy to narrow down the area the point should be in based on timestamps, but cannot do the same for miscellaneous points.

Defining Fords and Condition

- Fords – If rocks look intentionally placed (at least 5% gravel) in roadway, select “Natural ford”
- Overrun roads – if no rocks are present and there are signs of water going over the road (regardless of frequency and current state), go with “Overrun road”
- If anything seems questionable, it's best to go with “Uncertain” for either waterbodies (if wetlands are present on either side) or drains. That way there's at least a record available.

Assessing Risky Roads

- If a road ends on the tracking map before it ends on the ground, collect an “End of Road” point in Miscellaneous; do not collect any further.
- If a road continues on the tracking map, but condition is severe (extreme flooding or bushwhacking required), collect point as above and discontinue survey.
- Some roads may be driveways to private property. If a road on the tracking map leads to a private parcel and private property signs are posted, discontinue survey.
- Use your best judgement to decide navigability and safety of lower level roads. If uncomfortable proceeding, take a point, note the condition, and move on.

Random Culvert Issues

- If a culvert cannot be surveyed at time of collection due to being submerged, collect a placeholder point, filling out as much information as possible and try to take at least one picture showing the condition, if safe.
- Buried culverts should have a point collected for it, but no picture is necessary.

Appendix B:

SARP Stream Crossing Survey Data Form Instruction Guide

SARP Stream Crossing Survey Data Form Instruction Guide



Original developed by the
North Atlantic Aquatic Connectivity Collaborative

Adapted for the Southeast by the
Southeast Aquatic Resources Partnership

Version SE2.1 – September 2017

With funding from Florida Fish and Wildlife
Conservation Commission (State Wildlife Grants)
and United State Fish and Wildlife Service

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For more information, go to: **www.southeastaquatics.org**

ACKNOWLEDGEMENTS

The initial development of this instruction guide was completed by the NAACC and with permission and training support it has been adapted to the Southeast region. This adaptation could not have been completed without the involvement of the NAACC, in particular Scott Jackson of UMASS as well as regional experts from USFWS, USFS, FWC, MDWFP and TNC. The adaptation of the NAACC to the Southeast was largely funded by a State Wildlife Grant (SWG) awarded by the Florida Fish and Wildlife Conservation Commission, another SWG from Texas Parks and Wildlife Department, as well as funding from USFWS.

Jessica Graham

The following acknowledgments remain from the original instruction development by the NAACC.

The development of this instruction guide and the survey protocol it explains would not have been possible without the effort of many people involved with the NAACC. First and foremost, we would like to thank our colleagues from the NAACC Core Group who worked so diligently to develop and refine the concepts reflected here, and the documents resulting from their many days and hours of effort. The core group includes Rich Kirn of the Vermont Department of Fish and Wildlife, Jessie Levine, Erik Martin, and Michelle Brown of The Nature Conservancy, Jed Wright of the U.S. Fish and Wildlife Service Gulf of Maine Coastal Program, Melissa Ocana and Bob English of the University of Massachusetts Amherst, and Keith Nislow of the U.S. Forest Service. We are particularly thankful to Jessie Levine for her many hours of thorough editing.

In addition, the NAACC relies on a Working Group composed of dozens of professionals working across the region in state and federal agencies and nongovernmental organizations dedicated to improving stream connectivity for the health and resilience of our aquatic and terrestrial ecosystems, as well as safeguarding our infrastructure in the face of a changing climate and increasingly intense, and sometimes devastating storms. Thanks to all those who have lent their time and expertise to making our collaborative successful.

And, finally, thanks to the U.S. Fish and Wildlife Service North Atlantic Landscape Conservation Cooperative for funding this important work.

Alex Abbott & Scott Jackson

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OVERVIEW

This document provides guidance for completing the Southeast Aquatic Connectivity Program's Stream Crossing Survey Data Form.

The Southeast Aquatic Connectivity Program is one of many programs that the Southeast Aquatic Resources Partnership coordinates. SARP is a state-driven partnership that includes a network of individuals from universities, conservation organizations, and federal agencies. The state and federal agencies targeted connectivity as a priority objective needing to be address in the region. SARP connected with the existing efforts in the Northeast through the NAACC and has transferred that knowledge down to the Southeast region with some changed to the protocol to fit our unique geography. The NAACC developed common protocols for assessing road-stream crossings (culverts and bridges) and developed a regional database for these field data. SARP has created a regional database to house the data collected as well as a web-based field collector form through Survey123.

The survey data form is to be used for an entire road-stream crossing, which may include single or multiple culverts or multiple cell bridges. On the first page, the top of the form contains general information about the crossing, and the bottom half of that page is for data on the first (or only) structure at the crossing. Subsequent pages are used to add data where there are additional culverts or bridge cells. It can be difficult to determine how best to evaluate multiple culvert/cell crossings. Please remember that it is essential to gather all of the data required for each structure (pipe or bridge cell) for accurate assessment of the entire crossing in terms of aquatic organism passage. However, if the data sheet is incomplete for a variety of reasons, the data can still be entered into the database but may not be scored for passability.

Stream crossing survey data can be collected digitally in the Southeast using Survey123 or via paper datasheets and uploaded through the web-based entry form. Further instructions for data entry by each of these methods can be provided by Kat Hoenke.

Please be sure to complete every possible element of the field data form.

SURVEY PLANNING

GENERAL PLANNING

Any effort to survey stream crossings should be based on a plan that includes answers to the following key questions:

1. *Who is primarily responsible for managing the surveys?*

Currently, SARP staff can help inform priority areas for surveys and how to manage the data once surveys are completed. However, each entity may have their own priorities based on organizational goals and work plans that should not preclude you from using this protocol or uploading your data. Feel free to contact Kat Hoenke or Jessica Graham if you have any questions.

2. *How will surveyors be trained?*

At this time, training should be arranged through SARP until additional trainers are established throughout the region. The training includes both classroom and field survey practice. The most important elements of training are becoming familiar with this instruction manual and gaining practice through survey of a variety of crossings with an experienced surveyor and standardizing your assessments.

3. *When should surveys be done?*

Ideally, surveys should be conducted during low-flow periods for your specific geography.

4. *How should we decide where to survey?*

SARP can provide information on current ongoing efforts and SARP Conservation Opportunity Areas as well as regional biodiversity hotspots. However, survey locations are generally decided upon by the individual entity and can always be included in the database if the SEACN protocol is used. If you desired a larger conversation to align your entity's priorities with others across the region, SARP can assist in coordinating and facilitating such discussions. In an effort to help inform those who are looking to conduct surveys we maintain a basic map of current and past efforts surveying across the region using the SEACN protocol. This map can be found at

5. *How will we keep track of the sites visited?*

You should maintain records, possibly as notations on paper maps, or in a table listing each planned survey site, showing which sites have been surveyed and when. Organize your survey forms by date, and be sure each survey form is complete. Once data has been entered into the SARP database you will be able to see all surveyed sites through online maps to verify that you have completed all planned crossings.

6. *How can we access crossings on major highways, railroads and private land?*

Depending on the scope of your surveys, you should have easy access to stream crossings on most public roads, though it is important to be aware of the right-of-way to avoid inadvertently trespassing on private land. Access to interstate highways and railroads is generally much more limited. For cases with limited access to crossings, you are responsible for contacting the appropriate owner or manager of those crossings to request access to conduct surveys. Similarly, for crossings on private roads, you should make concerted efforts to notify private landowners to request permission to conduct surveys on their lands. It may help to work with a local land trust, town or county governments, or state resource agencies to gain access from these landowners, as they often have similar needs for conducting habitat surveys or other resource assessments. In some survey efforts, when allowed by specific laws in effect in those jurisdictions, it has been considered permissible to survey crossings on private roads, particularly if good faith efforts to notify landowners have been undertaken first, or so long as crossings are not on posted or gated roads.

8. *How can we be sure our data will lead to crossing improvements?*

For your data to be useful in setting stream restoration priorities, we encourage you to collect data as completely and accurately as possible and ensure that the data are entered properly into the database. Finally, be sure that all data, including survey forms and site photographs, whether collected digitally or on paper, are transmitted to SARP for archiving.

SAFETY

Streams can be hazardous places, so take care to sensibly evaluate risks before you begin a survey at each stream crossing. While these efforts to record data about crossings are important, they are not nearly as important as your safety and well-being. Working around roads can be dangerous, so be sure to wear highly visible clothing, preferably safety vests in bright colors with reflective material; some vests have the additional bonus of containing many pockets to hold gear. Take care when parking and exiting your vehicle, and when crossing busy roads.

These surveys are best undertaken by teams of two people. This will facilitate taking measurements, making decisions in challenging situations, and recording data.

Take measurements seriously and carefully, but make estimates if necessary for your safety. Avoid wading into streams – even small ones – at high flows and entering pools of unknown depths, and take care scaling steep and rocky embankments. There are usually ways to effectively estimate some dimensions without risk. For example, an accurate laser rangefinder is a safe way to measure longer distances when conditions are unsafe, such as measuring culvert lengths through them instead of across busy roads.

EQUIPMENT

To collect data on stream crossing structures, you will need several essential pieces of equipment for measuring and recording, and some other items to keep you healthy and safe:

- ✓ **Instruction Guide for the NAACC Stream Crossing Survey Data Form** (this document)
- ✓ **Measuring Implements** in feet and tenths (decimal feet rather than inches)
 - **Reel Tape:** For measuring structure lengths and channel widths; 100 feet.
 - **Pocket Tape:** Best in 6 foot “Pocket Rod” version with no spring to rust.
 - **Stadia Rod:** Telescoping, 13 feet long to measure structure dimensions such as water depth.
- ✓ **Safety Vests:** Brightly colored, reflective vests, preferably with lots of pockets to hold equipment, but most importantly to be seen on the road.
- ✓ **Waders or Hip Boots:** To stay dry, insulate from cold water, minimize abrasions, and allow access to tailwater pools and deeper streams.
- ✓ **Flashlight:** To be able to see features inside long dark structures.
- ✓ **Rangefinder** (optional): To safely take measurements without crossing structures, busy roadways or streams; should be accurate to within one foot for adequate data accuracy.
- ✓ **Sun Protection:** Hat, sunglasses, and sunscreen as needed.

- ✓ **Insect Repellent:** To protect from annoying or dangerous bites.
- ✓ **First Aid Kit:** To deal with any minor injuries, cuts, scrapes, etc.
- ✓ **Cell Phone:** In case of emergency, to coordinate surveys, or to ask questions of coordinators.

