

# Desert

# Trails



*Designing and Building Trails in a  
Harsh and Demanding Environment*

By Mark Flint



## **About the Author**

*Mark Flint began building trails in Oregon as a volunteer in the early 1990s. He has attended numerous trail construction and design workshops. After moving to Arizona in 1997 he was involved in design and construction on several trail projects, including the 24 Hour Race Course at Willow Springs, reroutes of the 50 Year Trail at Catalina and approximately 40 miles of the Arizona Trail from the Rincon Mountains to Oak Tree Canyon.*

*He is currently designing trails and supervising construction for Pima County.*

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*Man's heart away from nature  
becomes hard.*

*—Standing Bear*



## **Introduction**

*Building trails in the desert presents challenges not found in other environments. Soils are generally rocky and sandy; clay is rare, as are organic materials that help bind soil. In addition, water often arrives in copious quantities, and at high velocity. These factors combine to make trail erosion a major problem in the desert, requiring extra care and consideration in design and construction.*

*Some of the techniques were developed through trial-and-error experimentation; others are included because they just made sense. All have been tested by severe rainfall events, and have worked well.*

*This manual, while it touches on some of the basics of trail design and construction, is intended as a supplement that specifically addresses trail design and construction issues in the desert. It is not intended to be a comprehensive guide to trail design and construction. If you are looking for such a guide, there is none better than “Trail Solutions: IMBA’s Guide to Building Sweet Singletrack,” published by the International Mountain Bicycling Association. It can be purchased online at [www.imba.com](http://www.imba.com).*

# Trail Design

Trail design is part art and part science.

The art is in making a trail that people love to hike and ride, that provides a “magical” experience.

The science includes archaeology, biology, hydrology, pedology (formation, chemistry, morphology and classification of soil), psychology and sociology.



Specialists usually review trails to make sure that archaeological and biological resources are protected, but some knowledge in those disciplines can help avoid having to redo your alignment.

Hydrology, specifically how water is going to interact with the trail, is critical in designing a sustainable trail — one less susceptible to erosion.



*Trail users prefer an intimate experience; a narrow trail that winds its way across the landscape and takes them to places of natural beauty. The photo at top right is taken from a viewpoint on the Hidden Canyon Trail in Tucson Mountain Park. The trail above leads into Tucson Mountain Park from the 36<sup>TH</sup> Street trailhead. An ocotillo arbor, right, provides a unique Sonoran Desert perspective.*



*Erosion usually is the result of poor trail design (or no design at all) and/or construction. When erosion makes a trail difficult to negotiate, users will move to the side, widening the trail and in most cases creating another erosion channel. In the photo at left, users moved the trail, but that route, too, will erode. Repairing trails such as these is a task not unlike that of Sisyphus, a particularly nasty character in Greek mythology who was forced for eternity to roll a block of stone up a steep hill, only to have to start over when he reached the top and the stone tumbled back down. The most cost-effective solution, in the long run, is to reroute the trail.*

## **Desert Challenges**

In the desert, water often comes at a high volume and velocity, and can be highly erosive. Keeping water from running down trails is critical. The rule of thumb elsewhere is an average grade of 10%, but try to keep it 5-7% in the desert if at all possible.

Knowledge of soil types is also important in sustainable desert trail design. Decomposed granite will flow almost like water, for example, so it's critical in loose soils with low shear strength to use minimal grades and buttressing features, such as crib walls and grade reversals, where feasible.

## **Remember the Humans**

Predicting and accounting for human behavior is necessary to provide an experience that is aesthetically pleasing, challenging (the degree may vary, and a trail system should have varying levels of difficulty) and safe — including design that minimizes potential social conflict. Underlying these needs is the greater need to protect resources. This can be done both by encouraging users to stay on the trail and also by ensuring the trail doesn't compromise sensitive/critical habitat or archaeological sites.

It's important to keep in mind that a trail doesn't necessarily have a negative impact on habitat or archaeological sites. Many species will adapt to hikers, bicyclists and equestrians, or may not be adversely affected by their presence. Trails have been allowed on archaeological sites in many areas, with no negative impacts.

## **Take Them Where They Want to Go**

Trails need to take visitors where they want to go, such as viewpoints and places of interest. Social trails often occur as a result of land managers failing to understand and accommodate the needs of trail users. When designing a trail, keep these needs in mind, and develop positive control points that address them.



