Chapter Five
Preparing for the Field

Riding Takes All of Your Wits, Don't Impair Them

The most important and gratifying part of creating great trails occurs in the field. The saying that even a bad day in the field is better than a good day in the office is very true. The field is where the creative juices can flow; where there are options, challenges, and opportunities; and where all of the pieces of the puzzle come together. The planning and design team members can apply their understanding of the landscape, environment, recreation use, and physical forces to make informed decisions that will most benefit the riders while ensuring the protection of the resources. To make effective use of the time in the field, team members need to arm themselves with tools and techniques and have as much knowledge of the area as possible.

Section 1: Gearing Up for the Field

Safety and Risk Management

The field is a wonderful place, but it is full of personal risk. Before heading to the field, the team needs to take some time to examine the risk factors and mitigate them. The primary objective every day is to come back safely and the team does that by stacking the odds in their favor; being prepared and alert. What is the weather forecast? Dress accordingly. Are the soils slippery when wet? Wear appropriate footwear. What insects are in the area: bees, mosquitos, ticks, chiggers, scorpions? Wear appropriate clothing; take insect sprays; and look before walking, sitting, or reaching. If someone is allergic to any bites or stings, take an Epi kit. What animals are present: bear, deer, elk, moose, or domestic livestock? Don't be too proud to wear a bear bell or pack bear spray. What poisonous reptiles are present? Again, look before walking, stepping, and reaching. Snake gaiters are hot, bulky, and certainly not fashionable, but the peace of mind they offer is worth it. What poisonous plants are in the area? Know what they look like and where they grow and dress accordingly. Vehicles are needed to get the team in and out of the field every day. What condition are the trucks, ATVs, OHMs, etc. in? If there should be a mechanical malfunction, how will the team get out? Is there party or drug activity in the area? Are there people who want to live off the grid? Be aware and avoid walking into a situation that may put the team at risk. Finally, know the team members' physical limitations. If team members don't think they can safely traverse the terrain on a given day, don't go. Stay in and catch up on paperwork.

The proper gear helps you have a safe and enjoyable day in the field. Minimizing your risk will help ensure that you can enjoy another day tomorrow.

Certainly, one of the best things to do to keep the odds in a team's favor is to carry and use personal protective equipment (PPE). This may include riding gear, chainsaw gear, climbing gear, hardhats, high visibility vests, etc. There is no valid excuse to not wear it. Manage risk and keep everyone safe. No one can do trail work if they're hurt.

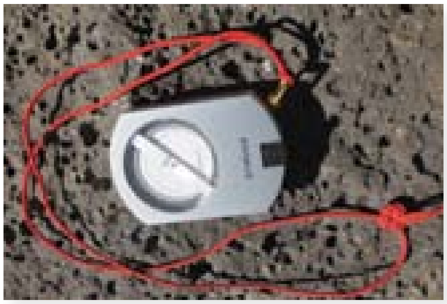

Being prepared can turn a cold, wet lunch from something to endure to an enjoyable event. When you take a bite of your sandwich and you get more bugs than sandwich, it's time for the bug nets.

The goal of all of this is not only to keep team members safe, but to maximize the efficiency of the time spent in the field. Many agencies formalize the project analysis and self-protection process on a Job Hazard Analysis (JHA) form.

Basic Field Instruments

Whether doing reconnaissance of a project site, assessing an existing trail, performing trail layout and design, or establishing construction controls, the team needs to have an array of tools available to help perform whatever task is needed. Once in the field, the office, supply room, and shop are in team members' day packs.

Consider taking a variety of key instruments and tools. A short list is described below. Additional information can be found on the Great Trails website at www.greatohvtrails.com.



A **clinometer** is an invaluable little device used to measure the percent of slope or degree of slope between any two points. It requires binocular vision and takes a little practice to use, but it is the number one companion of any trail designer. The clinometer is not highly accurate and if it gets knocked around in the field it can lose calibration. There is no calibration adjustment, but a good test is to shoot the grade to the uphill point and then once there, shoot the grade back to the downhill point. If they are off by 3 or more percent, it's time for a new one.

A **GPS receiver** uses global positioning satellites to pinpoint position, track progress, approximate elevation, and establish waypoints. Many have a built-in camera, radio, barometer, compass, or other handy features. Even recreation grade units are highly accurate. Team members should learn how to navigate and use the TRACKBACK or GOTO features on the GPS before they need them.