For Paper Surveys

- ✓ **Stream Crossing Survey Forms:** Best printed on waterproof paper. Bring along more than you expect to use. Even digital surveys should include these in case a digital device becomes inoperable.
- ✓ **Clipboard, Pencils & Erasers**
- ✓ **Stream Crossing Maps:** For planning sites to survey, and for recording sites assessed, a *DeLorme Atlas and Gazetteer* or similarly accurate and updated set of maps with topography is helpful for navigation.
- ✓ **GPS Receiver:** Set GPS to collect data in WGS84 datum, with Latitude and Longitude in decimal degrees.
- ✓ **Digital Camera:** Best if waterproof and shockproof, with sufficient battery power for a full day of surveying, and capable of storing approximately 100 low to moderate resolution images (approximately 100 - 500 kilobyte stored size, generally less than 1 million pixels–1 megapixel). Include batteries or battery charger, and download cable. A backup memory chip can be very useful to have on hand.

For Digital Surveys:

- ✓ **Tablet Computer:** Should be waterproof, and preferably shockproof, to be able to survive wet and rugged field conditions. Various mapping applications can be run to allow navigation to planned survey sites, replacing paper maps. For more information on this method of survey, refer to the NAACC Digital Data Collection User's Guide available at https://www.streamcontinuity.org/resources/naacc_documents.htm
- ✓ **GPS Receiver:** If not integral to the tablet computer, an external GPS device will be needed either to connect to the tablet via Bluetooth or wire, or at the least, to be able to provide correct coordinates for entering to the tablet manually.
- ✓ **Stream Crossing Survey Forms:** As a backup in case digital devices fail.

UNMAPPED SITES AND NONEXISTENT CROSSINGS

Survey teams may encounter unmapped crossings, or it may be unclear whether a crossing they have found in the field is on their map because its location does not match the map. In most cases, the surveyed crossing should be within 100-200 feet of the planned crossing. Survey teams also may encounter unmapped crossings because either the road was not mapped, as in the case of a road built to serve a new housing development, or because of an error in the road or stream data.

If there is no planned crossing near the site you are assessing, you need to assign a temporary *Crossing Code* to that crossing. A *Crossing Code* is composed of the prefix "xy" followed by the latitude and longitude of the site, with decimal degree latitude and longitude values as seven-digit numbers. For instance, a crossing located at 42.32914 degrees north and -72.67522 degrees west, will have the resulting *xy code* = "xy42329147267522," followed by the notation: "NEW XY" to indicate that this crossing site must be added to the map.

Conversely, a crossing may exist on the map but not in the field. If you try to navigate to a site and are certain that there is no crossing in the vicinity, you should select the "No Crossing" option for *Crossing Type* on the field data form. Some crossings may not actually exist due to errors in generating the crossing points. Another possibility is that there may have been a road crossing there at one time, but the crossing has been removed, but may still need to be surveyed to note passage problems. For these sites, you will select the "Removed Crossing" option. Similarly, sometimes an entire stream reach has been moved, particularly underground, in which case you will select the "Buried Stream" *Crossing Type*.

In all cases where a survey crew either cannot locate a mapped crossing or intends to add a new unmapped crossing, it is essential to check the location carefully to minimize navigation and data collection errors.

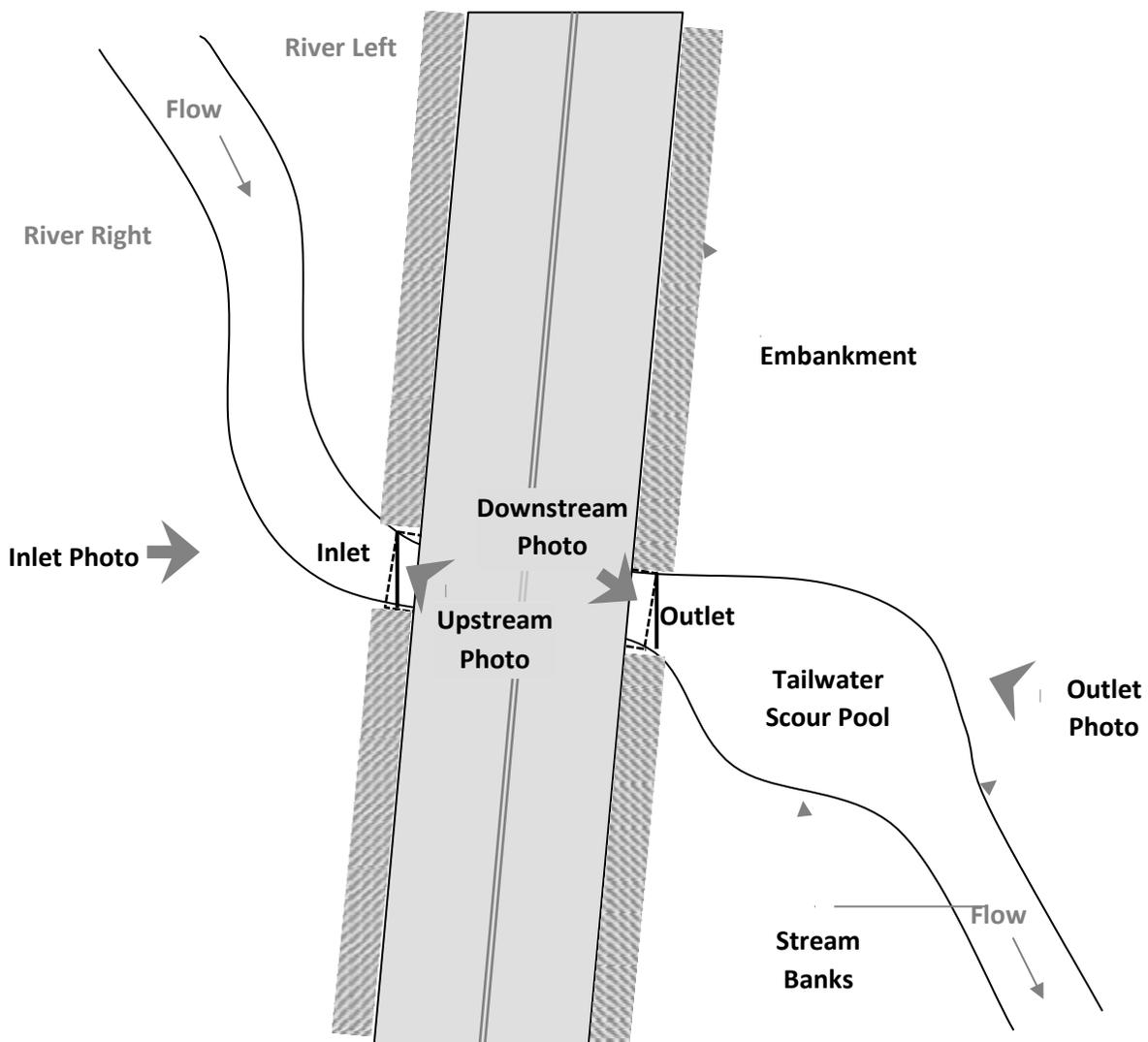
THE SURVEY DATA FORM

SHADED BOXES

The shading on the data form is intended to make the form easier to follow and complete. The different shading sets off elements related to certain groups of information from others.

SITE IDENTIFICATION

While each crossing will be different from others in its details, many common features will be assessed, measured, or otherwise observed during all surveys. The diagram below contains the basic terminology for key stream crossing features in a simplified overhead view.



UNDISTURBED STREAM REFERENCE REACHES

When conducting crossing surveys, elements of this data form require you to understand key characteristics of an undisturbed, “natural” section of the stream (called a *reference reach*) near where the crossing is located. These characteristics include the stream’s approximate width, depth, and velocity, and the type of substrate that predominates there. In general, you will need to go a distance upstream or downstream from the crossing that is between 10 and 20 times the width of the stream to get away from the influence of the crossing. This means for a 10-foot wide stream, you will need to go between 100 and 200 feet upstream or downstream from the crossing to find an undisturbed reach. The distance will be much larger for larger streams. Note that sometimes you will be unable to locate such a reference reach, either because upstream and downstream reaches are too disturbed or modified, or because access is limited, such as by *No Trespassing* signs. If the reference reach is restricted but you can access the crossing, do your best to assess it based on what you can see and make a note in the comments section that an adequate reference reach was inaccessible.

CROSSING DATA (Top Section)

Complete this section for the entire crossing. Choose only one option for the fields with checkboxes in the crossing data section.

Crossing Code: This is the 18-character “xy code” assigned to each planned survey crossing on survey maps. Be very careful to record the correct numbers, as they represent the precise latitude and longitude of the planned crossing, which can be compared with the actual location you record as GPS Coordinates below.

Local ID: Optional field for a program’s own coding systems. Does NOT replace the Crossing Code.

Date Observed: Date that the crossing was evaluated, following the form *M/D/Y*.

Lead Observer: The name of the survey team leader responsible for the quality of the data collected.

Town/County: The town or county in which the assessed crossing is located according to the map.

Stream: The name of the stream taken from the map, or if not named on the map, the name as known locally, or otherwise list as *Unnamed*.

Road: The name of the road taken from the map or from a road sign. Numbered roads should be listed as “Route #”, where # is the route number, with multiple numbers separated by “/” when routes overlap at the crossing (e.g., “Route 1/95”). For driveways, trails, or railroads lacking known names, enter *Unnamed*.
Multilane: > 2 lanes, including divided highways (assumed paved)

Road Type: Choose only one option:

Paved: public or private roads

Unpaved: public or private roads

Driveway: serving only one or two houses or businesses (paved or unpaved)

Trail: primarily unpaved, or for all-terrain vehicles only, but includes paved recreational paths

Railroad: with tracks, whether or not currently used

GPS Coordinates: Latitude and Longitude in decimal degrees to 5 decimal places. Use of a GPS (Global Positioning System) receiver is required, but your smart phone or tablet computer may include this capability.

Map Datum: It is best to use *WGS84* datum.

Location Format: Use Latitude-Longitude decimal-degrees (often in GPS menu as “hddd.ddddd”).

You should stand above the stream centerline, and ideally on the road centerline, when taking the GPS point, but use your judgment and beware of traffic.

Location Description: If there is any doubt about whether someone could find this crossing again, provide enough information about the exact location of the crossing so that others with your data sheet would be confident that they are at the same crossing that you evaluated. For example, the description might include “between houses at 162 and 164 Smith Road,” “across from the Depot Restaurant,” or “driveway north of Smith Road off Route 193.” This information could also include additional location information, such as a site identification number used by road owners or managers.

CROSSING DATA (Bottom Section)

Crossing Type: If a crossing is found at the planned location, choose the one most appropriate option.

