Private Water Crossings

Considerations before you build or rebuild

June 2009

FEMA

Table Of Contents

1. Introduction

This booklet addresses the necessity for careful consideration of a number of issues to gain or regain, and to maintain safe ingress and egress over water bodies utilizing private crossings.

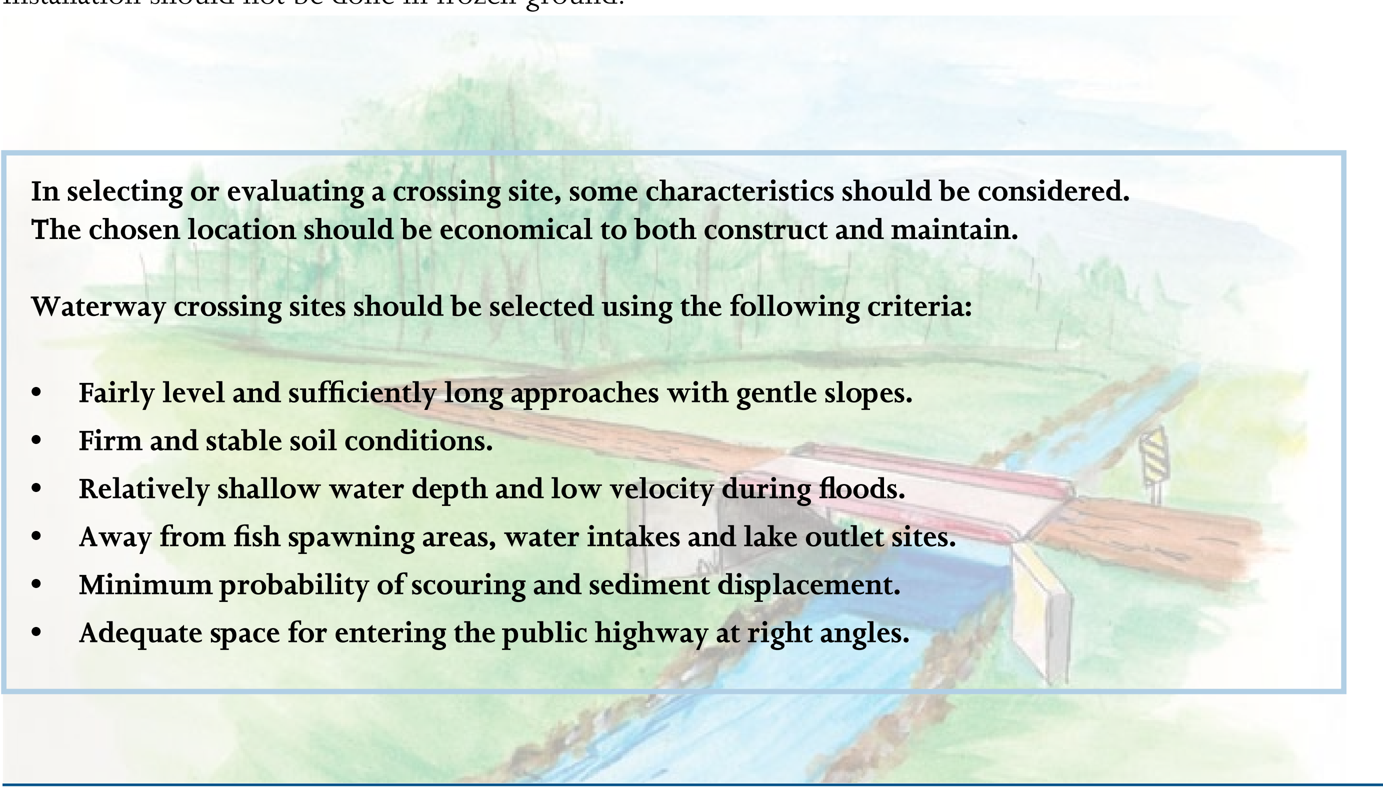
It is imperative that all watercourse crossings, including bridges, low water crossings and culverts be properly designed and constructed to perform safely and adequately under varying natural conditions. Any watercourse crossing has the potential to alter or disrupt the waterway characteristics from the low to high flow conditions. Improper installations can result in extensive loss and damage to public and private property, danger to human life, as well as damage to the environment as a result of flooding, erosion and washouts. Maintaining the overall integrity of the waterway is of the utmost importance.

Construction should be performed during dry weather and not prolonged. This will minimize risks to both the project and the environment. Installation should not be done in frozen ground.

Structural design should be based on maximum anticipated water depth and velocity in addition to the intended use of the crossing. Longer and higher bridges are often more economical because they will sustain less damage in future flood events.

The actual design and installation of the crossing needs to be coordinated with all persons who may be involved in the project: owner, engineer, contractor and governing agencies (local, state and federal).

Because each land and water site is unique, and the type of materials and the quality of construction vary, mechanisms must be customized to each location. It is not possible or desirable to attempt to address all considerations. The Federal Emergency Management Agency (FEMA) therefore does not warrant the completeness, inclusiveness or comprehensiveness of the discussion that follows.



In selecting or evaluating a crossing site, some characteristics should be considered. The chosen location should be economical to both construct and maintain.

