



## PCTA Trail Skills College Curriculum Instructor Planning Guide



# Course 200. Basic Trail Design

For curious trail workers who want to understand why so many trails are in bad shape because of how they were made. Learn how better design and layout makes trails more sustainable and less prone to erosion. Introduction to different trail design standards appropriate for different kinds of trails. This class is for anybody interested in these topics, but students with some trail building and maintenance experience will benefit the most.

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### STUDENT SKILL OUTCOMES:

- Appreciation of well planned trails versus trails that “just happen.”
- A basic understanding of hillside hydrology and how trails should work.
- Some knowledge of basic trail design and layout principles.
- Developing “trail eyes” for control points, causes of erosion, and factors influencing sustainable trail grades.

### KEY TERMS:

Forest Service Trails Handbook, PCT Plan, Trail Classification, User and Trail Types, Trail Design Parameters, Levels of Difficulty, NEPA, User Trail, Renegade Trail, Hillside Hydrology, Sheet Flow, Curvilinear Alignment, Fall Line, Sustainable Design Principles, Soil Types, Control Points, Grade, Maximum Sustainable Grade, Topographical Turn, Switchback, Climbing Turn, Trail Restoration

### TOOLS NEEDED PER 8 STUDENTS:

Digital projector and Course 200 slideshow, sample documents (EA, Forest Plans, etc.), 4-8 clinometers (or abney levels), 2 tennis balls or oranges, 2 Topographic Quad maps of field area, 4 photocopies of same, 4 rolls of different colored flagging tape, 80 pin flags.

### WORK SITE REQUIREMENTS:

A section of well designed side hill trail with grade reversals, as well as a section of poorly design fall line &/or flat ground trail would be ideal. An area of relatively open untrailed side hill to survey in a trail is needed also, ideally a trail that might be built. Could be a relocation of a poorly designed trail. Possibly more than one site.

### KEY CONCEPTS:

- 1) Trail Origins:
  - Early Progression of Trails
  - Establishment of Federal Land Reserves
  - Renegade/ User Trails
- 2) Trail Planning and Design Process:
  - Establish User Type and Standards
  - Research: Topo maps, Land Management Plans
  - Identify Major Control Points
    - Areas the trail corridor needs to go to (positive) or miss (negative)
    - Major controls are identified before reconnaissance
  - Establish Broad Corridor Alignment
  - Minimize trail impacts on the environment if possible by avoiding meadows, prime habitat areas, and known nesting sites.
  - Get Big Picture Overview
  - Field Check by Reconnaissance
    - Establish minor control points
    - Assess land capabilities
    - Take advantage of inherent aesthetics
  - Plot Control Points and Trail Corridor
  - Bring In Resource Specialists
- 3) Trail Layout Process:
  - Hydrologic Influences of Trail Alignments
    - When trails divert sheet flow
    - Fall line trails cannot be drained
    - Arbitrary drainages/waterbars are not ideal
    - Better: curvilinear alignment, good outslope, full bench, grade reversals in natural drainages
  - Determine Maximum Sustainable Linear Grade
    - Use type, level; Precipitation volume, intensity; Soil type, durability
    - Rise over Run
  - Determine Grades Between Control Points
    - If too steep, add run with well-placed turns
  - Common Design Mistakes

- Inadequate planning
- Alignment too steep/on Fall line, Ridge tops, Flat/soggy land, Meadows
- Lack of restoration
- Flag the Trail Alignment
  - Clinometer use: Zeroing on a partner, Shooting grades across terrain
  - Flag between control points
  - Include grade reversals, especially in natural drainages
- Loose flagging and tight flagging
- 4) Safety Documents and Concerns (for field exercise):
  - Personal Protective Equipment (PPE), Job Hazard Analysis (JHA)/ Tailgate Safety Session (TSS), Emergency Action Plan (EAP)
- 5) Develop “Trail Eyes”:
  - Notice trail grade, soil type, erosion concerns, control points

## BACKGROUND

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### Trail Origins

The very first trails arose long ago as faint paths created by wildlife migrating from place to place seeking food and shelter. With their arrival, Native Americans on foot and later horseback reenforced these game trails as they followed wildlife and migrated from place to place, also seeking food and shelter. In turn settlers, used some of these paths, further establishing the trails for their purposes, and in some cases making them into roads. Most of these earliest trails followed natural features such as creeks, rivers, and ridges that provided easy to follow corridors from one often visited place to another.