Taking handwritten notes or typing in waypoint data on a GPS receiver can be laborious. Instead, it's faster and easier to record the data on a **voice recorder**. This data can be digitally downloaded and saved to a computer. A voice recorder app on a smartphone can also be used.

Though a lot of other devices have built-in cameras, a quality pocket-sized **digital camera** still takes better pictures and offers more functions. Because there can never be enough photos taken in the field, it's a good idea to have one at all times. Don't forget a fully charged spare battery. A flexible mini-tripod is also handy to capture the perfect shot.

Roll-up **100-foot cloth tapes** are very handy for measuring or designing structures or facilities.

Small multi-blade, **multi-function tools** are invaluable in the field.

Spare batteries should be packed for whatever device uses batteries. Field time is valuable. Don't have it cut short because of dead batteries.

Team members should have **radio communication** so they can coordinate and work together more effectively and safely. The little consumer-grade GMRS or FRS radios have a good range and good call quality.

Flagging and Pin Flags

The flagging that comes in a roll is called ribbon flagging and it is offered in a variety of colors and patterns. Flagging is used to mark the trail alignment as well as various work items. Most projects have a list of flagging protocols that spell out the color and pattern to be used for each work item. It is very important that the flagging used for a trail does not conflict with what is used by other agencies or industry for timber sale boundaries, road surveys, proposed utility corridors, mining claims, seismic lines, transect surveys, etc.

Ready for the field with the day pack, pin flags and carrier, and pre-tied paper clips on an embroidery hoop.

A key point to remember about flagging is that it is not very durable. Deer, cows, rodents and insects eat it; the UV rays from the sun can fade the color in just a few months; and the wind, hail, and cold tear it to shreds. Hanging long streams of flagging is great for visibility, but it is more susceptible to the critters and the elements and thus has limited longevity. Shorter flags last longer. Since a large percentage of the flags will disappear, tie them close together. A 15-foot interval works well. It can be several years from the time a trail is designed to the time the trail gets constructed.

What is the best method to tie the flags? A simple overhand knot works well for temporary flags. A key thing about knots is that they should be simple to tie and untie when there are changes. A double overhand knot is not simple to undo. A bow knot is simple. One pull on the loose end and it comes off. Unfortunately, if that pull is coming from an animal, the flag will be lost. A loop knot works well. Fold the piece of flagging into a loop, place the loop over the limb, and pull the tails through. This simple knot is easy to tie and untie. Repeat the process for a double loop.

A simple loop knot is easy to tie and untie and it's durable. (loosely tied to illustrate the knot)

It takes more time, but tying a double or triple knot will last significantly longer and after a couple of years, only the knot will be left. The downside of using multiple knots is that it is very difficult and time-consuming to remove the flags to change the line. Tie the multi-knots on the last pass through a flagline, not the first.

A trick is to pre-tie flags onto smooth jumbo paperclips. These are easy to clip on and off, are durable, and are more visible when only the knot is left. There are four main advantages to the paperclip trick: it eliminates the fumbling and pain of trying to tie a knot in a briar patch; knots are tight and consistent since they are tied in a warm controlled environment; it is fast, clip it on and move on; and rather than focusing on reaching in and tying a difficult knot, the designers can stay focused on what the trail grade, alignment, or drainage is doing.

The loop knot tied onto a jumbo paper clip is a slick trick: fast, efficient, durable.

The paper clips come in boxes of 100. Tie a box at a time and hook them onto a string. When ready to use, transfer them from the string to a slightly modified steel spring-tensioned embroidery hoop from a fabric store and head to the field.

A pin flag is a wire whip with a colored flag on top. The length of the wire and the size of the flag vary. Pin flags are handy in open areas or meadows where there are few trees or brush to hang flagging. The longevity of pin flags can be shorter than that of ribbon flagging. The flag tends to break off in the wind and cold leaving only a rusted wire as a marker. The wire will usually stay in place and at least the critters won't eat it, but it can be very hard to find once it is no longer shiny or if it's in tall grass. It is best to install the flags at short intervals. Pin flag carriers or quivers are available in a variety of lengths. Pin flags provide a great visual because they highlight the flow of the trail. They can be especially helpful when creating circular curves in the field.

