FIELD INSTRUCTION MANUAL FOR ARCHAEOLOGICAL SITE MAPPING USING THE TOPCON TOTAL STATION

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INTRODUCTION

The Archaeological Site Mapping manual is organized around the step-by-step procedures integral to setting up and operating the Topcon total station and data collector in field contexts. The sections are divided according to important topics and procedures in the chronological order that they will be encountered when site mapping. Sections entail thorough discussion of all of the necessary steps, such as establishing the site datum, setting up the total station, recording points, and changing mapping stations. Later sections include information on how to translate the site files stored on the data collector into detailed and professional site maps, include how to edit the data acquired.

This manual does not attempt to describe all features of the Topcon total station and data collector, but only discusses those regarded as relevant to archaeological site mapping. For further information regarding the Topcon total station, refer to the Topcon GTS-210 Series Instructional Manual, and for the data collector, refer to the TDS-48GX Surveying Card User's Manual and TDS-48GX Surveying Card Reference.

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PART 1: TECHNICAL INFORMATION

1. BASIC MAPPING TERMS AND CONCEPTS

To be able to map archaeological sites, and to operate the Topcon total station and data collector effectively, it is necessary to know some basic mapping concepts related to how locations are designated. It is essential that one is familiar with how to use a compass and how to read topographic maps. In fact, it is recommended that one know how to map a site using a compass and measuring tape or pacing before learning how to use the total station. If the cardinal directions and distances are understood well, then one will be able to know if he or she is using the total station correctly.

First, it is important to know about azimuths and bearings, and how either of these readings along with distance can be used to plot the location of a point. Second, one needs to know how to read and determine UTM coordinates. The total station records points by translating the azimuth and distance between the site datum and the point being recorded into UTM coordinates. Therefore, it is crucial that one understand the relationship between azimuths/bearings and distances, and UTM coordinates.

1.1 CARDINAL DIRECTIONS

The cardinal directions refer to north, east, south, and west, which are essential reference points for archaeological site mapping. There is both true and magnetic north, and the difference between them at any given point on the earth varies based on the latitude, longitude, and year. The difference between true and magnetic north is referred to as the **declination**. The declination for a region is listed in the lower left-hand corner on USGS 7.5" Series maps along with the date when the declination was recorded. For example, the declination in southern California ranges from 14° to 16° E from south to north, respectively. This means that when standing in San Diego, magnetic north is currently about 14° east of true north. In contrast, places in North Carolina range in their declination from 0° to 6° W, which means that the true north line intersects the western portion of the state.

Depending on the mapping project it may be more appropriate to record locations relative to true rather than magnetic north. For example, if the site map is going to be incorporated into some larger map, such as a USGS 7.5" Series map, then it is easier to use true north because such maps are oriented according to true north. The azimuths recorded in the field can be related directly to directions plotted on the map. However, if multiple people are using compasses, and there is potential for error when adjusting for the declination, then it may be easier to record points using magnetic north. Keep in mind that if points are recorded based on magnetic north and, at a later date it would be useful to generate a map based on true north, then all of the points can be changed accordingly on the data collector.

Azimuths

An **azimuth** is any direction read on a 360° circle, which relates to the cardinal directions. North is read as both 0° and 360°, east as 90°, south as 180°, and west as 270°. When using a compass to map a site, points are plotted according to the azimuth between the site datum and the point, and the distance between them is recorded generally in meters (m). The primary exception to this rule is when documenting historic sites, which should be recorded in feet (ft) because it was the measurement interval used to construct most historic structures in the United States.

Regardless, the site datum is the reference point for all locational data recorded at a site and, therefore, it is where all mapping activities must begin. The total station serves the same purpose as a compass in terms of keeping track of how azimuth designations relate to actual directions. However, it differs in that it can not determine true or magnetic north by itself; an external compass must be used to determine north, and then the direction is set on the total station.

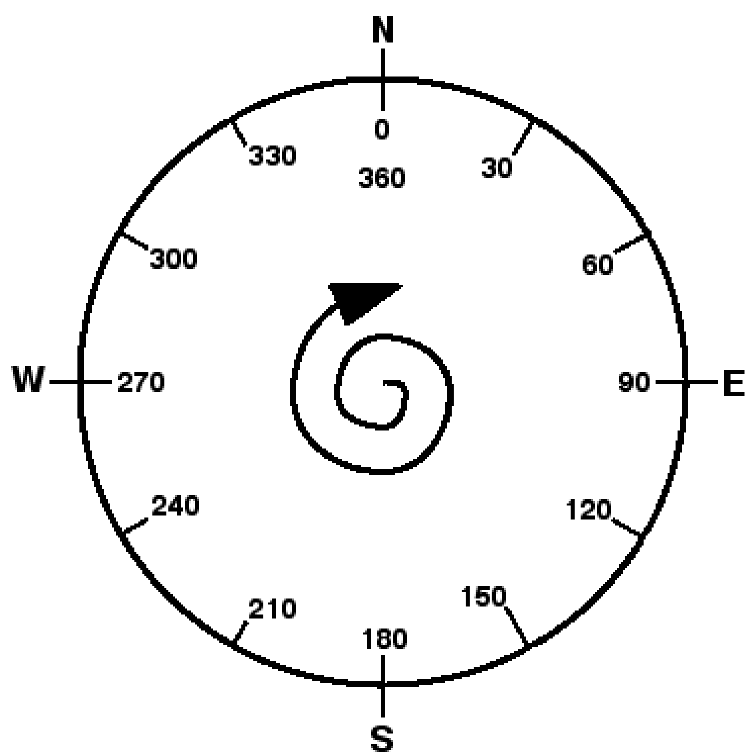


Figure 1-1: Azimuths. The figure shown above illustrates how azimuths are referred to numerically, which increase in size in a clockwise direction. For example, directly northeast has an azimuth of 45°, the azimuth for directly southwest is 225°, and the azimuth for directly northwest is 315°. When moving along an east-west axis, the azimuth designations are 90°/270°; on a north-south line, the azimuths are referred to as 0°/180°.

Bearings

A **bearing** is similar to an azimuth in that it refers to any direction on a circle. However, how the directions are referred to differs from azimuths. Bearings are used less frequently in archaeology to refer to locations, and definitely should not be used when documenting general site locations. In fact, it is recommended that bearings should not be used for archaeological site mapping since there is potential for error in reading and determining bearing designations. Nonetheless, bearings are useful to understand when using the total station for site mapping, since they are used frequently for other mapping applications.

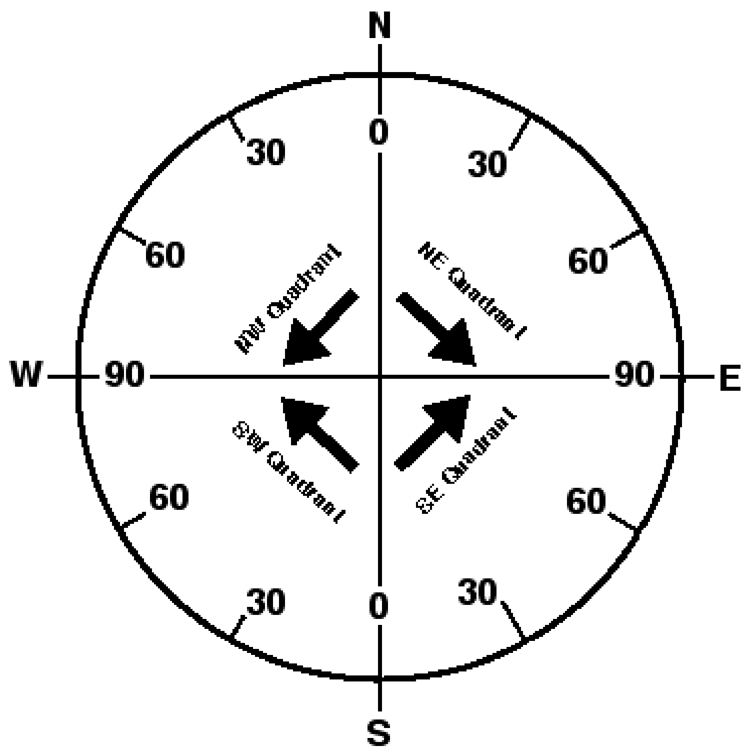


Figure 1-2: Bearings. As illustrated in the figure above, bearings are based on four quadrants that are 90° angles divided in terms of northeast, southeast, southwest, and northwest. To determine bearings in the two northern quadrants, 0° represents north and 90° represents both due east and due west. Likewise, when figuring out bearings in the two southern quadrants, 0° represents south and 90° represents both east and west. For example, when standing on a line that is oriented 15° east of north, its bearing is designated as N 15° E; when standing on a line that is 15° west of north, its bearing is N 15° W. In addition, an azimuth of 45° is equal to a bearing of N 45° E; 210° is equal to S 30° W; and 350° is equal to N 10° W.

Azimuths and bearings are useful when referring to the location of points relative to one another at a site. For example, the extent of a lithic scatter at one point may be located 50 m away from datum at an azimuth of 170°, or a bearing of S 10° E. Or, a shell midden is eroding off a cliff edge, which at one point is located 35 m from datum at an azimuth of 235°, or a bearing of S 55° W. The points can be plotted on site maps using this information. However, when generating a site map and plotting the site on larger maps or with larger scales, it is necessary to know the site location in terms of its actual position on earth, rather than just relative to another point.

1.2 UTM COORDINATES

When site mapping, archaeologists generally employ a combination of azimuths/bearings and **UTM** (Universal Transverse Mercator) coordinates. In some contexts, it may be useful to also determine locations relative to longitude and latitude and/or United States Public Lands Survey (USPLS) coordinates. Among various reasons, what map systems are used depends on the nature of the mapping project, the location on earth, and what cartographic conventions are used in that region. For official site maps in California, for example, it is necessary to include the UTM coordinates, township and range information (USPLS), verbal descriptions of the site locations, and site location maps, which are plotted typically on USGS 7.5" Series maps or something comparable.

UTM coordinates may be conceptualized as a metric grid superimposed on the earth in which the X-axis is oriented east-west and the Y-axis is north-south. Coordinates on the X-axis are referred to as Eastings (E), and on the Y-axis as Northings (N). Imagine the earth as a cylinder rolled out to form a flat grid. The grid is composed of 60 zones that each consists of 6° of longitude (east-west distance). When referring to longitude, the Prime Meridian that transects Greenwich, England is set at 0°, which means that 180° is located in the center of the Pacific Ocean. Therefore, Zone 1 refers to the 6° zone located in the ocean immediately to the east of 180°. Zone 11 transects California and part of the United States Southwest; Zone 19 includes part of Chile; and Zone 31 is located immediately east of the Prime Meridian.

Easting coordinates are determined based on the north-south central line of the zone being occupied. The false 0° Easting is set at an arbitrary point of 500,000 m west of the centerline, which means that the centerline of each zone has an Easting coordinate of 500000 E. The further one moves to the east, the larger the Easting coordinate will be until the next zone is reached.

In contrast, in terms of the Y-axis, 0° refers to the equator, which is conceived of as the dividing point between the northern and southern hemispheres. The equator is 0° N for locations in the Northern Hemisphere. For UTM coordinates in the Southern Hemisphere, 0° N is set at an arbitrary line located 10,000,000 m south of the equator. The Northing coordinate increases in number as one moves north beyond 0° N.

To reflect the north-south axis of the earth, zones (based on longitudinal degrees) are divided into quadrilaterals, which are each composed of 8° of latitude. Each quadrilateral is referred to by designated letters (i.e., C through X with the exception of I and O). However, it is important to note that these letters are dropped when referring to UTM coordinates within the United States. The UTM grid on USGS 7.5" Series maps represents a simplified version of the worldwide UTM grid.

Figure 1-3: UTM Grid in the United States. The figure shown below represents the worldwide UTM grid, as it appears superimposed on the United States. The numbers at the top of the map refer to the degrees in longitude of the zones, and the numbers at the bottom represent the zone numbers. The rectangles depicted are quadrilaterals (6° longitude by 8° latitude).

1.3 READING UTM COORDINATES ON USGS MAPS

In the United States, maps are made based on smaller units than quadrilaterals that are referred to generically as quadrangles. Some maps encompass 2° longitude x 1° latitude, for which the scale is 1:250,000. Since each degree is composed of 60 minutes ("), the next smaller map is 1° longitude x 30" latitude, which has a scale of 1:100,000. There are also 30" x 30" maps, scale of 1:125,000; 15" x 15" maps, scale of 1:62,500; and 7.5" x 7.5" maps with a scale of 1:24,000. Logically, USGS 7.5" Series maps refer to squares that are 7.5" by 7.5". The 7.5" maps are used most commonly when plotting the location of archaeological sites, since they are small enough to show most changes in topography, but large enough to depict the nature of the region.

