Part 3 -- Stream Crossings

Helpful Hints:

BMPs for the four most common types of stream crossings are provided:
- *Bridgemats*
- *Culverts*
- *Fords*
- *Pole Crossings*

Stream crossings are often necessary for roads, skid trails and firelines to gain access to forestland for management. Permanent crossings usually are for roads, or in some cases, firebreaks. Temporary crossings are most common for timber harvesting or other short-duration forestry operations, such as site prep, tree planting, fertilization or herbicide application.

Because of the obvious potential for water quality impacts at stream crossings, there are several rules that require practices be used or actions taken. Since the North Carolina FPGs were enacted in 1990, stream crossings have been the most frequent location on a job site where sediment may get into the water.

Rules Related to Stream Crossings

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Forest Practices Guidelines Related to Water Quality (FPGs)

North Carolina General Statute 77-13 and General Statute 77-14

DWR riverbasin and watershed 'Riparian Buffer Rules'
These 'buffer rules' for specific river basins and watersheds set limitations on stream crossings within the 50-foot buffer zone

North Carolina Dredge and Fill Law
This state law requires that permits be secured for discharges of dredged or fill material in certain locations within the 20 Coastal Area Management Act (CAMA) counties. Refer to Chapter 6 for more information on this law.

Planning Stream Crossings

Stream crossings should be carefully planned in advance of their need to determine how water quality can be best protected. This section provides suggested BMPs when planning crossings.

BMPs for Planning Stream Crossings

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- Avoid having stream crossings if possible. Take note of the FPGs.

- Use maps, photos and/or on the ground examinations to determine the minimum number of crossings needed to efficiently access the property while protecting water quality.

Helpful Hints:

Recommendations on stream crossings are available from:
- *Consulting Foresters*
- *N.C. Forest Service*
- *Soil & Water Conservation Districts*
- *USDA-Natural Resources Conservation Service (NRCS)*

- Designate the location of the proposed stream crossing on the ground to avoid confusion about where to construct the crossing.

- When conditions allow, give preference to locations for crossings where:
  -- The stream is relatively straight so crossing distance is minimized.
  -- Approaches to the stream are relatively flat to better control runoff.
  -- The crossing can be installed at a right-angle (90°) to the stream channel so crossing distance is minimized.

- Select the type of stream crossing(s) based on site characteristics and the ability to best protect water quality while providing safe, efficient access.
- Maintain as close to normal (pre-construction) streamflow by maintaining depth, width, gradient and capacity of the stream channel at the crossing.
- Perform construction, installation, and removal work during low-water flow if circumstances allow.
- Stabilize the approachways and/or stream crossing locations so sediment is not transported into the stream as prescribed in the FPGs.

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Caption:
The BMPs noted here:
- Properly sized culvert.

- Culvert installed to handle low flow stream conditions.

- Sloped road fill, reinforced with a side support log/timber.

- Ample fill material over the culvert.

- Headwall reinforced with large rock.

Figure 5Q: A permanent stream crossing on a forest road

A Note on Permanent Bridges:

Permanent bridges require professional engineering expertise. Specifications are beyond the scope of this Manual. Some generic BMPs to consider:

- *Use bridges on deep, wide streams with heavy streamflows.*
- *Minimize soil disturbance during construction.*
- *Avoid placing a bridge in the curve of a stream or road.*

Bridgemats

Bridgemats are heavy wood or steel panels placed over a stream or ditch channel, usually for temporary crossing. Other names include dragline mats, skidder bridges or pontoons. When bridgemats are carefully installed, used, and removed, they typically do a very good job of protecting water quality.

BMPs for Bridgemats

- When site conditions allow, select a stream crossing location that has these characteristics:
  -- Narrow channel width.
  -- Firm, stable streambanks.
  -- Solid footing on either side to support bridgemats and equipment.
  -- High, level ground on each side.
- Create a solid-surface crossing that provides a barrier over the channel to minimize debris, soil, and other materials from falling into the water.
- Keep equipment out of the channel during installation and removal of the crossing unless doing so is necessary for handling the bridgemats.

