

Field Work

Few people use striped ribbon, so consider using it to mark the preliminary route. Carry at least two different combinations of colors (red and white stripes and orange and black stripes or other combinations) (figure 9).

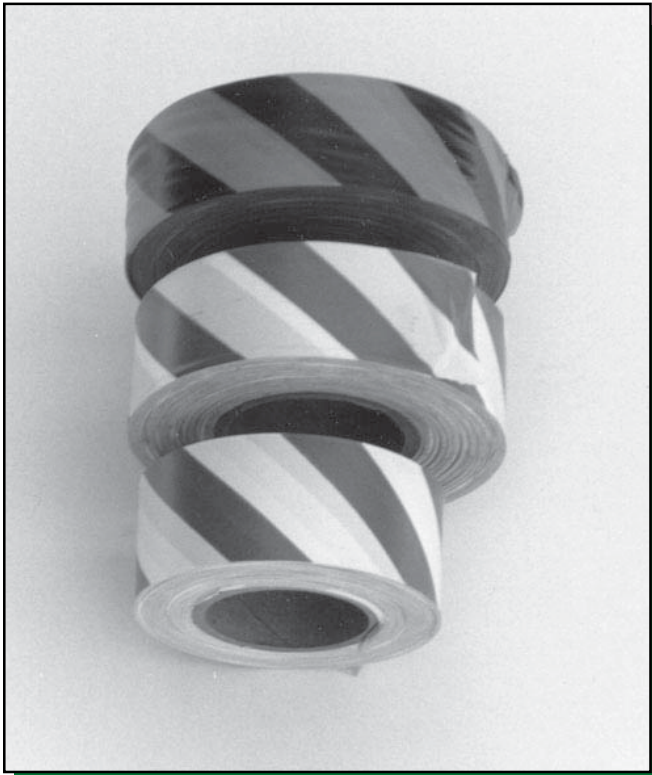


Figure 9—Vinyl flagging ribbon comes in many colors. Striped ribbon is good for marking the preliminary route.

If a portion of the route has to be changed, use the second color of ribbon. Do not tear down the ribbon for the first route that appears to be undesirable; it may prove to be better than the alternative route. Tie the new color of ribbon next to the piece of the first color where you want to depart from the first route. The outcome will be a preliminary route or P-line.

Coordination

The layout of an interpretive wetland trail should be a collaborative effort between people experienced in trail construction and those who will be responsible for the interpretation of the completed trail. All parties need to be brought in at the planning and layout stage. The interpretive staff is in the best position to identify interpretive points.

Part 2 of 8

On an interpretive trail, the interpretive points will be among the control points. Routing any trail through all possible control points would result in a long, zigzag trail that would be expensive to build and would look ridiculous. Usually there must be a compromise between alignment, the length of the trail, construction cost, maintenance problems, and the number of esthetic and interpretive control points along the route. One 600-foot length of trail was built near a beaver dam for its interpretive value. Soon, that length of trail was under almost 2 feet of water and had to be rerouted. That location turned out to be a poor compromise.

After agreement on the P-line, the various compliance specialists should be contacted and, if necessary, brought in to walk the route. These may include specialists from your own agency, perhaps others from the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service, and cultural resource specialists such as historians and archeologists.

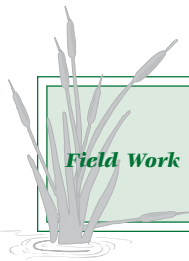
Blue Line

It helps to go back over the P-line and refine it with an eye toward reducing construction problems, views of the trail by other trail users, and views of constructed structures from the trail. Refine the alignment to avoid sharp turns and long straight sections.

Blue ribbon is often a good choice for this more precise line. Blue has proven to be the most visible color in areas of dense vegetation. Spending time flagging the blue line will make the final layout work easier and faster. In some agencies, specific colors of ribbon denote specific purposes. Be sure your blue flagged line isn't going to be confused with a logging unit boundary, for example. Sometimes, because of vandalism and removal of the ribbon, the proposed route should not be too obvious. Solid green or black-and-yellow striped ribbon are usually the most difficult to see against vegetation and less likely to be removed. Sometimes cattle and wildlife chew on the ends of the ribbon. You may be able to locate the flag line by looking for the remaining knots of ribbon.

