Chapter 5

TRAIL STRUCTURES

Trail structures discussed in this chapter refer to those which are necessary for trail passage. Trail structures normally respond to user safety and environmental protection issues—not user convenience issues. In this context, almost all structures refer to passing through or across wet areas or open water such as bridges, puncheon, or boardwalks. Steps and stiles apply to passage of topographical or human-caused barriers. Standards for trail structures are summarized in Figure 2 (page 50).

Trail structures are necessary to meet the demands of various situations. However, those required to correct a problem also require a major commitment in terms of both initial and subsequent costs, time, and maintenance. Therefore, it is recommended that alternatives be considered. The most simple technique to correct a problem should be tried and utilized for a year or two to see if it works. If the simple solution proves unworthy, a decision can always be made to incorporate a structure. For instance, digging a small drainage ditch to drain a mudhole may be tried first. It may take a year or so for a long-existing mudhole to firm up. If it does, the solution was easy, quick, and inexpensive. If it doesn't, the complexity of the solution is elevated. Perhaps a few well-placed, flat stepping stones or a small section of puncheon or turnpike will do the trick. Another alternative to a structure is to re-route the trail. Even this seemingly major action may be the best long-term solution. However, there are situations when the decision to construct a structure is obvious and can be made immediately.

Trail structures should be built of quality, long-lasting material and designed to harmonize with the surrounding environment. Minor structures such as puncheon, turnpike, retaining walls, culverts, and small bridges can be built of suitable native material, if it is available. Rock—as used by the CCC—makes a longer lasting retain-ing wall, bridge sill, or water bar than does wood. Certain species of wood are more durable than others. The most durable material should be used, and time taken to work with it will pay off in the long run. When native materials are used, the source site should be left in as natural a state as possible.

Whenever possible, the trail route should be located to avoid areas with seasonal or year-long water problems. Trail construction in these areas is both difficult and expensive. In addition, permits are usually required for crossing officially defined wetlands or navigable streams. Where wet areas are unavoidable, structural improvements should be used to provide a dry, stable treadway for the North Country NST. Regarding wet areas of the trail, a "dry boot" philosophy is the goal, except within ROS primitive areas and during inclement weather or heavy dew. Hikers should not normally have to wade through streams or saturated wetland areas—this is not only unpleasant and dangerous, but potentially damaging to the environment.

BOARDWALKS

Boardwalks are employed to cross areas that have deeper water than can be crossed by puncheon. Typical locations are where the trail has to cross a cattail area, deep marsh, or other water body that has little fluctuation in its level and flow. The distinction between a boardwalk and puncheon is that the surface of a boardwalk is constructed of boards that are perpendicular to the direction of the trail, and the entire structure is supported by posts driven or anchored into the bottom of the wetland, similar to a dock. Boardwalks do not rest on sill logs. Another distinction is that puncheon is normally less than a foot above the surrounding wetland, while a boardwalk can be 2 to 3 feet above the water—like an elongated dock. Wetland crossing permits will almost surely be required.

Boardwalks are normally made of treated material. If they cross areas of fluctuating water levels, the support posts need to be driven deep into the substrate or anchored in concrete to prevent the boardwalk from lifting or warping. Since boardwalks are a major, long-term investment, and they often cross moderately deep water, the standards specified in Figure 2 are designed as an accommodation to safety and provide for wheelchair passage. A kickplate is required to reduce the chance of falling into the water when the boardwalk is slippery due to rain, frost, or ice. The kickplate also makes the boardwalk safer for wheelchairs. The width should be a minimum of 28 inches between the kickplates. Depending on the situation and the desires of the local manager, handrails are optional. (The formula shown in footnote 1 in Figure 2 should not be attempted. It does not apply because, in this handbook, a boardwalk is not considered a bridge).

BRIDGES

Bridges are structures for crossing permanent and seasonal streams, dry ravines or gorges, and other obstacles in a safe, environmentally sensitive manner. The use of bridges to cross streams and ravines is strongly encouraged. On the other hand, constructing and maintaining a bridge is a major, long-term investment. Bridges are expensive to build, require regular inspections, and need frequent maintenance. All stream crossings should be reviewed to determine whether or not they are really necessary. Perhaps the trail was originally laid out to cross a stream several times because it simplified construction. Evaluating the route may show that the number of crossings can be reduced. The possibilities should be studied carefully. Relocation may often be safer and less expensive than building a bridge. Each state has its own rules regarding bridge specifications and placement. It is necessary to work closely with responsible state agencies to ensure that all specifications are met and all the required permits obtained. Plenty of lead time is critical as this can be a lengthy process, depending on the stream being crossed and the complexity of the bridge.