Waterway crossing sites should be selected using the following criteria:

- **Fairly level and sufficiently long approaches with gentle slopes.**
- **Firm and stable soil conditions.**
- **Relatively shallow water depth and low velocity during floods.**
- **Away from fish spawning areas, water intakes and lake outlet sites.**
- **Minimum probability of scouring and sediment displacement.**
- **Adequate space for entering the public highway at right angles.**

2. Obtaining a Permit

All construction of waterway crossings require permits from at least one if not multiple local, state and federal agencies before any work can begin. Permits may also be required for any or all of the following: Alterations, enlargements, repairs, maintenance and removal of bridges, culverts or low water crossings. No matter where you live, there exists some form of permitting process required for any watercourse encroachment or alteration. Very often a local soil conservation district agency works along with the United States Army Corps of Engineers, Federal and State Clean Water Act representatives, Department of Natural Resources, Environmental Protection Agency, United States Fish and Wildlife Service, State Division of Highways and a local Floodplain Administrator.

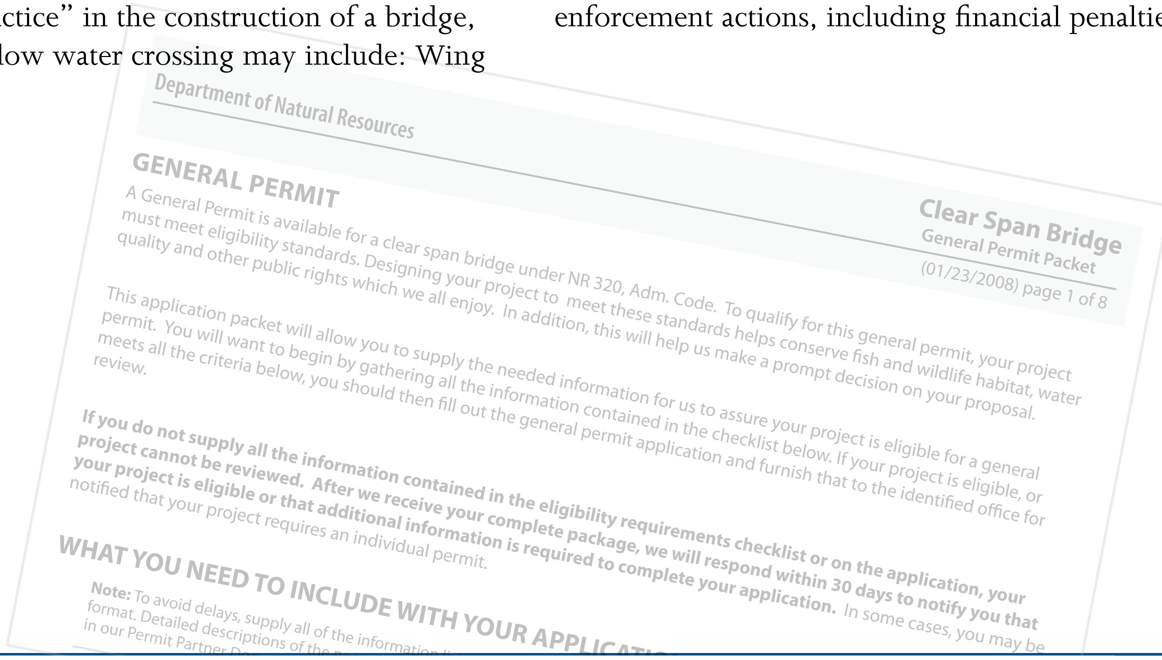
Documentation or verification should be given to the Floodplain Manager establishing that the flood carrying capacity within the altered area of the stream in question will be maintained. If hydrologic and hydraulic analyses are required, qualified personnel shall perform them.

Building techniques that may be required to present a "best practice" in the construction of a bridge, culvert or low water crossing may include: Wing walls, trash grates and the sizing of openings to carry anticipated future increases in flood heights.

The design or redesign and the actual construction of a waterway crossing are separate parts of the total project often handled by different persons. If so, it is important that installation procedures are considered during the design phase of the crossing. Communication and coordination between designer, builder and regulating agencies is necessary to achieve a quality-finished product with a minimum of environmental alterations or damage to the site. A minimal amount of time should be spent in the actual water channel.

The builder usually is responsible for obtaining the necessary permits and ensuring the day-to-day construction practices follow all local, state and federal regulations, specifications and guidelines. Each waterway crossing is unique and requires well-planned construction methods.

Failure to follow the local permitting process and obtaining approval from all authorities having jurisdiction can result in a delay of your installation or an order to stop construction and formal enforcement actions, including financial penalties.


Department of Natural Resources

Clear Span Bridge
General Permit Packet
(01/23/2008) page 1 of 8

GENERAL PERMIT

A General Permit is available for a clear span bridge under NR 320, Adm. Code. To qualify for this general permit, your project must meet eligibility standards. Designing your project to meet these standards helps conserve fish and wildlife habitat, water quality and other public rights which we all enjoy. In addition, this will help us make a prompt decision on your proposal.

This application packet will allow you to supply the needed information for us to assure your project is eligible for a general permit. You will want to begin by gathering all the information contained in the checklist below. If your project is eligible, or meets all the criteria below, you should then fill out the general permit application and furnish that to the identified office for review.

If you do not supply all the information contained in the eligibility requirements checklist or on the application, your project cannot be reviewed. After we receive your complete package, we will respond within 30 days to notify you that your project is eligible or that additional information is required to complete your application. In some cases, you may be notified that your project requires an individual permit.

WHAT YOU NEED TO INCLUDE WITH YOUR APPLICATI...

