APPENDIX 4

INFORMATIONAL SUMMARIES FOR TEMPORARY STREAM CROSSING OPTIONS

Fords

Description of option:

A low-water crossing that uses the streambed as part of the road or skid trail.

Area of application:

A ford is appropriate for stream crossings in which the use will be short-term and traffic levels low. A ford crossing can be used: (1) in an area where a ford crossing was previously in existence, resulting in less soil disturbance during installation, (2) in an area where the stream is straight and conforms to the shape of the natural stream channel, (3) in streams with low water where the normal summer flow does not exceed about 2 feet (0.6 m) in depth, (4) in streams with banks that are no higher than about 4 feet (1.2 m) and are not steep, (5) in an area with a natural gentle grade leading to the stream, providing a graded finished slope less than about 5:1 (horizontal to vertical), (6) in an area where firm banks and a natural rock or coarse gravel streambed capable of supporting equipment are present or where a mat (e.g., wood mat, tire mat, rubber mat) or expanded metal grating can be temporarily placed to provide that stability, and (7) if allowed by pertinent regulations. Construction and use of fords should not occur during fish spawning and migration.

Advantages:

Quick installation and removal.
Low maintenance.
Low cost.

Disadvantages:

Site criteria (e.g., low firm banks, firm streambed, straight portion of stream, low flow rates) restrict application.
Limited to use during times of low water flow.
Cannot be constructed or used during fish spawning, incubation, or migration periods.
Equipment crossing the ford should be clean and well-maintained with no oil or gas leaks. Mud and debris dragged in on skid loads, or on tracks and tires, and oil and fuel leaks contribute to polluting the water.

Source(s):

On-site materials, unless supplemental materials are required.

Recommended supplemental material:

Clean, dirt-free rock, if a firm base needs to be created on the streambed or banks.
Non-woven geotextile or woven geotextile below any imported rock, coarse gravel, or gabions that are placed on the streambed or banks.
Wood mats, tire mats, rubber mat, or expanded metal grating on the streambed and banks if the soil is weak and needs to be stabilized (see wetland crossing options).
Protecting the approaches to a ford with gravel, corduroy, wood mats, or other materials is recommended.
Non-woven geotextile if a wood mat or expanded metal grating is used.
Cable attached to an upstream tree or other fixed object to anchor wood mats or expanded metal grating.

Approximate purchase price of materials:

None. Moderate if supplemental materials are required.

Construction directions and/or diagram and time required:

Before constructing a ford crossing, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and construction. Do not construct the crossing during the time of fish spawning or migration. To facilitate construction of a ford where the stream bed is not dry, it may be desirable to temporarily divert the main flow of the stream around the work site using ditches, berms, dikes, piping, high capacity pumps, or an existing alternate channel crossing. This makes placement and compaction of fill much easier and avoids significant sediment movement in the stream. Create gradual approaches to the stream so that the graded finished slope does not exceed about 5:1 (horizontal to vertical). Minimize disturbance to the stream banks and bed, including minimizing the amount of vegetation removed adjacent to the water crossing. Add clean, dirt-free, rock, coarse gravel, or gabions to the stream bed as necessary. Place the clean rock, coarse gravel, or gabion on top of either a woven or non-woven geotextile. Maintain the natural shape and elevation of the stream channel to avoid obstructing the movement of fish and other aquatic organisms. During construction and use of the ford, keep out of the stream any machinery that has soil on the tires, the body, or the undercarriage of the vehicle or where oil, fuel, or lubricant is leaking. Protecting the approaches to a ford with clean gravel, corduroy, wood mats, or other materials is recommended. Before applying that surfacing material, place a woven geotextile fabric down on top of the soil to reduce sinking of the fill material. At least 12 inches (30 cm) of fill are needed on top of the geotextile. Before installing the geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. Wood mats, tire mats, a rubber mat, or expanded metal grating can be used to stabilize the stream bed. It may also be desirable to place large rocks or logs or to construct a sediment trap below a ford to catch sediment introduced by use of the ford. However, this should be done only with the advice of a qualified hydrologist or licensed engineer and approval of the appropriate regulatory authorities. A water bar or broad-based dip should be constructed to divert water off of the road and into a vegetated area so that the road does not become a source of sediment to the stream. Revegetate all bank cuts immediately following construction to reduce erosion.

Construction time is generally less than 1 hour, as long as rock does not need to be added. One or two days may be required if extensive rock armoring is necessary. It took about 3 hours to construct a ford that was 14 feet wide x 40 feet long (4.3 m x 12.2 m) using about 30 cubic yards (22.9 m^3) of gravel on top of a woven geotextile fabric.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

If wood mats are used, the equipment must have at least a 12-foot (3.7-m) lift span.

Installation approach and time:

Not applicable.

Patent protection of product design:

No.

Culverts

Description of option:

A culvert conveys water through it under the access road. Manufactured culverts come in several shapes (round, oblong, or arched) and many sizes (lengths and diameters). They are typically made of corrugated steel, concrete, or polyethylene. An arch culvert has concrete footing walls along each side into which the steel arch is fitted.

Area of application:

Streams that have a well-defined, deep channel and that are narrow enough to require no more than three culverts for the crossing. A single large diameter culvert is better than two or more smaller culverts. Culverts should not be used in streams with a lot of woody debris because this material can get lodged in the inlet of the culvert.

Advantages:

Quick installation and removal.

Very portable and usually readily available locally.

Disadvantages:

Appropriate technical assistance from a hydrologist or engineer is required to properly size a culvert.

Requires the addition of fill (e.g., soil) around the culvert, often causing sedimentation of the stream during installation and removal of the culvert.

Frequently installed incorrectly (e.g., culvert is too short, not wide enough to carry peak loads, not buried deep enough below the road surface to support vehicular traffic and/or road maintenance, not buried deep enough into the stream channel to allow fish migration).

Cannot be installed during fish spawning, incubation, or migration periods.

Requires frequent maintenance to keep it from becoming plugged with debris.

Source(s):

Local suppliers for new culverts.

Highway departments or local road authorities may be a source for used culverts.

Local pipeline, drilling, or construction company may have used casings, pilings, and gas pipelines.

Recommended supplemental material:

Pump, if water is to be lifted over the crossing during installation.

Rock or gabions to armor the culvert inlet and outlet.

Wooden poles or lumber to facilitate proper packing immediately adjacent to the culvert.

Approximate purchase price of materials:

Moderate.

Construction directions and/or diagram and time required:

Does not apply.

Equipment needed for construction, installation, and/or removal:

Backhoe or excavator.

Installation approach and time:

Before installing a culvert, contact the appropriate regulatory agency to determine whether a permit is required and to solicit advice on sizing, placement, and installation. Culverts should not be installed during fish spawning, incubation, or migration periods. Obtain technical assistance from a hydrologist or other specialist to appropriately size a culvert. Size the culvert so that its diameter is large enough to handle anticipated flows and so that it is long enough to extend to at least the toe of the fill slope. To facilitate installation and/or removal of a culvert where the stream bed is not dry, it may be desirable to temporarily divert the main flow of the stream around the work site using ditches, berms, dikes, piping, high capacity pumps, or an existing alternate channel crossing. This makes placement, compaction, and/or removal of fill much easier and minimizes sediment movement in the stream. It may also be desirable to construct a sediment trap or place large rocks or logs below a culvert to catch sediment introduced by use of the crossing. This, however, should be done only with the advice of a qualified hydrologist or licensed engineer and approval of the appropriate regulatory authorities. Excavate a channel that is at least twice the width of the culvert to accommodate the culvert and people working around it. Both the slope and direction of the excavated channel need to follow the natural drainage. Culvert depth below the stream bed needs to meet local regulations. Pack the base of the excavated ditch before placing the culvert. Place the culvert in the ditch and then deposit fill partially around it. Pack the fill around the culvert, paying special attention to the sides and lower portion. Wooden poles or lumber may be required to facilitate proper packing immediately adjacent to the culvert. Cover the top of the culvert with fill through a series of lifts, packing each layer. The culvert should be covered with fill to a depth of 12 inches (30 cm), or one-half the diameter of the pipe, whichever is greater. Pack the side slopes of the fill. Armor culvert inlets and outlets with rock to reduce bank and channel erosion and sedimentation. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

Installation time is generally less than 2 hours, unless extensive diversion of the stream is needed.

