

# ROCK ARMORING



West Virginia University

BRAD AND ALYS SMITH OUTDOOR ECONOMIC  
DEVELOPMENT COLLABORATIVE

# WHY ROCK ARMORING?

- Fortify Wet Areas
- Stop User-Based Erosion
- More Durable
- Add Technical Challenge
- Increase Difficulty Level
- Optional Lines/Skills Progression
- Visitor Management
- Diversify Trail Experiences
- Create a Natural Feel

# MOVING ROCKS SAFELY

- Lift smart
- Share the load
- Use the right tools
- Slow down



# MOVING ROCKS SAFELY



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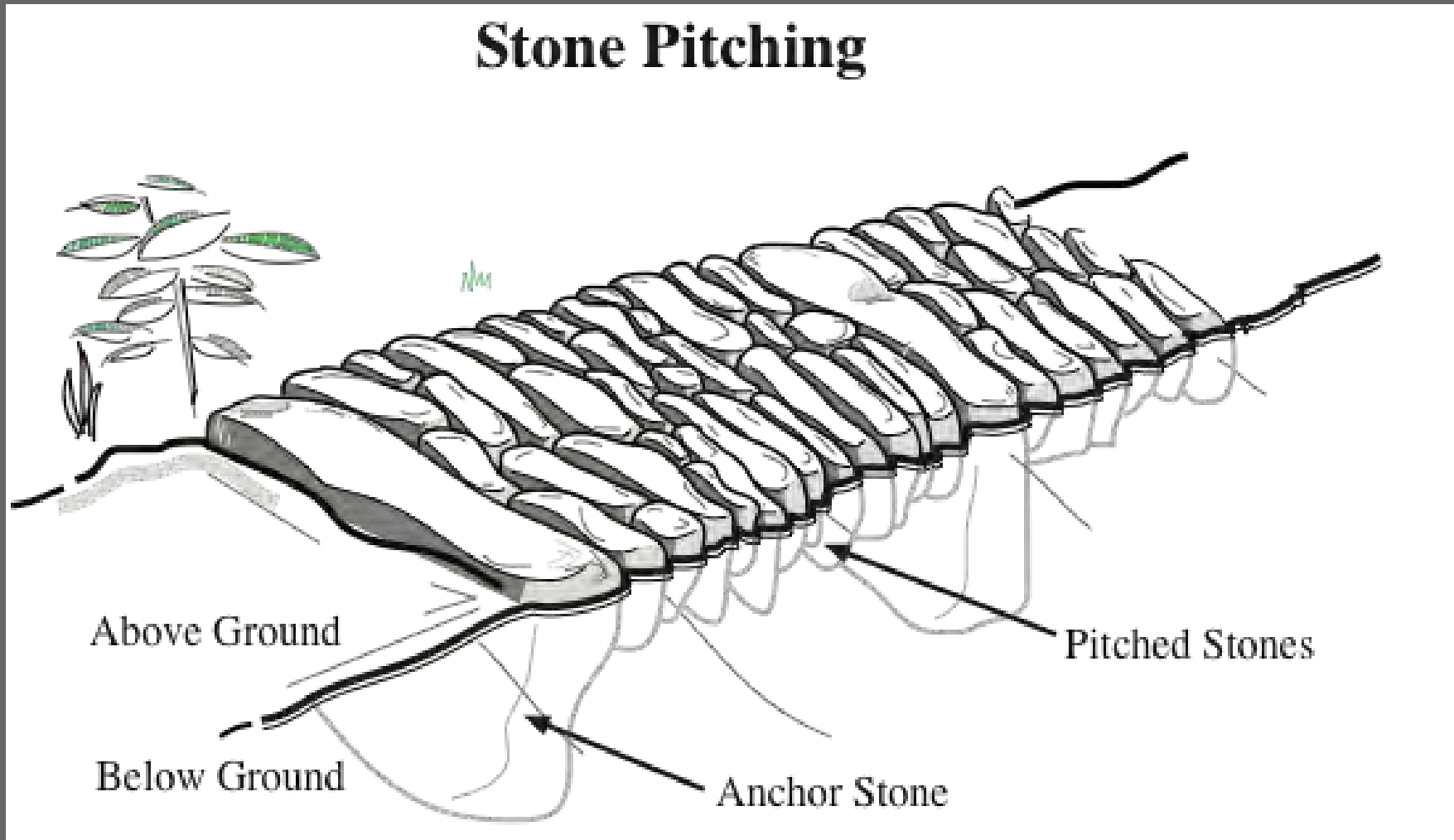
# TYPES OF ROCK ARMORING

- Pitching – generally smaller stones are pitched between larger stones. Pitched stones create more of a “rumble strip” sensation. Pitching can also be useful in seeps or wet areas, as the more cracks and spaces between rocks allow for better water flow
- Flagstone – should be large rocks (greater than 100lbs) , embedded 2/3 of the way into the earth. Texture can be determined by stone type and placement, angular or round rocks may produce more rigousity, while large flat faces can be conducive to smooth hard tread.
- Anchors - very important in rock armoring and general trail construction. Anchors are large (greater than 100lbs) rocks embedded at least 2/3 that visually and physically push users to the inside, or centerline of tread. Use anchors to keep people on the trail.
- Foundation - used to armor wet areas, excavate to firm hard soil and place rock in trench, then cap with native soil. Foundation armoring can make use of small stones, even gravel, as its intended to provide a firm surface during wet conditions. It must be capped by 1-2 inches of native soil
- Raised Tread – similar to causeways raised tread is used in wet area. Raised tread should use anchors to guide the trail tread. Flagstone and pitching should be used to raise the tread. Aggregate such as gravel or sand should be used as fill, it is very important to ensure all cracks and spaces are packed with aggregate. In general a mix of small and medium particles (fines up to 2 inches) should be used for best results.