Note: To avoid delays, supply all of the information ... format. Detailed descriptions of the ... in our Permit Partner D...

3. Water Crossings

This booklet places crossings in three categories: bridges, culverts and low water crossings. Specific information about each follows.

Watercourse crossings should be appropriately designed to minimize the disturbance of streambeds and flow velocities.

If designed and constructed properly, bridges are preferred to culverts and low water crossings, since the latter two can alter the natural flow of the water.

3.1 Bridges

Quality designed and constructed bridges can maintain the original watercourse channel bed without any alteration or disturbance. Some types of structures tend to restrict and obstruct the normal and above normal flow of the waterway.

Clear-span bridges do not require infilling or restrict the area of water flow as culverts or multi-span bridges do.

Bridges provide better capacity to accommodate high flows while creating better inlet and outlet conditions that allow debris to pass through without blockage.

Flood damage to bridges includes floodwaters overwhelming the deck and superstructure as a result of inadequate attention paid to the hydraulic capacity of the bridge. Damage also results from impact and accumulation of debris.

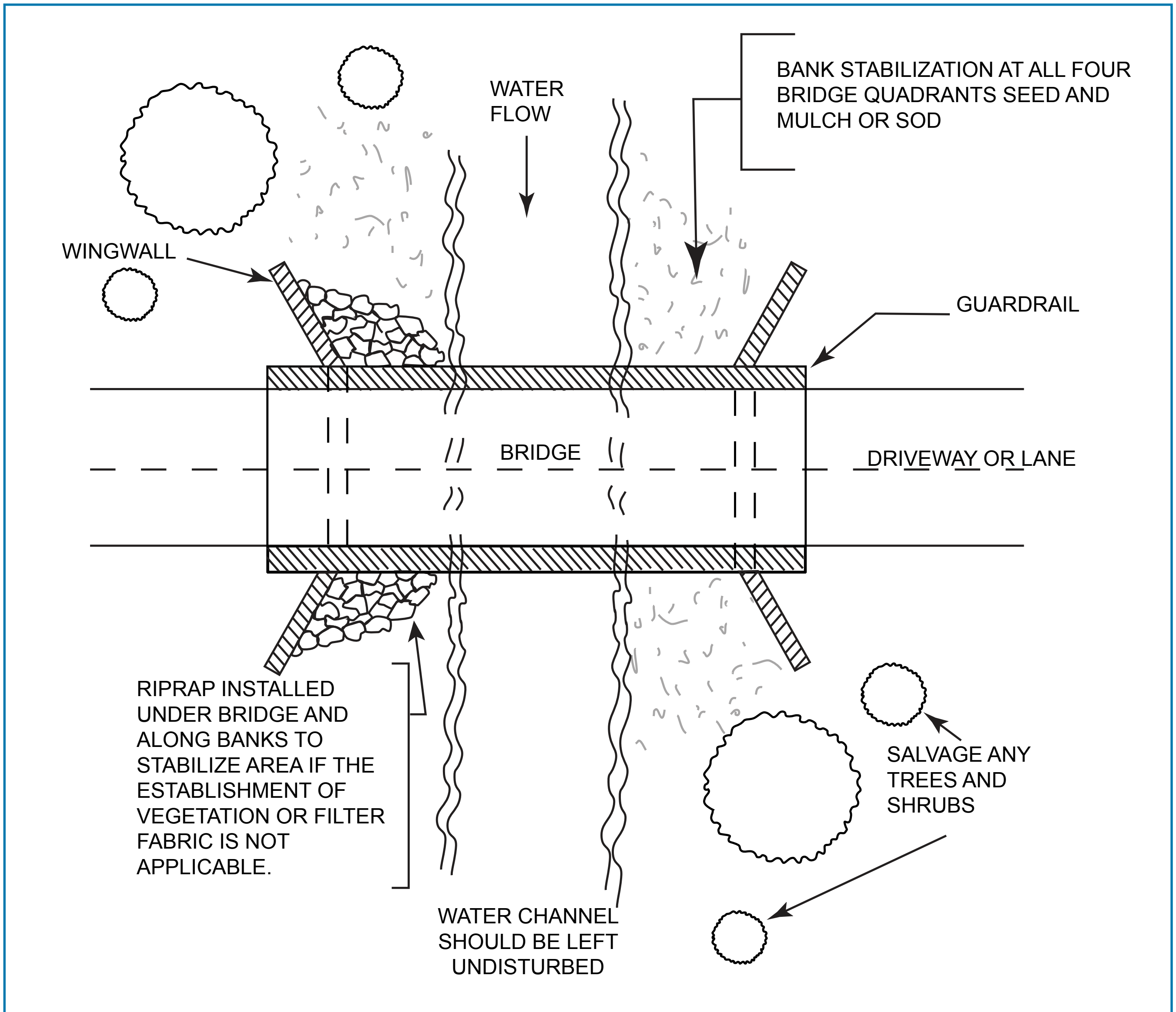


Figure 3.1-1. Plan view of bridge

Design consideration for bridges:

- Span the entire water channel without altering the water banks or bed and having the abutments or piers encroaching into the channel.
- Adequately handle storm water runoff from the roadway.
- Utilize a "perched" bridge design with low roadway approaches to sacrifice the roadway and save the bridge under severe flood conditions.
- Install wing walls to direct the water flow into the bridge opening to eliminate potential erosion.
- Avoid the direct contact of uncured concrete and pentachlorophenol - treated wood with the water to avoid the toxic reaction to aquatic life.
- Handrails or guardrails should be installed where necessary.
- Stabilize the disturbed areas with native vegetation whenever possible versus using structural solutions: bulkheads, riprap and other structural solutions.