On USGS 7.5" Series maps, the UTM grid is subdivided further into 1000 x 1000 meter units for easy reference. On some recent maps, the grid has been drawn on the map itself; whereas, on other maps, blue ticks and numbers listed on each side of the maps represent the UTM grid. Depending on who owns the map, it is recommended that the blue ticks should be connected to draw the UTM grid on the map to make it easier to read. The numbers on the left and right sides of the maps, such as ^{38}14, ^{38}15, and ^{38}16, are the Northing coordinates, which refer to 3814000, 3815000, and 3816000 m north, respectively. The numbers on the top and bottom of the maps, such as ^{2}45, ^{2}46, and ^{2}47, are the Easting coordinates, which are 245000, 246000, and 247000 m east, respectively. The last three digits of the coordinates are omitted on the sides of the maps because they represent locations within each of the 1000 x 1000 m grid units.

If the exact site location is known, then the UTM coordinates for the site can be determined by using a UTM template on the appropriate USGS map. The intersection of the X- and Y-axes on the template should be lined up on the center of the site. If the site is relatively large (e.g., site dimensions of 200 x 300 m), then it may be useful to generate two or more sets of UTM coordinates to represent the full extent of the site. Regardless, the X-axis line on the template should intersect the nearest UTM line south of the site, and the Y-axis line should intersect the nearest UTM line west of the site.

When determining the UTM coordinates for a site, it is useful to always remember the phrase "read right, then up", which means that the Easting coordinate should be determined first and then the Northing coordinate. The Easting coordinate is composed of 1) the numbers listed for the southern UTM line as the first three digits (e.g., ^{2}46), and 2) the difference in meters between the location of the site and the southern UTM line as the last three digits (e.g., 550 m). The Northing coordinate is based on 1) the numbers listed for the western UTM line as the first four digits (e.g., ^{38}15), and 2) the difference in meters between the location of the site and the western UTM line as the last three digits (e.g., 200 m). For example, a site is located in Zone 11 at 550 m east of the ^{2}46 Easting line and 200 m north of the ^{38}15 Northing line. The UTM coordinates for the site should be listed as 246550 E / 3815200 N in Zone 11.

When site mapping, it is useful to visualize the UTM grid in one's mind based on the UTM coordinates for datum, where north is located, and the distance between datum and recorded points. For example, the UTM coordinates for the site datum are 246550 E / 3815200 N. The north line has been set up with a pin flag marking a point that is 20 m directly north of datum. Therefore, the UTM coordinates for the pin flag marking north are 246550 E / 3815220 N. For another example, a secondary mapping station has been set up 50 m directly west of datum at the same site. The UTM coordinates for the new mapping station should be 246500 E / 3815200 N. The relative locations of points should be engrained in one's mind to the degree that errors can be detected when looking at the recorded UTM coordinates. One should always be asking the question "Do these numbers make sense based on everything I know about the site?"

2. BASIC COMPONENTS OF THE TOTAL STATION

2.1 PRISM REFLECTOR (ROD)

Basic Components

There are two basic components of the prism reflector. The prism reflector is an updated version of the stadia rod that is used in conjunction with conventional optical transits. The prism reflector itself is the small square-shaped piece that contains a circular mirror. This piece is attached to the metal rod by screwing its base into the top of the rod. Make sure that the prism reflector is screwed in tightly, so that it will not fall off during mapping, but not so tight as to keep it from being removed later. Both parts together will be referred to generically in this manual as the rod.

How the Prism Reflector Operates

Unlike conventional transits, the advantage of the Topcon total station and similar equipment is that the person recording the points does not have to read numbers on the stadia rod to calculate locational information. Instead of relying on the person's eye, the total station emits a laser signal that bounces off the prism reflector at the top of the rod and then returns to the gun. The distance and slope at which the laser beam travels provides the basis on which the data collector calculates the azimuth to and elevation of the point on which the rod is placed.

Adjusting the Rod Height

The rod height may need to be adjusted regularly depending on the site topography and where points need to be recorded. For example, the point to be recorded may be located on a slope extending downward from where datum is located. To compensate for the slope, it may be necessary to raise the rod higher until the person operating the total station can see it.

There are two black spring-loaded grips on the rod used to adjust the height. The rod can be extended or shortened when the grips are depressed by wrapping the palm of the hand around them. The rod measures 1.65 m in height at its shortest, and can be extended to a maximum of 3.78 m using both of the grips.

To raise the rod height, depress the top grip and pull the rod up to the desired height. The height is marked in feet and meters on the metal surfaces immediately above each grip. The rod is marked in 5 cm increments with numbers and at each cm increment with single lines. The numbers above the top grip extend from 1.65 m to 2.75 m.

If the rod height needs to be higher than 2.75 m, first make sure that the rod part controlled by the top grip is fully extended to read 2.75 m. Then, depress the bottom grip and extend the rod to the appropriate height. When the rod is fully extended at both grips, the rod height will read 3.78 m. If the rod still can not be seen from the total station, then a new mapping station needs to be set up.

Holding the Rod When Site Mapping

The most important aspect of holding the rod when recording points is to maintain as much accuracy as possible. First, the base of the rod needs to be placed precisely at the location that is to be recorded. If the rod can not be placed directly on the point, then position it as close as possible and record the difference in the field notes. For example, when recording a site that is partly eroding off an unstable cliff edge, the rod should be placed some distance back from the cliff where it is safe. Estimate how far the cliff edge is from where the rod is positioned, and then write down the distance and direction. For example, "the cliff edge is located 1 m directly south of point 50." The location of the point can be corrected later when editing the job file for the site.

Second, it is important that the rod is level to ensure that the elevation is recorded correctly. The rod has a built-in leveling bubble for this purpose. The person holding the rod should stand in a stable position (it is best to have your legs spread apart somewhat), and then firmly hold the rod near where the leveling bubble is located. Once the person is in position and the rod is leveled, the point is ready to be recorded. While the point is being shot, the person should keep his/her eyes on the leveling bubble to make sure that the rod doesn't move.

The taller the rod is, the more difficult it is to keep it level in windy and inhospitable conditions. Consequently, points should be recorded at the lowest rod height possible to make it easier on the person holding the rod. The rod height can be changed at any time and as many times as necessary. However, it is critical that the person using the total station is notified each time the rod height is changed so that it can be adjusted on the data collector.

If the rod holder forgets to tell the person using the total station that the rod height has been changed, then the error can be written down in the field notes and corrected later. The person needs to write down as much as he or she knows about the following: the numbers of the points impacted, the rod height listed on the data collector when the points were recorded, and the actual rod height. For example, it can be written down that the rod height should have been 2.75 m rather than 2.15 m for points 20 through 30.

Another rule of thumb is to never stand the rod up by itself. Rather, it should always be held firmly by someone. The rod is unstable because of the point at its base and, therefore, will eventually fall if not held. While the rod will be okay, the prism reflector can be damaged. If the rod is going to be set down between shooting points, then it is good to always place the cap on the mirror to prevent it from being covered in dirt or damaged in some way.

2.2 TOTAL STATION (GUN)

The Topcon total station is referred to generically as the gun, which is an analogy that will be used throughout this manual. The process of sighting the rod with the gun, and then recording the locational data using the data collector, is referred to as "shooting" points. The primary components of the total station are the gun and tripod to which the data collector is attached.

The features on the gun that are relevant to its set-up and use are referred to in two manners. First, the name for the feature as it is discussed in the Topcon GTS-210 Series Instructional Manual is listed in Italics. By maintaining the nomenclature, it will be easy for the user to consult the manual provided with the equipment, if necessary. Second, many of the features are also referred to in more simple terms that are handy to use in the field. For example, the sighting collimator and telescope eyepiece are discussed simply as the sight and eyepiece.

Tripod

Several types of tripods that can be used to support the gun, most of which being simple in their design and use. The primary differences between tripods include material, maximum height, and weight. Materials include wood, aluminum, and wood/fiberglass, of which aluminum tripods are the lightest (13-14 lbs.) and wood/fiberglass ones (16-18 lbs.) are the heaviest and most durable. The kind of tripod used depends on the circumstances of the mapping, including whether the tripod has to be carried for long distances, if conditions are windy, and other factors. The tripod described below is made of wood/fiberglass.

Black clamps located about midway down each of the legs control the length of the legs. When a clamp is lifted up, the leg to which it is attached can be extended or retracted. The clamp can be locked, thereby securing the leg length, by pushing it downward against the leg. Whenever the gun is going to be placed on the tripod, make sure that all of the clamps are locked down.

Another important feature on the tripod is the *tripod screw* that allows the gun to be attached securely to the tripod. The tripod screw is a large black screw attached to a metal arm located in the hole in the top of the tripod. When the gun is to be attached to the tripod, the tripod screw should be screwed firmly into the base of the gun.

For complex mapping projects, such as ones with multiple mapping stations, more than one tripod is recommended. Having several tripods to work with will allow for more efficiency when occupying multiple mapping stations and using multiple back sight points. The tripods, along with tripod bracket (for leveling purposes), can be set up such that the location of the gun and prism are easily interchangeable.

Optical and Mechanical Plumb Bobs

There are two plumb bobs, so to speak, that can be used to accurately position the gun on the site datum or any other locational marker. In all cases, the location from which points are going to be shot will have to be established before setting up the gun. Depending on various factors that are discussed in detail in section 3, the location can be marked with benchmarks, nails, pin flags, or stakes. Regardless of what the location is marked with, the gun will have to be positioned precisely over the marker to maintain precision in distance measurements. Either plumb bob can be used to position the gun depending on the preference of the user.

First, there is the *optical plummet telescope*, or optical plumb bob that looks like another knob and is located immediately to the left of the data screen. The optical plumb bob can be viewed through to see the ground directly below the center of the gun. When using this plumb bob, the gun can not be screwed into the tripod, since it will obscure the view. The gun must be sitting on top of the tripod loosely, so that it can be shifted around until it is positioned directly over the marker. When looking through the knob, there are two black circles and one dot arranged in a "bulls-eye" fashion that allow the user to line up the gun precisely on a location.

Second, there is the mechanical plumb bob that can be used for the same purpose. The four components of the mechanical plumb bob are stored along with the gun. One, there is a small metal bar that is shaped like a V with a hook extending from the base of the V, which allows for the plumb bob to be attached to the tripod. The ends of the top of the V are inserted into the base of the tripod screw. Two, there is the string that extends between the metal bar and the plumb bob. The string is attached to the hook at the base of the V. Three, there is a metal strip that has two holes in it and is curved on both ends. The string is threaded through the metal strip such that it can be used to adjust the length of the string. Four, there is the actual plumb bob that is attached to the other end of the string, and should hang immediately above the marker.

There are advantages and disadvantages to using both kinds of plumb blobs. The primary advantage of using the optical plumb bob is that it can be used in windy conditions, whereas the mechanical plumb bob will have the tendency to sway too much. However, the optical plumb bob affords a limited view of the ground below the gun. It is easy to get "lost", meaning that it hard to tell exactly where the marker is located relative to the "bulls-eye" when looking through the knob. (Note: If you lose the mark on the ground that you are trying to set up over, it can be helpful to use your foot to relocate yourself and move inwards toward the target point.) The mechanical plumb bob is best to use when the weather is calm, and it is easy to see the location of the plumb bob hanging in the air relative to the marker immediately below it.

Leveling Screws

There are three *leveling screws* located at the base of the gun, which allow the gun to be leveled once it is secured to the tripod. When one of screws is turned to the right, it lowers that side of the gun. When it is moved to the left, it will raise the gun on that side. When adjusting the leveling screws, use the leveling bubble, or circular level, located next to where the connector cable for the data collector is inserted. The process of using the circular level to adjust the leveling screws appropriately is referred to as coarse-grained leveling.

When setting up the gun on the tripod, it is useful to have all of the leveling screws set at the same level. It is best to have them all rotated the same number of turns so that they are positioned at a middle height. This allows for the screws to be adjusted up or down when leveling the gun.

Focus Adjustment Knobs

There are two focus adjustment knobs located on the right-hand side of the gun when facing the data screen. These knobs allow the gun to be rotated 360° horizontally and vertically from its base on the tripod. As long as the prism reflector is visible, the knobs allow the user to line up the gun with the rod regardless of its relative horizontal or vertical location.

The lower knob that juts out from the gun to the right is the knob that controls the horizontal orientation of the gun. There are two separate adjustments on the knob, of which one is closer to the gun than the other. The closer part of the knob is referred to as the *horizontal lock clamp*, and the further part is referred to as the *horizontal tangent screw*. When horizontal lock clamp is turned all the way to the left, or towards the gun, it is totally loose and the gun can be rotated in any horizontal direction. When it is turned all the way to the right, the gun is locked in that position and can not be moved horizontally.