Bridge: A bridge has a deck supported by abutments (or stream banks). It may have more than one cell or section separated by one or more piers, in which case enter the number of cells to *Number of Culverts/Bridge Cells*. Enter data for any additional cells in *Structure 2 Data*, *Structure 3 Data*, etc.

Culvert: A culvert consists of a structure buried under some amount of fill. If it is a single culvert, you need only complete the first page of the data form.

Multiple Culvert: If there is more than one culvert, you must indicate that in *Number of Culverts/Bridge Cells* to the right. Data must be entered in sections for additional structures starting on the second page (*Structure 2 Data*, *Structure 3 Data*, etc.). Count ALL structures, regardless of their size.

Ford: A ford is a shallow, open stream crossing, in which vehicles pass through the water. Fords may be armored to decrease erosion, and may include pipes to allow flow through the ford (*vented ford*).

If a planned crossing cannot be found or surveyed, the site will fit one of the following types:

No Crossing: There is no crossing where anticipated, usually because of incorrect road or stream location on maps. No further data is required. (Be sure you are in the correct location.)

Removed Crossing: A crossing apparently existed previously at the site but has been removed, so the stream now flows through the site with no provision for vehicles to cross over it. Continue to complete the survey form to the extent possible. Include information in Crossing Comments to explain your observations. For instance, indicate if an old culvert pipe is seen at the site, or if removal of the previous crossing structure left the stream with problems for aquatic organism passage.

Buried Stream: The planned crossing site does not include an inlet and/or outlet, likely because a stream previously in this location has been rerouted, probably underground. In this case, survey is not possible, and no further data is required.

Inaccessible: Survey is not possible because roads or trails to the crossing are not accessible. This may be due to private property posting, gates, poor condition, or other factors. Record in Crossing Comments why the site is inaccessible. No further data is required.

Partially Inaccessible: Use this option when you can access a crossing well enough to collect some but not all required data. This is most likely to occur when you cannot access either the inlet or outlet side of a crossing and cannot reasonably estimate the dimensions or assess things like inlet grade, outlet grade, scour pool or tailwater armoring.

No Upstream Channel: This option is for places where water crosses a road through a culvert but no road-stream crossing occurs because there is no channel up-gradient of the road. This can occur at the very headwaters of a stream or where a road crosses a wetland that lacks a stream channel (at least on the up-gradient side).

Bridge Adequate: Coordinators have the option of using this classification for large bridges for which it is obvious that they present no barrier to aquatic organism passage. Observers may collect and enter data for these crossings but these data are not required.

Number of Culverts/Bridge Cells: For all Bridges with multiple sections or cells, and for all multiple culverts, you must enter the number of those cells or culvert structures here.

Photo IDs: All surveys should include a minimum of four digital photos of the following: crossing inlet, crossing outlet, stream channel upstream of crossing, and stream channel downstream of crossing. These photos are

immensely useful in setting priorities for restoration. Note that photos of buried streams are optional but recommended.

It is essential that all photos be associated with the correct crossing. If you take photos with a digital camera (and sometimes when using a smart phone or tablet computer), you should record the photo numbers assigned by the camera on the survey form in the space for each photo perspective. To record the correct photo numbers from any camera, each person taking photos must be familiar with the numbering system of the camera used. Record the ID number of each photo in the blanks on the data form.

While you may take multiple photos at a site in order to choose the best ones later, you must record on the data form the ID numbers of all photos taken at the site. It can be very helpful to have one or more additional photos, especially when important characteristics are not captured on the four required photos. For instance, if there is extreme erosion at the site, or if other aspects of the crossing make it a likely barrier to connectivity, it is useful to capture these with one or two additional photos.

A simple way to know which photos were taken at a particular site is to use a black marker on a white dry-erase board to record the date and Crossing Code, and to have the first photo at the crossing show this white board displaying the date and Crossing Code. The white board should be strategically placed in the photo so that it is legible and does not block key features of the crossings. This will make the photo readily identifiable with the appropriate crossing. Some people have noted that white dry-erase boards and white paper reflect so much light that they are often “washed out” in the photos, making the codes written on the board impossible to read; use of a small blackboard and chalk may be preferable depending on light conditions.

Here are several additional tips for taking useful photos:

- Always include more than just the structure or stream area you are photographing; it is better to capture more context. Remember that with digital photos, we can zoom in to see detail.
- Including a stadia rod in photos of the inlet and outlet can be valuable to verify some measurements, and as a general reference for scale.
- When available, use a date/time stamp to code each photo.
- Set your camera to record in low to medium resolution so that the photos do not take up too much space on the memory card and when downloaded for storage. To minimize storage space but still allow a reasonable quality image, each photo should be between 100 and 500 kilobytes in size when downloaded. This often equates to a camera resolution setting of “1 Megapixel.”
- Review photos at the site to discard bad photos and to be sure all perspectives are well represented.
- If you haven’t used the camera before, practice to be sure you know how to take photos in dark or mixed light situations, as these often exist when surveying stream crossings.

The following are some examples of useful photos:



Upstream



Downstream



Flow Condition: Check the appropriate box to indicate how much water is flowing in the stream. Normally, the value selected for the first perennial crossing of the day will hold for all perennial sites in the area during that day, unless a rainfall event changes the situation. Choose only one option.

No Flow: No water is flowing in the natural stream channel; this option is typical of extreme droughts for perennial streams, or frequent conditions for intermittent or ephemeral streams.

Typical-Low: This is the most commonly used and expected value for surveys conducted during summer low flows, particularly on perennial streams. Water level in the stream will typically be below the level of non-aquatic vegetation, exposing portions of stream banks and bottom.

Moderate: This value is selected when recent rains have raised water levels at or above the level of herbaceous (non-woody) stream bank vegetation.

High: This value is selected only rarely, when flows are very high relative to stream banks, making crossing surveys very difficult or impossible, normally due to very recent, or ongoing major rain events. Avoid surveying crossings under high flows as data will not reflect more frequent flow conditions.

Crossing Condition: Check one box that best summarizes the condition of the crossing, based on your observations of the overall state or quality of the crossing, including all structures, particularly the largest or those carrying most of the flow. We are primarily trying to identify crossings in immediate danger of failing or in imminent need of replacement, as well as those that have been very recently installed. Focus primarily on the condition of structure materials.

OK: This is the value given to the vast majority of crossings. Many crossings have deficiencies such as surface rust, dents, dings, or cracks which do not indicate risk of failure.

Poor: This value is intended for structures where the material appears to be failing, such as metal culverts with rot (not just surface rust), or concrete, stone or wooden structures that are already collapsing, or in danger of immediate failure (see images below as examples).



New: This value is assigned only to a crossing that has been installed very recently. Look for unblemished structures with new riprap and/or vegetative bank stabilization.

Unknown: This value applies to all sites where the condition of the crossing cannot be assessed, such as when submerged.

Tidal Site: Sites in tidal areas will often require additional survey to fully assess aquatic organism passage. This element is primarily meant to identify sites in a tidal zone. Choose only one option. Survey of tidal crossings is best done within one hour of low tide to improve access and provide the most useful data. Freshwater streams influenced by tides, often at great distances from the ocean, are more difficult to identify. Determining areas that may be influenced by the tide should be conducted prior to field collection. If surveys will be conducted in a potential area that is tidally influenced, we suggest bringing a salinity meter with the field gear to verify each site.

Yes: Evidence shows that tidal waters regularly reach the crossing site. Evidence includes a clear wrack line (line of debris) marking the limit of recent tides. Other indications include observation of salt marsh plants (*spartina spp.*, not upland vegetation or freshwater wetland plants like cattails and common reed (*phragmites*), though both of these wetland plants *can* exist on the fringes of salt marshes) in the vicinity.

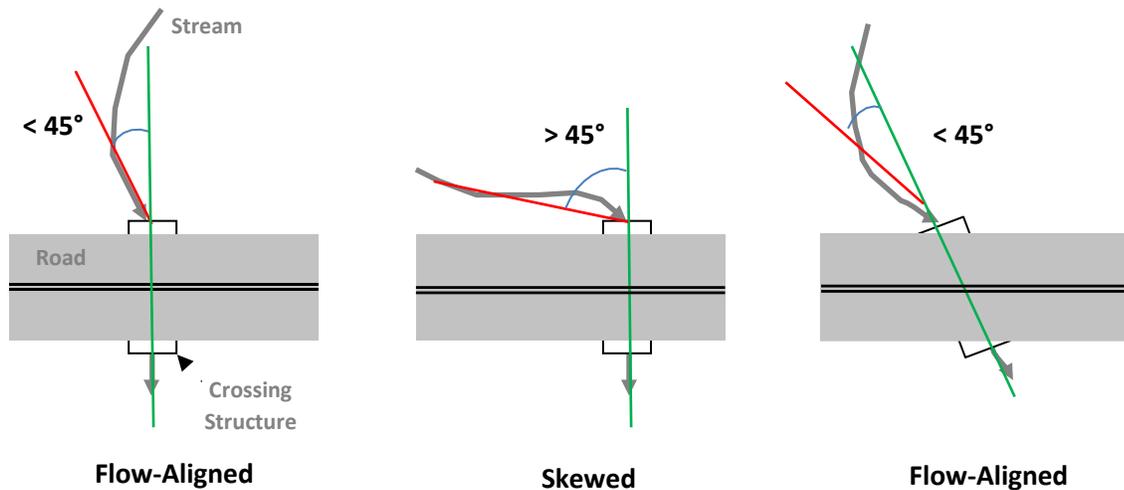
No: Sites are not tidal if downstream banks obviously contain plants that could not survive salt water inundation, such as alders, maples, ferns, etc., normally seen on stream banks in upland areas.

Unknown: Select when unsure of whether a crossing is in a tidal zone.

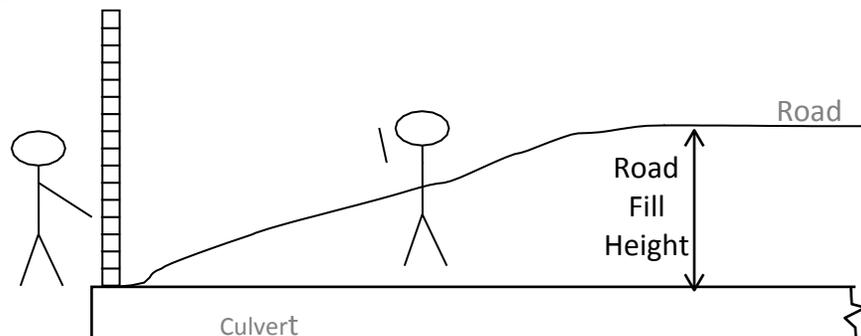
Alignment: Indicates the alignment of the crossing structure(s) relative to the stream at the inlet(s). Compare the crossing centerline (green lines below) to a centerline of the stream where it enters the crossing (red lines below).

