Field Guide
Explanations and Instructions for
Inventory and Assessment of Culverts on Fish Bearing Streams

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Note: This version is newer than that found on our CD. Check back often as the project continues to evolve.

This document is intended to provide general instructions and explanations for how to use the accompanying fish passage field data sheet. The data sheet and field guide were developed for collecting information required for inventory and assessment of culverts on fish bearing streams, with the specific purpose of using the FishXing software as an analysis tool.

The field guide and data sheet are only one component of a culvert assessment for fish passage. Once the general stream crossing data has been collected the sites need to be categorized by whether or not they are an obvious barrier, passable, or undeterminable. If it is not readily apparent whether a culvert is a fish barrier, further hydraulic analysis should be performed using FishXing. The Help system within FishXing should assist in guiding you through the analysis.

Once the fish barriers are identified, priorities must be assigned to develop a clear strategy for remediating the passage problems. Priorities are often assigned based on the cost of the fix and the quantity and quality of the habitat that would become accessible. This requires some degree of habitat assessment and identification of additional barriers upstream and downstream of the stream crossing. The Fish Passage Barrier Assessment and Prioritization Manual produced by Washington Department of Fish & Wildlife covers these issues in detail and is available at:

http://www.wa.gov/wdfw/hab/engineer/fishbarr.htm.htm

Header Information

Surveyors: You and your partner's name.

Culvert # of Total #: If a stream crossing contains more than one culvert, each culvert must be surveyed separately. Start with surveying the culvert closest to the left bank (looking downstream). Fill out a separate data sheet for each culvert.

Road , Mile post , and Cross Road: Road name and the mile post were the stream crossing is located. If there are no posted miles, note location where you began (i.e. intersection of a road) and use your odometer to estimate the mile post. Also enter the name of the nearest cross road.

Named Stream: From USGS 7.5' quad or other local sources.

Watershed: Enter the name of the watershed or sub-watershed.

Fisheries Information

Fish Species/Age Class of Concern: List all the species and associated age classes of fish that the stream crossing should pass in both directions.

Presence observed during survey?: If fish are observed during the survey, check the box appropriate to where you observed them and note the species and age class or size.

Length of upstream habitat (ft):

> Historical – The total length of stream channel upstream of the culvert that was accessible by fish prior to the existence of any constructed barriers (i.e. upstream culverts or small dams). If the surveyed culvert is a barrier, this will assist in quantifying the amount of potential habitat that can be made accessible if the upstream barriers are also removed.
>
> Currently Accessible – Length of stream channel that is, or would be accessible to fish assuming no barrier exists downstream. If the culvert is a barrier, this will assist in quantifying the amount of habitat that will be made accessible by correcting the problem.

Upstream Culverts: Check the yes box if any culverts exist upstream within the range of historical habitat. Do not count culverts that are on historically non-fish bearing portion of the stream.

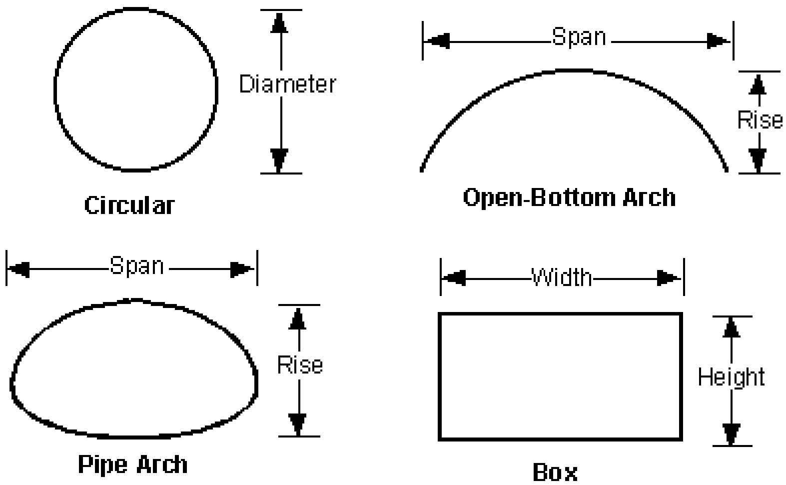
> No. of Culverts: Number of upstream culverts.
>
> Barriers: Check yes if any of these culverts are barriers to upstream fish movement. To answer this question, a complete analysis of the upstream culverts may be required.
>
> Distance: If there are upstream culvert barriers, measure the stream distance from the culvert inlet to the first upstream culvert barrier. This is best done using a hip-chain, but can be estimated using air photos or USGS topographic maps. If your not sure if an upstream culvert is a barrier, a hydraulic analysis may have to be preformed in the office before filling out this field.