A Note on Log Bridges:

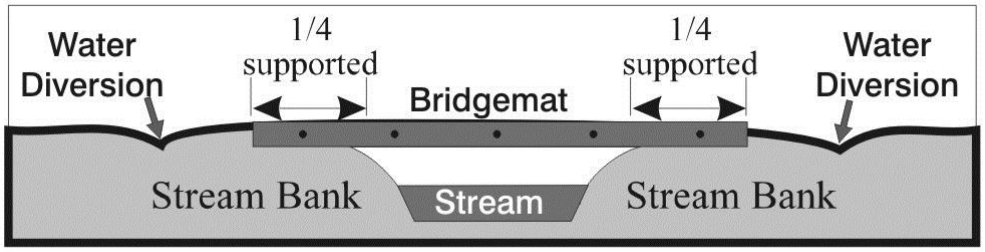
Temporary crossings constructed of de-limbed logs may be suitable in certain cases.

A log bridge is not the same as a 'pole crossing', which is explained later in this Chapter. A log bridge should completely span the watercourse:

- *Avoid gouging or damaging stream channel with the logs as they are installed and removed.*
- *Keep logs butted tight to each other to minimize debris and soil from falling between.*
- *Keep equipment out of the stream when placing and removing logs.*

- Minimize the amount of over-hang from logs, trees, or trucks/trailers that may disturb the channel or approachways.
- Control runoff and/or capture sediment on the approachways. See Part 1 and Part 2 of this Chapter for possible options.
- As needed, periodically inspect the crossing and take action to provide for safety while protecting water quality from runoff, debris, soil, or other potential pollution factors.
- Stabilize the approachways and crossing location in accordance with **FPG .0203** and **.0209**.

Figure 5R: Schematic drawing of proper bridgemat installation



Bridgemat for Stream Crossing

Caption:
BMPs noted here include:

- Good support on each end of the bridgemat.

- Adequate clearance between the stream flow and bridgemat.

- Three panels are used to create full-width crossing, with no gaps.

Figure 5S: Side view of a wooden bridgemat skid trail crossing

Figure 5T: Steel bridgemat installed for a skid trail stream crossing

Caption:
BMPs noted here include:

- A full-width panel crossing is used, with no center gap that could allow debris to fall into the stream.

- A straight section of stream is used for the crossing location.

- The bridgemat ends are well supported to prevent damaging the stream banks.

Culverts

Culverts are typically used for forest road stream crossings but can also be used for skid trail crossings. While culverts are readily available and can be a relatively inexpensive method, a major disadvantage of culverts is that they require disturbance in the stream channel. That includes placing fill material in close proximity to the water.

For Forest Owners

Smaller diameter culverts (less than 15 inches) can get clogged or blocked too frequently and create potential water quality problems.

A single larger diameter culvert is usually better than multiple, smaller diameter culverts since the smaller culverts may be more prone to blockages.

The cross-sectional area of a culvert opening cannot simply be added together to determine multiple culvert needs. Two 24 inch diameter pipes DO NOT provide the same volume as one 48 inch diameter pipe.

BMPs for Culverts

- Use a culvert sized to meet your needs that can carry the expected amount of runoff and streamflow from the upstream watershed:
  -- Take into account the volume of heavy runoff that can result from precipitation and storms.

- Use a culvert long enough to extend at least 12 inches beyond the edge of the fill material:
  -- If a shorter culvert is required, then protection should be added to the inlet and outlet headwalls. Examples include rip-rap, stone, sandbags, drop-inlets, or other erosion-preventing material.

- For forestry stream crossings, it is recommended to use culverts that are at least 15 inches in diameter.

- For temporary culvert installation, refer to Table 5-3 as a quick-reference table of suggested culvert diameters.

- For permanent culvert installation, refer to Table 5-4 for recommendations of culvert diameters.

- If multiple culverts are used, provide adequate cross-sectional opening area of the culverts to handle the expected streamflow. Refer to Table 5-4 for suggested diameters of multiple culverts.

- Install the culvert crossing during low-flow periods in the stream, if possible.

- Place culvert approximately in the center of the existing or expected water flow within the channel.

Helpful Hints:

If a culvert is partially imbedded into the streambed, a larger diameter pipe may be needed to make up for this loss of open area within the pipe itself.

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Avoid backfill with debris or large rocks that could create air pockets within the backfill or damage the culvert.

Moist mineral soil usually works best.

- Set the culvert(s) with a downslope grade so streamflow is not impeded and to prevent debris from clogging the pipe.

