

# TRAIL

## CONSTRUCTION & MAINTENANCE

# GUIDE



A black and white line drawing of a hiker walking away from the viewer on a dirt trail. The hiker is wearing a hat, a backpack, and carrying a long walking stick. The trail is flanked by dense foliage on the left and a grassy field with a mountain in the background on the right. The title 'TRAIL CONSTRUCTION & MAINTENANCE GUIDE' is at the top, and 'YELLOWSTONE NATIONAL PARK' is in a box on the left.

**YELLOWSTONE  
NATIONAL PARK**

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## INTRODUCTION

This trail maintenance guide has been prepared for the use of National Park Service employees and others working on trails in Yellowstone National Park. The contents represent a condensed version of information contained in National Park Service and Forest Service handbooks and manuals, and from practical experience. It is published in pocket size so that it can be carried easily in the field for ready reference.

This guide covers normal problems and practices found in the field. It is not the "elixir" to all situations, and should be used accordingly. Situations not covered should be referred to your supervisor.

## SAFETY MESSAGE

The applicable sections of the National Park Service Safety Management Handbook, Occupational Safety and Health Administration Regulations, and other related Federal agency standards must be followed in trail work. New employees will be given safety instructions before going to work. Persons engaged in this type of work must be in good physical condition. They will be trained or tested to assure that they are able to competently use all of the tools on the job. Trail crews normally work in isolated areas where medical facilities are not readily available, and transportation of an injured person is often difficult and dangerous. A good safety record depends on being safety conscious at all times. This applies in camp as well as on the job. One member of the crew may be designated responsibility for safety, but every member of the crew should consider himself the safety inspector for the job by working in a safe manner and pointing out unsafe practices to other crew members.

# ***LOCATION GUIDELINES***

## LOCATION GUIDELINES

Trail location objectives are to provide a facility on the ground that produces a minimum physycal impact on the land, is visually pleasing, requires minimum maintenance, and functionally provides for the intended use. In addition to a knowledge of the criteria listed, the locator must have a "feel" for the "as-constructed" trail as he proceeds along the selected corridor. This "feel" or mental perspective is gained through experience in laying out trails, seeing them built, and critiquing the final product against the original location criteria.

The locator must be aware of the adjacent terrain, vegetation, soil types, and moisture conditions. All of these factors will directly influence how the trail should be located and subsequently how well the constructed trail will function.

The following General and Specific Criteria should be used as a guide:

### I. GENERAL CRITERIA

- A. Use existing trails as much as possible.
- B. Terrain and elevational variety should not be extreme; suitable for family backpacking.
- C. Locate predominantly on National Park Service land.
- D. Route is suitable for long season of use , while maintaining ecological variety, i.e., not all forest; use forest edges bordering meadow when possible.
- E. Locate where suitable for both winter and summer activity to the degree terrain and climatic patterns will accommodate it.

- F. Provide access points to trailheads as applicable.
- G. Exposure on high elevation ridges should not be excessive.
- H. Trail will meander to take advantage of scenic panoramas, historical, and resource management situations for interpretation purposes.
- I. Trails should not make great or sudden changes in elevation.
- J. Trail grades should contour rather than undulate up and over steep topography.
- K. Main trail networks should disperse visitors away from fragile or heavily used areas.

## II. SPECIFIC CRITERIA

### A. Wildlife

- 1. Avoid known bear concentration areas.
- 2. Winter trails should avoid areas where big game species concentrate.
- 3. Provide vistas, observation points, or overlooks for observing wildlife in areas where they are likely to be seen.
- 4. Avoid bighorn sheep spring and winter range.

### B. Soils

- 1. Locate on stable soils except where short sections, up to 50 yards, can be structurally contained and/or a relocation would create more conflict.
- 2. Locate trail around extended bedrock areas.

### C. Water

1. Locate trail to overlook streams and lakes and not follow along the water's edge.
2. Meander trails to provide water access points for users as well as pack and saddle stock.
3. Try for water access every one hour of walking.
4. Bridge crossings should be avoided if a relocation of the trail can make the structure unnecessary.

### D. Safety Hazards

1. Avoid talus slopes or rock slide areas.
2. Avalanche zones should be avoided.
3. Avoid areas with concentrated numbers of snags. (If not practical to avoid, plan during construction to remove snags that are adjacent to the trail.)
4. The trail should avoid areas with erosion, snowbank, bogging, or icy surface potential.
5. Avoid severe high wind and lightning-prone areas.
6. Take advantage of natural shelter.

### E. Wild Outdoor Atmosphere

1. Take advantage of natural vegetation and terrain to maintain a wild outdoor feeling where possible. These will become a part of the overall educational potential - some wilderness, some historical, etc.

### F. River and Road Crossings

1. Special attention should be given to the safety problem that traffic noise can create for horsemen.
2. Provide adequate visibility when roads of low traffic volume are crossed at grade.

3. Take advantage of natural or existing features to afford an easy and quick crossing without breaking the continuity of the trail.
4. Trail will enter and leave water on a descending and ascending grade to prevent water from draining down the trail.
5. Stream fords should be over cobblestone-size or smaller rocks. Avoid or remove any abundance of 10 inch diameter or larger rocks that make horse crossings dangerous.

#### H. Provisions for User Facilities

1. Provide areas away from camping sites where stock may be controlled.
2. Provide spur access to campsites rather than locating the main trail through the camp.

#### I. Alignment

1. The ideal alignment will "fit" the trail to the ground and afford the user the best views from the trail. The alignment should follow the contours of the land and be generally curvilinear. Sharp, angular turns over 50 degrees and long, straight stretches should be avoided.
2. The alignment should angle across the natural slope of the hillside rather than take a route directly up or down the slope which affords little opportunity to drain water away.
3. If a switchback is necessary, it should be constructed as shown in "Details of Switchbacks" (See Appendix). The most desirable alignment for a switchback utilizes a topographic feature as a turning point so that it does not appear to be "carved" out of the hillside. Provisions for screening and protecting the switchbacks with trees or brush should be incorporated in the design when the trail cannot be constructed around a natural topographic feature.



## J. Grade

1. As a general rule, the trail should not be steeper than 7 percent (7-foot rise in 100 linear feet). Grades of 1 to 7 percent are ideal. Grades from 7 to 10 percent should not exceed 1,000 feet in length; 10 to 15 percent grades should not exceed 600 feet in length. No grade should be so steep that erosion is a problem. Do not locate zero grades. As a general rule, some grade must be provided to adjust to drainage needs. Long stretches of a given grade should be avoided. The grade should undulate gently to provide natural drainage and to eliminate monotonous, level stretches and long, steep grades that are tiring to the traveler. Grades should be lessened at approaches to switchbacks, and the turns should be as nearly level as practical.

2. A trail designed especially for hikers may incorporate short sections of steps or steeper grades within the controls indicated if these will not cause undue disturbance, and adequate drainage can be provided to prevent erosion.

## III. SPECIAL SITUATIONS

The general and specific principles of trail location will apply to most of the land managed by Federal agencies along the length of the trail. There are, however, special situations which may require some modification of the location criteria.

# ***DESIGN GUIDELINES***

## DESIGN GUIDELINES

The design of park trails should be in keeping with the purpose of the trail. In general, it should be designed to produce minimum disturbance to the natural environment and should consider the protection of the adjoining resources, the safety and enjoyment of the user, the volume and type of traffic, and related esthetics. The design should incorporate features that reduce adverse impacts upon the environment, that result in a trail of high quality and permanence, and that provide the least cost to maintain.

### I. SPECIFIC DESIGN ELEMENTS

#### A. Dimensions

Trail dimensions will be based on the type and volume of use anticipated, stability of the native materials, and type of terrain along the route. Generally, the trail tread width will be not less than 18 inches minimum for foot trails and 24 inches minimum for horse trails. Thirty inches should be the maximum tread width unless additional width is required for safety or impacts from heavy traffic.

The following exceptions are noted:

Along a precipice or hazardous area, the trail base should be at least 48-60 inches wide in order to provide safety to the hiker and horseman.

Special trail sections, such as fords through small streams or built-up sections across flat areas, should have a usable tread at least 36 inches wide. At switchback landings, graded trails should be designed to minimize the amount of excavation and cutbank exposure.

The specific details of the trail's dimensions are shown in the Appendix.

#### B. Clearing

Clearing requirements vary with the intended trail use. For clearing dimensions, see discussions under Construction Guidelines and the diagrams in the Appendix.

#### C. Structures

Materials used for structures generally should be of a quality to permit long life. Structures should be designed to harmonize with the surrounding environment (see Appendix). Minor structures such as log corduroy, elevated sections (puncheon), retaining walls, and foot bridges (under 30 feet) may be built of suitable native materials if they are available near the site. When native materials are used, the site from which they were removed should be left with a natural appearance.

In designated Wilderness, structures should be limited to those necessary to provide safety to the user, be built from native material when possible, and conform to the requirements of the Wilderness Act.

Where a bridge for horses is not necessary, stepping stones or a large log with hand railing may be provided for hikers (see (Appendix)).

