Total Station Procedures
for the
Columbia Habitat Monitoring Program

Nikon Nivo 5C, Survey Pro 4.11.2

May 20, 2015

Prepared by the
Columbia Habitat Monitoring Program

Prepared for and funded by the
Bonneville Power Administration

This document was funded by Bonneville Power Administration's Columbia Habitat Monitoring Program (CHaMP; Project #2011-006-00).

Developer
Kenny DeMeurichy, Utah State University

Contributors
Boyd Bouwes, Watershed Solutions, Inc.
Nicolaas Bouwes, Eco Logical Research, Inc.
Stephen Fortney, Terraqua, Inc.
Andrew Hill, Eco Logical Research, Inc.
Rueben Miller, Terraqua, Inc.
Meagan Polino, Eco Logical Research, Inc.
Joe Wheaton, Utah State University
Shane Aldrich, Rocky Mountain Transit

Acknowledgements
Chris E. Jordan, NOAA- Northwest Fisheries Science Center
Michael B. Ward, Terraqua, Inc.

SECTION 5: GLOSSARY

Term	Description
Assumed Coordinate System	Fictional coordinate system of a survey established by attributing the first occupied point of a new site survey with the following coordinates: 3000 northing, 2000 easting, 1000 elevation. All new site surveys will be attributed an assumed coordinate system during the initial survey.
Backsight	Survey routine used to establish a basis for horizontal, vertical, and angular measurements within the surveying instrument. Backsight checks are used to assure the continued accuracy of a survey.
Benchmark	A permanent control point (typically capped rebar) used to establish new site surveys, and establish revisit site surveys. There is a minimum of 3 benchmarks established at each site.
Control File	File containing benchmarks and control points from previous surveys that are used to re-occupy the established coordinate system.
Control Point	Any permanent or temporary location used to set up or orient the surveying instrument. Includes any station setup, benchmark, and backsight locations.
Established Coordinate System	Spatially accurate coordinate system (Universal Transverse Mercator) established after the first survey of a site. All revisit site surveys must re-occupy the exact same established coordinate system as the first survey.
Foresight	A foresight is a control point that will be used for a future station setup location.
Horizontal Error	The X and Y value difference from a foresight to a backsight at a control point.
New Site Survey	The topographic survey of a new site where an established coordinate system has not been previously established. New benchmarks and control points must be established. The survey is conducted in an assumed coordinate system.
Orientation	Location relative to a compass.
Re-occupy	To orient the surveying instrument into an established coordinate system for revisit site surveys using previously existing benchmarks and control points.
Resection	Survey routine used to re-occupy an established coordinate system by surveying at least 2 known benchmarks or control points from a centralized, previously unsurveyed point.
Revisit Site Survey	The topographic survey of a previously surveyed site where benchmarks and control points have been established. Survey is conducted in a previously established coordinate system.
Site	The specific point, location or length of stream where measurements are taken and metrics derived. Represents a single sample unit within a monitoring program's study design.
Stake Point	Survey routine used to check the accuracy of benchmark and control point locations when re-occupying an established coordinate system. Also used to re-locate the position of benchmarks and control points.
Total Station	An electronic/optical instrument used in modern surveying. The total station is an electronic theodolite (transit) integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point.
Traverse	Survey routine used to move the surveying instrument from one control point to the next. Done by 1) surveying a new control point (foresight) where instrument will be moved, 2) moving instrument to new location, and 3) backsighting to previous station setup location.
Vertical Error	The Z value difference from a foresight to a backsight of a control point.

Care of Tools

Improperly maintained tools can be a source of annoyance, as well as being a safety hazard. Each employee is responsible for keeping his or her tools and equipment in good condition. To prevent loss of small equipment and tools, avoid laying them on the ground, on vehicles, or on equipment which might be moved. When not in use, carry them in scabbards and pouches.

A. Repair or replace any driving tool that is burred or fractured on any part of the striking or driving face. Many surveyors have been injured by the "shrapnel" effect from gads and sledges which had ragged edges. The same is true for "bull points" or other tools which are driven.
B. Crooked or warped handles can cause injury as well as mishitting and damage to the tool. Promptly replace such handles and those that are cracked or broken. Handles should be firmly secured in all cutting and driving tools.

TABLE OF CONTENTS

The most damage occurs to rods when being placed in or taken out of survey vehicles. The life and usefulness of rods can be significantly extended if compartments are constructed so that the rods are not riding on or against other equipment.

General Care and Maintenance of Surveying Equipment and Tools

Surveying equipment and tools are designed and constructed to provide years of reliable use.

The following general principles of care and servicing should be applied as a routine matter for all survey equipment and supplies:

A. Mud, dirt, water and vegetation are a transport media for invasive species and should be removed from all equipment before leaving a reach.
B. Instrument cases are a transportation device for invasive species as well as the instrument and should be cleaned internally and externally before leaving a reach.
C. All equipment and tools should be kept as clean and dry as is practicle, particularly if they are to be transported or stored for any length of time.
D. Wooden surfaces should be wiped clean of caked mud or moisture prior to returning the equipment to the vehicle. The original painted or varnished surfaces should be repaired as often as needed to keep moisture from entering the wood.
E. Metal surfaces should be cleaned and wiped as dry as practicable. A coat of light oil should be applied to tapes and the ferrous metal parts of tools to prevent rusting during storage. Excess oil should be wiped off. No oil on aluminum, glass, plastic, fiberglass or wood.

Transporting

The major portion of damage to equipment and tools occurs when they are being placed into or taken out of the survey vehicle. Other damage occurs during transport, when equipment is jostled against other tools or equipment. Compartments (lined with carpeting, when possible) should be provided to keep equipment and supplies separated. This not only keeps the equipment from being damaged, it facilitates finding such items more rapidly. Heavier items should be carried in the lower parts of vehicles and they should never be in direct contact with other tools or equipment below them.

A. The care, organization, and general housekeeping of a vehicle are good indications of the attitude of the entire survey crew. Keep passenger compartments free of unnecessary clutter and equipment. Any equipment or material carried in the passenger compartment should be firmly secured.
B. Transport and store instruments in positions that are consistent with the carrying case design. Many instrument cases indicate the position in which they should be transported. Treat optical targets, prisms, tripods and survey rods with the same consideration.
C. Remember, loose equipment, out of place tools, and general clutter not only contributes to damage of the items, they also waste crew time in locating them and are a safety hazard.

Each manufacturer of EDM's supplies special prisms and prism holders that are compatible with its equipment. The single lens, tiltable holder with provisions for direct connection on the top of a sectional or telescoping survey rod is the most common type used in most survey work. Such prism holders are generally equipped with a sighting target mounted above or below the prism to provide parallel sight between the sighting and measuring beams. The maintenance of parallel sight becomes more significant in the accuracy of measurements as the distance is decreased. The use of the tiltable holder, with properly mounted target, maintains the parallel sight relationship, particularly in rough terrain. The surveyor should understand the necessity for parallel sights and know what the telescope aiming point is for the type of EDM being used. It is important that the proper prism constant is used; otherwise a systematic error will be introduced in all the measurements made between a particular EDM and prism. The best way to verify that true measurements will be made is to test the EDM and prism on a baseline of a previously established distance.

Care of Prisms

As with any survey equipment, proper care will extend the useful life of sighting equipment.

A. When not in use, keep prisms in their proper containers with face covers in place. They should be kept clean and moisture free to ensure maximum light return. Clean the reflective surface with a camel hair brush or soft lens tissue.
B. Traverse kits should be treated as any other precision equipment. They should be transported in their carrying case in the proper compartments. They should never be put away wet or dirty. The tribrachs should be kept in the same adjusted condition as Total Station tribrachs.

Survey Rods

Survey rods are an essential tool for accurate surveying. A survey rod must be straight and capable of being leveled for control work. Rod length should always be kept to a minimum, never longer then absolutely necessary. The height indicated should be checked by using a tape; measuring from the rod tip to the center of the prism.

Care of Survey Rods

Some suggestions for proper Survey Rod care are:

A. Maintain firm snugness in all metal fittings, but never tighten them to the point where they will unduly compress or injure the rod, strip threads or twist off bolts or screws.
B. Rods should be checked to be sure they are straight.
C. The level bubble should be calibrated periodically.
D. The rod point should be firmly attached and appropriate for the task at hand.
E. The rod should never be used as a wading staff.
F. When wet the rod should be inverted to drain water.
G. While surveying keep the rod away from overhead power-lines.

SECTION 1: INTRODUCTION

1.1 Policy Background

The 2008 Biological Opinion (BiOp) on the Federal Columbia River Power System (FCRPS) identified offsite mitigation actions, largely in the form of habitat restoration and changes in land management, as a means to offset mortality imposed by the FCRPS on anadromous salmonids. In 2010 the Bonneville Power Administration (BPA) began development of the Columbia Habitat Monitoring Program (CHaMP) to meet FCRPS Action Agency (2010) programmatic prescriptions for habitat monitoring, and also to help meet adaptive management requirements and other prescriptions of the 2008 BiOp.

CHaMP (BPA Project 2011-006) is a fish-centric habitat status and trend monitoring program designed for implementation across the Columbia River Basin's salmon and steelhead populations. The CHaMP protocol measures the quantity and quality of, and changes in, stream habitat for salmonid fishes of interest under the BiOp. CHaMP is the result of collaboration among BPA, the National Oceanic and Atmospheric Administration (NOAA) and other regional fish management agencies to implement a tributary habitat condition assessment program. CHaMP was also designed to help measure habitat responses to land management and stream restoration actions by evaluating the effectiveness of restoration, rehabilitation, and conservation actions across the basin. In 2010, BPA asked the Integrated Status and Effectiveness Monitoring Program (ISEMP), a BPA-funded project (2003-017) specifically tasked with assessing and developing standardized monitoring protocols for fish and fish habitat in the Columbia River Basin, to recommend a habitat protocol for BPA-funded Columbia River Basin monitoring programs to adopt. Based on ISEMP's initial recommendations (Bouwes et al. 2010), BPA and several collaborating agencies, with technical and coordination assistance from ISEMP, began to build CHaMP through the development of a set of coordinated proposals.

1.2 Topographic Survey

This manual outlines the procedures for operating the Nikon Nivo 5C Total Station with SurveyPro 4.11.2 in support of the CHaMP protocol. The Total Station is a fundamental tool used to conduct a topographic survey of the stream channel. The procedures outlined in this manual should be followed in order to conduct spatially accurate and repeatable surveys. For additional information regarding topographic sampling procedures, please reference the CHaMP protocol:

CHaMP (Columbia Habitat Monitoring Program). 2014. Scientific protocol for salmonid habitat surveys within the Columbia Habitat Monitoring Program. Prepared by the Integrated Status and Effectiveness Monitoring Program and published by Terraqua, Inc., Wauconda, WA.

SECTION 2: TOTAL STATION PROCEDURES: SurveyPro 4.11.2

2.1 Total Station New Site Setup Procedure

Reference: Section 5.1, Columbia Habitat Monitoring Program protocol

Equipment: Total station, tape measure, tripod, prism, prism pole, backsight setup (i.e., tribrach with riser/prism adapter, tripod, and prism or bipod, prism, and prism pole), pencils, field notebook

Objectives: The purpose of the initial survey is to establish and monument a small control network of benchmarks (BM) that can be relocated in subsequent years. The control network should maintain an equilateral spatial configuration that adequately spans the site length. Collect a sufficient amount of topographical points to accurately describe the geomorphic features of the stream.

- Choose a location for your first Total Station (TS) setup that is over one of the three BMs or at a location where all three benchmarks can be surveyed. The initial setup location should also have a maximized line of sight to the channel.
- Establish and monument the benchmark or control point (CP) for your first setup using an appropriate method (i.e., rebar with cap, nail and whiskers, or an "X" etched into a boulder.)
- Center and level the total station over the CP using the tripod and tribrach. The chosen location should provide a safe and stable work space for both instrument and surveyor; enabling 360 degree movement around the setup.
- Establish your backsight setup (i.e., tripod or bipod with prism) over one of your benchmarks. Measure the height of the prism before leaving your setup.
- Record all pertinent data in the field notebook. This includes the occupied point description, height of instrument, backsight point description, and height of backsight prism.
- Turn on the total station, initiate Survey Pro, and begin setting up a new survey 'JOB'.