# ROCK ARMORING

## Stone Pitching



# ROCK ARMORING



# STONE PITCHING



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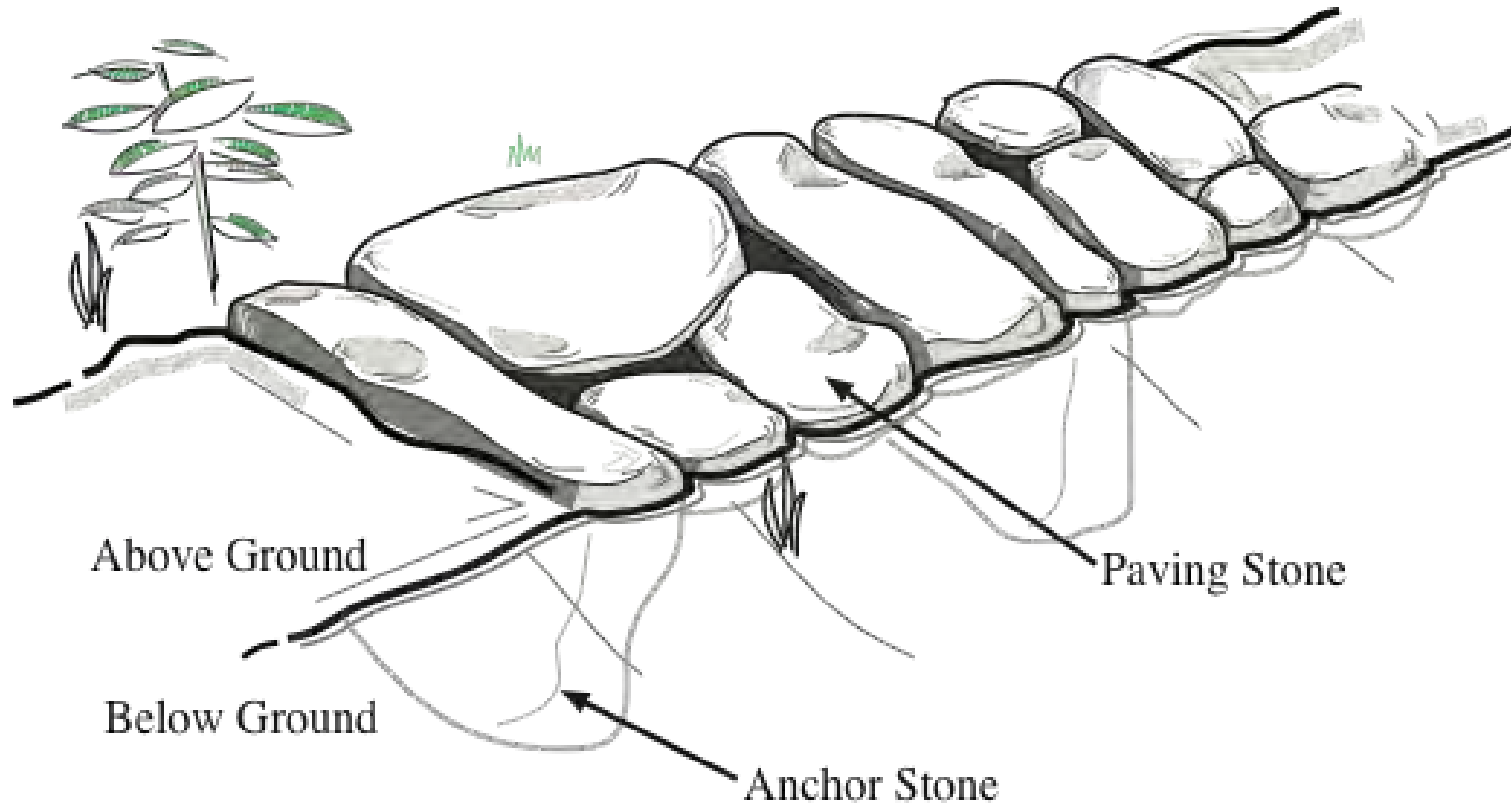
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# ROCK ARMORING

