Chapter 10
Bridges

"Bridges -- usually the best, but most expensive drainage crossing structure. Protect bridges against scour."

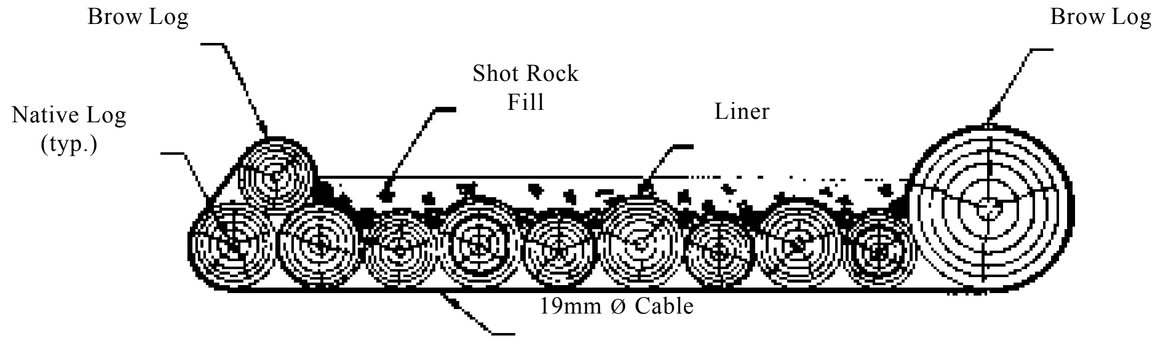
BRIDGES ARE relatively expensive but often are the most desirable stream crossing structure because they can be constructed outside of the stream channel and thus minimize channel changes, excavation, or placement of fill in the natural channel. They minimize disturbance of the natural stream bottom and they do not require traffic delays once constructed. They are ideal for fish passage. They do require detailed site considerations and specific hydraulic analyses and structural design.

The bridge location and size should ideally be determined by an engineer, hydrologist, and fisheries biologist who are working together as a team. When possible, a bridge should be constructed at a narrow channel location and should be in an area of bedrock or coarse soil and rock for a bridge site with good foundation conditions. **Many bridge failures occur due to foundations placed upon fine materials that are susceptible to scour.**

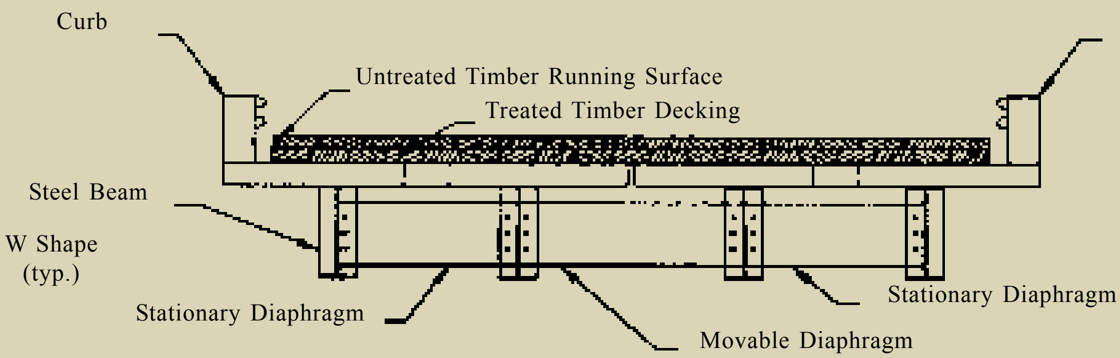
Bridges should be designed to ensure that they have adequate structural capacity to support the heaviest anticipated vehicle or posted for load limits. Simple span bridges may be made of logs, timbers, glue-laminated wood beams, steel girders, railroad car beds, cast-in-place concrete slabs, pre-

Photo 10.1 Culverts, fords, or bridges may be used for stream crossings. Use bridges to cross large permanent streams, minimize channel disturbance, and to minimize traffic delays. Use an opening wide enough to avoid constricting the natural channel. Locate the bridge foundation on bedrock or at an elevation below the anticipated depth of scour.