Beginning the late 1800’s with the establishment of federal land reserves such as National Forests and National Parks, land managers began to build trails to provide access to remote areas for fire fighting and other management duties. In that same era the very first recreational trails were established by enterprising outdoor enthusiasts who had founded the Sierra Club, and Appalachian Mountain Club, among others. The depression era Civilian Conservation Corps (CCC) did much more of this work in the 1930’s. Some of these routes followed old existing trails and others established new direct corridors deep into the backcountry. Unfortunately, reflecting a lack of knowledge, many such trails were poorly designed, constructed, and maintained and eroded over time.

In the latter half or the 20th century, the art and science of trail design and management developed rapidly to provide quality recreation opportunities for hikers and horse riders, and later nordic skiers, mountain bikers and Off Highway Vehicles (OHV’s such as motorcycles, snowmobiles, and four-wheelers). The techniques of trail design, construction, and maintenance have been improved steadily by a growing cadre of agency, private, and volunteer trail experts. Today there are books, DVD’s, and workshops produced by professional organizations across the country to educate people about trail topics.

With the steep decline of Federal recreation budgets in the last several decades, more and more trail work has been taken on by volunteers, led by local and regional organizations such as the Pacific Crest Trails Association (PCTA). Unfortunately, at the same time unsanctioned **renegade trail** builders have also appeared on the scene, often building poorly designed trails and in some cases damaging archeological and ecological sites. Also, with increasing human population, many new destructive **user trails** arise simply from people wandering off official trails following their curiosity.

### Trail Planning

Before actually designing a trail on the ground, considerable planning work needs to be done (<http://www.fhwa.dot.gov/environment/fspubs/07232806/page03.htm>). Trail Planners must consider the input of the specialists (more on NEPA below), as well as the public, when considering where and what kind of trail to build. Together they determine: a) the area in which the trail will go; b) the users for whom a given trail will be designed; 3) the intended **Trail Class**; and 4) the level of difficulty to which the trail will be built, among other considerations. Obviously, a trail designed for horses or OHV’s will be very different than one designed just for hikers or bicyclists. Discuss the usefulness of a trail classification system for planning trail maintenance and providing different trail experiences.

Trail planners need to research whether the area they have in mind for the trail already has land

management plans in place, for example, plans pertaining to recreation, wildlife, forestry, or watersheds. Additionally, some pieces of Federal land have special Congressional designations such as Wilderness Area, Wild and Scenic River, or National Scenic Trail. Such lands, including the Pacific Crest National Scenic Trail, have special management plans that further guide trail planning and design, along with other topics ([http://www.pcta.org/pdf/PCT\\_Trail\\_Criteria.pdf](http://www.pcta.org/pdf/PCT_Trail_Criteria.pdf)).

## Trail Design

During the trail planning process, preliminary trail design begins so that specialists can study rough proposed routes (<http://www.fhwa.dot.gov/environment/fspubs/07232806/page04.htm>). It is worthwhile to bring into focus the most likely corridor(s) before going into the field and wandering about the hillside.