- Minimize the height that water drops from the outlet of the culvert:
  -- For temporary installation, placing the culvert immediately upon the stream bottom is usually suitable.
  -- For permanent installation, it may be appropriate to place the culvert partially imbedded into the stream bottom to allow better passage of fish and other water-living organisms.

- Backfill over the culvert with at least 12 inches of suitable material. Culverts larger than 30 inches diameter should have backfill thickness equal to at least one-third of the culvert's diameter.

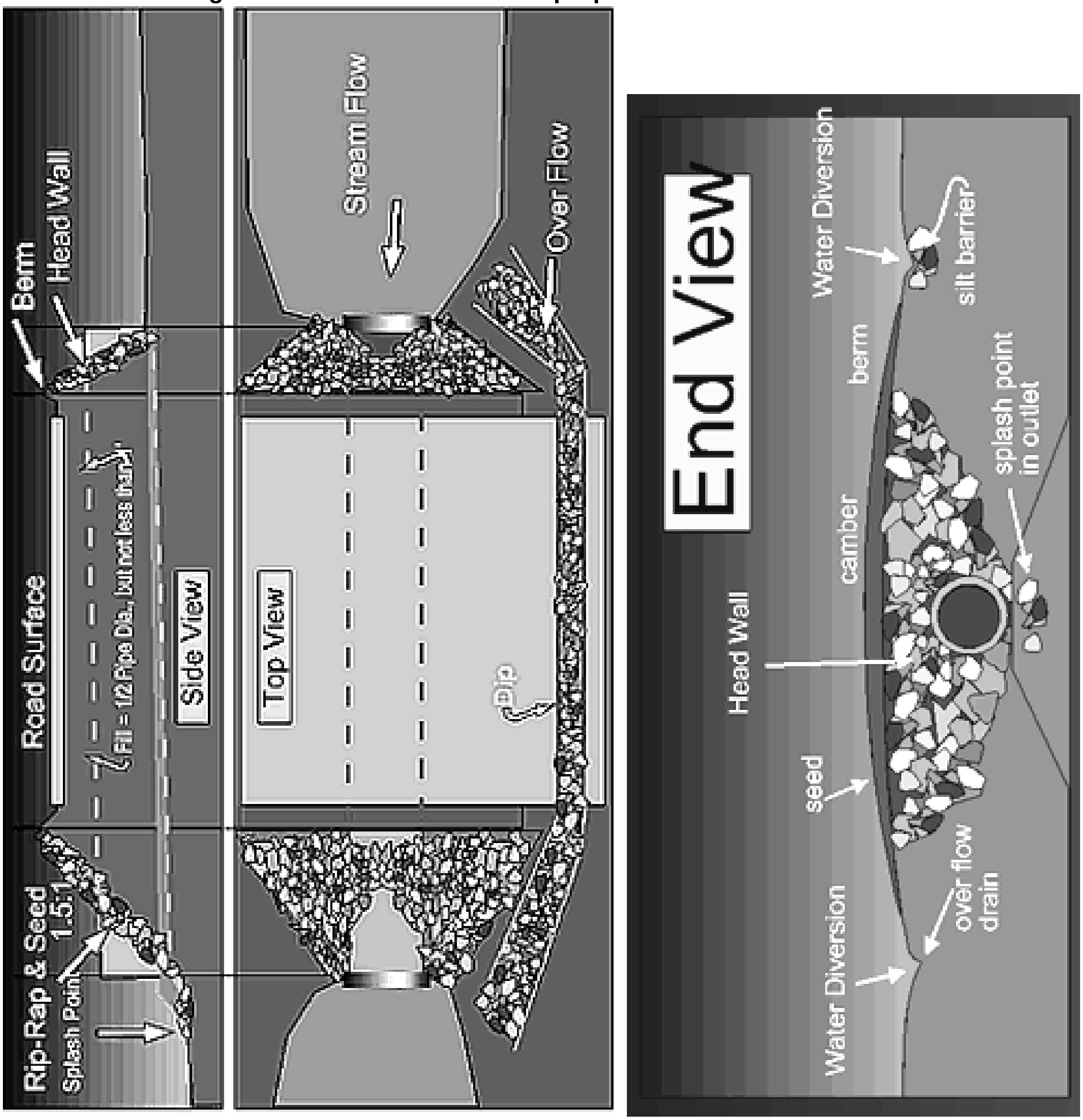
- Use backfill material that will pack down tightly. Secure the culvert in place and provide adequate support for vehicle traffic:
  -- Tamp down the backfill along the length of the culvert to block seepage that may flow around the culvert and wash it out.