#### D. Drainage

Surface and subsurface water can be handled in many ways. A discussion of various methods and design standards is covered in the Construction Guidelines and illustrated in the Appendix.

#### E. Trail Surface

Tread surfacing material which will blend with and preserve the natural environment will be provided where native soil cannot support the traffic, as necessary to minimize severe conditions of erosion, dust, mud, or when crossing slide rock areas.

#### F. User Facilities

User facilities such as trailhead loading docks, sanitary facilities, parking areas, and water supplies are items which require individual analysis and design. If it is administratively decided to construct such facilities, designs will be provided.

#### G. Revegetation

During design, plan for adequate revegetation of cut and fill slopes, borrow pits, or other areas where surface vegetation has been removed. Followup action must also be included after initial seeding to assure complete restoration of vegetation. Seed mixes, volume of application (pounds per acre), and season of application should be keyed to local conditions, and have prior approval of the Chief of Maintenance.

# ***CONSTRUCTION GUIDELINES***

## CONSTRUCTION GUIDELINES

### I. CLEARING

A trail designed for horse use will be cleared of all projecting limbs, brush, downed logs, debris, and sapling trees to a minimum width of 8 feet and a minimum height of 10 feet above the trail tread. Overhead clearing should permit a man on horseback to ride over the trail without interference from limbs and brush.

A trail designed for hikers only will be cleared of all small limbs, trees, brush, downed logs, and debris to a minimum width of 6 feet and a minimum height of 10 feet above the trail tread.

Travelway Clearing (see Appendix) shows the clearing dimensions graphically. Clearing beyond that necessary for adequate room along the trail may be desirable to provide openings so the traveler can enjoy a particular scene. These clearings should be planned to give the appearance of a natural opening and to enhance a scenic vista. The Park Landscape Architect should assist in laying out these openings.

For protection against erosion and for the appearance of the area, leave standing all healthy trees with a greater than 10 inch base diameter which will not interfere with loaded pack animals. In sparsely timbered country, do not remove any healthy trees except where these interfere with trail traffic, and the trail cannot be relocated to eliminate the interference.

Cut trees flush with the ground, and then shovel soil on the remaining exposed wood. Remove trees and stumps if the tree roots will interfere with grading. Cut all brush flush with the ground. Cut all dead or leaning trees which might fall across the trail.

Cut off green limbs flush with the tree trunk to permit the cut to heal over. Widen clearing areas at waterholes, resting places, and scenic points where stock may pass while the riders of one party are dismounted. Widen clearing on the upper side to permit passing at intervals in places where sideslopes are light.

Chain saws should not be used to clear limbs, because of the noise factor and the likelihood of scarring tree trunks. Limbs to be cleared should be cut flush to the tree, and not allowed to lay at the base of the tree, but scattered away from the trail, with butt ends facing away from the trail. Every effort will be taken to make the scene look natural with minimal impact from man.

## II. BASE CONSTRUCTION

### A. General

Do not unnecessarily disturb the existing ground surface to obtain a trail base, especially on flat areas. Construction of sidehill trails usually requires grading a shelf for the trail, but if the existing surface is flat and provides a suitable tread, leave it undisturbed. This will reduce erosion and maintenance. On level ground, form the trail base by building up rather than cutting down. Remove all duff before making cuts or fills for the tread.



Start grading at the upper slope stake and carry it down to the finished grade. The usual procedure is to "scratch" a continuous line between the upper slope stakes using a shovel or pulaski. Remove any excess duff at this time. Begin excavation along this line using a plow if available, hand tools, or other means. Keep the working surface approximately level or slightly inslope until the final grade is reached. On slopes 20 percent or over, the trail base should be constructed totally in native soil. Fills on slopes greater than 20 percent are hard to maintain. Fills on slopes which exceed 40 percent are often unsafe for horse traffic.

A soil berm along the outside of a trail should only be used when the trail fill consists of loose, disintegrated granite or other unstable material which may erode easily. The use of a soil berm is related to special handling of surface runoff drainage (see Appendix). A rock berm should be used for safety on horse trails when the sideslope is 80 percent or greater to keep the horse from walking on the outer edge. Trail base width should also be widened to provide adequate tread area. If soil or rock berms are used, it should be recognized that more frequent maintenance is usually required to keep the berm intact.

NOTE: Before using turnpike, puncheon, or corduroy sections, make every effort to locate the trail around the problem area.

## B. Turnpike Sections

Turnpiking is a process of utilizing material from parallel side ditches to build up the trail base (see Appendix). Their use is primarily in flat areas that are wet or become wet during the rainy season. The most important consideration is getting the water level down below the trail base and carrying the water under and away from the trail at frequent intervals. When ditch material is of poor, boggy soil, it will be necessary to import better material from nearby to build up the base. Blasting techniques can be used to form these ditches. However, only properly trained and certified personnel can do this work. Turnpike sections will be considered only when better methods are not available.

## C. Puncheon

Puncheon construction utilizes sawn, treated timber or native logs to elevate the train tread above wet areas that are not feasible to drain nor to utilize a turnpike section (see Appendix).

Puncheon consists of a 5 foot wide deck of native logs, or sawn, untreated planks laid on stringers. Treated, sawn planking may sometimes be used economically. The deck is laid on stringers set on mud sills. The stringers are generally placed at each edge of the widened trail at about 4 foot centers. The mud sills are set at right angles to the trail 6 to 8 foot intervals. Provide proper subdrainage under the stringers and mud sills (see Appendix).

Take care that puncheon is level from side to side and that the entire structure extends far enough so that soft spots or jumpoffs do

not develop at the ends. Approaches to each end must be installed on a modest grade not exceeding 5 percent.

Securely spike the decking to the stringers and spike a binding pole or guard along each edge to keep traffic in the center of the puncheon. Where practical to do so, the utility and life of the structure can be increased by covering the deck with a layer of dirt to cushion the traffic and save wear on the deck planks caused by shod horses.

Filling small, boggy places in the trail with large, flat rocks comes under the general heading of puncheon. This is an effective way to treat these places; but, to give a satisfactory footing, cover the rocks with gravel or other stable material as a tread surface.

#### D. Corduroy

Corduroy construction is basically a primitive type of puncheon. It consists of laying three native logs (about 6 inch diameter) on the ground as stringers with 5 foot cross logs (4 to 6 inch diameter) laid side by side across the stringers and bound together with wire or nails. If native soil is placed over the deck, logs should be lashed along the edges to retain the material. Flatten the top of the deck logs for ease of walking if soil is not used. Corduroy, normally short-lived, is considered as a temporary crossing until a more permanent solution can be installed (see Appendix).

### III. TREAD CONSTRUCTION

Normally the native soil used to construct the trail base is adequate to carry foot and light horse use. Select surfacing (tread) is a costly item and should only be used for extreme needs such as on heavy use trails, in wet areas, across rock slides, or to provide footing across solid rock areas.

When surfacing is required, pit run native gravel in the area should be used first. If no gravel is available on site, consider importing from farther sources. Gravel is usually found around streambeds or in small pockets along the trail. It is loaded by hand and hauled by duffel carrier, wheelbarrow, or in packhorse panniers. Because of the relatively high labor cost per cubic yard of material in place, the source location is of greater importance than the quality of material. In other words, from a cost standpoint, a poorer material close by may be more desirable than better material farther away.

The depth and width of surfacing must be determined in each case based on the quality of the native material and the use anticipated on the trail. As a general rule, 3 inches of gravel will last about 5 years with 10-15 horses per day over the trail.

### IV. SWITCHBACK CONTRUCTION

Switchback construction requires good initial trail centerline reconnaissance in relating its location and layout to the existing terrain.

When switchbacks are necessary, construct the turns as flat as possible. On sideslopes of less than 20 percent, treat the switchback as any other section of the trail by following a long, radius curve. If this results in the centerline grade being steeper than is desirable, shorten the radius and build a conventional 8 foot radius switchback with the grade of the upper and lower legs meeting at the radius point. Start excavation along the upper slope stakeline of the upper leg, and carry down to grade at the radius point before starting the lower leg. In order to provide proper drainage, carry the upper leg cut well out beyond the radius point, then shape and complete the turn area (see Appendix).

Log or rock barriers should be installed between the lower and upper legs of the switchback. Provide 15-20 feet of barrier back from the turning point to prevent foot or horse traffic from cross-cutting inside the switchback. Otherwise ruts and erosion may result.

## V. DRAINAGE

### A. General

Drainage control on a trail relates to two primary types of water control, surface and subsurface water.

Any provision for the discharge of surface water must include precautionary measures that will prevent silting, erosion, or gullyng of areas off the trail. Rock replacement at the discharge point will help dissipate the water and stop erosion.

## B. Surface Water

Surface water is the water from rain or snow that, before the trail was built, flowed in a sheet along the natural ground surface but is now cut off and channeled into the trail. This water will flow along the trail. This water will flow along the trail, and if allowed to accumulate above a certain critical combination for soil type, slope, and velocity will erode the trail surface.