## Flagstone Paving



# FLAGSTONE PAVING



# FLAGSTONE PAVING



# FLAGSTONE PAVING



# FLAGSTONE PAVING



# FOUNDATION ARMORING

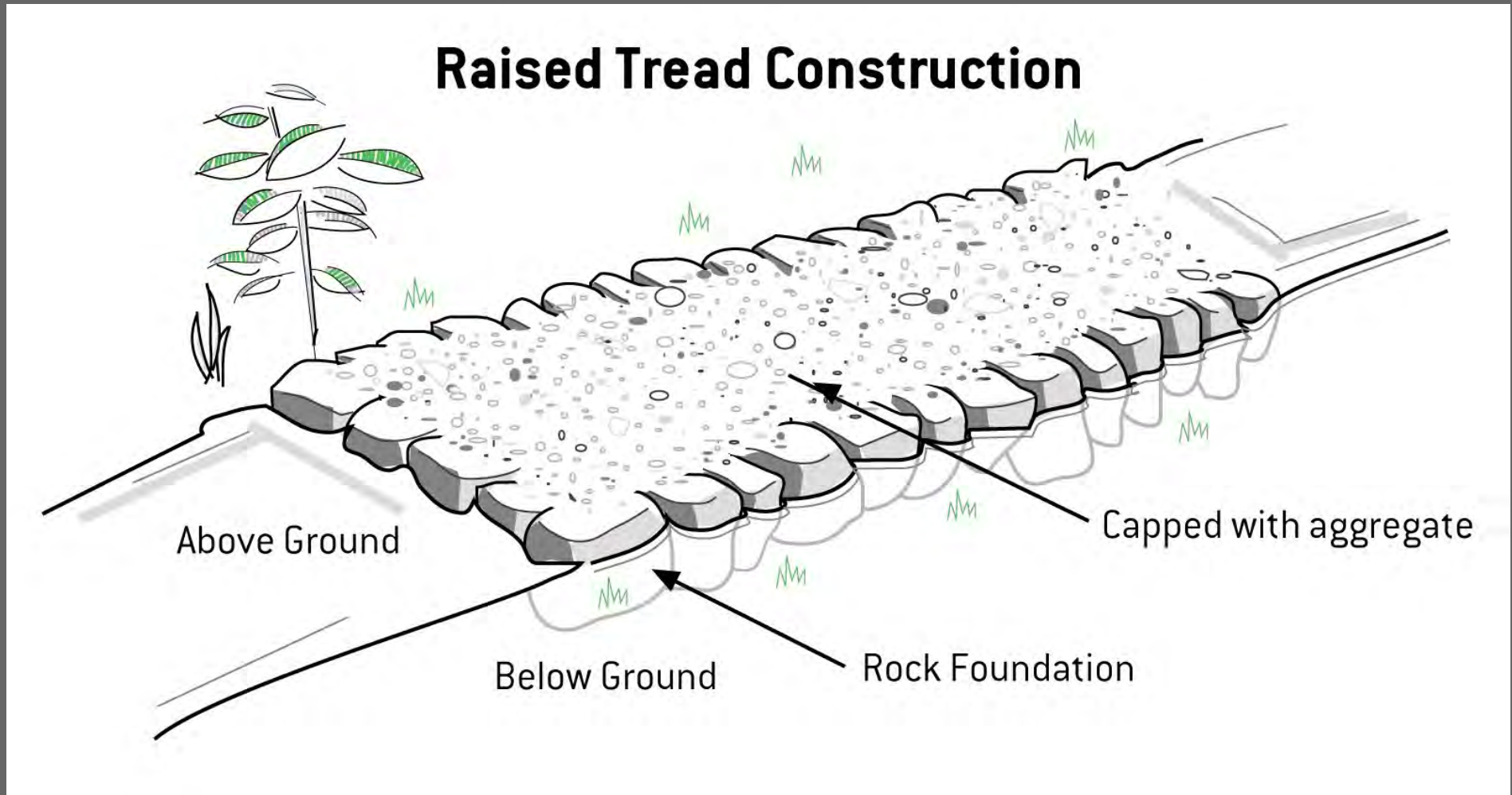


# FOUNDATION ARMORING

- Used in wet areas
- Natural construction is typically better than wooden features
- Rocks will wear through, depending on goals may require heavy maintenance
- Substrate can be gravel up to large stones



# RAISED TREAD





# RAISED TREAD



# RAISED TREAD



# RAISED TREAD



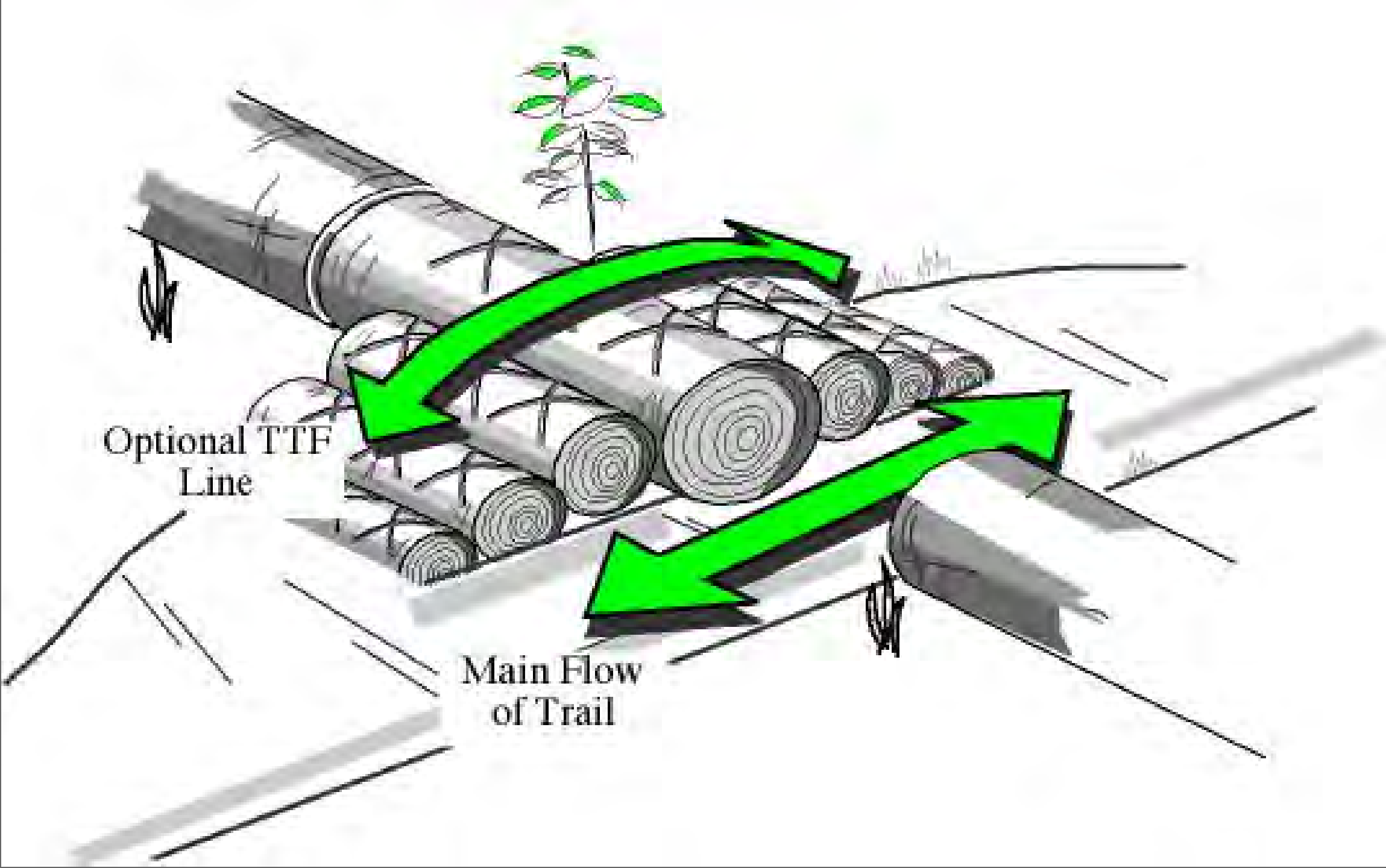
KEEP SMOOTH TRAILS SMOOTH AND GNARLY  
TRAILS GNARLY



# OPTIONAL FEATURES

- Optional features (A-line/B-line, alternate lines, etc.) are features or very short segments of optional trail that provide a different difficulty level challenge than the actual trail
- They provide a wide variety of visitor management potential and add tremendously to trail systems
- Providing on trail opportunities for riders to challenge themselves and “level up” is a great way to provide risk management and progression
- Often humans learn best by watching, and see its possible, others – optional features in trails create chances for riders to see others accomplish the feature and realize they too can do it!
- For best results, optional features or alternate lines should reward to visitor – generally this means providing a faster way to travel the trail
- I.E. a rock garden on the inside of a slight chicane will be more likely to be ridden because it rewards riders who want to tackle the chunky texture with a faster more direct line
- Feature placement can be very subtle, blend with nature, and provide alternate benefits
- I.E. an anchor stone can be place on the outside edge such that walkers, runners, and beginner mountain bikers avoid it (it pushes them inside, as an anchor is intended to do) – but the skilled rider may see that stone as a side hit, something to grab air off of, especially if it sets them up nicely into a roller/landing
- Alternate lines should be very visible, if they are hidden from sight its unlikely they will be regularly used
- Signage can be very important, if the A-line is a large drop that is out of place for the trail, a sign denoting its advanced skill may be advised
- Signage can also point out alternate lines that may not be obvious, if they veer from the trail significantly
- Good sightlines on alternate lines are important, especially if the line requires more speed the user may carry as they merge back onto the trail