- Protect the inlet and outlet of the culvert and the fill material to minimize erosion from the streamflow and runoff.

- Construct the crossing so it allows floodwaters to flow around the crossing location to minimize water backups and the potential of the culvert from being washed away (commonly called 'blowing out'):
  -- Elevating the backfill over the culvert and creating a very slight crown can help divert floodwaters around the crossing location.
  -- Creating a low depression area within the approachways can provide a flow-way for floodwaters to bypass around the crossing.

- Use surface hardening materials on the culvert crossing and approachways as needed to provide vehicle support and minimize erosion potential.

Figure 5U: Schematic views of proper culvert installation



Caption: *The top illustration (side view) shows proper culvert layout along the contour, with a slight downslope gradient to promote good streamflow and minimize back-ups or blockages.*	*The middle illustration (top view) shows the overflow dip that should be installed to allow floodwaters to flow around the culvert location and reduce the likelihood of the culvert blowing-out.*	*The bottom illustration (end view) shows how the road should be crowned over the culvert, with rock used to stabilize the inlet and outlets. Also note the water diversions on each approachway.*

Culvert Sizing Diameters for Temporary Installation

The information on this page can be used for temporary installations of round culvert. Table 5-3 is based upon streamflow that could normally be expected from a '1 to 3 year' interval storm-flow event.

You should consider the recommendations found in Table 5-3 for sizing culverts:

- **When needed for temporary access.**
- **During dry periods.**
- **On sites with low soil moisture.**
- **No precipitation has occurred or is forecast to occur while the crossing is needed.**

Table 5-3: Suggested Diameter Sizes of Round Culverts for Temporary Installations

Average Channel Width (inches)	***Average Channel Depth (inches)***						
	6	***12***	***18***	***24***	***30***	***36***	***42***
12	15	18	18	24	24	30	36
18	15	18	24	24	30	30	36
24	15	24	30	30	36	36	48
30	18	24	30	30	36	48	48
36	18	24	30	36	48	48	48
48	24	30	36	48	48	48	60

FIGURE 5V: Sketch of a stream channel cross-section for determining temporary culvert size