The methods of diverting surface water are by outslope, grade dips, water bars, ditches, and by varying the trail grade when it is constructed. Intercepting ditches appropriately located above the trail in wet, swampy areas and led into the drainage structures located under the trail can also be used to advantage to minimize erosion on the trail.

## C. Subsurface Water

Perhaps the most troublesome drainage problem in trail construction is subsurface water. The best solution to extensive subsurface water on flat ground is to relocate the trail on the sidehill and bypass the trouble. If this is not practical, the next best solution is to lower the water table and permit the ground above to dry out sufficiently to support the trail loads. As a last resort, puncheon or corduroy construction should be used. In some cases, a drain ditch can be dug by hand to divert the water into a stream. In areas that are too wet for ordinary methods, it is possible to blast drainage ditches by using ditching powder. This method should be used only by men who have been properly trained and are certified in this type of work. Drainage ditches that can be left

open should be designed and built to provide continuous service without unusual maintenance. Perforated culverts or French drains may be used when open ditches are not practical (see Appendix).

Occasionally, trail construction on an apparently dry hillside will open up subsurface water in the form of springs. A small collection ditch that leads the water to a culvert under the tread will solve this drainage problem. A small amount of water is not objectionable if allowed to flow across the trail undisturbed, provided the trail base and tread will not become boggy.

#### D. Drainage Facilities

##### 1. Outslope

Outslope of the tread is probably the best method and the one most commonly used to divert surface water. This method requires periodic maintenance of the tread to prevent the formation of a rut and channel in the trail. Outslope should not exceed 1 inch in 18 inches. Outslope is most satisfactory when used in combination with grade dips.

##### 2. Grade Dips

Grade dips are sections of trail where a short piece of the trail, generally not over 5-6 feet, has been built with a grade slightly adverse to the prevailing grade of the trail (see Appendix). This prevents the flowing water from passing that point. The trail is outsloped at the low point in the dip to divert the water from the trail. Grade dips are

most satisfactory when they are built into the original construction, and the designed grade allows for the adverse grade. When grade dips are built into an existing trail, the upper portion generally is too steep for proper maintenance. Instead of building grade dips in an existing trail, it is customary to build water bars.

### 3. Water Bars

Water bars are generally made with an 8 to 10 inch diameter log laid at a 20 to 25 degree angle with the trail and fastened in place with heavy stakes, posts, or steel pins. Light rebars or wire mesh may be used for reinforcing if a soil cement installation is made. Well-embedded rock may be used if logs are not available (see Appendix).

Make the tread flush with the top of the log, downgrade from the water bar. Upgrade, make the tread approximately at the center of the log. Immediately above the water bar, slope the outer edge of the trail outward to permit release of the water.

Earthen water bars can also be constructed from the natural mineral soil located within the trail prism without benefit of rock, log, or other materials when the trail grade and surface runoff are moderate.

This type of water bar adapts itself to installation in a trail at the low undulating dip sections. Earthen water bars should not be constructed in unstable material when trail grades exceed 7 percent or on high-use horse trails.



#### 4. Culverts

Metal, wood, or rock culverts are one means of draining wet spots or passing small streams under the trail base. They must be adequately covered (minimum 12 inches) to avoid puncture, especially from shod horse traffic (see Appendix).

#### 5. French Drains

French drains consist of a systematically placed row of rocks, graduated in size, usually placed in a boggy or springlike water source, usually below the surface. This structure in effect collects the local water in the trail area and transmits it under the trail base, usually permitting a dry trail surface. If an adequate volume and graduated size of rock are available within a reasonable distance of the planned installation, the structure is a cheap and effective way to drain small, wet spots on the trail. To be effective, however, the drain must be on a gradient (2 percent minimum, more if drained area will permit) to permit gravity to assist in the drainage operation (see Appendix).

#### 6. Fords

Fords are generally selected rather than constructed, but there are times when some improvement of the stream channel is required to provide good footing. Often fords are necessary in conjunction with a bridge, with the bridge for foot use, and the ford for pack and saddlehorse use. Fords should not be used when the water is swift or the water depth exceeds 3 feet during the normal season of use. Safety of the user is a major concern in determining whether to use a ford or bridge.

In fast-moving streams, the tread across a ford often can be improved by pulling the larger rocks into a line across the stream parallel with the trail and below the downstream edge of the crossing. This allows sand and gravel to deposit above the barrier and develop a smooth, level tread. In slow-moving streams, move the larger rocks out of the way to improve footing for horses.

Construction of a ford consists of widening the trail base to a 36 inch minimum, removing large rocks, and leveling of the stream bottom to make a relatively smooth and level crossing for foot or horse traffic. Trail gradient into and out of a ford should be graded to keep the water from running down the trail (see Appendix).

## VI. STRUCTURES

The use of structures in the backcountry should be held to a minimum. Alternatives should be considered, including the economics of using native versus prefabricated materials. Transportation of materials by pack animals, duffel carriers, or helicopter is expensive. Hand methods of construction are normal, and the size and weight of pieces become important. Special designs may be necessary to facilitate transport and construction of the structure.

### A. Bridges

The basic difference between a horse and foot bridge is the load-carrying ability and width of the structure. Construction practices and procedures are normally the same. Several diagrams of typical bridges are included in the Appendix.

When native logs are used, the selection, preparation, and fabrication of the logs should be guided by the following:

Logs to be used as stringers for bridges should be carefully selected. All Stringer logs for any one span should match in diameter, taper, and inherent stiffness. They should be straight, sound, free of scars, cat faces, wind shake, splits, or other defects which might impair their strength.

High standard workmanship in the selection, fabrication, and fitting of logs can mean the difference between a short-lived and a long-lived bridge. Cut the logs 1 year in advance. In order to reduce checks, season them with the bark on and peel them immediately before use. During the seasoning period, set them on blocks to keep them from contact with the ground. Have adequate equipment on hand for moving and handling the logs and other timbers. Insist on careful fabrication. Allow no misfit joints and uneven bearing surfaces; these will detract materially from the life of the bridge.

Care must be exercised in the selection of a bridge site, that adequate foundation is obtained for abutments and stream piers when bridge span requires them. Adequate high water and debris clearance under the bridge stringer is also of major concern to the life and useful service of the structure.

Bridge structures should normally be located at right angles to the stream they cross.

When repairing or replacing corduroy, puncheon or bridges, the job is not complete until the replaced or unused material is properly disposed of. Old bridges, corduroy, etc., will not be left to rot in place and remain an eyesore to backcountry users for years to come. Any replaced or unused material should be hauled out of sight into a wooded area and allowed to "return to the ecosystem". Such replaced or unused material should not be allowed to remain in meadows or open areas; all nails, spikes, wire, etc., should be removed from the material and hauled out.

#### B. Retaining Walls

Retaining walls are structures of wood or stone designed to stabilize the trail base on a side-slope. Native logs should be used only if rock is not readily available and only when side-slopes do not exceed 50 percent. A solid foundation on earth or rock is a must to obtain a rigid, safe retaining wall (see Appendix).

The thickness of the rock 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 edge of trail should be at least 6 inches higher than the inside.

Only rocks which are sound, durable, and have a good bearing surface should be used. The largest rocks readily available that can be safely handled should be used in the body of a wall. Smaller rocks may be used for filling voids. Round rocks should not be used in a wall.

Joints in walls should always be staggered at least 6 inches or more horizontally from the adjacent joint in the next course. At least one-fourth of the front and rear faces of the wall should be headers having a length at least two and one-half times their thickness. All projecting points should be removed from top and bottom of main rocks so that each is laid with good bearing on the broadest face. All headers must be laid with their greatest dimension extending into the wall and never parallel to it except at corners. Here, alternating headers should cross. The outer face of the wall should have an inward slope of at least 3 inches to every foot of height. The wall should have a front and rear face well tied together with header stones of suitable size.

Drainage should be provided around, beneath or through the retaining wall so that water cannot accumulate behind it.

# ***OPERATION GUIDELINES***

## OPERATION GUIDELINES

### I. SIGNING

#### A. Regulatory, Warning, and Guide Signs

Sign planning and procurement shall be through the District Ranger, who will follow approved signing requirements. All sign installations will be made with the full knowledge of the District Ranger, who will be aware of the type of use and the season of use on the trail.

#### 1. Types

There are three classifications of signs:

- a. Regulatory signs give notice of laws or regulations such as "Trail open to foot traffic only."
- b. Warning signs call attention to conditions on or adjacent to a trail that are potentially hazardous to traffic, such as "Bear Warnings".
- c. Guide signs show directions, destinations, distances, and identify features. Included in this classification are markers, but because of their special significance on trails, they will be discussed separately.

#### 2. Location

The principal sign placement points are:

- a. Trailheads
- b. Hazards
- c. Intersections
- d. Major topographic features shown on maps, particularly those that are destination points.
- e. Facilities such as campsites.
- f. Interpretive sites.