Taking the best topographical maps, aerial photos, and other research into consideration, and before on-the-ground reconnaissance, designers should identify major control points. Positive **control points** are highly desirable places by which they want the trail to pass. Examples include a trailhead

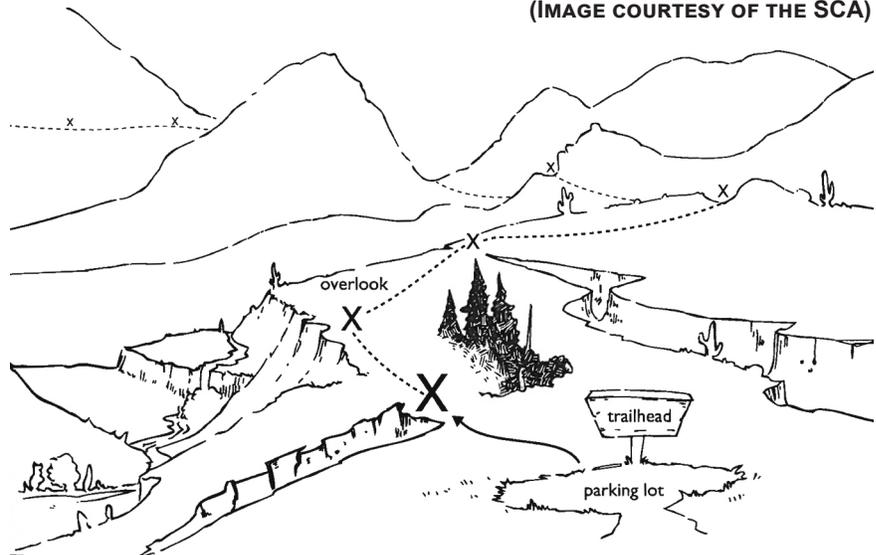
location with adequate parking, stream crossings for affordable bridges (narrow and high-banked) or safe fords (shallow and firm), scenic viewpoints, and side-hill terrain with durable soils on which to build a sustainable trail. Negative control points are places that should be avoided such as swamps, rock slides, avalanche chutes, critical wildlife habitat, and fragile archeological sites, among many others. Major control points not obvious on maps can become evident with a big picture overview, that is, a high visual overview of the shorter corridor unit. Designers may be able to view the target area from the opposite side of a valley, from a body of water, or from detailed aerial photos (eg, Google Earth).

Now it is time to field-check the likely trail corridor(s) with careful on-the-ground reconnaissance. During reconnaissance, designers establish minor **control points**. These may cause minor shifts in the trail alignment, but won't change the overall route. Examples include rock outcrops, springs/seeps, big trees, and rock slides/debris flows. Designers keep track of rough grades between control points with a **clinometer**. Reconnaissance also allows designers to determine an alignment that highlights the natural aesthetics of the area.

Reconnaissance is also the time for careful assessment of land capabilities. Soil type and vegetation are clues as to whether or not the terrain is suitable for a trail. Best are durable soils on hillsides that can sustain a full bench with good outslope (more on these topics below). A varied matrix of good material, (eg, clay-sand, and angular gravel), will compact and keep soil moisture content, sustaining steeper grades and heavier use.

After reconnaissance, designers plot a rough trail corridor, either on a map, with GPS, or on the ground with loose flagging. Then it is time to call in resource specialists for their on-the-ground surveys. A trail that is to be built on any Federal land must follow guidelines of the National Environmental Policy Act (**NEPA**) to be sure that trail construction and use do minimal damage to fragile ecological, historical, or archeological resources. This involves the analysis by a variety of specialists, including botanists, wildlife and fisheries biologists, and archeologists, among others ([http://www.imba.com/resources/trail\\_building/itn\\_11\\_5\\_wildlife.html](http://www.imba.com/resources/trail_building/itn_11_5_wildlife.html)). If the specialists reveal sensitive areas that a trail could disrupt,

Figure 1. Control Points  
(IMAGE COURTESY OF THE SCA)



designers then consider these major control points, and reassess the proposed route.

For further reading, review the Forest Service Trails Handbook to see the type of guidance given to trail planners ([http://www.fs.fed.us/recreation/Chapter\\_10.pdf](http://www.fs.fed.us/recreation/Chapter_10.pdf) [see especially, p. 7-10, 12, and 23]).