Adjustments of Tribrachs

An out of adjustment tribrach can cause small random errors and each tribrach should be routinely checked for centering. Careful adjustment with a plumb bob is quite fast and should provide a centering accuracy within 1 millimeter. A more accurate method is to rotate the tribrach 120 degrees over a smooth markable surface. For the first sighting, a soft pencil line is drawn on the tripod head around the tribrach base. The tribrach is carefully leveled and the sighting point marked. The tribrach is then rotated 120 degrees, carefully set in the pencil marks, re-leveled, and a new sighting point marked. Repeat this procedure. If the tribrach is slightly out of adjustment, the three rotational marks should form a triangle. The plummet should be sighted to the center of the triangle and the optical plummet adjusted to that setting. The test should be repeated to verify the adjustment.

Tripods

Tripods provide a fixed base for all types of surveying instruments and sighting equipment.

Types of Tripods

In the past, different equipment required different tripods. However, due to standardization by instrument manufacturers, most of today's equipment utilizes the same tripod. The same tripod can be used for total station, levels, and GPS. Tripods are made of either metal or wood composite. Wooden tripods are recommended for precision surveys to minimize errors because they are less subjected to expansion and contraction due to heat and cold than metal.

Care of Tripods

A stable tripod is required for precision measuring Instruments. A tripod should not have any loose joints or parts which might cause instability. Some suggestions for proper tripod care are:

A. Maintain firm snugness in all metal fittings, but never tighten them to the point where they will unduly compress or injure the wood, strip threads or twist off bolts or screws.
B. Tighten leg hinges only enough for each leg to just sustain its own weight when legs are spread out in their normal working position.
C. Keep metal tripod shoes tight and free of dirt.
D. Keep wooden parts of tripods well painted or varnished to reduce moisture absorption and swelling or drying out and shrinking.
E. Replace top caps on tripods when not in use.

The most damage occurs to tripods when being placed in or taken out of survey vehicles. The life and usefulness of tripods can be significantly extended if compartments are constructed so that the tripods are not riding on or against other equipment.

Prisms

describe conditions under which the instrument does not function properly, i.e., coldness, dampness, etc. If a "loaner" is needed, this should also be indicated.

Wherever possible, the instrument should be "double cased" for shipping, with its case packed inside a cardboard container that is padded sufficiently.

Operators Manual

Each new instrument is furnished with an operator's manual. The Nikon Nivo 5.c manual is available at: *nikon-spectra.ru/doc/NivoC_Ver_A100.pdf* or on the champmonitoring.org website under crew resources in the 'field equipment manuals' tab. The manual may also be available on the instruments memory. The manual contains a description of the instrument, specifications of its various components and capabilities, and applications. The manual also contains basic instructions for use of the instrument and describes recommended servicing and adjusting methods. The operator's manual should be available for use. Each operator should thoroughly study the manual prior to use of the instrument, particularly whenever prescribed field adjustments are to be made. If the manual is lost, stolen, or damaged beyond use, a replacement copy should be obtained as soon as is practical.

Accessories

Tribrachs

A tribrach is the detachable base of all total stations and traverse kit type prism assemblies. Tribrachs are equipped with a bulls-eye bubble for leveling and optical plummets for setting up precisely over a survey mark. The discussion on tribrachs is conducted in a separate section because they are being used with a wide variety of surveying equipment.

Use of Tribrachs

The ability to "leapfrog" between instruments occupy point and backsight setup location by using interchangeable tribrachs increases the speed, efficiency and accuracy of the traverse survey. Whenever possible, the tribrach should be detached from the instruments and placed on the tripods for TS setups. This procedure speeds up the setting up process and protects the instrument from accidents.

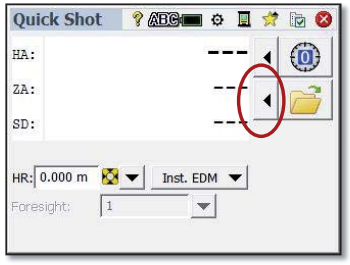
Care of Tribrachs

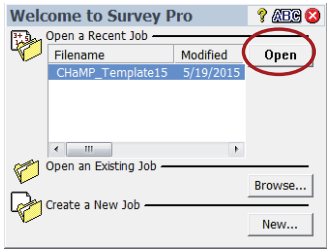
Tribrachs are an integral part of the precision equipment and should be handled accordingly. They should be transported in separate compartments or other containers to prevent damage to the base surfaces, bulls-eye level, and optical plummet eye piece. Over tightening of the tripod fastener screw can put undue pressure on the leveling plate.

Although the leveling screws are covered, dirt or dust can work into the threads and cause wear. Repairs should be done in the shop by someone experienced in such work, should such damages occur.

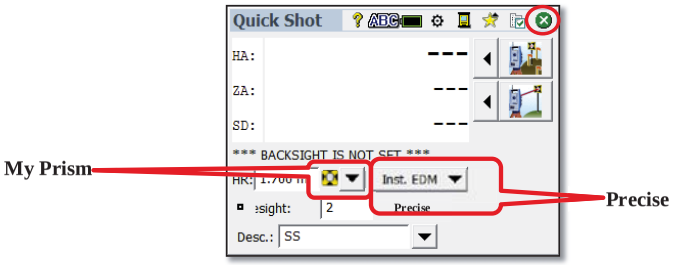
Step 1. Start a new survey.
If you haven't done so already, make sure the digital bubble level is centered and the compensator is enabled (this will alert the surveyor if the machine goes out of level enough to prevent staying within set tolerances.) Enter.

Step 2. From the 'Quick Shot' screen, click on the arrow to the left of the Folder symbol and choose "Open/New". In "Open an Existing Job," Browse to the CHaMP_Template15.job, select and Open.

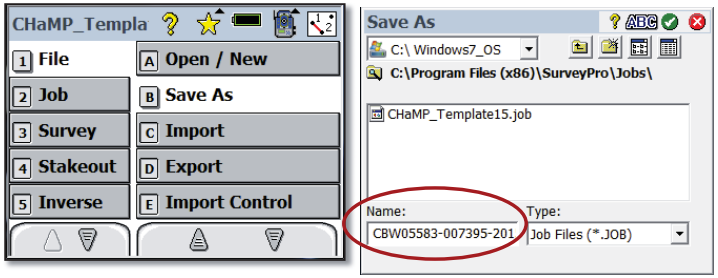




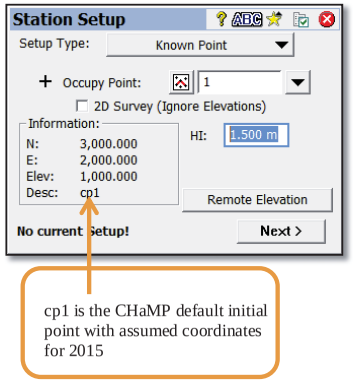
Step 3. In the Quickshot screen; set the target type to "My Prism" and the Instrument's Electronic Distance Measurement (EDM) setting to "Precise" in order to achieve the greatest level of accuracy while setting or checking control points. Both of these options can be found at the bottom of the screen. Once this has been completed, exit out of the Quick Shot screen by selecting Enter.



Step 4. In the Main Menu, select File→Save As, and rename the job file in Name: field using the following convention: **SiteID-Date-Organization** (e.g., **CBW05583-007395-20150710-ODFW**.) Select Enter to return to the Main Menu.



Step 5. In the Main Menu select Survey→Station Setup. The following sequence is where the location and height of the total station is specified. For Setup Type, choose "Known Point." For "Occupy Point" select the preexisting (CP) point provided in survey template. Enter the height of instrument (HI) in the last remaining field, and confirm that 2D survey box is left unchecked Select Next.



Care During Instrument Setups

Whenever possible, select instrument stations where operation is not dangerous to the instrument operator, other crew members, or the instrument. Select stable ground for the tripod feet. Do not set an instrument closely in front of or behind a vehicle or other large equipment which is likely to move without warning. Take a safe route to all setups.

A. At the site, clear debris and brush out of the way to provide a stable area for the tripod. Firmly plant the tripod with its legs widespread. Push along the legs downward, not vertically. On smooth surfaces, use some type of tripod leg restrainer to keep the legs from sliding outward.
B. Always have the tripod firmly set over the point before removing the instrument from its carrying case. Immediately secure the instrument to the tripod with the instrument fastener.
C. Never leave an instrument or its tribrach on the tripod without securing either to the tripod. Moderate pressure on the fastener screw is sufficient. Excessive tightening causes undue pressure on the foot screws and on the tribrach spring plate. Make sure the tribrach clamp is in the lock position.

Total Station Calibration

The CHaMP survey equipment endures a significant amount of rough conditions during field use and transport; the total stations are no exception, with their most common affliction being loss of proper calibration. A total station must be calibrated periodically to attain accurate measurements. Thus, it is wise to check that the instrument is operating within acceptable tolerances frequently to avoid collecting unusable data. If a total station undergoes any sort of trauma; such as a particularly rough truck ride, is banged or dropped, it absolutely must be calibrated before it is employed to collect data. Additionally, a calibration is advised if a crew encounters unexplainable errors during a survey.
The field calibration sequence can help the surveyor obtain horizontal corrections reasonably well, while vertical correction and EDM correction must be performed by a certified instrument technician. However, unless the instrument has been severely mistreated in some way, the Nikon Nivo C series Calibration routine in Section 2.12 should be sufficiently effective.

Normally, each instrument should be periodically checked at a Survey Standard Site (see Section 3) where the best conditions for testing are possible. Only the adjustments described in the Nikon Nivo C series Calibration Procedures should be made in the field. Do not "field strip" (dismantle) instruments.

Major Adjustments

When an instrument has been damaged or otherwise requires major adjustments, it will need to be sent to an authorized repair shop by the CHaMP Equipment Quartermaster. The instrument should be accompanied by a written statement indicating the types of repairs needed and details of possible causes for the incurred damages. In the case of electronic devices, the request should

Excessive dust within the electronics of the machine can also cause the instrument to overheat during operation.

E. Dirt and dust should be removed only with a clean soft cloth or with a camel hair brush. Compressed air can also be used to carefully blow particles off of the instrument.
F. Clean the external surfaces of lenses with compressed air or a fine lens brush and, if necessary, use a dry lens tissue. Do not use silicone treated tissues, as they can damage the coated optics. It is permissible to breathe on the lens before wiping it, but liquids, such as oil, benzene, water, etc., should never be used for cleaning purposes. DO NOT loosen or attempt to clean the internal surfaces of any lens.
G. Cover an instrument whenever it is uncased and not being used for any length of time, particularly if there is dust or moisture in the air.

Casing and Uncasing

Before removing an instrument, study the way it is placed and secured in the case. The instrument must be replaced in the same position when returned to the case.

Lifting - Instruments should be removed from the case with both hands. One hand on the instruments carrying handle; the other hand should support the base. One hand should continually be on the handle until the tribrach lock is engaged and the tripod fixing screw secured.

Do not grip where pressure will be exerted on tubular or circular level vials.

Instrument cases are a transportation device for invasive species as well as the instrument and should be cleaned internally and externally before leaving a reach. Keeping the case closed and locked while surveying can minimize accumulation of such species, as well as keep dirt and dust from entering, and is highly recommended.

Field Transport of Surveying Instruments

Do not "shoulder" or carry a tripod mounted Total Station. The instrument(s) should always be removed from the tripod(s) and secured in carrying case(s) when moved.

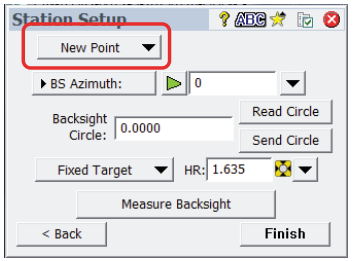
These precautions are necessary because the center spindle (center spigot or standing axis) of a total station is hollow and relatively short. When carried horizontally while on the tripod, the alidade's weight is an excessive load for the hollow centerpiece to bear. Instrument damage can result if the above precautions are ignored. Also, the instrument fastener can break, causing the total station to fall.

