FISH PASSAGE GUIDELINES WHEN INSTALLING STREAM CROSSINGS

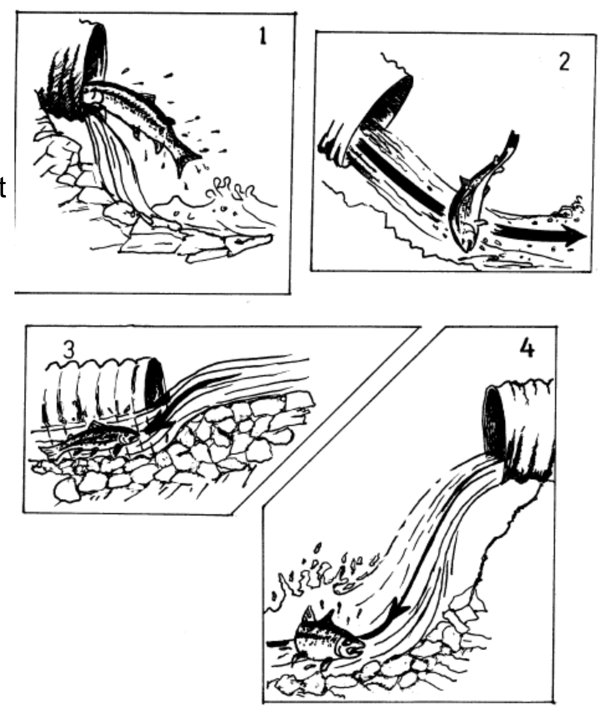
IDAHO DEPARTMENT OF LANDS

State Forester Forum

Under the Idaho Forest Practices Act and the Stream Channel Protection Act, all stream crossings on fish bearing streams must provide for fish passage. This Forester Forum provides guidelines that will help individuals design and install stream crossings that will not impede or delay fish passage. This is accomplished by: 1) stating the minimum standards for fish passage at stream crossings required by Idaho law, 2) providing design alternatives for traditional non-embedded culverts that meet hydraulic requirements of Idaho law, 3) providing design alternatives for stream crossing structures other than traditional non-embedded culverts that attempt to simulate the natural stream channel. Step-by-step guidelines for choosing an appropriate stream crossing structure are provided. These guidelines were developed in cooperation with the Idaho Departments of Fish and Game and Water Resources.

Minimum Requirements by Law

The requirement and direction to provide fish passage at forest road crossings can be found in State of Idaho law. The Idaho Forest Practices Act, Title 38, Chapter 13, Idaho Code, pertaining to road construction, reconstruction and maintenance (Rule 040) states: “Culvert installations on fish bearing streams must provide for fish passage.” Specific guidelines are found in the Rules Pertaining to Stream Channel Alteration, Title 37, Chapter 03, Idaho Code. These rules state that in streams where fish passage is of concern, the following criteria must be met to ensure that passage will not be inhibited by a proposed crossing:



1. Minimum water depth at crossing will be at least 8 inches for salmon and steelhead, and at least 3 inches in all other cases.
2. [Depending on the type of fish present, salmon/steelhead, resident fishes, or both] Water velocities shall not exceed those shown in the Alaskan Curve for more than a 48 hour period (see Figure 1).
3. Upstream drops at culvert entrance (inlet) will not be permitted.
4. A maximum outlet drop of 1 foot will be permitted if an adequate jumping pool is maintained below the drop.

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Hydraulic Design Procedure for Installing Traditional Non-Embedded Culverts

The rules stated above require a design process that attempts to match the hydraulic performance of a culvert with the swimming abilities of a target fish species. For the purpose of developing this guidance, a 6 inch cutthroat trout was used as the target fish species requiring passage through a culvert during high flows that are exceeded 5% of the time during average flow years. Allowing a 6" cutthroat trout to pass at high design flow should allow smaller fish and aquatic organisms to pass as flows through the culvert decrease.

Hydraulic analysis of the velocity component of the Stream Channel Alteration rule using the stated target fish and design flow has led to the following specific guidelines (Chart 1, and Figure 2A) for installing traditional non-embedded culverts at stream grade. This guidance assumes the culvert is properly sized to handle a 50-year-peak flow event as required by Idaho's Forest Practices Act.