Final Layout

The designer and one or two assistants measure the route and keep notes (appendix A) on distances and locations and on the lengths of items that will be needed during construction. This information is extremely important for preparing accurate cost estimates, ordering materials, tools and equipment, and determining the size of the construction crew.



Field Work

Distances are usually recorded by station, an engineering measuring system used for roads, railroads, and utility lines. Traditionally, in this system 100 feet is written as 1+00; 1,254 feet is 12+54. The distances are measured with either a 100-foot or 50-foot measuring tape and are “slope measured” (measured along the slope). Wire flags are marked with the station distance and stuck in the ground at the approximate location that has been measured. In the Forest Service, the measurements are metric, with 100 meters written as 1+00; 1,254 meters as 12+54.

The trail grade (the slope of the trail route) is measured on the ground between stations and between obvious changes in slope. At most sites a clinometer or Abney hand level is sufficiently accurate for this work. Precision is not as critical for a trail as it is for a road.

Measure the slope as a percentage of grade (the vertical rise or fall in feet per 100 feet of horizontal distance, or meters per 100 meters of horizontal distance) and record it in the notes. Where the route rises, it is shown as a positive or plus grade. Where the route drops, it is a negative or minus grade. Appendix B has slope conversion information.

A crew of three is more efficient than a crew of two for doing final layout. A crew of three is almost essential in areas of dense vegetation.

The field notes can be kept on Rite-in-the-Rain waterproof paper and stored in a 4- by 6-inch ring binder (figure 10). A blank form that you can copy is included in appendix A.



Figure 10—This field notebook is a tried and true technology that works.

The form shown (figure 11) is 4¼- by 5½-inches or a half sheet of paper. After the workday, remove the notes from the ring binder and leave them in the office or at camp. Normal surveyors' notebooks are awkward for trail field notes—they keep trying to close up and they are difficult to copy.

The field notes should include important basic information: location, project, date, weather, first and last names of the crewmembers, job assignments, color of the flagging ribbons, and the location of the 0+00 station referenced to fixed objects on the ground. Clear and consistent handwriting and language skills are important. Standard abbreviations should be used and the abbreviations must be explained to others on the crew. Provide a legend for unusual abbreviations. Sketches and maps are also valuable sources of information. Eventually, the field notes will get to the office where someone else may have to interpret them.

What a waste of time it would be to go through all this work and end up with notes that are unusable. Paper is inexpensive compared to the time required to gather this information. Do not write notes too close to each other. When you make an error, put a single line through the mistake. Do not try to write over or erase it. Go to the next line and write in the correct information.

It is critically important to note the colors of ribbon that you used. Trail construction workers will need to know the color of ribbon they will be looking for. Six months after the field layout, even the workers who laid out the trail will not remember what colors were used.

Drawings, Specifications, and Cost Estimates

Regardless of who builds the trail, the field notes must be converted to drawings and specifications that can be used in the office for estimating costs and ordering materials, and in the field for construction.



Field Work

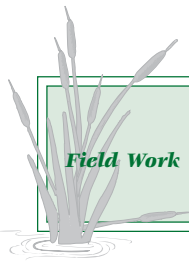
Station & distance	Tread width	Sideslope (percent)	Gradient (percent)	Notes
				Pingree Park—Accessible wetland trail.
				9/10/97—Sunny, warm.
				Bob Pilk, Terri Urbanowski, Bob Steinholtz. Red ribbon/red flags.
				0+00-35' east of flag pole/north curb.
0+00				
	4'	25	5	
0+50				
	4'	30	5	
0+75				Enter willow brush
	4'	30	5	Heavy brush clearing
1+00				
		35	5	
1+76				Intersection with wetland
		10	4	loop—rt (south route) end willow brush clearing.
1+81				Begin bog bridge/piles
		0	4	
2+04				End piles, begin B.B. on
		0	-2	sleepers

Figure 11—Sample field notes are legible and have the information needed to locate the trail and plan for materials.