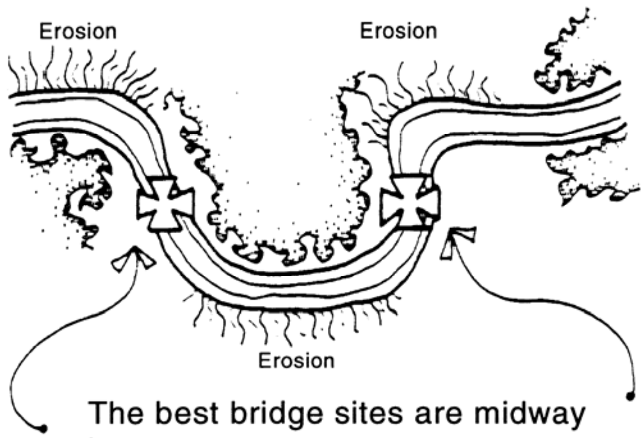
BEFORE AFTER

It should be noted that some of the bridge standards in Figure 2 (width, railing requirements, etc.) do not apply to other water-related structures such as puncheons or boardwalks and there is no clear way to distinguish between bridges and other structures. A bridge is defined as something that spans a definable stream, ravine, or other obstacle, rather than resting on a long series of sills (puncheon) or posts (boardwalk). However, a bridge can have one or more piers. Common sense should be used when defining a bridge. A bridge should not be confused with puncheon or boardwalks when looking at the standards shown in Figure 2. In this context, "bridge" is not the correct name for something crossing a widespread area of wet soils or general surface water such as that found in a wetland. However, a wetland often has a stream flowing through it that requires a bridge. In such a situation, there may be a boardwalk across much of the wetland with a bridge across the stream in the middle.

Safety of the user is a primary reason for building any bridge and a consideration in the design of the bridge itself. Not only can it be unsafe to ford a stream (see section on fords), but descending steep, often slippery stream or ravine embankments can also be dangerous because of slipping and falling hazards. The steeply descending trail is a source of erosion that can degrade stream quality. For these reasons, a bridge is often appropriate when crossing even small streams or dry ravines. Certainly, it provides for less wear and tear on the legs of a pack-laden hiker.

When a bridge is necessary, alternative locations should be carefully evaluated. The clearance of the bridge must provide for passage of high water, ice, and debris. Only bridges built with an adequate opening to accommodate such flood waters will survive. Generally, the highest reasonable height above the stream should be sought. A location that is narrow and has a high bank or ledge to anchor the ends of the bridge is best. Such a site can eliminate the need to construct cribs.

The volume of flood water and the bridge height needed can be estimated from careful observation and research. However, observation will probably only yield information on recent high water levels, not historical peak flows. Determining peak flows is a complicated process which considers specific elements such as the size of the watershed and historic precipitation—it is best done by someone trained in this area. In addition to safety considerations, this is one reason why the standards shown in Figure 2 call for engineering design on all bridges that are greater than 25 feet in length or higher than five feet. Assistance should be sought from agency partners, the Natural Resources Conservation Service (formerly the Soil Conservation Service), private engineering consultants, or other qualified personnel.



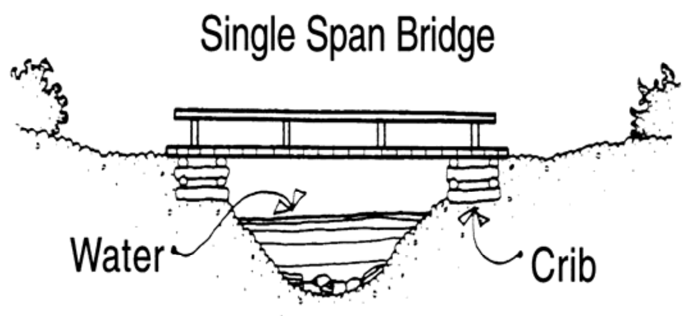
The best bridge sites are midway between turns.

Whenever possible, the entire wet area should be spanned, or ramps used to get onto an elevated bridge. This eliminates the need for steps which are an accessibility barrier. As seen in the section on steps and perrons (later in this chapter) it is recommended that steps be minimized.

Type of bridge - There are many different bridge designs that ensure adequate public safety at stream crossings while maintaining the appropriate ROS setting of the trail. It is not the purpose of this handbook to undermine the traditional creativity of volunteers. Rather, it is expected that creativity will be channeled to design a bridge which meets the standards shown in Figure 2. All bridges should incorporate high quality materials and workmanship. There are three major categories of bridge designs—(1) puncheon type, (2) single span stringer bridges, and (3) multi-span bridges, suspension bridges, and other more complicated designs. The height and span of the bridge, plus the applicable ROS setting , determines what kind of bridge structure to build and what materials to use. (Several bridge designs are included in Appendix 1.)
When the span is less than 10 feet and the bridge is not subject to flooding, a simple puncheon type bridge may suffice.

Crossings over 10 feet wide can often be crossed with a single-span bridge. These normally require the construction of cribs or fills on each bank, two to three solid timber or laminated support beams, a board deck, etc. Depending on the circumstances and dangers, a railing may be required.