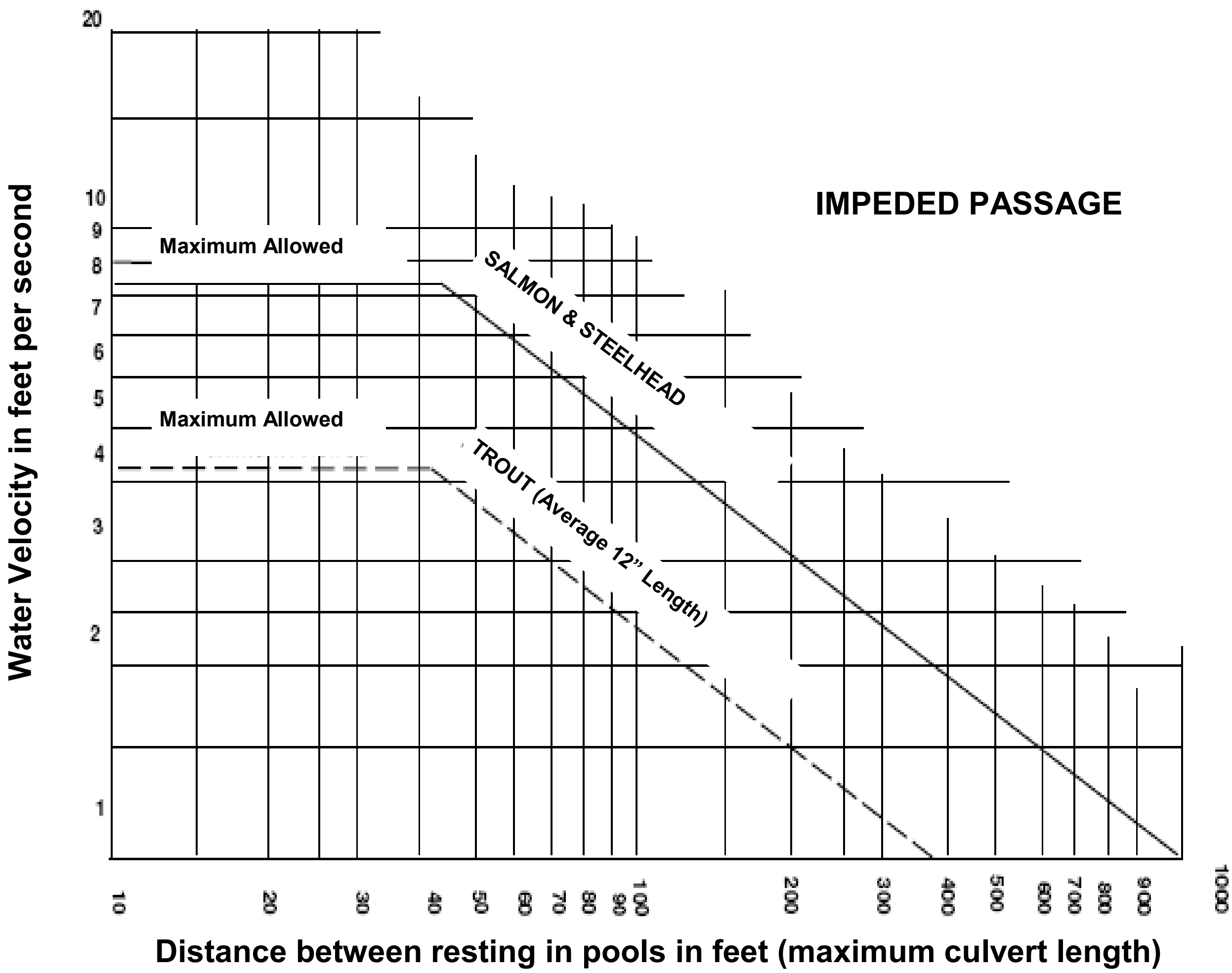

FIGURE 1. Swimming capability of migrating salmon and trout (Alaskan Curve)

Chart 1. This table shows the maximum allowable gradient at which a traditional non-embedded culvert can be installed that will meet Idaho's hydraulic design criteria for fish passage. This table assumes that the culvert is sized to pass a 50-year-peak flow event.

Drainage Area (Acres)	***Maximum Allowable Gradient of Installed Culvert***
<200	3%
201-350	2%
351-1000	1%
1001-2600	0.5%
2601-8200	0%

By looking at Chart 1, one can see that the use of traditional non-embedded culverts on fish bearing streams is limited to relatively low gradient streams.