The second knob is located above the lower knob and juts out in a forward direction from the gun. The upper knob controls the vertical orientation of the gun, of which the parts are referred to as the *vertical lock clamp* and *vertical tangent screw*. In contrast to the horizontal lock clamp, when the vertical lock clamp is turned all the way to the right, it is loose and the eyepiece can be rotated up or down. The gun is locked in position when the vertical lock clamp is turned all the way to the left. Whenever a point is being shot, it is essential that the lock clamps be locked down in this manner.

The horizontal and vertical tangent screws control the fine-grained adjustment once the lock clamps are locked down. This means that the lock clamps can be locked down when the prism reflector is close to being centered on the crosshairs viewed in the eyepiece. Then, fine-grained adjustments can be made such that the prism reflector is lined up perfectly with the crosshairs.

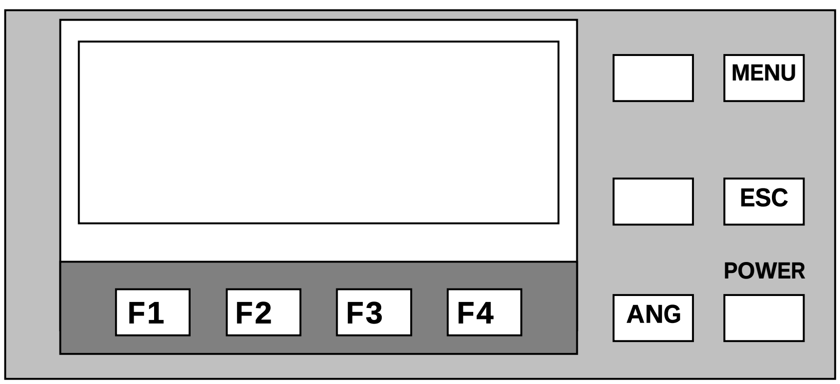
Sight and Eyepiece

The easiest way to line up the crosshairs on the prism reflector is to rely on the *sighting collimator*, or sight, which is located on the top of the gun below the carrying handle. The sight can be used to get the gun into range with great accuracy without having to look through the eyepiece. The key is to line up the triangle viewed in the sight on the prism reflector. This should place the prism reflector close enough to the crosshairs such that the focus adjustment knobs can be locked down without having to look through the eyepiece. Once the knobs are locked down, the user can look through the eyepiece and make fine-grained adjustments to line up the prism reflector on the crosshairs perfectly. However, it will take some practice using the sight and knowing how the sight works in order to do this accurately every time.

There are two ways to focus the eyepiece such that both the prism reflector and the crosshairs can be viewed clearly. First, if the prism reflector is blurry, rotate the gray ring, or *objective focusing knob*, that encircles the eyepiece until it is clear. Second, if the crosshairs are blurry, adjust the small black knob that is part of the eyepiece, which is known as the *reticle focus knob*.

Data Screen

Figure 2-1: Data Screen on the Gun.



The gun can be used without the data collector, and that is when the data screen on the gun is used for more purposes. For more information on how to use the gun independent of the data collector, refer to the Topcon GTS-210 Series Instruction Manual. However, it is more common that all operations are conducted using the data collector, to which the gun is regarded as a “slave.”

Battery

The BT-23Q battery is attached to the gun on the right hand side when facing the eyepiece and data screen. The battery locks into place with a locking lever at the top of the battery. It is essential that the battery be re-charged daily when conducting fieldwork. There should always be at least one fully charged spare battery in case the one being used needs to be replaced.

The battery must be re-charged with the charger that is supplied with the Topcon equipment. To do this, simply connect the cable that extends from the charger to the plug-in at the top of the backside of the battery. Then, plug the charger into an outlet. It should take about 1.5 hours for the battery to recharge. The charger will display a green light when the recharging process is finished.

To know when the battery needs to be recharged, the battery level is indicated on the data screen with small black bars positioned in the lower right hand corner. When three bars are shown, the battery is fully operational. Two bars means that the battery level is going down, but it is still possible to take distance measurements. When there is one bar blinking, it means that the battery should be replaced immediately. The length of operating time for the battery varies depending on factors such as the ambient temperature, how long the battery was charged for, and how many times it has been charged and drained. Note: the amount of charge stored in the battery each time it is charged diminishes gradually and will eventually need to be repacked (in 2-3 years depending on usage).

2.3 DATA COLLECTOR

Basic Components

Environmental Box

The data collector is stored in an environmental box to prevent the elements from penetrating into the equipment. In particular, the environmental box prevents heavy misting and light rain from affecting the performance of the data collector. However, one note of caution is that condensation can build up inside the environmental box in humid and sunny conditions. In humid environments, it is recommended that the data collector should be taken out of the environmental box when not in use and allowed to "breathe." Furthermore, it may be necessary to clean the contacts on the data collector regularly, even nightly, to prevent potential problems. Too much humidity (more than 90% relative humidity) can corrode the contacts such that data collector can not read information from the gun, and therefore can not record points. In general, the data collector should be stored in moderately cool, shady, and dry conditions as much as possible when it is not being used.

HP-48GX Calculator and TDS-48GX Survey Card

The data collector is composed of the HP-48GX calculator with TDS-48GX survey card that is inserted into the back of the calculator. The data collector refers to the calculator when the survey program is enabled. If some of the calculator features need to be used, exit out of the survey program by selecting **[EXIT]** in the Main Menu and then **[YES]** when the screen displays “Are you sure?” Then, remove the overlay that is on the keyboard, which lists all of the key options for the data collector, to view the calculator key options. For further discussion of the calculator features, refer to the HP 48G Series User's Guide.

Batteries

There are two parts of the data collector that use batteries: the calculator and the RAM card. It is essential that there are always spare batteries in the field. Whenever one is preparing to go into the field to conduct site mapping, make sure that extra batteries of both kinds are included in the bag in which the data collector is stored.

The calculator is operated using three AAA alkaline batteries. To change the batteries, open the environmental box by unscrewing the two spring-loaded screws located on the front of the box when viewing the calculator. Then, lift the calculator out carefully and turn it over. The batteries are located inside the calculator at the base of its backside.

The RAM card is located immediately below the survey card in the back of the calculator. The card uses one 3-volt lithium battery (CR2016) that should be replaced about once a year. When the battery is low, it will be indicated by a symbol displayed on the data collector screen: ((■)).

To change this battery without risking losing data on the RAM card, follow the instructions provided in the HP 48G Series User's Guide (Appendix A) and as paraphrased below:

1. Back up your data prior to replacing the battery.

2. Remove the data collector from the environmental box, turn it over, and remove the plastic port cover to access the RAM card.

3. With the calculator turned ON, hold the RAM card in place with one hand as you remove the battery from the RAM card in your other hand. Direct quote from the HP 48G Series User's Guide: The RAM card runs off the calculator batteries only when the calculator is ON. RAM memory may be lost if you remove a RAM card battery while the calculator is off, or while the card is not installed in the calculator.

4. Replace the port cover and put the calculator back into the environmental box.

Data Screen

The data collector is turned on by pressing the **[ON]** button that is located in the lower-most left-hand corner of the keyboard. It is turned off by pressing the **[↱]** right-hand arrow key (located immediately above the ON button) and the **[ON]** button at the same time.

Accessing Data Collector Options

When the data collector is turned on, the screen shown is the one that was occupied when the data collector was turned off last.

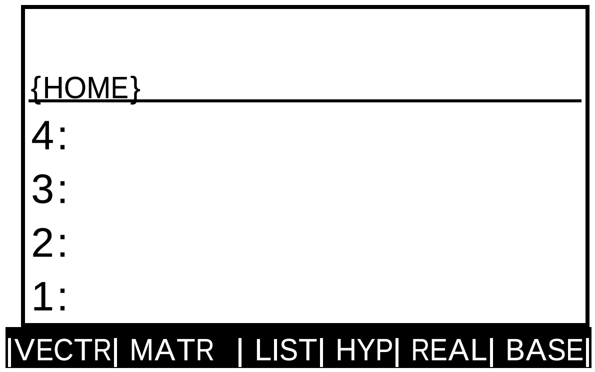


Figure 2-2: Home Screen on the Data Collector. The screen shown above is displayed when the data collector program is not open on the calculator. From this screen, it is possible to access and use the calculator functions.

Step 1: To access the data collector program from this screen, press the **[α]** alpha key twice, which is located above the **[ON]** and arrow keys on the calculator pad.

Step 2: Type in **[T] [D] [S] [4] [8]** and then press **[ENTER]**, which is located above the **[ON]** key. The next screen will be the Main Menu for the data collector options, which is discussed in section.

3. ESTABLISHING THE SITE DATUM

In some contexts, the site datum will have already been established and can be occupied readily if there is some permanent marker indicating its location. If there are benchmarks or other known points located on or near the site, then one of these points should be occupied first because they are the most accurate. Even if a benchmark is located several hundred meters or more from the site, but is still sighted with the gun, then it can be used to set up the location of the datum.

In many situations, it will be necessary to establish the site datum as a new point, particularly when recording the site for the first time, or in an area where no permanent markers can be left because of potential looting and/or disturbance.

3.1 SELECTING THE SITE DATUM

Before selecting the site datum, the site boundaries should be determined and ground characteristics assessed. The extent and location of natural features such as bedrock exposures, gullies, cliff edges, and dense vegetation that obscures ground visibility should be noted, and flagged if needed. Furthermore, all significant cultural features, such as structures, different site loci, areas of midden erosion, and dense concentrations of artifacts (e.g., flint knapping stations) should be noted and flagged. Once the site characteristics have been assessed and the ones that are going to be mapped are marked in some clear fashion, then the location of the site datum can be determined.

Unlike conventional mapping, where the datum should be placed centrally in the site, the datum or primary mapping station should be established where the line of sight is the best. One mapping station may be sufficient for small and simple sites. However, complex sites (i.e., large size, irregular topography, etc.) may require several mapping stations to complete the job. Therefore, the site datum should be placed in a location from which all of the mapping stations are visible. Furthermore, it is recommended that the mapping stations should be situated outside of the site boundaries to ensure that no points recorded are too close to the gun. Contrary to one's intuition, measurements taken at greater distances are more accurate than those taken at close range.

If there are no constraints on leaving permanent markers, then there are several options for establishing the site datum depending on how often the area is going to be mapped. In cases where the site is going to be returned to again and again, it is recommended that site datum are made of durable materials, such as sinking rebar reinforced with concrete into the ground. However, more simple options include pounding in a metal or wooden stake and clearly labeling it with the site number.

If the datum marker must be removed after the mapping has been completed, then use a large nail (i.e., PK nails). Then, mark the stake or nail with flagging tape and pin flags to ensure that it can be relocated easily. It is important to maintain as much accuracy as possible; it should be possible to relocate the points for mapping stations down to the centimeter.

3.2 ESTABLISHING NORTH

Step 1: After datum has been marked, the next step is to establish the north direction from datum. Set up a reliable and accurate compass directly over the datum marker. It should be sitting in a stable and level position on a tripod.

Step 2: Line up the compass to north.

Step 3: Using a measuring tape, pace 20 m on the north line. When the walker reaches 20 m, the person who is sighting the north point should make sure that the walker is lined up directly on the north line. When the walker is in the right position, he or she should place one or more pin flags in the ground to mark the point.

Step 4: Remove the compass from datum.

Step 5: Set up the total station on the same exact location.

4. SETTING UP THE TOTAL STATION

In order to set up the total station on datum, the following equipment is needed: tripod, gun, data collector, gun-data collector connector cable, and recharged or new batteries for the gun and data collector.

4.1 PLACING AND LEVELING THE TRIPOD ON DATUM

Step 1: Before setting up on datum, adjust the legs of the tripod until they are relatively equal in length, unless the datum is located on sloping ground that requires the tripod to be skewed. When setting up on a slope, the most stable position for the tripod is with 2 legs set up downhill and 1 leg placed uphill.

Make sure that the tripod legs are extended to a length that is suitable according to the height of the person(s) using the gun. He or she should be able to look readily through the eyepiece regardless of its orientation.

Step 2: Place the tripod over datum such that the datum marker can be seen through the center of the tripod.

Step 3: Secure the ends of the tripod legs by stepping on them and pushing them firmly into the ground. Then, make the tripod as level as possible, which may require adjusting the legs several times. If the tripod can not be leveled well, then dislodge the tripod legs from the ground and readjust their locations.

How far the tripod legs are inserted into the ground depends on the nature of the ground surface (i.e., sand, rock, grass, etc.). If the tripod is on sand, the legs should be planted deep into the sand (about 5 cm) for more stability. If the ground is rocky, and if this is permissible at the location, it is recommended that holes for the legs should be chipped into the ground surface.

4.2 PLACING AND LEVELING THE GUN ON THE TRIPOD

Step 4: Place the gun on top of the tripod, but do not screw it into the tripod head yet since it will obscure the view of the optical plumb bob.

Step 5: Before securing the gun, adjust its position on the tripod until it is level according to the circular level. However, at the same time, make sure that the gun is still sitting directly over datum by viewing through the optical plumb bob or using the mechanical plumb bob.

