Instructor Planning Guide

Course 203. Waterbars and Checks

Intended for someone who has taken 201 Drainage Design and Drain Dips and/or has considerable experience doing drainage work. Where earthen rolling drain dips are not feasible, drainage features are sometimes armored using rock or log. Learn contemporary techniques to build water bars. The class will include a review of “old school” waterbars, and how to convert “old school” waterbars to a more effective design. Furthermore, learn how to install rock and log checks where tread is gullied and cannot be drained, or in other situations requiring tread armoring.

STUDENT SKILL OUTCOMES:

- Understanding of ideal logs and rocks for constructing effective waterbars and checks.
- Safe peeling and transport of logs.
- Safe quarrying and transport of rock, especially safe use of rock bars.
- Understanding of where to locate waterbars and checks.
- Ability to reconstruct “old school” waterbars.
- Developing “Trail Eyes” and ability to “Think like Water.”

KEY TERMS:

“old school” waterbar, log waterbar, rock waterbar, check dam, leverage, rock shopping, rowing rocks, rock crush, guide rocks, apron, ramp, backramp, outfall ditch, drain dip

TRAIL MAXIMS:

“Learn to see water flowing down the trail, even on a sunny day.” “Think like water.”: “Give me a lever long enough, and I can move the world” --Archimedes; “Better to slide it than roll it; better to roll it than carry it; and don’t carry it alone.”

TOOLS NEEDED PER 8 STUDENTS:

1 clinometer, 1 fire shovel, 2 McLeods, 1 adze hoe, 2 Pulaskis, 1 pick mattock, 2 small chisel-tipped rock bar, 1 tamping bar, 1 rheinhard, 2 five-gallon bucket or canvas dirt bag, 1 heavy sledge hammer, 1 light sledge hammer, 1 rock stretcher or rock sling (if available), 1 webbing sling or log carrier. Tennis ball or orange.

WORK SITE REQUIREMENTS:

One half mile section of trail, ideally near a trailhead, in need of waterbars, with nearby suitable logs and rocks. Ideally a trail that allows horses and has grades of 10-20% to justify installation of waterbars. The site should also have at least 50 feet of gullied or eroding tread for which checks are an appropriate fix. If there are some old school waterbars in need of upgrading, so much the better. For this class it is important to teach techniques for both log and rock. If you don’t have one of these materials at your site, consider importing, or changing sites.

KEY CONCEPTS:

1) Safety Documents and Concerns:
   - Personal Protective equipment (PPE), Job Hazard Analysis (JHA), Tailgate Safety Session (TSS), Emergency Action Plan (EAP)
2) Trail Crew Leave No Trace: Have a positive impact on the land through trail work and be sensitive to off trail and camping impacts.
3) Proper/ Improper Tool Care and Use:
   - Fire shovel, McLeod, adze hoe, Rheinhard, Pulaski, pick mattock, rock/ tamping bar, heavy/ light sledge
4) Hillside Hydrology/ How Trails Work:
   - Effects of water in diverse soil types
   - Trail design/ tread and drainage structures
5) Developing “Trail Eyes”:
   - Suggest hiking in rain to better understand water on trails
   - Notice every drainage, even disappearing ones
6) Locating New Waterbar Sites:
   - Locate areas of erosion, fix any existing drainages, reevaluate
   - Berm and slough removal versus new drainage structure
   - Trail conditions for new waterbar versus rolling drain dip)
     – Grade greater than 10%, moist durable

soil, avoid top/ bottom of hill
  - Spacing between drainages determined by grade, soil, volume of water
- Choose log or rock waterbar based on native resources
  - If possible use rock first, more durable

7) Constructing New Waterbars
- Materials
  - Log: have certified sawyer fall a green tree 10-12” diameter > measure it out, cut it, peel off bark
  - Rock: safely quarry and transport rocks > box shaped rocks with flat sides are ideal
- Build a broad gradual apron
  - 15% or greater outslope to help self clean
- Bury bar completely so top is level with original trail surface
  - Set at 45 degrees at high point of backramp, less/ more angle to match force of water
- Excavate a 24” wide outfall ditch
  - Extend below tread as far as you need to keep water off trail
- Entire structure, including ramp, apron, and backramp, should be at least 20 ft long.
- Convert “old school” waterbars to newer design
- Pack soil VERY well
- Test drainage with tennis ball

8) Checks are for retaining tread in less than ideal conditions
- May be appropriate for:
  - Gullied tread, especially if fall line and not drainable
  - Unstable or steep tread

9) Materials: rock or log, same instructions as for waterbars

10) Setting Checks
- Perpendicular to the tread, level across top
- Space at least 6’ apart to match gait of horse
- Bury rock or log about half its height
- Rise not to exceed 6-8”
- Embed ends into banks
- Secure rock or log so it does not wiggle
- Backfill with crushed rock
- Flank each step with guide rocks or rip rap

11) Any fill material needed should be mined carefully

12) Report Work Promptly

BACKGROUND

Hillside Hydrology **and How Trails (are supposed to) Work**

Water from rain, melting snow and seeps is a major threat to trails. In a perfect trail world, water traveling down a hillside encounters a trail with good ***outslope*** and immediately crosses the trail and continues down the hillside without causing any ***erosion*** of the trail ***tread***. In the worst case, hillside water flow is interrupted and follows the trail instead. As the water gains volume and speed on steep ***grades***, it erodes a trail into a deep gully filled with rocks and roots left behind after the soil has been carried away.

This can happen all at once in a major storm event, or slowly over years due to a lack of trail maintenance. Regardless, the outcome is the same: a trail difficult to use and sediment carried downhill, often into streams causing habitat damage. Such a trail needs major reconstruction or to be abandoned. But it doesn’t need to happen, if trail workers prevent it; and that is the objective of this class.

In a more typical world of trails, diverse circumstances cause tread erosion in varying amounts. Trails in soft soils, and especially on steep grades, are at most risk of erosion. In such conditions, trail users (hikers and horses on the PCT) loosen tread soil as they walk. When water comes along (and to a lesser extent wind), the loosened soil is carried away leaving a concave or ***cupped tread***. Simple compaction of soft soils exacerbates cupping.