Outlet drops are not permitted unless an adequate resting/jumping pool is maintained below the culvert outlet. Ideal jumping conditions exist when the ratio of pool depth to jump height is 1.25:1. In order to avoid the formation of inlet and/or outlet drops, non-embedded culverts must be installed at stream grade.

The process for applying Chart 1 is as follows:

1. Determine watershed size (acres) and stream gradient (use survey equipment to determine stream gradient %); if stream gradient is greater than 3% at the site of the proposed crossing, choose a stream crossing structure other than a traditional non-embedded culvert.
2. Determine maximum allowable culvert gradient by watershed size.
3. When the stream gradient is less than or equal to the maximum allowable culvert gradient, install culvert at stream gradient.

Newly installed stream crossings are subject to regulatory inspection by private forestry specialists employed by the Idaho Department of Lands. For regulatory purposes, an unsatisfactory condition exists if the maximum allowable gradient of installed culvert exceeds that shown in Chart 1 for a given drainage area.

The following are examples of how to apply Chart 1:

Example 1: Stream XY at a proposed stream crossing has a surveyed stream gradient of 1.5% and watershed drainage area of 325 acres. Look up drainage area on Chart 1 to determine the maximum allowable gradient of installed culvert. At 325 acres, the maximum allowable gradient of installed culvert is 2%. Since stream gradient (1.5%) is less than maximum allowable gradient for this particular site, the culvert can be installed at stream gradient and meet Idaho's hydraulic design criteria for fish passage. For regulatory purposes, the culvert will be measured to ensure that it was installed at less than 2%.

Example 2: Stream AB at a proposed stream crossing has a surveyed stream gradient of 4% and watershed drainage area of 1350 acres. Look up drainage area on Chart 1 to determine maximum allowable gradient of installed culvert. At 1350 acres, the maximum allowable gradient of installed culvert is 0.5%. A traditional non-embedded culvert will not meet Idaho's hydraulic design criteria for fish passage at this location.

Stream Channel Simulation

Stream simulation is based on the principle that, if fish can migrate through the natural stream channel, they can also migrate through a man made channel that simulates the natural stream channel. Taking this approach eliminates the need to consider such parameters as target species, timing of migration, and fish passage hydrology because it simply mimics what already exists. The criteria required in the State's hydraulic design criteria (velocity and depth) do not have to be calculated. Culverts and other structures designed to simulate stream beds are sized to match or exceed the channel width, and the bed inside the structure is sloped at a similar gradient to the adjacent stream reach.

The rest of this forum is dedicated to discussing and depicting alternative stream crossing methods and designs that will provide uninhibited fish passage at all stream grades. Based on use requirements, these stream crossing alternatives have been divided into permanent and temporary structures. After the various stream crossing alternatives are discussed, a section is included that provides a step-by-step guide to help the landowner choose an appropriate stream crossing.

Permanent Stream Crossing Structures

Permanent structures are placed at stream crossings where the transportation network requires years of continuous use. These types of crossings are usually installed on main haul routes, and major access roads. Careful consideration of alternative transportation and logging systems should be considered prior to installing new permanent stream crossings.

Permanent stream crossing structures that allow for fish passage include:

1. Culverts
2. Culverts installed with fish ladders
3. Structures such that simulate the natural stream bed
4. Bridges that span the stream to allow for long-term dynamic stream channel stability.

Table 2 (page 6) lists the different kinds of permanent stream crossing structures, and provides information that will help the landowner choose the appropriate structure for a given crossing. Figure 2 B-D depicts various embedded culvert and fish ladder design considerations.

Temporary Stream Crossing Structures

Temporary stream crossings are installed across a stream or watercourse for short-term use (a period of less than one year) then removed. Unlike permanent stream crossings, temporary stream crossings are not necessarily required to pass fish as long as the structure is removed prior to important fish migration and spawning times. Specialized knowledge of the type of fish present and important migration and spawning times is required prior to installing a temporary stream crossing that is not designed for fish passage. Temporary stream crossings may consist of a ford, log crossing, culvert, existing crossing structure or bridge.

Table 3 (page 7) lists the different types of temporary stream crossings, and provides information that will help the landowner choose the appropriate structure for a given crossing.

Table 1 (page 5) lists the general spawning and migration times of salmonid species in Idaho. These spawning and migration times may be further refined by consulting a fish biologist with local knowledge.