## Trail Layout

Once they have the go ahead from the planning team, a designer considers the specific **design parameters** for the trail class and **managed use** established by the final trail planning document ([http://www.fs.fed.us/recreation/Chapter\\_20.pdf](http://www.fs.fed.us/recreation/Chapter_20.pdf) [see especially p .6-7, 11, and 16-19]). If you review the design parameters you'll see that trail design varies significantly from one managed use to another.

It is critical that students understand the hydrologic influences upon proper trail alignment. **Hillside hydrology** and How Trails Work: Water from rain, melting snow and seeps is a major threat to trails. In a perfect trail world, when water **sheet flows** down a hillside and encounters a trail with good **outslope**, it gently crosses the trail and continues down the hillside without causing any erosion of the trail tread.

In the worst case, hillside sheet flow is interrupted and follows the trail instead. Water quickly gains volume and speed on steep **grades**. On trails where water can't be drained off, especially if the trail follows the **fall line**, it erodes 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 decommissioned.

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 the trail. 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.

Waterbars and drain dips, the most common triage remedies to cupped tread, are often placed arbitrarily along a trail. When water accumulates on the trail and is arbitrarily drained off it can create erosion below the drain point. Vegetation and wildlife communities below are affected by changing the amount of water they receive. The worst diversions result in the coupling of two drainages together, causing the dewatering of one and the destabilization of the other.

The best way to protect trails from typical erosion patterns is by good trail design and construction, whereby a new trail has **curvilinear** alignment and modest grades (less than 10-15%). Such a trail should pass only through durable soils on hillsides that can sustain a well-compacted **full bench** and generous outslope. This facilitates sheet flow and minimizes the need for drainage structures. For extra drainage insurance, designers include **grade reversals (aka swale or draw)**. Grade reversals are especially important wherever the trail passes through a natural topographical drainage, no matter how small. ([http://www.imba.com/resources/trail\\_building/up\\_down.html](http://www.imba.com/resources/trail_building/up_down.html), [http://www.imba.com/resources/trail\\_building/contour.html](http://www.imba.com/resources/trail_building/contour.html), [http://www.imba.com/resources/trail\\_building/sustainable\\_trails.html](http://www.imba.com/resources/trail_building/sustainable_trails.html))

Figure 3 is a Forest Service Trail Handbook chart suggesting spacing of grade reversals for specific soil types (because of their varying durability) for different trail grades.

A designer must determine the trail's **maximum sustainable grade** considering many factors. These include Use type and level; Season of use; Precipitation volume and intensity; Soil type and durability. If possible, a designer should assess similar trails in the nearby area and observe what grades are sustainable there. For the purposes of this class, supply the class with a pre-determined maximum grade, say 10%.

Show students how to calculate grade between two control points, dividing rise by run (elevation

change by distance). For a given trail, while the overall target average grade may be 10%, the grade between any pair of control points is likely to vary. Make sure to work between two control points when ready to flag; otherwise, starting from the beginning and “blind flagging” at 10% will result in sudden grade adjustments as minor controls are encountered.

If the grade between two points exceeds maximum, a designer needs to add run (distance) with well-placed turns. **Topographical turns** are preferable to **switchbacks** or **climbing turns**, because they are less detectable, and therefore less prone to cutting.

If switchbacks or climbing turns are necessary, each one should be located very deliberately. Locate to facilitate drainage away from the corner by using a ridge nose or a natural topographical swale/drainage. There must be good separation between the two legs to prevent cutting, so designers look for a bump in the topography, trees, rocks and brush to provide a barrier between the two legs. Incorporating vistas into switchback corners, where possible, will help prevent cutting. When using multiple switchbacks, maximize the distance between each switchback to eliminate “stacking.” Ideal spots for turns are not easy to come by. Therefore, when a designer finds a good spot for a turn, that becomes a control point and influences trail alignment.