Some of the loosened soil is moved to the downhill side of the tread, where combined with leaves and needles, it forms a ***berm***. Berm by itself, or combined with cupped tread, disrupts the outslope of ideal tread and prevents water from leaving the trail.

The same process that forms berm happens on the uphill side of the tread, often exacerbated by additional material falling onto the trail from the ***backslope***, creating what is called ***slough***.

Water moves faster on steeper trail grades, giving it more force and thus eroding more soil. Greater water volume also increases the amount of soil that can be moved. To protect a trail from erosion one or more of three things need to happen: 1) reduce the amount of water running down a trail; 2) reduce the speed of the water moving down a trail; and 3) reduce the erosive force of users' feet loosening the soil.

The best way to achieve these objectives is by good ***trail design*** and construction, whereby a new trail is built with modest grades (less than 15%), passing only through durable soils, and includes ***grade reversals*** at regular intervals that naturally shed water (http://www.imba.com/resources/trail_building/up_down.html). In addition, such an ideal trail is well constructed to precise standards with generous outslope on a well-compacted full ***bench*** (http://www.imba.com/resources/trail_building/contour.html).

Alas, because many trails had unskilled designers and poor construction and/or maintenance, today trail volunteers often must work on trails with erosion problems. To remedy such problems the two most common solutions are to construct either earthen ***drain dips*** (aka rolling grade dips) (http://www.imba.com/resources/trail_building/gradedips_2.html) or modern style ***waterbars*** made of rocks or with a log.

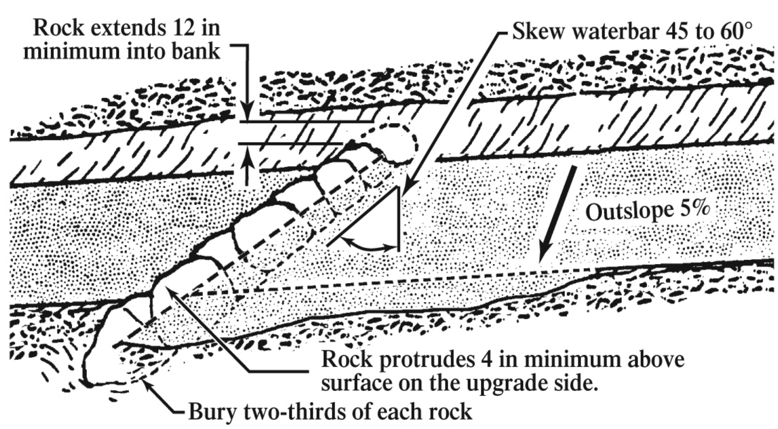
It is important for students to understand that the natural aging process of trails requires vigilant maintenance. If neglected, the problems will only grow worse and require major reconstruction or decommissioning the trail. In some cases poor design, construction and maintenance have exacerbated such problems. This all adds up to trail workers facing much work to do to improve tread and prevent further erosion. But that gives us lots to do!

PCT volunteers need to identify the portions of their trail section that need the most drainage work and regularly give them special attention.

Quality Work

Waterbars have been built for decades and until recently were constructed so that running water was deflected off the trail by directly hitting the rock or log bar. It is still common to see such outdated drainage structures, which PCTA calls "***old school" waterbars***. Their design flaws include: 1) they fill with sediment rapidly; 2) the exposed bars are damaged by horses; and 3) the bars are often eroded out completely; and 4) they are abrupt, detracting from users trail experience and sometimes causing them to leave the trail to avoid them.

Figure 1. "Old School" rock water bar. (Image courtesy of the USFS)



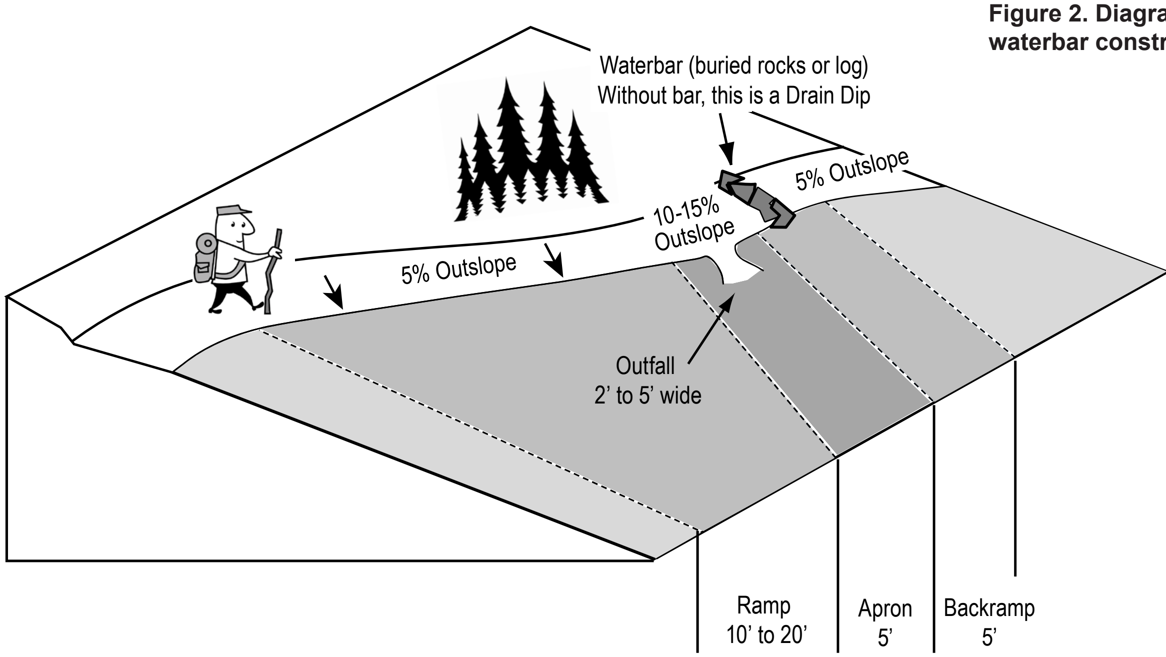
Contemporary waterbar design favored by PCTA is a broad earthen ***drain dip***, reinforced at the the high point of the ***backramp*** with a completely buried log or line of tightly fitted large rocks. See diagrams and "Key Concepts" above for drain dip and waterbar specifications.