Transport and store instruments in positions that are consistent with the carrying case design. Many instrument cases indicate the position in which they should be transported.

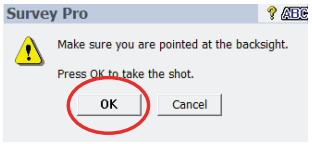
Always keep the total station in a secure position while traveling to field sites which prevents it from bouncing around unnecessarily on particularly rough roads (i.e. in the front of the truck).

Step 6. Determine the control point (usually a benchmark) that you will backsight to. Select "New Point" in the upper left box, and specify a BS Azimuth of zero and Backsight Circle of zero. Select "Fixed Target or Roving Target" select Fixed Target if you are using tripod and prism as backsight (Use the drop down arrow to determine which is appropriate) and input the height of rod (HR:). Aim the TS at the center of the BS prism.

Select "Send Circle." Then Measure Backsight.



The following window will open, proceed as prompted.



Proper aiming of the Total Station to the Prism is vital for surveying control and benchmarks. The Nikon instrument used by CHaMP for surveying does not have a feature to find the center of the prism. The instrument operator is required to center the optical crosshair directly at the center of the glass portion of the prism.

Correctly aimed Total Station

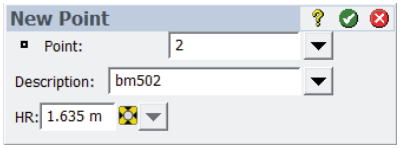
Improper aiming of the TS to the Prism produces errors. The Electronic Distance Measurement (EDM) function measures the distance to a reflective surface. The instrument measures the horizontal angle and the vertical angle of the crosshair and using trigonometry calculates the location of the location of the prism.

Incorrectly aimed Total Station

Vertical Error

Horizontal Error

Step 7. In the New Point window. The description code (Table 3) that CHaMP utilizes is always placed in the Description field. In this example the description bm502 is used, The New Point window displays the new backsight point. In this example bm502 will be the second point in the file. Check the HR and select the green check button. **Note: that in 2015, the naming conventions for new BMs and CPs will be bm501, bm502, etc. and cp501, cp502, etc.**



SECTION 4: SURVEY EQUIPMENT MAINTENANCE

It is imperative to properly care for and maintain Survey equipment. Survey equipment is used in harsh conditions, exposed to extreme weather conditions, and is often subject to being jostled about during transportation. Proper care in the methods by which equipment is used, stored, transported, and adjusted is a major factor in the successful completion of the survey. Lack of good maintenance practices not only causes unjustified replacement costs, but can also seriously jeopardize the efficiency and accuracy of the entire survey.

The crew leader is responsible for ensuring that all crew members are properly trained in the use of equipment for its intended purpose and the maintenance of all survey instruments, tools, and accessories. Should the need for additional assistance, training, or repairs arise during the course of the season, a crew supervisor should be notified.

Total Stations

Total stations are today's primary measuring instruments, particularly on all baseline and control surveys. A total station is a battery operated electronic device that measures angles and distances, and then performs an on-board computation which ultimately results in a coordinate for a location.

Care of Total Stations

Although the instruments are ruggedly built, careless or rough use and unnecessary exposure to the elements can seriously damage them. The shafts, spindles, pendulums, and electronics of precision instruments can be compromised by one careless act or a continued lack of attention to prescribed procedures for the care and adjustment of the instrument. If handled appropriately, they will provide consistently good results with minimal downtime for repairs or professional adjustment. Some general guidelines for the care of these instruments are:

A. NEVER point the TS directly at the sun. The focused rays of the sun can damage sensitive internal parts.
B. Protect the TS from excessive heat. Heat can cause erratic readings and deterioration of components; as with any electronic equipment. Do not leave instruments in closed vehicles that are parked in the sun. Avoid rapid changes in temperature, particularly from extreme cold to warm, which can cause condensation in the internal parts of the instruments. Condensation can normally be avoided by leaving the instrument in its carrying case for at least 10 minutes and then opening the case to allow any trapped moisture to evaporate. An instrument taken from a warm office or vehicle to an extremely cold operating environment may require some time to adjust itself. The same type of precautions should be taken to let the instrument cool off slowly.
C. Although the instruments are very water resistant, keep them as dry as possible. The case and battery compartments should be left open, allowing the instrument to dry in a warm dry room when not in use; particularly after it has been exposed to moisture.
D. Frequently clean the instrument externally. Any accumulation of dirt and dust can scratch the machined or polished surfaces and cause friction or sticking in the motions.

SECTION 3: SURVEY STANDARD SITE USE AND DEVELOPMENT

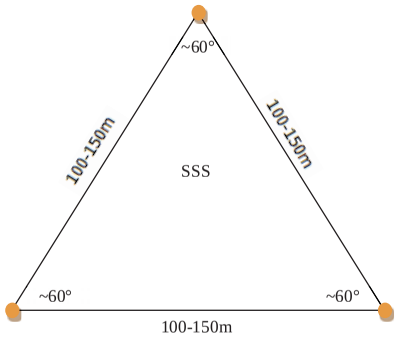
The Survey Standard Site (SSS) shall be developed to create a set of benchmarks with an accurately established coordinate system that can be utilized as a test site for equipment as well as crew development. Whenever possible the SSS should be in a location easily accessible to multiple crews, such as near a bunkhouse or a CHaMP collaborators office.

SSS utilization examples:

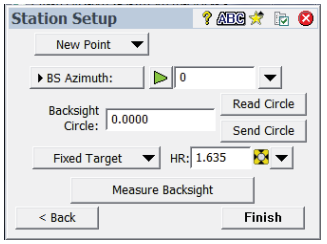
- The crew encounters unexplained errors in a survey.
- The crew encounters resurveys with large errors relative to the original surveys.
- The instrument or equipment has endured a traumatic event.
- The crew is unsure of a survey results.
- The site can be used to perform an Instrument calibration.
- The site can be used to develop crew member skills.

Criteria for site development:

- Established with more than usual care by an experienced crew member.
- Established with calibrated and properly maintained equipment.
- Established with the traverse function using face left and face right.
- Use Precise EDM setting.
- Preferably can be established using multiple instruments and technologies.
- Benchmarks set and monumented in stable locations.
- Resurveyed yearly after spring thaw.
- Strong geometrical site layout.
- A surveyed traverse consisting of at least three benchmarks.

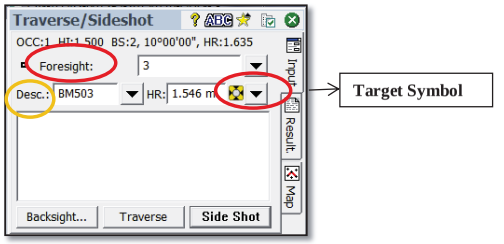


The Station Setup is complete. Select Finish.



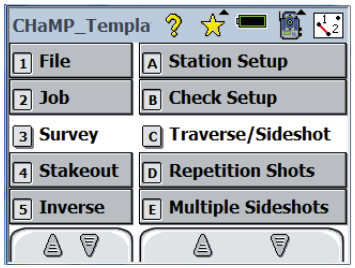
Step 8. From the Main Menu, select Survey→Traverse/Sideshot. The Foresight field displays the next point number that will be captured; Survey Pro will continue to number each point consecutively throughout the course of the survey unless otherwise specified by the operator. "Desc" allows the surveyor to assign a description code (Table 3) to each point, while HR will require inputting an accurate rod height for each shot before recording.

Lastly, there is an option to specify target type ("My Prism" and "My Reflectorless" being the defaults). An appropriate target can be selected by clicking the dropdown arrow to the right of the target symbol although this could have been specified earlier while in the Quickshot Screen. Note that the first shot recorded should always be to the BS. This shot and all subsequent BM and CP shots require using a prism (My Prism setting) and the EDM setting to achieve higher precision.

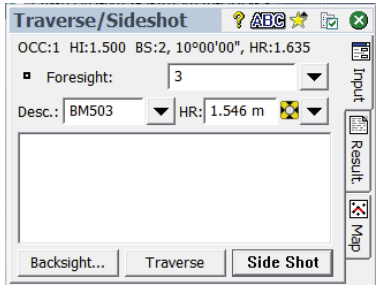


The survey has been successfully setup and it is time to survey all additional BMs using the precise EDM setting. Then begin collecting topographic points. Points can be stored in one of three ways: 1) Selecting "Side Shot" on the touchscreen, 2) Pushing the yellow "MSR" (Measure) button on the lower right face of the TS, or 3) Pushing the blue "Enter" button on the lower right face of the TS.

Step 9. Survey any additional benchmarks or control points using the Traverse/Sideshot screen. In main menu select Survey, Traverse/Sideshot.



In the description field input the BM# or CP#. Aim TS at target prism and select Side Shot. Once all BMs have been stored you can begin collecting topographic data.



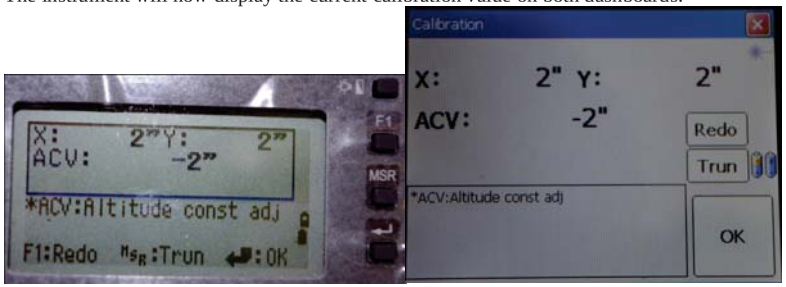
Before collecting topographic data, change the Instrument EDM back into "Normal" mode, as it generally speeds up the point collection process. To do this, navigate back to the Quickshot screen by pressing the F1 key on the main dashboard of the total station. Once the selection has been made, press enter to return to the Sideshot/Traverse screen and resume surveying.

F1 key: Return to Quickshot screen

Flip the Scope to Face 2 and very accurately re-sight the prism. When ready, press the enter button on the smaller dashboard.

Enter button

The instrument will now display the current calibration value on both dashboards.

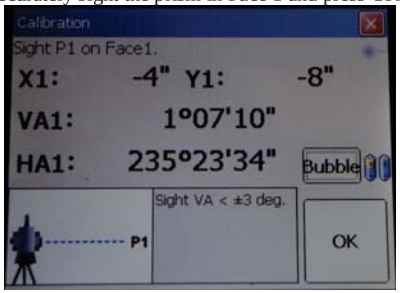


Write the results in the fieldbook. Select OK and the values displayed will be applied.

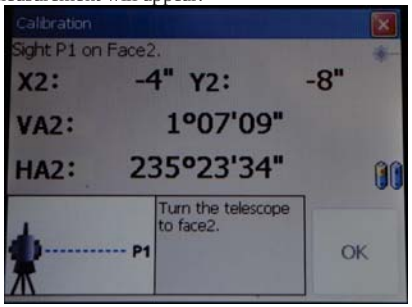
If the X or Y value is less than -5" or greater than 5", level the instrument and run the calibration again. If repeated attempts are not successful at obtaining values between -5" and 5" please notify the CHaMP Equipment Quartermaster.

On the Windows Toolbar Press the Start icon / Programs / Calibration. This will open the Nikon calibration program.

In the Nikon calibration window, select the bubble button and make sure the instrument is properly leveled. Very accurately sight the prism in Face 1 and press OK.



The results of the first measurement will appear.



2.2 Total Station Site Revisit Setup Procedure

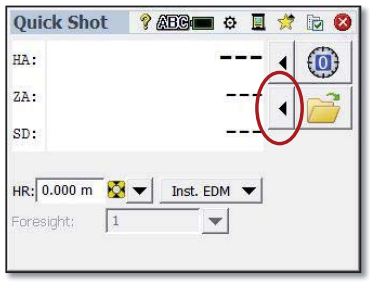
Reference: Section 5.2, Columbia Habitat Monitoring Program protocol

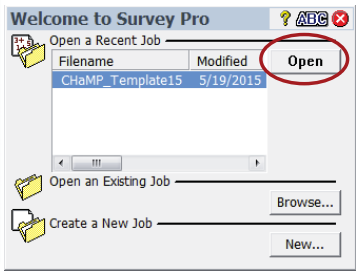
Equipment: Total station, tape measure, tripod, prism, prism pole, backsight setup (i.e., tribrach with riser/prism adapter, tripod, and prism or bipod, prism, and prism pole), pencils, field notebook

Objectives: The primary objective of the revisit survey setup procedures is to re-occupy the coordinate system established in previous visits using the existing control network (benchmarks).