Flow-Aligned: The stream approaches the crossing at less than a 45 degree angle from the centerline.

Skewed: The stream approaches the crossing structure(s) at an angle greater than 45 degrees from the centerline. Note that for some crossings the centerline is not perpendicular to the road.

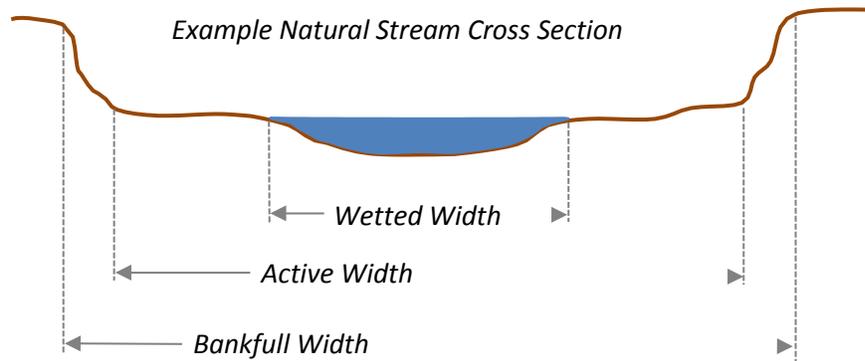


Road Fill Height: Within 1 foot, measure the height of fill material between the top of the crossing structure(s) and the road surface. This is best measured with two people when the road surface or fill height is above a surveyor's height, with one person holding a stadia rod, and the other sighting the elevation of the road surface from the side (see diagram below). For multiple culverts with differing amounts of fill over them, provide an average fill height.



Stream Measurement

Refer to the general illustrations below, and check the appropriate description from the list below to assess how constricted the flow of the stream is by the crossing compared to either the *bankfull*, *active*, or *wetted* channel. Choose only one option.



Active Channel: This is the area of the stream that is very frequently affected by flowing water. The width of the *active channel* can often be very close to the *bankfull width* when stream banks are very steep.

Wetted Channel: This is simply the area of the stream that contains water at the time of survey, which may be significantly less than the *active channel*, depending on flow.

Bankfull Width (optional measurement): This is a measure of the active stream channel width at bankfull flow, the point at which water completely fills the stream channel and where additional water would overflow into the floodplain. Estimates of the frequency of bankfull flows vary, but they may happen as often as monthly in part of the southeast, or only once every one or two years. This measurement takes practice and training to get correct and at times is difficult to determine. When done with high confidence (see next metric), bankfull width can be an extremely useful measurement, but it can be difficult and time consuming, and it will not be possible for all surveyors and sites (even with experienced surveyors). The first step is to identify bankfull flow indicators in an undisturbed reach, and the second step is to measure the width from bank to bank at those locations.

Indicators of bankfull flow (shown in the photographs below as the red line) include¹:

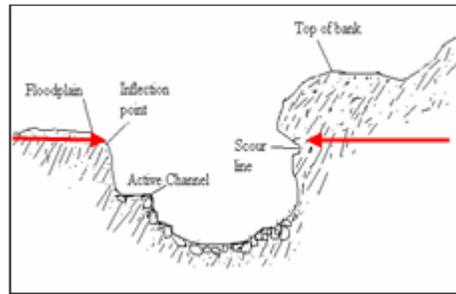
Abrupt transition from bank to floodplain: The point of change from a vertical bank to a more horizontal surface is the best identifier of bankfull stage, especially in low-gradient meandering streams.



Top of point bars: The point bar consists of channel material deposited on the inside of meander bends. Set the top elevation of point bars as the lowest possible bankfull.



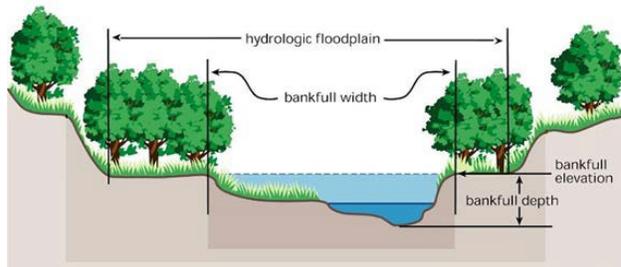
Bank undercuts: Maximum heights of bank undercuts are useful indicators of bankfull flow in steep channels lacking floodplains.



Changes in bank material: Changes in the particle size of sediment (rocks, soil, etc.) may indicate the upper limits of bankfull flows, with larger sediments exposed to more frequent channel-forming flows. Deposition of finer sediments on top of banks can also be used as an indication of previous flow heights.



Change in vegetation: Look for the low limit of woody vegetation, especially trees, on the bank, or a sharp break in the density or type of vegetation.



¹ Adapted from Georgia Adopt-A-Stream "Visual Stream Survey" manual. Georgia Department of Natural Resources, 2002.

Bankfull Width Confidence: This qualifies your assessment of Bankfull Width based on your experience with its measurement and whether sufficient criteria were met in your measurements. Choose only one option.

High: Select this option only when you are highly confident that your assessment of Bankfull Width meets the following criteria:

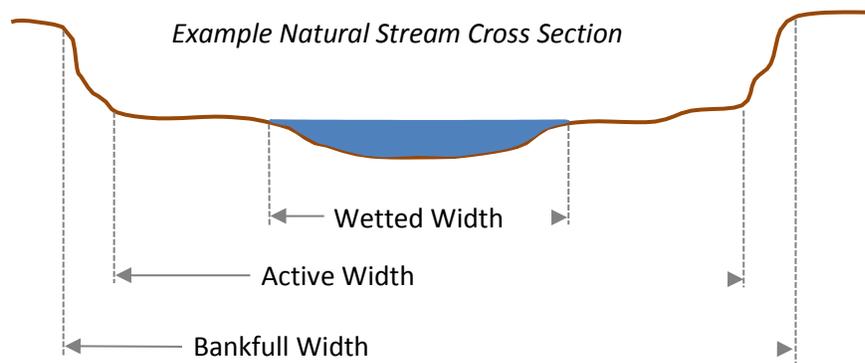
- Clear indicators are present to define the limits of Bankfull Width.
- The recorded value is an average of at least three measurements in different locations.
- All measurements of Bankfull Width were taken in undisturbed locations well upstream or downstream of the crossing.
- No tributaries enter between the crossing and your area(s) of measurements.
- No measures taken at stream bends, pools, braided channels, or close to stream obstructions.

Low/Estimated: Select this when **any** of the above criteria cannot be met.

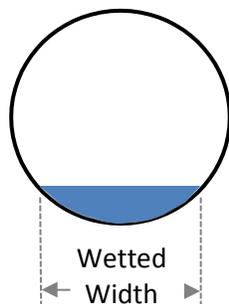
Constriction: Regardless of whether you measured Bankfull Width above, this element assesses how the width of the crossing (including all of its structures) compares to the width of the natural stream channel. Refer to the above section on determining Bankfull Width for reference. Two other ways of assessing the width of the natural stream channel consider the *active channel* and the *wetted channel*.

The **active channel** is the area of the stream that is very frequently affected by flowing water. The width of the *active channel* can often be very close to the Bankfull Width when stream banks are very steep. The **wetted channel** is simply the area of the stream that contains water at the time of survey, which may be significantly less than the *active channel*, depending on flow.

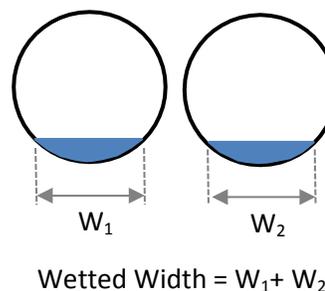
Refer to the general illustrations below, and check the appropriate description from the list below to assess how constricted the flow of the stream is by the crossing compared to either the *bankfull*, *active*, or *wetted* channel. Choose only one option.



Example Culvert Cross Section



Example Multiple Culvert Cross Section



Severe: The total width of the crossing (sum of widths of all crossing structures) is less than 50% of the bankfull or active width of the natural stream, or the total *wetted width* of the crossing is less than 50% of the wetted width of the stream.

Moderate: The crossing is *greater than* 50% of the bankfull or active width of the natural stream, but less than the full bankfull or active channel width.

Spans Only Bankfull/Active Channel: The crossing encompasses the approximate width of the bankfull or active channel.

Spans Full Channel & Banks: The crossing completely spans beyond the *Bankfull Width* of the natural stream, as often evidenced by banks within the crossing structure.

Tailwater Scour Pool: This is a pool created downstream of a crossing as a result of high flows exiting the crossing. Use as a reference natural pools in a portion of the stream that is outside the influence of the crossing structure. A scour pool is considered to exist when its size (a combination of length, width, and depth) is larger than pools found in the natural stream.

None: There is no difference between the length, width, or depth of the tailwater pool compared with reference pools, or no tailwater pool exists at the site.

Small: The tailwater pool is between one and two times the length, width, or depth of reference pools.

Large: The tailwater pool is more than twice the length, width or depth of reference pools.

Inlet Scour Pool: This is a pool created upstream of a crossing as a result of a multitude of factors including constriction, large flood plains, and high flows entering the crossings structure. In the Southeast this is not episodic and often occurs during any large summer rain event. Use as a reference natural pools in a portion of the stream that is outside the influence of the crossing structure. A scour pool is considered to exist when its size (a combination of length, width, and depth) is larger than pools found in the natural stream. Check Large if the length, width or depth of the pool is two or more times larger than of pools in the natural stream channel. Otherwise, check Small if the pool is between one and two times the length, width, or depth of pools in the natural channel (see above).

None: There is no difference between the length, width, or depth of the tailwater pool compared with reference pools, or no tailwater pool exists at the site.

Small: The tailwater pool is between one and two times the length, width, or depth of reference pools.