Optional TTF  
Line

Main Flow  
of Trail

# FEATURES



# FEATURES





# FEATURES



# OPTIONAL LINES



# OPTIONAL LINES





# PROGRESSION

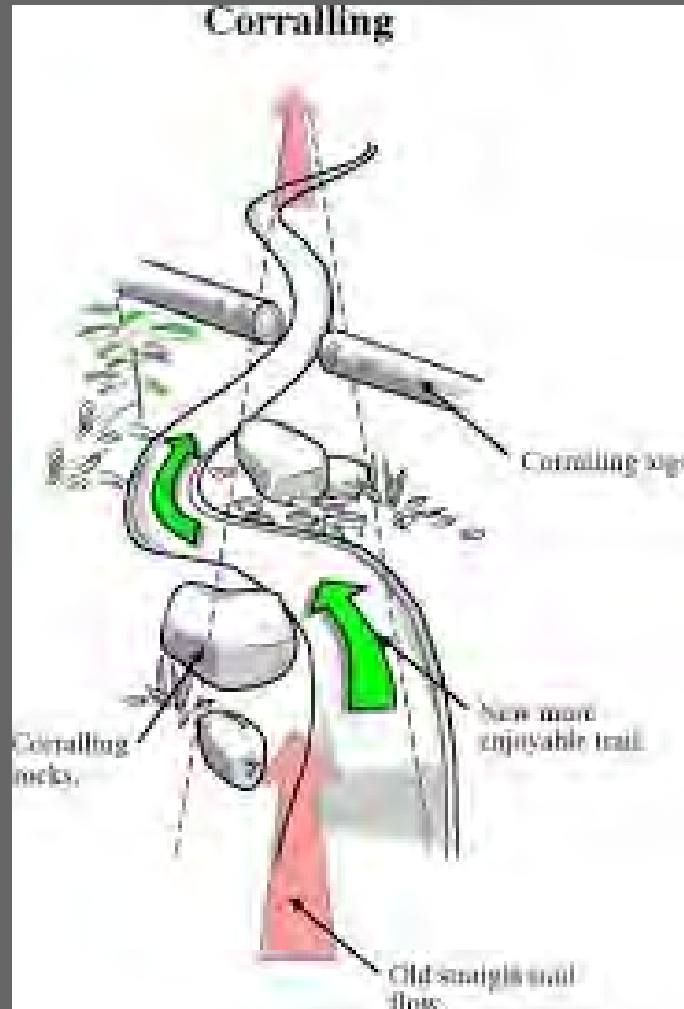
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# SHARED-USE VISITOR MANAGEMENT

- Shared-use trails are typically the most prone to negative social interactions
- The leading cause of a negative experience between visitors is surprise – generally due to speed differentials in their rate of travel
- Reducing visitors speed, especially before places where interaction between visitors is highest, is the key to successful shared-use trails
- Corraling, gateways, and anchoring – using natural features like trees, downed logs, or rocks to pinch the trail down
- Generally, anchoring the downside edge is advised as the uphill side is anchored by the backslope
- Steep sideslopes mean narrow benches and steep backslopes, these will be more difficult for passing, can you leave room in some places for people to get off tread?
- Humans generally avoid large steps, rocks, awkward footing, roots, anything that resembles a harder path – they look for the easiest way!
- To keep visitors on your trail tread, especially if its rough, uneven, etc. – anchor your trail!
- Uphills are the best way to slow visitor speeds – but tight gateways and rocky rumble strips are also useful techniques
- Sightlines are vital to good shared-use trails, ensure your sightlines are regularly opened up and meet the speed differential of the visitors using the trail



# VISITOR MANAGEMENT



# VISITOR MANAGEMENT



# MAINTENANCE AND COMMON DRAINAGE SOLUTIONS





# TRAIL MAINTENANCE

Develop a work Plan

Identify problems and solutions that:

- Improve The Trail
- Don't cause new problems
- Are achievable with the tools and team available

Not everything will be fixable, so don't try.

- Choose successful locations
- Skip hopeless sections and document for trail manager



# TRAIL MAINTENANCE

Develop a work Plan

Three common maintenance types

1. Tread erosion from running water and visitors
2. Soft or muddy tread from puddling and seeps
3. Trail corridor brushing and sightline clearing



# TRAIL MAINTENANCE

Develop a work Plan

Problem: Erosion by moving water and/or visitors

Symptoms: Rills, gullies, headcutting, deposition, skid marks

Solutions: Drains, Grade reversals & armoring

Important questions:

- Can we get the water off the trail and keep it off?
- Does the trail break the half rule ? (fall line)
- Can we place the drain in place where it won't be awkward
- How steep is it
- Is there any rock and will riders be happy we used it?



# TRAIL MAINTENANCE

Develop a work Plan

Problem: Soft or Muddy tread from puddling or seeps

Symptoms: Wet and soft when rest of tread is dry

Solutions: Outslope, Elevate, foundation, armor

Important questions:

- Can we get the water off the trail to dry it out?
- Can we move the trail just a little to get it to a higher location?
- Why is it wet? Is it a low spot or groundwater?
- Is there rock or stone available and will riders be happy we used it?



# TRAIL MAINTENANCE

Develop a work Plan

Problem: Trail or sightlines are obscured and causing visitor unhappiness

Symptoms: overgrown trail, logs down, short sightlines

Solutions: Pruning and swamping (cutting & dragging)

Important questions:

- Water is the expected corridor limits?
- What tools can we use?
- What is the preferred sightline distance?
- Any limits on what we can prune?
- Is there poison ivy or oak?