Patent protection of product design:

No.

PVC Pipe Bundles

Description of option:

Four-inch (10.2-cm) diameter Schedule 40 polyvinyl chloride (PVC) or SDR11 high-density polyethylene (HDPE) pipes are cabled together using 3/16-inch- (4.8-mm)-diameter galvanized steel cable to form mats of varying length. A non-woven geotextile is used under the mats to provide added support to the crossing and separate it from the underlying soil.

Area of application:

Small streams or stream channels with confining banks (U-shaped channel) that are less than 10 feet (3 m) wide, 4 feet (1.2 m) deep, slow moving water, straight channel, and little, if any, cross slope of the stream bottom. Pipe bundles should not be used in a stream that has a lot of woody debris because this material can get lodged at the inlet of the pipes. Durability of the pipes during periods of extended frozen conditions is unknown.

Advantages:

Material is lightweight and readily available.
Easy to construct, install, remove, and repair.
Can be constructed by the operator.
No fill required.
Can be easily adapted to different stream channel shapes and sizes.
Low cost
Reasonably durable

Disadvantages:

Requires maintenance to keep pipes from becoming plugged.
Surface moves and is slick during use without stiff surfacing (e.g., frozen ice/snow or non-woven geotextile with wood plank, wood mat, expanded metal grating) to provide traction.
May inhibit migration of aquatic organisms.
Requires cleaning between uses to remove soil.
Standard pipe is sensitive to ultraviolet (UV) light and will degrade. Need to cover the pipe or use an ultraviolet-resistant type of pipe. Pipe should be stored out of the sun.
Use during extended frozen conditions has not been evaluated.

Source(s):

Local hardware or plumbing supply store.

Recommended supplemental material:

Non-woven geotextile placed both below to protect stream bed and facilitate removal, and above to prevent soil from dropping into the stream and reduce UV exposure of the pipes.
Running surface material (e.g., wood planking, wood mat, expanded metal grating) to provide traction.
Cable attached to upstream tree or other fixed object to anchor one end of the structure.
Material to protect the approaches to the crossing if the soil is weak (e.g., wood mats, wood planks, corduroy, or expanded metal grating with non-woven geotextile).
A welding torch or some other means of controlling cable end fraying will increase threading speed when constructing the pipe bundle.

PVC Pipe Bundles (continued)

Approximate purchase price:

Initial construction cost of a 10-foot x 12-foot (3-m x 3.7-m) section is about $450. Two sections are needed to build a crossing for a 6-foot-wide x 2-foot-deep (1.8-m x 0.6-m) channel. Non-woven geotextile, approach stabilization material, and surfacing are extra.

Construction directions and/or diagram and time required:

Use 20-foot (6.1-m) lengths of Schedule 40 PVC or SDR11 HDPE; black for UV protection may be needed. Maximum pipe diameter should be 4 inches (10.2 cm). Saw pipes into 12-foot (3.7-m) lengths and the remaining 8-foot (2.4-m) sections in half. Drill four 1/4-inch (6.4-mm) diameter holes through the 12-foot- (3.7-m)-long pipes at locations that are 2 feet (0.6 m) and 4 feet (1.2 m) from both ends. Drill two holes through each 4-foot (1.2-m) section 1 foot (0.3 m) from each end. When constructing a 12-foot- (3.7-m)-wide bundle, alternate between two 12-foot- (3.7-m)-wide sections and two rows of 4-foot- (1.2-m)-wide sections. The two 4-foot- (1.2-m)-wide sections should be placed within each short row, 2 feet (0.6 m) from each other. String 3/16-inch (4.8-mm) galvanized steel cable through all sections. It may be necessary to control cable end fray before stringing the cable through the sections. Loops should be made at the end of each cable, extending beyond the last pipe, and secured using 3/16-inch- (4.8-mm)-diameter cable clamps. Each cabled section should be loose so that pipes can conform to the stream channel. Use tightened cable connections for a single layer crossing.

Add surfacing and approach materials as necessary.

For two people using two hand drills and one saw, about 1 hour is needed to cut, drill, and cable PVC that is 4 inches (10.2 cm) in diameter and 20 feet (6.1 m) long to build a 10-foot x 12-foot (3-m x 3.7-m) section.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

Before installing a pipe bundle crossing, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. Wash off the pipes on the outside and inside at an upland location away from the crossing to remove sediment. Place non-woven geotextile on the stream bottom and layer in the bundles. Before installing the geotextile fabric on the stream banks, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. While the top and bottom layers should be cabled together into separate bundles, intermediate layers can be created using loose pipe. Place non-woven geotextile (if needed) and then surfacing material on the top. During installation, it is important to tuck the ends of all cable loops under the bundles to avoid their being caught by a vehicle or a skidded load of material. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

About 20 minutes were needed to install a PVC pipe bundle crossing using a backhoe in a 6-foot- (1.8-m)-wide, 2-foot- (0.6-m)-deep channel. The crossing consisted of non-woven geotextile along the stream bottom, two 10-foot x 12-foot (3-m x 3.7-m) sections layered above, and a wood plank on top. Each approach was protected with a wood mat.

Patent protection of product design:

No.

Ice Bridges

Description of option:

Ice bridges are a common type of winter stream crossing in areas where there are extended periods of temperatures below freezing. They are constructed by packing snow and/or pumping water onto the existing ice. Some jurisdictions permit slash or brush to be placed in the stream channel when there is no ice to build on, but this is generally undesirable because it is often difficult to remove the brush.

Area of application:

A winter crossing over open water (e.g., lake, pond, wetland), streams, and rivers with low flow rates or dry channels and existing ice. Approaches need to be low to minimize the gradient. Snow and a source of water for freezing down the packed snow are required. Because an ice bridge will take longer to melt than the stream, it may not be appropriate on streams with large or high velocity spring flows.

Advantages:

No need to remove the structure.
Can be constructed by the operator.
Low cost.

Disadvantages:

Safety concerns due to weather, water flow, and fish impacts on ice strength and thickness.
Need a source of water to apply to the snow to create sufficient ice thickness.
Need to periodically check ice condition for safety, especially toward the end of winter.
May require more than a day to build the bridge, depending on temperature.
Local jurisdictions may not allow brush or other vegetation to be incorporated into the bridge.
Soil may be pushed into the stream with the snow during construction.

Source(s):

On-site.

Recommended supplemental material:

None.

Approximate purchase price of materials:

None.

Construction directions and/or diagram and time required:

Before constructing an ice bridge, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. For a stream crossing, select an area where the flow velocity is slow or the channel is dry or frozen, where some ice already exists on top of flowing water, and where approaches are low to minimize the gradient. Push snow into stream channel, pack it down, and then apply water. Repeat the process once the surface has hardened until the crossing reaches the desired height and width. Keep soil, brush, and other vegetation out of the crossing because the material will end up in the stream after the bridge thaws. Pack snow on the approaches to avoid disturbing the banks.

Depending on the outside temperature and the size of the desired crossing, an ice bridge can be constructed in 1 or more days.

Equipment needed for construction, installation, and/or removal:

Equipment to pile snow.
Pump or other means of applying water.

Installation approach and time:

Not applicable.

Patent protection of product design:

No.

Timber Bridges — Log Stringer

Description of option:

Log stringer bridges are built from trees felled in the area of construction. After abutments are set on both banks, the log stringers are placed on top of the abutments in the areas where vehicle traffic will pass. Lumber is frequently nailed to the top of the log stringers. Because engineering specifications for logs are limited, special care needs to be exercised when constructing this type of bridge.

Area of application:

Small streams or stream channels where the maximum span distance is less than 16 feet (4.9 m). A firm, stable stream bank is required.

Advantages:

Materials available on-site.
Little site preparation is usually needed.
Materials may be reusable, as long as they are still sound.
Low cost.