Station & distance	Tread width	Sideslope (percent)	Gradient (percent)	Notes
2+38				End B.B./begin turnpike.
		0	+2	
2+74				End turnpike/begin B.B. on
		0	+2	sleepers—medium willow
				brush clearing.
3+06				
		±10	0	Hummocky/begin B.B. with
				cribbing, some cribbing one
				side only.
3+58				Timber culvert: 8' span by
	4'	0	0	4' height
3+66				
		0	0	
3+86				River on rt. Suggest 20 lf
		10	-1	of Geoweb in turnpike.
4+19				End turnpike. Begin trail on
	4'	0	+2	solid ground.
4+97				Sta. 4+97 = 1+76

Figure 11—(continued).



Field Work

The drawings should include the approximate layout of the route, indicating landmarks and major items of construction. A second drawing at a larger scale should indicate by station or distance where these items begin and end. These distances are subject to field adjustment. Several large-scale drawings may be needed to show the whole trail route.

Drawings with construction details will also be needed for cost estimates and construction. These large-scale drawings show the construction materials, their dimensions, how they are put together, and how they are attached.

A specification defining the quality of the materials and craftsmanship must also be written. For a simple project, this information can be included on the drawings. The specification is also needed by the cost estimator, the individual ordering the materials, the crew chief, and the project inspector.

Preparing drawings and a specification may sound like a lot of work, but preparation reduces the questions of the construction crew and the time spent by the designer in the field during construction. Such work also reduces the possibility that the wrong materials could be delivered to the work site. Written drawings and specifications are essential for contracts. Forest Service employees should follow the format of *Standard Specifications for Construction and Maintenance of Trails* (1996) and *Standard Drawings for Construction and Maintenance of Trails* (1997).

If the work is to be done in-house with an experienced crew, sometimes the procedures can be simplified. It is still a good idea to have drawings and written specifications, because they can prevent misunderstandings.





Wetland Trail Structures

At least eight types of trail structures are commonly built in wetlands. Some of these are built with no foundation. Others have sleepers (sills), cribbing, or piles as foundations. Most of these structures are built of wood.

The oldest methods for building a wetland trail were corduroy and turnpike, which require no foundation. Turnpike may require constructing timber culverts, which involves building two small timber walls. The walls must rest on a buried timber sill. Planks span the space between the walls.

The various types of puncheon, gadbury, and the simplest form of bog bridge construction may be built on a foundation of sleepers, or on log or timber cribbing. Cribbing is more difficult to construct and is used occasionally where the terrain is hummocky (having small mounds of vegetation interspersed with depressions that hold water).

Bog bridges and boardwalks are often supported on pile foundations. Three types of pile foundations have been used for bog bridges and boardwalks: end-bearing piles, friction piles, and helical piles. Piles are the most labor-intensive foundation. Helical piles and some friction piles require specialized machinery for installation.

Floating trails are another, less common, technique. Where they are used, you need some form of anchorage.

In this manual we describe the structures more or less in historical order. The oldest are early in the list, and the newest or most difficult to construct appear toward the end. The older techniques can be done without machines, although machines make the work go faster. The newer techniques are almost impossible to build without machines.

Sustainable Design

Sustainable design essentially asks the trail designer or builder:

- ➔ Can we use the proposed construction technique and expect the materials and the various processes to be available years from now if we need to replace part of the trail?
- ➔ When the item is no longer usable, can any of the materials be recycled?

- ➔ Can recycled materials be used in the construction?
- ➔ Are recycled materials appropriate for the proposed use?

These criteria should be considered by all agencies, especially conservation agencies.

Corduroy

Corduroy was originally used to provide access through wetlands to areas being logged or mined. Essentially, the technique involved laying a bridge on the ground where the soil would not support a road. Two log stringers or beams were placed on the ground about 8 feet apart. Small-diameter logs or half logs were placed on the stringers, spanning them. The logs became the tread or surface of the road. They were spiked or pinned to the stringers (figure 12).