The faster water moves on steeper trail grades, the more force it has and thus the more soil it can erode. Greater water volume also increases the amount of soil that can be moved. Waterbars are built at angles appropriate for the speed and quantity of water that regularly runs on the trail. Modest water flows need only a 30 degree angle. Greater flows suggest 45 or greater angles.

In this class, students should learn how to install both rock and log waterbars. Since rock waterbars can be more technical, you'll probably want to devote more time to them.

Log Waterbar: Have a PCTA or Forest Service employee fall green trees 10-12" diameter of the most durable species available. Peel them using drawknives or any sharp tool (even a shovel works in a

Figure 2. Diagram of modern waterbar construction



pinch). Peeling is most easily done in the spring when sap is rising strongly in trees. Trees should be felled out of sight from the trail, peeled, measured and cut in the same place and then carried or dragged to the waterbar site using a log carrier or a sling wrapped around the log. All scraps and peelings should be scattered out of sight from the trail.

Dig a ditch in which to set the log bar, ONLY as wide and deep as needed for the log you have selected. If on a side hill, make sure that the ditch goes into the backslope. This allows stable compacted soil to hold the log firmly in place. If for some reason the ditch ends up too deep or wide, use small rocks or ***rock crush*** packed in with a sledge or tamping bar so that the log bar DOES NOT MOVE. Remember, the top of the log should be no higher than the original surface of the trail, maybe a couple inches lower. This can be assessed using a shovel handle or pole laid across the trail from edge to edge.

Old school log waterbars were staked with wooden pegs driven on either side of both ends of the log, and sometimes wired together. This is no longer done as the log bar is no longer exposed to eroding water. In some rare situations rebar is driven through a pre-drilled hole in the log and deep into the ground. Generally, a well set log bar will be stable simply from the compacted earth around it. Wooden stakes can be used if there is concern over the bar's stability however. A large rock on top of the uphill end of the log, set in the ***backslope*** of the trail, and/or another large rock at the downhill end of the log can also be used to secure the bar.

Rock Waterbar: Selecting rocks for waterbars takes patience and persistence. Large (approximately 75 lbs.), box shaped rocks with flat sides are ideal. Look for rocks uphill or to the side of the trail. Only look downhill if there are no other options and you have a rock carrier or rigging. Dig a ditch in which to set the bar rocks, ONLY as wide and deep as needed for the rocks you have selected. This allows stable compacted soil to hold the rocks firmly in place. If for some reason the ditch ends up too deep or wide, use smaller rocks or ***rock crush*** packed in with a sledge or tamping bar so that the rocks making up the bar DO NOT MOVE, even when you dance a jig on them. Remember, the top of the rocks should be no higher than the original surface of the trail, maybe a couple inches lower. This can be assessed using a shovel handle or pole laid across the trail from edge to edge.

The rocks needed to do quality rock work are usually too big to lift safely, even with two people. It is essential for rock workers to learn how to move rock without straining or smashing body parts.

All excavation and ramping for waterbars should be very gradual so users hardly notice the drainage structure as they walk through it. Sculpt the structures so water exits with increasing speed. This is done by accentuating the outslope of the whole ***apron*** so that it is greater than the trail grade leading into it. By increasing the speed of flowing water this helps to insure that the structure is somewhat self-cleaning, thus requiring less maintenance.

Spread and compact clean excavated soil on both sides of the bar to protect it from erosion. Bury logs and rocks completely so they are just barely showing, insuring that water exits well before bar. If there is excess moist dirt, look for cupped tread to fill down the trail from the drainage--never let good dirt go to waste. Some trail workers advocate using the IMBA "knick" shape (seen in rolling grade dips) for all drain dips and waterbars.

If you use the funnel shape, clear the ***outfall ditch*** to carry water away easily. It should be 24" or wider and end 12" below the level of the tread. On nearly ***fall line*** trails, extend the ditch as far as it needs to go to keep water from returning to the trail. It is essential to remove any rocks, fallen logs, branches, or saplings that obstruct the outfall ditch. All loose dirt and debris excavated from the outfall ditch should be moved to the down hill side of the ditch to help divert water away from the trail--NOT into the path of the flowing water.

After completing a waterbar, step well back and assess if trail users, especially horses, might be tempted to go around the waterbar. If so, place large ***guide rocks***, and/or logs at the ends, to keep users from going around, without blocking water flow. This step is essential since user and horse psychology will often make them look for ways around waterbars.

Finally, to test a new drainage, roll a tennis ball or orange to test efficacy of the final work--it should easily leave the trail.

Notes: In loose dry soils that do not cohere well, it is impossible to durably build modern ramped waterbars or reconstruct old school ones. Such work must be done when there is good moisture in the soil so that it can be well compacted with a McLeod and boots. The ideal time is just prior to winter when fall rains have moistened the ground and winter snow will further compact the work. Alternatively, consider bringing a watering can or a bucket to moisten soil as you build up layers and compact them. Ideally, material is compacted so that a thumb pressed into the dirt will not penetrate more than a quarter inch--this takes persistence and firm tamping.

On increasingly steep trails (> 15%), waterbars become progressively shorter from beginning to end (from the dip to the ramp over the bar) and, the bar is often more of an old school barrier. This is because it is very difficult to stabilize compacted soil on such a steep trail grade, and because of past erosion on such steep trails, there is often little dirt available, unless imported from a borrow site.