Step 6: Once the gun is positioned in an acceptable manner, tighten the tripod screw until the gun is secured firmly to the tripod.

Step 7: Line up the data screen on the gun such that it is parallel with two of the leveling screws. In your mind, label these two screws as A and B, of which A should be the screw that is located below the circular level.

Step 8: Rotate screw A until the leveling bubble moves away from the edges of the circular level and from the ends of the plate level. The plate level is located immediately above the data screen.

Step 9: Rotate the gun until the data screen is parallel to screws A and C. Rotate screw C until the leveling bubbles are centered better.

Step 10: Rotate the gun such that the data screen is parallel to screws B and C. Check the plate level to see if the gun has been leveled enough. If the gun still needs to be leveled, then rotate screw B, which will require further adjustments for screw A.

Step 11: Continue to rotate the gun and adjust the screws until the gun is leveled according to both the circular and plate levels.

Leveling the gun is an art that requires some practice. Make sure that each screw is not being rotated repetitively to the left and to the right when shifting from one gun orientation to another. It is easy to get stuck continually adjusting the screws up and down by the same amounts and not getting anywhere in terms of leveling the gun. To avoid this problem, choose one of the screws as a pivot point, and adjust the other two accordingly.

4.3 LINKING THE DATA COLLECTOR TO THE GUN

Step 12: Once the gun is leveled, attach the data collector to one of the tripod legs.

Where the data collector is placed depends on the direction in which most of the points will be shot. For example, if most of the points to be shot are located to the east, then the data collector should be set up either on the northwest or southwest side of the total station. The data collector should be readily accessible when shooting points, but it should also be skewed to the side so it will not get in the way of the person looking through the eyepiece.

Step 13: Secure the data collector by undoing one side of the black rubber band that is attached to the back of the data collector. Wrap the band around the tripod leg and then re-attach the end to the data collector.

Step 14: Connect the cable between the gun and data collector. Do not attempt to force the cable into the gun. The cable end will fit only when oriented in one direction, so move it around until the correct orientation is found and then insert it firmly. Make sure that the cable end attached to the data collector is in place and locked.

4.4 TURNING ON THE GUN

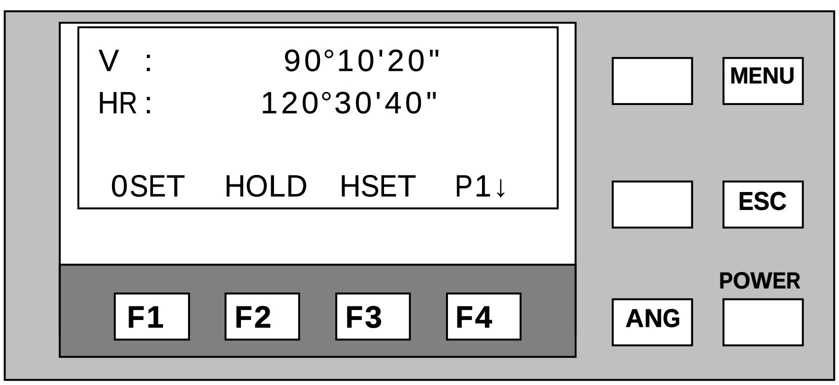
Step 15: Once the total station has been set up on the site datum, turn on the gun and data collector.

Figure 4-1: Setup Screen on the Gun.

POWER

Step 16: Make sure that the horizontal and vertical lock clamps are loose, so that the gun can be moved. Rotate the part of the gun with the eyepiece until it is upside-down, and then return it to its original position. The screen should now display readings for vertical (V) and horizontal (HR) angles, which will need to be reset. The following is an example of what will appear in this screen.

Figure 4-2: Main Screen on the Gun.



0SET Option

The 0SET conventionally refers to north. This option allows the user to reset the direction in which the gun "thinks" that it is pointed to 0°00'00". This option (or HSET) must be set to reflect either magnetic or true north each time the total station is set up on a mapping station. The data collector will calculate the UTM coordinates for recorded points based on the north direction set on the gun.

HOLD Option

The HOLD option freezes the angle shown on the data screen such that the gun can be rotated and the angle will not change. This option does not have much applicability in site mapping.

HSET Option

The HSET option is similar to the 0SET, although it can be set to any angle. This is useful when setting up on a secondary mapping station. Rather than establishing a north line when setting up on another location, the gun sighted to datum. The backsight azimuth from datum to the point now occupied can be calculated when the point was shot, and then it can be used as the horizontal angle for the HSET.

P1↓ Option

The P1↓ Option scrolls the screen to the next page.

5. DATA COLLECTOR OPTIONS AND SETTINGS

5.1 MAIN MENU

Some Main Menu options have been omitted from this manual since they are not relevant to archaeological site mapping. These options are useful for those who need to translate distances and angles from paper to the ground, as when constructing buildings or delimiting property boundaries. For further information regarding Stake Out, Leveling, Sun Shot, Curve Menu, and Print Menu, refer to the TDS-48GX Surveying Card User's Manual and TDS-48GX Surveying Card Reference.

Figure 5-1a: Main Menu on the Data Collector (Page 1)

```
     < Select G to S >
G    Open/Edit a job
H    Setup menu
I    Stake out
J    Traverse/Side shot
K    Show directory
L    Leveling
| MORE|    |    |    |   |EXIT|
```

Main Menu Options

[G] - Open/Edit a Job

The Open/Edit a Job Menu includes most of the options that are used to create, open, modify, and delete jobs and individual points. The Job refers to the individual site file, or any discrete set of points. For example, some files may contain locations for benchmarks and other points that will be used repeatedly to map several sites in the area, which are referred to as control files.

The Job Menu options are discussed in detail in sections 6 (creating and opening jobs) and 12.3 (modifying and deleting jobs and points.)

[H] - Setup Menu

The Setup Menu includes all of the basic setup options for the data collector, such as distance unit (i.e., meter), baud rate, parity, enabling prompts for various data, and what kinds of coordinates will be displayed (i.e., Northing, Easting, and elevation.) The most relevant Setup Menu options are discussed in section 5.2. In addition, the Setup Menu includes options for selecting and deselecting control files. When and how to create, open, and use control files are discussed in section 9.1.

[J] - Traverse / Side Shot

The Traverse / Side Shot option is used to shoot points. How to take side shots to record points is discussed extensively in section 7.

[K] - Show Directory

The Show Directory option displays the names of all of the job files that are stored currently in the data collector.

More Main Menu Options

The screen shown below is accessed from the first screen of the Main Menu by selecting **[MORE]**.

Figure 5-1b: Main Menu on the Data Collector (Page 2)

M	CO-GO Menu
N	Survey Adjustment
O	Sun shot
P	Screen plot
Q	Curve menu
R	Print menu
S	File Transfer

| | | | | EXIT |

[M] - CO-GO Menu

The CO-GO Menu contains options that are used primarily to obtain information for editing job files, such as calculating the azimuth and distance between two points, which can be used to adjust point locations. In addition, there is an option for determining the site area based on specified points, such as the midden boundary, which can be useful when filling out site forms. The relevant CO-GO Menu options are discussed in sections 9.3 (calculating the site area) and 12.3 (editing errors).

[N] - Survey Adjustment

The Survey Adjustment options are used primarily to edit points and / or entire job files. Options include adjusting the elevation for one or more points, such as when the instrument or rod height was entered incorrectly or the elevation for datum was set wrong. In addition, points can be shifted in space according to an azimuth and distance, or rotated around datum by a specified number of degrees. The second option is used when north was established incorrectly or it is known for some reason that some points were recorded at the wrong azimuth. All of these options are discussed in section 12.3 (editing errors).

[P] - Screen Plot

The Screen Plot option plots recorded points (or lines between them) on the data collector screen based on their azimuths and directions. While the plots are small in display size, their advantage is that they provide a means to check for gross errors in the data while in the field, where they can be corrected, rather than finding the errors weeks later in the lab. The Screen Plot option is discussed in section 9.2.

[S] - File Transfer

The File Transfer allows job files to be transferred from and to the data collector. This manual explains how to transfer job files from the data collector to a computer with the TFR-map transfer software, from which files can be transferred to mapping applications. How to transfer files in this manner is discussed in section 10.1. However, job files can be transferred to any application (e.g., Kermit) in which they can be saved as ASCII files for future use. Job files can also be downloaded using a modem or to another TDS-48GX data collector, both of which options are discussed in the TDS-48GX Surveying Card User's Manual.

5.2 BASIC SETTINGS

In general, the basic settings for the data collector, as displayed in the Setup Menu, should be checked whenever the total station is being taken into the field. If the total station is being used on a daily basis, then there is no need to check the settings every time it is set up. However, it is recommended that checking the Setup Menu should be included as a fundamental part of setting up the total station at a new site.

Furthermore, if the data collector freezes and / or is reset, then the Setup Menu should be checked immediately after the problem is solved. When the calculator batteries are replaced or the TDS-48GX Surveying Card is reinstalled, there is great potential for the Setup Menu to be reset.

Step 1: Select **[H]** – Setup menu – from the Main Menu.

Figure 5-2: Setup Menu

```
Setup Menu
G    Time / Date
H    Devices
I    Operating modes
J    Repetition modes
K    Select contrl file
L    Deselect contrl file
|     |     |     |     |EXIT |
```

Setup Menu Options

The Setup Menu options that are relevant to archaeological site mapping are primarily Devices, Operating Modes, Select Control File, and Deselect Control File. When and how to use the Devices and Operating Modes options are discussed below, while control files are discussed in section 9.1.

Step 2: Select **[H]** – Devices – from the Setup Menu.

Figure 5-3: Device Setup Screen

```
Device Setup
Instrmnt  : >Topcon
  Model   : >GTSB-D & 4
Instrument: >Enable
Instr dist unit:>Meter
Dist measur:>Single
Use lumi-light:>No
|     |COLLI|   |FAST|     |EXIT |
```

Step 3: The options for the device setup should read as listed above. Check that the instrument distance unit reads METER. However, when mapping historic sites, select FEET as the distance unit by pressing the right arrow key.

Step 4: Select **[EXIT].**

Figure 5-4: Instrument Communication Setup Screen

```
Instrument
 communication setup

Baud rate:     >1200
Parity:        >Even
     [RESET] for
     default setting
|RESET|     |     |     |     |EXIT |
```

The baud rate and parity shown above are the default settings for the data collector.

Step 5: Select **[EXIT]** to return to the Setup Menu.

Step 6: Select **[I]** – Operating modes – from the Setup Menu.

Figure 5-5a: Operating Modes Screen (Page 1)

```
Operating Modes
Azimuth: >N. azimuth
Scale factor: 1.0000000
Earth curve adj:    >OFF
Storing pause:      >ON
Dist unit: >Meter
Angle unit: >Degree
| MORE| |     |     |     |EXIT|
```

Step 7: The options for the operating modes should read as listed above. Check that the distance unit reads METER.

Step 8: Select **[MORE]** to view additional options.

Figure 5-5b: Operating Modes Screen (Page 2)

```
OP Modes (cont.)
Beeper:> ON
Prompt for rod Ht:  >Yes
Prompt for desc.:   >Yes
Prompt for setup:   >Yes
Station length: >100
Coor. Disp:>N,E, ELV
| PREV|     |     |     |EXIT|
```

The following options should always appear as shown above: Beeper, Station Length, and Coordinate Display. The prompts for different information are optional, although is recommended that the Prompt for Description should be ON. When learning how to use the data collector, all of the prompts should be turned on to remind the users about inputting new information.

Prompt for Rod Height

When the Prompt for Rod Height option is turned on, there is a screen prompt that is displayed before each shot is taken that asks for the rod height. This option is useful particularly when working in an area in which there are dramatic changes in elevation, which requires constant alterations in the height of the rod (e.g., when recording midden slump down the side of a knoll). The screen prompt is a useful reminder to note the change in the rod height.

Prompt for Description

When the Prompt for Description is on, there is a screen prompt that is shown immediately after each shot is taken that allows for a new point description to be entered. The screen will show the description of the previously recorded point. If it is the same as the description, then **[ENTER]** should be pressed and the shot will be recorded. If it differs, then the new description should be entered.

Prompt for Setup

When the Prompt for Setup is turned on, there is a screen prompt that is shown when the Occupy Point is changed (e.g., moving from the site datum to a secondary mapping station). The screen will display the Backsight Setup, which is the screen in which the instrument height and rod height can be changed. The Backsight Setup options are discussed in section 6.1.

Step 9: Select **[EXIT]** to return to the Setup Menu.

Step 10: Select **[EXIT]** to return to the Main Menu.