### 3. Installation

Install signs so that the message can be easily detected and read by the user while keeping it within the visual scale of its surroundings. On summer hiking trails, a mounting height of 4 feet and placement at the clearing limits are standard. Where heavy winter use is expected, a minimum mounting height of 6 feet is desired. Signs should be mounted on posts. Face directional signs toward traffic; feature identification signs may be placed parallel to the trail.

Posts should be securely set into the ground at a depth of 2 1/2 to 3 feet. It is preferable to use fasteners such as galvanized carriage bolts to aid removal for maintenance. Do not use trees as signposts (see Markers for exception), and do not attempt to anchor signs by piling rocks around the post.

### B. Trail Markers

Markers are a series of symbols designed to reassure the trail traveler. Markers convey their message through the use of a standard shape, size, and color. They are designed to be a low cost supplement to other signing.

#### 1. Types

There are two types of markers: Trail tags and cairns. The system used, except for rock cairns, should be consistent for the full length of the trail. The rectangular shaped trailblazer is the standard National Park Service marker.

#### 2. Location

Location markers immediately beyond crossing of roads or streams where the route



is not readily discernible and as reassurance when other signing is widely spaced.

### 3. Installation

In contrast to other signing, markers should be mounted on natural objects and, except for rock cairns, be at least 8' above the ground. When a tree is used for mounting, it is preferable that the tree be at least twice as wide as the marker.

Cairns are typically used in alpine areas where vegetation is low to the ground, and the maintenance cost of post mounts is high.

Cairns should be constructed to resist extreme weather conditions and be intervisible and recognizable at a distance of 300 feet. paint or other delineators are not to be used with cairns.

## II. MAINTENANCE

Maintenance is the upkeep of the entire trail facility as is necessary for its safe, efficient utilization and to maintain its originally constructed standard. The type of the trail determines what level of maintenance work is required. Maintenance must provide for: (1) protecting the adjacent resources and safety of the user; (2) preserving the investment in the trail itself; (3) user convenience.

Available time is always critical in mountain trail maintenance. There are usually more miles to cover than can be worked into short

summer periods. Consequently, it is important that maintenance personnel understand why they are maintaining a particular section of trail, and that they perform only those maintenance activities needed to satisfy the objective. Although mountain trails have varied origins - from game trails to wagon roads - maintenance should be based on what the trail will be used for in the immediate future.

#### A. Maintenance Activities by Type of Trail

##### 1. Major Trails - Type A

Routes marked, improved, and maintained for foot and horseback traffic. The main trail through an area of the park reaching many of the main attractions and serving as a terminus for many of the minor and wilderness trails. A developed trail with necessary bridges, corduroy, drainage, gradients, 36" maximum tread, etc. Trails in the type are to have priority for maintenance.

##### 2. Minor Trails - Type B

Routes marked, improved and maintained to accommodate foot and horseback traffic, but of an overall lower construction standard. A maximum 24" tread, these trails will serve special scenic areas, fishing trails, study area access, protection and management trails, etc. Many of these will have their termini on Major - Type A trails and roadways. The tread does not have to meet the maximum standard, and in general will be limited to the space required to form a single file of foot or horse travelers, except on grades where the maximum is justified.

##### 3. Wilderness Trails - Type C

Routes will be marked, but unimproved except for clearing and some work on dangerous areas.

These trails will be used by experienced wilderness travelers, for fire suppression, and administrative use only.

#### 4. Walks - Type D

Although classed as trails, this type trail will not be discussed as to type of construction and maintenance in this handbook. This class includes sidewalks, boardwalks, bituminous surfaced, etc., interconnecting developed areas, short scenic walks or nature interpretive trails. These represent foot travel only on high standard construction.

### III. CAMP AREAS & PATROL CABIN USE

Patrol cabin use is restricted to official use only. Due to their location, and to the management necessary in certain backcountry areas, a few patrol cabins are used most of the summer and some of the fall season for administrative needs, which precludes their use. When patrol cabins are to be used by trail maintenance personnel, every effort will be made to make prior plans with the district ranger for that particular area.

When used, the crew leader will register the date of arrival and departure. That person shall also register any information about defective equipment or maintenance needs to help the district ranger maintain the cabin in satisfactory condition.

Do not picket horses around or near cabins as this leads to overgrazing and sign of heavy impact. Do not tie stock to trees for any length of time as this leads to girdling of the tree trunk and digging away of soil, exposing and damaging roots. Upon departure

from the cabin, manure in the vicinity should be scattered and any scuffing from stock tied to trées should be renaturalized.

Except in emergency conditions, the staples stored in patrol cabins will not be used.

When a patrol cabin is vacated, the crew leader must personally see that the cabin is thoroughly cleaned, that an adequate supply of cut wood is left behind, and that the cabin environment is left in such a manner that only your footprints remain behind. Routine preventative maintenance will be given where needed, and all litter will be packed out.

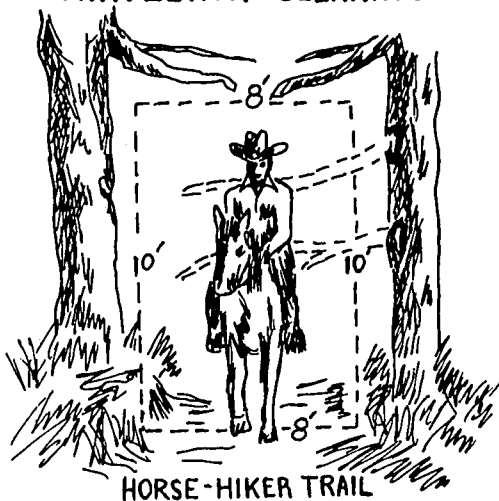
When camps have to be established to remain within a reasonable distance from work, the campsites will be established away from designated through-trails a minimum of 200 yards, and from designated backcountry campsites a minimum of one-quarter a mile. Campsites must be kept in an orderly and clean condition. All litter must be disposed of in accordance with methods developed by the district ranger. Pack and riding stock will not be kept near these campsites.

#### IV. BEAR AWARENESS

Due to the large population of black and grizzly bear in Yellowstone, great efforts will be made to maintain clean campsites and work areas. Crew leaders shall make every effort to orient crew members in the proper methods of living and working within bear country. Cleanliness in all endeavors is of prime concern.