# TRAIL MAINTENANCE

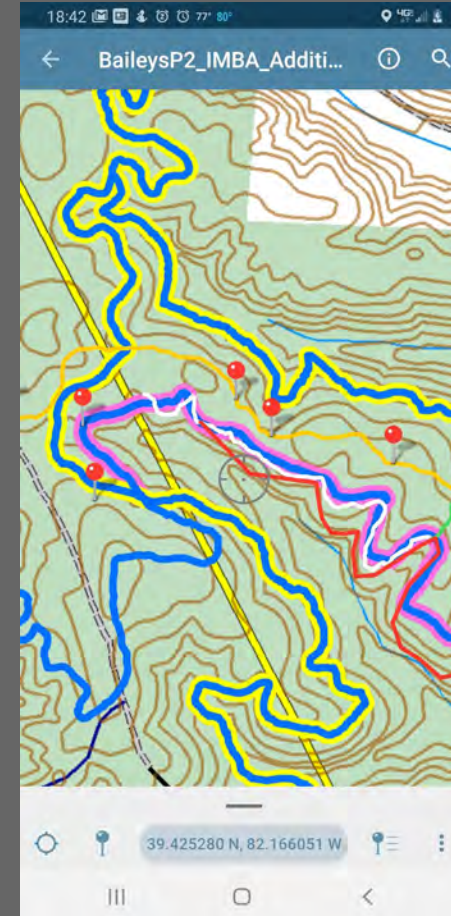
## Monitor your trail

### Document trail conditions

- Geo- referenced photos
- Videos (360)
- Maps
- Inspection logs
- Avenza Pro Map app

### Informed decisions

- Help plan the next work days
- Provide information to land manger on conditions
- Identify sections that require additional help



# TRAIL MAINTENANCE

Safety First!

## Personal Protective Equipment

Head – hard hat

Feet – solid shoes or boots

Eyes – glasses or goggles

Hands – Gloves

Legs - pants

Other – first aid kit and bug spray

## Proper Clothing and Protection

Tool and Safety talk before work

Emergency action plan



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# PUDDLES AND MUDHOLES

Why is it wet - seep or puddle?

**Puddles** are filled with surface collected stormwater with no subsurface flow

**Seeps** are places where groundwater comes to the surface.

Puddle Solutions:

- Drain downslope if cupped on slope
- Regrade trail so it drains to somewhere lower than it.
- Elevate trail tread with compacted soil fill.
- improve material to handle being wet if grading can't keep it dry





# PUDDLES AND MUDHOLES



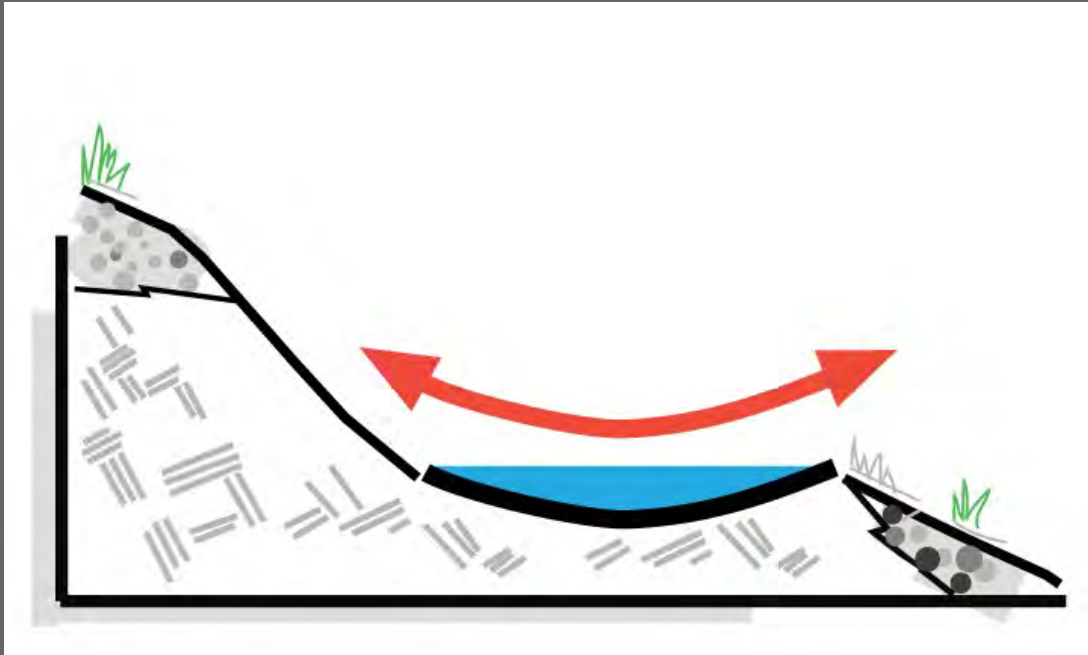
Seeps and places that stay wet

- Fed by subsurface flow
- Porous solutions such as pitching and foundation all less likely to create a dam

Works when wet:

- Raised tread (rock or stone fill above grade)
- Foundation (rock or gravel fill below grade)
- Flagstones and/or pitched stones

# TRAIL CUPPING



# TRAIL CUPPING

Cupping is the slight indentation of the trail tread

- Generally develop over time as center of tread is compacted by users
- Reinforces poor drainage and over time can lead to more serious impacts

With slope

- Knick or de berm outside edge to ensure positive drainage

In flat areas (like the picture)