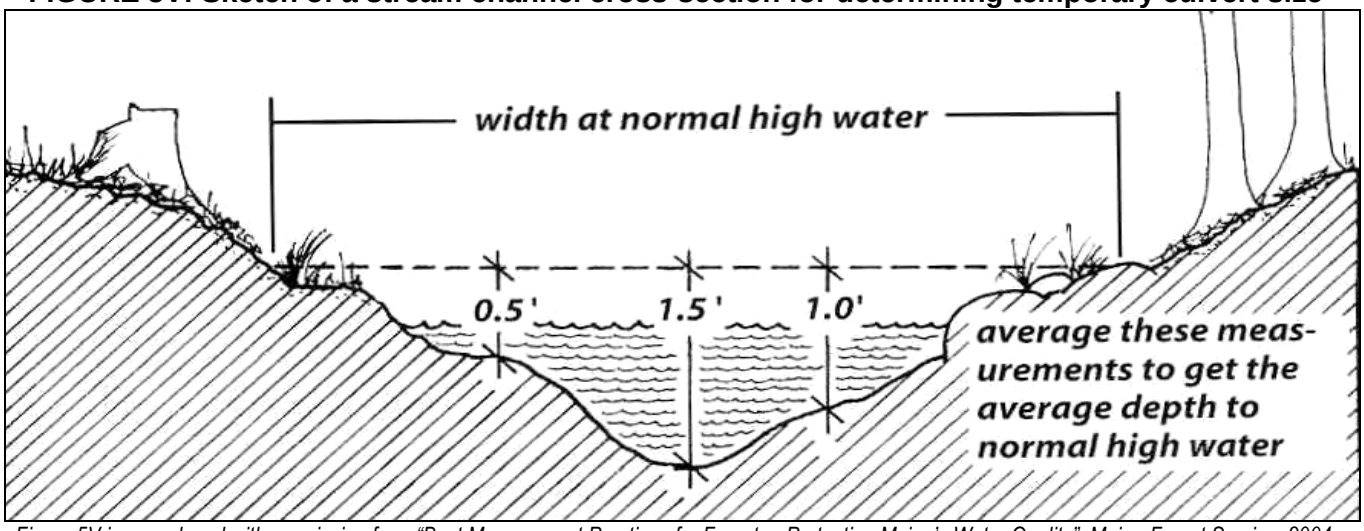


Figure 5V is reproduced with permission from "Best Management Practices for Forestry: Protecting Maine's Water Quality". Maine Forest Service, 2004.

Determining Average Channel Width for Table 5-3:

Measure how wide the channel is at the point of normal high water mark. Take several measurements and average them together to get the Average Channel Width for Table 5-3.

Determining Average Channel Depth for Table 5-3:

Measure how deep the channel is from the point of normal high water mark. Take several measurements and average them together to get the Average Channel Depth for Table 5-3.

NOTE: ***In each case, do not simply measure how deep the water is. Instead, you need to measure the average stream channel dimensions at the point of normal high water mark.***

Table 5-4: Suggested Diameter Sizes of Round Culverts for Permanent Installations

The recommended culvert sizes on Table 5-4 should be considered for crossings that are expected to be in place for more than one year. Table 5-4 is adapted from Talbot's formula for a 2.5-inches-per-hour rainfall. The complete Talbot's formula table is in Appendix 9 for further reference.

	Impervious 100% runoff	Steep slopes, heavy soils, moderate cover		Moderate slopes, heavy to light soils, dense cover		Gentle slopes, agricultural-type soils and cover		Flatland pervious soils
	The letter 'C ' indicates the amount of runoff to expect. High value C means more runoff and heavier streamflow volume Low value C means less runoff and lighter streamflow volume							
Acres	*C = 1.00 Bare soil*	*C = .80 Higher Runoff*	*C = .70 Lower Runoff*	*C = .60 Higher Runoff*	*C = .50 Lower Runoff*	*C = .40 Higher Runoff*	*C = .30 Lower Runoff*	*C = .20 Normal runoff*
2	15	15	15	15	15	15	15	15
4	18	18	15	15	15	15	15	15
6	24	18	18	18	15	15	15	15
8	24	24	18	18	18	15	15	15
10	30	24	24	24	18	18	15	15
20	36	30	30	30	24	18	18	18
30	42	36	36	30	30	24	18	18
40	48	42	36	36	30	30	24	24
50	48	42	42	36	36	30	24	24
60	36+36	48	42	42	36	36	30	24
70	30+30+30	48	48	42	42	36	30	24
80	36+36+24	30+30+30	48	48	42	36	30	30
90	48+48	36+36	48	48	42	42	36	30
100	48+48	36+36+24	30+30+30	48	48	42	36	30
150		48+48	36+36+36	36+36+24	30+30+30	48	42	36
200			48+48	36+36+36	36+36+36	30+30+30	48	36
250	**A Note About Multiple Culverts:**					36+36+36	48	42
300	It is recommended that if a crossing requires an opening					36+36+36	30+30+24	42
350	greater than 48 inches, that you use bridging, arch-culverts or multiple						30+30+30	48
400	round culverts. Some options for multiple culverts are offered in this table.						36+36+24	48
450	• There may be other combinations that can work.						36+36+30	48
500	• Consult with someone who has experience if you are unsure.						36+36+36	30+30+30

Caption:
This culvert installation exhibits these BMPs:
- Properly sized to accommodate stormflow.
- Situated at, or just below grade to allow low-flow conditions.
- Headwall stabilized with rock.
- Vegetation established on bare soil near the water's edge.

Figure 5W: Culvert installed on a forest road in Montgomery Co., N.C.

Fords

For Forest Owners:

When properly built and maintained, fords can provide efficient and inexpensive road access.

Fords are hardened-surface, low water crossings in which a vehicle drives directly through and across the stream channel. Places where a ford crossing may be appropriate include:

- A stream that has an existing rocky bottom surface.
- Streams that are too wide for bridgemats or multiple culverts.
- Areas prone to beaver activity that could dam-up a culvert crossing.