In areas where the span becomes too long for a single span bridge, the design becomes more complicated. Multi-span bridges with a support structure(s) in the middle of the stream, or a suspension bridge, may be necessary.



Bridge width - Because bridges provide passage over a trail barrier, and because they are long-term investments requiring substantial commitment of funds, they should not become a barrier in and of themselves. If a mobility-impaired individual has successfully negotiated a segment of trail, the bridge should not be the bottleneck that is impossible to cross because of its width. Therefore, the minimum clearance width should be as shown in Figure 2. These widths were selected to minimally accommodate accessibility, even on trail segments that are not specifically designed to be barrier-free or fully accessible.

Bridge railings - A railing is often necessary for visitor safety and to increase the comfort level of users. Considerations such as depth or swiftness of water, height above the ground or water, length and width of the bridge, desired experience level, and other factors help determine when railings are necessary, and whether one or two railings are installed. Weather related factors such as ice, snow, frost, rain, and the increased chance of slipping and falling from the bridge need to be considered. Besides the element of danger, another consider-ation is that there are some trail users who are simply frightened of walking across what they consider to be a narrow structure. Some agencies will insist that railings be placed on every bridge because of their concern for liability. These and other factors argue for railings.

In some situations railings may actually increase the risk of someone falling. This train of thought follows that if a railing is present, a user will linger longer on the bridge rather than hurrying across to solid ground, thus increasing their exposure to the hazard. Another consideration is that railings are often considered to be the weak point of a bridge. Depending on the method used to fasten the railings to the bridge deck, trapped moisture can lead to decay of the railing support or the main beam of the bridge. If this goes undetected, it could lead to a railing giving way if someone leaned on it. In situations where there is little danger, the inclusion of railings can change the character of the trail and the user experience—it is not desirable to over-build. These and other factors argue against railings.

Everyone's perception of dangers is different—one person may say a railing is a definite need, another person may say it is unnecessary. To establish a degree of uniformity along the North Country NST and to provide some direction to trail volunteers and others, use of the bridge railing formula shown in Figure 2 is recommended. Revisions may be necessary as experience dictates. Bridge builders may decide to be more strict than the formula and install railings anyway, depending on the hazards.

Bridge rail height - When railings are necessary, 42 inches is the standard height adopted by a number of state and federal agencies. It is a common height that provides for a fair degree of visitor safety and therefore is the accepted standard for the North Country NST.

Bridge engineering design - Bridges must be designed to provide for visitor safety, withstand snow loads, accommodate flood waters, etc. A bridge is a major investment and it is common sense to seek engineering consultation for certain bridges—those greater than 25 feet in length or greater than 5 feet in height (above the water level or the bottom of the dry ravine). All trail bridges should be designed to bear a load that meets or exceeds current management standards for architectural design and engineering of pedestrian structures. To achieve this standard, qualified personnel, such as engineers, should review the elements of proposed designs (stringer size, strength, snowload, peak flows, etc.) and approve them prior to installation. The National Park Service, the Forest Service, and other agencies generally require that an engineer either develop or review all bridge plans. While it is specified that engineering design or review is required only on certain bridges, agency partners should be consulted because they may have more stringent standards. The intent of this policy is to ensure professional review of proposed bridges or bridge reconstructions. Before providing funding assistance, such as Challenge Cost Share proposals, on any bridge project where the standards call for engineering design, a project sponsor must provide adequate details showing the need for the bridge, a map showing the location, and construction drawings that show the bridge's span, height, materials used, and other details. If qualified engineering expertise is available, either through an agency partner or trail club member, their review and documentation is suggested when seeking NPS approval or funding.

Bridge clearance above navigable waters - Navigability is defined by the individual state. At least one of the trail states bases their determination on a historical use of the stream—can a log be floated down the stream? Generally, if a canoe can be floated down the stream during spring flows, it is considered to be navigable. The trail states require the issuance of a permit before spanning a navigable stream and will specify the clearance heights. Generally, this is 5 feet above the water surface, but it is recommended that this be confirmed with state agencies and necessary permits be obtained.

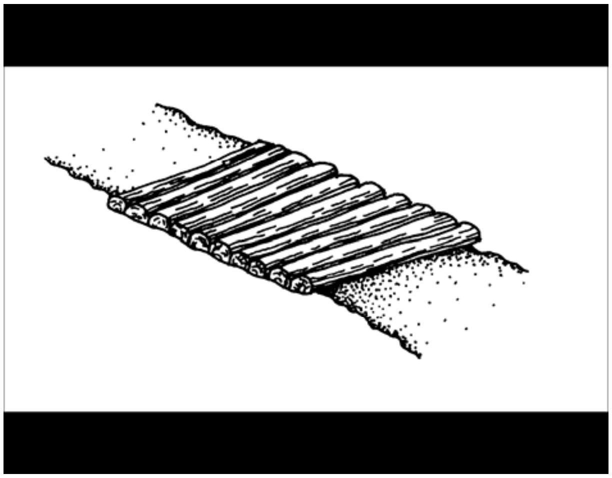
Bridge inspection and maintenance - Bridges require periodic maintenance to insure their stability and safety. Debris should be cleaned from cribbings, bolts checked and tightened, sills inspected for rot, etc. Bridges should be carefully checked by trail maintainers and all major bridges (>25 feet long or > 5 feet high) should be inspected by qualified personnel at least once every three years. This inspection should be documented. In addition, trail club members should be alert to the development of hazardous conditions between inspections, and should also routinely inspect smaller bridges.