Disadvantages:

Need sound timbers that are at least 10 inches (25.4 cm) in diameter on the small end and are at least 8 feet (2.4 m) longer than the maximum span distance.
The stringers and/or abutments may become frozen to the ground in cold weather, making them difficult to remove.
Engineering specifications are limited for logs. Rot, decay, knots, and grain can greatly affect their strength properties. Some of these factors become more important the longer a bridge is in use, especially if the species does not have a high decay resistance.
May not support fully loaded truck, except for situations where the span distance is short.
The surface may wear quickly during skidding.
Bridge should be inspected between uses to make sure that it is still structurally sound.
They may be installed improperly (e.g., not enough overhang on stream banks, inadequate abutments), which will decrease load capacity and compromise safety.

Source(s):

On-site.

Recommended supplemental material:

Lumber that is 8/4 inches (2 inches or 5.1 cm) or thicker to serve as a surface deck for the bridge.
Annularly threaded (ring-shank) or helically threaded (spiral) spikes that are at least 9 inches long to attach the surface deck to the log stringers.
Galvanized steel cable that is 3/16 inch (4.8 mm) in diameter and 3/8-inch (9.5-mm) cable clamps to bind together stringers below each wheel track.
Material (e.g., logs, poles, ice, soil) to build a ramp approach on both banks.
Cable attached to upstream tree or other fixed object to anchor one end of the structure.
Abutments (e.g., logs) for both sides of the stream to set the bridge on.
Material to protect the approaches to the bridge if the soil is weak (e.g., wood mats, wood planks, corduroy, or expanded metal grating with non-woven geotextile).
Guardrails or curbs on the bridge, if it is to be used during truck hauling.

Approximate purchase price:

Low.

Construction directions and/or diagram and time required:

Before installing a log stringer timber bridge, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. Cut six logs that are at least 10 inches (25.4 cm) in diameter on the small end to a length at least 8 feet (2.4 m) longer than the maximum distance to be spanned. More logs may be required if the tree species selected has relatively low strength (e.g., basswood, aspen), if heavier equipment (e.g., fully-loaded trucks) must be supported, and/or if the span is longer than normal. Place abutment material (e.g., two logs) on each bank parallel to the stream flow. For each wheel path, place three logs on the abutments and tie them together with three cables and clamps. Connect the two sets of log stringers together with lumber, to provide stability and to prevent debris from falling into the stream during use.

A log stringer bridge can be constructed in about 2 hours.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

Build the approach ramps. Stabilize to the approaches as necessary. Attach one end of a cable to the bridge and the other end to an upstream tree or other fixed object to anchor the structure. Add guardrails or curbs to the bridge if it is to be used during truck hauling. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

It takes about 1 hour to install a 13-foot wide x 16-foot long (4-m x 4.9-m) plank bridge.

Patent protection of product design:

No.

Timber Bridges — Solid Sawn Stringer

Description of option:

Solid sawn stringer bridges are built from new lumber, railroad ties, or demolition material. After setting abutments on both banks, the stringers are placed on top of the abutments in the areas where vehicle traffic will pass. Lumber is frequently nailed to the top of the stringers.

Area of application:

Streams or stream channels where the maximum span distance is limited by the dimensions of the available timbers, providing at least 2 feet (0.6 m) of overlap on each bank. A firm, stable stream bank is required.

Advantages:

Materials generally available locally.
Little site preparation is usually needed.
Materials may be reusable, as long as they are still sound.
For new lumber, the material is a known species and grade so structural properties are known (engineering specifications may be available).

Disadvantages:

The stringers and/or abutments may become frozen to the ground in cold weather, making them difficult to remove.
Engineering specifications are limited for railroad ties and demolition materials. Rot, decay, knots, and grain can greatly affect their strength properties. Some of these factors become more important the longer a bridge is in use, especially if the species does not have a high decay resistance.
The surface may wear quickly during skidding.
Bridge should be inspected between uses to make sure that it is still structurally sound.
Length limits its application in some instances (too short or too long).
They may be installed improperly (e.g., not enough overhang on stream banks, inadequate abutments), which will decrease load capacity and compromise safety.

Source(s):

Local lumber yard or demolition company.

Recommended supplemental material:

Lumber that is 8/4 inches (2 inches or 5.1 cm) or thicker to serve as a surface deck for the bridge.
Annularly threaded (ring-shank) or helically threaded (spiral) spikes that are at least 9 inches (22.9 cm) long to attach the surface deck to the solid sawn stringers.
Material (e.g., logs, poles, ice, soil) to build a ramp approach on both banks.
Cable attached to upstream tree or other fixed object to anchor one end of the structure.
Abutments (e.g., logs) for both sides of the stream to set the bridge on.
Material to protect the approaches to the bridge if the soil is weak (e.g., wood mats, wood planks, corduroy, or expanded metal grating with non-woven geotextile).
Guardrails or curbs on the bridge, if it is to be used during truck hauling.

Approximate purchase price:

Low to moderate. About $800 to purchase hemlock lumber to construct a 13-foot-wide x 16-foot-long (4-m x 4.9-m) bridge.

Construction directions and/or diagram and time required:

Before installing a solid sawn stringer timber bridge, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. Place abutments (e.g., two or more sill logs) on each bank parallel to the stream flow. For each wheel path, place sawn timbers on the abutments. Nail lumber to the top of the bridge, tying together the two wheel paths, to provide stability and to prevent debris from falling into the stream during use.

A solid sawn stringer bridge can be constructed in about 1 hour.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

Build the approach ramps. Provide stabilization to the approaches as necessary. Attach one end of a cable to the bridge and the other end to an upstream tree or other fixed object to anchor the structure. Add guardrails or curbs to the bridge if it is to be used during truck hauling. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

It takes about 1 hour to install a 13-foot-wide x 16-foot-long (4-m x 4.9-m) solid sawn timber bridge.

Patent protection of product design:

No.

Timber Bridges — Laminated Panel

Description of option:

Bridge panels are constructed using stress-laminated, glued-laminated (glulam), dowel-laminated, or nail-laminated materials. Generally, two panels are placed side-by-side to form the bridge. The panels are treated in some cases. After setting abutments on both banks, the panels are placed on top of the abutments in the areas where vehicle traffic will pass. If there is a space between the panels, lumber should be used to tie them together.

Area of application:

Streams or stream channels where the maximum span distance is limited by the dimensions of the panels, providing at least 2 feet (0.6 m) of overlap on each bank. A firm, stable stream bank is required.

Advantages:

Commercially available.
Little site preparation is usually needed.
Materials are generally reusable, as long as they are still sound.
For new bridges, the material is a known species and grade so structural properties are known.
Engineering specifications may be available.

Disadvantages:

Need to periodically retension steel rods in stress-laminated bridge.
Lamination may become damaged during installation, removal, and transport.
The stringers and/or abutments may become frozen to the ground in cold weather, making them difficult to remove.
The surface may wear quickly during skidding.
Panels should be inspected between uses to make sure they are still structurally sound.
Length limits its application in some instances (too short or too long).
They may be installed improperly (e.g., not enough overhang on stream banks, inadequate abutments), which will decrease load capacity and compromise safety.

Source(s):

Commercial vendors.

Recommended supplemental material:

Lumber that is 8/4 inches (2 inches or 5.1 cm) or thicker to connect multiple bridge panels so that debris does not fall between them.
Annularly threaded (ring-shank) or helically threaded (spiral) spikes that are at least 9 inches (22.9 cm) long to attach the surface deck.
Material (e.g., logs, poles, ice, soil) to build a ramp approach on both banks.
Cable attached to upstream tree or other fixed object to anchor one end of the structure.
Abutments (e.g., logs) for both sides of the stream to set the bridge on.
Material to protect the approaches to the bridge if the soil is weak (e.g., wood mats, wood planks, corduroy, or expanded metal grating with non-woven geotextile).
Guardrails or curbs on the bridge if it is to be used during truck hauling.

Approximate purchase price:

High. Prices exceed $6,000 for a 30-foot long x 12-foot wide (9.1-m x 3.7-m) bridge.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

Commercially available products generally include installation instructions.