- It is pertinent that the previously established Benchmarks (BM) be reoccupied to re-orient the total station (TS).
- Coordinates for the previously established BMs at each revisit site will be stored in the total station as a text file (*.TXT) and will need to be imported to the new (*.JOB) as a CONTROL Layer. Points stored in this layer are 'protected' and therefore cannot be altered.
- Revisit sites will also have a previously defined 'survey extent' polygon stored in the total station as a (*.DFX) file which will also need to be imported to the new survey job as a 'basemap.' This will assist surveyors in replicating the same boundaries set by prior crews.
- All previously established BMs and Control Points (CPs) will be relocated and flagged where possible. When all three BMs cannot be located or the BM placement is unacceptable due to a poor spatial configuration, a new BM(s) will need to be installed.
- When new BMs are established, old BMs will be left in place and used to reorient the TS at the beginning of the survey. All usable BMs will be surveyed from as many total station setup locations as necessary.

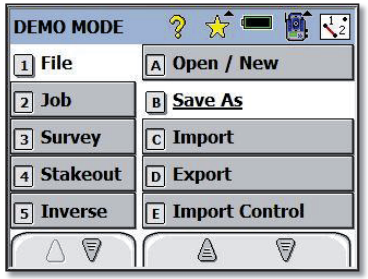
Step 1. Setting up the survey.
Center the digital bubble level using the thumb screws on the tribrach and enable the compensator. The compensator alerts the surveyor when the machine is not level.
From the 'Quick Shot' screen, click on the arrow to the left of the folder symbol and choose "Open/New". Browse to the **CHaMP_Template15.job** located in "Existing Jobs," select, and open.

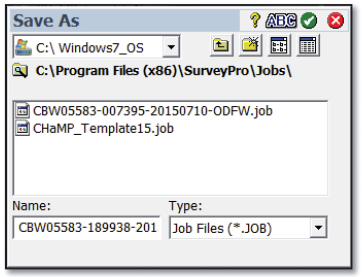




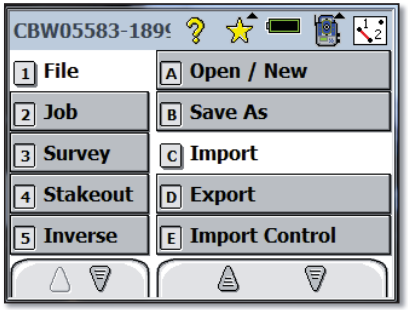
Step 2. Back in the Quickshot screen; set the target type to "My Prism" and the Instrument EDM setting to "Precise" in order to achieve the greatest level of accuracy while setting or checking benchmarks and control points. Both of these options can be found on the bottom half of the screen. Once this has been completed, exit out of the Quick Shot screen by clicking Enter in upper right of screen.

Step 3. Once in the "Main Menu" screen, select File→Save As, and rename the job file using the following convention: **SiteID-Date-Organization** (e.g., **CBW05583-189938-20150710-ODFW.**) Enter.





Step 4. Back in the Main Menu, select File→Import. **DO NOT select "Import Control!"**



2.12 Nikon Nivo "C" Series Calibration Procedure

The CHaMP survey equipment endures a significant amount of rough conditions during field use and transport; the total stations are no exception, with their most common affliction being loss of proper calibration. A total station must be calibrated periodically to attain accurate measurements. Thus, it is wise to check that the instrument is operating within acceptable tolerances frequently to avoid collecting unusable data. If a total station undergoes any sort of trauma; such as a particularly rough truck ride, is banged or dropped, it absolutely must be calibrated before it is employed to collect data. Additionally, a calibration is advised if a crew encounters unexplainable errors during a survey.

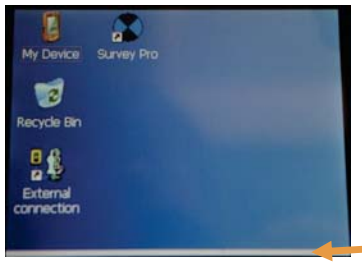
The field calibration sequence can help the surveyor obtain horizontal corrections reasonably well, while vertical correction and EDM correction must be performed by a certified instrument technician. However, unless the instrument has been severely mistreated in some way, the following routine should be sufficiently effective.

Note: the instrument should be acclimated to the current weather before running the calibration routines. While conducting a calibration be sure that the Instrument reticle and focus is perfectly adjusted so that no parallax is present.

When sighting the prism for calibration please be very accurate and consistent. While sighting the prism in face 1 and face 2, adjust the reticle from left to right, then top to bottom to perfectly locate the center of the prism.

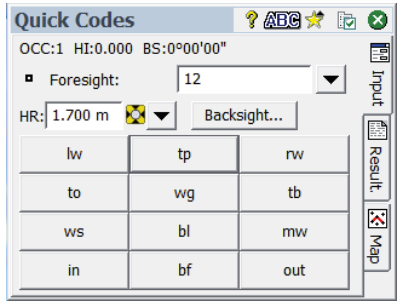
Set a target approximately 100 meters from the instrument. The target should be roughly at the same elevation as the instrument.

Using the stylus tap the grey area at the bottom of the Windows Home screen to open the Windows toolbar.



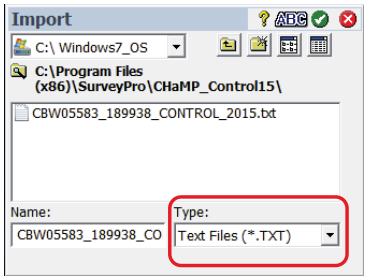
Type in the desired code or choose from the Description List by clicking on the drop down arrow to the right of the open field and selecting "Show Description List." Select the appropriate code, and *Enter* to return to the main Quick Codes screen. Repeat this process until all the tabs have been assigned a CHaMP code description. *Hint: When structuring Quick Codes, it is wise to place codes near others that cannot be mistaken for one another in the case that the wrong tab is hit by accident while surveying.*

iii. Once the Quick Codes have been set to your liking, this is a fast and efficient screen from which to survey when using multiple codes alternatively

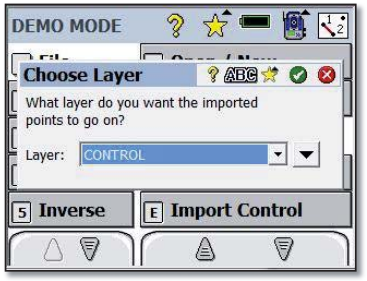


iv. To collect points using Quick Codes tap desired description on screen. When a description button is highlighted you can use the return/enter button on face of TS just above MSR2 button to rapidly collect points with same description.

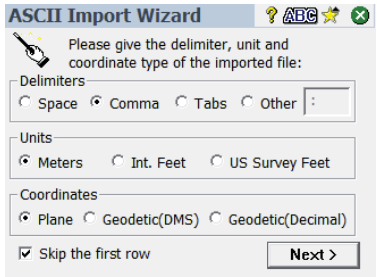
Step 5. The Import window will open. In the "Type" field select Text Files (*.TXT). Browse to the correct file (e.g., SiteID_CONTROL_2015), select, and Enter ✔.



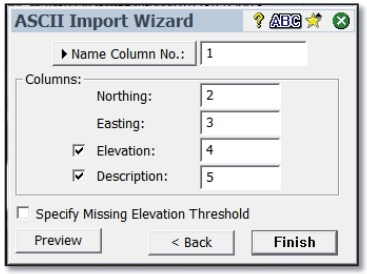
Step 6. Survey Pro will prompt you to choose the layer. Using the dropdown, select 'Control.' Select Enter ✔.



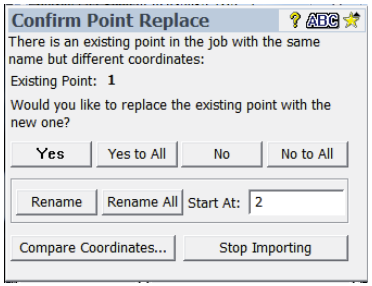
Step 7. The ASCII Wizard will proceed through a couple screens in which the TS operator will need to specify a number of parameters related to the control file import. Make sure that the settings are the same as listed below. Click Next.



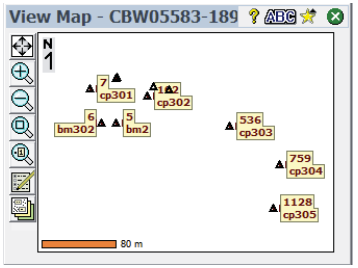
Again, make sure the settings are the same as displayed in the window below. This is the coordinate order in the Control text file provided by CHaMPmonitoring.org. Select Finish.



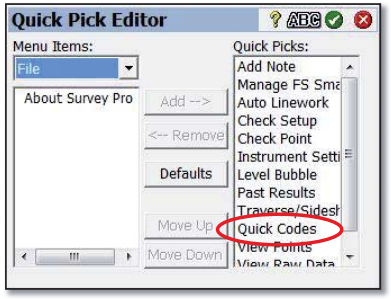
The following window will prompt to overwrite existing arbitrary coordinates of default point cp1 with the correct, transformed coordinates of the CONTROL file cp1. Select Yes then select Ok.in pop-up window to return to main menu.



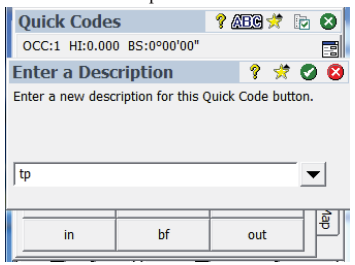
From the main menu, select the Map button  in upper right to open the map. Review the imported benchmark and control points.

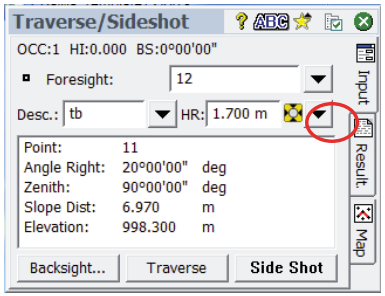


II. There are a few other settings available within Survey Pro which are not crucial to the survey, but can help promote a more efficient survey.
   a. Edit Quick Picks to display only the features within Survey Pro that are used frequently.
      i. Activate Quick Pick by clicking on the yellow star at the top of most screens in Survey Pro.
      ii. At the bottom of the list, choose "Edit Quick Picks. From the Quick Pick Editor Screen, you can add and remove "Menu Items" to your Quick Pick list by highlighting and selecting the appropriate action. You can also move items up or down in the list while editing. *Note: Be sure "Quick Codes" is incorporated into your Quick Pick list.*
      iii. Once satisfied with your choices, click *Enter* to exit and continue surveying.

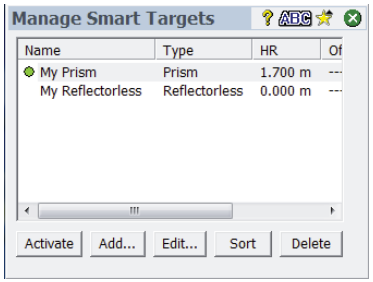


   b. Edit Quick Codes to reflect the CHaMP Description List.
      i. Access the Quick Codes Screen from the Quick Picks list; activated by clicking the yellow star at the top of the screen.
      ii. Click and hold on one of the twelve tabs until the option pops up for you to "Enter a new Description".

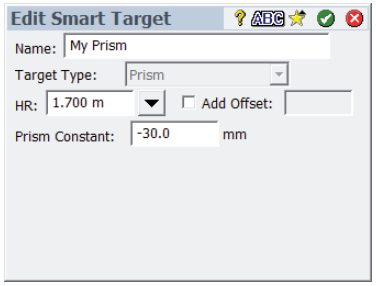




b. In the list that appears select Manage Smart Targets. The following Screen will open.