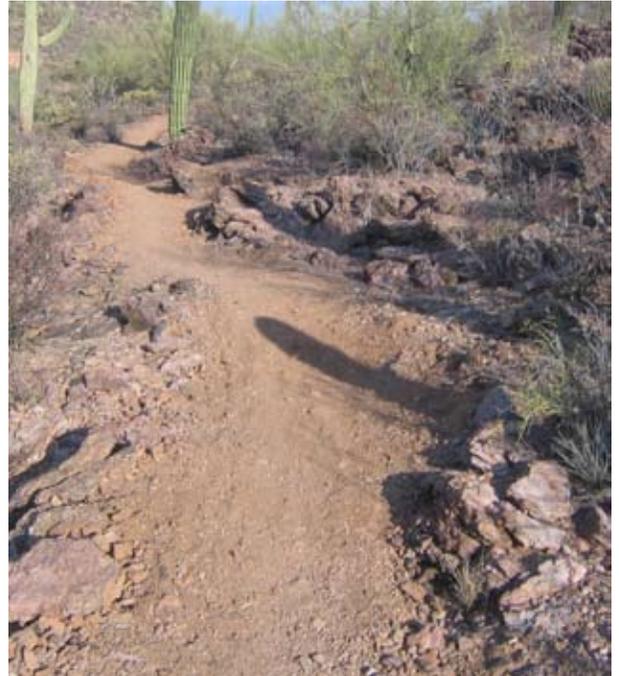
## Protect Resources by Discouraging Off Trail Travel

Corner-cutters and peak-baggers — people who insist on going off trail — will always be with us. While you can't eliminate these practices, you can minimize them. One way is to make it unattractive or difficult for trail users to go where you don't want them to go. The desert provides us natural barriers to travel; cholla and prickly pear in the center of a climbing turn, for example, will discourage cutting across the center of the turn — and they make a natural and visually consistent feature, unlike piled deadwood and rocks.

## Make it Fun

Giving trail users a pleasant experience helps keep them on the trails. Surf your contour trails — the low spots are utilitarian, creating grade reversals to shunt water off the trail — and avoid long straight stretches.

In addition to creating sustainability issues, steep grades are just not fun for your average hiker or rider. While trail systems should include some challenging loops for the more adventurous, the majority of the trails should be aimed at the recreational hiker and rider.



*A trail that undulates across the landscape not only contributes to a more enjoyable experience, but also provides opportunities to shed water, as the dips in the photo above illustrate. The trail in the photo below gradually gains elevation without sacrificing sustainability. It is also less demanding on hikers and riders.*



## Mental Health for Trails

A trail should have a stable personality, not switch back and forth from mellow to steep and technical. Sudden changes should be avoided.

If a trail does need to morph from one type, such as a nicely undulating contour to another, perhaps a steep, rocky section or a major drainage crossing, it should give users some warning. Put in a few gradually tighter turns, or pinch it together with large boulders. Use natural features that slow the users down and subtly say, “Pay attention, folks.”



*Rocks strategically placed in three spots before a turn, left, provide a subtle cue to mountain bikers that they need to slow down. A subtle turn, above, signals the end of a long straight stretch.*

## Safety Features

Exposure to risk is unavoidable on trails — and for some trail users, part of the fun. Mountain bikers, equestrians, hikers and trail runners often lament when land managers “sanitize” trails, removing challenges that they may have spent a lot of time learning to master.

However, reasonable precautions, such as providing adequate width for passing on a steep side hill, making sure crib walls are strong and stable, and avoiding poor sight lines, need to be included in design and construction.

One of the causes of conflicts between mountain bikers and other trail users, and a potential safety hazard, is the speed a mountain bike can attain. Calming devices that slow down bikes are just as much fun to ride as a fast downhill run. These can include turns, tight spots (threading the trail between boulders) and rocky sections of tread.

Open sight lines are important to give users time to see one another.

Education, including trailhead signage, also can help trail users have a safe and enjoyable experience.

# Construction

Most of our construction challenges in the desert deal with water: keeping it from running down the trail and from crossing it with too much velocity.