6. CREATING A NEW OR OPENING AN EXISTING JOB FILE

Once the Setup Menu has been checked, the next step is to create a new job file or open an existing one. Each site should be assigned its own job file. In general, it is better to store discrete groups of points as separate files than to include them in one file. For example, there are several known points within the survey area (e.g., USGS benchmarks), which are used to generate UTM coordinates for all of the sites recorded. The known points should be stored in a file separate from all of the job files representing sites. If, at a later date it seems appropriate that two or more groups of points should be included in the same file, then the groups can be merged. Merging files, which is an option in the TFR-Map program, is discussed in section 12.

6.1 CREATING A NEW JOB FILE

Step 1: Select **[G]** – Open / Edit a job – from the Main Menu.

Figure 6-1a: Job Menu (Page 1)

```
Job Menu
G    Create new job
H    Open existing job
I    Current job info
J    Edit coordinates
K    Raw data file
L    Delete job
| MORE| |     |     |EXIT |
```

Figure 6-1b: Job Menu (Page 2)

```
M    Rename file
N    Delete points







|     |     |     |     |EXIT |
```

Step 2: Select **[G]** – Create new job - from the Job Menu.

Figure 6-2: New Job Screen

```
New Job
Job name(α):
Raw data: >ON
Start Point: 1
Northing : 5000.0000
Easting  : 5000.0000
Elev     : 100.0000
| CREAT|    |    ||    |EXIT  |
```

Job Name

Step 3: Press the **[α]** key to enable the alpha option, and then type in the job name. The job name should be based on the site name or number (e.g., SCRI277, PUNTA, etc.) to make the file easy to identify.

Step 4: Press the **[α]** key to disable the alpha option.

Step 5: Use the arrow keys to scroll down the screen.

Raw Data

Job files are stored as coordinate (.CR5) files, which contain the following information: point number, UTM coordinates, elevation, and point description. The following is an example of how points are stored in a coordinate file.

Point #	Northing	Easting	Elevation	Note
1	3776740.0000	233585.0000	130.0000	DATUM
2	3776760.5490	233560.3238	145.2897	CON
3	3776763.6723	233557.5869	143.3465	CON

In contrast, raw data (.RW5) files store the actions performed by the data collector user, including shooting points, moving to a new Occupy Point, and changing the instrument or rod height. The following is an example of how points appear in a raw data file.

OC, OP1, N 3776740.000,E 233565.000, EL130.0000,--DATUM

BK, OP1, BP1, BS0.0000, BC0.0000
LS, HI1.5650, HR1.8000
SS, OP1, FP2, AR0.0000, ZE87.37100, SD9.060, --CON
SS, OP1, FP3, AR0.0000, ZE87.37510, SD9.050, --CON

The raw data file provides a detailed field record of all of the activities conducted on the data collector, which can be very useful when editing job files. In this example, it shows the UTM coordinates and elevation of datum, which is designated as the Occupy Point, and is point # 1. It displays the instrument and rod height inputted when any point is first occupied. Therefore, it is recommended that the raw data option should be ON always.

Step 6: If the raw data option is OFF, then use the right arrow key to select ON.

Start Point

Step 7: The start point, which will be the site datum, should be numbered 1 unless there is some advantage to starting with another number. In the case of using control files, it is recommended that the start point for the job file is numbered 100 or above, which is discussed in detail in section 9.1.

Locational Coordinates for Datum

Step 8: Enter the Northing and Easting for the site datum. If the site has already been recorded, then the UTM coordinates may be copied from the site record. If not, they can be obtained by using a GPS unit in the field, or calculated based on plotting the site on a USGS 7.5' series map or something comparable.

For several reasons, it may be easier to use arbitrary points for the site datum, such as the default UTM coordinates on the data collector - Northing 5000 and Easting 5000. One, the UTM coordinates for the location may not be known at the time of mapping. Two, using arbitrary numbers such as these makes it easier to notice errors in locational data when out in the field. The coordinates may be adjusted later in the mapping process, as described in section 10.5.

Elevation for Datum

Step 9: Enter the elevation for the site datum. The elevation may be obtained in the manners described above, or may be entered arbitrarily as 100, which is the default on the data collector.

Step 10: Once the site information has been entered correctly, select **[CREAT]** in the New Job screen.

Figure 6-3: New Job Description Screen

```
              α
Enter Point 1
description
:  START



|CREAT||      |      |EXIT  |
```

Step 11: Type in the name of the first point to be occupied, which is represented by the UTM coordinates and elevation entered when creating the new file. The first point to be occupied should be the site datum and may be referred to as DATUM, MAP1, BENCH (if it is also a benchmark), or any other term that clearly indicates the nature of the point.

Step 12: Select the **[α]** key to disable the alpha option.

Step 13: Select **[CREAT]** to proceed with creating the file. The screen momentarily will read – Storing point 1 (or whatever number is designated as the start point).

Figure 6-4: Current Job Information Screen

```
Current Job Info.
Job Name :
Raw data  : >ON
Start Point: 1
Last Point:
Free memory(pts):
Control file:
|      |      |      |      |EXIT |
```

The first three options (job name, raw data, and start point) are the same as those listed in the previously shown New Job screen. The last three options (last point, free memory, and control file) are more relevant when opening an existing file, and are discussed below in section 6.2.

Step 14: Check the job file information for errors and then select **[EXIT]** to continue.

Figure 6-5: New Job is Opened Screen

A new job is opened.
Do you wish to setup
occupy and backsight
points now?

| YES | | | | NO |

Step 15: Select **[YES]** to change the backsight, instrument height, and rod height.

Figure 6-6: Occupied Point has Changed Screen

The occupied point has
been changed.
Do you wish to set the
Backsight & HI?

Backsight can be a
point or an azimuth.

| YES | | | | NO |

Step 16: Select **[YES]** to continue.

Figure 6-7: Backsight Setup Screen

```
     Backsight Setup
>BS azm:      0.0000
  BS circle reading
    Of gun: 0.0000
Occupy pt:
HI:                  HR:
BS Azm:       0.0000
|SOLVE|CHEC|     |FAST|CIRCL|EXIT|
```

<u>Backsight Azimuth</u>

Step 17: Enter the backsight as an azimuth (BS azm) or point (BS point).

The backsight may be entered as an azimuth (i.e., 0.0000), bearing (i.e., N0.0000E), or as a known point (e.g., 5). Use the right arrow key to change between the azimuth, bearing (BS brg), and point.

According to the scenario described in this manual, the backsight for the primary mapping station should be the north point. Therefore, the backsight azimuth should read 0.0000 (at both the top and bottom of the screen) to indicate that the orientation of datum is correlated with north, rather than another azimuth or angle. However, if another point in the landscape is known, such as an additional benchmark, then it should be used as the backsight for more accuracy.

The backsight point option may be used when the total station has been moved to a new mapping station, and it is necessary to link the new mapping station with datum. When occupying datum, the new mapping station should be recorded as a point. Then, when the total station is placed on the new mapping station, datum (e.g., point 1) should be used as the new backsight point. How to establish a new mapping station and link it to the datum with a backsight is discussed in detail in section 8.

<u>Occupy Point</u>

Step 18: Enter the number of the point that is currently being occupied. The Occupy Point will be either datum or another mapping station.

<u>Instrument Height</u>

Step 19: Enter the instrument height (HI), meaning the height of the total station, in meters. Calculate the measurement down to the millimeter (e.g.,

1.756). The instrument height is measured from the ground to a line indented on the side of the gun that is parallel with the eyepiece.

The height may be measured with a conventional tape measure or a stadia rod for better accuracy. Either one should be placed with one end flush with the ground surface at datum and one end adjacent to the indented line on the gun.

Rod Height

Step 20: Enter the rod height (HR) in meters as marked on the rod. The rod height will inevitably change multiple times during the course of recording points for a site. Therefore, it is important to maintain good communication with the person who is holding the rod in order to know when he or she has changed its height.

Step 21: Once the information has been entered correctly, select **[EXIT]** to return to the Job Menu.

6.2 OPENING AN EXISTING JOB FILE

Step 1: Select **[H]** – Open existing job – in the Job Menu.

The screen will display all files stored in the data collector. To scroll through the files, use the up and down arrow keys, or select **[PGUP]** or **[PGDN]**.

Step 2: When the correct file is highlighted, press **[SELCT]**.

The screen will display the Current Job Info for the selected job file. As discussed in section 6.1, the first three lines indicate the job name, whether or not the raw data option is ON, and the start point. The screen also lists the last point recorded, and whether the job file is linked to a control file. If a control file has been selected, then the file name will be listed on the last line.

In addition, the screen displays how much free memory (additional points) is available in the data collector. Prior to creating a new job or adding on to an existing file, it is important to make sure that there is enough memory available on the RAM card. If it anticipated that thousands and thousands of points are going to be taken during a field season, then it is recommended that several RAM cards are available for use.

Step 3: Check the information for errors, note how much free memory is available, and then select **[EXIT]**. The screen will display the New Job is Opened Screen that was discussed previously.

Step 4: Select **[YES]** if the occupied point, or mapping station, has been changed. The next screen will be the Backsight Setup, which is discussed in section 6.1.

If nothing has been changed, or the information is going to be entered from the Side Shots screen, select **[NO]** to return to the Job Menu screen.

7. SHOOTING POINTS

7.1 IMPORTANT POINTS TO SHOOT

As discussed in section 3.1, when first setting up the total station at a site, it is important to thoroughly inspect the area and observe all surface features relevant to mapping the site accurately. First, any significant changes in the topography should be mapped, such as cliff edges, ravines and gullies, knoll slopes, rock outcroppings, and human disturbance such as roads and dirt mounds. Points should be recorded at regularly spaced intervals in a manner that will adequately document the shifts in elevation and the nature of the features. When possible, points should be recorded at the top and along the sides of hills, ridges, and outcroppings as well as in the bottoms of gullies and at the base of cliffs and slopes. Useful descriptions for such points are BED (bedrock exposure), EDGE (cliff edge), GULLY (drainages), RIDGE (ridgeline), and OCEAN (cliff edge overlooking the ocean). Whatever abbreviations are used to describe the points should be easy to understand and consistently applied.

Second, lack of change in elevation is as significant as changes in topography when site mapping. For example, the site may be situated on a large plateau or in a flat river valley. Or, the location may be some combination of flat and irregular, such as a site that is eroding off of a cliff edge, but is located mainly on the gently sloping grassland extending up from the cliff. It is important that points are recorded consistently to detect even small changes in elevation. Depending on the size of the area to be mapped, points should be recorded at 2 to 5 m intervals to adequately document the topography, and to eventually generate contour lines on site maps. Make sure that points are recorded well beyond the site boundaries (e.g., about 20 m) in order to "place" the site accurately within its larger topographic context.

In some cases, it may be useful to record points along transects to ensure that the topography is being mapped thoroughly. The distance between transects should be between about 5 and 10 m depending on the nature of the topography and the goals and time constraints of the mapping project. In general, transects and the points recorded on them should be spaced closer together, about 2 to 5 m, when there is greater surface variability. Furthermore, the direction of transects depends on how the site is positioned in space, meaning its general orientation (e.g., the longest axis is oriented north to south). For example, the site to be recorded is bounded on one side by an east-west trending cliff edge, and has tremendous topographic variation beyond that. Therefore, one may record points that are spaced about 5 m apart along transects that are oriented on a 90°-270° axis and are spaced 5 m apart. Useful abbreviated descriptions for such points are CON (contour lines) and TOPO (topography).

Third, anything that distinguishes the area visually and aids in relocating the site should be recorded, as long as it seems that the feature will be in the same location in a few years, such as rock outcroppings, large trees (e.g., oaks), fence lines, roads, and telephone poles. Bad examples include vehicles, shrubs, and shifting sand dunes. Keep in mind that the site map is going to be used by other archaeologists to locate the site; therefore, all useful features should be recorded to help those people out.

Fourth, any cultural feature related directly to the site should be recorded, such as house depressions, structures and walls, rock features, lithic scatters, and the extent of midden deposits. Site boundaries, which are indicated by features such as changes in soil color and composition and/or shifts in the densities of lithic scatters and shell middens, should be documented at regular intervals. Useful descriptions include LITHIC (extent of lithic scatter), INTACT (extent of intact midden), SLUMP or MID (midden that has eroded from its original location), and BOUND (site boundary).

Fifth, the location of all archaeological activities should be documented thoroughly, including grid units for surface collection, surface scrapes, auger holes (AUG#), shovel test pits (STP#), column samples (CS#), and test units (TU#).

7.2 NORTH AS THE SECOND POINT

Before shooting north or another point as the second point (datum is point 1), check the following information on the data collector and change it if necessary: occupy point (OC), foresight point (FS), instrument height (HI), and rod height (HR). All of these fields may be accessed from the Traverse/Side Shot screen.

Step 1: Once the appropriate job file has been opened, select **[J]** – Traverse/Side shot – from the Main Menu.