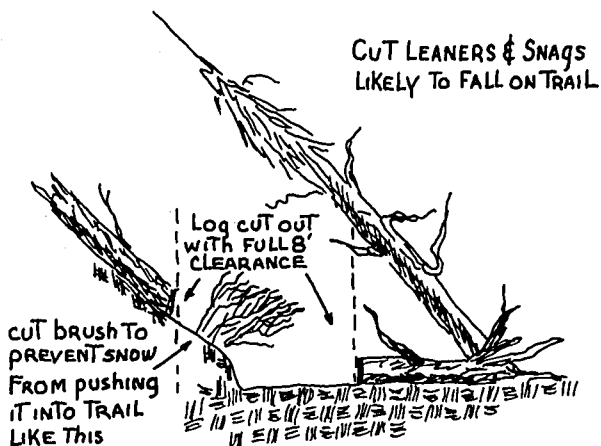
# ***DIAGRAMS***

# TRAVELWAY CLEARING





**FOR SAFETY  
REMOVE ALL LEANERS**



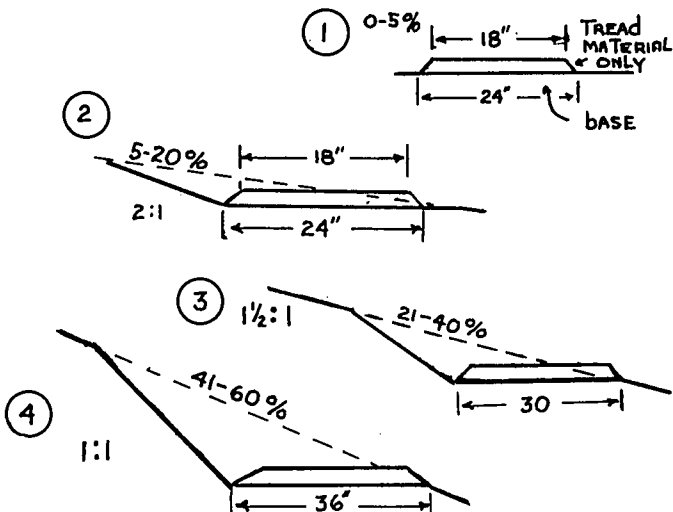
## GOOD CLEARING PRACTICE

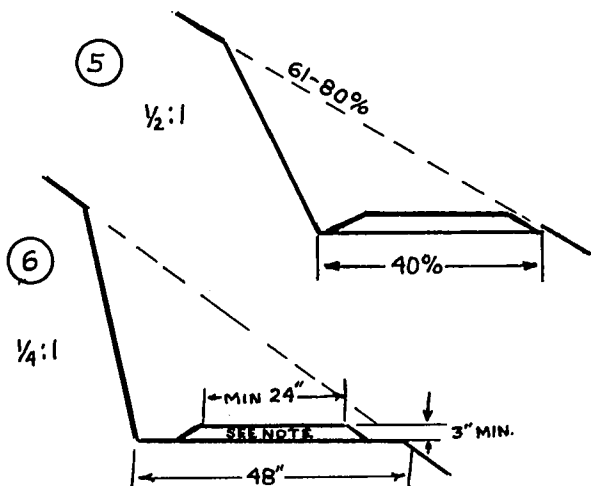


# TYPICAL TRAIL BASE CROSS SECTION

## DIAGRAM

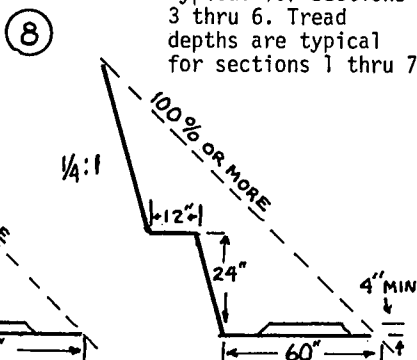
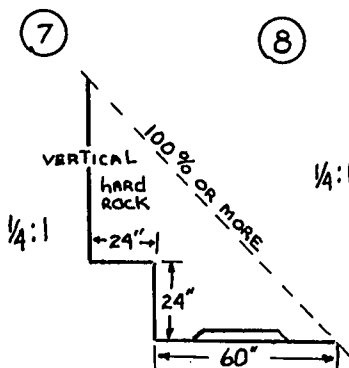
1. Minimum base widths are in native material when slope exceeds 20%.
2. Sections 1-8 are applicable to all-purpose trails. Sections 1-6 are applicable to hiker trails. Minimum base width of hiker trails will be 48 inches when sideslope is above 100%.



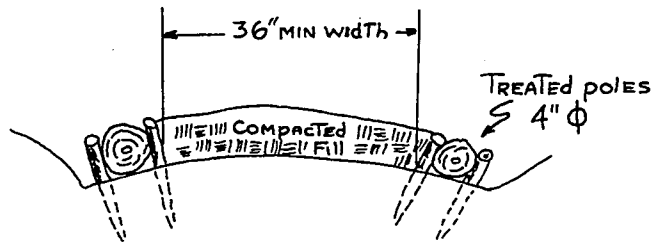


NOTE:

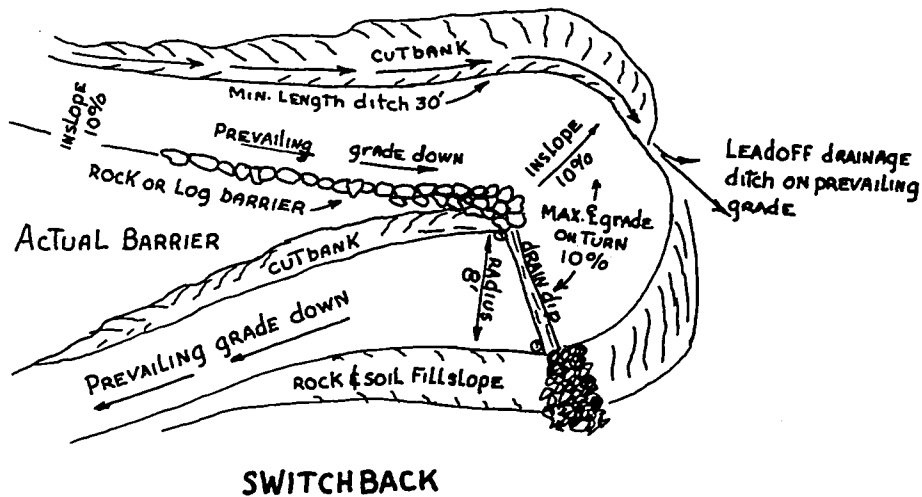
Tread widths are typical for sections 3 thru 6. Tread depths are typical for sections 1 thru 7