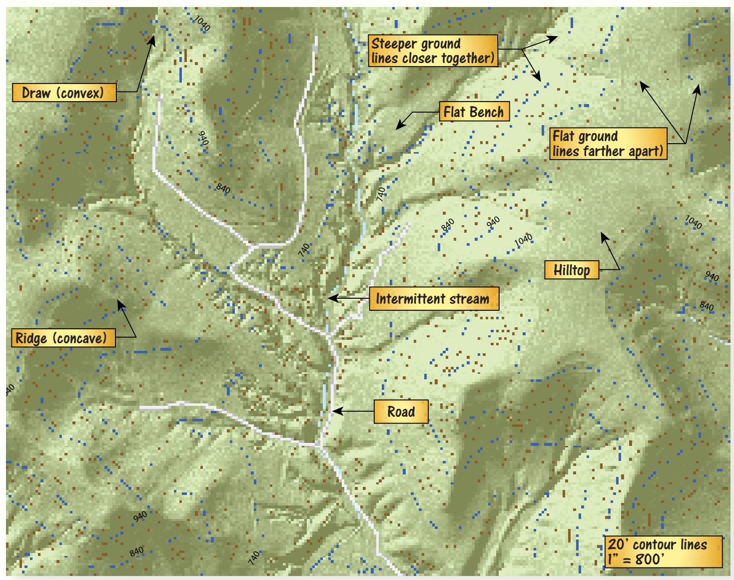
Re-flagging is necessary on most projects that won't be implemented within one year. Making an accurate survey of the flagline with a good GPS is essential in order to re-establish the line.

Section 2: Finding the Way in the Field

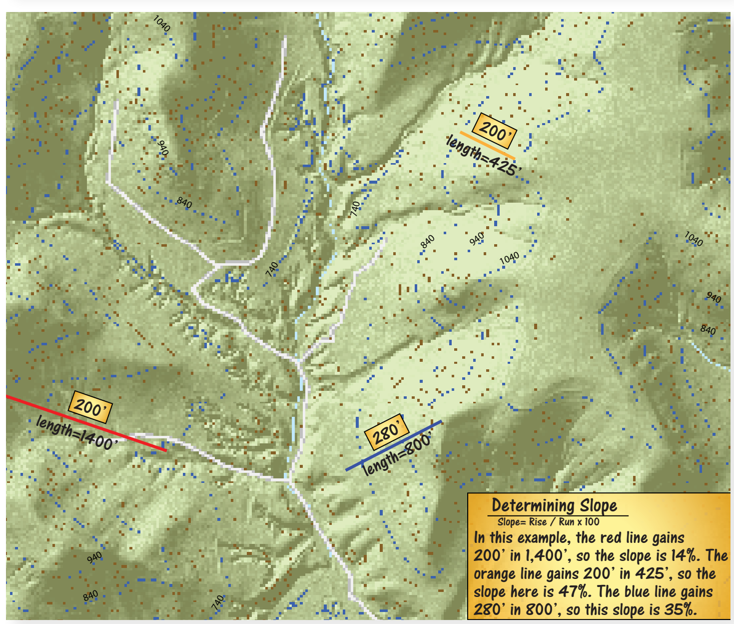
Before going to the field, planning and design teams should arm themselves with as much knowledge of the site as possible. They should study maps and imagery for valuable information on the site, where to go, and how to get there. Resource data in GIS layers can show opportunites as well as constraints. Knowing how to use a GPS receiver in conjunction with maps can help the team efficiently navigate to where they want to go and can tell them where they are in relation to the opportunities and constraints. Mapping technology is constantly evolving with more recreation-grade products, higher quality, more features, and lower cost.

Using Topographic Maps in the Field

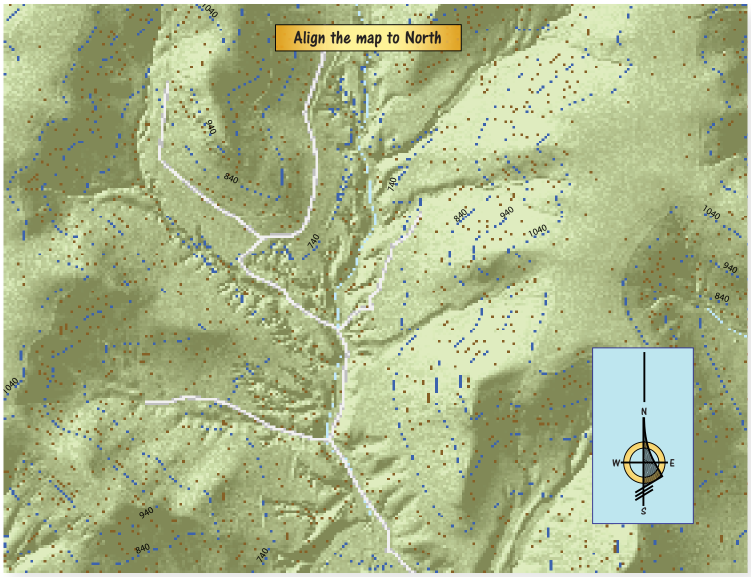
Topographic (topo) maps illustrate features such as contour lines, mountains, roads, trails, streams, lakes, towns, buildings, power lines, forested areas, open areas, and other features. These features are mapped using aerial photographic interpretation called photogrammetry. In the United States, most of this mapping was done by the U.S. Geological Survey. The entire country is divided into named rectangles and the maps are referred to as USGS quadrangles, or quad maps.