Table 1. Timing of migration and spawning of salmonids in Idaho.

FISH SPECIES	*TIMING OF SPAWNING MIGRATION*	*TIMING OF SPAWNING*
Rainbow trout	Mid Fed.—Late June	Mid March—Late June
Cutthroat Trout	Early March—Early July	Late March—Early July
Chinook Salmon	Mid May—Late Sept.	Early August—Early Oct.
Bull Trout	Late May—Early Oct.	Mid August—Late Oct.
Brook Trout	Early July—Late Oct.	Early Sept.—Late Nov.
Brown Trout	Mid July—Early Jan.	Late Sept.—Early Dec.
Kokanee	Late July—Early Jan.	Early Sept.—Early Jan.
Lake Whitefish	Early Oct.—Late Jan.	Early Oct.—Late Jan.
Mt. Whitefish	Early Oct.—Mid Feb.	Mid Oct.—Early Feb.

Table 2. Information on various **permanent** stream crossing alternatives that can help with design plans.

Stream Crossing Alternatives	Maximum stream gradient allowing fish passage	Technical Difficulty (low/ med/high)	Culvert Oversizing Needs	Potential of Plugging (low/ med/high)	Problems with minimum depths during low flow	Additional Comments
1. Culvert installed at stream grade	~0%, >2601 acres ~0.5%, 1001 - 2600 acs ~1.0%, 351 - 1000 acrs ~2.0%, 201 - 350 acres ~3.0%, < 200 acres	low	No need to oversize culvert	medium	Yes	Smooth or concrete culverts require flatter slopes than those listed. Round culverts maintain the deepest depths during low flows. If depths < 3" occur during low flow, consider another alternative.
2. Culvert with fish ladder	4.0%	medium	increase culvert size 1 diameter class	medium	No	The detachable fish ladder can be removed from a culvert if complications occur. Must be seeded with adequate substrate at installation and maintained over time.
3. Culvert with buried inlet and outlet	5.0%	Medium/high	encompass bankfull width	medium	Usually Not	Backfill culvert with cobble and boulder substrates. Culvert width must encompass bankfull width for substrate to remain in pipe. May not work in streams dominated by boulder, bedrock, or all fine grained.
4.Culvert with inlet burried more than outlet	6.5%	Medium/high	encompass bankfull width	medium	Usually Not	Backfill culvert with cobble and boulder substrates. Culvert width must encompass bankfull width for substrate to remain in pipe. May not work in streams dominated by boulder, bedrock, or all fine grained.
5.Culvert with baffles; Inlet and Outlet burried	8.0%	high	encompass bankfull width	medium	No	Backfill culvert with cobble and boulder substrates. Culvert width must encompass bankfull width for substrate to remain in pipe. May not work in streams dominated by boulder, bedrock, or all fine grained.
6. Open bottom structures	15.0%	medium	NA	medium	No	Structure must encompass bankfull width. This type of structure may not be appropriate on fine grained alluvium (silt and
7. Ford	any stream grade	low-high depending on stream gradient	NA	low	No	Fords typically do not allow year round or heavy traffic. On stream gradients > 2% special designs are required. Use of crossing may be limited by flow conditions and timing of fish spawn.
8. Bridges	any stream grade	medium	NA	low	No	Although this alternative is the most expensive, it is usually considered the best for fish passage, has longevity, and minimal maintenance requirements.

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Table 3: Information on various **temporary** stream crossing alternatives.

Stream Crossing Alternatives	Maximum stream gradient allowing for fish passage	Technical Difficulty (low/med/high)	Seasonal Timing Issue	Potential of Plugging (low/med/high)	Additional Comments
1. Glulam Mat	any stream grade	low	Yes	medium	Utilize on crossings for minimal disturbance. Ends of Mat should bear on even level ground at least 5 feet wide. Place mats next to one another to achieve desired crossing width.
2. Steel Bridge (Pass Through Design)	any stream grade	medium	No	low	Typical pass through bridge design geometry, with bridge structure removed when not needed. Footings may be left in place or removed depending on next use. Rip rap of approaches may or may not be needed.
3. Log Crossing	15.0%	low	Yes	high	Cut to length log crossing utilizing at least one 18 to 24 inch diameter culvert, cables placed on bare ground for less disturbance at removal. Geotextile fabric used at bottom and top of logs. Highly restrictive time of use based on fish species present.
4. Culverts Designed for Fish Passage	see Table 1	low to high	No	medium	Smooth or concrete culverts require flatter slopes than those listed. Round culverts maintain the deepest depths during low flow. If depths < 3" occur during low flow consider another alternative. `
5.Culverts Not Designed for Fish Passage	any stream grade	low	Yes	medium to high	Temporary culvert installation should be sized for 50 year event. Highly restrictive time of use based on fish species present. Must have good fish species information to utilize this
6. Removal of Existing Stream Crossing	any stream grade	low to medium	Yes	none	Remove existing stream crossing structure at end of timber sale. Lay back or remove fill approaches, and construct sediment mitigation structures; possibly barricade road. May be an opportunity to construct a ford crossing.