Before installing a timber panel bridge, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. Place abutments (e.g., two or more sill logs) on each bank parallel to the stream flow. Place the bridge panels on top of the abutments. If the panels are not placed side-by-side, nail lumber to connect them together so that debris does not fall into the stream during use. Build the approach ramps. Stabilize the approaches as necessary. Attach one end of a cable to the bridge and the other end to an upstream tree or other fixed object to anchor the structure. Add guardrails or curbs to the bridge, if it is to be used during truck hauling. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

It takes about 1 hour to install a timber panel bridge.

Patent protection of product design:

Commercial designs are likely patented.

Used Railroad Cars and Truck Flatbeds

Description of option:

Used railroad cars (flatcars and boxcars) and truck flatbeds can be retrofitted for use as temporary bridges. The retrofitting provides additional reinforcing support in the wheel paths.

Area of application:

Wide streams or stream channels with a firm, stable bank.

Advantages:

Commercially available.
Truck trailer frames are generally locally available.
Can span wider streams, especially railroad cars.
Engineering specifications may be available.

Disadvantages:

Railroad cars, especially flatcars, are heavy.
Used railroad cars and truck flatbeds are available in a limited number of lengths, generally about 85 feet (25.9 m) long for railroad cars and about 60 feet (18.3 m) long for truck flatbeds. This limits their usefulness at narrow stream crossings.
The railroad cars, truck flatbeds, and/or abutments may become frozen to the ground in cold weather, making them difficult to remove.
Used railroad cars and truck flatbeds that are sold "as is" should be inspected before use.
Requires retrofitting of main support beams to ensure adequate strength.
The width is generally narrow (less than 12 feet [3.7 m]). Two used railroad cars or truck flatbeds may be needed.
Bridge should be inspected between uses to make sure that it is still structurally sound.
They may be installed improperly (e.g., not enough overhang on stream banks, inadequate abutments), which will decrease load capacity and compromise safety.

Source(s):

Commercial vendors.

Recommended supplemental material:

Material (e.g., logs, poles, ice, soil) to build a ramp approach on both banks.
Cable attached to upstream tree or other fixed object to anchor one end of the structure.
Logs or timber sills/abutments for both sides of stream to set the bridge on.
Material to protect the approaches to the bridge if the soil is weak (e.g., wood mats, wood planks, corduroy, or expanded metal grating with non-woven geotextile).
Guardrails or curbs on the bridge if it is to be used during truck hauling.

Approximate purchase price:

High. It costs about $9,000 (FOB) to purchase a 60-foot-long x 10.5-foot-wide (18.3-m x 3.2-m) railroad flatcar and about $3,000 (FOB) to purchase a 50-foot-long x 10-foot-wide (15.2-m x 3-m) railroad boxcar.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Knuckleboom loader or excavator for smaller railroad cars and truck flatbeds. A crane may be required for larger units.

Installation approach and time:

Commercially available products generally include installation instructions.

Before installing a used railroad car or truck flatbed bridge, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. Place abutments (e.g., two or more sill logs) on each bank parallel to the stream flow. Place bridge panels on top of abutments. If the bridge panels are not placed side-by-side, nail lumber to connect the panels together so that debris does not fall into the stream during use. Build the approach ramps. Stabilize the approaches as necessary. Attach one end of a cable to the bridge and the other end to an upstream tree or other fixed object to anchor the structure. Add guardrails or curbs to the bridge, if it is to be used during truck hauling. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

It takes about 1 hour to install a used railroad car or truck flatbed bridge.

Patent protection of product design:

No.

Steel Bridges

Description of option:

Steel bridges include hinged portable bridges and modular bridges. Hinged bridges fold up for transport. Modular steel bridges are designed as a series of individual panels that interlock, forming a bridge of variable length.

Area of application:

Streams or stream channels where the maximum span distance is limited by the dimensions of the available materials. A firm, stable stream bank is required.

Advantages:

Protects the streambed
Commercially available.
Engineering specifications should be available.
Low maintenance.

Disadvantages:

High initial cost
Bulky and heavy.
The panels and/or abutments may become frozen to the ground in cold weather, making them difficult to remove.
Bridge should be inspected between uses to make sure that it is still structurally sound.
Length limits its application in some instances (too short or too long).
They may be installed improperly (e.g., not enough overhang on stream banks, inadequate abutments), which will decrease load capacity and compromise safety.

Source(s):

Commercial vendors.

Recommended supplemental material:

Material (e.g., logs, poles, ice, soil) to build a ramp approach on both banks.
Cable attached to upstream tree or other fixed object to anchor one end of the structure.
Logs or timber sills/abutments for both sides of stream to set the bridge on.
Material to protect the approaches to the bridge if the soil is weak (e.g., wood mats, wood planks, corduroy, or expanded metal grating with non-woven geotextile).

Approximate purchase price:

High. About $12,600 (FOB) for a 30-foot x 13-foot (9.1-m x 4-m) hinged bridge.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Dozer, skidder, snatch block. Large bridges may require special equipment (e.g., crane).

Installation approach and time:

Commercially available products generally include installation instructions.

Before installing a steel bridge, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. Place abutments (e.g., two or more sill logs) on each bank parallel to the stream flow. Place bridge on top of abutments. Build the approach ramps. Stabilize the approaches as necessary. Attach one end of a cable to the bridge and the other end to an upstream tree or other fixed object to anchor the structure. Add guardrails or curbs to the bridge if it is to be used during truck hauling. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

It takes about 1 hour to install a steel bridge.

Patent protection of product design:

Commercial designs are likely patented.

Pre-Stressed Concrete Bridges

Description of option:

Bridge panels are made of precast, pre-stressed concrete. Generally, two panels are placed side-by-side to form the bridge. It is important to make sure that the panels are engineered to handle the anticipated loads.

Area of application:

Streams or stream channels where the maximum span distance is limited by the dimensions of the available materials. A firm, stable stream bank is required.

Advantages:

Commercially available.
Engineering specifications should be available.
Low maintenance.

Disadvantages:

Bulky and heavy.
The panels and/or abutments may become frozen to the ground in cold weather, making them difficult to remove.
Concrete may break during handling.
Panels should be inspected between uses to make sure that it is still structurally sound.
Length limits its application in some instances (too short or too long).
Exposed steel may corrode and decrease structural strength.
They may be installed improperly (e.g., not enough overhang on stream banks, inadequate abutments), which will decrease load capacity and compromise safety.

Source(s):

Commercial vendors.
Highway departments or local road authorities may be a source for used panels.

Recommended supplemental material:

Material (e.g., logs, poles, ice, soil) to build a ramp approach on both banks.
Cable attached to upstream tree or other fixed object to anchor one end of the structure.
Logs or timber sills/abutments for both sides of stream to set the bridge on.
Material to protect the approaches to the bridge if the soil is weak (e.g., wood mats, wood planks, corduroy, or expanded metal grating with non-woven geotextile).

Approximate purchase price:

Moderate.

Construction directions and/or diagram and time required:

Not appropriate.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment. Large bridge panels may require special equipment (e.g., crane).

Pre-Stressed Concrete Bridges (continued)

Installation approach and time:

Before installing a pre-stressed concrete bridge, contact the appropriate regulatory organization(s) to determine whether a permit is required and to solicit advice on placement and installation. Place abutments (e.g., two or more sill logs) on each bank parallel to the stream flow. Place bridge panels on top of abutments. Build the approach ramps. Stabilize the approaches as necessary. Attach one end of a cable to the bridge and the other end to an upstream tree or other fixed object to anchor the structure. Add guardrails or curbs to the bridge if it is to be used during truck hauling. Revegetate all bank cuts or disturbed areas near the stream immediately following construction of the crossing to reduce erosion.

It takes about 1 hour to install a pre-stressed concrete bridge.

Patent protection of product design:

No.

APPENDIX 5

INFORMATIONAL SUMMARIES FOR TEMPORARY WETLAND CROSSING OPTIONS

Wood Mats

Description of option:

Wood mats are individual cants that are strung together using two 3/16-inch (4.8-mm) galvanized steel cables to make a single-layer crossing. Four 3/16-inch (4.8-mm) cable clamps are used to tie off the ends of each cable with a loop after they have been threaded through the cants. The loops facilitate installation and removal of the mats. The length and dimension of the cants may vary according to anticipated loads and soil strength. A 10-foot- (3-m)-long, 4-inch x 4-inch (10.2-cm x 10.2-cm) cant is the recommended minimum size. Longer cants may be needed on weaker soils (e.g., soft clay or organic soils).