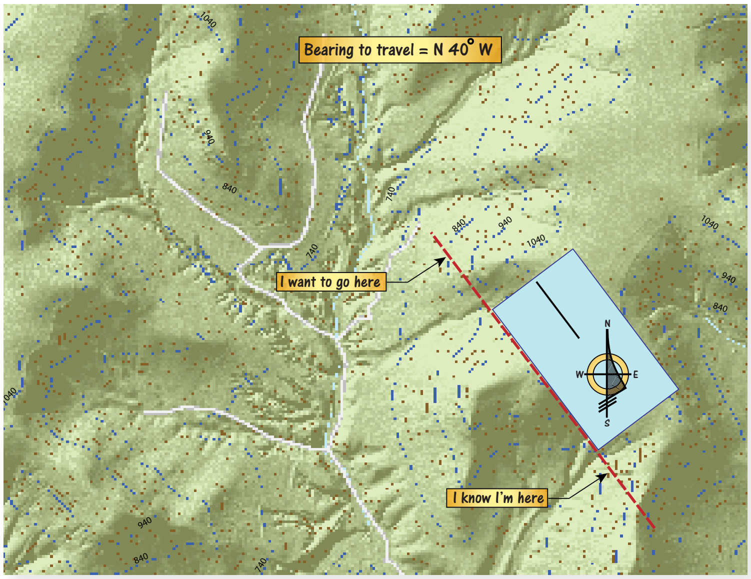


Contour lines are informative features on topo maps and represent points of equal elevation (height) joined together to form a line. Contour lines typically represent elevation intervals of 10, 20, or 40 feet. The exact contour height above sea level is less important than how the lines represent the shape and slope of topography. The closer the contour lines are together the steeper the topography is. Contour lines also illustrate ridges, valleys, and depressions. Convex lines pointing uphill represent valleys or drainages. Concave lines pointing downhill represent ridges or hills. Contour lines that are concentric circles indicate a hilltop. Saddles are flat areas on a ridgeline often between two hilltops. Saddles are indicated where the same contour line on each side of a ridge comes close together without touching. Lines that have small segments at right angles to the contour line represent depressions or sinks and are typically wetlands, lakes, or holes. A contour line ending at the edge of another one depicts a cliff that has height but no width.



Topo maps are useful not only because they show vertical relief as contour lines, but also because they are plotted in a horizontal scale, usually 1:24,000 or 1:50,000. This means that 1 inch equals 24,000 inches (or 50,000 inches). Because topo maps are two-dimensional, the distance is horizontal distance, not slope distance. The slope of the ground or the grade of a trail can be calculated from the elevation difference and the horizontal distance between any two points. As planners and designers become more familiar with contour lines, they will be able to understand slope simply by studying the contour lines. An experienced trail designer can create a conceptual trail alignment by drawing it on a topo map and then refining it in the field.





While topo maps can be used to plot a trail, there are often features such as large rocks and sometimes ledges that do not appear on contour maps. Aerial imagery used in conjunction with the topo map can help identify these features, but often they need to be located in the field, marked on the map, and recorded with a GPS unit.

Using Aerial Imagery in the Field

While topo maps and other maps are very useful, they still don't allow a clear visual of the landscape before venturing into the field. Aerial photographs merged into a seamless map are available from several software sources. Some are free, but the ones with highest quality imagery and the best drawing and editing tools are not. With aerial mapping, planners and designers can see the ridges, draws, creeks, ponds, rock knobs, cliffs, vegetation type and density, timber management units, wildfires or fire management units, and other important features.