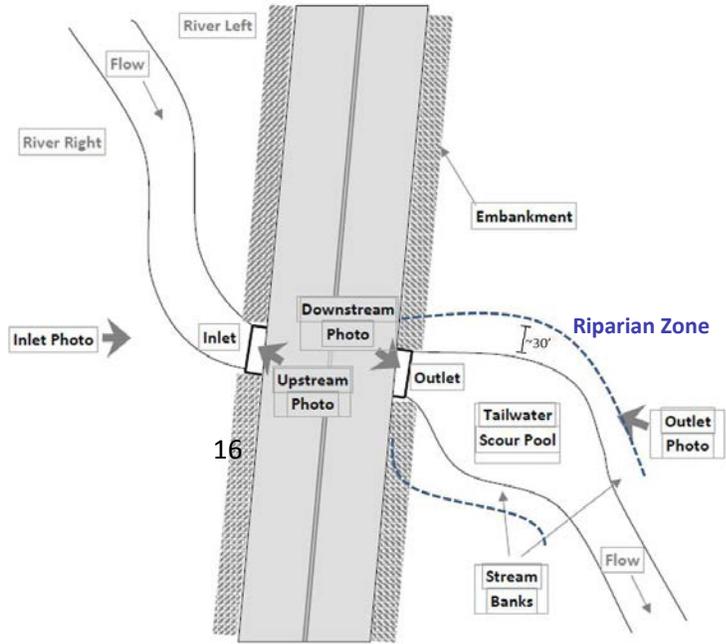
Large: The tailwater pool is more than twice the length, width or depth of reference pools.

Riparian Vegetation (Tailwater & Inlet sides): This metric was added in an effort to capture the risk of habitat degradation surrounding the culvert and scour pools. Lower levels of vegetation indicate a higher risk of erosion, scouring, structure undermining, as well as impacts to instream habitats. This metric is considering the immediate 30' buffer zone surrounding the scour pools (see image below for example area around tailwater scour pool). If the vegetation type (overstory, understory, and ground level) is greater than 50% then it is high, if less than 50% then it is low.

Overstory: Defined as the upper layer or zone formed by mature tree crowns

Understory: For this protocol, the understory is defined as the layer below the overstory and above the ground level. It includes layers commonly referred to as midstory, woody understory, herbaceous, and shrub layers.

Ground level: This refers to the immediate ground cover that is below the herbaceous/shrub layer. This refers primarily to rooted vegetation and not leaf litter. However, if there are significant leaf litter (complete coverage) it should be noted in the notes section.



Crossing Comments: Use this area for brief comments about any aspect of the overall crossing survey that warrants additional information. Do not use this box for comments about particular structures; comment boxes for each structure are provided elsewhere on the form.

STRUCTURE DATA

Outlet

Choose only one option for structure data fields **except** when identifying Internal Structures and Physical Barriers.

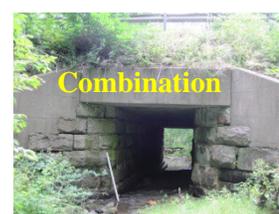
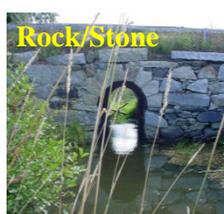
When there are multiple culverts and/or bridge cells, **number them from left to right, while looking downstream toward the culvert inlet.**



The left-most structure is Structure 1, and structure numbers increase to the right. See examples below.

For each structure, you will complete all of the following information.

Structure Material: Record here the primary material of which the structure is made, i.e., the material that makes up the majority of the structure. When in doubt, focus on the material that is most in contact with the stream. If a structure is made of two materials, such as a bridge with concrete abutments and a steel deck structure, a metal culvert that has been lined along its entire bottom with concrete, or a crossing with different types of structures at inlet and outlet, select *Combination*. Choose only one option.



Outlet Shape:

Refer to the diagrams on the last page of the field data form

Record the structure number that best matches the shape of the structure opening observed at the inlet of the culvert. This is usually simple, but when a shape seems unusual, you should carefully choose the most reasonable option from among the eight available. We collect this information to be able to find the “open area” inside the structure above any water or substrate, so the shape is vital to accurately calculate area. Choose only one option.

1 - Round Culvert: This is a circular pipe. It may or may not have substrate inside, even though the diagram on the field form shows a layer of substrate. It may be compressed slightly in one dimension, and should be considered round unless it is truly squashed so that it reflects a type 2 shape below.



2 - *Pipe Arch/Elliptical Culvert*: This is essentially a squashed round culvert, where the lower portion is flatter, and the upper portion is a semicircular arch, or as on the right below, more of a pure ellipse. It may or may not have substrate inside (the diagram on the field form shows a layer of substrate).



3 - *Open Bottom Arch Bridge/Culvert*: This structure will often look like a round culvert on the top half, but it will not have a bottom. There will be some sort of footings to stabilize it, either buried metal or concrete footings, or concrete footings that rise some height above the channel bottom. There will be natural substrate throughout the structure. To distinguish between an embedded Pipe Arch Culvert and an Open Bottom Arch, note that the sides of the Pipe Arch curve inward in their lower section, while the sides of the Open Bottom Arch will run straight downward into the streambed substrate or to a vertical footing. Beware of confusion between an Open Bottom Arch and an embedded Round Culvert; Open Bottom Arches tend to be larger than most Round Culverts. This shape could also be selected for certain bridges that have a similar arched shape and are not well represented by other bridge types (Types 5, 6, 7, below).



4 - *Box Culvert*: These structures are usually made of concrete or stone, but sometimes of corrugated metal with a slightly arched top. Typically, they have a top, two sides, and a bottom.

A box culvert without a bottom, called a bottomless box culvert, should be classified as a *Box/Bridge with Abutments* (#6, below). If you cannot tell if the structure has a bottom, classify it as a *Box/Bridge with Abutments* (#6). The images below show *Box Culverts* (#4).



5 - *Bridge with Side Slopes*: This is a bridge with angled banks up to the bottom of the road deck. This type will have no obvious abutments, though they may be buried in the road fill.



6 - *Box/Bridge with Abutments*: This is a bridge or bottomless box culvert with vertical sides.



7 - *Bridge with Side Slopes and Abutments*: This is a bridge with sloping banks and vertical abutments (typically short) that support the bridge deck. (Arrows below show the abutments.)



Ford: A ford is a shallow, open stream crossing that may have a minimal structure to stabilize where vehicles drive across the stream bottom. The arrows below indicate the length of a ford, to be measured as Dimension *L*, described below.



Unknown: Select when a structure's shape is unidentifiable for any reason. Typically, the inlet shape may be unidentifiable because it is submerged or completely blocked with debris.

Removed: Select when the structure is no longer present.

Outlet Armoring: Select from the options to indicate the presence and extent of material placed below the outlet for the purpose of diffusing flow and minimizing scour. The most common form of outlet armoring is a layer of riprap (angular rock) placed below the outlet. A few pieces of rock that may have fallen into the stream near the structure's outlet **do not** constitute outlet armoring. Armoring of the road embankment and stream banks should not be confused with armoring of the stream bottom at the outlet. Choose only one option.

Refer to the photos below for examples of each option.

None: This situation represents the majority of crossing structures. You may observe rocks that have fallen from the embankment or that are natural to the stream. Most cascades do not constitute armoring unless specifically put in place to minimize outlet scour.



Not Extensive: There is of a layer of material covering an area *less than 50% of the stream width* placed purposefully below the outlet specifically to minimize the effects of scour.

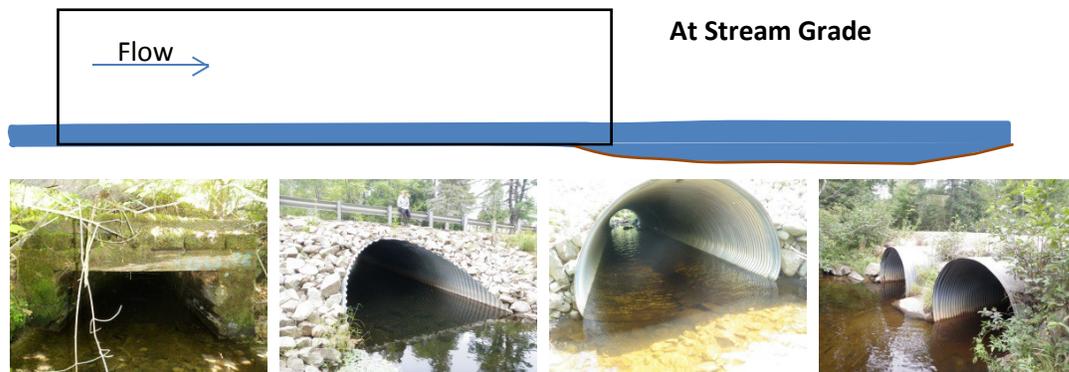


Extensive: Select this option only if you observe an extensive layer of material covering an area more than 50% of the stream width, which was put in place specifically to minimize scour at the outlet.

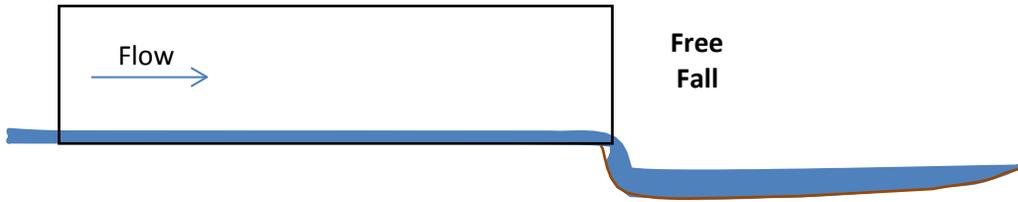


Outlet Grade: Outlet grade is an observation of the relative elevation of the structure to the streambed and how water flows as it exits the structure. This is not an assessment of stream slope (gradient).
Choose only one option.

At Stream Grade: The bottom of the outlet of the structure is at approximately the same elevation as the stream bottom (there may be a small drop from the inside surface of the structure down to the stream bottom), such that **water does not drop downward at all** when flowing out of the structure. Such outlets can normally be considered to be “backwatered” by the downstream stream bed.



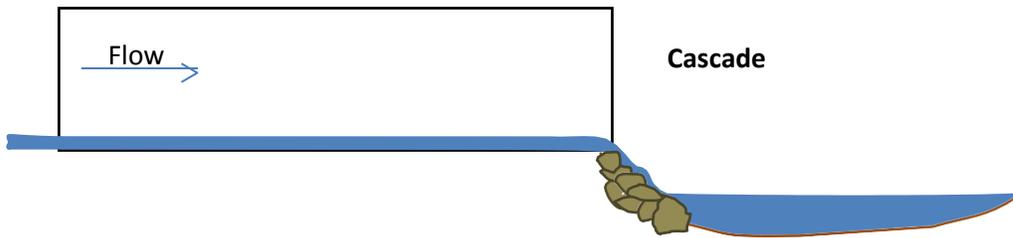
Free Fall: The outlet of the structure is above the stream bottom such that **water drops vertically** when flowing out of the structure.