Downstream Culverts: Check the yes box if any culverts exist downstream of the stream crossing.

> No. of Culverts: Number of downstream culverts.
>
> Barriers: Check yes if any of these culverts are barriers to upstream fish movement. To answer this question, a complete analysis of the downstream culverts may be required.
>
> Distance: If there are culvert barriers downstream, measure the stream distance from the culvert outlet to the first downstream culvert barrier.

Culvert Information

Culvert Type: Choose appropriate type of culvert. Depicted below are the end-sections of common culvert types.



Height- The height, rise, or diameter (measured vertically) of the culvert, measured from the inside of the corrugations. If the culvert bottom is completely covered with bedload (embedded) estimate the culvert height based on the shape (e.g. assume the height = width for circular culverts). For Open-Bottom Arches, measure the height from the streambed to the top of the culvert.

Width- The maximum width, span, or diameter (measured horizontally) of the culvert, measured from the inside of the corrugations. It is important to measure both the height and width on circular culverts since they often become squashed after installation.

Length- Culvert length measured from the inlet to the outlet. Do not include inlet and outlet aprons.

Material: If the culvert material does not fall into one of the following categories, give a brief description characterizing the roughness of the material.

> SSP = Structural Steel Plate pipes are constructed of multiple plates of corrugated galvanized steel bolted together.
>
> CSP = Corrugated Steel Pipes are constructed of a single sheet of corrugated galvanized steel.
>
> Aluminum = Corrugated aluminum, no rust line.
>
> Plastic = Often has corrugations.
>
> Concrete = Most box and some circular and arch culverts are constructed of concrete.

Log/Wood = Includes log stringer (Humboldt) crossings. Also includes some older box and circular culverts that are constructed of wood.

Corrugations: Measure the width and depth of the corrugations in inches. Most CSP have 2 2/3 in. x ½ in. corrugations. SSP pipes often have 6 in. x 2 in. corrugations. The size of the corrugations determines the culvert roughness.

Spiral: Spiral culverts have helical corrugations, reducing the culvert roughness.

Rustline Height: Measure the height of the rustline (at the peak) above the culvert bottom. The rustline height should be measured two to three diameters downstream of the inlet. The rustline can be used both as a field indicator for undersized culverts and as a check for the accuracy of the calculated fish passage flow for that specific stream. Rustlines greater than 1/3 the culvert height (diameter) are often considered hydraulically undersized. Also, the flow associated with the rustlines height (normal depth = rustline height) can sometimes be correlated to the basin hydrology (i.e. flow at rustline is approximately the 20% exceedence flow).

Pipe Condition: The categories below apply primarily to steel culverts. When appropriate, give a brief description of other observed problems with the stream.