Figure 3.1-2. Concrete is being poured into a wood form for a cast in place reinforced concrete bridge abutment with wing walls. This abutment design was dictated by a short approach, but it is still high and set back far enough from the water channel to allow unobstructed water flow and safe passage to and from the property.

Figure 3.1-3. Bridge with wing walls direct water flow during high water to avoid washout of bridge approach and increase of water flow velocity. Guardrails on bridge safeguard traffic passage.

Figure 3.1-4. This bridge design was dictated by exposed bedrock. Site-specific conditions and good judgement resulted in safe traffic passage and a practical approach to stream protection. Even during high water, this bridge should maintain appropriate flow and streambed and not constrict the stream.

Figure 3.1-5. Private bridge with secured handrails and unobstructed water flow allows for safe traffic passage and creates no noticeable change in the stream flow or streambed. The bridge crossing is wide and high relative to its length.

Figure 3.1-6. Perched bridge and low water crossing. The low water crossing is used only for infrequent passage by heavy farm equipment. The perched bridge is for regular access to property, but can become an island during a flood if the road on both sides is under water.

Bridge Crossing Problems

Figure 3.1-7. A bridge pier located in the water channel creates scouring and debris catch which exacerbates the impact of flooding. Routine maintenance is required to prevent accumulation of debris.

Figure 3.1-8. Bridge abutments encroaching into the stream creates a weakening of the structural integrity of the crossing during high water flow by erosion and scouring.

Figure 3.1-9. The lack of wing walls and a short bridge span causes loss of bridge approach during high water. A longer bridge span with abutments set back from the water channel utilizing wing walls would avoid scouring and erosion.

The bridge design below has been successfully used where the stream banks are firm enough to prevent erosion and support the abutments. No concrete is needed. The stringers are welded to the steel abutment members that sit directly on the soil. Appropriately designed bridge foundation can also be gabion abutment, footings or logs set into rock or firm stable soil.

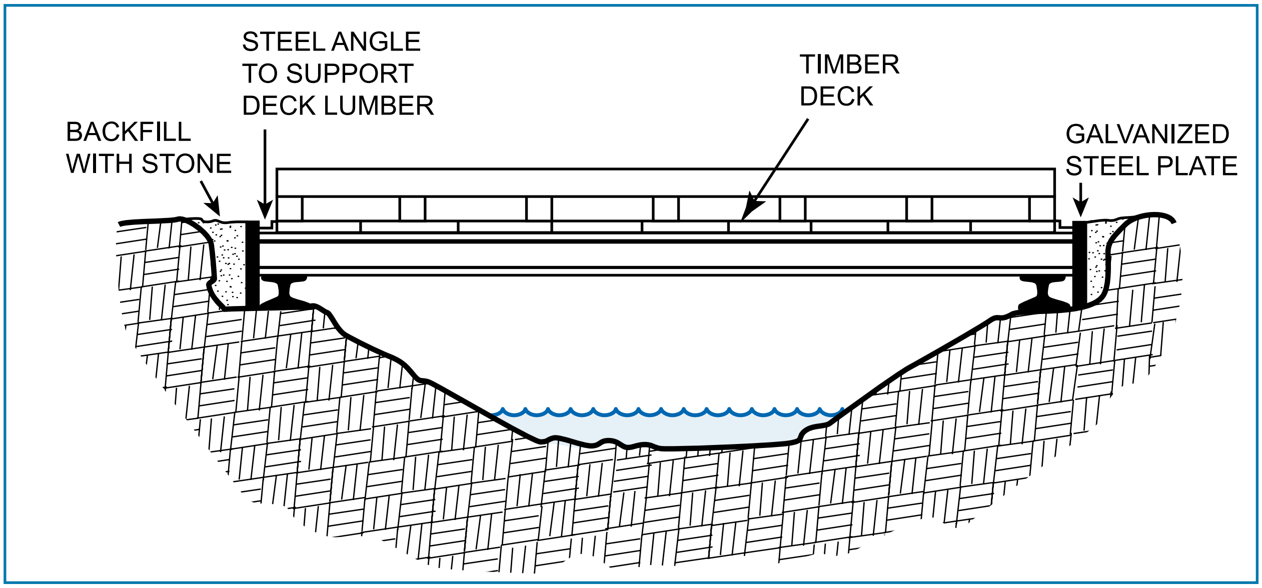


Figure 3.1-10. Side elevation section view of private bridge without concrete abutments

The deck slab or stringers should be set above the expected high water level to allow for debris and storm flow passage. Add protection against sour, such as riprap, gabions or vegetation.