Free Fall



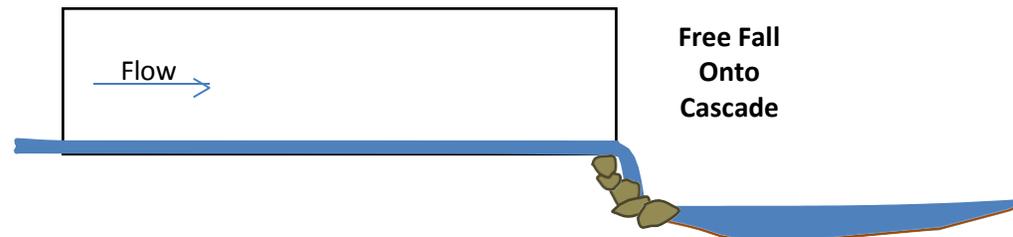
Cascade: The outlet of the structure is raised above the stream bottom at the outlet such that **water flows very steeply downward across rock or other hard material** when flowing from the structure. Think of this as series of small waterfalls at the outlet.



Cascade



Free Fall Onto Cascade: The outlet of the structure is raised above the stream bottom at the outlet such that **water drops vertically onto a steep area of rock or other hard material, then flows very steeply downward** until it reaches the stream.



Free Fall
Onto
Cascade



Outlet Dimensions: Four measurements should be taken at the outlet and inside all structures, and an additional two should be taken for all structures with an Outlet Grade marked as *Free Fall, Cascade* or *Free Fall*

Onto Cascade. The four measurements are shown on the diagrams on the last page of the field data form, and the others are illustrated below.

Dimension A, Structure Width: To the nearest tenth of a foot, measure the full width of the structure outlet according to the location of the horizontal arrows labeled **A** in the diagrams. Take this measurement **inside** the structure.

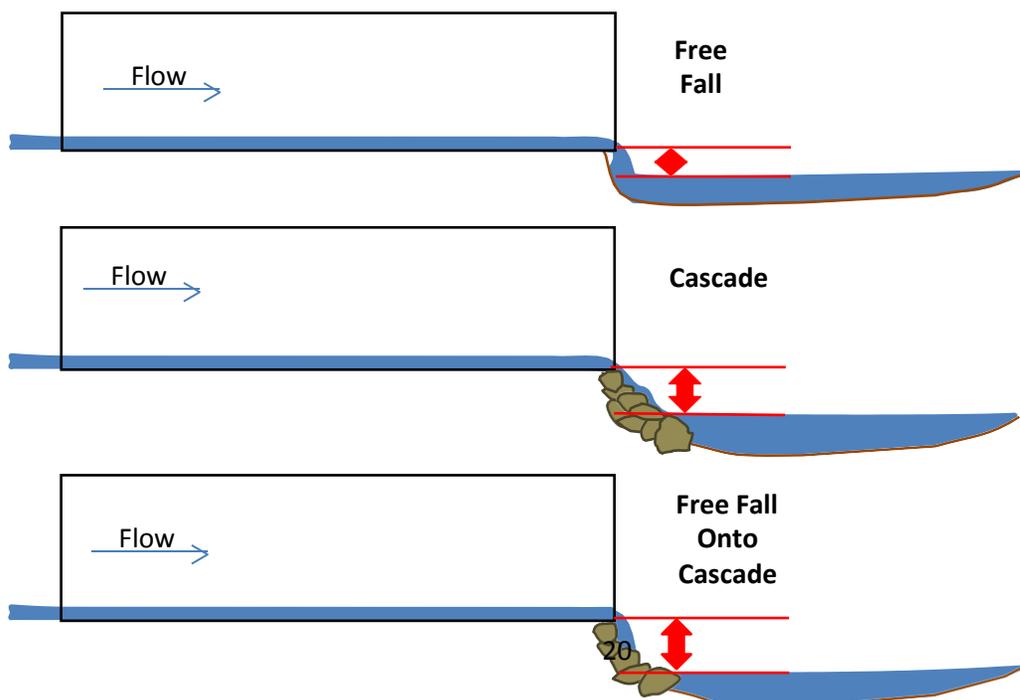
Dimension B, Structure Height: To the nearest tenth of a foot, measure the height of the structure outlet according to the location of the vertical arrows labeled **B** in the diagrams. Take this measurement **inside** the structure. If there is no substrate inside, this will be the full height of a structure from bottom to top. If there is substrate inside, this will be the height from the top of the stream bottom substrate up to the inside top of the structure.

Dimension C, Substrate/Water Width: To the nearest tenth of a foot, measure the width of **either** the substrate layer in the bottom of the structure, or of the water surface, whichever is **wider** according to the general location indicated by the arrows labeled **C** in the diagrams. This measurement must be taken **inside** the structure near the outlet. Some rules of thumb for Dimension C are below:

- When there is no substrate in a structure, measure only the width of the water surface.
- When there is no water in a structure, but there is substrate, measure the width of substrate.
- When there is no substrate or water in a structure, C = 0.

Dimension D, Water Depth: To the nearest tenth of a foot (except when < 0.1 foot, to the nearest hundredth of a foot), measure the average depth of water in the structure at the outlet according to the location of the vertical arrows labeled **D** in the diagrams. This measurement must be taken **inside** the structure. When there are lots of different depths due to a very uneven bottom, take several measurements and record the average. For fords, measure the water depth at the downstream limit of the ford.

Outlet Drop to Water Surface: This measurement is only applicable to *Free Fall*, *Cascade* and *Free Fall Onto Cascade* outlets. To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the water surface outside the structure. For *Cascade* and *Free Fall Onto Cascade* structures, measure to the surface of the water at the bottom of the cascade. Refer to the diagrams and photos below for guidance; the red arrows indicate where to make this measurement. When assessing *At Stream* Grade structures or dry structures in streams without flow or water in an outlet pool, this measurement must be **zero**.





Free Fall



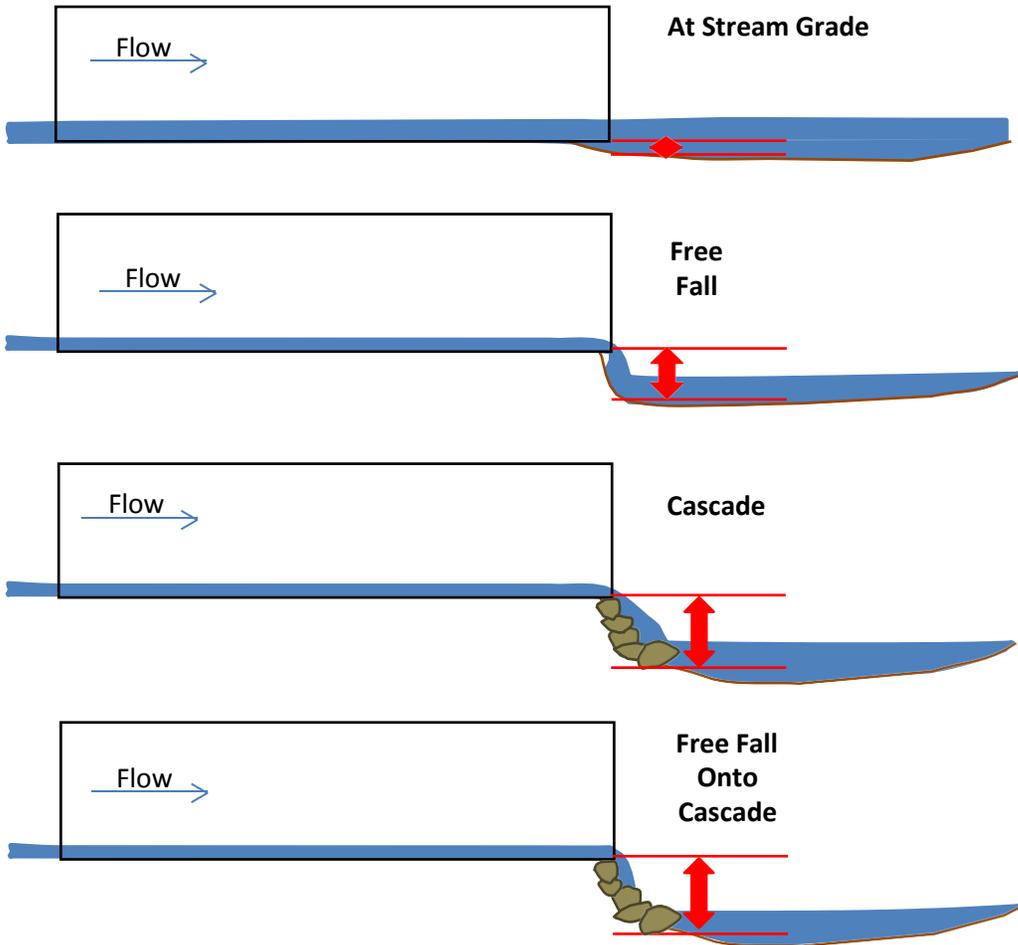
Free Fall



Free Fall Onto Cascade



Outlet Drop to Stream Bottom: To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the stream bottom at the place where the water falls from the outlet. For *At Stream Grade* structures, this may be hard to measure, and may be a very small drop. For *Cascade* and *Free Fall Onto Cascade* structures, measure the full vertical drop to the stream bottom at the end of the cascade. Refer to the diagrams below for guidance.



Abutment Height, Dimension E: This measurement is taken only when surveying a *Bridge with Side Slopes and Abutments* (#7 structure). To the nearest foot, measure the height of the vertical abutments from the top of the side slopes up to the bottom of the bridge deck structure.



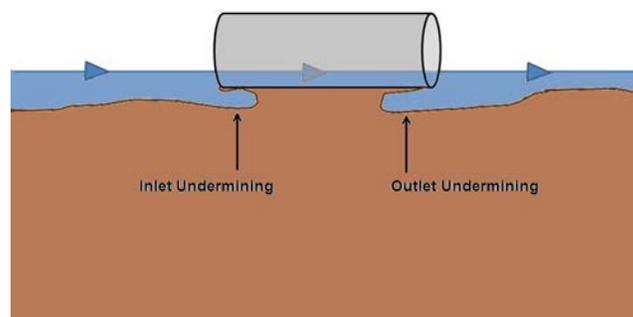
Structure Length, Dimension L: To the nearest foot, measure the length of the structure at its top.



Evidence of Undermining (Outlet and Inlet): Undermining occurs when water velocity causes a scouring underneath the structure. If there is evidence of undermining it indicates a greater likelihood of structure failure. In the Southeast this can occur on both the inlet and outlet sides. Undermining is present if there is space greater than 6" under the structure. If so, then select **Yes**, if less than 6" or none, select **No**.

Yes: Defined as a space greater than 6" underneath the structure itself. (Not to be mistaken with the scour pool).

No: Defined as a space less than 6" or none present at all.