Area of application:

Wet mineral or sandy soils or existing road beds. Wood mats are not recommended for undisturbed peat or very weak clay soils. They require a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or lateral movement of the option outside of the planned travel area. They are most appropriate for use during hauling or forwarding operations. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Materials are readily available.
Can be constructed on-site by the operator.
Conforms to uneven ground.
Easy to install and remove.
Easy to remove broken pieces by disconnecting the cable clamps and sliding off the broken section(s).

Disadvantages:

Breakage may occur if applied on top of high stumps, rocks, or uneven ground.
Log skidding and tire chains will damage the mat.
The surface can be slick, resulting in loss of traction.
A rippling or wave movement may occur on very weak soils.

Source(s):

Wood: Local sawmill or lumber supply store.
Components: Local supply store.

Recommended supplemental material:

Non-woven geotextile to place below the mats.
Expanded metal grating if the running surface becomes slick and traction is lost.
Quick links or other heavy duty connectors to link together adjacent wood mats.

Approximate purchase price:

Low. About $170 (US) to initially construct a 10-foot-long x 12-foot-wide (3-m x 3.7-m) mat using 4-inch x 4-inch (10.2-cm x 10.2-cm) cants.

Construction directions and/or diagram and time required:

Drill holes 1/4-inch (6.4-mm) in diameter through each cant about 1 to 2 feet (0.3 to 0.6 m) from each end. To reduce errors in marking and drilling time, establish one set of drilling marks on the ground and make sure that several hand drills are available. Thread a 3/16-inch (4.8-mm) galvanized steel cable through each set of holes to connect the cants. A welding torch or some other means of controlling cable end fraying will increase threading speed. Loops should be made at the end of each cable, extending beyond the last cant, and then secured with 3/16-inch (4.8-mm) diameter cable clamps. The loops are used to pick up the mat during installation and removal. The connection between the cants should be tight to reduce any rippling or wave movement when vehicles pass. Improperly tightened cable clamps can lead to slip and loss of connectivity within the mat.

Limiting mat length to about 10 feet (3 m) reduces weight and facilitates construction, installation, and removal.

About 30 minutes are needed for two people with two hand drills to drill and cable together one 10-foot x 12-foot (3-m x 3.6-m) mat from 4-inch x 4-inch (10.2-cm x 10.2-cm) material. It took three people up to 3 hours to cut, drill, and cable together a 20-foot-long x 10-foot-wide (6.1-m x 3-m) wood mat.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment that has at least a 12-foot (3.7-m) lift span.

Installation approach and time:

Wood mats should not be installed on areas with firm, high spots (e.g., stumps), large rocks, or ruts to reduce the chance that they will break during use. Before installing the non-woven geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the non-woven geotextile fabric across the area where the crossing is to be placed. Install preconstructed wood mats in front of the installation equipment. The mats can be connected to each other on-site using quick links or other heavy duty connectors to increase overall crossing strength. During installation, it is important to tuck the ends of all cable loops under the mats to avoid their being caught by a passing vehicle.

Installation takes about 15 minutes for a 10-foot x 12-foot (3-m x 3.7-m) mat, including laying down the non-woven geotextile.

Patent protection of product design:

No.

Wood Planks/Panels

Description of option:

Wood planks or panels are constructed using lumber planking to create a two-layer crossing. Parallel runners are laid down on each side where the vehicle's tires will pass and then lumber is nailed perpendicular to these runners. Annularly threaded (ring-shank) or helically threaded (spiral) spikes can be used to attach the planks. The actual running surface may be on either side of the panel, unless the nails have gone all the way through it. A panel 8-feet x 12-feet (2.4-m x 3.7-m) constructed with 3-inch x 8-inch (7.6-cm x 20.3-cm) lumber is the recommended minimum size. Lumber longer than 12 feet (3.7 m) may be needed on weaker soils (e.g., soft clay or organic soils). The number of reuses possible for planks will increase if the wood used is dense and strong. The individual planks can be either preconstructed or constructed on-site.

Area of application:

Most wetland soils, if sized appropriately. The surface width needed depends on the soil strength. Wood plank crossings require a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or lateral movement of the planks outside of the planned travel area. Wood planks/panels are most appropriate for use during hauling or forwarding operations. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

- Can be constructed on-site by the operator.
- Little lateral movement under a load.
- Easy to install and remove.
- Easy to replace broken pieces.

Disadvantages:

- Heavy if preconstructed.
- Breakage may occur if applied on top of high stumps, rocks, or uneven ground.
- Log skidding and tire chains will damage the planks.
- Surface may become slick when wet or when operating in fine-textured soils, resulting in loss of traction.
- No space between planks to facilitate chains being placed for installation and removal.

Source(s):

- Components: Local supply store.
- Lumber: Local supply store or sawmill.

Recommended supplemental material:

- Non-woven geotextile to place below the planks.
- Four 3/16-inch (4.8-mm) galvanized steel cables formed into loops for attaching to the corners to facilitate installation and removal of the crossing.
- Four 3/8-inch (9.5-mm) cable clamps to tie off the ends of each cable loop.
- Eye hooks with quick links or other heavy duty connectors to link together adjacent wood planks.
- Expanded metal grating, if the running surface becomes slick and traction is lost.

Approximate purchase price:

Low. Initial construction cost of an 8-foot-long x 12-foot-wide (2.4-m x 3.7-m) wood plank is about $150. Connectors and non-woven geotextile are extra.

Construction directions and/or diagram and time required:

For the planks, use 3-inch-thick x 10-inch-wide x 12-foot-long (7.5-cm x 25.4-cm x 3.7-m) lumber. Longer lumber is needed on weak soils. To create an 8-foot- (2.4-m)-long plank, the lumber runners should be 3 inches thick x 10 inches wide x 8 feet long (7.5 cm x 25.4 cm x 2.4 m). Create two parallel rows of runners on the ground, each containing three pieces that are next to each other. Place the two rows of runners 6 feet (1.8 m) apart on center or whatever width is required to support vehicle tires. Place the planks on top of the runners in a perpendicular direction, leaving a 1-inch (2.5-cm) gap between planks. Use annular or ring shank nails annularly threaded (ring-shank) or helically threaded (spiral) spikes to attach the planks to the runners. For ease of construction, starter holes should be pre-drilled into the top board. To reduce withdrawal, spikes should be placed at slight angles from vertical with one spike angled toward the traffic and one away from it. To facilitate installation and removal, attach four 3/16-inch (4.8-mm) galvanized steel cables, one to each corner. Create a loop on the exterior portion of each cable using a 3/8-inch (9.5-mm) cable clamp.

About 1 hour is needed for two people to nail together an 8-foot x 12-foot (2.4-m x 3.7-m) plank mat.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

Wood planks should not be installed on areas with firm high spots (e.g., stumps), large rocks, or ruts to reduce the chance that they will break during use. Before installing the non-woven geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the non-woven geotextile fabric across the area where the crossing is to be placed. Install the preconstructed wood plank mats in front of the installation equipment. The spacing between adjacent wood plank mats should be minimized. They can be connected to each other on-site through the use of quick links or other heavy duty connectors that are attached to the loops. During installation, it is important to tuck the ends of all cable loops under the planks to avoid their being caught by a passing vehicle.

It takes about 15 minutes to install a non-woven geotextile and a preconstructed 8-foot x 12-foot (2.4-m x 3.7-m) plank crossing.

Patent protection of product design:

No.

Wood Pallets

Description of option:

Wood pallet crossing mats are a sturdy, commercially available, multi-layered variation of a three-layer wood pallet (used for shipping or storage) that has been specially designed to support traffic. They are generally made from hardwood planks that are nailed together. They are specially designed to be interconnecting with adjacent mats, to be reversible, to allow for broken planks to be easily replaced, and to ensure that nail points won't surface. Some pallet mats are designed with the top and bottom pieces already interconnected like a traditional pallet, while others are designed with the top and bottom pieces separate, interconnecting during installation. The driving surface of a pallet should be fairly smooth and even to reduce stress to the pallets.