Choosing an Appropriate Stream Crossing Structure

To choose an appropriate stream crossing structure, consider long range planning objectives, timber harvest methods, cost, stream gradient, seasonal use, and ease of installation and maintenance. Tables 1 – 3 and Figure 2 discuss and depict the different stream crossing alternatives and can be used as a guide when planning and installing a stream crossing that meets Idaho's requirements for fish passage. When deciding which alternative to use, consider the following steps:

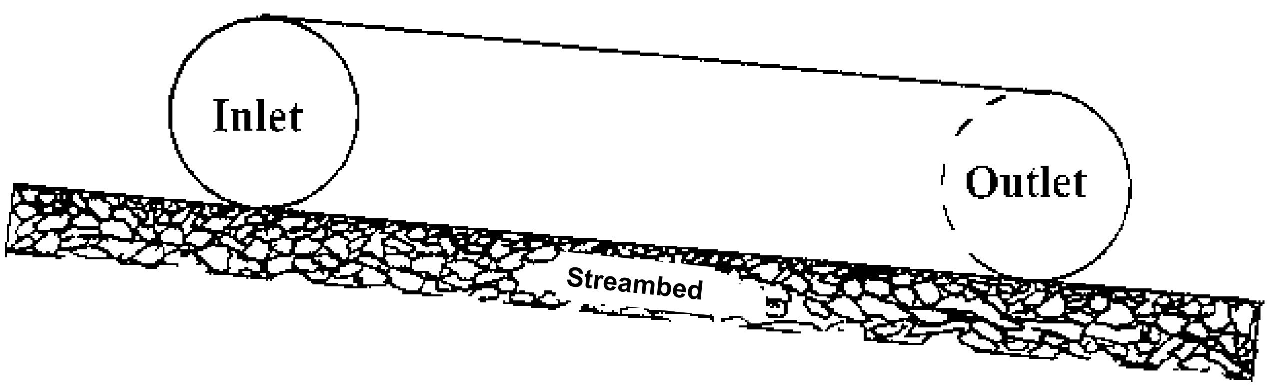
1. Determine if a permanent or temporary crossing is the best choice given long-term transportation requirements or seasonal use.
2. ***Determine the slope of the stream channel at the proposed crossing site using survey equipment***, clinometers and hand levels can not provide the level of accuracy necessary to design and install culverts.
3. Based on the stream's slope and transportation needs, use Chart 1, Tables 1-3, and Figure 2 to determine which types of stream crossings will allow fish passage.

Taking into account site conditions, cost, ease of installment and maintenance, choose the most appropriate stream crossing. Tables 2-3 and Figure 2 A-E provide general guidelines for installation. If unfamiliar with installation procedures for the chosen structure, consult a hydrologist, engineer, or fish biologist.

FIGURE 2. Details for installing various stream crossing alternatives.

A. Traditional non-embedded culvert at stream grade.

- A culvert should be selected that passes the 50-year-peak flow event.
- The resultant culvert grade should be the same as the original stream grade and comply with Chart 1.



B. Culvert with Buried Inlet and Outlet

- The culvert will have to be oversized in order to pass the design flow and encompass bankfull width.
- The outlet invert is countersunk below the channel bed by a minimum of 20% of the culvert diameter or rise.
- The inlet invert is countersunk below the channel bed by a minimum of 20%, and can be countersunk below the channel bed by a maximum of 40% of the culvert diameter or rise.
- Armoring and/or a grade control structure upstream and downstream of the culvert will minimize erosion and help substrates remain inside the culvert. Drops between grade control structures should not exceed 1.0 foot. It is best to backfill inside the culvert with angular cobbles and boulders.