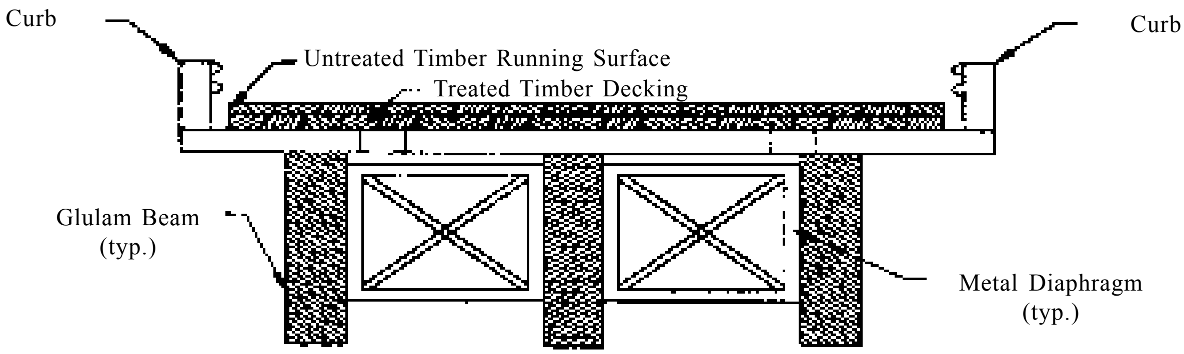
Figure 10.1 Cross-sections of typical types of bridges used on low-volume roads.



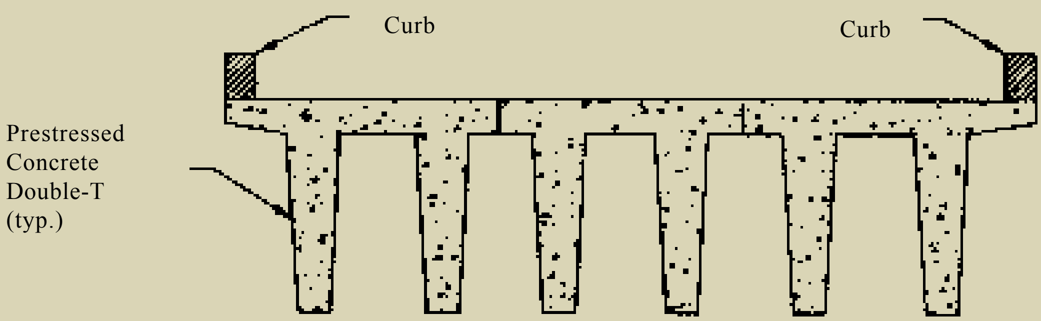
Native Log Stringer Bridge



Hamilton EZ Bridge (Modular)



Treated Timber Glue Laminated Bridge



Prestressed Concrete Single or Double-T Bridge

Photo 10.2 A bridge structure typically offers the best channel protection by staying out of the creek. Use local material for bridges as available, considering design life, cost, and maintenance. Inspect bridges regularly, and replace them when they are no longer structurally adequate.

fabricated concrete voided slabs or "T" beams, or using modular bridges such as Hamilton EZ or Bailey Bridges (see *Figure 10.1*). Many types of structures and materials are appropriate, so long as they are structurally designed (*Photo 10.1*).

"Standard designs" can be found for many simple bridges as a function of bridge span and loading conditions. Complex structures should be specifically designed by a structural engineer. Bridge designs often require the approval of local agencies or governments. Concrete structures are desirable because they can be relatively simple and inexpensive, require minimal maintenance, and have a relatively long design life (100+ years) in most environments. Log bridges are commonly used because of the availability of local materials, particularly in remote areas. However, keep in mind that they have relatively short spans and they have a relatively short design life (20-50 years) (*Photo 10.2*).