Waterbar Replacement: All waterbars have a life span. Properly sited and built log waterbars can last 10 to 30 years and rock ones even longer. When the time comes for their replacement, follow the same steps detailed in this course. Waterbars will last much longer if they are regularly maintained.

Converting Old School Waterbars: In many cases it is possible to convert "old school" waterbars into the contemporary style, if the soil binds well, moisture is high and the trail grade is below 15%. "Old school" waterbars can be converted by re-sculpting the dip further away from the bar and ramping well-compacted dirt on both sides of the bar.

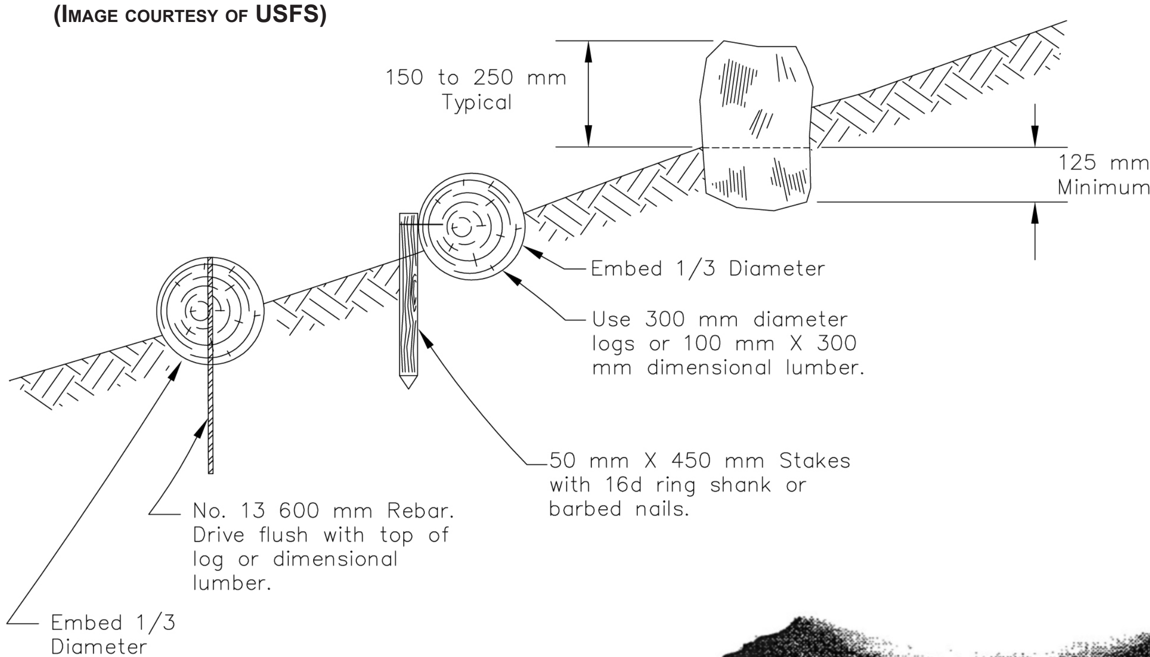
Checks: Checks can be effective triage for gullied tread. Waterbars and dips can't divert water from the trail if the trail follows the ***fall line***. In such cases, checks are simply a means to harden or ***armor*** the tread and slow further erosion.

Sometimes checks are used to armor the tread when it's not gullied, but simply unstable, or steep.

In this class, students should learn how to install both rock and log checks. Since rock checks can be more technical, you'll probably want to devote more time to them.

Also known as rock riser steps, or check steps, these are rocks (or logs) set perpendicular to a gullied

Figure 3. Check Dams.
(Image courtesy of USFS)



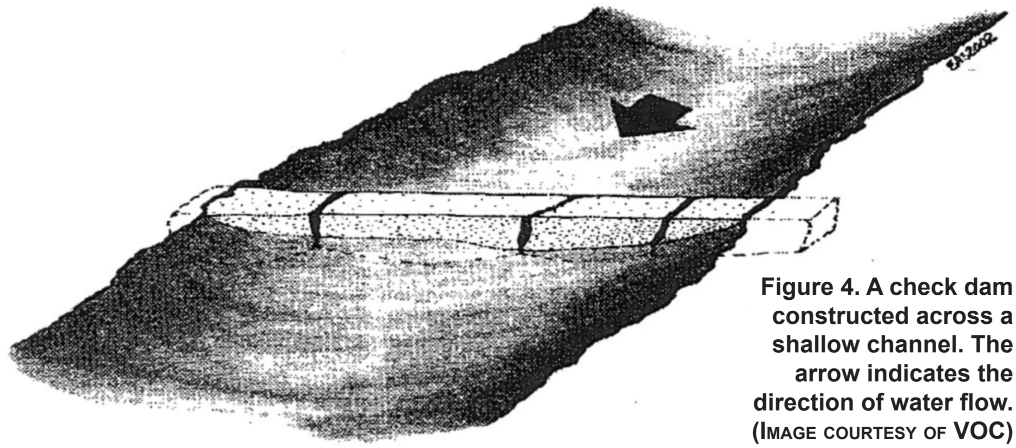


Figure 4. A check dam constructed across a shallow channel. The arrow indicates the direction of water flow. (Image courtesy of VOC)

trail, each step rising no more than 6-8”. If several checks are constructed on a horse trail, they should be about 6’, 12’, 18’, or 24’ apart to approximately match the gait of a horse. Users don’t generally like steps, so it is important to make them comfortable. It is also helpful to install ***rip rap*** (scree) or ***guide rocks*** on the flanks of the steps, to narrow wide gullies and keep users from going around steps.

One simple way to set a check step is to find a single rock with that is relatively flat and wide, and set it on edge tightly within a narrow slot trench. It should be at least 30” wide, 4” thick, and 16” high, so it can be buried half its height. When set, the rock should be level and straight across the top. Wedge and tamp crush rock into the trench until the check rock doesn’t wiggle, even when kicked with force.

Embed the rock (and/or its adjacent guide rocks) in both banks of the gully by 6-12”. In the absence of ideal check rocks, you can try fitting two rocks side by side, but if they don’t meet perfectly, backfill can leak through the gap. In that case, you may be better off with log checks.