BMPs for Fords

Watch Out!

Because a vehicle drives directly in the water, fords are usually the least preferred method of crossing for protecting water quality.

- Minimize the grade slope of the approachways into the ford crossing. Control runoff and capture sediment along and/or from the approachways.

- When site conditions permit, give preference to crossing at a:
  -- Low streambank.
  -- Solid and level bottom.
  -- Straight section of stream channel.

FORDS ARE NOT RECOMMENDED for use on skid trail crossings.

- If the stream bottom is soft and unstable, consider laying down geotextiles as underlayment for the added rock or hardening material.

- Use clean hardening materials to create a firm vehicle traffic surface. Avoid using asphalt-based materials.

DO NOT BLOCK the natural flow of water in the stream channel.

- Spread the material as even as possible across the channel to avoid dips or humps that could alter the streamflow:
  -- Leave a low trough within the centerline of the channel so streamflow can continue during low-flow or dry periods.

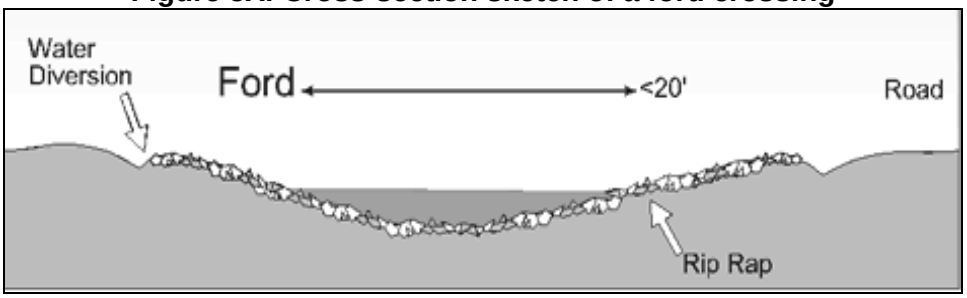
- Within the first 50 feet of the ford crossing, establish permanent groundcover covering at least 80 percent of the approachway area, or spread stone (or other suitable materials) atop each approachway.

Safety 1st - - -
Never drive through a ford during high water or rapid currents.

- When driving through the ford, you may need to:
  -- Maintain a slow speed to avoid damaging the crossing location.
  -- Stagger the tire-tracks through the ford to minimize creation of tire ruts.

- Inspect the crossing to insure safe usage, proper water flow, and water quality protection. Take action as needed to protect water quality.

Figure 5X: Cross-section sketch of a ford crossing



Caption:
This sketch drawing of a ford includes:
- Water diversions.

- Short fording distance.

- Hardened stream bottom.

Figure 5Y: A ford crossing in Henderson County, N.C.

Caption:
Note the BMPs on this ford crossing:

- Gentle grade on the approachways so runoff can be controlled.

- Substantial stone is used to stabilize the road approachway and provide a firm base.

- A shallow trough is left within the centerline of the stream channel to allow continued stream flow during low-flow periods.

Pole Crossings

Pole crossing is the name used to describe a temporary channel crossing that is made by stacking logs that are free of limbs and soil within the channel high enough so equipment can travel across.

Pole crossings are usually appropriate for temporary access across ditches or ephemeral drainages.

Pole crossings are not suitable for either an intermittent stream that has water, or for any perennial stream.

FPG

Read and understand the requirements of FPG .0202, FPG .0203, N.C. GS 77-13 and N.C. GS 77-14.

Helpful Hints:

To provide water flow, one possible option is to place one or more culverts on the base of the channel so water can still flow through.

BMPs for Pole Crossings

- Establish the pole crossing in a way that:
  -- Allows water to flow through the crossing location.
  -- Does not contribute to accelerated erosion, runoff or sediment transport.
  -- Protects the integrity of the channel's structure.
- Use only topped and de-limbed logs that are free of soil and excess debris.
- Use logs of a large enough diameter so they do not pack too tightly together. Logs of 'pulpwood' size or larger usually work best.
- Do not place soil within or on top of the pole crossing.
- Build up the pole crossing to an elevation higher than the adjacent channel or bank. That way, when the logs settle, the channel is still protected.
- Pack down limbs, tops, slash, or other woody material atop the approachways to the pole crossing to protect the channel structure.