Foundations for bridges may include simple log sills, gabions, masonry retaining walls, or concrete stem walls with footings. Some simple bridge foundation details are shown in *Figure 10.2*. Deep foundations often use drilled piers or driven piles. Most bridge failures occur either because of inadequate hydraulic capacity (too small) or because of scour and undermining of a foundation placed upon fine soils (*Photo 10.3*). Thus, **foundation considerations are critical**. Since bridge structures are typically expensive, and sites may be complicated, most bridge designs should be done with input from experienced structural, hydraulic, and geotechnical engineers.

Periodic bridge inspection (every 2-4 years) and maintenance is needed to ensure that the structure is safe to pass the anticipated vehicles, that the stream channel is clear, and to maximize the design life of the structure. Typical bridge maintenance items include cleaning the deck and "seats" of the girders, clearing vegetation and debris from the stream channel, re-

Photo 10.3 Scour is one of the most common causes of bridge failure. Use an opening wide enough to minimize constriction of the natural channel. Locate the bridge foundation on bedrock when possible, or below the depth of scour, and use stream bank protection measures such as riprap.

placing object markers and signs, repairing stream bank protection measures, treating dry and checking wood, replacing missing nuts and bolts, and repainting the structure.

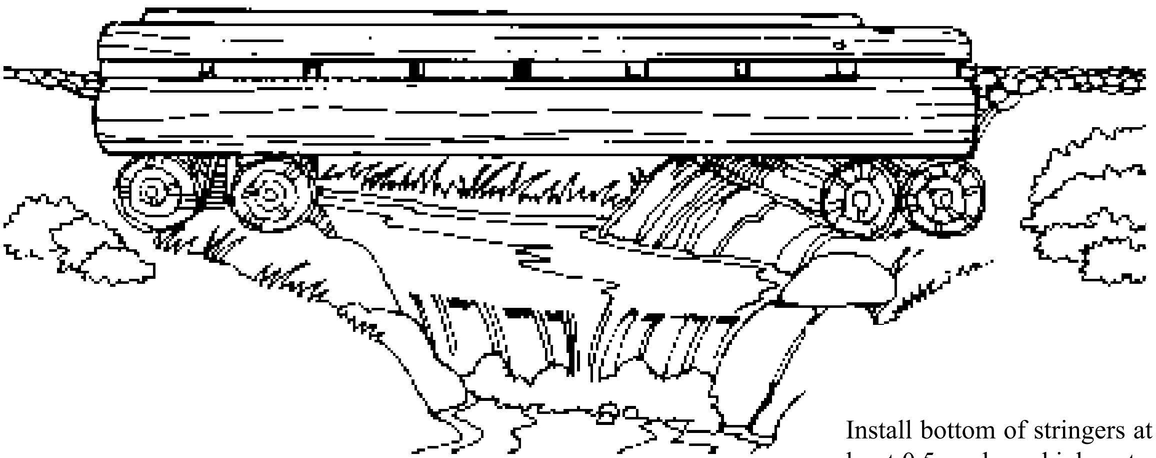
PRACTICES TO AVOID

- Placing piers or footing in the active stream channel or mid-channel.
- Placing approach fill material in the drainage channel.
- Placing structural foundations on scour susceptible soil deposits such as silts and fine sands.
- Constricting or narrowing the width of the natural stream channel.

RECOMMENDED PRACTICES

- Use an **adequately long bridge span** to avoid constricting the natural active (bankfull) flow channel. Minimize constriction of any overflow channel.
- Protect the upstream and downstream approaches to structures with wing walls, riprap, gabions, vegetation, or other slope protection where necessary (*Photo 10.4*).
- Place foundations onto non-scour susceptible material (ideally bedrock (*Photo 10.5*) or coarse rock) or below the expected maximum depth of scour. Prevent foundation or channel scour with the use of locally placed heavy riprap, gabion baskets, or concrete reinforcement. Use scour protection as needed.
- Locate bridges where the stream channel is narrow, straight, and uniform. Avoid placing abutments in the active stream channel. Where necessary, place in-channel abutments in a direction parallel to the stream flow.
- Consider natural channel adjustments and possible channel location changes over the design life of the structure. Channels that are sinuous, have meanders, or have broad flood plains may change location within that area of historic flow after a major storm event.
- For bridge abutments or footings placed on natural slopes, set the structure into firm natural ground (not fill material or loose soil) at least 0.5 to 2.0 meters deep. Use retaining structures as needed in steep, deep drainages to retain the approach fills, or use a relatively long bridge span (*Figure 10.2*).
- Design bridges for a 100- to 200-year storm flow. Expensive structures and structures with high impacts from failure, such as bridges, justify conservative designs.
- Allow for some freeboard, typically at least 0.5 to 1.0 meter, between the bottom of bridge girders and expected high water level and floating debris. Structures in a jungle environment with very high intensity rainfall may need additional freeboard. Alternatively, a bridge may be designed for overtopping, somewhat like a low water ford, and eliminate the need for freeboard, but increase the need for a erosion resistant deck and approach slabs (*Photo 10.6*).
- Perform bridge inspections every 2 to 4 years. Do bridge maintenance as needed to protect the life and function of the structure.