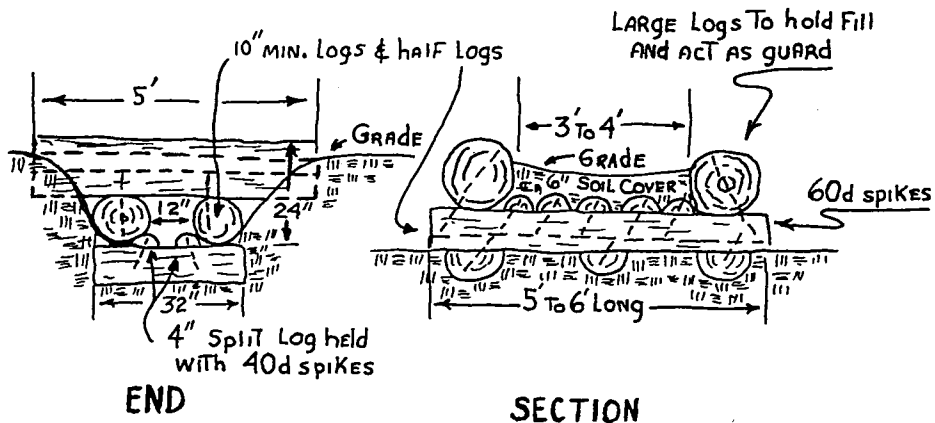


TREAD & BASE WIDTHS  
FOR HAZARDOUS SLOPES



TURN-PIKE SECTION

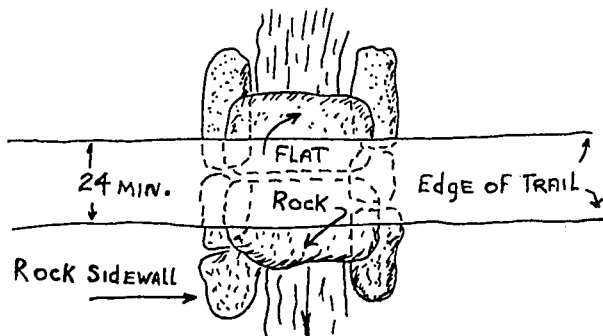




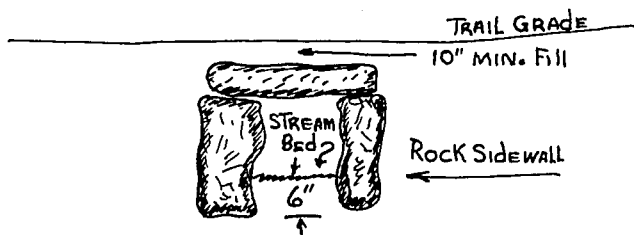
END

SECTION

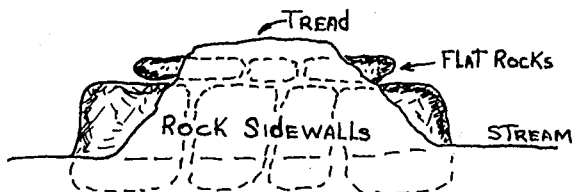
LOG CULVERT



**PLAN**



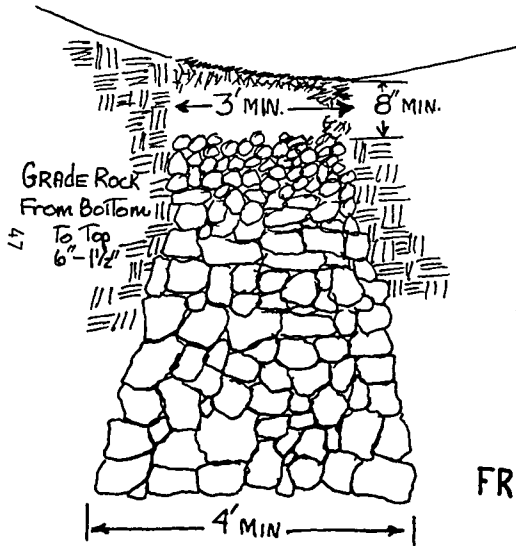
**ELEVATION**



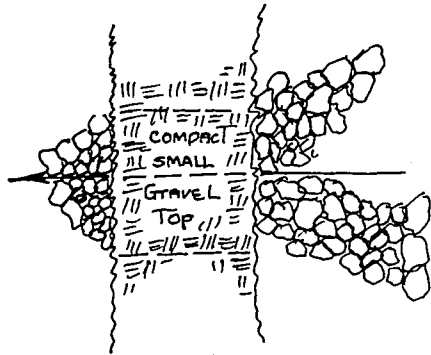
**CROSS SECTION**

## TYPICAL ROCK CULVERT

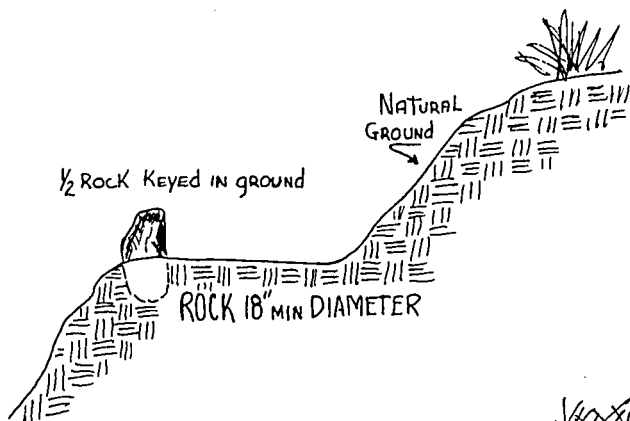
# SECTION



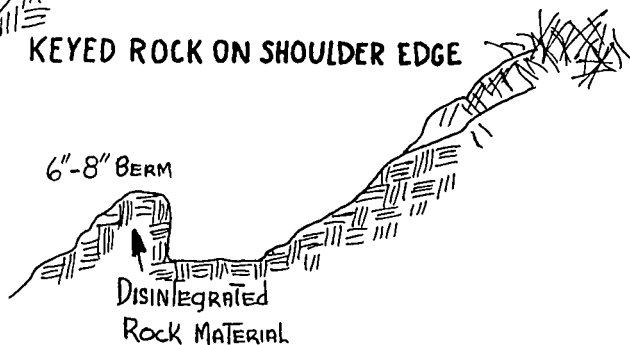
# PLAN



# FRENCH DRAIN

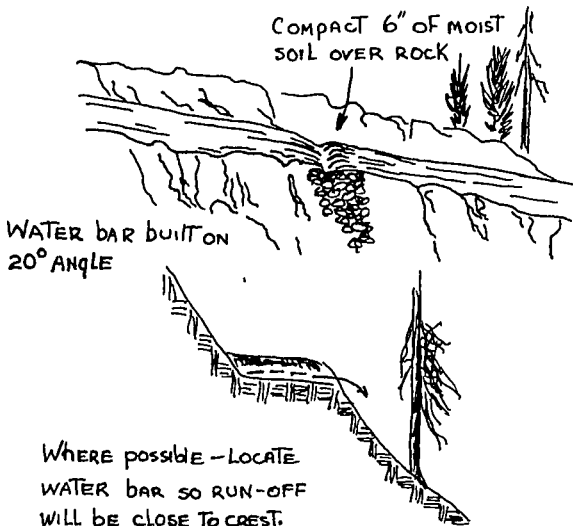


### **KEYED ROCK ON SHOULDER EDGE**

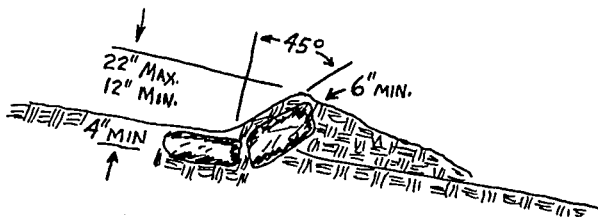


### **BERM-SURFACE DRAINAGE**

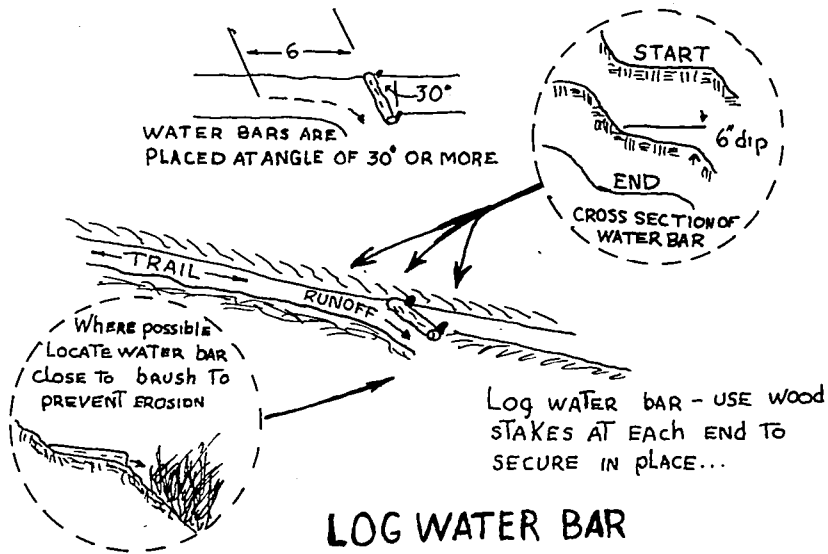


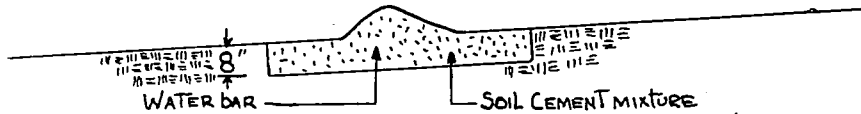


## WATER BAR



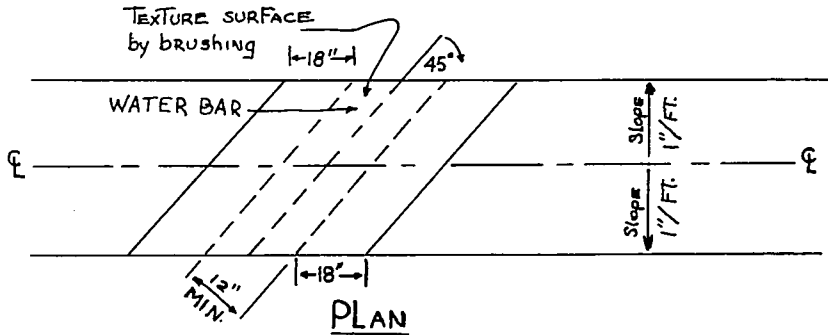
## ROCK WATER BAR





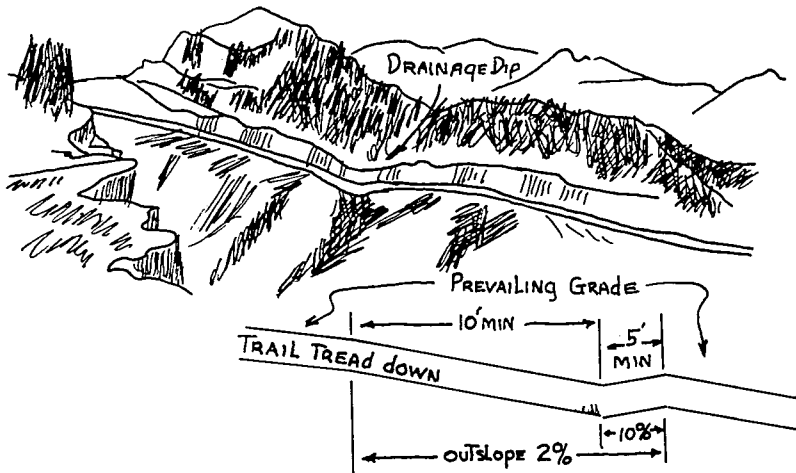
LONGITUDINAL SECTION ON CENTERLINE

NOTE: USE WATER BAR IN AREAS WHERE TRAIL SURFACE IS LOOSE GRAVEL OR A SOIL CEMENT MIX. DO NOT USE IF CENTER LINE GRADE EXCEEDS 5%



PLAN

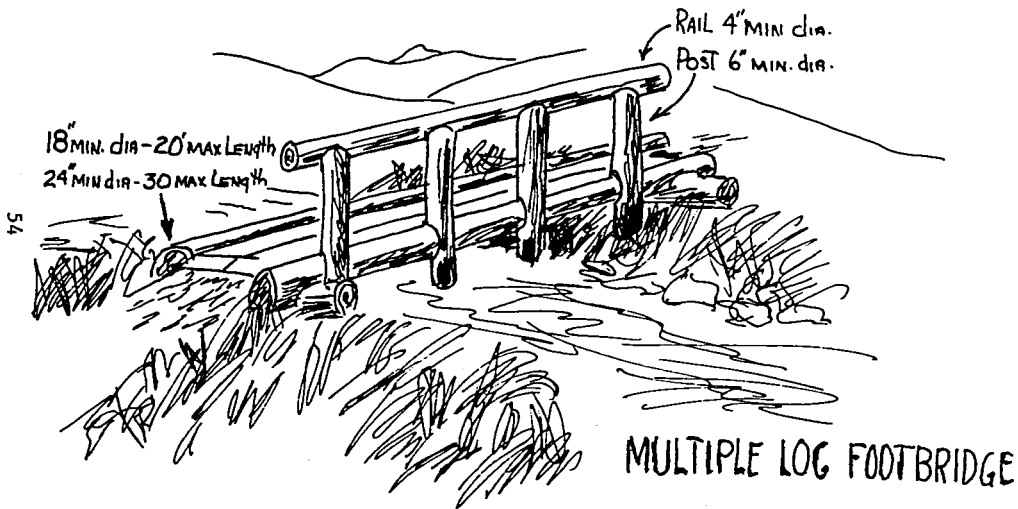
## DRAINAGE DIP DIMENSION



### WATER BAR SPACING GUIDE

<u>Trail Grade %</u>	<u>Max. Spacing - Ft.</u>
6	600
7	500
8	400
10	300
12	200
15	100

Allow for stability of soil type (characteristics that influence erosion), precipitation, and height and steepness of slope above trail in deciding on spacing of water bars.