Figure 7-1: Side Shot Screen

```
OC:                FS:
BS pt:
>Ang right     :
>Zenith ang    :
  Slope dist   :
Descα:
HI:                      HR:
|SIDES|REP|BACK|TRAV|OFFCT|EXIT|
```

Occupy Point (OC)

The Occupy Point is the point that is currently being occupied, which will either be datum or other mapping stations. Since datum is usually point 1, the OC line should read 1 when datum is occupied.

Foresight Point (FS)

The Foresight Point is the point that is going to be shot next, not the point that was just shot. However, the numbers displayed on the lines for angle right (Ang right), zenith angle (Zenith ang), and slope distance (Slope dist) are locational data for the point that was just shot.

Backsight Point (BS pt)

The backsight point (BS pt) is the point to which the currently occupied point maintains a backsight. How to backsight is described in detail in section 8.2.

The point description (Desc), instrument height (HI), and rod height (HR) designations are discussed in section 6.1.

How to Establish North

Once this information is checked, there are at least two options for how to establish north on the data collector, using either the rod or mechanical plumb bob.

Step 2: Set up the rod or plumb bob at the north point. The rod holder should be sure to note the height of the rod, as well as maintain its levelness by watching the leveling bubble and adjusting appropriately.

If using the plumb bob, carefully and steadily dangle the string directly over the marker for the north point.

Step 3: While looking through the eyepiece on the gun, rotate the gun such that the crosshairs overlay the center of the prism reflector, or the string from the plumb bob lines up between the two vertical parallel lines visible in the eyepiece. Focus the eyepiece if the crosshairs are not seen readily.

Once the crosshairs are in position, lock down the horizontal clamp to keep the gun lined up correctly. Then, lock down the vertical clamp when the crosshairs line up on the prism reflector. Use both tangent screws to further center the crosshairs when both lock clamps are locked down.

As soon as the gun is locked into place, the holder of the rod or plumb bob may relax and move on.

Step 4: On the data collector, select **[EXIT]** to return to the Main Menu.

Step 5: Select **[G]** - Open/Edit a job - from the Main Menu.

Figure 7-2: Job Menu

```
Job Menu
G    Create new job
H    Open existing job
I    Current job info
J    Edit coordinates
K    Raw data file
L    Delete job
| MORE| |      |      |EXIT  |
```

Step 6: Select **[J]** - Edit coordinates - from the Job Menu.

Figure 7-3: Point Data Screen

```
      Point Data

Point     :
Northing :
Easting   :
Elev      :
Descα:
| PT +| PT -|STORE|RCL|UNUS|EXIT |
```

Step 7: Enter the following information to establish the north point:

Point: 2
Northing: Add 20 m to the Northing for datum
Easting: Same as the Easting for datum
Elevation: Same as datum (to be edited later)
Description: North

Step 8: Select **[STORE]** to save the information for the point.

Step 9: Select **[EXIT]** twice to access the Main Menu.

Step 10: Select **[J]** - Traverse / Side shot - from the Main Menu.

Step 11: Select **[BACK]** to access the Backsight Setup screen.

Figure 7-4: Backsight Setup Screen

```
     Backsight Setup
>BS azm:      0.0000
 BS circle reading
   Of gun: 0.0000
Occupy pt:
HI:                HR:
BS Azm:       0.0000
|SOLVE|CHEC|    |FAST|CIRCL|EXIT|
```

Step 12: Enter the backsight point (BS point), which is the north point, 2.

Step 13: Select **[SOLVE]** to calculate the backsight, which will be listed on the top and bottom of the screen as 0.0000.

Step 14: Select **[CIRCL]** from the Backsight Setup screen.

Figure 7-5: Backsight Circle Screen

```
     Backsight Circle

G  Read BS circle from
   instrument
H  Send BS circle to
   instrument

|    |    |    |    |    | EXIT   |
```

Step 15: Select **[H]** to send the backsight circle to the gun. Then the gun (currently locked on north) will be set to 0.0000.

Step 16: Select **[EXIT]** until the Side Shot screen is reached.

7.3 SHOOTING POINTS

Step 1: In the Side Shot screen, make sure that the occupy point is 1, the backsight point is 2, and the foresight is 3.

Step 2: Set up the rod on the next point to shoot.

Step 3: While looking through the eyepiece on the gun, rotate the gun such that the crosshairs overlay the center of the prism reflector. Once the crosshairs are in position, lock down the horizontal clamp to keep the gun lined up correctly. Then, lock down the vertical clamp when the crosshairs line up on the prism. Use both tangent screws to further center the crosshairs when both lock clamps are locked down.

Figure 7-6: Side Shot Screen

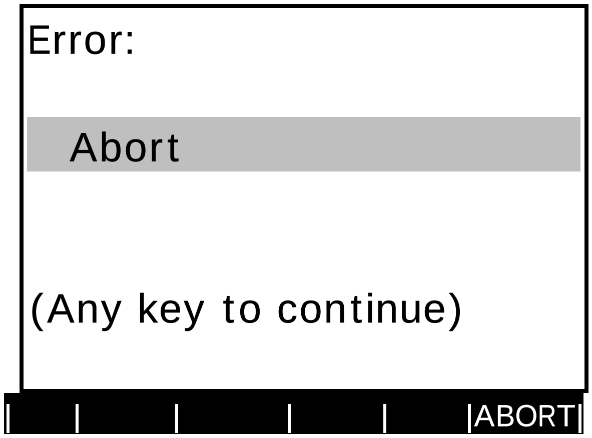
```
OC:               FS:
BS pt:
>Ang right      :
>Zenith ang     :
  Slope dist    :
Descα:
HI:                    HR:
|SIDES|REP|BACK|TRAV|OFFCT|EXIT |
```

Step 4: Select **[SIDES]** to take the shot. The total station will emit a series of beeps that represent the time it takes for the gun to send the laser signal and for the signal return to the gun. The screen will read "Taking a shot..." until the shot is completed.

If only two beeps are heard, then the gun is unable to take the shot. One reason for this may be that the prism reflector has moved and the gun it no longer sighting it. Have the rod holder rotate the prism, and then the gun should be able to complete the shot. If there is a serious problem, the shot may have to be aborted, the position of the rod altered, and the point shot again.

Another reason may be that the gun battery is dead, and the gun does not have the juice to complete the shot. Changing the battery may solve the problem. Then, the point can be re-shot.

Figure 7-7: Side Shot Error Screen



Step 5: If the gun can not complete the shot, then select **[ABORT]**. Then, the screen above will be displayed. Select **[ABORT]** again. The screen will appear the same except that instead of "Abort", it will read "Data error, try again." Select **[ABORT]** to return to the Side Shots screen.

Step 6: Once the shot is completed, the screen will display the UTM coordinates and elevation of the new point and the description of the previously recorded point. Check the UTM coordinates and elevation for general accuracy. The Northing should be 20 m greater than the Northing for datum, and the Easting should be the same. If it shows something different, then check the Backsight Setup screen. Make sure that the backsight azimuth and backsight circle reading of gun read 0.0000 because the initial backsight azimuth is oriented to north.

Step 7: Enter the description for the point, unless it is the same as the previously recorded point.

Step 8: Press **[ENTER]** to return to the Side Shots screen.

It is useful to designate short terms for general categories of points that are easy to understand and will be used consistently. For example, CON for contour lines, MAP# for numbered mapping stations, EDGE or BOUND for the site boundary, CLIFF, GULLY, etc.

Changing Options between Side Shots

The Occupy Point and instrument and/or rod height may be changed at any time between side shots through the Side Shots screen. Use the down arrow key to scroll to these options.

If the backsight point need to be changed between side shots, select **[BACK]** to access the Backsight Setup screen.

7.4 SHOOTING ADDITIONAL POINTS

Step 9: Proceed to shoot other points following the directions listed above. It is useful to work in a circle such that the gun does not have to be rotated that much between shots. It will keep the rod holder from having to constantly move around the site.

Remember that the data shown on the Side Shots screen represents that point that was just shot. The foresight (FS) represents the point number that will be assigned to the next shot taken.

8. CHANGING MAPPING STATIONS

8.1 ESTABLISHING A NEW MAPPING STATION

Selecting the Location for a New Mapping Station

Step 1: Make sure that the locations for other mapping stations are selected prior to setting up on the datum, with the following considerations in mind. First, the new mapping station must be visible from datum. Second, the new mapping station must provide some vantage from which points not "shootable" from datum may be recorded. (Note the word "shootable" rather than visible because, given the potential height of the rod, points may be shot that are not visible from the total station.)

For example, if the site to be recorded is located primarily on the top of a knoll, but there is also midden slumping extensively down the sides, then the datum may be placed at the top of the knoll. Then, additional mapping stations may be set up on the slope at locations high enough to be shot from datum and low enough to shoot points along the extent of the slumped-off midden.

Shooting a New Mapping Station

Step 2: Once the location is selected, record the new mapping station as another point. The description of the point should indicate that it is going to be used as another mapping station (e.g., MAP2, BENCH3). Record the point number and description in your field notes so that the number may be accessed readily when changing mapping stations. Also, write down the azimuth for the point (e.g., 135° from datum) in order to easily check the backsight azimuth when setting up on the new mapping station.

In addition, a nail or pin flag, for example, should be placed at the new mapping station. If it is anticipated that the station is going to be used repeatedly, for several days or in two weeks, for example, then something durable must be placed there is ensure that the total station can be set up readily on that exact location. For example, a large nail (i.e., PK nail) can be pounded into the ground, and then flagging tape and a pin flag or two can be used to mark the spot.

8.2 SETTING UP ON A NEW MAPPING STATION

Step 3: Follow the same setup directions as discussed in sections 4.1-4.4 to set up the total station on the new mapping station.

Step 4: On the data collector, select **[BACK]** to access the Backsight Setup screen from the Side Shot screen (select **[J]** in the Main Menu to get to the Side Shot screen).

Figure 8-1: Backsight Setup Screen

```
    Backsight Setup
>BS azm:      0.0000
  BS circle reading
   Of gun: 0.0000
Occupy pt:
HI:                 HR:
BS Azm:       0.0000
|SOLVE|CHEC|      |FAST|CIRCL|EXIT|
```

Step 5: Change the following: occupy point, instrument height (HI) (measure the height of the total station at this time), and rod height (HR), if necessary.

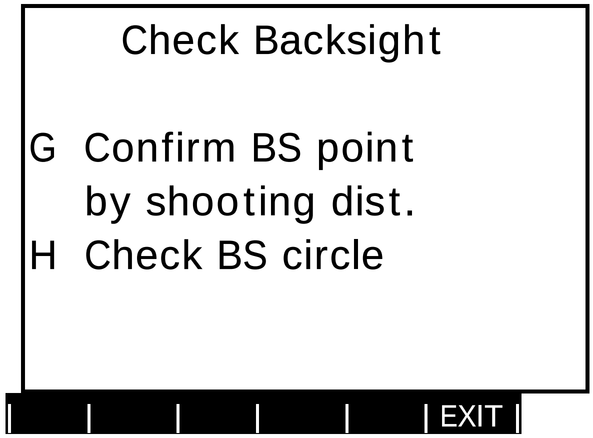
Step 6: Enter the backsight point (BS point), which is the mapping station from which the occupied point was shot.

Step 6: Select **[SOLVE]** to calculate the backsight, or inverse of the azimuth, recorded from the backsight (former occupied point) to the new mapping station (current occupied point) (e.g., 270° azimuth from datum - 180° = 90° azimuth from new mapping station). It is also convenient to use a hand-held compass as a quick check.

Step 7: Place the rod or plumb bob at the mapping station from which the currently occupied point was recorded. Then lock the sight of the gun on the prism or line up the plumb bob string between the two vertical parallel lines visible in the eyepiece.

Step 8: If the rod is set up on the backsight, then select **[CHECK]** to access the Check Backsight screen.

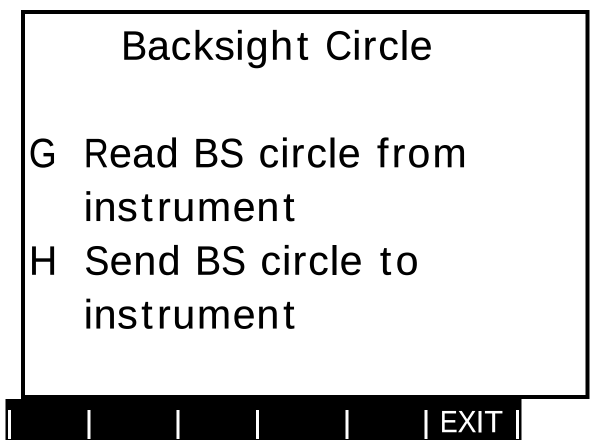
Figure 8-2: Check Backsight Screen



Step 9: Select **[G]** to confirm that the location is the correct backsight point. The data collector will determine the margin of error between the calculated and actual backsight. Whether the margin of error is accepted or it warrants setting up the total station again depends on the level of accuracy required for the mapping.