CAUSEWAY OR TURNPIKE

When enough rock, gravel, or earthen fill is available, the trail tread can be elevated through poorly drained areas by using a causeway or turnpike. This permanently hardens the tread and is a useful technique when soils are poorly drained but do not have standing water as found in a wetland. A typical causeway is built by first defining the width of the trail tread with parallel rows of rocks or logs. The defining rows also serve to retain the fill. When in place, the filling process should begin with medium-sized stones that will allow water to pass under the causeway. A fill of small stones, gravel, soil, or a mixture of materials should be continued to create the elevated causeway and ensure a smooth walking surface. The surface should be rounded 2 inches above the elevation of the defining logs or rocks to provide better drainage and to allow for settling.

A ditch can be dug parallel to and on both sides of the causeway to improve drainage. This variation is often called a turnpike. The material excavated from the ditches can be used to help fill the causeway.

CORDUROY



Corduroy construction is basically a primitive type of puncheon. It consists of laying native logs perpendicular to the trail to harden it through areas of unstable or saturated soil. If corduroy is left exposed, it provides uneven, slippery footing that is uncomfortable for the hiker, and does not convey the impression of a well designed trail. Consequently, on the North Country NST, exposed corduroy is not acceptable ,except as a temporary measure until a more permanent solution can be installed—and then only in areas that are not defined as wetlands. Puncheon is a better alternative.

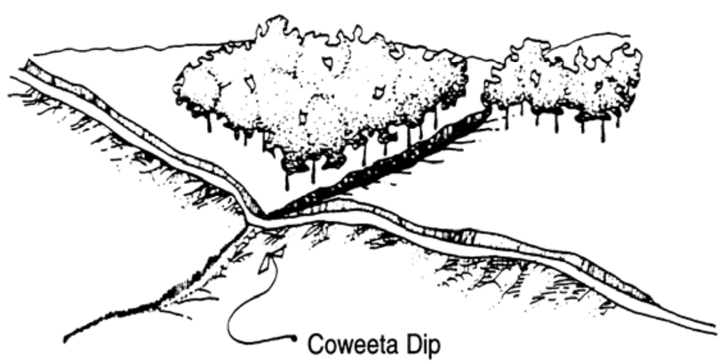
In some parts of the Lake States, roads were often constructed across boggy areas using corduroy and covered with soil. The log base provided the required degree of flotation and the soil cover provided the smooth driving (in this case walking) surface and kept the logs from rotting. While still employed to some extent, geotextile material now takes the place of the logs. The use of this technique can provide a suitable trail structure, but the ramifications of its use should be carefully considered. A corduroy bog structure can change the natural flow of water through the wetland, change the water level, kill the upstream vegetation, or change the species composition. Covered corduroy involves considerable modification to the site and is not recommended in the types of soils/sites where corduroy is typically employed. Wetland permits are usually required. Other alternatives such as puncheon or boardwalks are less intrusive on the site and easier to construct.

COWEETA DIPS

Coweeta Dips, or grade dips, are created when a short section of the trail is built with a grade slightly opposite to the prevailing grade. These are one of the most effective drainage techniques in trail construction, blend aesthetically into the landscape, and are almost maintenance free. They are cost-effective in controlling erosion and reduce the monotony of long, sustained grades.

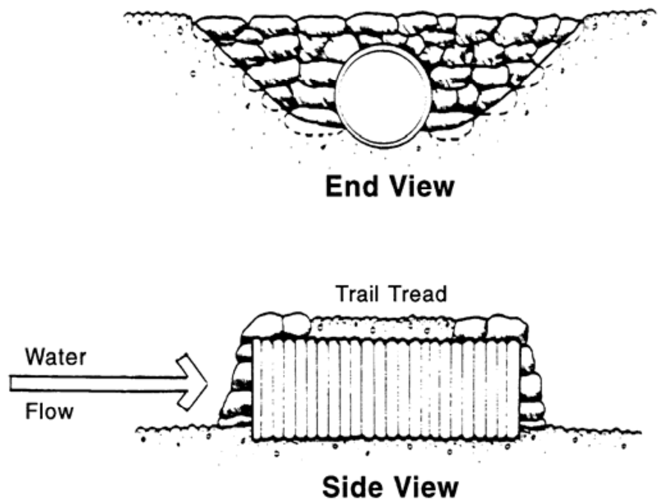
Dips are most effective when built as part of the original trail construction, but can be used when relocating short problem areas if the terrain allows. On an ascending trail segment the trail should level every 50 to 100 feet followed by about 15 feet of **slightly** descending trail before continuing upward. This almost imperceptible descent creates a dip (low point) and forces water coming down the trail to drain off—less than a foot of elevation is lost for the hiker. The dip itself requires no construction other than careful building of the sidehill trail to establish the dip's alignment.