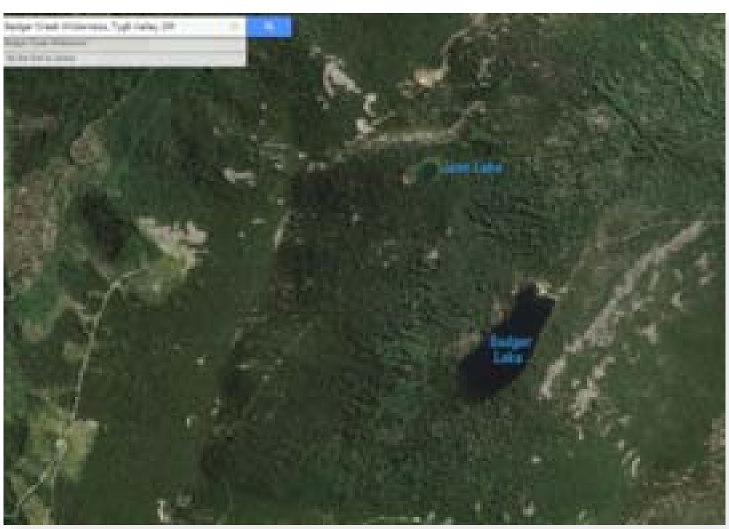
The most common free aerial mapping is Google Earth and the software for most GPS units can view the tracks and waypoints in Google Earth. While it is primarily used to view data, it can also be used as software to create very basic data by drawing points, lines, or polygons. GIS data can be exported from other software as KMZ or KML files and easily overlaid in Google Earth. Layers exported to these formats can easily be added by clicking on them as an email attachment or as a link on a webpage, or opened from within the program. The end user must have Google Earth software loaded on a computer and have an internet connection for this software to work. Aerial photography and terrain data are automatically loaded into Google Earth if an Internet connection exists. The quality of the aerial photography depends on the area of interest, but it tends to get very pixelated as the user zooms in.

Two views of the same landscape: above, a 2-D topo map with shaded relief showing Badger Lake using DeLorme Topo North America software; right, a projected 3-D view of the topo map with shaded relief.

Another useful tool is the ability to record a flyover path, which can also be shared with others. For example, a recorded path can illustrate the alignment of a proposed trail as a 3-D flyover.

Many of the better GPS units have aerial maps available at a cost from the manufacturer that can be downloaded and used as a base map in the GPS. Assuming that the mapping is current, this feature allows planners and designers to view the landscape not only where they are, but also where they may want to go. They can view a desirable feature on the GPS screen and the unit will give them a bearing and distance to get there. This can be a real timesaver when exploring new ground.

An aerial view of Badger Lake using ExpertGPS software.



The same view using Google Earth software.

Using GPS Technology

The global positioning system (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit around the world by the U.S. Department of Defense. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use the GPS signal. A GPS receiver or unit is used to receive the information from satellite signals and uses triangulation to calculate the person's exact location. Essentially, the GPS unit compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Adding measurements from a few more satellites enables the receiver to determine the person's electronic map or as a coordinate such as longitude-latitude. A GPS unit must be locked on to the signal of at least three satellites to calculate a 2-D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the person's 3-D position (latitude, longitude, and altitude). Once the person's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, altitude, sunrise and sunset time, and more.

Atmospheric and topographic conditions can affect the quality and strength of GPS signals and cause distortions in the data. The location of satellites at given times of the day provide for better or worse signal strength, which affects the accuracy of triangulation. This is typically only important when trying to locate a feature within a foot or two of where it is actually located. Cloudy, rainy, or snowy conditions can have an effect on signal strength and of course lead to moisture build-up in the electronics. GPS signals can be distorted by bouncing off buildings and rock cliffs. When working in areas with tall hard surfaces or in a deep canyon, it may be necessary to use higher quality GPS units that can filter distorted data or switch to the use of a map and compass in these areas. Another technique is to capture a good GPS position from a nearby high point and then measure a bearing and distance from that GPS position. Dense forest canopy can also have a significant effect on GPS signal strength. This can be overcome by using higher quality GPS units or using a combination of GPS, map, compass, and laser range finder. GPS units are usually more accurate after they have acquired GPS data for at least 15 minutes. A good accuracy test for a GPS unit is to see how accurately it is locating a known point such as a road intersection in an open area.

GPS units come in many sizes, colors, and most important price ranges. There is a general correlation between price, accuracy, and functionality. The most commonly used and lower cost GPS units are incorporated into smartphones and tablets. Smartphones formerly only used cellular signals to triangulate location; most now have GPS receivers so their navigation apps can work in remote locations. While these devices are more suited for general navigation purposes, they can be used as GPS units if they are thoroughly tested to make sure they provide adequate accuracy and a reliable signal. GPS accuracy is usually measured in both horizontal and vertical precision.