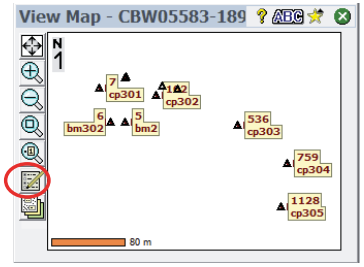


c. Highlight My Prism and select Edit. The following screen will open.

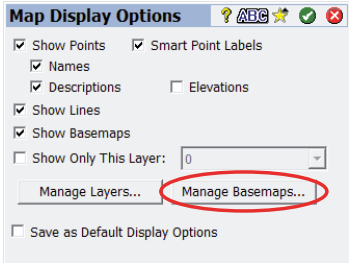


d. For the Purposes of CHaMP a -30 mm Prism Constant is used for My Prism and My Backsight Prism. To check My Backsight Prism follow above steps while in Station setup screens. CHaMP does not use Add Offset.

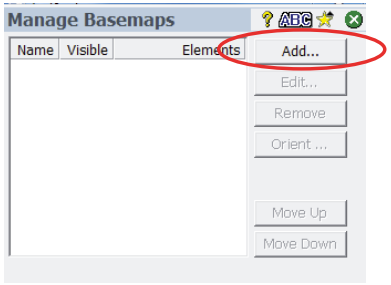
Step 8. CHaMP will also provide a *.dxf of the previously surveyed area which can be loaded into the map. Select the map display options button.



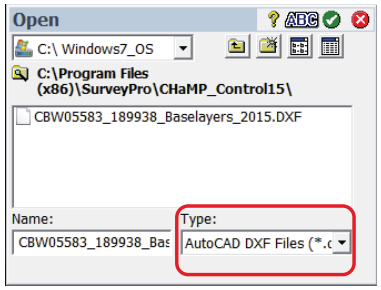
The Map Display Options window allows the operator to adjust what is displayed in the map.. Select Manage Basemaps.



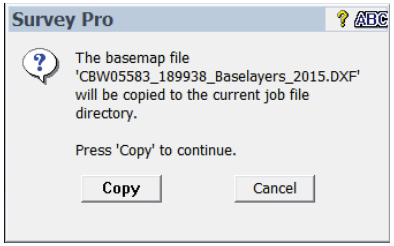
In the Manage Basemaps window. Select Add.



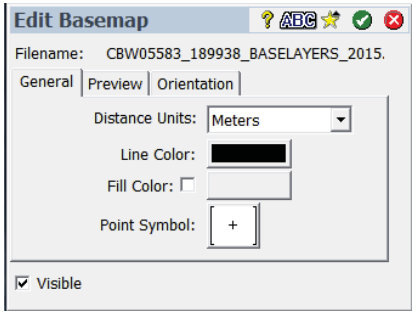
In the Type field, select AutoCAD DXF Files (*.dxf). Browse to the correct BASELAYER file identified by SiteID. Select, and Enter ✔.



In the following window, select Copy.

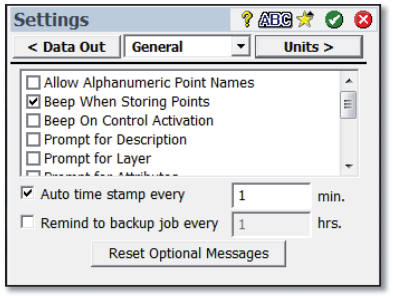


In the Edit Basemap window. Check the settings on all three tabs as displayed below. Select Enter ✔.

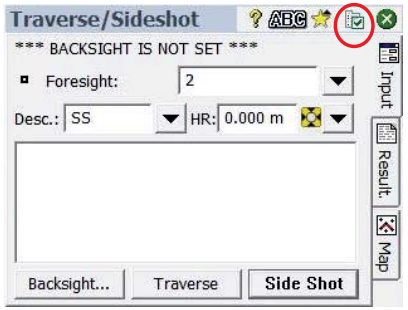


General: Mandatory setting is Auto time stamp every 1 minute.

Specify the settings indicated below, as well as further down in the list and out of sight in the figure below, "Use Smart Soft Input Panel Activation".



It is possible to access and even change some settings while working in a screen related to that setting. For example, activate "Survey Settings" from the Traverse/Sideshot screen by clicking the green checklist in the upper right hand corner, as shown in the red circle below.

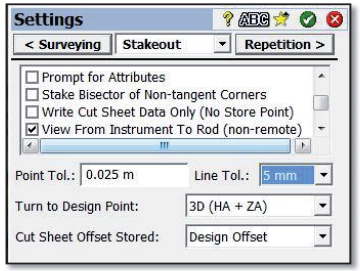


I. Managing Smart Targets in Survey Pro

Managing Smart Targets is used to adjust default settings for My Prism and My Backsight Prism.

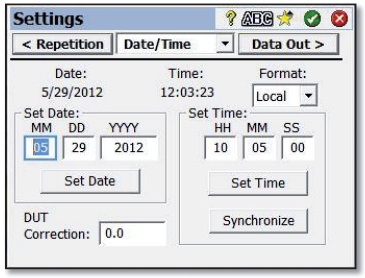
a. To adjust prism settings select dropdown next to HR: field while in Traverse/Sideshot screen.

Stakeout: Specify "View from Instrument to Rod" and "Always Start Stakeout in Coarse Mode" as well as information dictated at the bottom of this screen which refers to tolerances most importantly.

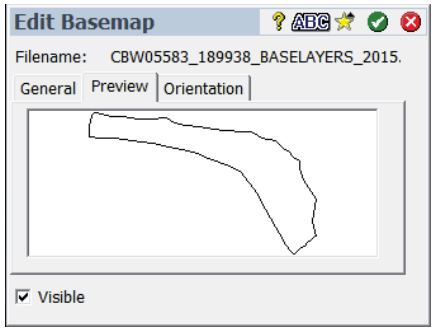


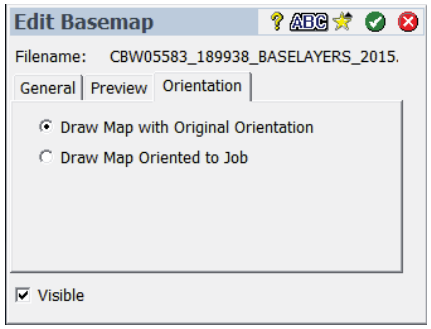
Repetition: We will not be executing Repetition Shots; no specific settings needed.

Date/Time: Specific to time zone in which you will be working (Pacific); thus, will need to be set accordingly in order for the total station to record correct time stamps within each survey.

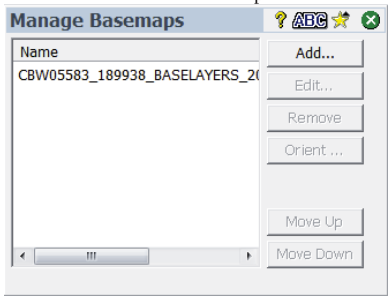


Data Out: This screen is specific to partnering a data logger or other source for storage with the total station. We will not be using this feature with the Nikon Nivo 5C.

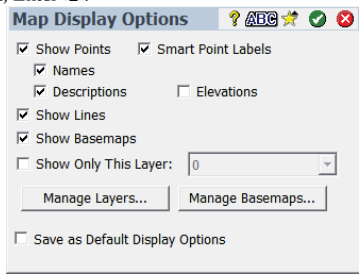




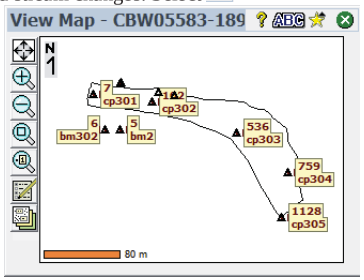
The Manage Basemaps window indicates that a basemap is attached. Select the ⊗ button.



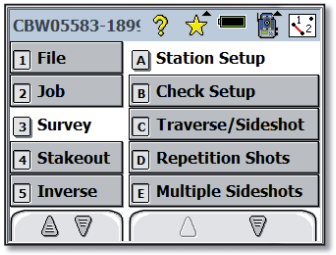
The Map Display Options opens. In this window the options shown below are helpful, but it is personal preference. Select, Enter .



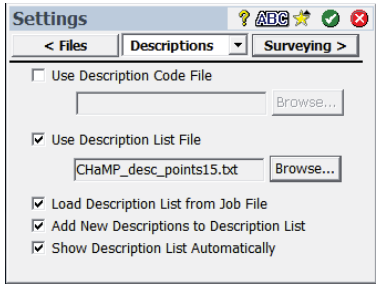
The Map will now display the data from the control file and the baselayer provided by CHaMP for revisit surveys. The baselayer is the survey extent of the previous survey. During revisit surveys you will survey everything within the baselayer extent. You may be required to survey areas outside the previous extents when necessary or specified by scout, to properly characterize current geomorphology and stream changes. Select



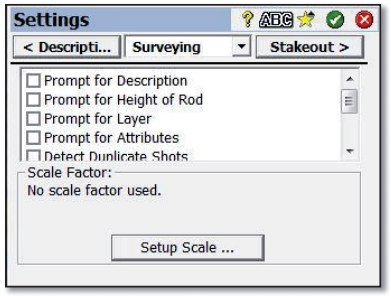
Step 9. Reoccupy existing coordinate system.
From the Main Menu and select Survey→Station Setup.



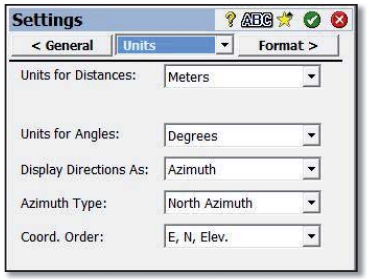
Descriptions: The CHaMP Description List will be imported with our Template Job. However, we will also direct Survey Pro to a text file which contains all point codes as backup in the unfortunate case that the CHaMP Template job should be lost or somehow modified.



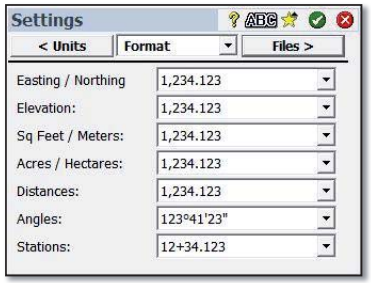
Surveying: Many of these choices are personal preferences. However, in the interest of executing a quick and efficient survey, it is recommended to leave all "prompts" inactive while surveying. We will not be using a Scale Factor.



Units: Unit settings dictate how distances and angles are measured. Azimuth type and order of coordinates are also specified in this screen, as shown in the following figure.

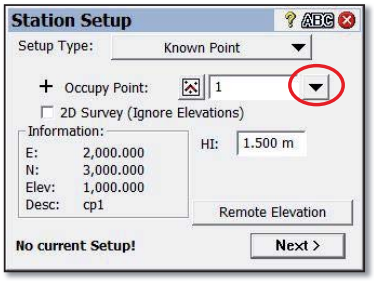


Format: Format settings refer to how data is presented in the survey and should be exactly as specified below.

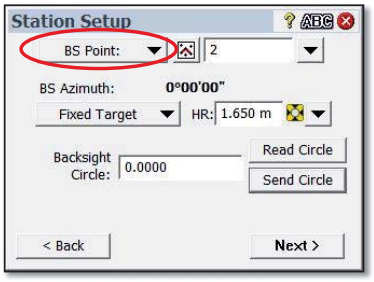


Files: We will not be using a Feature Code File for CHaMP surveys.

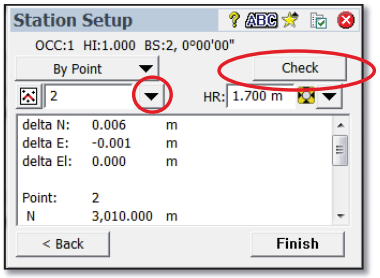
In the following sequence specify the location and height of the total station. For Setup Type, choose "Known Point." For "Occupy Point," choose from the drop down list by activating the arrow to the right of the "Occupy Point" field and select the appropriate point (i.e., **bm1**.) Alternatively, use the map button to select points from the map screen. Input the height of instrument (HI). Confirm that 2D Survey box is left unchecked. Select Next.