A variation of corduroy construction was to place the tread logs directly on the ground. No stringers were used, and the logs were not pinned or spiked to the ground or each other. Some excavation was required to ensure the tread logs were level. The tread logs eventually heaved up or sank, creating severe cross slopes in the tread.

Corduroy construction was often used in areas with deep shade and considerable rainfall. The combination of sloping, wet tread resulted in a slippery, hazardous surface. The stringers and tread logs soon rotted. With no support, the cross slope on the tread logs became worse and more hazardous.

When corduroy was laid directly on the ground, it interfered with the normal flow of runoff. Runoff was blocked in some areas and concentrated elsewhere. Erosion and relocation of minor streams resulted. No plants grew underneath the corduroy, further damaging the wetland resource. Many trees needed to be cut to provide the logs for the corduroy. In many cases, these impacts would be unacceptable today. The useful life of corduroy today is only 7 to 10 years. Corduroy is rarely replaced because suitable trees are even farther from where they are needed for the reconstruction job.

Corduroy did not represent sustainable design and required considerable maintenance. Corduroy is rarely used today. We do not recommend it.



Wetland Trail Structures

Corduroy

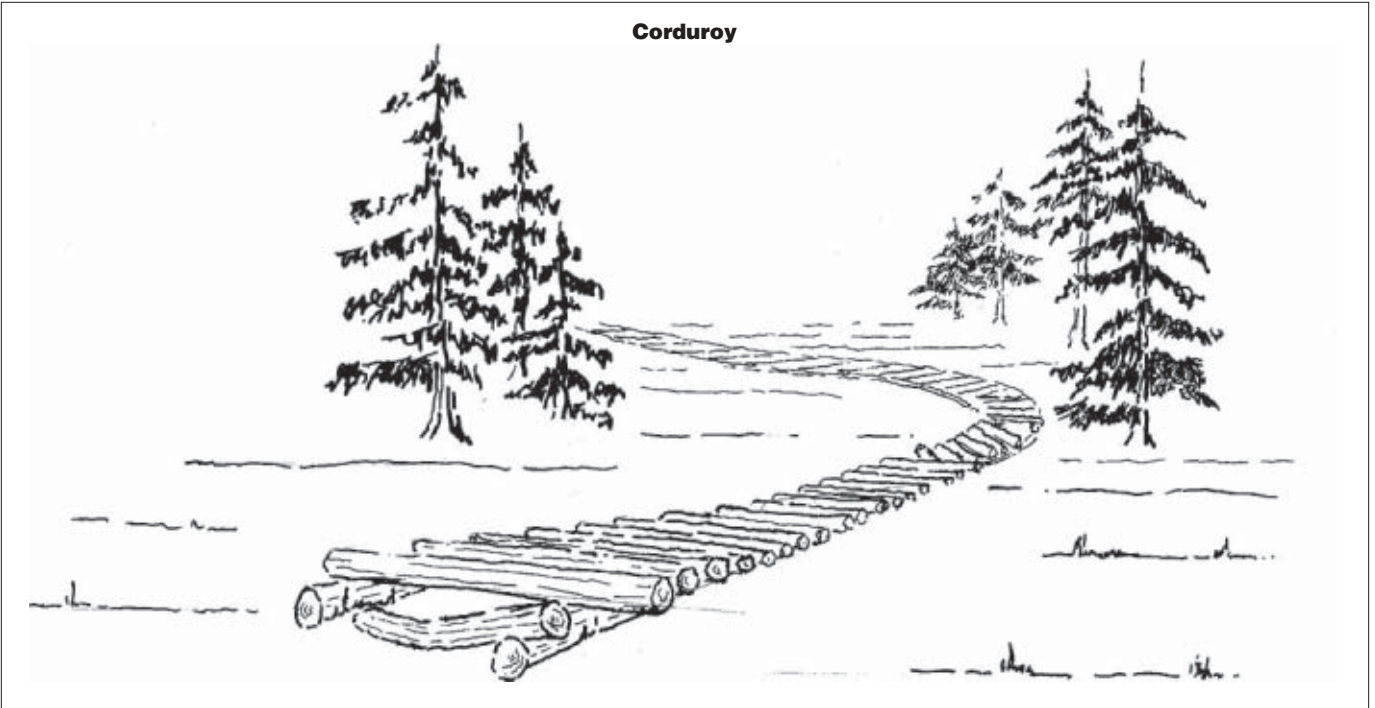


Figure 12—Corduroy requires a lot of native material, rots quickly to an unsafe condition, and is no longer recommended for new construction.