A Closer Look...

How are you going to use your photos? While it may be convenient for your GPS or other device to take pictures, the quality of those pictures may not be as good as with a digital camera. They may be fine for trail file or condition assessments, but they may not have the desirable quality for presentations and formal documents.

For general navigation and trail design work, planners and designers should find a GPS with an average horizontal accuracy of 3 meters or less. This means the GPS unit will consistently provide an average position within 3 meters or less of the actual location. Accuracy for vertical measurement, or elevation above sea level, is less precise and will usually be within 30 to 100 feet of the actual elevation. A couple of the most important features when shopping for a GPS include the ability to easily download GPS data from the unit and to display topo maps or other imagery on the unit. One of the biggest downsides of recreation-grade units and software is that they don't allow for large format printing. Only what is shown on the screen can be printed, so making a map involves the laborious process of printing several pages and cutting and pasting them together.

When selecting a GPS unit, make sure it has the ability to connect to a desktop computer or send files electronically.

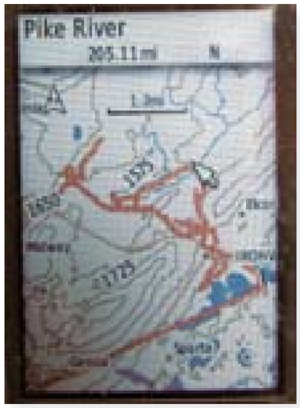
GPS units are very useful tools for a wide range of uses. Some of the most useful functions for trail-related work are provided below.

- Provide an accurate geographic location
- Provide the straight-line distance and direction to a destination
- Record the day's travel as a track, creating an accurate bread crumb trail to reverse and follow home, or use as backup data
- Provide the altitude within 30 to 100 feet
- Record or refer to destinations as waypoints
- Record or refer to trail alignments as tracks
- Load custom base maps on the GPS, including data such as topo map, slope map, recreation sites, trails, campsites, trailheads, sensitive areas, private property, etc.

A conceptual trail design alignment can be completed on a desktop computer and then loaded on the GPS unit. The loaded alignment can be used as a reference line while refining the trail design in the field.

A geotagged photo documenting a water issue

On the right, the GPS cursor shows a location right on a contour line. With the same map datum, it is easy to find the same location on the topo map. Note how the elevation displayed on the GPS matches the contour line elevation.



Smartphones and some GPS units geotag digital photos, which can be used to document the location of trail alignments, features, and scenic views.

Video and voice recordings can also be geotagged to provide more detailed documentation of trail designs and conditions for construction and maintenance purposes. If a video is geotagged to an entire trail GPS line, a split view of a map and video can be used to illustrate a trail design or existing trail. This provides a virtual tour of a trail before it's constructed.

Geotagging records a GPS coordinate within the header data of a jpeg photo. Software such as GeoJot can be used to create GIS points from this geotag information, which can then be illustrated on the GPS for future field work or on maps. GeoJot software can also be used to geotag photos from standard digital cameras using a GPS track or track log. There are digital cameras such as the Ricoh GPS camera that can assign location attributes to photos. This type of camera greatly improves efficiency and quality of digital photography.

Tip, Trick or Trap?

Tip: Practice, Practice, Practice

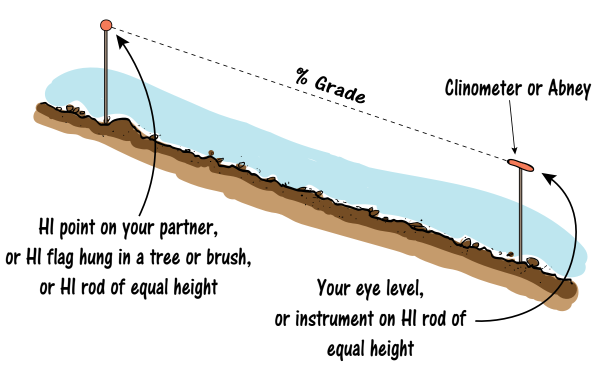
Spend plenty of time to get familiar with using your maps, compass, and GPS unit. Don't wait until you are in an emergency situation to learn how to use and trust all of the features of your GPS.

Transferring files from a GPS to a computer used to be difficult. While there are many kinds of files used by GPS units, there now are free tools such as the Minnesota DNR Garmin GPS tool and the GPS Bable tool available to convert between these types of files. ESRI ArcGIS software also imports and exports to the most common types of GPS files, including GPX files.