Since a place is needed to discharge the water, Coweeta Dips usually are best suited on sidehill trails. Coweeta Dips take advantage of the natural roll and drainage of the landscape. They should be positioned naturally into the terrain for maximum function without being obvious. Spacing should be varied to make the trail more interesting.



CULVERTS

Culverts are used to pass water under the trail. They are an excellent alternative to a small bridge and can be used to accommodate water flow from either spring runoff or small permanent streams. Culverts are most effective in natural drainage places where minimum excavation is required. They also can be used in flat areas to provide equalizing, cross-drainage under causeway or turnpike sections, and reduce the damming effect.



Culverts may be more cost effective and less obtrusive than a bridge. They are easier to install in most instances. They can be constructed of rock, logs, corrugated metal, corrugated plastic, or other suitable material. As stream size increases, engineering advice should be sought to insure that the culvert is sized to accommodate peak flows. If the stream is permanent or is a designated trout stream, permits should be obtained.

While culvert installation sounds simple, there are some basic principles which must be followed for the installation to last. Culverts should be installed with a gentle down-stream gradient of around 2% and should be properly bedded to ensure continued performance. If metal or plastic pipes are used, a minimum of 6 inches of soil (free of sharp rocks) is recommended for pipe cover. Pipe diameters less than 12 inches may present frequent cleaning problems.

FORDS

Due to safety concerns, legal implications, and the "dry boot" philosophy, fords should not be used. Fording on new sections of trail should not be accepted and any fords on existing trail segments should be bridged as soon as funding is available. A possible exception to this policy is across very small streams in ROS Primitive areas.

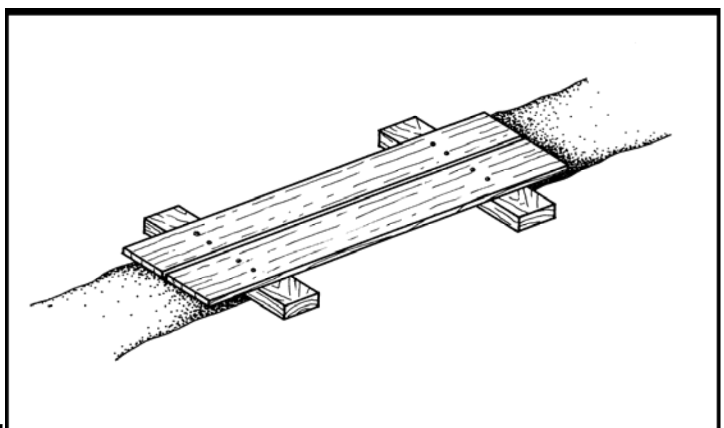
Drownings have occurred when hikers attempted to wade seemingly innocuous streams during high water periods. One unfortunate incident involved an experienced hiker (who had logged over 26,000 trail miles) who attempted to wade what by all appearances was a 25-foot-wide, shallow, Arkansas stream. The creek was not over knee deep and was not cold. However, it was fast flowing and treacherous enough to knock the hiker off his feet and sweep him to his death.

Because of the locations of the North Country NST and long distances through the Lake States, water is more than a short-term springtime concern. Water does not dissipate as quickly as in hillier areas, and lasts well into the summer. Permanent solutions (e.g., bridges) are more appropriate for these areas than fording.

PUNCHEON

Puncheon is an effective way to cross some types of bogs, shallow marshes, and wooded wetlands. It uses sawed, treated lumber or native logs to elevate the trail tread above wet areas that are not feasible to drain. It provides a hardened surface that lasts for many years depending on the material used. The walking surface is parallel to the direction of the trail, and the support structures (sills) rest directly on the ground. The use of puncheon is strongly recommended since a wet, muddy trail and the damage caused from hiking directly through wetlands are undesirable. A puncheon bridge can range from as little as 10 feet to hundreds of feet long for crossing a swamp.

Puncheon can be constructed using either native or milled materials and often is a combination of the two. Most typically, the sill logs are made of long lasting native material (such as cedar, tamarack, locust, etc.) and the walking surface is made of heavy, treated planks. The determination of the material depends on a number of factors—the distance from an access point, ability to haul materials to the site, the availability of native materials, the skills available for the difficult job of hewing native puncheon, the desired length of time between replacement, and the ROS setting.