good = slightly rusted

abraded = culvert worn thin by rust and passing sediment

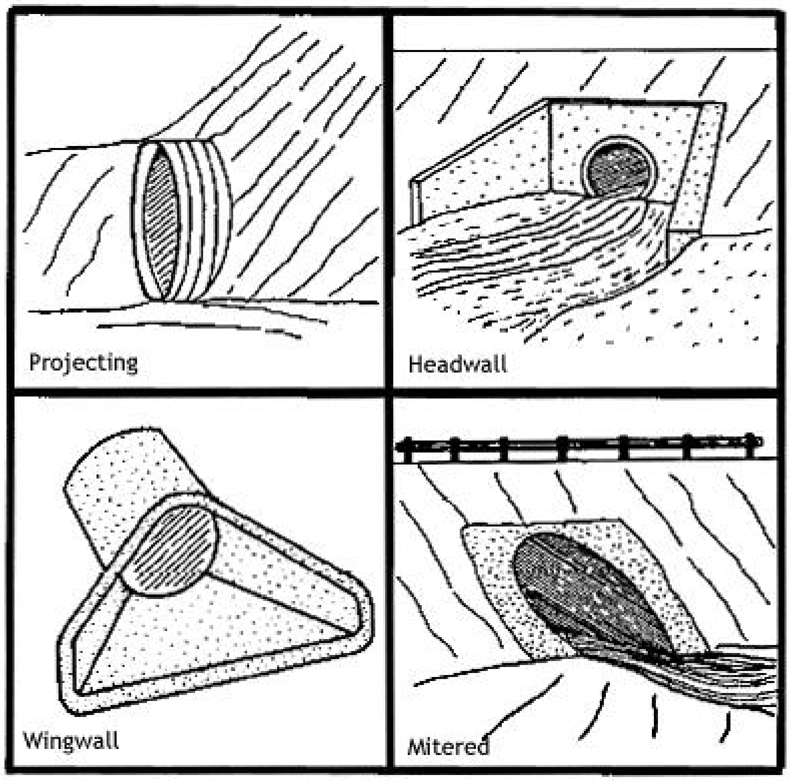
rust-through = a portion of the water flows through holes in the culvert bottom

Embedded: Check the yes box if the culvert has stream substrate retained within at least a third of the culvert. Estimate the depth of the substrate at the inlet and outlet. Estimating the culvert height and substrate depth can be difficult with pipe arch and box culverts that contain sediment throughout. Best estimates will suffice.

Location (beginning/end): If the culvert has only partial substrate coverage, measure the distance from the inlet to where the substrate either begins or ends. Enter the distance and circle whether the substrate begins or ends at that location.

Barrel Retrofit: If the culvert contains baffles or weirs record the type and give a brief description. Since baffle designs are often not standardized, a sketch of the retrofit along with dimensions is extremely useful. In particular, note the height and shape of the baffle/weir at the culvert outlet.

Inlet Types: Select the appropriate culvert inlet type. (see figure below)



Inlet/Channel Alignment: The approach angle of the upstream channel. Standing at the inlet looking upstream estimate the approach angle of the channel with respect to culvert centerline.

Channel approach angles greater than 30 degrees can increase the likeliness of culvert plugging which results in blockage of both upstream and downstream fish movement and can result in catastrophic failure of the stream crossing. Additionally, in some situations poor channel alignment can create adverse hydraulic conditions for fish passage.

Outlet Configuration:

> At stream grade = A swim through culvert that has no drop at the outlet.
>
> Freefall into pool = The culvert outlet is perched directly over the outlet plunge pool.
>
> Cascade over riprap = Culvert outlet is perched above the downstream channel and exiting water sheets over riprap or bedrock making it difficult for fish to swim or leap into the culvert.

Inlet / Outlet Apron: Aprons are commonly constructed of concrete or grout and extend upstream from the culvert inlet or downstream from the outlet. Inlet aprons are used to increase a culvert capacity, stabilize the channel bed or for other structural purposes. Outlet aprons are typically designed to prevent erosion at the toe of the stream crossing fill. Check the yes box if the culvert has an outlet apron and give a brief description. Note if the end of the apron has a weir or influences the flow within the culvert. Include a sketch on the back of the data sheet if needed.

Tailwater Control: The tailwater is the water surface immediately downstream of the culvert outlet. The location controlling the elevation of the tailwater is referred to as the tailwater control.

> Pool tailout = Commonly referred to as the riffle crest. Deposition downstream of the outlet pool controls the pool elevation.
>
> Log weir/Boulder weir/Concrete weir = Different weir types placed downstream of the outlet pool to control tailwater elevation.
>
> Channel cross-section = No outlet pool has formed allowing the water to flow unimpeded downstream of the culvert.

Upstream channel widths: Measure the width of the channel at the ordinary high water (OHW) level, sometimes referred to as the height of the active channel. The OHW location can be identified by locating the height of annual scour along the banks (typically devoid of vegetation or moss). Take five channel width measurements at locations upstream of the culvert influence. Space the measurements out over a 100-foot reach.