Students will recognize common design mistakes evident in many existing trails. Inadequate planning can result in the need later to realign sections at steep grades, or to decommission trails that erode too easily. Traditionally, many trails were located on broad ridge tops, where views are great, but opportunities to drain the tread are scant. The problem with ridgeline trails is one species of the problem with fall line trails. Better to locate trails on a hillside, and cross over the ridgeline at a saddle to provide views in the other direction. Flat areas and meadows, too, have historically been popular places to locate trails. However, these locations too are destined for drainage problems. Better to locate on a hillside, just outside the edge of a meadow, offering views into the meadow. For more on trail planning and design mistakes, see [http://www.imba.com/resources/trail\\_building/top\\_10\\_mistakes.html](http://www.imba.com/resources/trail_building/top_10_mistakes.html).

Emphasize that every trail plan and design must address the need to rehabilitate any abandoned, **renegade**, or **user trails** because such work can be nearly as significant as construction of a sustainable new trail [http://www.imba.com/resources/trail\\_building/reclaiming\\_trail.html](http://www.imba.com/resources/trail_building/reclaiming_trail.html).

## Trail Flagging

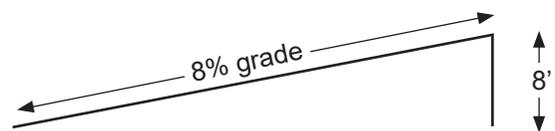
Explain briefly how to use a clinometer. Before the field exercise (see below), students will zero on a partner on flat ground. When using a clinometer on variable terrain, be careful not to shoot across big bumps or depressions, as this will distort results. Trail alignments should be flagged working between two control points. Grade reversals should be incorporated at each natural topographical drainage, no matter how small. Keep in mind that grade reversals will alter the average grade, so, many designers

**Figure 2. Frequency of Grade Reversals or Cross Drains**

Source: Forest Service Trails Handbook 2309.18, Chapter 3, Trail Pre-construction & Construction

Material Type	Grade (percent)						
	2	4	6	8	10	12	15
Loam	350'	150'	100'	75'	50'	*	*
Clay-Sand	500'	350'	200'	150'	100'	50'	*
Clay or Clay-Gravel	-	500'	300'	200'	150'	100'	75'
Gravel (rounded rock)	-	-	750'	500'	350'	250'	150'
Shale or Angular Rock	-	-	800'	600'	400'	300'	250'
Sand	Varies with local amounts of fine clay and silt. Drainage diversions generally are not required in “pure” sand because of the fast rate of water absorption. For sand with appreciable amounts of fine binder material, use “clay-sand” distances as shown above.						
* Grades not recommended in this material. - Generally no diversion required for soil stability.							

**Figure 3. Calculating Percent of Grade**



$$\text{Percent of grade} = \frac{8 \text{ feet (rise)}}{100 \text{ feet (run)}}$$

shoot for 7-8% if they do not want to exceed 10% after grade reversals.

Some trail designers carefully pin flag or stake every 5-10 feet of trail, noting the exact location of every grade reversal and drainage--such a detailed design is necessary if the trail is to be constructed by a private contractor ([www.trailbuilders.org](http://www.trailbuilders.org)). This is known as tight flagging. Others trail designers, if they have a skilled volunteer or staff crew to construct the trail, may flag more sparsely (loose flagging) and leave some decisions to the crew.

## TEACHING TIPS & TECHNIQUES

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This course's companion PowerPoint presentation can be downloaded from the PCTA website, <http://pcta.org/help/volunteer/trail-skills-college/curriculum.asp>. Depending on discussion, the PowerPoint can take up to two hours. It is highly preferable to include a field component for the second half of the day. If the class is taught entirely in a classroom, be prepared with lots of handouts, projected web links and digital images. Showing the Forest Service/IMBA trail design DVD or Forest Service switchback design DVD might be a good option, order DVDs at <http://www.fhwa.dot.gov/environment/rectrails/trailpub.htm>

Because some students will have difficulty paying attention to lectures, encourage participation by using a Socratic method of asking students why they think things might be as they are. For example, ask, "How do you think the first trails came to be?", rather than just telling them.