Backfill each check step with tamped rocks, each successive layer a smaller size of rocks, top with soil, and tamp again. If only soil is available, the best way to compact such soil is in layers about 2-4” at a time, using feet and McLeods. Firm, enthusiastic tamping is necessary. If it is dry, moisten the soil of each layer before tamping.

Any fill needed to raise the level of deeply gullied trails should be taken from borrow pits that are out of sight of the trail, and away from sensitive areas such as streams. When filling a gullied trail that is sidehill aligned (not fall line), you may have a large berm you can pull into the tread, after removing any organic material. Tree wells of wind-blown trees and their root wads are ideal places to obtain rocks and mineral soil with minimal ground disturbance. If there is no root wad available, when done excavating a borrow pit disguise it well with available debris, after breaking down any steep edges.

When checks are installed on a decommissioned trail, they can be left without backfill, to accumulate their own silt. These are known as ***check dams***. Or, they can be backfilled with rich soil and local vegetation, to aid in restoration.

Deep gullying can also result from a failed water bar or a sidetracked natural drainage up hill. In such cases, it is essential to install a water diversion structure up hill of the gully at the first feasible location to minimize future water running down the gully.

Some trails with very soft soil, such as volcanic ash or pumice, even without water running down them, gully simply from compaction and abrasion from heavy traffic. If available, importing 3/4” minus gravel or crusher reject are durable materials to harden such a trail. Waterbars and check dams have little effect because the gullying is minimally caused by water.

NOTE: If a crew is putting such a huge amount of effort into restoring a gully, the question will arise, shouldn’t we just relocate the trail somewhere else? Sometimes this is a good decision, but the crew should understand that the work to do so can be even greater. Such a relocation will involve new trail design, environmental analysis, construction, and then decommissioning the gullied trail in a way to minimize erosion (probably check dams anyway).

Trail Crew Leave No Trace: Students may protest, ‘Our job is to leave a trace.’ It’s true that trail work has an impact on the land… but the work that is completed is meant to reduce overall impacts on the land. There are ways to bring Leave No Trace ethics into all the work completed on the trail, including how we go about completing projects, where we choose to camp and take breaks, and how the crew behaves in relation to other visitors and wildlife. It is important that we foster a Leave No Trace ethic since we are a model for other public land users and are in the position to influence other’s behavior.

- Be respectful of other visitors: minimize visual impacts, hide brush whenever possible, store tools and take breaks off the trail, and never leave stubs (AKA staubs, pungy sticks) when brushing.
- Travel and take breaks on durable surfaces: keep off trail disturbance to a minimum
- Dispose of waste properly: pack out garbage you find or create, and dispose human & pet waste properly.

TEACHING TIPS & TECHNIQUES

Quality Work

Have students work in teams of two to build at least one successful waterbar and one check step each. Ensure that teams get to work with both rock and log. Rebuilding an old school waterbar would be a fine way to end the day.

Supervise closely to be sure that logs are large enough and peeled, and that rocks are large enough and of an appropriate shape. Encourage students to find and flag a few candidate trees and rocks and have an instructor evaluate them before they are transported to the trail. Use a similar approach to construction of the drainage structure itself. It is essential that students do good drainage work, or they will be wasting their own and future crews time. A poorly built waterbar may only take an hour to build, but it might not even last a year. A solid one may take 2-3 hours to build, but should last many years. Surely an extra hour or two is worth that extended life.

Rock work, of course, is not everyone’s cup of tea. If someone has no interest in such heavy and exacting work, assign them to collecting small rocks and making crush, or bringing in borrow soil. They might be good at fitting small rocks tightly around larger rocks or meticulously packing dirt. The key is to find the right job for each person.

General Principles: Demonstrate the proper stance and technique for each of the tools to minimize body strain. To reduce back strain bend the knees, have a powerful core, keep legs well apart, and use a rocking motion that uses the whole body.

Encourage each student to try all the tools during the day and decide which two they like best. They should see that everyone has their own preferred tools depending on body type and other factors.

Cut and peel trees out of sight of the trail so that the mess does not need to be picked up. Low stump the tree and scatter the bark so it can decompose quickly.

When working with rock stress the importance of doing everything slowly and carefully to avoid injuries. It is very easy to damage backs, hands, feet, and fingers!

Rock Shopping: look up hill or to the side; only downhill if you have a rock carrier or rigging. See Maxims. The main thing to teach is that rocks need to be big and well shaped, and it often takes patience and persistence to find and transport the right ones.

Assign each pair of students the task of bringing in enough suitable rocks to build one rock water bar.

Rockbars & Moving Rock: The rocks needed to do quality rock work are usually to big to lift safely, even with two people. Thus it is essential for rock workers to learn how to move rock without straining or smashing body parts. If you have time (more likely in Course 300), in an open area like a trailhead, demonstrate and have students practice lifting and ***rowing rocks*** using rock bars. Demonstrate principles of ***mechanical advantage***, specifically how placement of fulcrums changes the advantage. Using a tape measure show how advantage varies from 2:1 to 3:1 etc., based on relative position of the fulcrum and distance the bar handle moves versus the rock. Stress importance of a stable fulcrum to avoid sudden slips that can cause neck whiplash. Have them experiment with log versus rock fulcrums.

Make sure students learn how to remove a large buried rock by lifting it slowly with bars and then inserting smaller rocks under it. Repeat until the rock rises out of the hole. Or if the goal is to simply move a giant rock out of the way, dig a deeper hole off to the side, and lever the rock into it.

If rocks are being skidded or carefully rolled down a steep hill, make sure the area below is cleared of people. Trail workers have been killed by runaway rocks. If a rock gets away, SHOUT “rock!” so all can hear.

Demonstrate bumping rocks with a vertical bar for small horizontal rock adjustments.