Water is a powerful and relentless force, and if allowed to run down a trail, eventually will make it impassable. All too often in these situations, users will simply move to the side of the trail, creating another erosion channel. As the process repeats itself, the result is a large, ugly scar on the landscape.

While constant maintenance can keep erosion damage at bay, land management agencies with tight budgets rarely have the ability to repair erosion damage on an ongoing basis. Installing waterbars and steps may put off the problem, but structures such as these ultimately fail. The best and most cost-effective solution, in the long run, is to reroute the trail.

## Crossing drainages

Enter small drainages at a right angle to the flow. Contour into larger drainages.

Use rocks to make check dams above and below the trail to slow water down before and as it crosses the trail. Be sure that the sides are higher than the middle so water is channeled over the rocks. Failure to do this could allow water to channel around the rocks and scour a new channel. The larger the drainage, the more rocks you need. Fortunately, rocks usually are easy to find.



*A crib wall raises the bottom of this drainage, eliminating a fall-line drop into the wash. Rocks piled against the base of the crib wall prevent undercutting as the water flows over it.*

For larger drainages, use rock crib walls to build up the crossing. This may be necessary to avoid a fall-line entrance/exit on both sides of the wash.

Make sure the rocks are higher on the outside edges of the drainage, to direct water flow to the middle. Building a pile of rocks outward from the base of the crib wall will prevent the undercutting that would occur if the water were allowed to fall straight down the wall.

A causeway, or elevated trail across a wash, may be necessary to avoid a steep wash entry. When making a rock causeway, be sure the downstream side is higher than the upstream side to prevent scouring all the soil away.

## Large Washes

Because of the volume of water they may carry, large washes can wreak havoc on trail crossings. Selecting a good site for crossing large washes should be a critical control point in initial trail layout. The ideal crossing for a large wash will have a gentle slope into the wash, gently sloping bedrock to a relatively flat bottom, and — since we are asking for ideal here — good rock outcroppings just upstream of the trail entry points. These outcroppings will protect the trail during high water.

In selecting a wash crossing, observe what the water has been doing to form the banks. Selecting an entry point just downstream and on the outside of a bend, for example, will expose it to the full force of the water as it deflects from the bend toward the opposite bank.

Since Nature rarely gives us what we want, it may be necessary to improvise. A steep bank may require extra effort benching, and possibly crib wall construction.

Those rock outcroppings just upstream of your crossing may present themselves now and then, but when they don't, make your own. You can do this by piling rocks to build a jetty upstream. The jetty will slow the water down before it gets to the trail crossing.

## Damage Happens

Even a perfectly designed and constructed wash crossing is no match for a major flood event. If a microburst dumps 8-10 inches of rain upstream of your wash crossing you may have to rebuild it.

Working on tread on a wash bottom is not a good investment of resources because one good flow can undo all your work. Put that energy instead into finding a crossing that has natural protection from erosive forces, and enhancing that protection where possible.



*The trail ramp above faces upstream in a medium-sized wash. A large rock crib wall provides outside bank protection, and an upstream jetty (arrow) made of rock will protect the trail from a direct hit by the water.*

*In the photo below, the bank is reinforced by rocks, and a small jetty (arrow) will deflect flow from the trail entrance.*

*These jettys may not prevent damage from a large flood event, but they will protect the wash entrances during normal flows.*



## Molars and Crib Walls

Molars — rocks buried in the tread to keep soil from migrating downhill or to keep armoring in place — are effective in clay soils. But in sandy/rocky desert soils they can easily work loose. You must use a very large rock, or wedge several rocks together so they lock into place. In the desert, the best molar is one already buried in place.

Crib walls, a form of retaining wall, are great for supporting the downhill side of a trail. They can be used to take a bench above bedrock, or to raise the trail so the top is level with a protruding rock that can't (or shouldn't) be moved.

A crib wall should pass the “jump test.” If you jump on it and the rock wiggles, it's not set properly. In crib wall construction, the bigger the rock the better. Study the rock carefully before trying to place it, and sculpt the ground so the base nestles in with a good fit. Sometimes a rock will fall into a stable position before you expect it to, so be sure to check the rock for stability as you work with it. Occasionally a large rock just won't work into a stable position. Smaller rocks carefully locked together can be just as effective.