Step 10: After the backsight check is completed, select **[CIRCL]** from the Backsight Setup screen.

Figure 8-3: Backsight Circle Screen



Step 11: Select **[H]** to send the backsight circle to the gun. This reorients the gun to the existing grid system as recorded by the data collector based on the relative location of the backsight.

Step 12: Select **[EXIT]** until the Side Shot screen is reached and then return to taking shots.

9. OTHER DATA COLLECTOR OPTIONS

9.1 WHEN AND HOW TO USE CONTROL FILES

When to Use Control Files

Control files are useful when there benchmarks or other known points that may be used as reference points for several sites. Each relevant benchmark should be assigned a point number, and then the UTM coordinates and elevation for each one can be entered and stored in a control file. Control files are also used when large sites are being mapped and numerous mapping stations are going to be occupied at various times. For example, when mapping a residential complex that spans many hectares, it may be useful to first shoot all of the points that are going to be used as mapping stations and store them as a control file that can be accessed at any time.

How to Use Control Files

Step 1: Create the control file by following the steps for creating a job file, as described in section 6.

CAUTION: There is one major difference between control and job files in regard to the start point. The point numbers in the linked files can not overlap (e.g., 1-10 and 5-15), and control file numbers must be smaller than those in the linked job files. Otherwise, the data collector will use the numbers designated in the job file rather than accessing the points in the control file. The data collector first searches the open job file for the specified point number, and then searches the linked control file when the point number is not found.

The most effective way to avoid this issue is to reserve all numbers under 100 for control points, and then designate the start point for the relevant job files as 200, 500, or some other convenient number above 100.

Step 2: Record the control points as side shots, as described in section 7.2.

Step 2b (OPTIONAL): When the UTM coordinates and elevation are known for control points, then they may be generated without the use of the gun. The advantage of this option is that it saves time shooting points in the field. However, the actual points must have permanent markers of some kind, such as benchmarks, so that the total station can be placed on the exact location that the coordinates represent.

To enter control points in this manner, refer to the directions on how to edit the point coordinates, which is discussed in section 12.3 in the subheading “Editing Basic Information Point by Point.” Enter the new point number, Northing, Easting, elevation, and description (e.g., BENCH1, BENCH2, BENCH3).

Step 3: Select **[STORE]** after the information for each point is entered to ensure that it is being recorded by the data collector. The new data will not be stored automatically.

Selecting a Control File

Step 1: Select **[H]** – Setup Menu to link a control file to an existing job file.

Step 2: Select **[K]** – Select control file – in the Setup Menu.

Step 3: **[SELCT]** the appropriate control file from the files displayed on the screen. Then, the Current Job Information screen will display the name of the control file on the bottom line.

Step 4: Select **[EXIT]** to return to the Setup Menu.

Deselecting a Control File

Once a control file is selected, the data collector automatically assigns that control file to any other job file that is created or opened subsequently. Therefore, before opening another job file, deselect the control file option.

Step 1: Select **[H]** – Setup Menu - from the Main Menu.

Step 2: Select **[L]** – Deselect control file – in the Setup Menu. The Current Job Information screen will display nothing on the control file line.

Step 3: Select **[EXIT]** to return to the Main Menu.

9.2 PLOTTING POINTS

The screen plot option on the data collector is useful for checking the general accuracy of recorded points while in the field. Rather than waiting until the evening or later to download files from the data collector, the screen plot provides a quick method of plotting some or all of the points recorded for a site on the data collector screen. Gross errors in the UTM coordinates for the plotted points may be detected immediately.

Step 1: Select **[P]** – Screen plot – from the Main Menu.

Figure 9-1: Screen Plot Screen

```
      Screen Plot
>From point   :
To point      :

Plot pt number: >Yes

|POINT|PTLST|LINES|SCALE|PRINT|EXIT|
```

The more points included in the plot, the longer it is going to take the data collector to generate the plot map. Limit the plot only to the points that are relevant. For example, if the screen plot is being used to check the accuracy of the points taken for site boundaries, then select only the points that define the extent of the site. Besides saving some time, fewer points will allow the plot to be viewed more clearly on the small screen.

Step 2: Select the points to be plotted. One option is to specify the start and end points of the grouping to be plotted. Another option is to access an existing point list file that contains particular points.

Step 2b (OPTIONAL): Select **[PTLST]** to create, edit, select, or delete a point list file.

Figure 9-2: Point List Menu

```
      Point List Menu

G     Edit point list
H     Clear point list
I     STO list to file
J     RCL list from file
K     DEL list in file
|     |     |     |     |EXIT |
```

To generate a new point list, select **[I]** - STO list from file. Enter the name of the point list and then **[ENTER]**. Then, select **[G]** - Edit point list. At the <u>NXT PT?</u> prompt displayed on the screen, enter the point number(s) to be included in the point list, either as single (e.g., 1, 2, 8, etc.) or multiple (e.g., 10-15, 21-45) numbers. Press **[ENTER]** after each entry is completed. Select **[EXIT]** when the point list is completed.

To select an existing point list, press **[J]** - RCL list to file. Highlight the appropriate file and then press **[SELCT]**. Then, use the right arrow key in the Screen Plot screen to select the *Using point list* option.

Step 3. Returning to the Screen Plot screen, indicate whether or not the point numbers are to be plotted on the screen by selecting YES or NO on the Plot Point Number line.

If the point numbers need to be viewed, then the number of points included in the plot should be relatively limited due to the small screen size.

Step 4: Select **[SCALE]** in the Screen Plot screen to scale the plot to the size of the data collector screen.

Step 5: Select **[POINT]** to plot the points on the screen.

Step 6: When done viewing the screen plot, press the **[ON]** key to return to the Screen Plot screen.

9.3 CALCULATING THE SITE AREA

There will be contexts in which it is necessary to calculate the area of the site. For example, the site area will need to be recorded on the official site form. In addition, if larger regional maps are going to be generated, then the site area needs to be calculated to plot the sites to scale. The following is an easy way in which to calculate the site area on the data collector.

Step 1: Select **[M]** – CO-GO menu – from the Main Menu.

Figure 9-3a: CO-GO Menu (Page 1)

```
        CO-GO Menu
G    Area computation
H    Conversion menu
I    Intersections
J    Inverse between pts
K    Pt in direction
L    Resection (2 pts)
| MORE|    |    |    |    |EXIT |
```

Select **[MORE]** to view additional options.

Figure 9-3b: CO-GO Menu (Page 2)

```
M    Resection (3 pts)
N    Corner angle compu
O    Bench mark
P    Predetermined area



|     |     |    |    |    |EXIT |
```

Step 2: Select **[G]** – Area computation – from the CO-GO Menu.

Figure 9-4: Area Computation Screen

```
     Area computation
>From point   :
To point      :
Area (sq m):
Perimeter:


|SOLVE|PTLST|    |    |    |EXIT|
```

Step 3: Enter the start and end points for the area that is to be calculated, or select **[PTLIST]** to access a point list file as discussed in section 9.2.

Step 4: Select **[SOLVE]** to calculate the area. The area will be displayed on the screen in square meters.

Step 5: After the site area has been written down, select **[EXIT]** to return to the CO-GO menu.

10. TROUBLE-SHOOTING AND EDITING

10.1 GETTING THE DATA COLLECTOR TO WORK AFTER IT FREEZES

If the data collector freezes and no keys will function there is a problem either with the keyboard or some other aspect of the hardware. The simplest method to try to fix the problem is described below. If this does not work, then consult the troubleshooting section (Appendix G-6) in the TDS-48GX Surveying Card reference for further instructions.

Step 1: Select the **[ON]** and **[C]** keys at the same time, and then release them both.

The calculator screen will go blank and then will display the home screen (described in section 2.3). The survey program may be accessed from this screen and work resumed.

10.2 EDITING DATA POINT BY POINT

During the course of a day of fieldwork, errors should be recorded in detail in the field notes. For example, it may be observed that the point number or description for a specific point is wrong. Or, for safety reasons, the cliff edge is actually one meter south of the point being shot to demarcate the cliff edge. The difference in distance and direction should be recorded in the notes, and then the Northing coordinate for the point can be edited later.

Step 1: Select **[G]** - Open / Edit a job – from the Main Menu.

Step 2: Select **[J]** – Edit coordinates – from the Job Menu.

Figure 10-1: Point Data Screen

```
      Point Data

Point     :
Northing  :
Easting   :
Elev      :
Descα:
| PT +| PT -|STORE|RCL|UNUS|EXIT |
```

The Point Data screen lists the following information for each point recorded in the job file: point number, Northing, Easting, elevation, and description.

Step 3: Use **[PT +]** or **[PT -]** to sequentially move up or down the point numbers to reach the relevant one. If the point number to be reached is higher than the number currently displayed (e.g., 10 to 50), then enter on the Point line the number that is one lower than the desired number (e.g., 49) and select **[PT +]**. If the point number to be reached is lower than the number currently displayed (e.g., 50 to 10), then enter the number that is one higher than the desired number (e.g., 11) and select **[PT -]**.

Step 4: Once the appropriate point number is reached, edit the information by using the up and down arrow keys.

Step 5: Select **[STORE]** to save the changes.

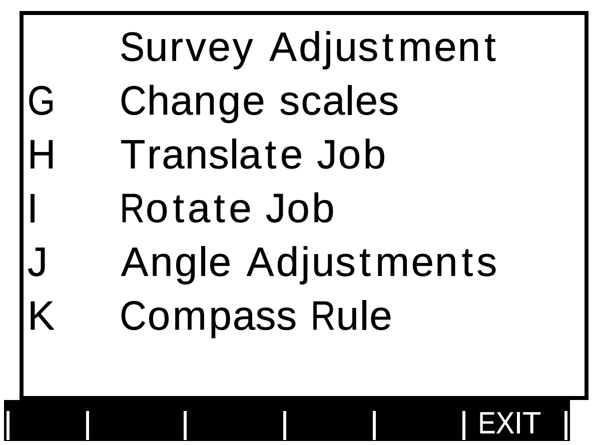
Step 6: Once the changes are completed, select **[EXIT]** to return to the Job Menu.

10.3 EDITING ELEVATION

There will be circumstances in which it may be necessary to edit the elevation for one or more recorded points. For example, the elevation for datum may have been entered incorrectly, and therefore all of the points in the job file have incorrect elevations. Or, it may be have been recorded in the notes that the instrument and/or rod height was wrong for one or more points.

Step 1: To change the elevation for one or more points, select **[N]** – Survey adjustment – from the Main Menu.

Figure 10-2: Survey Adjustment Screen



Step 2: Select **[H]** – Translate Job – from the Survey Adjustment menu.

Figure 10-3: Translate Job Screen

```
      Translate Job
>From point   :
To point      :
>Azimuth      :
Horiz dist    :
Elevation+/-  :

|SOLVE|PTLST|INVRS|     |     |EXIT|
```

Step 3: Enter the points for which the elevation is going to changed in the From Point and To Points options.

Step 4: Make sure that the Azimuth and Horizontal Distance options read 0.000.

Step 5: Enter the measurement by which the points are going to be raised or lowered in elevation. For example, when points 5-25 were recorded the rod height entered on the data collector was 2.00 m. However, it was remembered that the actual height on the rod had been changed to 2.75 at point 15. Therefore, 0.75 m needs to be subtracted from points 15-25, which would be entered as -0.75.

Step 6: Select **[SOLVE]** to adjust the elevations. The data screen will display "Computing…" and then the Translate Job screen is shown again after the elevations have been changed. Follow the steps in section 10.2 to be able to view the points.

Step 7: Select **[EXIT]** to return to the Survey Adjustment menu.

10.4 EDITING AZIMUTHS

There may be situations in which it is necessary to edit the azimuths, and therefore the UTM coordinates, for one or more points. For example, the north line may have been established on magnetic north, while the final printed map will be oriented relative to true north. Or, another mapping station was used besides datum and it is realized (by using the screen plot or other methods) that the backsight azimuth was calculated incorrectly. The azimuth for one or more points may be edited using the Rotate Job option.

Step 1: Select **[N]** – Survey adjustment – from the Main Menu.

Step 2: Select **[I] –** Rotate Job – from the Survey Adjustment menu.

Figure 10-4: Rotate Job Screen

```
     Rotate Job
>From point   :
To point      :

Rotation pt   :
Old bearing   :
New bearing   :
|SOLVE|PTLST|INVRS|     |        |EXIT |
```

Step 3: Specify the points to be rotated. As discussed in section 9.2 in regard to screen plots, the start and end points of a grouping (or individual number, i.e., 1 to 1) may be entered or a point list file may be accessed by selecting [PTLST].

<u>Rotation Point (Rotation Pt)</u>

Step 4: Specify the point around which the points are going to be rotated. The rotation point must be the point number of the mapping station at which the points specified where shot.