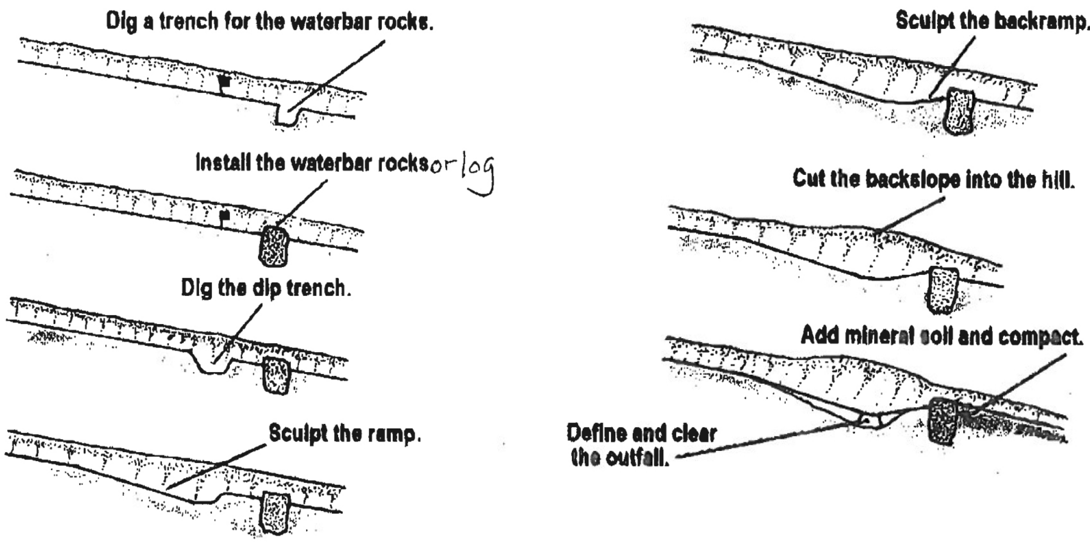
Tool Care: It is very easy for inexperienced trail workers to lose and damage tools. During lunch and rest breaks, store all tools so they are all easily found when you leave. Some crew leaders designate at each stop a “tool tree” or large rock to gather all the tools in one place so they will not be lost. Marking tools with bright paint can help make them more visible. Asking each crew member to be responsible for one or two specific tools half or all day can help.

Be sure to stress the difference between rock and tamping bars, and how easy it is to bend the latter if trying to use one for levering something.

Building Water Bars: All soil excavation and compaction should be gradual so users hardly notice the drainage structure as they walk through it. Sculpt the structures so water exits without losing speed by accentuating the outslope of the whole apron. This helps to insure that the structure is somewhat self-cleaning, thus requiring less maintenance.

When digging the drain dip ahead of a water bar, use any good dirt (not organic debris or rocks) from excavating the apron to accentuate the height of the back ramp and on over the bar, being sure to compact it well.

Figure 5. Seven Steps to Modern Water Bar Construction.
(IMAGE COURTESY OF VOC)



Pile and compact excavated soil on both sides of the bar to protect it from erosion. Bury log bars completely so they are just barely showing, insuring that water exits well before the bar. If there is excess dirt, look for cupped tread to fill down the trail from the drainage–never let good dirt go to waste.

Clear the outfall ditch to carry water away easily. It should be 24" wide and end 12" below where it leaves the tread, or however far it needs to go to keep water from returning to the trail. All loose dirt and debris excavated from the outfall ditch should be moved to the down hill side of the ditch to help divert water away from the trail.

Show (or if none available, describe) "old school" water bars and how they can be converted by re-sculpting the dip further away from the bar and ramping well-compacted dirt on both sides of the bar.

Finally, roll a tennis ball or orange to test efficacy of the final work–it should easily leave the trail.

TRAIL FUN

For a fun wrap-up do a fast-paced "Jeopardy"-style quiz based on the KEY CONCEPTS.

REFERENCES

Drainage Structures. OSI Trail Skill Series. Outdoor Stewardship Institute, a program of Volunteers for Outdoor Colorado. 2009. www.voc.org Based in Colorado, VOC has developed some excellent materials, including this booklet.

Lightly on the Land: The SCA Trail Building and Maintenance Manual. 2005. Robert Birkby. The Student Conservation Association and Mountaineers Books. Pages 159-165 covers rock drainage structures.

Trail Solutions: IMBA's Guide to Building Sweet Singletrack. 2004. An excellent book on drainage work (p.159-182). International Mountain Biking Association has some online resources. www.imba.com/resources/trail_building/index.html

PCTA Trail Skills College Curriculum

Field Reference

Course 203. Waterbars and Checks

STUDENT SKILL OUTCOMES:

- Understanding of ideal logs and rocks for constructing effective waterbars and checks.
- Safe peeling and transport of logs.
- Safe quarrying and transport of rock, especially safe use of rock bars.
- Understanding of where to locate waterbars and checks.
- Ability to reconstruct “old school” waterbars.
- Developing “Trail Eyes” and ability to “Think like Water.”

KEY TERMS:

Apron: (aka knick, swale, dip) the portion of a drain dip or modern waterbar that is excavated out of the trail tread to divert water off the trail. It consists of a descending ramp and rising back-ramp. The exact shape of the apron, though always broad and gradual, varies according to two different schools of thought. Some make it wider at the ***inside edge*** of the trail leading to a narrower ***outfall ditch*** and others make it wider at the ***outside edge*** without an outfall ditch.

Check: (aka check step, check dam) a log or row of rocks perpendicular to a gullied ***fall line*** trail, embedded in both banks, to slow the rate of water erosion. If several are constructed on a horse trail, they should be 6’, 12, 18’, or 24’ apart to approximately match the gait of a horse.

Drain Dip: (aka dip, drainage dip, earthen water bar, and rolling grade dip; a close cousin but different from a grade dip, Coweeta dip, knick, swale and bleeder) A broad, gradual excavated trail feature to shed water off the trail at regular intervals to prevent tread erosion by interrupting the normal grade of a section of trail. Soil excavated is mounded and compacted down the trail from the dip. Ideally 15-30’ long and 8-12” deep. To withstand horse use, drain dips should only be built in very durable soil with trail grades below 10-12%, ideally in the late fall when the soil is moist and just before winter, allowing snow to compact the dip before use in the spring.