Turnpikes

Turnpikes are used to elevate the trail above wet ground. The technique uses fill material from parallel side ditches and other areas to build the trail base higher than the surrounding water table. Turnpike construction is used to provide a stable trail base in areas with a high water table and fair- to well-drained soils (figure 13).

A turnpike should be used primarily in flat areas of wet or boggy ground with a 0- to 20-percent sideslope. The most important consideration is to lower the water level below the trail base and to carry the water under and away from the trail at frequent intervals. Turnpikes require some degree of drainage. When the ground is so wet that grading work cannot be accomplished and drainage is not possible, use puncheon or some other technique. A turnpike is easier and cheaper to build than puncheon and may last longer. A causeway is another alternative where groundwater saturation is not a problem and a hardened tread is needed.

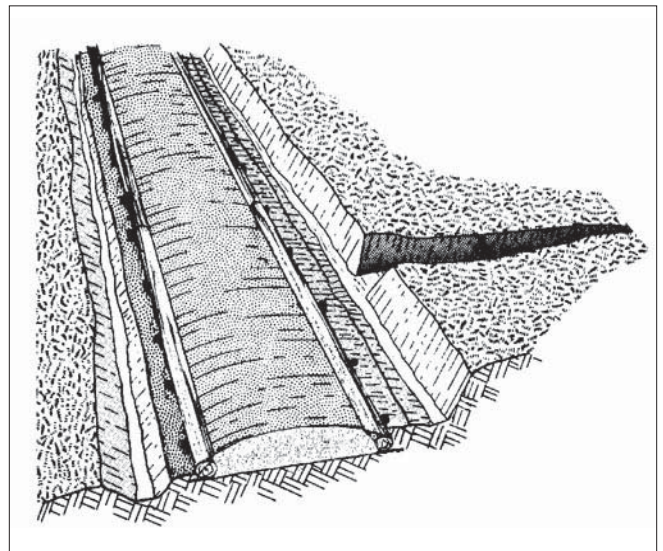


Figure 13—Trail turnpikes usually cost less than other techniques for crossing seasonally wet areas. Occasional culverts are needed for cross drainage under the turnpike.



Wetland Trail Structures

Begin the turnpike by clearing a site wide enough for the trail tread and a ditch and retainer log or rocks on either side of the trail tread. Rocks, stumps, and roots that would protrude above the turnpike tread or rip geotextiles should be removed or at least cut flush below the final base grade.

Ditch both sides of the trail to lower the water table. Install geotextile or other geosynthetic materials and retainer rocks or logs. Geotextile and geogrid should go under any retainer rocks or logs (figure 14). Lay the geotextile over the ground surface with no excavation, then apply high-quality fill. An alternative method, one that not only provides separation between good fill and clay, but also keeps a layer of soil drier than the muck beneath, is called encapsulation (the sausage technique). Excavate 10 to 12 inches of muck from the middle of the turnpike. Lay a roll of geotextile the length of the turnpike, wide enough to fold back over the top with a 1-foot overlap (figure 15). Place 6 inches of crushed stone, gravel, or broken stone on top of the single layer of geotextile, then fold the geotextile back over the top and continue to fill with tread material.

Rocks or logs can be used for retainers. Rocks last longer. If you use logs, they should be at least 6 inches in diameter, peeled, and preferably treated or naturally rot resistant. Lay retainer logs in a continuous row along each edge of the trail tread.

Anchor the logs with stakes or, better yet, with large rocks along the outside. The fill and trail surface keep the retainer logs from rolling to the inside.