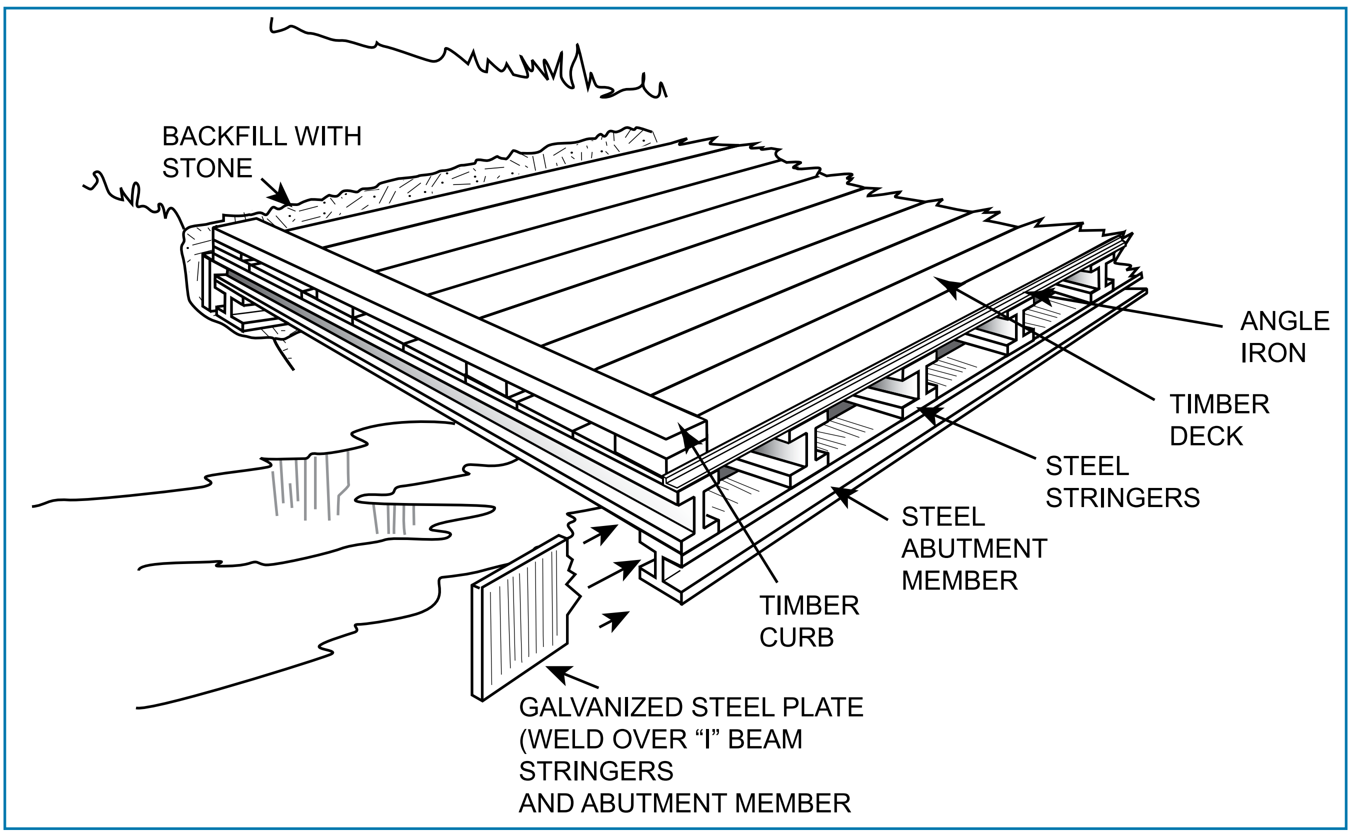
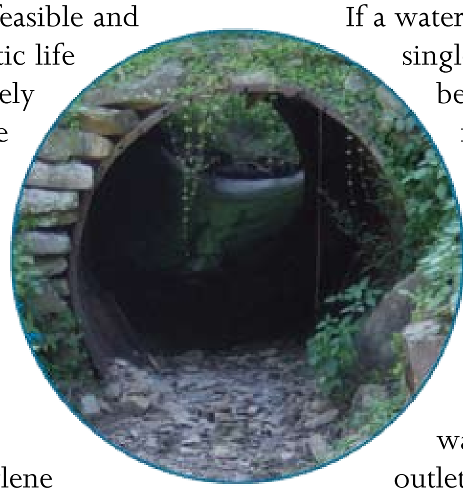


Figure 3.1-11. Perspective and section view of private bridge without concrete abutments

3.2 Culverts

Culverts can be used for a watercourse crossing where the installation of a bridge is not feasible and the impact on fish and other aquatic life is minimal. Culverts are appropriately used for access across drainage ditches, intermittent streams and small waterways. Culverts often fail to accommodate high water flows. This results in washouts, erosion and flow blockage by debris buildup.



Commonly available culverts are made of corrugated steel, polyethylene or reinforced concrete. Multiple culverts are not recommended due to the trapping of debris. If a waterway is too wide or large for a single culvert, then the design should be changed to a bridge. To correctly install a multiple or 'gang' culvert crossing, a thorough hydraulic and hydrologic analysis is needed. A minimum distance is needed between culverts with infill to be properly compacted. This fill must be protected from washing out by installing an end wall or armoring at the inlet and outlet areas. A debris guard could also be needed.