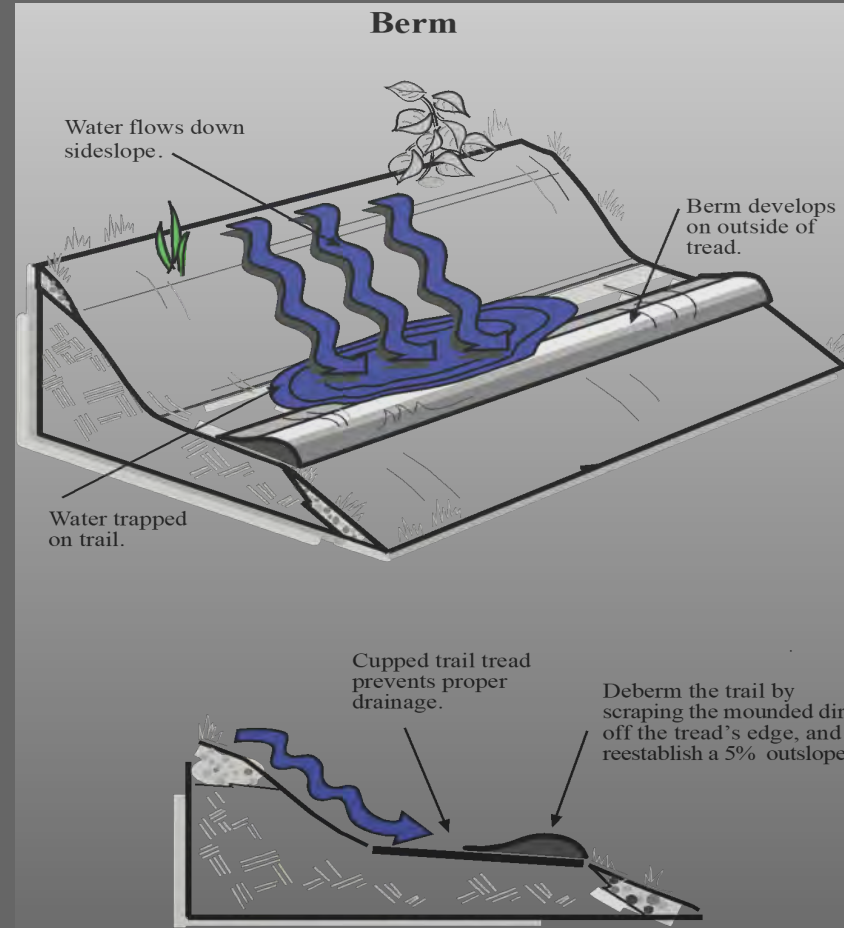
- Determine is this a serious problem? Will it lead to trenching and resource impacts or negative visitor experiences?
- May require more substantial maintenance to fix if so



# TRAIL TRENCHING



# TRAIL TRENCHING



# TRAIL TRENCHING

Trenching is the deep incision of the trail tread

- A much more severe case of cupping
- Channelizes flow down the trail, creating a positive feedback loop of erosion
- Often due to poor alignments (fall line)
- Softer soils (sands) will erode more easily, soil type is an important piece of trail design

Generally an entrenched trail will require a complete relocation. Knicks, deberming, and other light fixes will not solve the larger issue; poor trail layout and design.



# TRAIL TRENCHING



Cupping can lead to trenching!

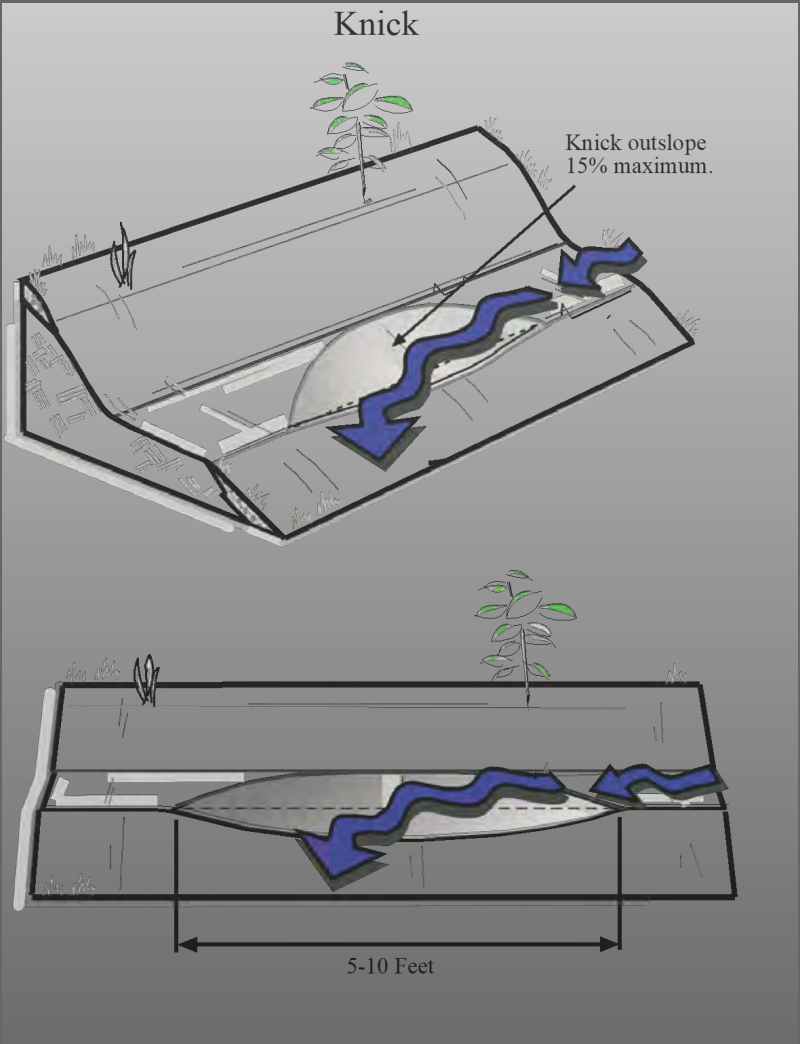
The image on the left and the image on the right are the same trail, just a few hundred yards apart. The cupping on the left is just uphill of the trench on the right.

Soft uncompacted soils and poor drainage led to cupping, which channelized water down the trail (reinforcing the issue).

The steep fall line grade increase water velocity, resulting in more erosive energy and worse impacts.