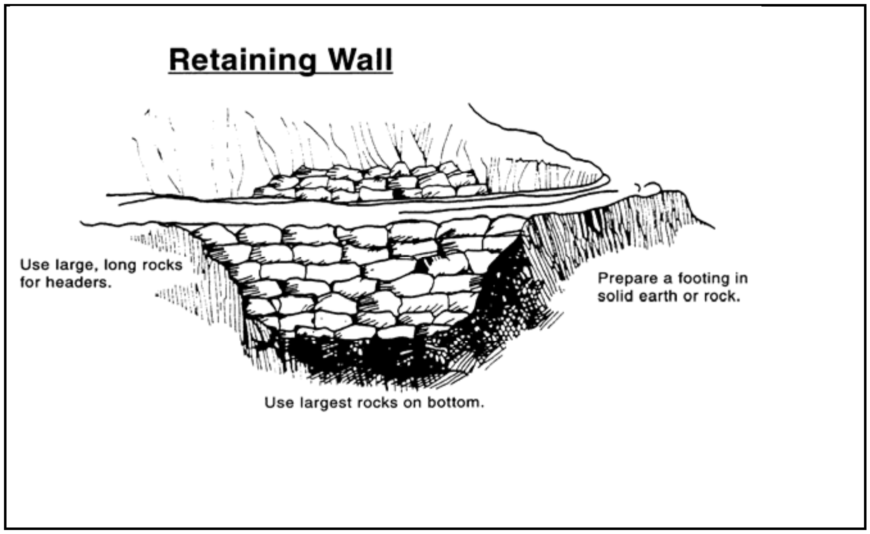
Once the route through a wetland is chosen and the trail is cleared, the first step is to obtain and place the sill logs. These rest directly on the wet soil and vary in length from about 3 feet to 5 or 6 feet depending on the amount of support provided by the wetland. The stringers (walking surface) are then placed on top of the sill logs and secured in place with large spikes. If native logs are used as stringers, some notching and fitting has to be done so they do not rock on the sills. Puncheon is normally built in 8 to 10-foot sections with no more than 6 inches from the end of one section to the beginning of the next. When treated planks are used, the ends typically rest directly on the sill logs—often without gaps between the sections. In this situation, one sill is located directly at the junction between two sets of planks. However, because planks have more flex, a center sill may be needed. In order to achieve the puncheon width specified in Figure 2, two 2″× 8″ or 2″ × 10″ planks will be needed.

The trail tread at both ends of the puncheon must be solid and dry; otherwise, the stepping-off point may become soft and muddy, eventually requiring the construction of an extra section of puncheon. It may be necessary to place several flat stepping stones at the ends of the puncheon to help the soil withstand the impact of hikers.

In areas subject to flooding, such as along streams or near beaver activity, puncheon is not a good choice because it can float out of position or even completely away. In these areas, relocating the trail or using boardwalk should be considered (provided it is protected from spring floods along streams).

RETAINING WALLS

Retaining walls are structures of stone or wood designed to stabilize the trail base on steeper side slopes. They are time consuming to construct but may be necessary to prevent soil slide or slump when sidehill trails are crossing the face of a slope that exceeds 40% to 50%. Retaining walls are a long lasting investment—many constructed by the CCC in the 1930's are still functional today.



Sound, durable rocks with good, angular (rather than rounded) bearing surfaces are the preferred material because of their locking ability and durability. Native decay-resistant or treated logs can also be used if rock is not available. The foundation must rest on solid earth or rock to obtain a rigid, safe retaining wall. The thickness of a rock retaining wall at the base should be at least one half the height of the wall or a minimum of 2 feet if the vertical height is less than 5 feet. The outer face of the wall should have an inward slope of at least 2 to 3 inches for every foot of height. Drainage is required around, beneath, or through the wall so that water will not accumulate behind it and build up pressure which could destroy the wall.

STEPPING STONES

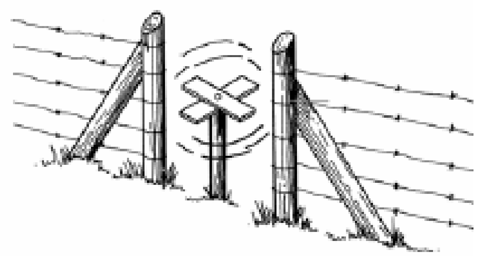
Stepping stones can effectively harden the trail tread across short wet areas or mud-holes. Suitable large, flat stones that are firmly set so that they do not rock—which may otherwise cause hikers to lose their balance—may be the least expensive, most durable solution to a problem area. Cut rounds of log should not be used as substitute stepping stones as they become slippery with moss and are a safety hazard. They are also less durable and convey the impression of poorly designed trail.