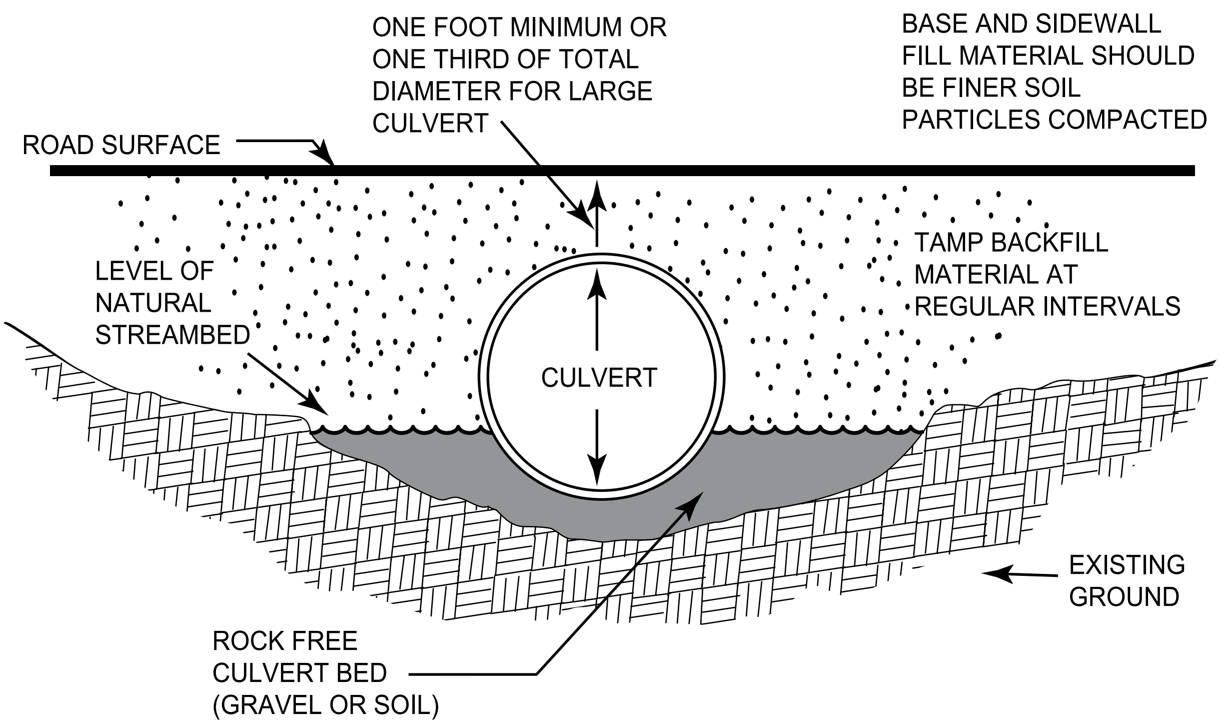


Figure 3.2-1. Culvert in section

The culvert must have a large enough opening to handle peak runoff. Ideally, a properly designed culvert's simulated bed will reflect the natural streambed where water flow conditions inside the culvert are much like the conditions at the upstream and downstream sites of the crossing.

Figure 3.2-2. This multiple culvert crossing is vulnerable to debris blockage and washout. To install multiple or a "gang" of culverts properly, each culvert must be spaced adequately to allow for proper soil compaction between the culverts. This fill must be well armored at each end to prevent the washing out between the culverts.

Figure 3.2-3. (right) Insufficient cover for culverts will result in washout and erosion as well as structural failure and collapse of culverts.

Design considerations for culverts:

- The culvert must provide for proper road width and side slopes.
- Wing walls may be used to aid in directing the flow of water at the outlet and directly into the inlet to help prevent erosion.
- Headwalls may prevent washouts at steep slopes and unstable fill sites.
- Culvert should be installed so that the existing waterway slope/gradient is not changed.
- The culvert should be aligned with the waterway, with no changes in water flow direction at the upstream or downstream area of the crossing.
- Culverts should never be installed with bends in them.
- Recess the bottom of the culvert to a depth at least 12 inches below the existing streambed or to the projected scour depth of the natural channel.
- When a debris barrier/trash grate is used to catch debris, the grate should be installed with a low incline to prevent floating debris from being held against the grate by the flow. This can cause washouts.
- Culverts should be inspected after heavy rainstorms and flood events.
- Height restrictions may require the use of a horizontally elongated culvert, which result in better low flow characteristics.

- Cast-in-place or self-setting concrete bag headwalls exposed to the watercourse are less desirable than pre-cast concrete or sandbagged headwalls, due to the release of leachate and resulting fish kill.
- Sandbagged headwalls are traditionally used as a temporary measure and for sandy non-clay soil conditions.
- Adequately designed and constructed bottomless arch culverts can maintain natural streambed and match the upstream and downstream water depth and velocity.

Figure 3.2-4. Culvert with sandbagged headwall is being used in a sandy soil drainage ditch. This method should not be used for permanent use in water courses.

Figure 3.2-5. Multiple culverts at driveway ditch crossing have adequate spacing and compaction. The concrete headwall and wing walls help direct water flow and prevent washouts during high water flow. There is also adequate cover and culvert length to allow liberal clearance of traffic.

Figure 3.2-6. This headwall at a culvert inlet protects against erosion and washout. Many inlet failures occur on culverts without headwalls or other entrance protection. When soils adjacent to the inlet are eroded or become saturated, pipe inlets can be subjected to buoyant forces causing culverts to dislodge and washout.

Figure 3.2-7. Culvert aligned with stream and armored with stone at inlet and outlet. Natural streambed conditions preserved by embedding culvert, allowing water to flow naturally without undercutting the inlet and causing erosion.

Figure 3.2-8. These culvert wing walls aid in directing water flow. The mitered or skewed ends of corrugated metal pipes, cut to conform to the embankment slopes, offer little resistance to bending or buckling without wing walls. Wing walls help prevent scouring and protect embankment slopes.