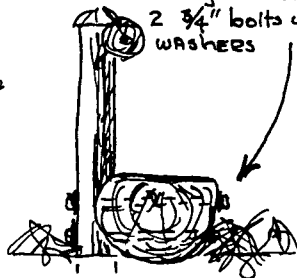
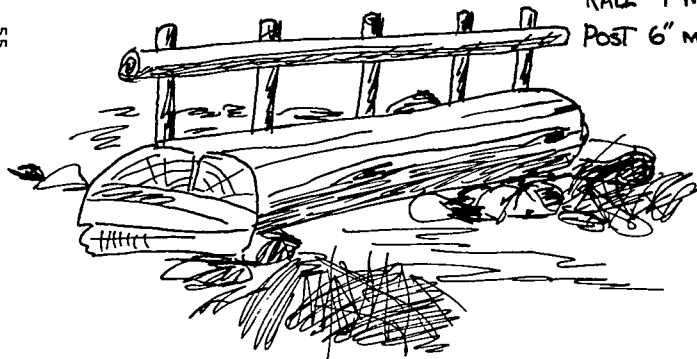


# SINGLE LOG FOOTBRIDGE

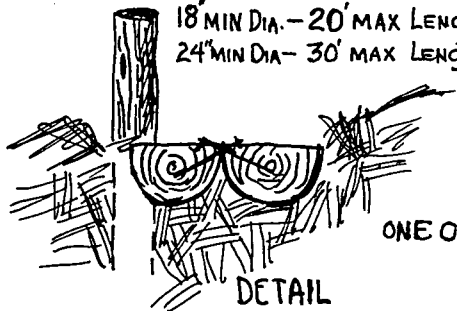
30" MIN DIA - 20' MAX LENGTH  
36" MIN DIA - 30' MAX LENGTH

RAIL 4" MIN DIA  
POST 6" MIN DIA

POSTS 5' INTERVALS  
ANCHORED TO  
STRINGERS WITH  
2  $\frac{3}{4}$ " BOLTS WITH  
WASHERS

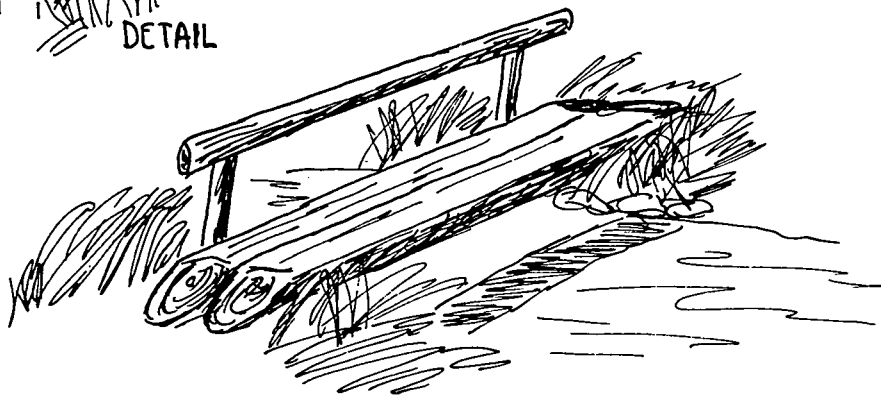


18' MIN DIA. - 20' MAX LENGTH  
24" MIN DIA - 30' MAX LENGTH



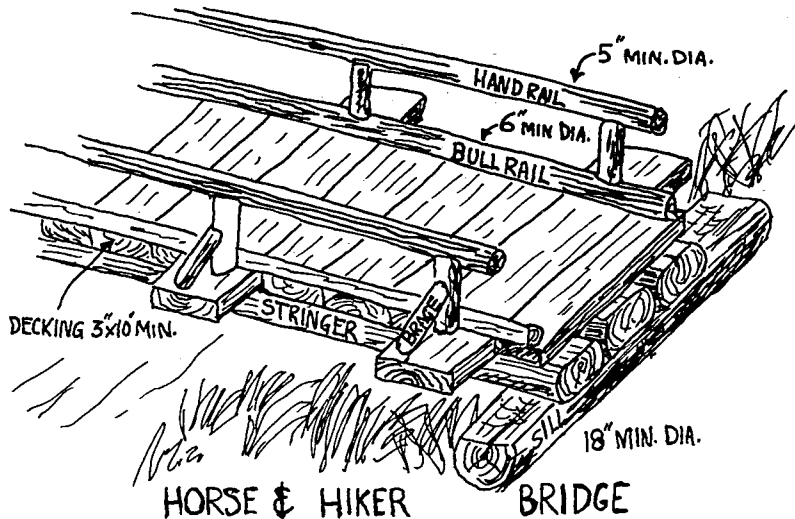
ONE OR TWO LOGS

DETAIL



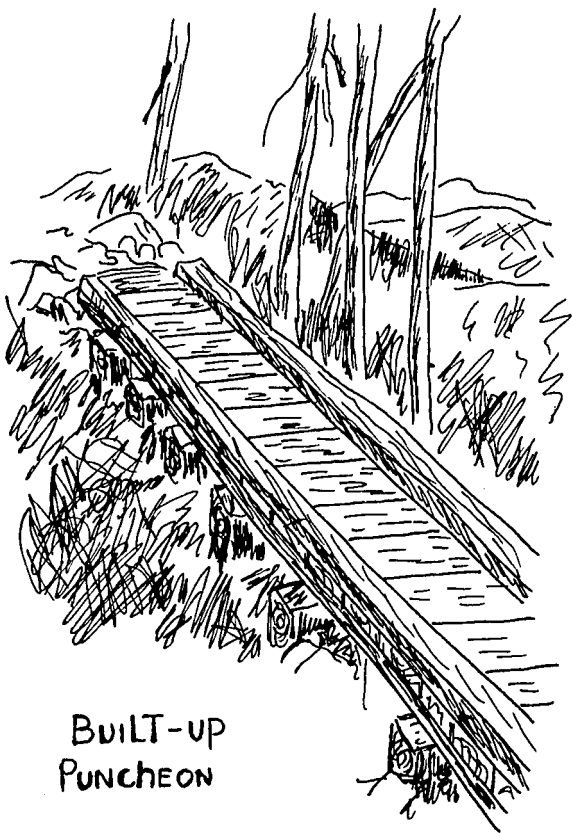


18" MIN. DIA. - 20' MAX. SPAN } STRINGERS  
 30" MIN. DIA. 30' MAX. SPAN }

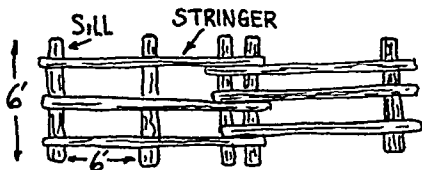


HORSE & HIKER

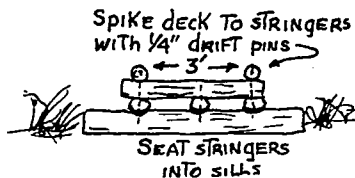
BRIDGE



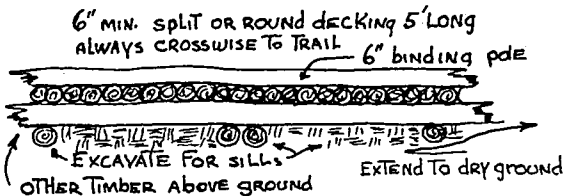
BUILT-UP  
PUNCHEON



LAY STRINGER ENDS SIDE BY SIDE  
AT JOINTS - ON DOUBLE MUD SILLS  
STRINGERS & SILLS AT LEAST  
10" IN DIAMETER - PEEL ALL LOGS.