“Old School” Waterbars: still seen many places and in some books, these are constructed so that water is deflected by the “bar” of rock or log. Such structures fail more quickly, as water and horse hooves directly undermine and erode the bar.

Outfall Ditch: (aka outwash, outlet or outflow ditch), 24” wide excavation to carry water away from the trail at a drain dip or waterbar. Ends when it is 12” below the trail grade or as far as it needs to go to keep water from returning to the trail.

Backramp: (aka Ramp) the descending and ascending facets of a drain dip or waterbar. Always well outsloped to shed water efficiently. Combined, they comprise the drain dip apron.

Waterbar (Log or Rock): (aka rock or log reinforced drain dip). As constructed by the PCTA, this trail drainage structure includes a drain dip reinforced by a peeled log or row of large rocks. The reinforcing log or rocks are buried securely at about a 45 degree angle across the tread and 36” down the trail from the bottom of the dip--thus water leaves the trail well before it reaches the log or rocks. Waterbars are generally required on trail grades in excess of 15%, rather than drain dips. See also, ***“Old School Waterbar”***.

KEY CONCEPTS:

1) Safety Documents and Concerns:
   - Personal Protective equipment (PPE), Job Hazard Analysis (JHA), Tailgate Safety Session (TSS), Emergency Action Plan (EAP)
2) Trail Crew Leave No Trace: Have a positive impact on the land through trail work and be sensitive to off trail and camping impacts.
3) Proper/ Improper Tool Care and Use:
   - Fire shovel, McLeod, adze hoe, Rheinhard, Pulaski, pick mattock, rock/ tamping bar, heavy/ light sledge
4) Hillside Hydrology/ How Trails Work:
   - Effects of water in diverse soil types
   - Trail design/ tread and drainage structures
5) Developing “Trail Eyes”:
   - Suggest hiking in rain to better understand water on trails
   - Notice every drainage, even disappearing ones
6) Locating New Waterbar Sites:
   - Locate areas of erosion, fix any existing

drainages, reevaluate
- Berm and slough removal vs. new drainage structure
- Trail conditions for new waterbar (vs. rolling drain dip)
  – Grade greater than 10%, moist durable soil, avoid top/ bottom of hill
  – Spacing between drainages determined by grade, soil, volume of water
- Choose log or rock waterbar based on native resources
  - If possible use rock first, more durable

7) Constructing New Waterbars
- Materials
  – Log: have certified sawyer fall a green tree 10-12” diameter > measure it out, cut it, peel off bark
  – Rock: safely quarry and transport rocks > box shaped rocks with flat sides are ideal
- Build a broad gradual apron
  – 15% or greater outslope to help self clean
- Bury bar completely so top is level with original trail surface
  – Set at 45 degrees at high point of backramp, less/ more angle to match force of water
- Excavate a 24” wide outfall ditch
  – Extend below tread as far as you need to keep water off trail
- Entire structure, including ramp, apron, and backramp, should be at least 20 ft long.
- Convert “old school” waterbars to newer design
- Pack soil VERY well
- Test drainage with tennis ball

8) Checks are for retaining tread in less than ideal conditions
- May be appropriate for:
  – Gullied tread, especially if fall line and not drainable
  – Unstable or steep tread

9) Materials: rock or log, same instructions as for waterbars

10) Setting Checks
- Perpendicular to the tread, level across top
- Space at least 6’ apart to match gait of horse
- Bury rock or log about half its height
- Rise not to exceed 6-8”
- Embed ends into banks
- Secure rock or log so it does not wiggle
- Backfill with crushed rock
- Flank each step with guide rocks or rip rap

11) Any fill material needed should be mined carefully

12) Report Work Promptly

Figure 1. “Old School” rock water bar. (Image courtesy of the USFS)