Area of application:

Most wetland soils, if sized appropriately. They require a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or the lateral movement of the pallets outside of the planned travel area. They are most appropriate for use during hauling or forwarding operations. While large pallets may need to be cut in half, they may become too small to support equipment on undisturbed peat or very weak clay soils. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Preconstructed.
Easy to install and remove.
Some designs make it easy to replace broken pieces.

Disadvantages:

Heavy.
Breakage may occur if applied on top of high stumps, rocks, or uneven ground.
Log skidding and tire chains will damage the pallets.
Commercial products traditionally overlap along an 8-foot (2.4-m) edge which is not a wide enough surface for vehicle traffic. Need to cut the pallets in half and place the smaller sections in the wheel path. Pallets can be custom-made so that the interconnection is along the 12-foot- (3.7-m)- or 14-foot- (4.3-m)-wide edge.
A forklift may be needed to install and remove the crossing if standard logging equipment is not sufficient.

Source(s):

Commercial vendors.

Recommended supplemental material:

Non-woven geotextile to place below the pallets.
Materials to facilitate handling (e.g., cable with clamps).
Connectors to link together adjacent pallets.

Approximate purchase price:

Moderate. About $350 (FOB) for a commercial 8-foot x 16-foot (2.4-m x 4.9-m) pallet.

Construction directions and/or diagram and time required:

Not applicable. To cut a commercial product in half requires about 30 minutes or more for a 12-foot (3.7-m) length.

Equipment needed for construction, installation, and/or removal:

A forklift may be required if standard logging equipment is not sufficient.

Installation approach and time:

Wood pallets should not be installed on areas with firm high spots (e.g., stumps), large rocks, or ruts to reduce the chance that they will break during use. Before installing the non-woven geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the non-woven geotextile fabric across the area where the crossing is to be placed. If the soil in the surrounding area is of adequate strength, place the loader equipment perpendicular to the area with weak soil or use a skidder to drag the pallets into place. Otherwise, install the pallets in front of the installation equipment. Interconnect the panels as appropriate. Where the top and bottom panels of the pallets are already nailed together, installation will not require that the two panels be interconnected on-site.

Patent protection of product design:

Commercial designs are likely patented.

Bridge Decking

Description of option:

The decking of a timber bridge can be used to cross a small wetland area. Bridge panel options that do not have steel or wood stringers, such as prefabricated stress-laminated, glulam, stress-laminated, and dowel-laminated bridges, may be most appropriate and available.

Area of application:

Most wetland soils, if sized appropriately. Bridge decking requires a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades and cross slope may result in loss of traction. Support may be inadequate if the road is not fairly straight. They are most appropriate for use during hauling or forwarding operations. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Easy to install and remove.

Disadvantages:

Breakage may occur if applied on top of high stumps or rocks.
Log skidding and tire chains will damage the bridge deck.
Length limits its application in some instances (too short).

Source(s):

Commercial vendors.

Recommended supplemental material:

Non-woven geotextile to place below the bridge deck.
Lumber that is 8/4 inches (2 inches or 5.1 cm) or thicker to connect the bridge panels, if they are not placed side-by-side.
Annularly threaded (ring-shank) or helically threaded (spiral) spikes that are at least 9 inches (22.9 cm) long to attach the surface deck.

Approximate purchase price:

High. Prices exceed $6,000 for a 30-foot-long x 12-foot-wide (9.1-m x 3.7-m) bridge.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

Before installing the geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the geotextile fabric across the area where the crossing is to be placed. If the soil in the surrounding area is of adequate strength, place the installation equipment perpendicular to the area with weak soil to lift the bridge deck panels into place. Otherwise, install the bridge deck panels in front of the installation equipment.

Installation time is generally about 1 hour.

Patent protection of product design:

Commercial designs are likely patented.

Expanded Metal Grating

Description of option:

Expanded metal grating is made of nongalvanized (regular carbon) steel that is 4 feet x 10 feet by 0.618 inch (1.2 m x 3 m x 15.7 mm), with a diamond-shaped opening that is 1.33 x 5.33 inches (34 mm x 13.5 cm). This grating is relatively light and inexpensive, and the surface is rough enough to provide some traction. The crossing is built by hand-placing the grating sections in the wheel paths.

Area of application:

Most shallow wetland soils, sandy soils, or on existing roads. Expanded metal grating is not recommended for undisturbed peat or very weak clay soils. It requires a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or the lateral movement of the option outside of the planned travel area. This option is most appropriate for use during hauling or forwarding operations. Heavy duty connectors are needed to keep the grating panels from moving laterally during use of the crossing. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Lightweight.
Readily available material.
No initial construction required.
Easy to install and remove by hand.
Can be installed without equipment.
Difficult to destroy or break.
Has multiple uses (can be used alone as a crossing option or in combination with other options to provide stiffness and traction).

Disadvantages:

Bends to conform to ruts, although the grating can still be reused.
Moves if it is not interconnected.
May be difficult to connect grating if it is already bent and connectors aren't large enough.
Easily stolen.
Not recommended for use during skidding.

Source(s):

Local building supply store.
National distributors.

Recommended supplemental material:

Non-woven geotextile to place below the grating.
Quick links that are at least 3 inches x 3/8 inches (7.5 cm x 9.5 mm) in size, reinforcing rod (rebar) "staples" (in a sandy soil, staples were 0.5 inches (12.7 mm) thick, 4 feet (1.2 m) long, bent into U shape with a 6-inch (15.2-cm) center and 21-inch- (53.3-cm)-long legs), or other heavy duty connectors.

Approximate purchase price:

Low to moderate (about $100 for a 4-foot x 8-foot [1.2-m x 2.4-m] grate).

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Gloves for use during handling.

Crescent wrench to tighten or disconnect the quick links when installing or removing the crossing.

A winch may be needed during removal to lift sections if they become anchored in the soil.

Installation approach and time:

Smooth any existing ruts to reduce grating deformation or lay the grating directly over the existing vegetation on top of a non-woven geotextile. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the non-woven geotextile across surface. Lay the grating in the wheel paths, parallel to the direction of travel. Connect adjoining pieces of grating with heavy duty connectors (e.g., quick links, reinforcing rod (rebar) "staples").

About 30 minutes were needed to lay a 32-foot- (9.8-m)-long crossing, including placement of a non-woven geotextile and the grating, and installation of connectors between grating sections.

Patent protection of product design:

None for this application.

PVC and HDPE Pipe Mats and Plastic Road

Description of option:

A PVC or HDPE pipe mat is constructed using 4-inch (10.2-cm) diameter Schedule 40 PVC or HDPE SDR11 pipes that are tightly connected using 3/16-inch (4.8-mm) diameter galvanized steel cables to form panels. A plastic road is similar to the pipe mat, except that PVC or HDPE transition mats/panels are built into the design to ease the transition of tires ramping up and then back down on the approaches between the firm soil and the mat. Also, the pipes in a plastic road are interconnected using 1-inch- (2.5-cm)-diameter Schedule 80 PVC or similar-size HDPE pipe.

Area of application:

Most wetland soils, if sized appropriately. Mat width needed depends on soil strength. These options require a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or the lateral movement of the mat outside of the planned travel area. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Lightweight.
Readily available materials.
Easy to install, remove, and repair by hand.
Can be constructed by the operator.

Disadvantages:

Extended use has not been evaluated.
Surface is slick and loss of traction can occur, especially on grades.
Standard pipe is sensitive to ultraviolet (UV) light and will degrade. Need to cover the pipe or use an ultraviolet-resistant type of pipe. Pipe should be stored out of the sun.
Log skidding and tire chains will damage the mats.

Source(s):

Local hardware or plumbing supply store.

Recommended supplemental material:

Non-woven geotextile below the mat and above it if a surfacing material is applied.
Running surface material (e.g., wood planking, expanded metal grating) to provide traction and to reduce the wave action on a pipe mat.
A welding torch or some other means of controlling cable end fraying.