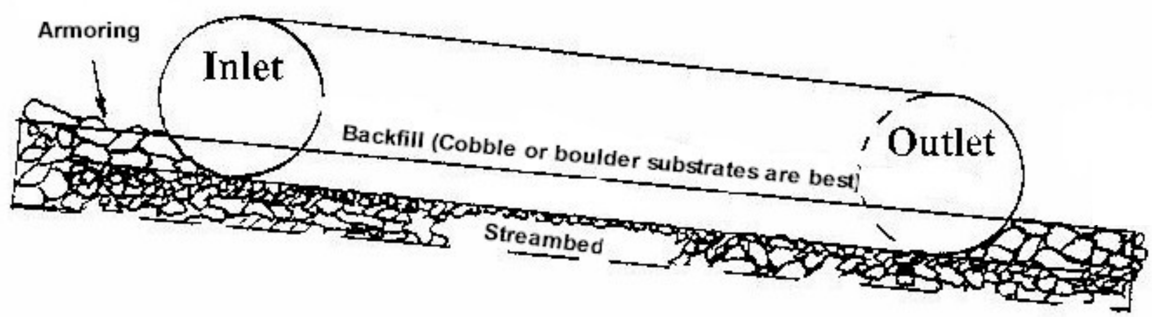
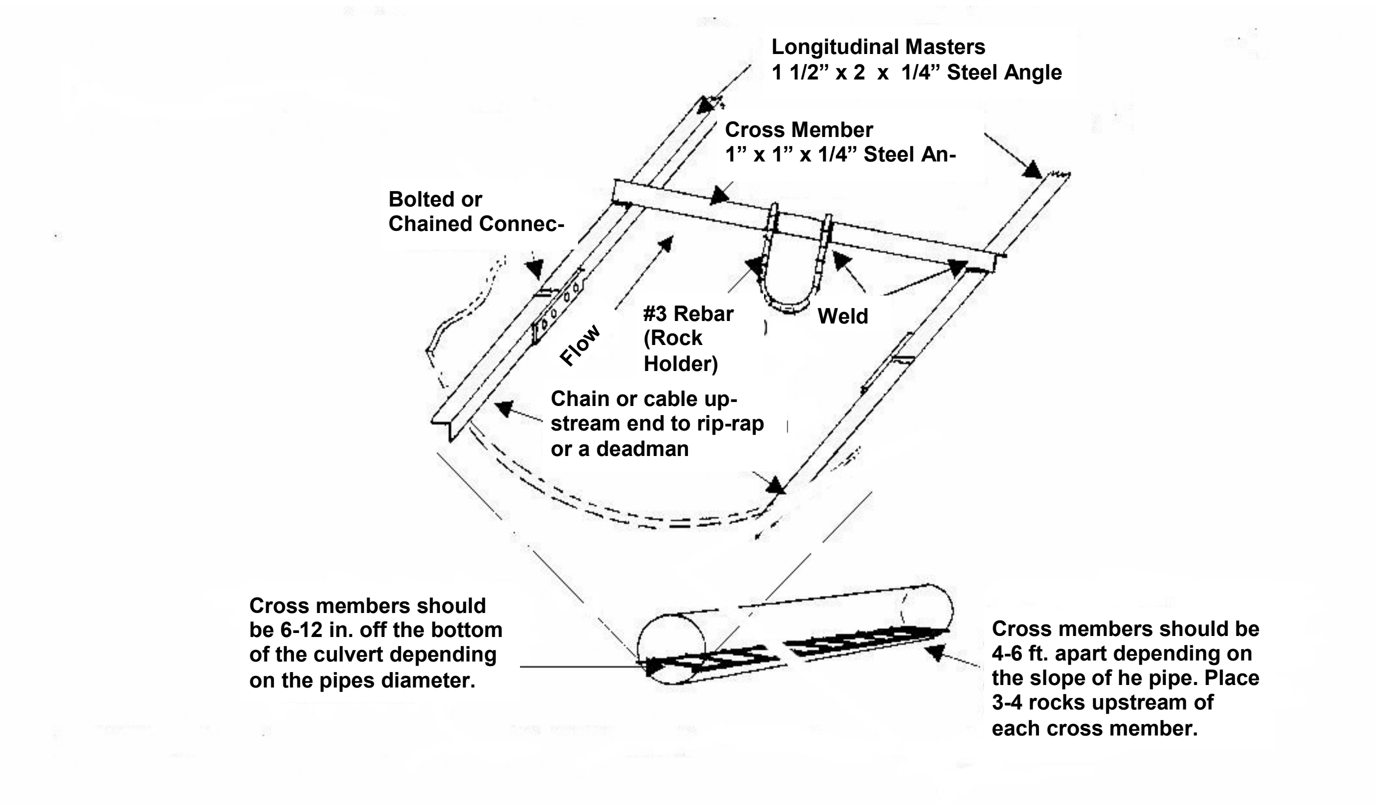


Figure 2. Cont. Details for installing various stream crossing alternatives.