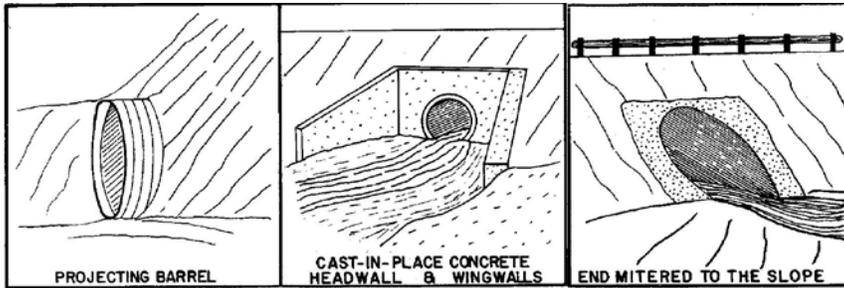


STRUCTURE DATA

Inlet

Inlet Shape: Refer to the diagrams on the last page of the field data form, and record here the number that best matches the shape of the structure at its outlet. Refer to the instructions for **Outlet Shape** for examples and photos.

Inlet Type: Choose only one option for the style of a culvert inlet, which affects how water flows into the crossing, particularly at higher flows. The drawings here are meant as general guides, but refer to the photos below for more specific images of each type.



Projecting: The inlet of the culvert projects out from (is not flush with) the road embankment.



Headwall: The inlet is set flush in a vertical wall, often composed of concrete or stone.



Wingwalls: The inlet is set within angled walls meant to funnel water flow. These walls can be composed of the same material as the culvert, or different material. It is relatively rare to see wingwalls without a headwall.



Headwall & Wingwalls: The inlet is set flush in a vertical wall, and has angled walls to funnel flow.



Mitered to Slope: The inlet is angled to fit **flush with the slope of the road embankment**. Note that many mitered culverts project out from the embankment, and should be recorded as *Projecting*.



Other: There may be some other inlet characteristics that do not match any of the above types and which may limit flow into the culvert (but are not *Physical Barriers*), in which case select *Other*, and explain in *Structure Comments*.

None: The inlet does not have any of the above features or characteristics.



Inlet Armoring: The same measurement as for the outlet. Select from the options to indicate the presence and extent of material placed below the inlet for the purpose of diffusing flow and minimizing scour. This is a common occurrence in parts of the Southeast where they will install armoring on both sides of the structure to diffuse flow during high rain events. The most common form of armoring is a layer of riprap (angular rock) placed below the inlet. A few pieces of rock that may have fallen into the stream near the structure’s inlet **do not** constitute armoring. **Armoring of the road embankment and stream banks should not be confused with armoring of the stream bottom at the inlet.** Choose only one option. (Pictures on page 19)

None: This situation represents the majority of crossing structures. You may observe rocks that have fallen from the embankment or that are natural to the stream. Most cascades do not constitute armoring unless specifically put in place to minimize outlet scour.

Not Extensive: There is of a layer of material covering an area *less than 50% of the stream width* placed purposefully below the outlet specifically to minimize the effects of scour.

Extensive: Select this option only if you observe an extensive layer of material covering an area more than 50% of the stream width, which was put in place specifically to minimize scour at the outlet.

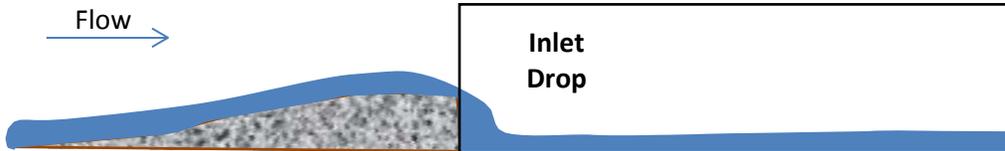
Inlet Grade: An observation of the relative elevation of the stream bottom as it enters the structure. This is not an assessment of stream slope (gradient). Choose only one option.

At Stream Grade: The inlet of the structure is at approximately the same elevation as the stream bottom upstream of the structure.

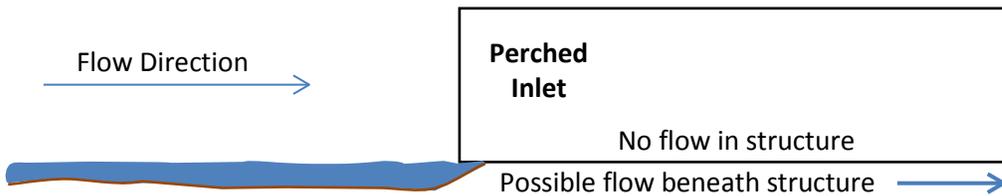




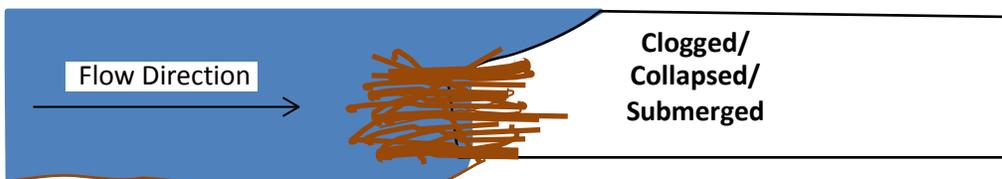
Inlet Drop: Water in the stream has a near-vertical drop from the stream channel down into the inlet of the structure. This usually occurs because sediment has accumulated above the inlet. The drop should be very obvious and not typical of natural drops in that stream. If there is a debris blockage or dam at the inlet, use **Physical Barriers** to record those features, and mark *At Stream Grade* here.



Perched: The inlet of the structure is set too high for the stream, and little water passes through the structure during normal low summer flows, though the stream has water upstream and downstream of the crossing. The structure inlet is above the surface of water in the stream. Water can enter the structure only at higher flows. This is a relatively rare condition, found mostly on very small streams. At such sites, there is generally water backed up above the inlet. In some cases water may be “piping” underneath the structure.



Clogged/Collapsed/Submerged: The structure inlet is either full of debris, collapsed, or completely underwater (not usually all three), making inlet measurements impossible. This may be found in places where beavers or debris have plugged a structure inlet so completely that water has backed up and covered the inlet, or where a crossing has collapsed to the point that it cannot be measured at its inlet.





Unknown: The inlet cannot be located or observed, or for some other reason you cannot determine the *Inlet Grade*, or take any inlet measurements.

Inlet Dimensions: There are four basic measurements to take at the inlet and outlet of each structure; these four measurements are to be made inside the structure. These are shown on the diagrams on the last page of the field data form.

Dimension A, Structure Width: To the nearest tenth of a foot, measure the full width of the structure inlet according to the location of the horizontal arrows labeled **A** in the diagrams. Take this measurement inside the structure.

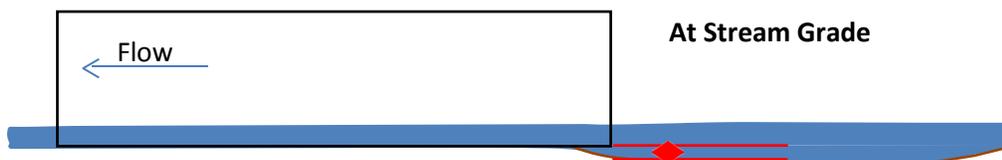
Dimension B, Structure Height: To the nearest tenth of a foot, measure the height of the structure inlet according to the location of the vertical arrows labeled **B** in the diagrams. Take this measurement inside the structure. This may be the full height of a culvert pipe if there is no substrate inside, or if there is substrate, it will be the height from the top surface of the substrate up to the inside top of the structure.

Dimension C, Substrate/Water Width: To the nearest tenth of a foot, measure the width of either the substrate layer in the bottom of the structure, or the water surface, whichever is wider, according to the general location indicated by the arrows labeled **C** in the diagrams. Take this measurement inside the structure at the inlet. Some rules of thumb for Dimension C are below:

- When there is no substrate in a structure, measure the width of the water surface.
- When there is no water in a structure, but there is substrate, measure the width of substrate.
- When there is no substrate or water in a structure, C = 0.

Dimension D, Water Depth: To the nearest tenth of a foot (except when < 0.1 foot, to the nearest hundredth of a foot), measure the average depth of water in the structure at the inlet according to the location of the vertical arrows labeled **D** in the diagrams. This measurement must be taken inside the structure. When there are many different water depths due to a very uneven structure bottom, take several measurements and record the average. For fords, measure the water depth at the upstream limit of the ford.

Inlet Drop to Stream Bottom: To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the stream bottom at the place where the water enters the inlet. For *At Stream Grade* structures, this may be hard to measure, and may be a very small drop. For *Cascade* and *Free Fall Onto Cascade* structures, measure the full vertical drop to the stream bottom at the end of the cascade. Refer to the diagrams below for guidance.



ADDITIONAL CONDITIONS

Slope %: (Optional) Calculate or estimate the percent slope of the crossing from inlet to outlet by using one of several optional methods described below. Note that this measurement or estimate can be important to calculating the hydraulic capacity of the crossing, and is difficult to measure accurately without the proper tools. In general, the ease and accuracy of these different methods relates directly to the cost of the tools needed, with the most easy-to-use and accurate measurement tools costing more.

- 1) The simplest accurate method for measuring slope is to use an accurate laser rangefinder/hypsometer with a slope function, and to measure from inlet to outlet at the same height in relation to each invert. For instance, a person with a known eye height of 5.0 feet sights from one end of a culvert by standing on top of the inlet to the 5.0 foot mark on a stadia rod on top of the outlet. You must take at least three measurements and average them, and be sure the instrument is set to read in percent, not degrees.
- 2) Another method for measuring slope is to use an auto level or other accurate survey instrument to measure the vertical difference between inlet and outlet invert elevations, then dividing this number by the length of the structure, and multiplying by 100.
- 3) The next best approach is to use a clinometer that measures slope to the nearest half percent, measuring from a fixed point above one invert (inlet or outlet) to the same height above the opposite invert such as described above under method 1. Many clinometers include both percent and degree scales; be sure to use the percent scale.
- 4) Another less accurate approach is to sight from a fixed elevation above the inlet invert with a hand level to a stadia rod at the outlet invert, to take the difference in height between the two points, divide by the structure length, and multiply by 100.

Slope Confidence: Rate the confidence you have in your slope measurement or estimate according to the criteria below:

High: Used method 1 above, taking multiple measurements and averaging them, or used method 2 above.

Low: Used methods 3 or 4 above, taking multiple measurements and averaging them.

Internal Structures: Indicate the presence of structures inside the crossing structure. These may include baffles or weirs used to slow flow velocities and help to pass fish, as well as trusses, rods, piers or other structures intended to support a crossing structure, but which may interfere with flow and aquatic organism passage. See photos below for examples of internal structures. Choose any option(s) that apply.