Generally, stepping stones should not be used to cross streams unless the stream is very small and requires only a few stones. Then, they can be used only where the bank is solid and will not become eroded. On navigable streams, or streams with a fish population, stepping stones are opposed by many state agencies because they can create an artificial barrier to water flow or modify the fish habitat. Stepping stones also pose a barrier to accessibility and can become slick with moss and water—a falling hazard for all persons. This application should be avoided whenever practical and considered a temporary solution until a bridge can be installed.

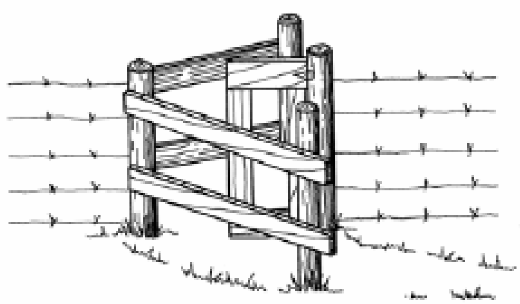
STILES

Pastures and other agricultural fields often occur on private lands and are separated by fences. These are primarily in rural/roaded natural ROS settings but also can occur in other areas. While it is desirable to minimize as many fence crossings as possible, they are impossible to avoid altogether. Whenever a fence must be crossed, it should be equipped with a stile to facilitate hiker passage and eliminate fence damage. Gates could serve the same purpose as a stile but they are more expensive to construct and maintain. There is also the likelihood that a gate may be left open allowing livestock to escape. The landowner should always be consulted to ensure that the stile is located and constructed to meet their needs. In areas where user conflicts exist, a stile can effectively serve as a barrier to unauthorized use by horses, bicycles, and ORVs.

Step Stile



Turnstile



Dodgeway

There are a wide variety of stiles in use, including step stiles, turnstiles,and dodgeways or pass-throughs.The stile of choice is often determined by the area's cultural traditions.

STEPS AND PERRONS

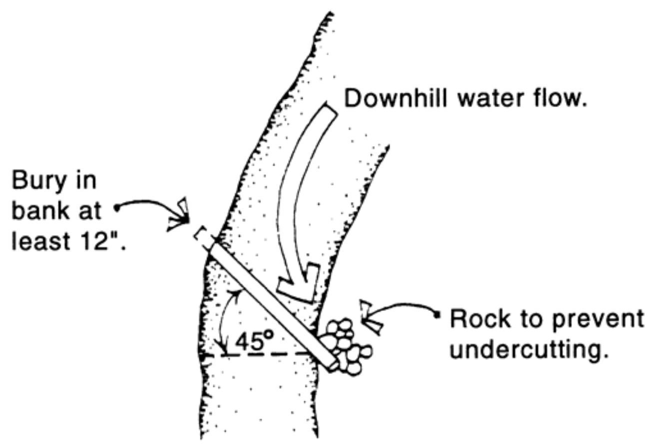
Steps and perrons (elongated steps—more like a series of connected platforms) should be avoided. In most cases, proper trail layout can alleviate the need for steps. These structures are difficult and time consuming to properly construct and often create an unnecessary impediment. They make an otherwise difficult but accessible section of trail inaccessible. Even persons who are generally considered to be ambulatory, but who may have knee or hip problems, find steps more difficult to negotiate than gradual inclines.

In some cases there may be unavoidable topographical barriers—such as where an escarpment separates two moderately sloped grades—or land ownership patterns that restrict where the trail can be built, forcing it to traverse a hill at a much steeper-than-desirable grade. In these types of circumstances, steps may be the only alternative.

Step construction details are not provided (other than Appendix 1) since use of steps is limited. Local experts and a copy of the Appalachian Trail Conference's *Trail Design, Construction, and Maintenance* by Birchard and Proudman are good references.

WATERBARS

Waterbars are rock or log structures that divert water off of the trail. Other innovative materials which offer more accessibility, such as rubber belting, have been used on some trails in recent years. However, these innovations take away from the natural character of the trail. On the North Country NST, traditional rock or logs are to be used—except on those segments of trail designed as fully-accessible. During new trail construction, the use of waterbars can be minimized through careful attention to the grade of the trail and use of Coweeta dips. On older trails, or where it is necessary to use steeper trail grades, waterbars may be the only effective way to divert water from the trail. Where water flowing down the trail is anticipated, it is better to install waterbars immediately than to wait for erosion to occur.



- Spacing

Waterbars keep the speed, volume, and distance water travels down the trail to a minimum. The actual number and spacing of waterbars depends on the amount of water entering the trail, the steepness of slope, the construction of the treadway, and the availability of places to divert the water.

Final placement of waterbars is dictated by terrain. They must be placed where diverted water does not return to the trail. If this is not possible, a waterbar should not be installed (e.g., where the trail lies in a high banked swale that requires extensive excavation in order for the waterbar to function properly).

The greater the slope and the more water channeled by the trail, the greater the need for waterbars. They should be placed below all points where a significant amount of water enters the trail. On uniform sustained grades, waterbars should be placed near the top of the hill to divert water before it does damage with others constructed periodically down the grade to keep water flow to a minimum.