3.3 Low Water Crossings

Low water crossings have limited application due to continued disturbance of the streambed and frequent inundation. Do not use a low water crossing to serve occupied dwellings where no alternate emergency access is available. They are more suitable for low volume roads with no habitable dwellings where the normal volume of water flow is relatively low.

Low water crossings can be useful for infrequently crossed waterways that experience flash floods, since it would be uneconomical to construct a bridge or culvert. Debris problems and other maintenance are minimized. Proper signs should be used warning of the dangers of high water.

Figure 3.3-1. Low water crossing - this can be suitable for very low-volume access. Unimproved ford is a natural crossing that is undesirable for daily use.

Figure 3.3-2. Concrete vented ford - this type of crossing has a low cost and low maintenance. Fish passage and scouring problems are a disadvantage as well as a danger to traffic during high flow periods.

The more stable the streambed and banks are with bedrock, and the lower the existing bank slopes and grades are, the more suitable the site is for a low water crossing. Approach grades should be less than 10%. Sites that consist mostly of sand and/or silt are not appropriate for fording/crossing.

Two types of low water crossings are the unvented ford and the vented ford.

Unvented fords are constructed of riprap, gabions, or concrete to provide a stream crossing without the use of pipes where streams are dry most of the year and crossing use is temporary. Water depth flow over an unvented ford should not exceed 6 inches.

Vented fords use pipes under the crossing to allow low flows to pass through without regularly passing over the crossing. The pipes or small culverts may be placed in aggregate, riprap, gabions or concrete.

A box culvert is a crossing design that is used more frequently in areas where habitat protection is important. A single or series of box culverts are embedded with continuous streambed material through the structure. These structures perform like a bridge by matching the channel width.

It is important that any washout of streambed material during high water flow is refilled naturally with sediment as flow recedes.

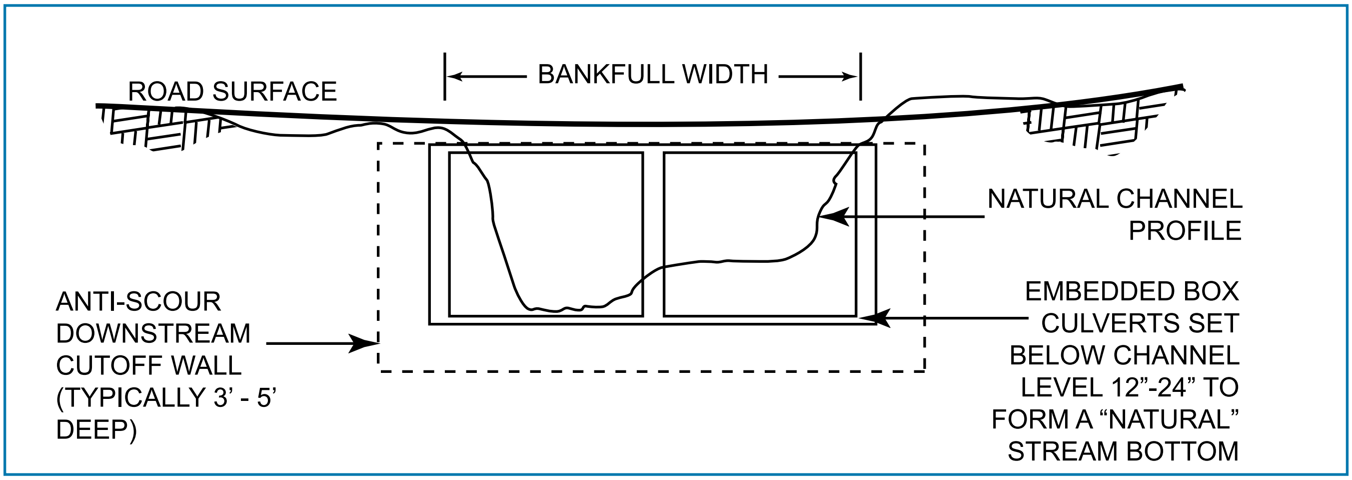


Figure 3.3-3. Embedded box culverts

Embedded box culverts maintain a continuous streambed through the structure. If site conditions permit, an open-bottom box with a natural stream channel bottom is preferable in sustaining channel function.