Select "BS Point" in the upper left box, and specify the correct BM in the coordinating field to the right where the backsight setup is located; select "Fixed Target" and input the Target Height (HR) and proper prism type. Check that the Backsight Circle is 0, center the TS on the BS prism, and select "Send Circle." Then Next.



Select "By Point" in the upper left, and Input the backsight point number using the drop down, highlighted below, input the Height of Rod re-check that TS is Centered on BS select "Check" to initiate the first "Station Check." Inspect the results to see that they are within the specified limits (< 0.03 Horizontal and < 0.015 Vertical). Record in field notebook. Select Finish. *Note: The hypotenuse of the Delta N and Delta E values represent HD error.*



If the coordinates do not fall within specified tolerances, there are a few likely errors that could be the culprit and are worth checking, in order to narrow the possibilities.

1) Check the prism constant. (For instructions on checking Prism Constant see Section 2.11, I: Managing Smart Targets in Survey Pro)
2) Check the height of the TS and that the TS is properly leveled and centered over the BM.
3) Check the height of the BS and that the BS is properly leveled and centered over the BM.

- If the coordinates seem considerably different, double check that you have selected the correct Occupied and BS points from the control file and
- Make sure you have imported the correct revisit survey points.

If all of these tests check out, try setting up over a different BM and repeat all Station Setup steps as described above. See Section 5, in CHaMP protocol, for troubleshooting revisit benchmark errors.

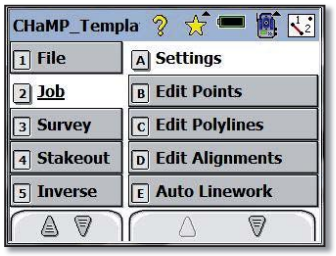
If any additional benchmarks are visible, survey them in using the Stake Points procedure (See Section 2.3).

2.11 Total Station Defaults and Settings: Nikon Nivo 5C

Purpose: Working within a large group to collaborate on a single project demands that the data collected from each individual survey provides the same information and in the same format so that each dataset is easily comparable. The easiest way to accomplish this task is to standardize the default settings from within the survey instrument; in this case, the total station.

Setting Defaults in the Total Station

Step 1. Access Settings from the Main Menu screen by selecting Job→Settings.

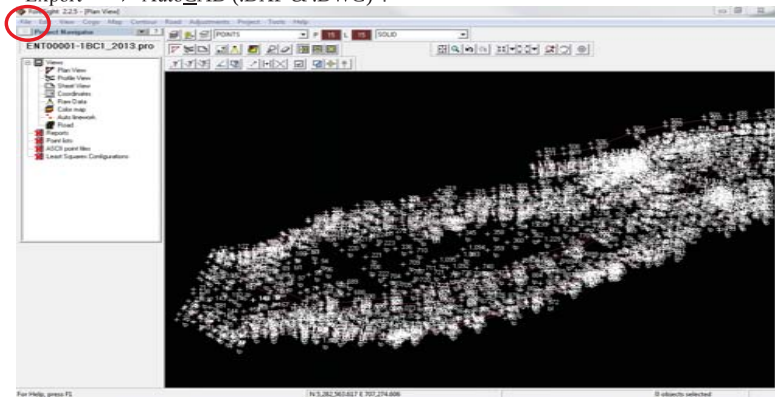


Step 2. In the Settings screen, scroll through each topic and specify the desired settings, beginning with "Units". Once the defaults have been chosen for a particular topic, move on to the next by activating the drop down list to the right of the top center box indicating the active topic or simply click either the tab to right or left indicating the next topic on the list up or down.

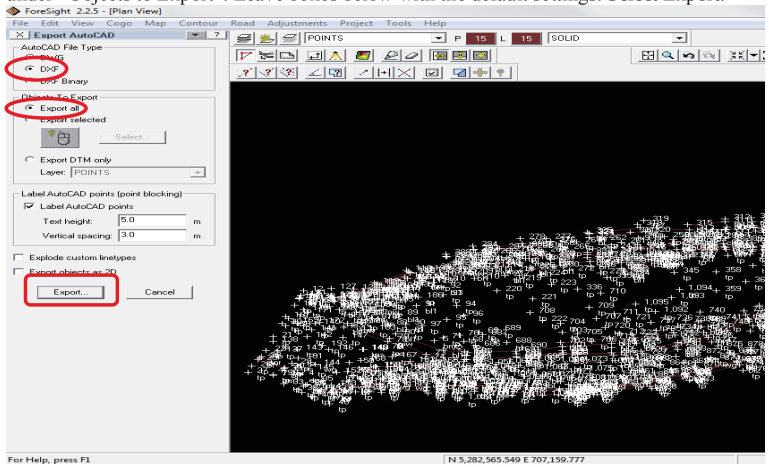
Step 3. Continue through all topics until all defaults are set. *Note: Before conducting CHaMP surveys with a different type of instrument and/or different software, be sure you are able to specify the following settings.*

Step 4. Most settings will be carried from one survey to the next by simply importing the **CHaMP_Template#.job** file. However, as the operator of the total station, or other survey instrument, it is important to understand what the default settings are and how they relate to the outcome of the survey.

The Plan View screen will open. In the upper left corner from the "File" drop down menu select "Export" ➟ "AutoCAD (.DXF & .DWG)".



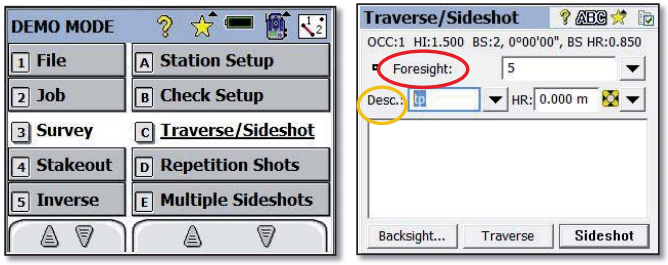
In the "Export AutoCAD" window, select DXF under "AutoCAD File Type". Select Export all under "Objects to Export". Leave boxes below with the default settings. Select Export.



Browse to the designated "Topo" folder. Input correct file name according to the CHaMP naming convention: SiteID-Date-Organization (e.g., CBW05583-189938-20150710-ODFW). Select Save. The (*.DXF) file has been succesfully exported. Close Foresight. When prompted to save changes select Yes. You are now ready to bring your data into ArcGIS.

Step 10. Start surveying.

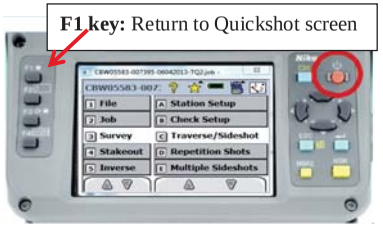
From the Main Menu, select Survey→Traverse/Sideshot. The Foresight window displays the point number of the next point that will be stored in the coordinate file. Survey Pro will continue to number each point consecutively throughout the course of the survey unless otherwise specified by the operator. "Desc" allows the surveyor to assign a unique description code (Table 3) to each point, while HR will require inputting an accurate rod height for each shot before recording.



Lastly, there is an option to specify target type ("My Prism" and "My Reflectorless" being the defaults). The appropriate target type can be selected by clicking the dropdown arrow to the right of the target symbol. The first shot recorded should always be to the BS which will require using a prism.

The survey has been successfully set up and it is time to begin collecting points. Points can be stored in one of three ways: 1) Selecting "Side Shot" on the touchscreen, 2) Pushing the yellow "MSR" (Measure) button on the lower right face of the TS, or 3) Pushing the blue "Enter" button on the lower right face of the TS.

Before collecting topographic data, it is recommended to change the Instrument EDM back into "Normal" mode, as it generally speeds up the point collection process. To do this, navigate back to the Quickshot screen by pressing the F1 key on the main dashboard of the total station. Once the selection has been made, press enter to return to the Sideshot/Traverse screen and resume surveying.



2.3 Stake Point Procedure

Reference: Section 5.2, Columbia Habitat Monitoring Program protocol

Equipment: Total station, tape measure, tripod, prism, prism pole, backsight setup (i.e., tribrach with riser/prism adapter, tripod, and prism or bipod, prism, and prism pole), pencils, field notebook

Objectives: The Stake Points method should be used for checking a backsight and checking to a BM or CP. It is also helpful for finding a lost point. The prerequisite for using the Stake point method is that there must be a pre-existing coordinate for the point you are shooting to in the coordinate file. The stake point method calculates a new measured coordinate verses a coordinate stored in the file (control coordinate) and provides the errors. These errors can come from several sources, including previous survey errors, when a BM or CP has been compromised (moved), or the current survey errors. Deciphering where the error lies can be difficult (see Section 5.4 for troubleshooting tips), but knowing there is an error empowers the crew to make good decisions to begin reducing errors. Example 1 is for a backsight check and for a check to a pre-existing BM or CP that has been located. Example 2 is for locating a lost BM or CP.

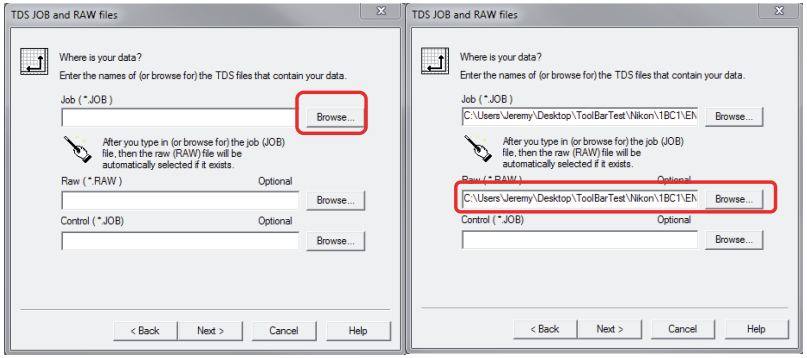
Example 1: Backsight check or check to located BM or CP.

Step 1. Turn on the Precise EDM

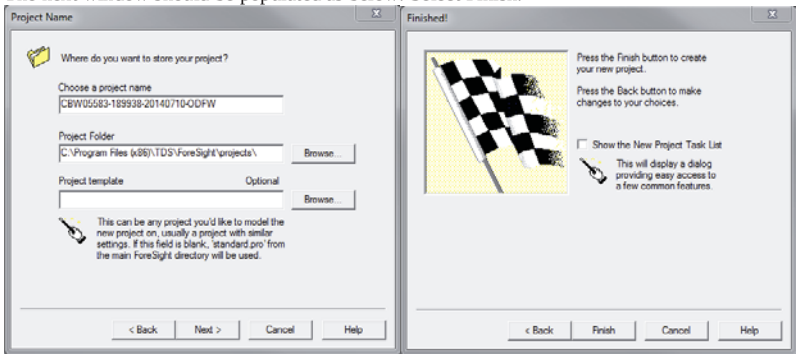
The precise mode shall be used to survey all benchmarks and control points, while Normal mode will be used to collect topographic data. On the left side of the instrument dashboard, Press the F1 button.

F1 key: Return to Quickshot screen

In the next window, select *Browse* button next to the "Job (*.JOB)" field. Navigate to the correct (*.JOB) file and select open. Note that the RAW (*.RAW) field has been populated automatically once JOB file has been selected The RAW file is only populated if JOB and RAW files are in same location. Leave Control field blank. Select Next.



The Project Name window opens next. The name field should be pre-populated with the name of the raw data files which is sufficient. If it is not sufficient, input a new/correct name. The Project Folder field can be left as default and the Project Template field should be blank. Select *Next*. The next window should be populated as below. Select Finish.