Section 3: Applying Engineering in the Field

Before going to the field, planners and designers need to be able to measure grades and apply basic engineering principles to measure or calculate lines, areas, and volumes.

How to measure grade

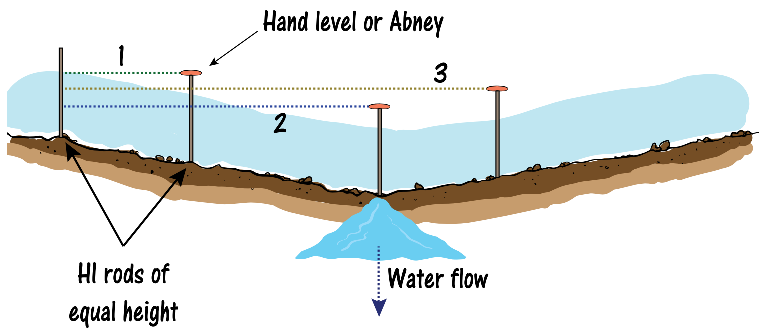


How to Measure Grade

There are three primary methods of measuring grade in the field. The first is the two-person method. On flat ground, two people stand toe-to-toe in front of each other. Using a clinometer or Abney, one person puts the bubble on zero percent and notes the spot where that hits his or her companion (chin, tip of nose, hairline, etc.). That spot becomes the height of instrument (HI) point or zero point on the partner.

Sighting on that same spot as the partner moves up and down the slope will give the percent of grade difference between the two people.

Determining the low point using the HI rod method



The second method is the HI rod method. Take two rods, sticks, or lath of equal length. If there are two people, have one person hold one rod stationary and vertically level while the other person moves up or down slope. If there is only one person, pound one rod into the ground just far enough so it will stand by itself. Put the other rod next to the first and mark the spot where the second rod is level with the top of the first or stationary rod. The first person moves up or down slope with the second rod. That person uses a clinometer or Abney to shoot between the mark on the top or the level marking of the first rod and the second. The result will be the grade difference between the two rods. On flat ground, up or down slope can be visually deceptive. Don't guess. This method is foolproof.

The third method is the one-person method. At a starting point, tie a short flag at eye height on a tree limb or brush (this becomes the HI flag), move ahead and up or down the slope as needed, sight back at the HI flag with the clinometer or Abney and the result will be the difference in grade or slope between the person and his or her starting point. This method does not work well in open areas where there is no vegetation at eye height or in places with very dense vegetation where the HI flag can quickly become obscured.

Tip, Trick or Trap?

Trap: Never rely on your "eye" to determine grades, especially on flat ground or when determining the low drainage point in a trail

How to Find the Lowest Point in a Grade Sag

On very flat ground or when trying to determine the low point of a drain, the HI rod method works very well. It is usually best to mark off elevation lines on the stationary HI rod and create a makeshift leveling rod. Take a tape measure and make a short dash at 1-inch intervals with a magic marker. It is best to use a hand level or Abney level set on zero because these are more accurate than a clinometer and they usually have magnification in the optics for easier reading. In the example above, sight #1 is below the top of the stationary rod, so elevation has been dropped. Sight #2 is below sight #1, so elevation is still dropping. Sight #3 is above sight #2, so elevation is now rising. Go back to the area of sight #2 and take a couple more shots at the stationary rod. The lowest reading or sight point on that rod will be at the low point of the trail.

How to Lay Out a Circular Curve without Instruments

A lot of work field technicians do is conducted without assistance, so to make effective use of time, they need to be able to perform basic engineering applications by themselves. As discussed in Chapter 4, circular curves provide improved flow, increased rideability, and reduced

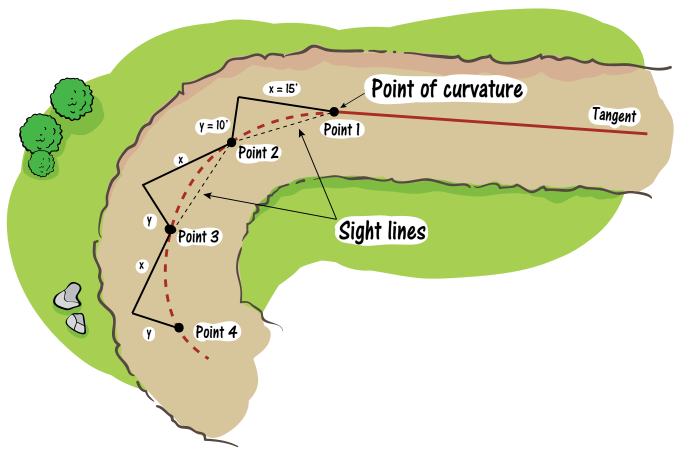
To be effective, climbing turns must have a smooth radius curve.

tread impacts. There are times when it is essential that the curve be circular such as when designing a climbing turn. These types of turns are the most effective way to gain elevation on a motorized trail, but they must be smooth, flowing, and circular; or significant tread impacts can develop.