The practices described above work best on turnpikes in mountain bogs or other areas that are not subject to periodic river flooding. In flood-prone wetlands, different techniques work better. One turnpike was flooded to a depth of 6 to 8 feet on two occasions in 1 month. Stones up to 1 cubic foot in an adjacent area of riprap were lost in the flood. The edges of that turnpike were logs pinned to the ground with diagonally driven drift pins that helped to keep the logs from floating up and away. The logs were still in place after the flood, but the fill material between the logs had been swept away. Geotextile fabric that had been installed between the fill and the ground was still in place. In retrospect, if geoweb or geogrid had been placed on the geotextile fabric and stapled, nailed, or placed underneath the logs, most of the fill material would probably have remained in place (figure 16).

Wood used in turnpike construction should be either a naturally rot-resistant species or treated poles. Pinned as described, the logs or poles should survive some floods.

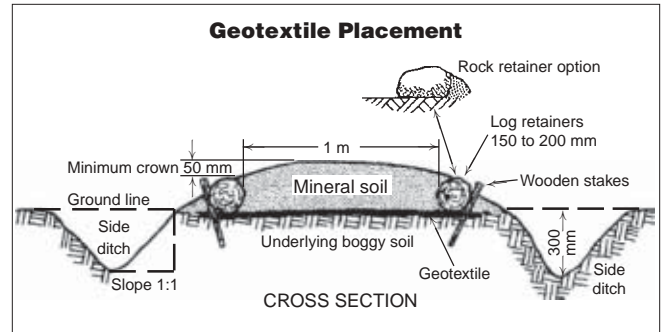


Figure 14—Place the geotextile under the retainer logs or rocks before staking it.

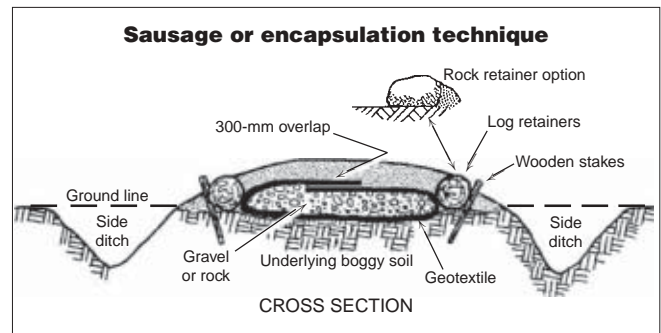


Figure 15—Sausage or encapsulation method.

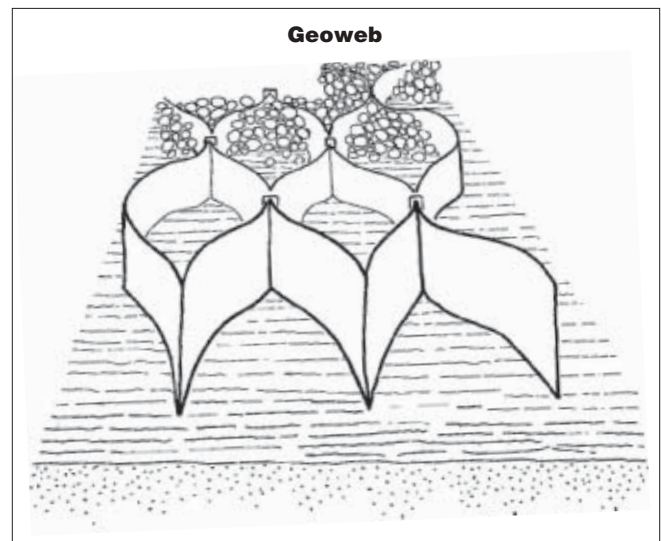


Figure 16—Geoweb may help keep fill in place in areas prone to flooding.



Wetland Trail Structures

Firm mineral soil, coarse-grained soils or granular material, or small, well-graded angular rock are needed for fill. Often, gravel or other well-drained material must be hauled in to surface the trail tread. If good soil is excavated from the ditch, it can be used as fill. Fill the trail until the crown of the trail tread is 2 inches or a minimum of 2 percent grade above the retainer. It doesn't hurt to overfill initially, because the fill will settle (figure 17). Compacting the fill with a vibratory plate compactor will help reduce settling.