2.10 Exporting Data Files: Nikon Nivo 5C

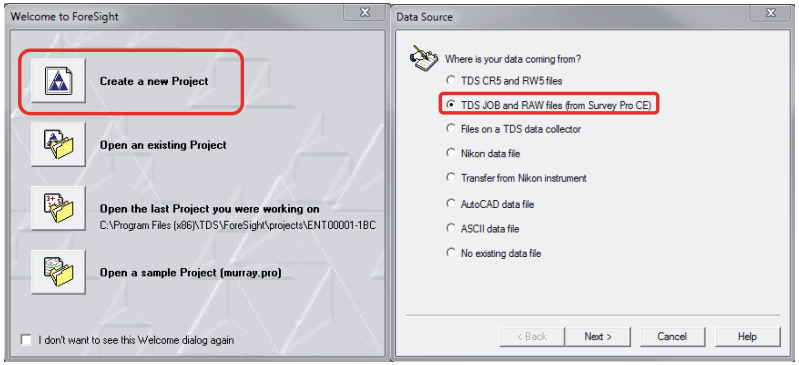
Objective: Data files on the Nikon need to be retrieved and converted into a format in order to work with the topographic data using the custom tools developed for CHaMP. The following outlines the correct procedures to ensure that the required data files are retrieved from the Nikon.

Step 1. Retrieving (*.JOB) and (*.RAW) files from the Total Station.

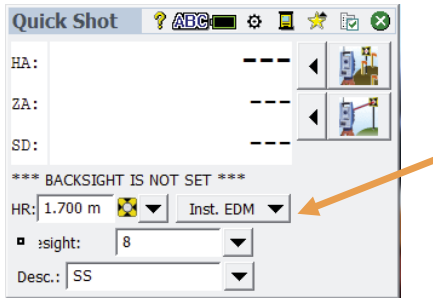
Connect the TS to the laptop using USB to Micro USB cord. Turn on the TS and wait for "Mobile Device Center" to open. Select "Connect without setting up your device". In the following menu select "File Management" ➡ "Browse the contents of your device". Open the hard drive of TS and navigate to "Survey Pro Jobs" folder. Select both the (*.JOB) and (*.RAW) files associated with the survey you wish to retrieve. Navigate to the "Topo" folder on the laptop associated with the desired site and "copy' and "paste" or drag and drop the raw data into the "Topo" folder.

Step 2. Exporting (*.DXF) files using Foresight 2.2.5.

In order obtain the required (*.DXF) file for GIS processing, CHaMP uses Foresight 2.2.5; a surveying software associated with Survey Pro. Before opening Foresight, insert Dongle into USB port. The Dongle contains the Foresight software license. Open Foresight 2.2.5 by selecting the Foresight icon on desktop. In the first window select "Create a new Project". In the following window, select "TDS JOB and RAW files". Select Next.



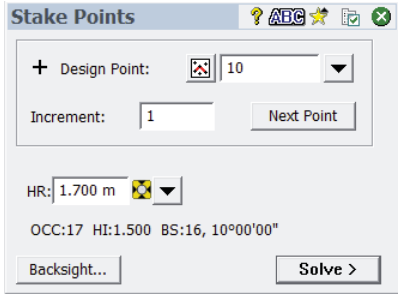
The Quick Shot window will open. Use the Electronic Distance Measurement (EDM) drop-down to select the precise mode.



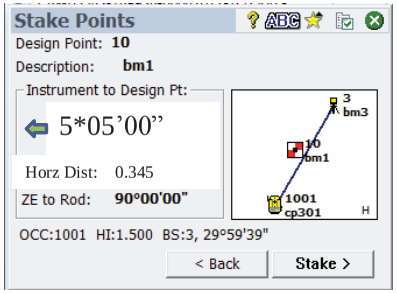
EDM mode drop-down.

Do a Station Setup procedure outlined in Section (2.3), or if you have been conducting topographic surveying, check the BS then proceed.

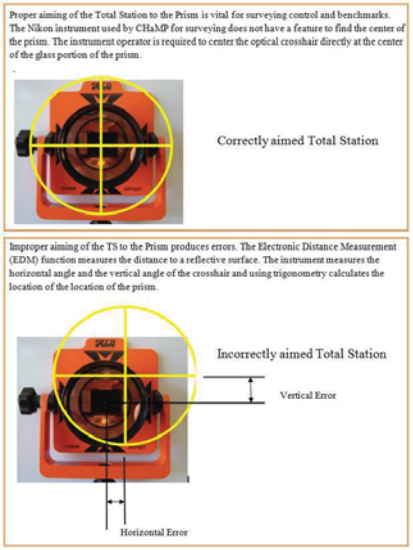
Step 2. From the Main menu select Stakeout→Stake Points. In the "Design Point" drop down, select the point to locate. Always select a BM or CP. In this example Design Point 10 which is bm1 is selected. Increment setting = 1. Make sure the prism is leveled and centered on the point. Enter the HR and prism type (My Prism). Select "Solve".



The “Stake Points” window provides angular instructions to the point being staked (design point). In the example below, the arrow indicates the design point (Point 10) is ~5° to the left. These angular values are difficult to interpret and it is easier to use distance measurements provided later.



Aim the TS at the prism and Select “Stake”. Make sure the TS is properly aimed.



In the following menu select “File Management” ➡ “Browse the contents of your device”.

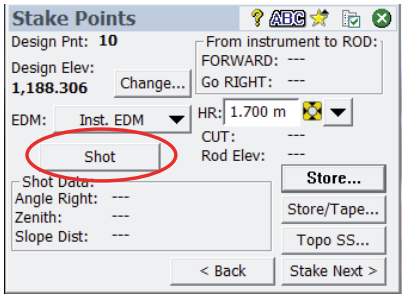
Step 2. Select the hard drive of the TS and open “Survey Pro” folder. Open folder labeled “CHaMP15_Control”. “Copy” and “Paste” or drag and drop the Control Files (*.TXT) and the Base layer files (*.DXF) of your choosing from their respective “Topo” folders.
The control files have been successfully loaded onto TS. Turn off the TS and disconnect the USB cord. For the process of importing Control Files into a survey see Section 2.9.

2.9 Adding Control Files to Total Station for Revisit Sites

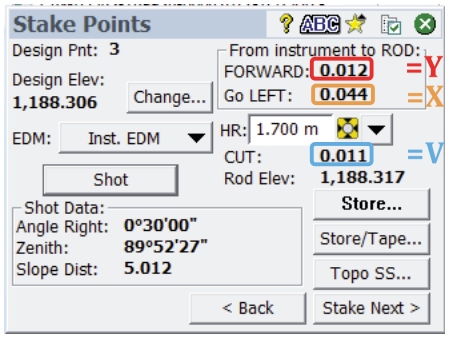
Objective: The CHaMP program utilizes customized GIS tools to produce control files and base layers for revisit sites. Control files provide the coordinates of previously surveyed Benchmarks, which allow operator to reoccupy the coordinate system of previous site visits. Base layers provide the survey extents of previous surveys to inform the operator of survey boundaries.

Step 1. Once the control file and base layer for a survey have been produced using the "Export Control File" tool in the CHaMP Toolbar in ArcMap, the TS operator must retrieve that data and add it to the TS. Turn on and connect Nikon TS to laptop using USB to Micro USB cord. The Mobile Device Center window should open once TS has been connected to computer. Select "Connect without setting up your device".

In the next Stake Points window. Select "Shot".



Step 3. The survey instrument measures and provides the window below which indicates distances to the point being staked. These are error values: current coordinates verses control file coordinates. If the error values are not within tolerance: check the instrument setup and height, the rod height and level, the station setup point descriptions. When the values are within tolerance, select Store.



How to determine horizontal (H) or vertical (V) errors from the information provided in the Stake Points window:

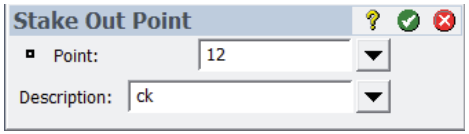
$$H = \sqrt{X^2 + Y^2}$$

Cut or fill = V

Maximum Acceptable Errors

Initial survey H= <0.03m and V= <0.015m
Revisit survey H= <0.05m and V= <0.03m

Store the point by entering the description "ck" and select Enter in upper right of window.



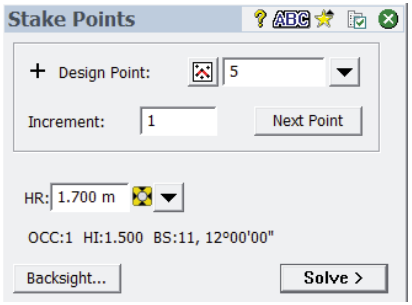
The Stake Point procedure is complete. Close stake points and open Traverse/Sideshot to continue topographic survey.

Example 2: Finding a lost point.

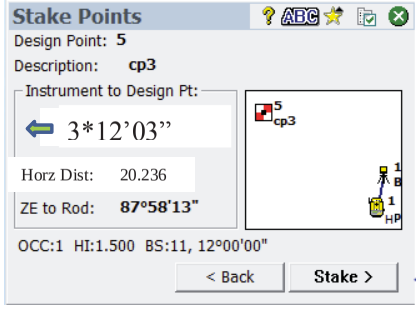
Step 1. Turn on the Precise EDM as shown in Example 1.

Do a Station Setup outlined in Section (2.3), or if you have been conducting topographic surveying, check the BS then proceed.

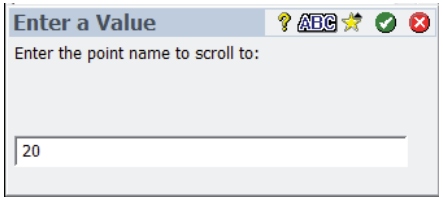
Step 2. From the Main menu select Stakeout→ Stake Points. In the "Design Point" drop down, select the point to locate. Always select a BM or CP, NOT a bs or ck. In this example, Design Point 5 which is cp3 is selected. Enter the HR and prism type (My Prism). Select "Solve".



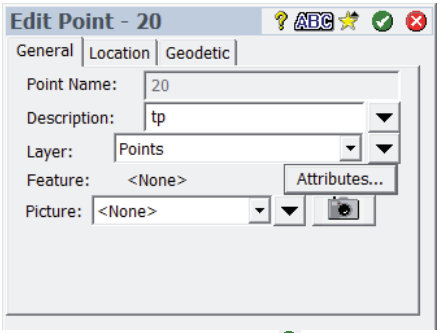
The Stake Points window provides angular instructions to the point being staked (design point). The angular values are difficult to interpret and it is easier to use distance measurements provided later. The rodman should be in the general location of the point. Aim the TS at the prism and Select "Stake".



Once Go To… is selected, input the point number then select the green check mark.



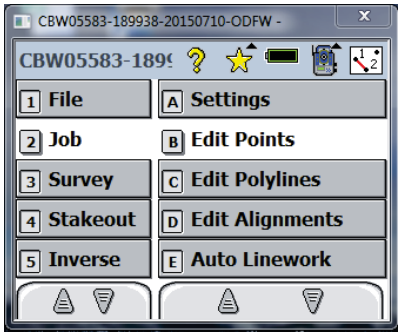
Once desired point is selected, surveyor can select delete button to remove point from survey, or edit button to change description. Selecting Edit will open the Edit Point window. In the Edit Point window, under the General tab, surveyor can change the description of a point by inputting correct description in the description field.



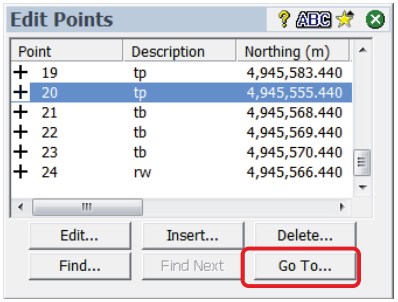
Once correct description has been inputted, select enter to update point.

2.8 Editing Point Data

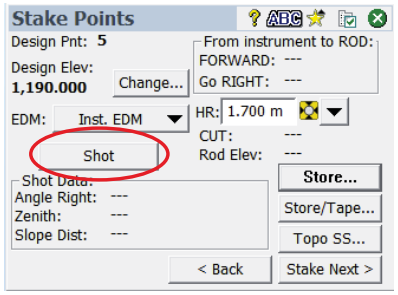
Editing point data on the Total Station (TS) may be useful in the field to ensure a clean survey if errors have occurred. Common errors include points collected with incorrect descriptions, incorrect height of rod, and misplaced points that need to be deleted.
In order to edit points during topographic survey, return to the main menu by selecting green circle with an x in upper right corner of screen. In the main menu select Job, Edit Points as illustrated below.