Undersized culverts can influence channel morphology and the OHW level for several hundred feet upstream as a result of frequent ponding and siltation. Avoid taking channel width measurements within the culvert influence. The maximum extent of the upstream influence can be assumed to be located where the channel bed elevation is the same as the road surface elevation at the stream crossing. In most situations the extent of influence is far less.

Surveyed Elevations

For accurately determining the culvert slope(s) and elevation of the tailwater at varying flows a survey must be performed. The minimum equipment required for surveying is a stadia rod, measuring tape, and either an auto level mounted on a tripod or a hand level placed on a monopod. When surveying breaks-in-slope within the culvert a flashlight and pocket stadia rod may also be required.

It is convenient to set up your level at a location that allows a clear line-of-sight to all the required survey points. This will avoid the need to move the instrument and keep the survey calculations simple. Often the easiest location to set up your level is in the channel directly downstream of the culvert. At crossings with small fills, the level can also be located on the road above the culvert if no slope breaks exist within the culvert. The site characteristics will generally dictate where you can set up the level.

It is important to tie all surveyed points to a common datum. The center of the culvert inlet bottom is often used, but any point that can be reoccupied in the future will suffice. An elevation must be assigned to the datum (100ft is commonly used). Then rod heights surveyed with the level are converted to elevations relative to the datum and entered on the data sheet. This may require a piece of scratch paper or calculator.

<u>TW control of 1st resting habitat upstream of inlet</u>: Identify the first potential resting location upstream of the culvert inlet, such as a pool. Then survey and record the station and elevation of the streambed at the pool tailwater, typically at the beginning of the riffle leading to the culvert inlet. This measurement will assist in determining if there is ample resting habitat for fish that successfully negotiate the culvert.

<u>Bed Elev. 2-culvert widths upstream of inlet</u>: Move two culvert widths upstream of the inlet and survey the stream bed thalwag elevation. Often undersized culverts interfere in the transport of sediment, depositing streambed material upstream of the inlet. This can cause a steep drop in the channel profile as it enters the culvert, hindering fish passage. This measurement can assist in identifying these sites.

<u>Inlet Invert (Bottom Elev.)</u>: Survey the point at the center of the culvert inlet. In embedded culverts this may not be the deepest point. The culvert length should be measured between the surveyed inlet and outlet points.

<u>Outlet Invert (Bottom Elev.)</u>: Located at the center of the culvert outlet.

<u>Inlet/Outlet apron or riprap</u>: If the culvert has apron(s), survey the beginning point the inlet apron and the ending point of the outlet apron. This will be used to determine the length and slope of the apron. If either the inlet or outlet has riprap within the channel survey the beginning/ending point of the placed rock.

Max depth within 5-feet of outlet: Survey the deepest point within five feet of the culvert outlet. If the fish must leap to enter the culvert, this elevation will be used to determine if the pool has sufficient depth.

Max pool depth: Survey the deepest point within the outlet pool. If there is no pool, survey the thalwag (lowest point in the channel) immediately downstream of the culvert.

TW Control: Survey the thalwag at the tailwater control. This defines the residual pool depth downstream of the culvert (see Tailwater Control for description).

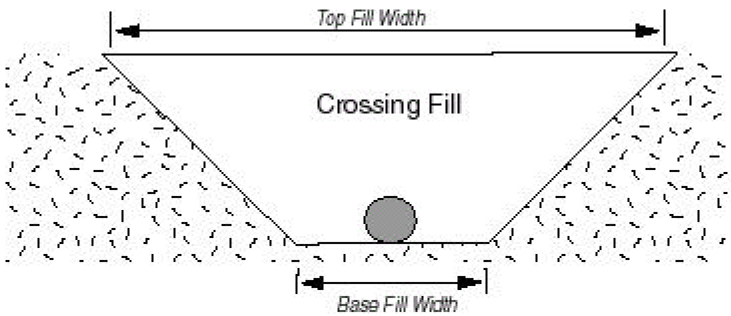
OHW elevation at TW control: Survey the elevation of the ordinary high water mark between the culvert outlet and the tailwater control. This will assist in identifying the elevation of the tailwater during fish migration flows (see Upstream Channel Widths for description of OHW).