Figure 17—A new turnpike will need additional fill as it settles, especially during the first year. This turnpike has a timber culvert.

Fill material imported from outside sources may contain seeds of invasive weeds. Instead, it is standard procedure to dig a borrow pit near the site. The pit and routes to it should be carefully located to avoid resource damage and a construction scar that will be seen for many years. The borrow pit should be dug into a slope so that the floor of the pit can slope out and carry runoff water out of the pit. After the trail has been completed, grade back the sides of the pit and revegetate the disturbed area with native plant material.

Keep water from flowing onto the turnpike by constructing a dip, waterbar, or a drainage structure at each end of the turnpike where necessary. Keep the approaches as straight as possible coming onto a turnpike, to minimize the chance that packstock or motorbike users will cut the corners and end up in the ditches.

Turnpike maintenance, especially recrowning, is particularly important the year after construction; the soil settles the most during the first year.

Causeways

A more environmentally friendly relative of the turnpike is the causeway, essentially a turnpike without side ditches (figure 18). Causeways filled with broken rock have been successfully used throughout the Sierra Nevada and elsewhere to create an elevated, hardened tread across seasonally wet alpine meadows. Often, multiple parallel paths are restored and replaced with a single causeway. Causeways create less environmental impact than turnpikes because they do not require ditches that lower the water table. In highly saturated soils the causeway could sink into the ground, a problem that geotextiles can help prevent.

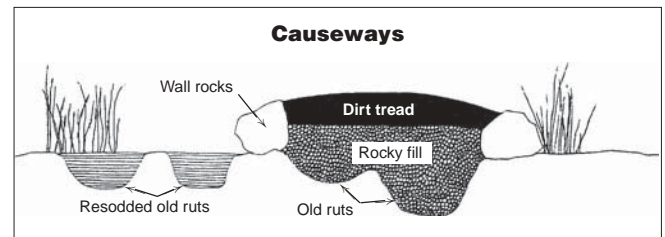


Figure 18—Causeways create an elevated, hardened tread across seasonally wet areas.

Improving Drainage Dips or Ditches

Turnpikes and causeways interrupt the flow of water along and across the trail. You need to take measures to ensure that water flows away from turnpikes instead of saturating them. The tools to ensure that water flows away from turnpikes include: dips (or ditches), open drains, French drains or underdrains, and culverts.



Wetland Trail Structures

Generally, dips are at least 12 inches deep, have flat bottoms, and sideslope ratios of 1:1. In many cases, the dip can be extended beyond the wet area to capture water that might flow onto the trail.

The simplest way to get water across a trail is to cut a trench across it. These open-top cross drains, or dips, can be reinforced with rocks or treated timbers to prevent cave-ins. These structures are not usually a good alternative because people and packstock stumble on them. One way to reduce this risk is to make the dip wide enough (at least 2 feet) so that packstock will step into the drain rather than over it (figure 19).

An open drain can be filled with gravel. Such a drain is called a French drain. Start with larger pieces of rock and gravel at the bottom, topping the drain off with smaller aggregate (figure 20). French drains are often used to drain a seep or spring underneath a trail bed. A perforated or slotted pipe in the bottom

of the drain reduces the amount of fill material needed and drains the area more effectively.

Culverts

Culverts provide better and safer drainage across turnpikes than open drainage gaps or ditches.

Historically, culverts were built as small bridges, using stone or logs. Stone culverts require large stones and a skilled mason. Finding large stones is difficult. Today, dry stone masonry is almost a lost art. Well-built stone culverts can be extremely durable. Some stone culverts that are at least 100 years old are still in use.