# KNICK





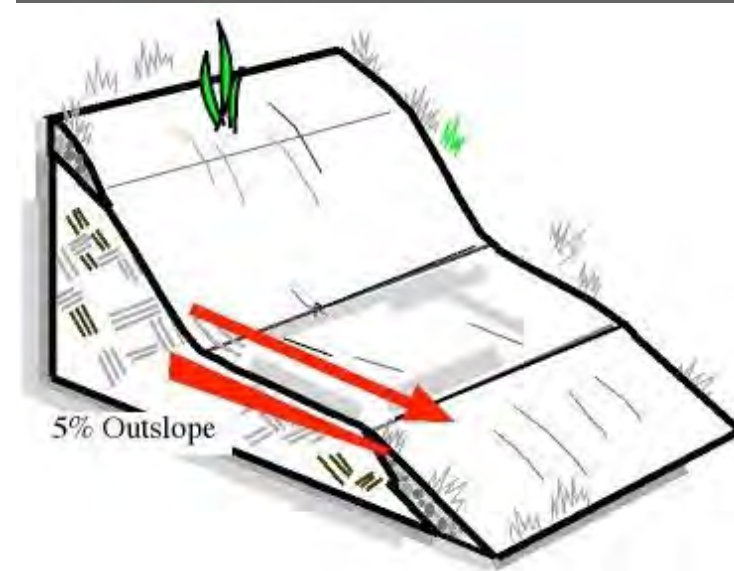
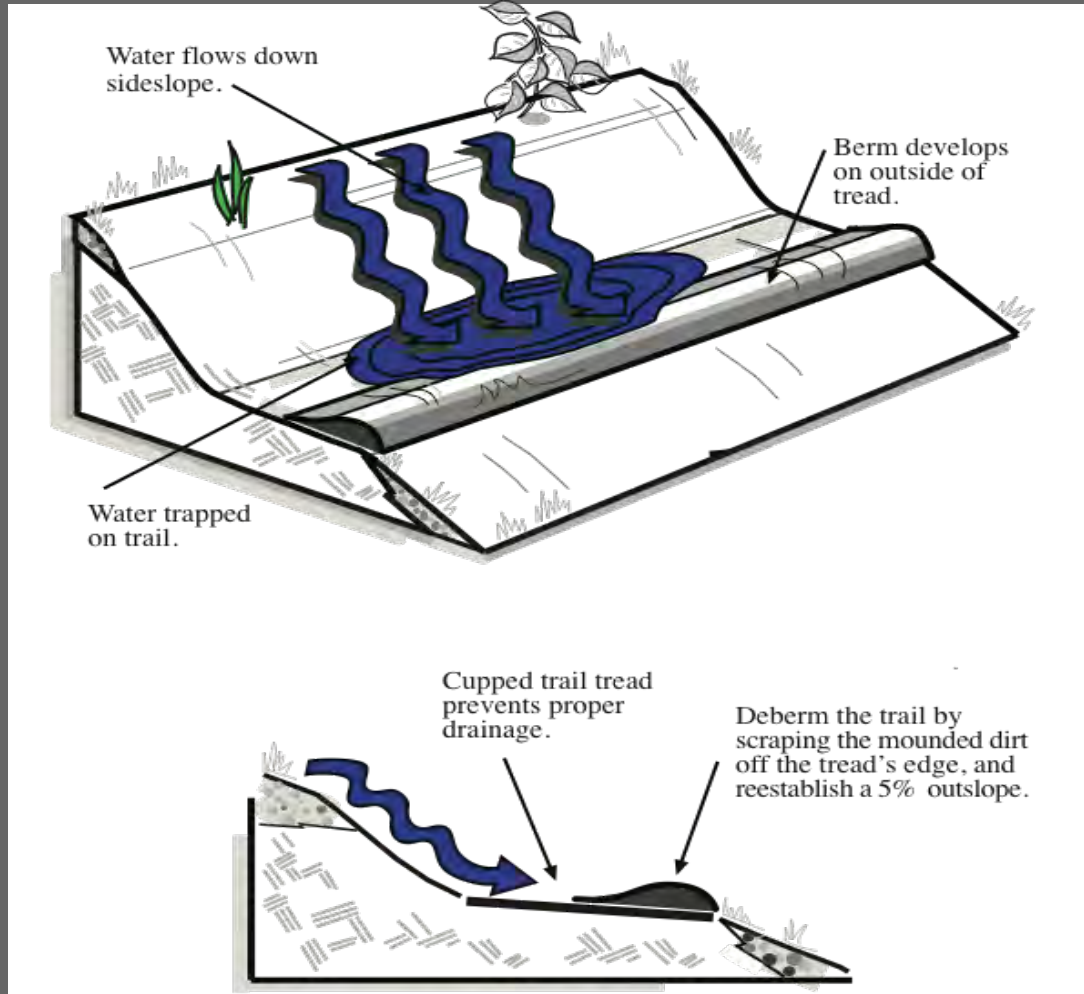
# KNICK





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# DEBERMING



# KNICK AND DERBERM

## Knicks

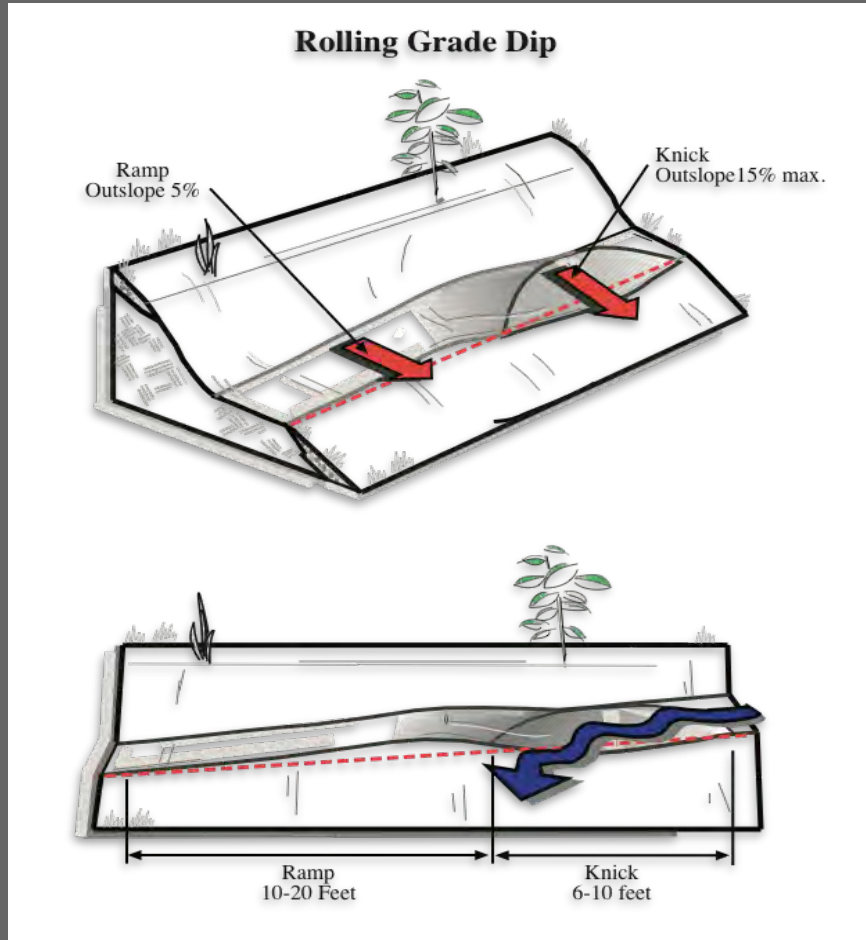
- Useful on small drainage issues. Especially on good trail alignments that have minor issues.
- Cannot nick flat trails, generally knicks are successful on outsloped long runs of trail that have minor erosion or puddling.
- Should be low and wide! Not steep and deep. 6-ft minimum, knicks should drain a wide area off the tread.
- Can be done with simple hand tools. Volunteer leaders can mark the center of knicks for work parties.
- Spoils and debris need to be removed below the tread to ensure positive drainage, even over time as material builds up.