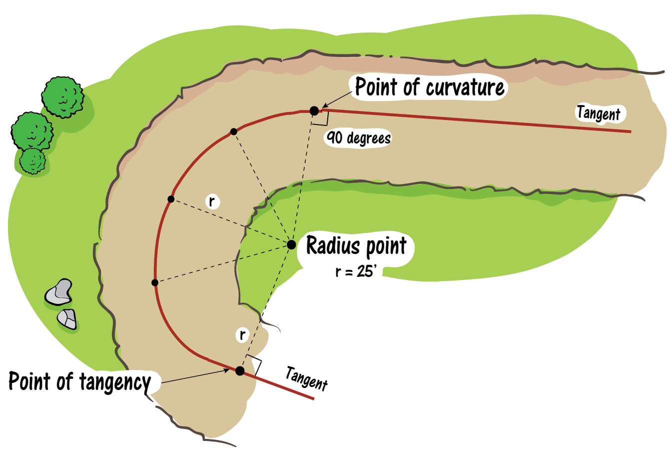
Any two points make a line and any three points can make a curve; that same progression can be applied in the offset method to make a curve. It is best to practice this technique in an open field with good visibility. At the starting point of the curve (called the PC or Point of Curvature), insert a pin flag or lath into the ground. This is point one.

Walk ahead 15 feet (x) staying on line between point one and the tangent behind it. From that point, measure 5 feet (y) in the direction the curve will go and insert another pin flag or lath at that offset point. This is point two. Walk ahead another 15 feet staying in line with points one and two. From there, measure 5 feet in the direction of the curve and insert another pin flag or lath. This is point three. A degree of curvature for the curve has now been established.

Offset method



Radius method



Planners and designers can now visualize how the curve is taking shape. They can continue this process until the curve is completed (called the PT or point of tangency). They can add intermediate flags as needed between points and adjust any that look out of place.

To make a tighter curve, increase (y) or increase (y) and decrease (x). Once planners and designers have practiced this technique, they can use steps or paces instead of measuring the distances. When they have mastered the technique, they will be able to lay out any curve using just flagging and their eyes.

Another method for laying out curves is the radius method. For this method, the radius (r) of the curve is known. If it isn't known, estimate the radius that will fit the site and then adjust it up or down as necessary. For example, assume a 25-foot radius is needed. From the starting point or PC, turn 90 degrees to the back tangent and measure 25 feet in the direction of the curve and insert a pin flag or lath. This is the radius point of the curve. From this point, measure out 25 feet and insert pin flags along the arc of the curve. If trees or brush are in the way, make several arc measurements. Add intermediate flags as needed between points and adjust any that look out of place.

In case you don't remember your basic geometry or trigonometry, we created a special crash course for you in Chapter 5 on our website. Find it at www.greatohvtrails.com.

This is a well-designed and well-constructed climbing turn. The person building the trail must have the same vision and understanding of OHV recreation as the person designing the trail or a great design will not become a great trail.

A Look Back...

Here are some of the elements discussed in this chapter:

- When preparing for the field, recognize hazards and manage risk. Take the proper clothing and survival gear and always wear the appropriate personal protective equipment (PPE).
- Take instruments to measure and record data easily and effectively in the field.
- There are pros and cons of flagging and pin flags. The paper clip trick and fingerless gloves will make the process of hanging flagging faster and less painful. Pin flags or stake flags generally have a shorter lifespan than flagging.
- Though only 2-dimensional, learning to read contour maps can give the field technician a good 3-dimensional view of the ground.
- A contour map, aerial imagery, GPS, and a compass are basic tools for efficiently navigating in the field.
- Points, lines, and polygons are the primary geometric shapes used in identifying and mapping important features and data.
- Three common methods to measure grade: 2-person method, HI rod method, 1-person method. Remember: Rise/Run x 100 = Grade. Never eyeball grade or drainage low points.
- On flat grades, use the HI rod method to find the low point for drainage.
- Two methods to stake a circular curve in the field without instruments: offset method and radius method