Figure 10.2 Bridge installation with simple foundation details.



Typical Log Bridge Installation
Ensure that the bridge has adequate flow capacity beneath the structure. Keep fill material and the abutments or footings out of the stream channel. Set footings into the streambank above the high water level or below the depth of scour if they are near the channel. Add protection against scour, such as riprap, gabions, or vegetation.

Set the stringers or deck slab at least 0.5 to 2.0 meters above the expected high water level to pass storm flow **plus** debris.

Bridge Abutment Detail
Set bridge foundation (gabion abutment, footings, or logs) into rock or firm, stable soil. Set footings 0.5-2.0 meters into firm material.

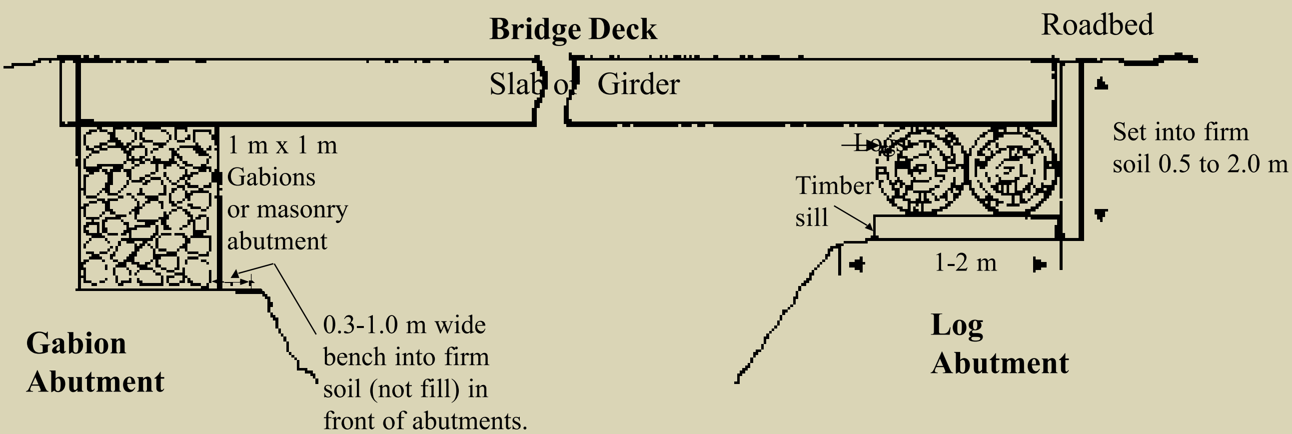


Photo 10.4 Concrete structures have a long design life and are typically very cost-effective for long bridge spans. Medium-length structures often combine a concrete deck placed upon steel girders. Use bank protection, such as riprap, to protect the entrance and outlet of structures.

Photo 10.5 Locate the bridge foundation on bedrock or on non-scour susceptible material when possible. When it is necessary to locate the bridge foundation on materials susceptible to scour, use a deep foundation or design the bridge with scour protection.

Photo 10.6 Here is a well built treated timber bridge with good streambank protection and adequate span to minimize stream channel impacts. The freeboard is marginally adequate.