Have groups of four examine topo quad maps (or project a quad) to be sure students are familiar with the maps. Utilize students with more expertise to explain how the map works to those with less experience.

In pairs, ask students to pencil in a conceptual trail alignment from a an assigned point A to B. Ask them to identify potential positive and negative control points along the route. Have them present their findings to the group, describing why they have selected their chosen route. Draw out issues such as side hill design.

Then have them calculate the grade, dividing feet of rise divided by feet of run (length). If their grade is goal is a grade never to exceed 10%, clarify that the average grade will need to be less to include regular grade reversals. If it is desirable to have short sections of trail exceeding 10%, then an average of 10% is acceptable. Have them adjust their trail alignments, if necessary, on the map.

Introduce clinometers, and have students zero on a partner of about the same height. In the field, have teams of two flag a section of side hill trail at 10%. Then have them place pin flags along the alignment indicating grade reversals. Walk and discuss after each step. Are there any minor control points along the route, to miss or go near for interest, such as a large boulder or tree?

If you have time have students flag and then pin flag a climbing turn and switchback.

Walk existing trails and have students evaluate grades and critique what is good or might be better about the trail design. If possible choose a section of trail that has serious grade and erosion problems. Ask students to design a relocation. Examine the relocation as a group and then discuss the relative merits of constructing the new trail combined with reclaiming the old trail versus reconstructing the existing trail.

Remind student of the concept of ***“Trail Eyes”***  Encourage students to heighten their awareness of all trails they walk to notice grades, erosion, control points, grade reversals, etc. Especially encourage students to get a pair of rubber boots and an umbrella, in addition to rain gear, so they can go out on a rainy day to examine closely how water interfaces with trails. Ask them to notice how water sheets off hillsides, accumulates in small rivulets and then crosses an outsloped tread, or follows one with berm, carrying loose sediment to drainage structures. The ultimate goal is by seeing water they gain the ability to “think like water” and possibly “see water running down trails, even on sunny days.”

## TRAIL FUN

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

## REFERENCES

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*Lightly on the Land: The SCA Trail Building and Maintenance Manual*. 2005. Robert Birkby. The Student Conservation Association and Mountaineers Books. Chapters 1 and 9 are fine introductions to trail origins and design.

*Natural Surface Trails by Design: Physical and Human Design Essentials of Sustainable, Enjoyable Trails* by Troy Scott Parker. 2004. [www.Natureshape.com](http://www.Natureshape.com) \$30. This is the most comprehensive reference on the theory of trail drainage. It digs into the many factors that affect the durability of trails, such as hillside hydrology, soil types, surrounding vegetation, user types, etc. Excellent discussion of switchbacks, drain dips, and other features, and especially what makes them sustainable. For trail wonks, this book is a must, but it's only for trail wonks.

*Trail Construction and Maintenance Notebook*. 2007. Woody Hesselbarth. USDA Forest Service. Pages 9-24 cover trail planning and design well.

[www.fhwa.dot.gov/environment/fspubs/07232806/page03.htm](http://www.fhwa.dot.gov/environment/fspubs/07232806/page03.htm) — planning  
[www.fhwa.dot.gov/environment/fspubs/07232806/page04.htm](http://www.fhwa.dot.gov/environment/fspubs/07232806/page04.htm) — design

*Trails Handbook*. U.S. Forest Service. 2008 edition, No. 2309.18. Chapters Zero (Definitions), Chapter 10 (Trail Planning), Chapter 20 (Trail Development), and 1991 edition of Chapter 3, Trail Preconstruction and Construction.

*Trail Management: Plans, Projects, and People*, a course offered at the National Conservation Training Center of the National Fish and Wildlife Service. 2009. Course resources posted online at <http://training.fws.gov/DEO/OUT8194TrailManagementPlansProjectsandPeople.html>

*Trail Solutions: IMBA's Guide to Building Sweet Singletrack*. 2004. IMBA (International Mountain Biking Association) has some excellent online resources.