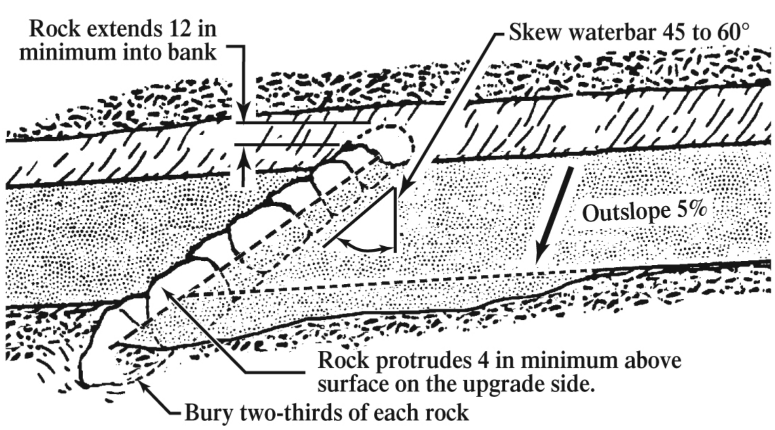


Figure 2. Diagram of modern waterbar construction

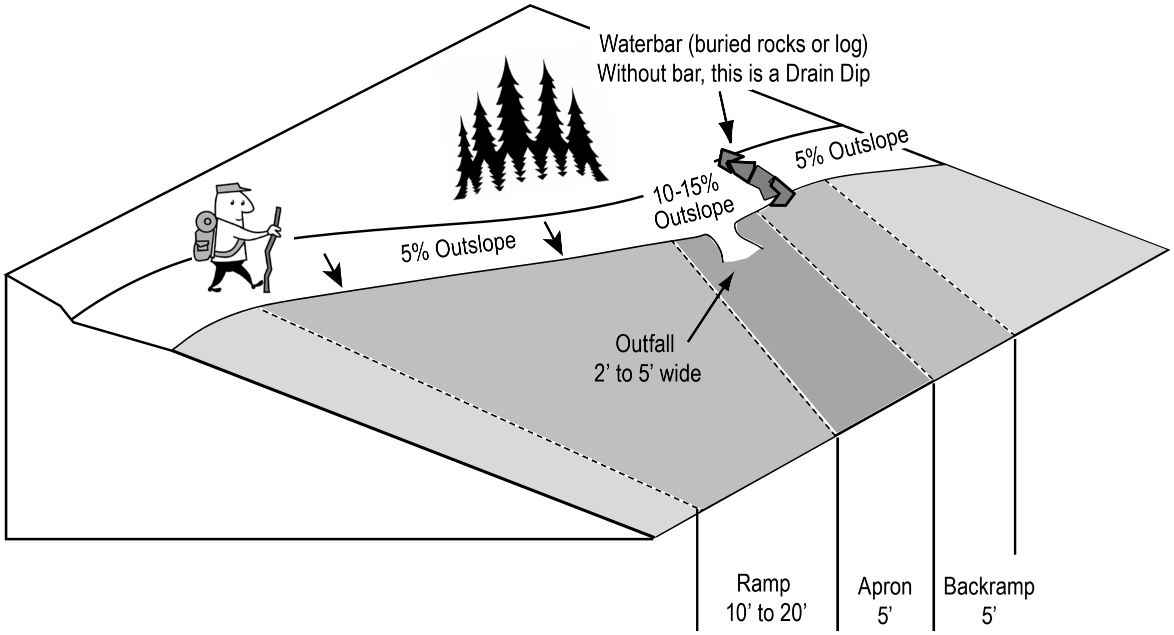
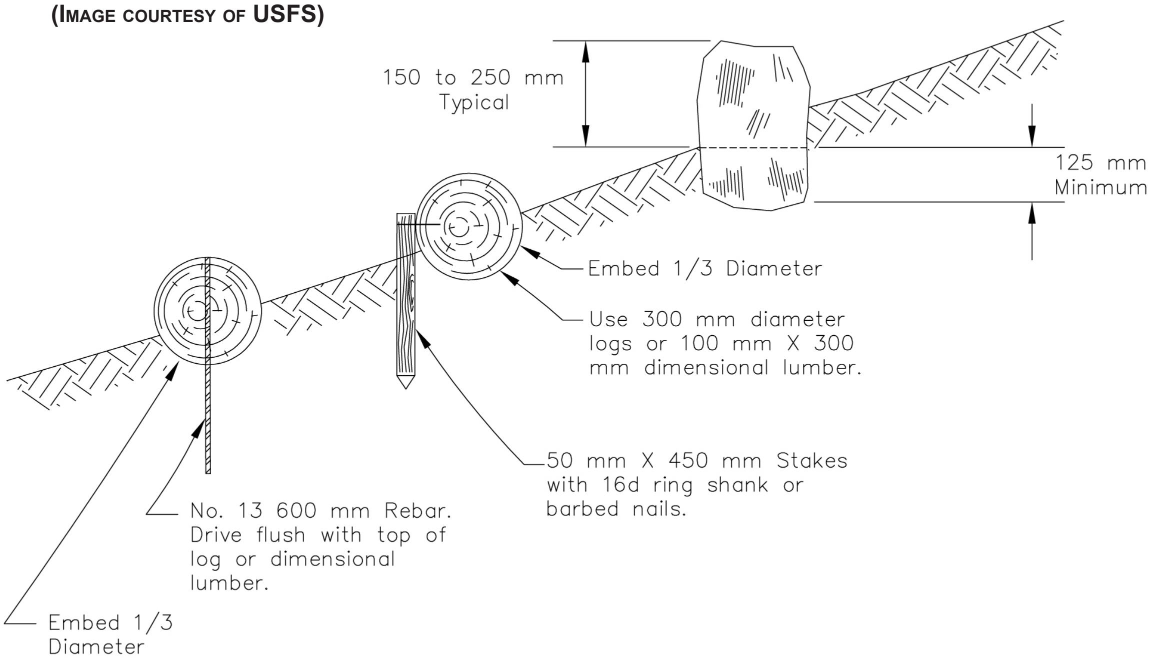


Figure 3. Check Dams.
(Image courtesy of USFS)



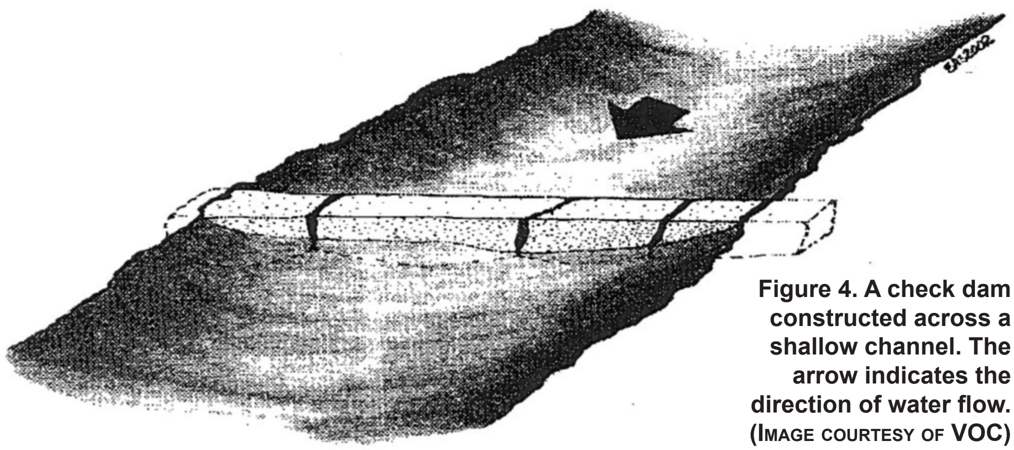


Figure 4. A check dam constructed across a shallow channel. The arrow indicates the direction of water flow.
(Image courtesy of VOC)

Figure 5. Seven Steps to Modern Water Bar Construction.
(Image courtesy of VOC)