## Deberm

- Only possible on bench cut, flat trails cannot be derbermed if they cup.
- Generally a fix for cupping, along with knicks can help fix typical minor drainage issues.
- Spoils should be scattered downhill and spread to not create a new berm or dam and prolong the issue.
- If the berm soil is mineral soil and useful, can pull back into tread and spread accordingly.



# ROLLING GRADE DIP



Drain needs to be steeper than trail grade.

Dip and rise need to be longer than the wheelbase of a bike (6+ feet).

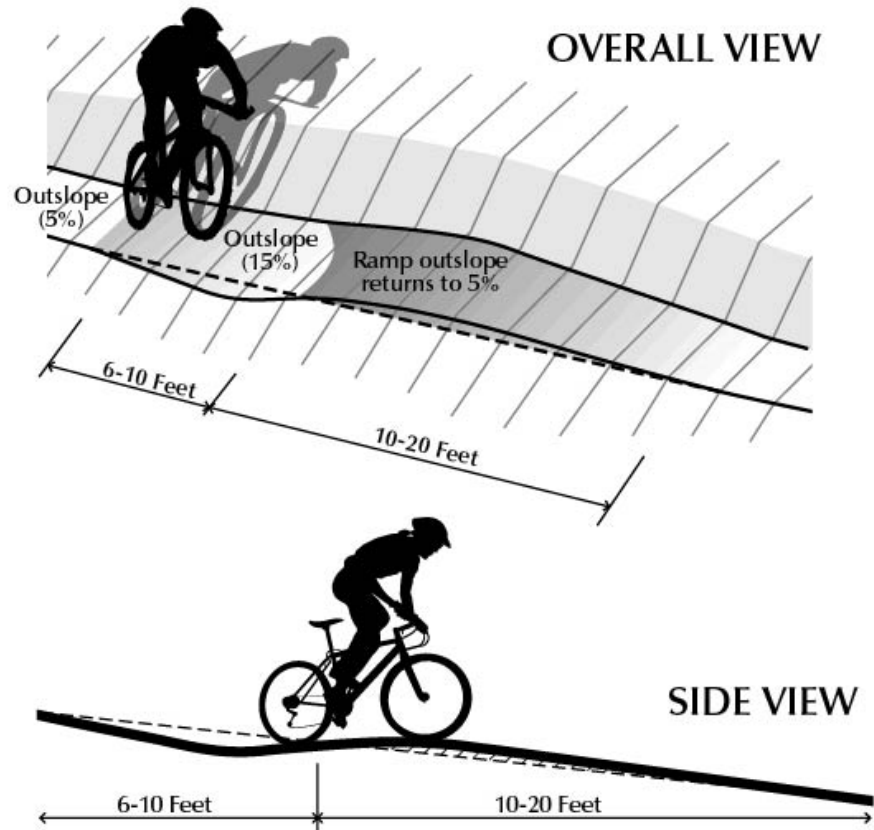
Compaction; expect settling.

You may need to armor the drain.

You can build core of ramp out of small rocks, then cover with soil.

Frequency and placement.

## ROLLING GRADE DIP



The most sustainable alternative to water bars. Rolling grade dips are large enough to be self-cleaning and subtle enough that users do not go around them. Dip itself is longer than a bicycle and shaped like a knick. Bondable soil from dip is used to build a long gentle ramp downtrail from dip. Ramp is nearly twice as long as

KTGA





# CAN THE TREAD BE MOVED TO ADJACENT HIGH GROUND?



# CORRIDOR CLEARING



- Ensure the trail corridor is passable until the next maintenance interval.
- Make sure sightlines are sufficient.
- Note and document material to big to safely handle. (Geotagged photo with scale item)





# WATER BARS

# WATER BARS

Water starts to channelize, gaining volume/velocity and picking up sediment

An obstacle abruptly changes the direction of the water, causing it to dump sediment behind the object

The water continues to erode soil on the down hill side of the obstacle



# USING MACHINES



# USING MACHINES



# USING MACHINES



photo courtesy of IMBA - [www.imba.com](http://www.imba.com)



TRAIL  
SOLUTIONS

I M B A

[www.imba.com](http://www.imba.com)

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# MACHINES

- Very useful!
- Very powerful!
- May trigger more scrutiny!
- Should only be operated by someone familiar with that machine in that landscape!
- Trailbuilding involves taking machines to places they really shouldn't be in many cases.
- Can you get the machine out? Know how to extract and rescue a machine before you take it in the woods.
- Machines add risk – do you have the proper PPE? Always be aware of your surroundings!
- While skilled operators can do a lot of things, hand building will almost always result in a lower impact, more intimate/natural, trail experience.



# KEY IDEAS

What is the intended experience of this trail?

Progression and diversity.

Riders look for difficulty level and styles.

Grade reversals, grade reversals, grade reversals.

Long and shallow.

Rocks help with a lot!

Machines can make a larger disturbance.

Naturalization is very important



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# RECAP

- Plan, plan, plan
- Experiences not activities
- Build on the contour
- Grade reversals for drainage
- Use a clinometer
- Half rule, 10% average, outslope
- Turns and intersections require careful design
- Rock armoring solves lots of problems





# THANK YOU!



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