*This crib wall raises the trail above bedrock, providing a nice, even tread.*



*The large rocks in this crib wall, which supports a trail as it enters a junction between a large wash and a side wash, protect the trail when the wash is running.*

Fill behind the crib wall should begin with fist-sized rocks (or larger, depending on how much fill is needed), with some dirt and smaller rock mixed in to hold the rocks in place. If available, the layer below the top layer of dirt should be gravel-sized rock to help water permeate.

On rocky side hills, use raised rock (or a raised crib wall) on the outside edge to reduce soil loss. This is to hold soil in while letting water escape through the cracks between the rocks. The trail is outsloped to the rock wall, which may be a couple of inches higher than the tread. Be sure the water has a place to go, or it will puddle.

When possible, try to place crib wall rocks with the weathered side out. This helps the wall blend in, and seem as if it was there before the trail was built.

## Moving Water Off The Trail

The rolling grade dip is another construction feature that doesn't do well in desert soils. Instead, use a modified knick, a shallow depression, 18-48" wide and 2-8" deep, that is sculpted so the entry and exit are very gradual. A well-built knick is not noticeable when walking on the trail. Width and depth of the knick should be determined by the amount of water it needs to handle.

Sometimes you can take the water off before it gets to the trail. Making a channel to divert water into a wash above a trail, for example, may be a good way to stop trail erosion before it starts.

A fairly aggressive outslope, 5-8%, also helps get water off the trail quickly. A good way to make sure the outslope is not too severe is to walk the trail. If your ankles want to roll, it's too much outslope. In places where you have soft soils, such as may be encountered on a wash embankment, an even more aggressive outslope angle may be needed to allow for compaction as the trail is used.

The steeper the trail, the more frequently it needs to have the water shunted off. As grades approach 10%, try to have knicks or grade reversals every 5-10 feet. Soil type is another factor in determining how many knicks are necessary. Take advantage of large rocks in the tread, which both can help stabilize the downhill side and also deflect water off the trail.

Another factor in determining how much effort is necessary to get water off the trail is where it is on the slope. A trail on or near a ridge top will experience less water than one that has a couple hundred feet of slope above it. However, all desert trails should be designed and built carefully to prevent erosion because a slow-moving storm cell that is dropping 4 inches of rain per hour can put a lot of water directly on a trail.

## Armoring

Armoring can be useful in those situations where you have no choice but to put in steep grade. Be sure to leave an un-armored option for equestrians on trails open to stock.

Start from the bottom and work up. If possible find a rock already buried that will serve as a molar. Try to fit the rocks so they are fairly close together, or use tools to shape them. Be sure the finished tread doesn't have too much variance in height — it doesn't have to be as smooth as pavement, but rocks that stick up above their neighbors are likely to become dislodged, not to mention presenting a tripping hazard.



*A few minutes with a McLeod was all it took to divert water off this embankment before it can get to the trail.*



*In places where the terrain forces the trail to run at a steep grade, an armored tread may provide a sustainable solution.*

# Aesthetics

We don't have the luxury of pine needles or dead leaves to cover up construction debris in the desert, and it can take years for disturbed soil to look natural again.

It's important to be more careful as you build trail in the desert. Some techniques that will help your trail look like it's been there for years include:

- Dispose of cuttings out of sight of the trail. Palo Verde branches can be placed under other Palo Verde trees, cut end toward the trunk (but just one or two per tree).
- Work the dirt lengthwise on the trail, not from the uphill side to the downhill edge. This keeps it from accumulating below the trail.
- Pile excess dirt in the middle of the trail and either broadcast it as far as it can be thrown with a shovel or wheelbarrow it out of sight.
- Save rocks with exposed (weathered) surfaces as you brush and grub the trail, and place them strategically, weathered side up, after construction is complete. Rocks that have been excavated and don't have weathered surfaces should be hidden. (If rocks are scarce and you need them for crib walls or drainages, they may have to be used.)
- If you pull rocks out from the hill above the trail, be sure to cover the holes with other rocks; often you can move rocks that are lying on the surface, or better yet, lying on other rocks, without exposing more bare soil.
- Make sure your final punch list walk-through includes looking above and below the trail for any out-of-place construction debris or vegetation.



*Rock Wren Trail, Tucson Mountain Park, constructed winter 2006-2007. No construction debris or pruned vegetation can be seen from the trail, giving it the appearance of having been there for years.*