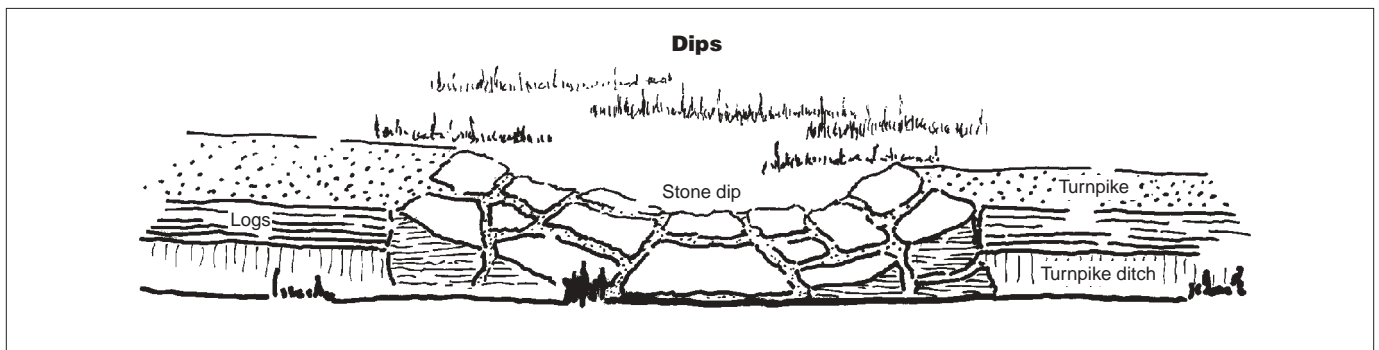


Figure 19—Dips and ditches are a simple and effective way to drain wet areas. The slope angle and depth vary with soil and water conditions. Stones help reinforce the dip.

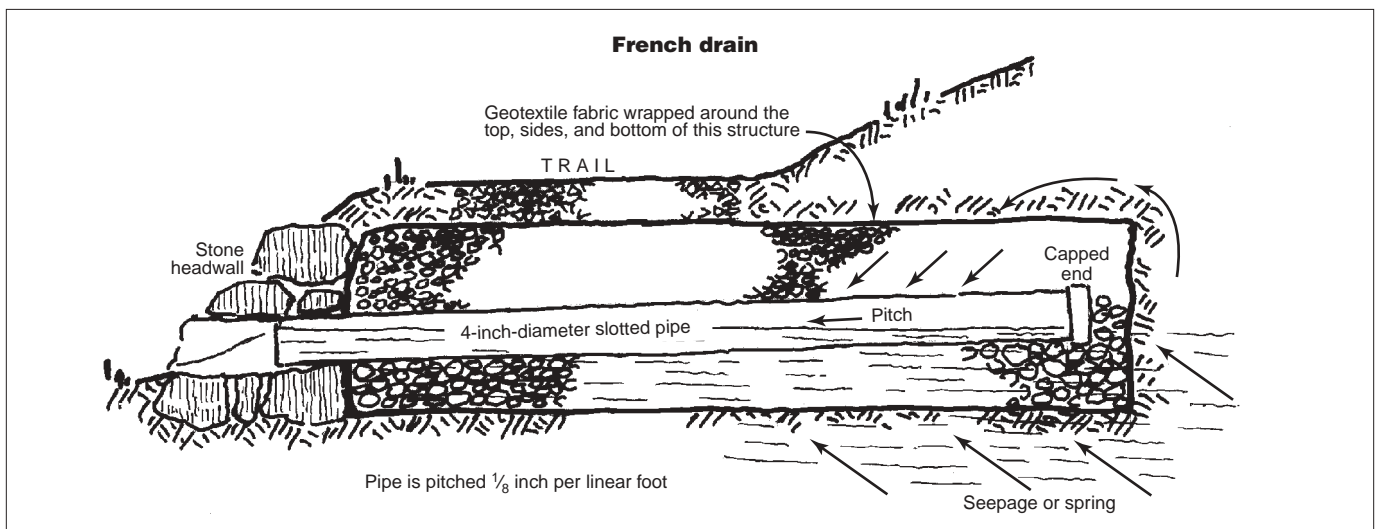


Figure 20—Wrapping French drains with geotextile helps prevent clogging. French drains or underdrains are used to drain springs and seeps that have a low flow.