Frequency of Waterbars

Material Type	**Grade (percent)**						
	2	**4**	**6**	**8**	**10**	**12**	**15**
Loam	350'	150'	100'	75'	50'	*	*
Clay-Sand	500'	350'	200'	150'	100'	50'	*
Clay or Clay-Gravel	-	500'	300'	200'	150'	100'	75'

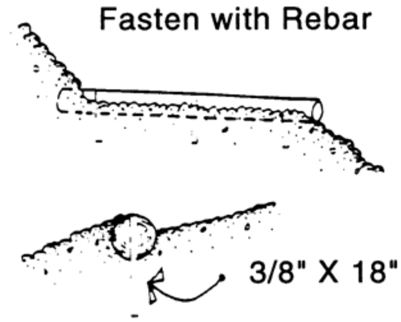
* These grades not recommended in this soil material. - No diversion required for soil stability.

- **Construction**

After waterbar spacing and location is determined, a trench should be dug across the trail at about a 45° angle. Waterbars may slow water too much causing it to clog with silt and debris if less than 30°. Those placed at 45° or more will tend to be self-cleaning. The trench should be deep enough to contain about ½ of the diameter of a log waterbar or _ of the height of the rocks used for a rock waterbar. The waterbar should be a minimum of 4 inches above the level of the ground on the uphill side and should extend 12 inches into the side of the hill and 6 inches beyond the side of the trail on the downhill side. The waterbar should be securely fastened in place using one of the techniques illustrated in Appendix 1, or with stakes obtained on site.

Re-bars are often used to fasten log waterbars in place. When used, holes are drilled through the log at a slight angle and the re-bars driven so that no portion protrudes above the log. If using native material for stakes, a tree 2 to 3 inches in diameter should be cut into 18-inch pieces.

The stakes should be driven on each side of the log waterbar, with the tops of the stakes slanting over the bar, so the stakes tend to pin the log to the ground. The stakes should be flush with the top of the waterbar—excess should be trimmed to prevent a tripping obstacle or their loosening from being kicked.



On the uphill side of the waterbar the tread should be graded several feet down into the trench. All excavated soil and rock should be placed on the downhill side of the bar and packed so the tread is flush with the top of the waterbar. Waterbars require regular maintenance so that they continue to function properly. Accumulated soil and debris must be cleaned out at least annually.

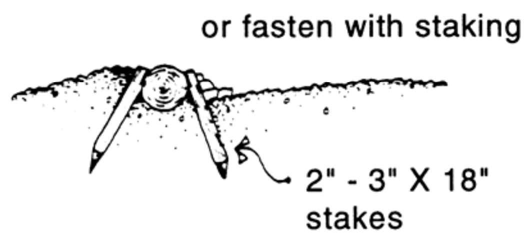


Figure 2. **NORTH COUNTRY NATIONAL SCENIC TRAIL**
DESIGN STANDARDS FOR TRAIL STRUCTURES

Standards (desired)	**ROS Class**			
	Urban	**Rural and Roaded Natural**	**Semiprimitive**	**Primitive**
Bridges (width) Hiking Segment Accessible Segment	 60" 72"	 36" 48"	 28" 36"	 *
Bridge Railings Hiking Segment Accessible Segment	 Y Y	 Formula (1) "	 Formula(1) "	 Formula(1) N/A
Bridge Rail Height	42"	42"	42"	42"
Bridge Engineering Design	Y	If length > 25 ft. or height > 5 ft.	Same as at left.	Same as at left.
Clearance above Navigable Waters(2)	5'	5'	5'	5'
Bridge Kickplate Required (3) Hiking Segment Accessible Segment	 Y Y	 N Y	 N Y	 *
Other Structures Puncheon (4) Hiking Segment Accessible Segment	 N/A N/A	 16-18" width N/A	 16-18" width N/A	 *
Boardwalk(5) Hiking Segment Accessible Segment	 60" 72"	 36" 48"	 28" 36"	 *
Corduroy Hiking Segment Accessible Segment	 N/A N/A	 (6) N/A	 (6) N/A	 *
Culverts(7)	OK	OK	OK	*

(1) Railings are required if: (½ length X height²)/width _ 40
(2) Navigability as defined by the individual state. Clearance requirement may vary.
(3) Kickplates are often included for safety when handrails are not required.
(4) Puncheon rests on sills and is generally less than 1' high.
(5) Boardwalk is generally less than 2' above water level and should have kickplates.
(6) Generally not acceptable—but can be used as a temporary measure in areas not defined as wetlands.
(7) Length must be calculated to provide for 2:1 fill slope beyond the normal trail clearing. Size (engineering consultation) to accommodate peak flows. Water crossing permits often required.
* In Primitive ROS (wilderness), structures are provided only for visitor safety or resource protection—not for visitor convenience or comfort.