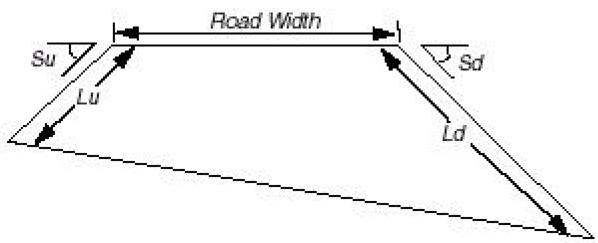
Breaks-in-Slope: In addition to measuring the average slope of the culvert, it is important to survey each change in slope within the culvert. Culverts often settle and become bowed through time. Typically the upper portion of the culvert becomes steeper than the lower section. When a culvert consists of compound slopes these steeper sections may become fish barriers. Be mindful that fish passage assessment using the average culvert slope instead of analyzing each compound slope independently may mistakenly suggest the stream crossing is not a barrier.

If the culvert contains observable breaks in slope, record the number of breaks (note that a culvert consisting of two compound slopes has only one break). Measure the distance from the inlet to the break and survey the elevation of the break point. Often a flashlight will be required to illuminate the stadia rod. In small culverts you may need to use a pocket stadia rod.

Fill Volume

Estimating the fill volume is useful when attempting to set priorities for stream crossing replacements. Excavation of existing fill can add substantial cost to a project. Conversely, when stream crossings with large fill volumes fail they can deliver greater amounts of sediment directly into adjacent streams. Dramatically undersized stream crossings with large fill volumes, even if they are not fish barriers, may need to be replaced.





Crossing fill measurements. Note that Ld, the downstream fill slope length often extends below the culvert outlet. These measurements are for obtaining a rough estimate of the fill volume and not intended for use in contract specifications.

Lu: Upstream fill slope length, measured from toe of the fill at the culvert inlet to inboard edge of road surface.

Su: Upstream fill slope, measured with clinometer.

Ld: Downstream fill slope length, measured from toe of the fill near the culvert outlet to outer edge of road surface.

Sd: Downstream fill slope, measured with clinometer.

Road Width: Width of the road above the stream crossing, measured perpendicular to the road centerline.

Top Fill Width: Width of the fill measured along the road centerline and perpendicular to culvert axis.

Base Fill Width: Width at the base of the fill (original channel width) measured perpendicular to culvert axis.

For a description of how to calculate the fill volume refer to Flanagan et al. (1998), which can be downloaded at:

http://watershed.org/wmc/pdf/xing_handbook.pdf

Tailwater Cross-Section

This section of the data sheet is optional. The tailwater cross-section is used to estimate the tailwater elevation at different flows by constructing a flow verses tailwater elevation rating curve. This method is most appropriate for stream crossings with unimpeded flow downstream of the outlet and possessing little or no outlet pool. It can also be used successfully when the tailwater control is the pool tailout. Although cross-sections of downstream weirs can not be used explicitly in FishXing, they can be informative when attempting to estimate water elevations at various flows.

The cross-section should be located at the tailwater control perpendicular to the stream channel. Cross-sections typically start on the left bank looking downstream. String a measuring tape across the channel from left to right. Make sure the first survey point is well out of the channel. Proceed to survey along the tape, taking points at each break in slope. Record the station (distance across the channel as indicated on the tape) and survey the rod height. The rod heights must then be converted to elevations relative to the datum. Also record points of interest, such as the locations of the OHW and bank full.

<u>Channel Roughness</u>: Describe the substrate at, and immediately downstream of the cross-section. This information will be used to estimate a Manning's roughness coefficient. For boulder or log weirs, describe the size of the boulders or the diameter of the logs.

<u>Channel Slope at Tailwater Control</u>: The slope of the channel reach leading downstream from the tailwater cross-section. The change in elevation of the channel thalwag over a measured length will be used to calculate the channel slope.

Select the length of channel to measure. The channel reach should begin at the cross-section and continue until the channel slope or width noticeably changes, typically 20 to 30 feet. Survey the thalwag near the tailwater control and record the rod height. Then proceed to survey the thalwag at the downstream end of the selected reach. Record the rod height and measure the distance between the two points. The change in the rod height divided by the length will give you the channel slope downstream of the tailwater control.