Approximate purchase price:

Initial construction cost of a 4-foot x 12-foot (1.2-m x 3.7-m) pipe mat is about $200. Materials for an 8-foot-wide x 40-foot-long (2.4-m x 12-m) plastic road cost about $2,000. Non-woven geotextile is extra.

Construction directions and/or diagram and time required:

The pipe mat is constructed using 20-foot (6.1-m) lengths of 4-inch (10.2-cm) diameter Schedule 40 PVC or SDR11 HDPE pipe. Black PVC for UV protection may be needed. Saw pipes into 12 foot (3.7 m) lengths and saw the remaining 8-foot (2.4-m) sections in half. Drill four 1/4-inch (6.4-mm) diameter holes through the 12-foot- (3.7-m)-long pipes at locations that are 2 feet (0.6 m) and 4 feet (1.2 m) from each end. Drill two holes through each 4-foot (1.2-m) section 1 foot (0.3 m) from each end. When constructing a 12-foot- (3.7-m)-wide pipe mat, alternate between two 12-foot- (3.7-m)-wide sections and two rows of 4-foot- (1.2-m)-wide sections. The two 4-foot- (1.2-m)-wide sections should be placed within each short row, 2 feet (0.6 m) from each other. String 3/16-inch (4.8-mm) galvanized steel cable through all sections. A welding torch or some other means of controlling cable end fraying will increase threading speed when constructing a pipe mat. Loops should be made at the end of each cable, extending beyond the last pipe, and then secured using 3/16-inch (4.8-mm) diameter cable clamps. Each cabled section should be tight.

The plastic road is constructed using 2-inch- (5.1-cm)-, 3-inch- (7.6-cm)-, and 4-inch- (10.2-cm)-diameter Schedule 40 PVC or SDR11 HDPE pipe of varying lengths, 1-inch- (2.5-cm)-diameter Schedule 80 PVC or similar-size HDPE pipes, 3/8-inch (9.5-mm) diameter galvanized steel cable, and 3/8-inch- (9.5-mm)-diameter cable clamps.

Add surfacing materials as necessary.

For two people using one drill press, about 1 hour is needed to construct a pipe mat 4 feet x 12 feet (1.2 m x 3.7 m).

Equipment needed for construction, installation, and/or removal:

Pickup truck to haul materials and two people to place the pipe mat or plastic road.

Installation approach and time:

Before installing the geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the geotextile fabric across the area where the crossing is to be placed. Hand carry and place the individual mats on the geotextile.

About 30 minutes were needed to install a 30-foot x 12-foot (9.1-m x 3.7-m) pipe mat crossing, including a non-woven geotextile below the mats.

An 8-foot-wide x 40-foot-long (2.4-m x 12-m) plastic road crossing was installed by two people in about 1 hour.

Patent protection of product design:

No.

Tire Mats

Description of option:

A tire mat is a mat or panel of tires created by interconnecting tire sidewalls with corrosion-resistant fasteners. Tire treads are also used in some designs. Mats of varying length and width can be developed.

Area of application:

Most wet mineral soils with different designs for distinct soils and situations. Tire mats require a relatively level surface with grades up to 5 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or the lateral movement of the mats outside of the planned travel area. Tire mats are most appropriate for use during hauling or forwarding operations. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Relatively low maintenance.
Some designs may not require non-woven geotextile.
With appropriate care, tire mats may have a long life.

Disadvantages:

Product is very heavy and flexible, making it difficult to install and remove.
Not recommended for use when skidding material.
If the individual mats are dragged into place, it is difficult to use a non-woven geotextile below the mats.
Use of a clam loader to install or remove the mats may damage the fasteners (e.g., bolts) that hold the mats together.
Operators may not install product correctly.

Source(s):

Commercial vendor.
Homemade from waste tires and fasteners (e.g., cables, bolts).

Recommended supplemental material:

Non-woven geotextile to place below the mats, unless they are dragged into place.

Approximate purchase price:

Moderate. About $300 for a 5-foot x 10-foot (1.5-m x 3-m) mat.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Skidder (if mats are dragged), forwarder, or a truck with a loader.

Installation approach and time:

Before installing the geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the geotextile fabric across the area where the crossing is to be placed. Depending on the configuration of the mats and the strength of the soil where the mats are to be installed, they can be either positioned in front of the installation equipment, laid from a perpendicular position, or dragged into place.

About 30 minutes are needed to install two 5-foot x 10-foot (1.5-m x 3-m) sections, including a non-woven geotextile.

Patent protection of product design:

Commercial designs are patented.

Corduroy

Description of option:

Corduroy is a crossing made of brush, small logs cut from low-value and noncommercial trees on-site, or mill slabs that are laid perpendicular (most often) or parallel to the direction of travel. The effect of corduroy is to spread the load over the whole length of the log or slab, effectively increasing the load-bearing area. Flotation increases with increasing surface area, especially length, of the individual pieces of corduroy. Brush corduroy will provide less flotation than small logs or mill slabs. Temporary corduroy normally is not covered with fill. During installation, application of a geotextile is recommended to separate the logs or mill slabs from the underlying soil. The geotextile should result in less corduroy being required.

Area of application:

Most wetland soils. Corduroy crossings require a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or the lateral movement of the corduroy outside of the planned travel area. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Material is generally available on-site or from a local sawmill.

Easy to adjust crossing width to accommodate different soil strengths.

Disadvantages:

Installation is slow.

Difficult to remove the corduroy.

Corduroy may be dirty when removed from the crossing, making it difficult to process or sell to a forest products company.

Source(s):

On-site materials.

Slabwood, which is available from a sawmill, may be substituted for logs on some wet mineral soils.

Recommended supplemental material:

Non-woven geotextile to place below the corduroy.

Wood plank wheel path for truck hauling across corduroy.

Approximate purchase price:

Low.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

Before installing the geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the geotextile fabric across the area where the crossing is to be placed. Place bucked pieces of roundwood or mill slabwood into the wet area perpendicular to the direction of travel. The roundwood should be as wide as the weak area of soil or at least as wide as the equipment that will be using the crossing. Multiple layers of roundwood may be required.

About 45 minutes are needed to build a 12-foot-wide x 20-foot-long (3.7-m x 6.1-m) crossing using precut roundwood.

Patent protection of product design:

No.

Pole Rails

Description of option:

When attempting to support skidding or forwarding machinery equipped with high flotation or dual tires, one or more straight hardwood poles cut from on-site trees can be laid parallel to the direction of travel below each wheel. The poles can either be with or without limbs. If the poles are not delimbed, more flotation will be provided at the top of the tree where the diameter is smallest.

Area of application:

Skidding and felling machinery equipped with wide, high flotation tires and used across small mineral soil wetlands. They require a relatively level surface with grades up to 4 percent, a fairly straight alignment, and no cross slope. Steeper grades, cross slope, or curves may result in loss of traction or the lateral movement of the pole rails or the equipment outside of the planned travel area. This option will not work well if the machinery is equipped with conventional width tires because they are too narrow and are operated at too high a pressure to stay on top of the poles. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Easy to install.
Material is available on-site.

Disadvantages:

Only applicable if machinery has wide or dual tires.
Not advisable as an option on crossings that are much longer than one tree length.
Poles may sink in crossings that have deep wet spots, making it difficult to remove them.
Dirty poles may be difficult to process or sell to a forest products company after being removed.

Source(s):

On-site materials.

Recommended supplemental material:

Cable or chain to bind together logs, if needed.

Approximate purchase price:

Low.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Standard logging equipment.

Installation approach and time:

For each wheel path, place tree-length or full-tree sections into the wet area parallel to the direction of travel at the required distance apart for the equipments' tires. If possible, the pieces should be as long as the crossing. Individual poles should be no more than about 10 inches (25.4 cm) in diameter on the large end so that they penetrate the wet area to a sufficient depth that the tires come in contact with the soil. Two or more poles may need to be laid parallel to each other if only small diameter material is available or if sufficient flotation is not provided. For a crossing that is longer than the length of one pole, additional poles may need to be laid in a linear manner. Place the end of the pole that has the most flotation (the end of the log with the largest diameter for tree-length sections or the top of the tree for full-tree material) in the end of the crossing with the weakest soil. After placing the poles, it is important to drive across them a few times without carrying a load to get them properly seated in the soil. Remove the poles when there is no additional need to cross the wet area.