C. Culvert With Detachable Fish Ladder



D. Open Bottom Structures

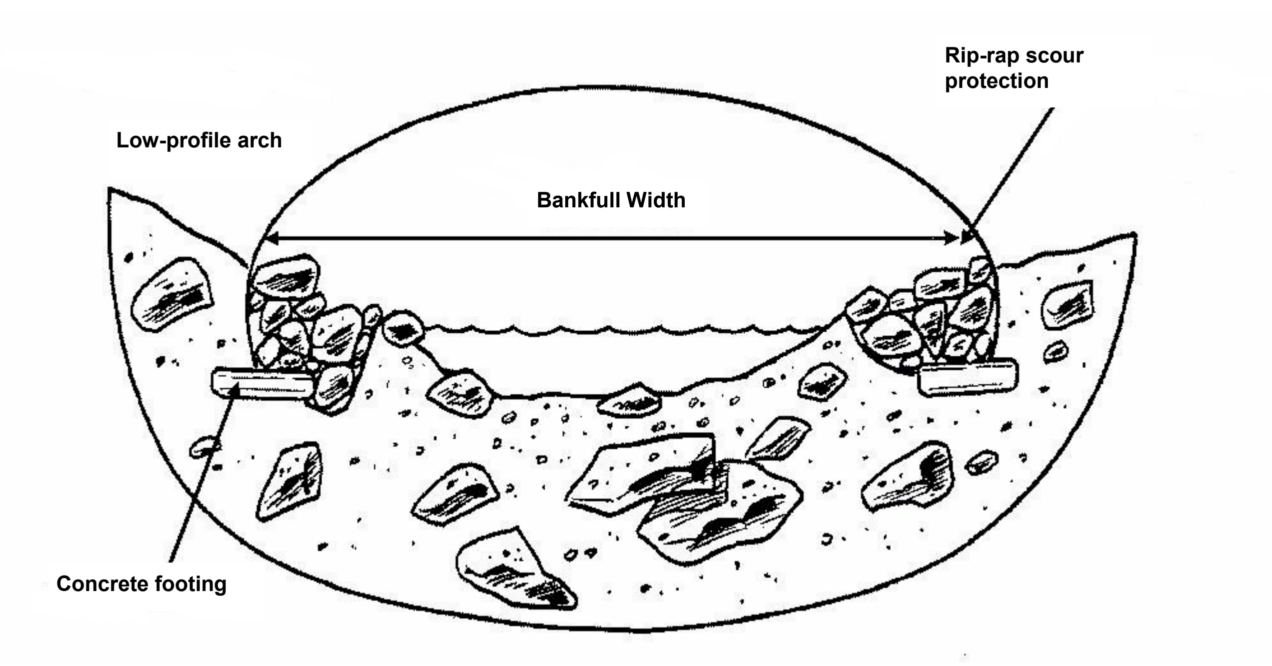


Figure 2. Cont. Details for installing various stream crossing alternatives.