[www.imba.com/resources/trail\\_building/index.html](http://www.imba.com/resources/trail_building/index.html) IMBA and the US Forest Service teamed up in 2006 to make a great DVD, *Building Mountain Bike Trails: Sustainable Singletrack*. A copy, along with other DVD and paper materials, can be ordered at: <http://www.fhwa.dot.gov/environment/rectrails/trailpub.htm>



## PCTA Trail Skills College Curriculum Field Reference



# Course 200. Basic Trail Design

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### **STUDENT SKILL OUTCOMES:**

- Appreciation of well planned trails versus trails that “just happen.”
- A basic understanding of hillside hydrology and how trails should work.
- Some knowledge of basic trail design and layout principles.
- Developing “trail eyes” for control points, causes of erosion, and factors influencing sustainable trail grades.

### **KEY TERMS:**

**Control Points:** specific locations on a landscape that a newly designed trail must pass through (positive control points) or avoid (negative control points). Examples of positive control points include low mountain passes, the best trailhead location, and ideal bridge locations. Negative control points include areas of highly erodible soils, avalanche chutes, and boulder fields, among others.

**Curvilinear Alignment:** The opposite of **Fall Line** alignment, curvilinear means the trail basically follows the contour lines of the topographical map. This alignment helps runoff to sheet across the trail without accumulating or diverting.

**Fall Line:** the shortest and steepest way down a hill, indicated by a clinometer or a rolling ball. Trails that follow the fall line are likely to erode badly and are impossible to drain. Ideally they should be relocated to follow the side slope at a grade less than 10% or have check dams installed to slow further erosion.

**Grade:** the angle or slope of any surface, though here most concerned with the grade trails climb, as well as that of tread out-slope, back-slope, and also of the natural hillside fall line or side slope.

In trail work, grade is expressed as a percentage (%), determined by dividing rise (vertical) over run (horizontal). Most commonly in trail work grades are measured with an instrument called a clinometer. Note that clinometers have both a percent scale (usually on the right) and degree scale, which are not the same.

**Hillside hydrology:** generally describes how water from rain, melting snow, and seeps travels down natural slopes. Here we are especially concerned with how such water interacts with trails. Troy Parker uses the additional term, “tread watersheds”, to describe the subsections of a hillside that shed water to a particular piece of trail between two drainage structures.

**Maximum Sustainable Grade:** Each trail’s tendency to erode will be influenced by many factors, including Use type and level; Season of use; Precipitation volume and intensity; Soil type and durability. The more prone to erosion the tread is, the more gentle its maximum grade should be.

**NEPA:** A trail that is to be built or significantly relocated on any Federal land must follow guidelines of the National Environmental Policy Act to be sure that trail construction and use do minimal damage to fragile ecological, historical, or archeological resources. This involves the analysis by a variety of specialists, including botanists, wildlife and fisheries biologists, and archeologists.

**Renegade Trail:** (aka illegal trail) a trail built by individuals and groups without the permission or guidance of professional land managers. Such trails often are poorly designed, constructed, and maintained, leading to erosion and damage to wildlife, plant, and archeological resources.

**Sheet Flow:** the passage of rainwater and snow melt down a hillside as a thin layer, causing minimal erosion until it reaches a drainage. Such sheet flow, when it reaches a uniformly outloped trail, simply crosses the trail and continues down the hillside. If it is interrupted by a flat, cupped, or insloped tread, the water is diverted down the trail and erodes the tread.

**Trail Class:** A rating indicating the level of development of a given trail. It is based on many factors including the land through which it passes, the intended users for whom it is designed and built, the resulting design parameters and its likely level of maintenance. Forest Service Trail Classes are 1 to 5 with 1 being most primitive, such as a faint wilderness trail, and 5 most developed, such as a paved trail. (See [www.fhwa.dot.gov/environment/fspubs/07232806/page03.htm](http://www.fhwa.dot.gov/environment/fspubs/07232806/page03.htm) especially pages 6-10.) A trail class is closely related to its difficulty level.