<u>Old Bearing and New Bearing</u>

The data collector will calculate the angle by which the points are going to be rotated based on the difference between the old and new bearings. It is not necessary that the old bearing is the correct bearing; however, the difference between the old and new bearings must be correct.

For example, it was discovered that north had been skewed 30° to the west when recording points at datum. This means that the data collector "thinks" north is where 330° is in reality. Therefore, those points must be rotated from the Old Bearing of N 30° W to the New Bearing of N 0° W. For that matter, any bearings can be used as long as they represent the 30° difference and direction of error, such as from N 75° E to S 75° E or from S 10° E to S 20° W. Bearings are discussed in detail in section 1.1.

Step 5: Specify the old and new bearings.

For example, in the process of changing mapping stations, the backsight was entered incorrectly and the gun was reoriented wrong. Points 50 to 100 were shot at this mapping station, which was recorded as point 20. North is in reality 20° to the west, which means that the gun reads the actual direction of 0° as 20°.

Therefore, specify the From Point as 50, To Point as 100, Rotation Point as 20, the old bearing as N20.000E, and the new bearing as N0.000E.

Step 5b (OPTIONAL): Rather than converting azimuths to bearings by hand, this can be determined by the data collector. Select **[M]** - CO-GO menu - from the Main Menu, and then **[H]** - Conversion Menu.

Figure 10-5: Conversion Menu

```
        Conversion Menu

G       Azimuth<->Bearing
H       Zenith & Slope D

|      |      |      |      |      |EXIT |
```

Step 6: Select **[G]** – Azimuth <-> Bearing – from the Conversion Menu.

Figure 10-6: Azimuth-Bearing Screen

```
        Azimuth<->Bearing

Azimuth:

Bearing:

| AZB | BZA |      |      |      |EXIT |
```

Step 7: Enter the Azimuth and select **[AZB]**. Then, the screen will display the correct bearing, which should be written down.

Step 8: Continue to select **[EXIT]** to return to the Main Menu and then return to the Rotate Job screen.

Step 9: Once all of the information is entered correctly in the Rotate Job screen, select **[SOLVE]** to rotate the points. The screen will momentarily read "Computing . . ." and then return to the Rotate Job screen.

Step 10: Select **[EXIT]** to return to the Survey Adjustment menu. It is recommended that the points should be viewed immediately to make sure that they were rotated correctly.

10.5 EDITING COORDINATES

There may be situations in which the UTM coordinates generated for one or more points are wrong, and need to be modified. For example, default UTM coordinates (5000 E / 5000 N) may have been used to establish the job file because the actual UTM coordinates for the site were not known at the time. This process is slightly more cumbersome than changing the elevation or an azimuth because the coordinates can not be modified solely by entering the correct ones.

Step 1: Determine the distance and azimuth from the current coordinates and the new ones. The easiest way to calculate these is to use the data collector. Select **[M]** - CO-GO menu - from the Main Menu.

Step 2: Select **[J]** - Inverse between points - from the CO-GO menu.

Figure 10-7: Inverse by Points Screen

```
     Inverse by Points
Begin point:        0
End point:          0
Bearing   :     N0.000W
Azimuth: 0.0000
Horiz dist:     0.0000
Vert dist:      1.0000
|SOLVE |     |BYCRD|BYLIN|     |EXIT |
```

Step 3: Select **[BYCRD]** to be able to input the coordinates for the current and new points. Make sure that the coordinates are written down for easy reference.

Figure 10-8: Inverse by Coordinates Screen

```
Begin N   :     5000.000
Begin E   :     5000.000
End N     :     0.0000
End E     :     0.0000
Bearing   :     N0.0000W
Azimuth   :     0.0000
Horiz dist:     0.0000
|SOLVE |BYPTS|     |BYLIN|    |EXIT |
```

Step 4: Enter the current UTM coordinates as the Begin Northing and Being Easting. Enter the new UTM coordinates as the End Northing and End Easting.

Step 5: Select **[SOLVE]**, and then the screen will display the Bearing, Azimuth, and Horizontal Distance between the current and new UTM coordinates. Write all of this information down in the field notes.

Step 6: Continue to select **[EXIT]** until the Main Menu is accessed. The next steps are similar to that described in section 10.2 regarding the process of editing the elevation.

Step 7: Select **[N]** - Survey Adjustment - from the Main Menu.

Step 8: Select **[H]** - Translate Job - from the Survey Adjustment menu.

Figure 10-9: Translate Job Screen

```
      Translate Job
>From point    :
To point       :
>Azimuth       :
Horiz dist     :
Elevation+/-   :

|SOLVE|PTLST|INVRS|     |        |EXIT |
```

Step 8: Enter the points for which the UTM coordinates are going to be changed in the From Point and To Point options. If the UTM coordinates were entered incorrectly for the site datum, then all of the points stored in the job file will need to be edited. The number of the last point may be found in the Current Job Information screen when the job file is open.

Step 9: Enter the Azimuth or Bearing and Horizontal Distance that were written down during the previous steps.

Step 10: Select **[SOLVE]** to adjust the UTM coordinates. Once completed, select **[EXIT]** several times to return to the Main Menu, and then promptly view the modified coordinates for errors. The easiest way to check for errors is to look at the new UTM coordinates for the site datum.

It must be remembered that when the UTM coordinates are edited, the data collector adjusts them as though the points were being moved in space. Therefore, if there is a significant difference between the old and new UTM coordinates (e.g., from 5000 E / 5000 N to 235810 E / 3815720 N), then there is potential for error in the calculation of the new coordinates. The reason for this error is that the Azimuth / Bearing is rounded to the nearest four decimals when it is calculated or entered by hand. For example, new UTM coordinates will be generated based on an Azimuth of 43.5247 rather than an Azimuth of 43.52466. When moving across significant amounts of space, this minute difference can skew the new UTM coordinates by several meters.

The way to alleviate this problem is to go through several rounds of translating the job until the correct UTM coordinates are reached. For example, the points are to be translated from 5000 E / 5000 N to 262000 E / 3855000 N. After the first translation, it is noticed that the datum has the correct Northing (3855000 N), but it is skewed 10 m directly to the east (262010 E). The next time the job is translated, enter the Azimuth as 270° (west), which is the inverse of 90° (east), and 10 m as the Horizontal Direction. The next time the UTM coordinates for datum are checked, they should be 262000 E / 3855000 N.

Step 11: Repeat the translation process until the new UTM coordinates are correct.

10.6 DELETING POINTS

Some points that are recorded may be errors, or are used as tests to check the accuracy of the recording (e.g., shooting north). If it is known while the point is being shot that it is going to be deleted, then the description should be something that indicates that it should be deleted at a later time (e.g., DEL.)

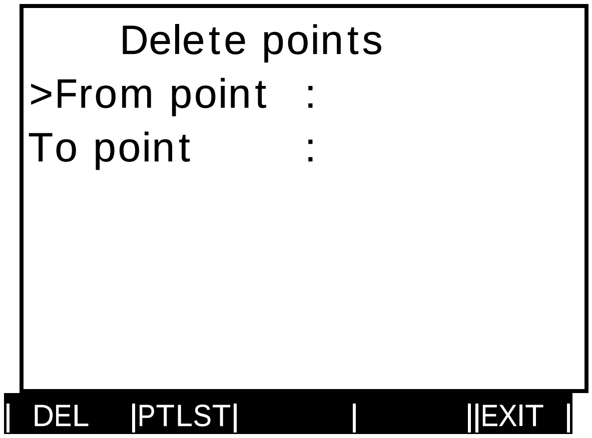
The points may be deleted when either using the data collector or accessing the data in its Microsoft Excel or Surfer worksheet format. The following are steps for how to delete the points using the data collector.

Step 1: Select **[G]** – Open / Edit a job – in the Main Menu.

Step 2: Select **[MORE]** to view additional options in the Job Menu.

Step 3: Select **[N]** – Delete points – in the Job Menu.

Figure 10-10: Delete Points Screen



Step 4: Specify the points to be deleted. As discussed in section 9.2 in regard to screen plots, the start and end points of a grouping (or individual number, i.e., 1 to 1) may be entered or a point list file may be accessed by selecting **[PTLST]**.

Step 5: Select **[DEL]** to delete the point(s).

Step 6: The next screen will read "Are you sure?" Select **[YES]** or **[NO]** accordingly. If **[YES]**, the screen will momentarily display "Computing. . ." and list the points being deleted, and then return to the Delete Points screen. If **[NO]** is selected, then the Delete Points screen is displayed again.

Step 7: Select **[EXIT]** to return to the Job Menu.

11. DOWNLOADING FILES FROM THE DATA COLLECTOR

Step 1: Connect the data collector to the computer com ports by using the long blue connector cable provided with the equipment or something comparable. The COM port to which the data collector is connected (i.e., COM1 or COM2) must be specified in the TFR-Map program, which is discussed below.

Step 2: Turn on both the data collector and computer. Then, access the TFR-Map program on the computer.

Step 2b (OPTIONAL): If the TFR-Map program must be accessed in MS-DOS, then enter the following:

C:\ **cd tfrmap**

C:\tfrmap\ **tfr**

Step 3: On the data collector, select **[S]** – File transfer – from the Main Menu.

Figure 11-1: File Transfer Screen

```
File type :    >CRD
IR/wire   :    >Wire
Baud rate:     >9600
Parity:        >None

Start pt: 0
End pt:   0
| SEND  | RECV  | SBLK|  GET| MODE|EXIT|
```

Step 4: Check all of the options listed. The options shown above are the default options for transferring files, of which the IR/Wire, Baud Rate, and Parity options should always be the same. In general, the file type should be coordinate (CRD), although there also may be contexts in which raw data (RAW) and point list (PLST) files should be transferred.

Step 5: Select **[SEND]** to select the job file to be transferred. The next screen will be the directory listing all of the stored job files. Highlight the appropriate job name, but do not press **[SELCT]** yet.

Step 6: Before selecting the file, and thereby sending it to the computer, select **[ALT] + [T]** in the TFR-Map program to access the Transfer menu.

Figure 11-2: Transfer Screen in the TFR-Map Program

```
O                    TRANSFER
  [A]   Receive File from Data Collector
  [B]   Send File to Data Collector
  [C]   View/Print File
  [D]   Raw Data Conversion
  [E]   Coordinate File Conversion
  [F]   File Management Menu
  [G]   Transfer through Modem
```

F1	F2	F3	F4	F5	F6
					EXIT

Step 7: Select **[A]** – Receive File from Data Collector – in the Transfer menu.

Figure 11-3: Receive File Screen

```
O                   Receive File
Data collector:                  >TDS

Destination file name for
non-TDS data collector:

Archive Raw data files:          Yes

COM port  :                      >COM1
Baud      :                      >9600
Parity    :                      >None
Store TDS coord. file as: >Sequential
```

F1	F2	F3	F4	F5	F6
REC V	FILE				EXIT

Step 8: Check all of the options listed in the Receive File menu, which should appear as shown above. Be sure that the correct COM port is indicated (i.e., COM1 or COM2). To download the coordinate and raw data files for one

job simultaneously, make sure that the coordinate file (CRD) is selected in the File Transfer screen on the data collector, and the Archive Raw Data Files option in the Receive File screen in the TFR-Map program reads YES.

Step 9: On the data collector, Press **[SELCT]** from the File Transfer menu on the data collector to send the job file to the TFR-Map program.

The data collector screen will read Connecting until the connection to the TFR-Map program is established. The screen will read Retry# (i.e., 1-9) as long as the data collector is attempting to send the job file and the TFR-Map program has yet to receive the information. After nine retries, the transfer process will be terminated automatically, and the data collector will display the File Transfer screen.

Step 10: Select **[F1]** – RECV - to enable the TFR-Map program to receive the job file from the data collector.

The Receive File screen in the TFR-Map program will read as follows:

Waiting for data…
Receiving…(file name)

The file name will be listed once the link has been established and the job file is being transferred. The data collector will read as follows:

Sending (file name)
Packet: #

The number listed on the Packet line is the point in the job file that is currently being transmitted. All of the points stored in the job file will be listed sequentially during the transfer process. It is useful to watch the Packet numbers to ensure that the entire job file is being transferred. The small arrow in the upper right hand corner of the data collector screen will blink until the transfer process is completed.

Once the job file has been transferred to the TFR-Map program, the data collector will display the File Transfer screen and the TFR-Map program will display the Receive File screen.

Step 11: Check the job file in the TFR-Map program to ensure that it was transferred correctly. Press **[ALT] + [T]** to access the Transfer menu.

Step 12: Select **[C]** – View / Print File – to access the Select File screen through the file is opened.

Step 13: Use the arrow keys to highlight the appropriate file. Then, press **[F1]** – SELCT - to open the file. The screen will display the following information for each point stored in the job file: point number, Northing, Easting, elevation, and point description.

Step 14: Select **[F6]** – EXIT - to close the file. Continue to press **[F6]** – EXIT - until all of the screens and menus are closed.