E. Bridge Design Considerations

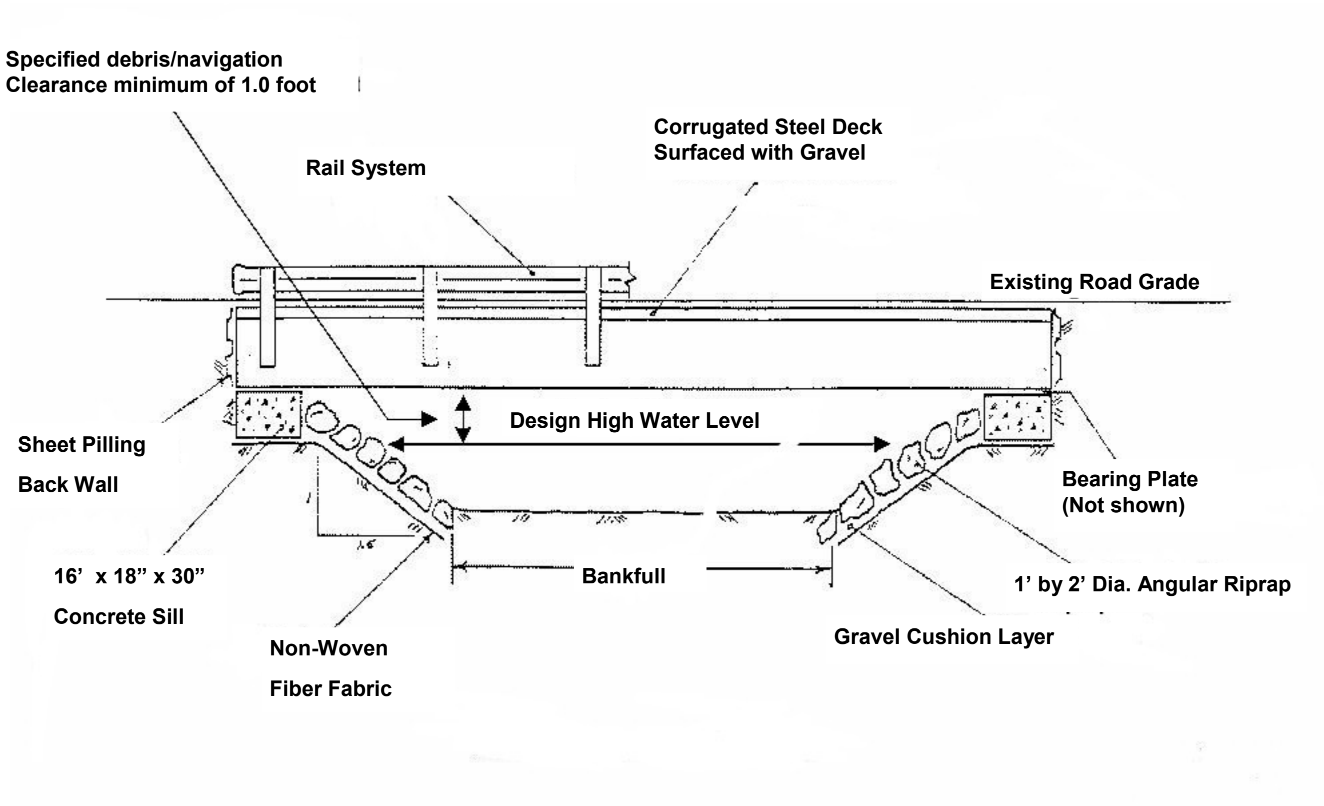


Figure 2. Cont. Details for installing various stream crossing alternatives.

GLOSSARY	
Armoring:	A layer of stone armor placed on the stream bottom to protect erodible material lying underneath.
Backfill	Placing earth or a specified size of material in place of material removed during construction, such as in a culvert or trench.
Bankfull Width	The bankfull width is marked by a break in slope of the bank and change in vegetation, such as a change from point bar gravel to grasses and forbs. Bankfull discharge flow is sometimes synonymous with ordinary high water flow.
Culvert Diameter Class:	Culverts are built in certain sizes, which are classified in diameter classes. Each diameter class increases in six inch increments (18, 24, 30, 36, 42, 48, 54, 60, etc.).
Removable Fish Ladder:	Constructed angle iron placed into a culvert to improve fish passage.
Grade Control Structure:	A structure placed across a stream channel used to prevent the stream channel from headcutting and used to raise upstream water levels.
Headcutting:	The upstream erosion and displacement of stream bottom substrates. The stream channel erosion will often migrate in an upstream fashion.
Inlet:	Water flows into the inlet end of the culvert.
Outlet:	Water flows out of the outlet end of the culvert.
Resting/Jumping Pool:	A pool downstream of the outlet of a culvert that is deep and flows slowly to allow fish to rest before migrating through the culvert. If a drop occurs from the outlet of the culvert, the resting pool should be deep enough to allow fish to make a run before it jumps. Ideal jumping conditions exist when the ratio of pool depth to jump height is 1.25:1.
Salmonids:	The family of fish including all trout, char, salmon and whitefish.
Substrate:	Stream bottom sediments, which may include silt, sand, gravel, cobble, bolder, and bedrock.

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