None: There are no apparent structures inside the crossing structure.

Baffles/Weirs: Baffles (partial width) or weirs (full width, notched or not) are incorporated into the structure, either inside or at its outlet, to help aquatic organisms move through the structure.

Supports: Some type of structural supports, such as bridge piers, vertical or horizontal beams, or rods apparently meant to support the structure, are observed inside the crossing structure.

Other: Structure(s) other than the categories above are present inside the crossing structure. Provide a very brief description of those structures here, or more fully describe them under **Structure Comments**. **Do not** include here items such as bedrock, material blockages, structural deformation, or inlet fencing to exclude beavers, which will be recorded below as **Physical Barriers**.



Structure Substrate Matches Stream: Choose only one option based on a comparison of the substrate (e.g., rock, gravel, sand) inside the structure and the substrate in the natural, undisturbed stream channel.

None: Select this option when there is very little (e.g., a thin layer of silt or a few pieces of rock) or no substrate inside the structure.

Comparable: The substrate inside the structure is similar in size to the substrate in the natural stream channel.

Contrasting: The substrate inside the structure is different in size from the substrate in the natural channel.

Not Appropriate: The substrate inside the structure is very different in size (usually much larger) than the substrate in the natural stream channel. Imagine turtles that typically move along a sandy stream trying to traverse an area of large cobbles, angular riprap or boulders (rarely observed).

Unknown: There is no way to observe if there is substrate inside the structure or what type it is. Select this option when deep, fast, or dark water or other factors do not allow direct observation.

Structure Substrate Type: Choose only one option from the table below to indicate the most common or dominant substrate type inside the structure. If you are certain that the structure contains substrate, but cannot assess the type, select *Unknown*. If there is no substrate in the structure, select *None*.

Substrate Type	Feet	Approximate Relative Size
<i>Silt</i>	< 0.002	Finer than salt
<i>Sand</i>	0.002 – 0.01	Salt to peppercorn
<i>Gravel</i>	0.01 – 0.2	Peppercorn to tennis ball
<i>Cobble</i>	0.2 – 0.8	Tennis ball to basketball
<i>Boulder</i>	> 0.8	Bigger than a basketball
<i>Bedrock</i>	Unmeasurable	Unknown - buried
<i>Organic Mtrl.</i>	Unmeasurable	Most commonly leaf litter or grass/algae

Structure Substrate Coverage: Choose one option, based on the extent of the substrate inside the crossing structure as a **continuous** layer across the entire bottom of the structure from bank to bank (side to side).

None: Substrate covers less than 25% of the length of the structure, or there is no substrate inside the structure at all.

25%: Substrate covers *at least* 25% of the length of the structure.

50%: Substrate covers *at least* 50% of the length of the structure.

75%: Substrate covers *at least* 75% of the length of the structure.

100%: Substrate forms a **continuous** layer throughout the **entire** structure.

Unknown: It is not possible to directly observe whether substrate forms a continuous layer on the structure bottom.

Physical Barriers: Select any of these barrier types in or associated with the structure you are surveying, but do not include here information already captured in **Outlet Grade**. Note here additional barriers, including those associated with Inlet Grade or blockages, or Internal Structures. If a barrier feature affects more than one structure at a crossing (e.g., a beaver dam), include it for all affected structures. Refer to the photos below for examples of physical barriers.

Note that some structures have a combination of physical barriers. Check all that apply.

None: There are no physical barriers associated with this structure aside from any already noted in **Outlet Grade**.

Debris/Sediment/Rock: Woody debris or synthetic material, rock, or sediment blocks the flow of water into or through the structure. This can consist of wood or other vegetation, trash, sand, gravel, or rock. Do not check this option if you observe only very small amounts of debris that are likely to be washed away during the next rain event. Also, do not confuse sediment inside a structure that constitutes an appropriate stream bed with an accumulation that limits flow or passage of organisms.



Deformation: The structure is deformed in such a way that it significantly limits flow or inhibits the passage of aquatic organisms. This does not include minor dents and slightly misshapen structures.



Free Fall: In addition to its **Outlet Grade**, which may include a *Free Fall*, the structure has one or more **additional** vertical drops associated with it. These may include a dam at the inlet, a vertical drop over bedrock inside the structure, or some other feature likely to inhibit passage of aquatic organisms. Note that a *Free Fall* inside a structure is often more limiting than similar size drops found in an undisturbed natural reach of the same stream which occur where there may be multiple paths for organisms to follow. A *Free Fall* can exist because of a debris blockage, so both physical barriers would be recorded.



Fencing: The structure has some sort of fencing, often at the inlet to deter beavers. Depending on the mesh size of that fencing, it may directly block the movement of aquatic and terrestrial organisms, and it may become clogged with debris. If also blocked with debris, be sure to check *Debris/Sediment/Rock* as a **Physical Barrier** type as well.



Dry: There is no water in this structure, though water is flowing in the stream. Note that if you recorded *No Flow* for crossing Flow Condition, you should not select *Dry* here, as we expect a dry structure at a dry crossing; it is not in itself a physical barrier. This barrier type helps to identify passage problems associated with overflow or secondary crossing structures.



Other: There may be different situations that do not fit clearly into one of the above categories, but may still represent significant physical barriers to aquatic organism passage. Use this option to capture such situations, and add information in Structure Comments. Below are examples of some unusual physical barriers which may not fit under Physical Barrier categories listed above.



These are examples of structures with a combination of physical barriers. Multiple relevant barrier types should be selected.



Severity: Choose only one option for each surveyed structure, and rank the severity based on an assessment of *the cumulative effect of all physical barriers affecting that structure* according to the table that follows. Do not consider information already captured in **Outlet Grade**. Decide on an overall severity for each structure by considering all the different Physical Barriers present. If any barrier affects more than one structure at a crossing, it should be included in the severity rating for each structure affected. Refer to the table below for guidance in choosing the **Severity** rating.

Physical Barrier	Severity	Severity Definition
None	<i>None</i>	No physical barriers exist - apart from Outlet Grade
Debris/Sediment/Rock <i>Logs, branches, leaves, silt, sand, gravel, rock</i>	<i>None</i>	None beyond few leaves or twigs as may occur in stream
	<i>Minor</i>	< 10% of the open area of the structure is blocked
	<i>Moderate</i>	10% - 50% of open area blocked
	<i>Severe</i>	> 50% of open area of structure blocked
Deformation <i>Significant dents, crushed metal, collapsing structures</i>	<i>None</i>	Small dents and cracks – insignificant effect on flow
	<i>Minor</i>	Flow is limited < 10%
	<i>Moderate</i>	Flow is limited between 10% - 50%
	<i>Severe</i>	Flow is limited > 50%
Free Fall <i>Vertical or near-vertical drop</i>	<i>None</i>	No vertical drop exists - apart from Outlet Grade
	<i>Minor</i>	0.1 - 0.3 foot vertical drop - apart from Outlet Grade
	<i>Moderate</i>	0.3 - 0.5 foot vertical drop - apart from Outlet Grade
	<i>Severe</i>	> 0.5 foot vertical drop - apart from Outlet Grade
Fencing <i>Wire, metal grating, wood</i>	<i>None</i>	No fencing exists in any part of the structure
	<i>Minor</i>	Widely spaced wires or grating with > 0.5 foot (6 inch) gaps
	<i>Moderate</i>	Wires or grating with 0.2 - 0.5 foot (~ 2-6 inches) spacing
	<i>Severe</i>	Wires or grating with < 0.2 foot (~ 2 inch) spacing
Dry	<i>Minor</i>	May be passable at somewhat higher flows
	<i>Moderate</i>	Not likely passable at higher flows
	<i>Severe</i>	Impassable at higher flows
Other	<i>Minor</i>	Use best judgment based on above standards
	<i>Moderate</i>	Use best judgment based on above standards
	<i>Severe</i>	Use best judgment based on above standards

Water Depth Matches Stream: Compare the water depth inside the structure with the water depth in the natural stream channel away from the influence of the crossing. Choose only one option.

Yes: The depth in the crossing falls within the range of depths naturally occurring in that reach of the stream and for comparable distances along the length of the stream. For example, if a structure has a water depth of 0.2 feet through the entire structure’s length of 60 feet, and there comparable sections of the stream with a 0.2 foot water depth for approximately 60 feet of the channel, select Yes.

No-Shallower: This means that the water depth in the crossing is less than depths that occur naturally in a similar length of the undisturbed stream, or the shallower depth through the structure covers a greater length than occurs in the natural stream.

No-Deeper: This means that the water depth in the crossing is greater than depths that occur naturally in a similar length of the undisturbed stream. This is rarely observed.

Unknown: A comparison of structure depth to natural stream depth is not possible.

Water Velocity Matches Stream: Compare the water velocity inside the structure with the velocity in the natural stream channel away from the influence of the crossing. Choose only one option.

Yes: The water velocity in the crossing falls within the range of velocities naturally occurring in that reach of the stream for comparable distances. If velocities in the crossing are observed in the natural stream channel, and those velocities persist over the same distance as the structure length, select *Yes*.

No-Faster: This means that the water velocity in the structure is greater than velocities that occur naturally in a similar length of the undisturbed stream, or the velocity through the structure persists over a longer distance than occurs in the natural stream.

No-Slower: This means that the velocity in the crossing is less than velocities that occur naturally in a similar length of the undisturbed stream. This is rarely observed.

Unknown: A comparison of structure velocity to natural stream velocity is not possible.

Dry Passage Through Structure? Consider this question two different ways, depending on whether water is flowing through the structure. Choose only one option.

If there is water flowing in the structure: Is there a continuous dry stream bank through at least one side of the structure that allows the safe movement of terrestrial or semi-aquatic animals, and does this dry pathway connect to the stream banks upstream and downstream of the structure?

If there is no water flowing in the structure: then there is continuous dry passage through the structure.

Yes: A continuous bank connects upstream, through the structure, and downstream, or there is otherwise continuous dry passage through the structure.

No: There is no dry passage, the dry passage is not continuous, or the dry passage through the structure does not connect with stream banks upstream or downstream.

Unknown: It is not possible to determine if continuous dry passage exists through this structure.

Height Above Dry Passage: If there is dry passage through the structure, measure the average height from the dry stream bank to the top of the structure directly above (i.e., the clearance) to the nearest tenth of a foot. If both stream banks are dry and connected, record the higher measurement. If the structure has no water flow, measure the average height above the bottom of the structure or dry stream bed to the top of the structure.

Comments: Use this area to briefly comment on any aspects of the structure needing more information. Enter comments about the overall crossing in the **Crossing Comments** box.