**Topographic Turn:** Better than a switchback or climbing turn, because they utilize a feature in the topography to wrap the trail around. Unlike “stacked” switchbacks, they are less detectable, and therefore less prone to cutting and erosion.

**User Trail:** (aka **social trail, bootleg trail**) a trail created by the feet of users without proper design, construction, or maintenance. Some present few problems, while others are prone to erosion and damage habitat. A common problem is the development of a net of many such trails in an area, leading to user confusion and excessive impact on plants. See also, renegade trail.

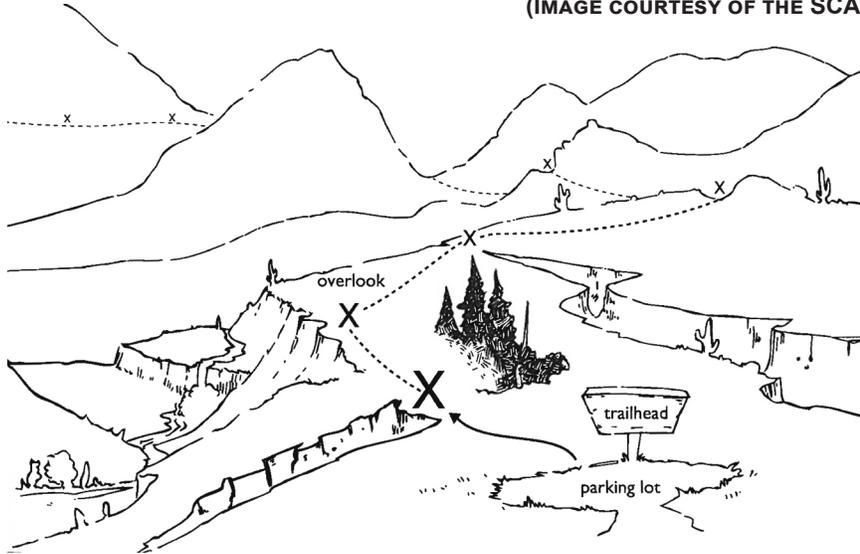
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  - Determine Grades Between Control Points
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  - Establish minor control points
  - Assess land capabilities
  - Take advantage of inherent aesthetics
- Plot Control Points and Trail Corridor
- Bring In Resource Specialists

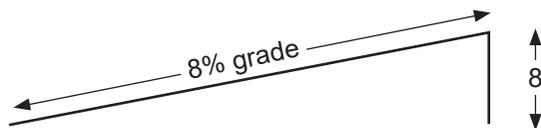
**Figure 1. Control Points**  
(IMAGE COURTESY OF THE SCA)



**Figure 2. Frequency of Grade Reversals or Cross Drains**  
Source: Forest Service Trails Handbook 2309.18, Chapter 3,  
Trail Pre-construction & Construction

Material Type	Grade (percent)						
	2	4	6	8	10	12	15
Loam	350'	150'	100'	75'	50'	*	*
Clay-Sand	500'	350'	200'	150'	100'	50'	*
Clay or Clay-Gravel	-	500'	300'	200'	150'	100'	75'
Gravel (rounded rock)	-	-	750'	500'	350'	250'	150'
Shale or Angular Rock	-	-	800'	600'	400'	300'	250'
Sand	Varies with local amounts of fine clay and silt. Drainage diversions generally are not required in "pure" sand because of the fast rate of water absorption. For sand with appreciable amounts of fine binder material, use "clay-sand" distances as shown above.						
* Grades not recommended in this material. - Generally no diversion required for soil stability.							

**Figure 3. Calculating Percent of Grade**



$$\text{Percent of grade} = \frac{8 \text{ feet (rise)}}{100 \text{ feet (run)}}$$