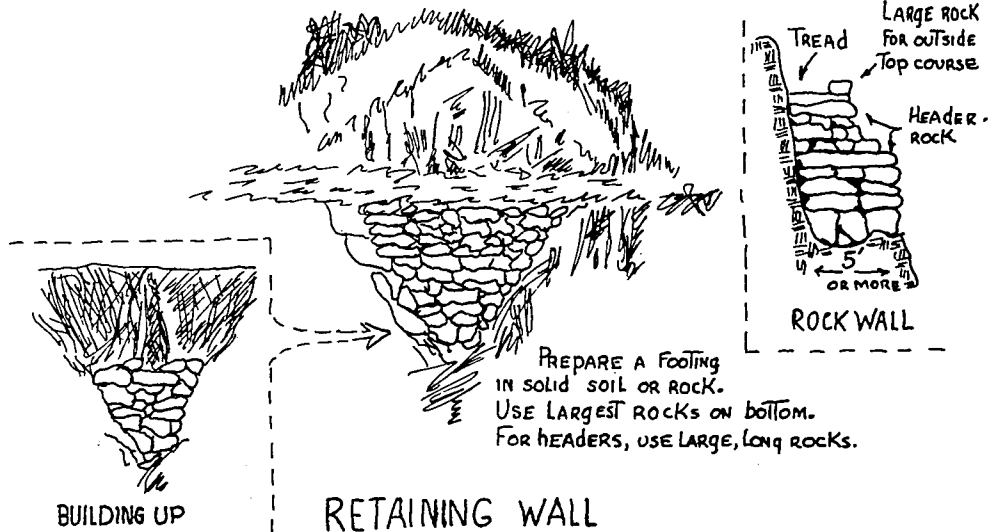


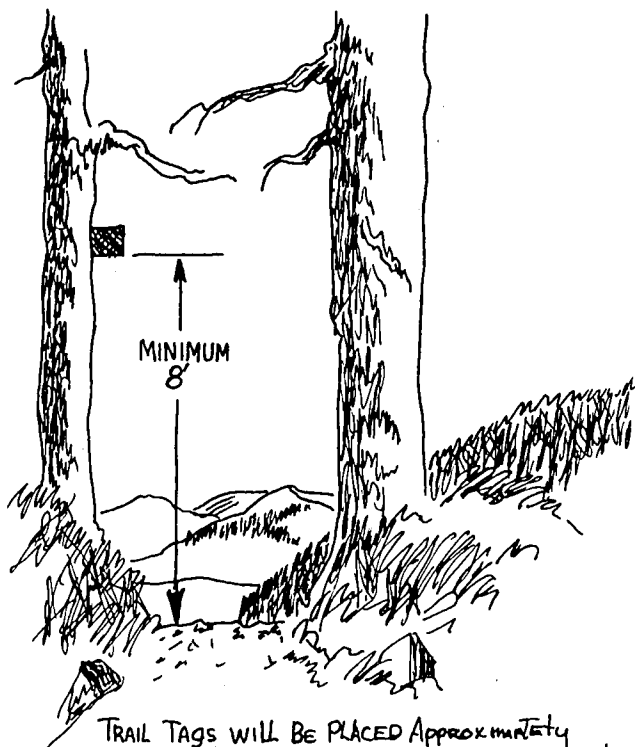
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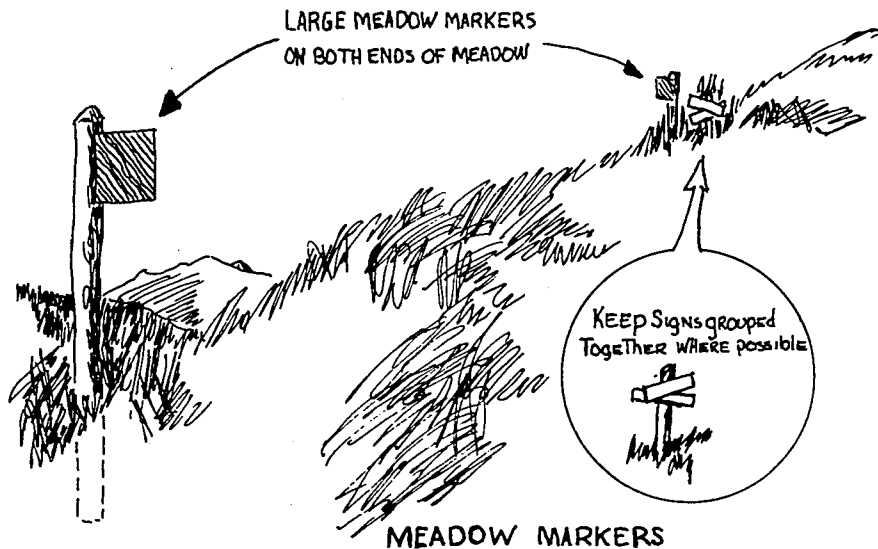
SIDE

CORDOUROY





TRAIL TAGS WILL BE PLACED APPROXIMATELY 8 FEET ABOVE THE SIDE OF THE TRAIL TREAD, NAILED TO THE SIDE OF THE TREE WITH 2 (TWO) NAILS. THEY WILL BE ADEQUATE IN NUMBER TO BE SEEN FROM ONE TAG TO THE NEXT, BUT USED SPARINGLY.



# ***HAND TOOLS***

## HANDTOOLS

Handtools and equipment most commonly used for trail construction and maintenance are:

Abney Hand Level	Graduated in degrees and percent, with carrying case.
Axes (with protector sheaths)	Double bit, Western style, 3 1/2 lb. or 4 1/2 lb. head with 34" or 36" wood handle.  Single bit, 2 1/2 lb. or 3 1/2 lb. head.
Bars	Digging - 1 1/8" x 6' Prying - 1 1/2" x 6' thickened, broad chisel end.
Blasting Machine	Galvanometer and related equipment. Blasting equipment and work will be provided and performed by a certified National Park Service blaster.
Canteen, Water	4 quart plastic, with carrying strap and chained screw cap.
File	Flat mill bastard, 8" x 10" length, with wood handle and leather or rubber belting protection disk.
Flagging	Vinyl plastic - orange, red, yellow, etc., 1 3/16" width.



Hammers	Carpenter, claw; sledge, 8-10-12 lb. head, wood handle.
Hard Hats	Meet ANSI and OSHA standards, with elastic chin strap.
Marking Crayon Holder	Use with carbon black, lumber marking crayon.
McLeod Tool	Used as grubbing and raking tool.
Measuring Wheel	Dual counter, heavy duty.
Pack	Sack, canvas, waterproof, olive drab, 6 1/2" x 14" x 17".
Picks	Contractors, point and chisel ends, wood handle. Mattock, point and broad ends, wood handle.
Pliers	Fence, heavy duty, 10" length, with prong and hammer heads. Linemen's side cutter, 8", plain handle.
Pulaski Tool	4 1/4 lb. head, wood handle, used for grubbing.
Saws	1 man cross cut; 2 man cross cut; pruning saw, hand; pruning saw pole, 8" length.
Sharpening Stones	Axes, 5/8" x 3" diameter minimum, round shape, two-grit stone.

Shovel	Round point, "0" or No. 1, long wood handle.
Tape	Engineers, 100' metallic with case.
Wedges	Wood - used to secure handles on axe, pulaski, picks, mat-tacks. Steel - for use in felling and splitting.

NOTE: Tools can be dangerous. Handle them carefully. To be effective, they must be kept in good working condition. Use the proper tool for a specific job.

# ***GLOSSARY***

## GLOSSARY

Abutment (Bridge)	The foundation at either extreme end of a bridge that supports the sill, stringers, and deck structure.
Backslope	The cut bank formed by the excavation extending upward from the tread.
Base	The primary excavated bed of a trail upon which the tread or finished surface lies.
Berm	The ridge of dirt or rocks placed on the outside edge of the trail base.
Blaze	A standard trail mark cut into the bark of a tree with an axe to designate the trail location.
Classification	The general designation indicating the standard of a trail.
Maintenance Activity	A specific type of work that is carried out to keep a trail in its originally constructed serviceable standard.
Maintenance Level	The degree to which each maintenance activity must be performed to satisfy the purpose and the safe use of the trail.
Cairn	A constructed mound of rock located adjacent to a trail. Used in open alpine areas.

Deck or Flooring	That part of a structure which provides direct support for trail traffic.
Dip	A reverse in the grade of the trail accompanied by an angling outslope which will divert water off the trail.
Drainage, cross	Running water in swamps, springs, creeks, drainages, or draws which the trail must cross.
Drainage, surface	Rain or snow runoff from the surface of the tread.
Ford	A natural stream crossing improved sufficiently for use by saddle or pack animals.
Grade, maximum	The steepest grade permitted on any part of the trail.
Header	A long, uniform stone laid with its end toward the face of a retaining wall or crib used intermittently to structurally tie-in the other rocks laid in the wall.
Outsloping	A method of base grading which leaves the outside edge of the trail lower than the inside.
Pier (Bridge)	Intermediate bridge supports located between two adjacent bridge spans.

Run Plank	Plank laid lengthwise on top of bridge decking used as the tread surface.
Sideslope	The natural slope of the ground measured at right angles to the centerline of the trail.
Sill	The crosswise member at the top of a pier or abutment that supports the stringers.
Specifications	The standard of workmanship and type of materials for all component parts of the trail base, trail tread, clearing, grade, bridge, culvert, puncheon, etc.
Stakes, grade & slope	Stakes set by the locator to establish the elevation and cross section of the completed tread.
Stakes, line	Stakes set by the locator to establish the centerline of the trail.
Station	One hundred feet measured along the centerline of the trail.
Stringer	The lengthwise member of a structure that supports the deck.
Switchback	A sharp curve in the trail, used on hillsides to reverse the direction of travel and to gain elevation.

Trail Tag	A rectangular-shaped, orange marker 3 inches by 5 inches in size used to identify the trail location and located on tree or post adjacent to the trail.
Tread	The surface portion of the trail upon which the traffic moves excluding backslope, ditch and shoulder.
Turnout	A place where the trail is widened to permit trail traffic traveling in opposite directions to pass.
Water Bar	A device for turning water off the trail, usually made of logs, stones, soil cement, or by contouring the native material within the trail prism.

# ***NOTES***