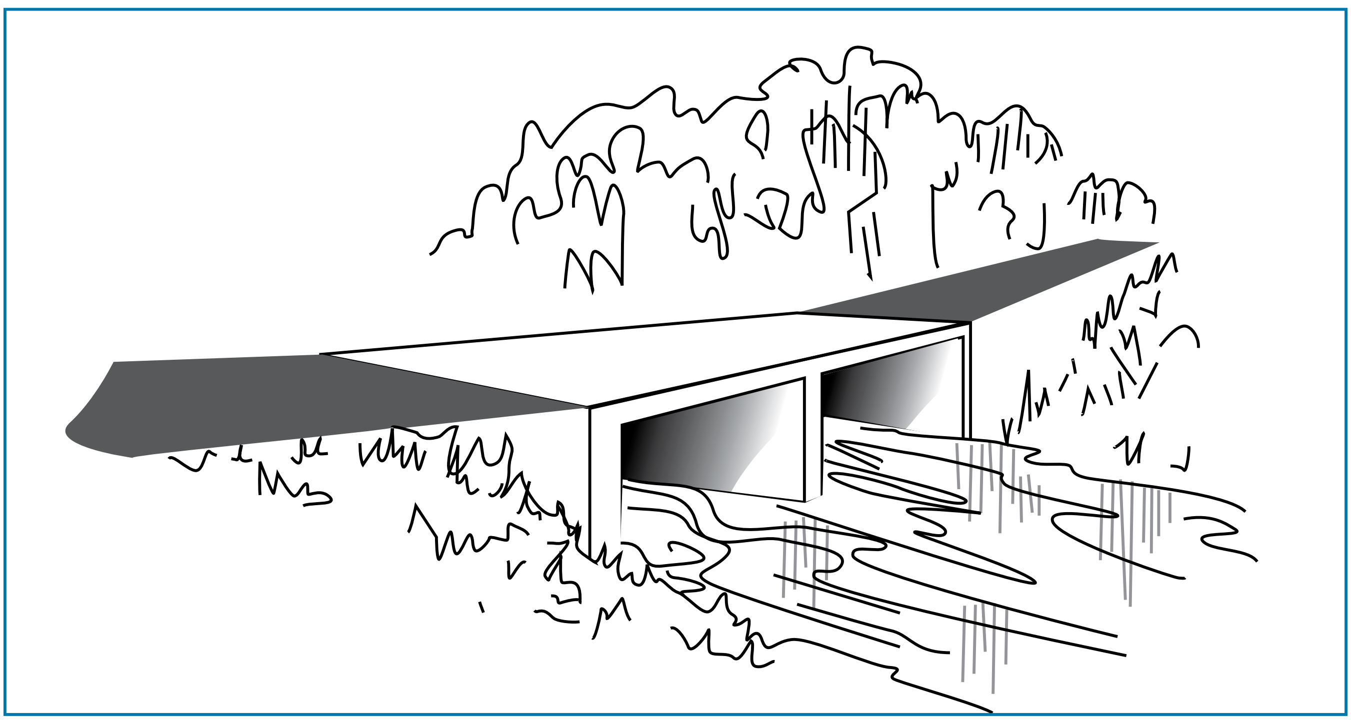


Figure 3.3-4. Concrete vented ford - The number of box openings depends upon the width and flow of the channel. A continuous streambed maintains channel function.

4. Definitions

Abutment: Part of a structure which supports the end of a span; often supports and retains the approach embankment.

Aquatic Life: All forms of living things found in water, ranging from bacteria to fish and rooted plants. Insect larva and zooplankton are also included.

Armoring: A facing layer (protective cover), or riprap, consisting of very large stones placed to prevent erosion or the sloughing off of an embankment.

Best Practice: The optimum construction method put into practice at a particular place and time.

Bridge: A watercourse crossing that can maintain the original natural watercourse channel bed without any alteration or disturbance. This crossing structure is built so that people can get from one side to the other.

Cast-in-place concrete: Concrete in an unhardened state, primarily as ready-mix and poured in forms to harden on-site.

Clear-span: Bridge structures that completely span a watercourse and do not encroach on the natural channel width by the placement of abutments, footings or armoring so that there is no restriction to the natural channel processes.

Conduit: Any pipe, tube, or drain tile through which water is conveyed.

Conveyance: Floodwater carrying capacity in a passage area of a watercourse.

Culvert: A drain, pipe or channel which allows water to pass under a road or embankment.

Debris: Any material including floating woody materials and other trash, suspended sediment or bed load moved by a flowing stream.

Deck: The top surface of a bridge which carries the traffic.

Embankment: Angled grading of the ground.

Filter fabric: Geotextile erosion fabric used to cover and stabilize topsoil for use with riprap and ground cover.

Floodwaters: Water flows that have risen above the stream bank and flow over adjoining lands.

Gabion: A galvanized wire box filled with stones/riprap used to form an abutment or retaining wall.

Headwall: A wall at the end of a drainage structure designed to prevent erosion of the embankment at its entrance or outlet.

Infilling: Soil, rock, gravel or a combination placed in a depression or ditch to fill the void. Used in conjunction with a culvert.

Low water crossing: A fording site of a waterway.

Multi-span bridge: Multiple horizontal spaces between two abutment supports, with one or more piers at a location between abutments.

Perched bridge: Style of bridge elevated or raised at both ends to avoid floodwaters and create low roadway approaches. The bridge is higher than the floodplain, but the approaches are much lower.

Pier: A vertical structure (column or pile), which supports the ends of a multi-span superstructure at a location between abutments.

Piping: Washing out or erosion between and around culverts.

Pre-cast concrete: Concrete components which are cast and partly matured in a factory or on the site before being lifted into their final position as part of a structure.

Riprap: Rock placed on embankment slopes to prevent erosion.

Sediment: Stone, gravel or cobbles that originate from the weathering of rocks and is transported by, suspended in, or deposited by water.

Scour: The result of an erosive action of flowing water in waterways, excavating and carrying away material from the bed and banks.

Span: The horizontal space between two supports of a structure. Also refers to the structure itself.

Trash Grate: A debris guard or screen placed at the upstream entrance of a culvert, which stops heavy floating debris away from the culvert entrance during high velocity flow.

Watercourse: Any natural or artificial channel through which water flows; a lake, river, creek, stream, wash, arroyo, channel or other topographic feature on or over which waters flow at least periodically.

Wing wall: Side extensions of a retaining wall as part of an abutment; used to contain the fill of an approach embankment and to direct and confine the flow.