About 15 minutes are needed to build a 40-foot- (12.2-m)-long crossing using two precut 40-foot- (12.2-m)-long poles.

Patent protection of product design:

No.

Wood Aggregate

Description of option:

Wood particles ranging in size from chips to chunks (fist-size and larger) can provide cohesion and support to soft soils. Wood aggregate is used in the same way gravel might be, except that it is lighter weight and temporary because of natural deterioration.

Area of application:

The trafficability of most wet soils can be improved substantially with the application of wood aggregate. Although the wood is not removed after use of the crossing, it will naturally biodegrade over time. Wood aggregate can be used on a variety of grades, alignments, and cross slopes. It can also be used during skidding operations. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support.

Advantages:

Easy to install, lightweight, and naturally biodegrades over time.
Allows low flow drainage through the subgrade.

Disadvantages:

Cannot be easily removed, but will biodegrade over time.
Chips, sawdust, and hog fuel particles are available, but chunk-size material is not.

Source(s):

Whole-tree chipping and grinding operations, sawmills, and other wood processing plants.

Recommended supplemental material:

Non-woven geotextile to place below the wood aggregate, if warranted by conditions.

Approximate purchase price:

Competitive with local sources of gravel fill.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Standard road construction equipment (e.g., dump truck and dozer).

Installation approach and time:

A biodegradable geotextile should be used with wood aggregate that will be left in place. Before installing the geotextile fabric, smooth out any high spots and fill in any ruts to reduce the potential of the geotextile tearing during use. For sites with grass mounds or other uneven vegetation, blading should not disturb the root mat associated with that vegetation. Roll out the geotextile fabric across the area where the crossing is to be placed. Layer the wood aggregate over the geotextile to the desired depth, which will depend on the underlying soil conditions. Between 6 and 16 inches (15 and 41 m) of wood aggregate is usually adequate.
Installation time for a 15-foot x 40-foot (4.6-m x 12.1-m) section is about 1 hour.

Patent protection of product design:

No.

Equipment with Wide Tires, Duals, Bogies, or Tire Tracks

Description of option:

These mobility options provide a method for increasing the contact area between the equipment and the soil so that the machine's weight is spread over a larger surface area. Wide or high flotation tires are wider than conventional tires, normally between about 34 and 72 inches (0.9 and 1.8 m). Dual tires consist of four conventional width tires on a single axle. Dual tires can be used on one machine axle (usually the back) or on more than one axle. A bogie system has two tires mounted in series on each end of a rocking axle assembly. It is possible to add wrap-around tracks to existing, individual, conventional width rubber tires to make them wider. For example, tracks can extend the width of a 30-inch (0.76-m) tire up to either 42 inches (1.1 m) or 53 inches (1.3 m) and extend a 44-inch (1.1-m) tire up to 65 inches (1.6 m). Similar tracks have been designed for use on the adjacent wheels of a bogie.

Area of application:

Many wetland soils. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support to the equipment.

Advantages:

Reduces the need to construct temporary crossings.
Allows movement off of designated trails.
Extends seasonal access into wet areas.
Can increase travel speed, load size, and productivity and decrease fuel consumption on wet sites.
Can decrease operational site impacts on most sites.
Tire tracks can be installed on bald, worn-out tires to improve traction and extend life.

Disadvantages:

May not be needed on every site, necessitating tire or track changes.
Loss of maneuverability and turning radius.
Extended machine width may reduce ability to move through standing timber, gates, or bridges.
Special oversize permits may be needed when transporting machinery equipped with wide tires.
Extended and/or heavy-duty axles and a heavy-duty transmission required, increasing costs.
Increased machine wear.
Operators may build bigger, heavier loads, negating the environmental benefits.
Operators may traverse soils they normally wouldn't, negating the environmental benefits.

Source(s):

Commercial vendors only.

Recommended supplemental material:

None.

Approximate purchase price:

High. Wide tires may cost more than $4,000 each. Tire tracks may cost about $7,000 for a set of two tracks.

Construction directions and/or diagram and time required:
Not applicable.

Equipment needed for construction, installation, and/or removal:
Not applicable.

Installation approach and time:
Not applicable.

Patent protection of product design:
Yes.

Equipment with Tracks

Description of option:

Tracked machines travel on steel or rubber tracks instead of tires, providing a larger area of contact between the equipment and the soil. This spreads the machine and load weight over this larger surface area, lowering static ground pressure and increasing flotation.

Area of application:

Many wetland soils. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support to the equipment.

Advantages:

Reduces the need to construct temporary crossings.
Allows movement off of designated trails.
Extends seasonal access into wet areas.
Can decrease operational site impacts on most sites.

Disadvantages:

Tracks may require frequent cleaning and maintenance.
Tracked machines are generally slower than those with wheels.
Operators may build bigger, heavier loads, negating the environmental benefits.
Operators may traverse soils they normally wouldn't, negating the environmental benefits.

Source(s):

Commercial vendors only.

Recommended supplemental material:

None.

Approximate purchase price:

Normally higher than rubber-tired equipment.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Not applicable.

Installation approach and time:

Not applicable.

Patent protection of product design:

Yes.

Lightweight Equipment

Description of option:

Lightweight equipment achieves lower ground pressure by reducing the weight of the machinery. In many cases, there is little change in contact area with the soil surface as compared to traditional-sized equipment.

Area of application:

Many wetland soils. Performance is enhanced in areas where there is an adequate root or slash mat to provide additional support to the equipment.

Advantages:

Reduces need to construct temporary crossings.
Allows movement off of designated trails.
Extends seasonal access into wet areas.
Can decrease operational site impacts on most sites.
Smaller size (width) increases the machine's ability to maneuver in thinnings without damaging residual trees.

Disadvantages:

Reduced load capacity and overall productivity.

Source(s):

Commercial vendors only.

Recommended supplemental material:

None.

Approximate purchase price:

High.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Not applicable.

Installation approach and time:

Not applicable.

Patent protection of product design:

Yes.

Equipment with Central Tire Inflation

Description of option:

Central tire inflation technology is a low ground pressure option currently for use on hauling vehicles only, but will likely be available on other equipment in the future. It allows an operator to automatically and uniformly vary the inflation pressure of the tires while the vehicle is moving. The reduced tire pressure, when used with radial ply tires, results in a longer tire "footprint," which reduces the vehicle pressures applied to the ground.

Area of application:

Trucks used for hauling across many wet mineral soils.

Advantages:

Can adjust vehicle flotation when road surface strength changes.
Reduces quality of road needed for hauling, thereby reducing road construction costs.
Increased tire traction, making it possible to operate on steeper grades without assistance.
Reduced tire wear (as much as 90 percent) and increased tire life.
Reduced truck maintenance (fewer vibration-related and frame repairs).
Reduced amount of road maintenance required.
Reduced sediment runoff from unpaved roads, due to reduced rutting and surface damage.

Disadvantages:

Cannot be installed by operator.
Change in inflation pressure is not immediate.
Potential for additional tire wear if operator fails to adjust tire pressure for existing road conditions.

Source(s):

Commercial vendors only.

Recommended supplemental material:

None.

Approximate purchase price:

The cost to retrofit a vehicle depends on the number of axles that are to be retrofitted. For an 18-wheel log truck with a three-zone system, the cost will probably exceed $16,000.

Construction directions and/or diagram and time required:

Not applicable.

Equipment needed for construction, installation, and/or removal:

Not applicable.

Installation approach and time:

Not applicable.

Patent protection of product design:

Yes.

Printed on recyclable paper.

Blinn, Charles R.; Dahlman, Rick; Hislop, Lola; Thompson, Michael A. 1998. **Temporary stream and wetland crossing options for forest management**. Gen. Tech. Rep. NC-202. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 125 p.

Discusses temporary options for crossing streams and wetland soils with forest harvesting and transportation equipment. Reviews the available literature on the environmental effects of temporary crossings. Provides an overview of regulations pertaining to temporary crossings for several jurisdictions in the Great Lakes Region.

KEY WORDS: Forest access structures, harvesting, transportation, environmental effects, regulations.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.