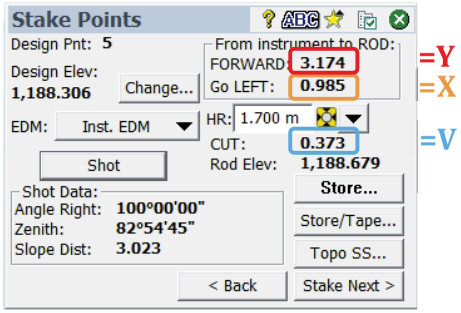
The Edit Points window allows the surveyor to edit and delete points. To navigate to desired point use scroll bar or select Go To…



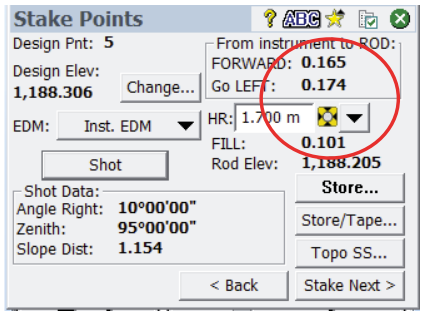
In the next Stake Points window. Select “Shot”.



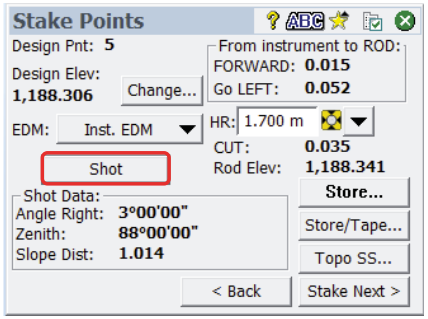
The survey instrument measures and provides the window below which indicates distances to the point being staked. In the example below the rod person would be instructed to move forward 3.17 m, and left 0.98 m as indicated. Interpreting cut/fill: In the example below the coordinate currently being measured is (.373m) lower than the coordinate in the file. After the rodman moves, select Shot again.



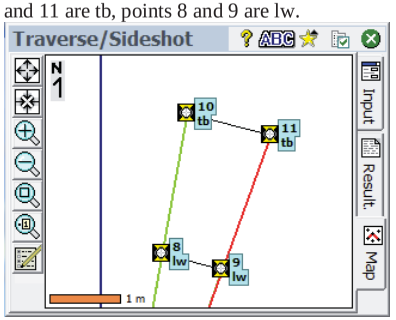
Again, the instrument measures and provides the window below which indicates distances to the point being staked. In the example below the rod person would be instructed to move forward 0.16 m, and left 0.17 m as indicated. Interpreting cut/fill: In the example below the coordinate currently being measured is 0.1 m below the coordinate in the file. The rodman moves again, then select Shot.



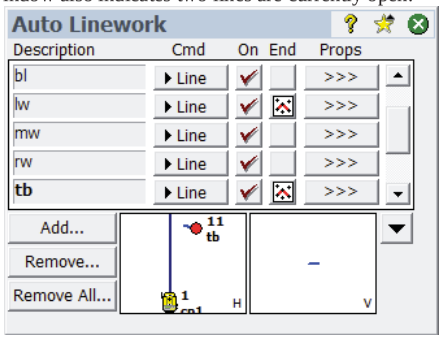
Again, the instrument measures and provides the window below which indicates distances to the point being staked. In the example below the rod man should dig near the base of the rod to find the point .035m below the rod. When the CP or BM is located, level the rod on the point, select Shot.



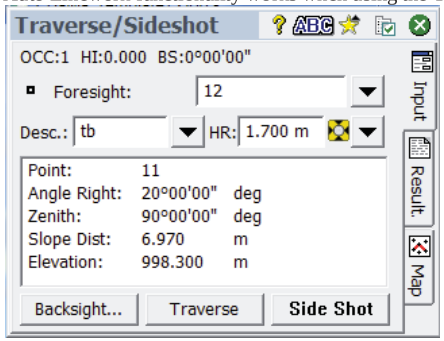
In the example below note the sequecnce of point numbers indicates two lines are run simultaneously. Point 10 and 11 are tb, points 8 and 9 are lw.



The Auto Linework window also indicates two lines are currently open.

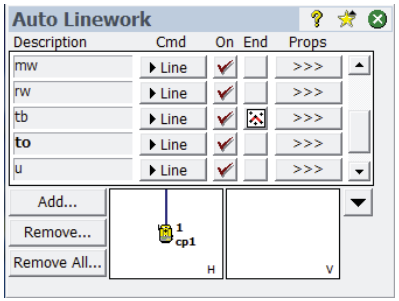


The same Auto Linework functionality works when using the Traverse/Sideshot screen.

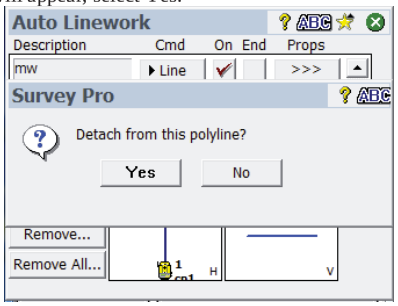


Happy Surveying!

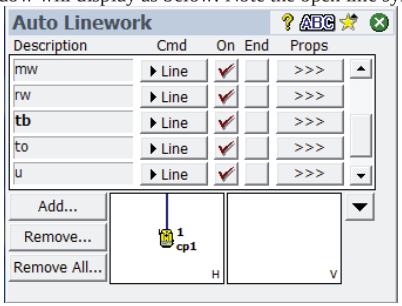
Open the Auto Linework window to check the status of a line,. In this example a line is open for the tb description. With the stylus tap the tb in the Description column to display the line in the H and V windows.



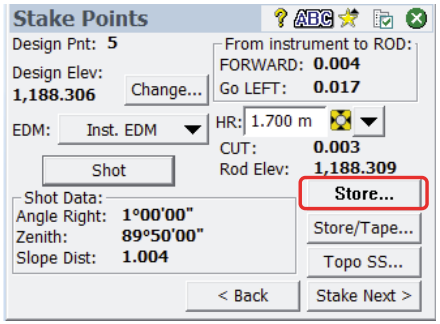
To end the line in the Auto linework window select the open line symbol 
The following window will appear, select Yes.



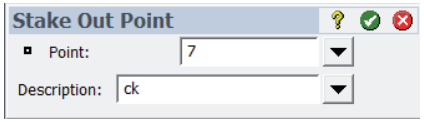
The Auto Linework window will display as below. Note the open line symbol is not displayed.



Again, the instrument measures and provides the window below which indicates distances to the point being staked. These are error values: current coordinates verses control file coordinates. If the values are within tolerance select Store.



Store the point by entering the description “ck” and select Enter  in upper right of window.



The Stake Point procedure is complete. Close stake points and open Traverse/Sideshot to continue topographic survey.

2.4 Total Station Resection Procedures

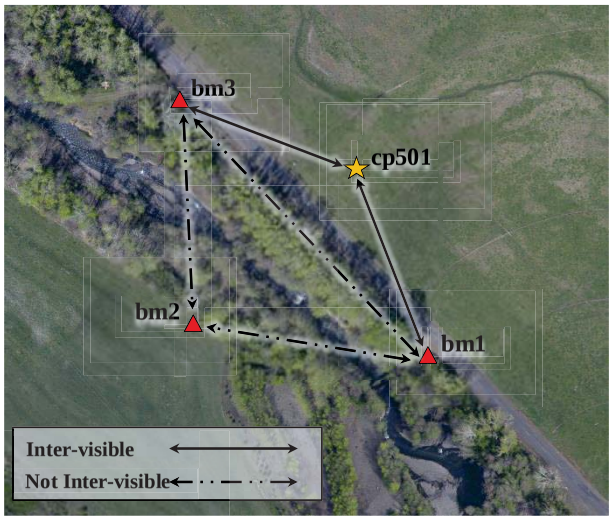
Reference: Section 5.2, Columbia Habitat Monitoring Program protocol

Equipment: Total station, tape measure, tripod, prism, prism pole, backsight setup (i.e., tribrach with riser/prism adapter, tripod, and prism or bipod, prism, and prism pole), pencils, field notebook.

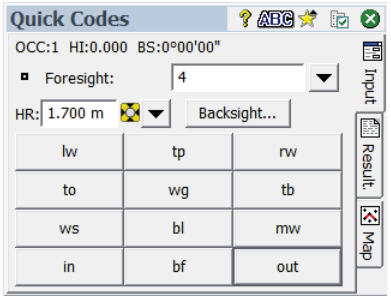
Objective: A resection is only performed at revisits when there are not any inter-visible benchmarks. It is always preferable to set up the instrument over a known point (benchmark) and backsight to a known point (benchmark) when performing a station setup at revisit sites (Section 2.2). If this cannot be done, use the Resection procedure.

To set up a total station and record points in a given coordinate system, the instrument first needs to be positioned and oriented. Resectioning is a process that allows the instrument to calculate a coordinate for its position based on triangulation between two or more points (benchmarks or control points) with known coordinates. A resection works best when the geometry of the known points relative to the total station are well distributed in space surrounding the instrument (i.e., not clustered in same quadrant), and well distributed over the area you wish to survey.

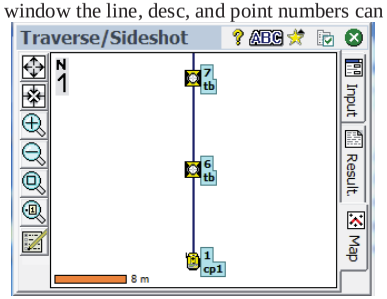
In the example below, point cp501 will be the new point of occupation and the resection will utilize bm1 and bm3. Bm2 was set in a field and was subsequently destroyed by a tractor. Use all available benchmarks or control to conduct a resection. Three or more points allow for a more robust calculation and analysis of the new point of occupation coordinate. A minimum of two known points are needed to conduct a resection.

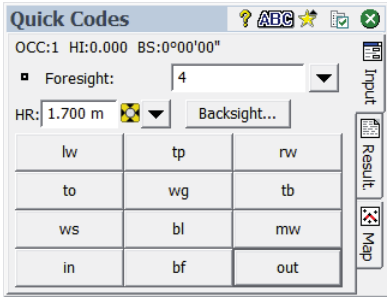


In the Quick Codes window check the HR and the Prism type to make sure settings are correct. When using rod and prism check Prism Constant settings. See Section 2.11, I: Managing Smart Targets in Survey Pro for instructions on correct settings and how to adjust Prism Constant using Manage Smart Targets. Aim the TS at the Prism and select the button with the description for the line. The instrument measures and the Foresight number increments. The rodman moves to the next location. Select the button with the description for the line. The instrument measures and the Foresight number increments.

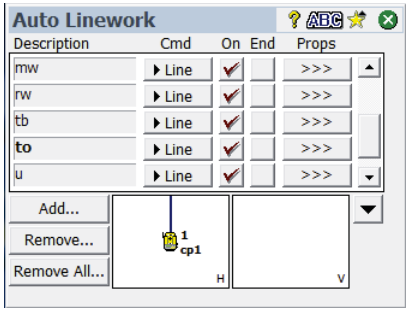


In the Map window the line, desc, and point numbers can be viewed.



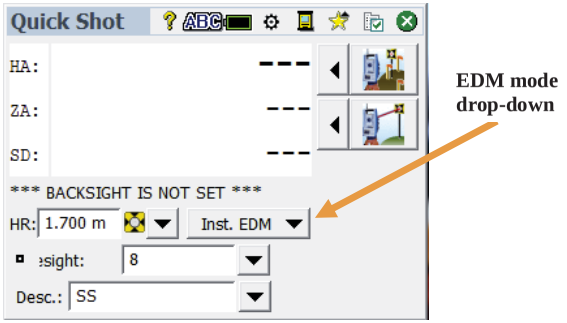


Use the favorites button  to open Auto Linework window to check and be sure that the settings are correct. There should be a check in the **On** column for the descriptions that are used to collect lines.

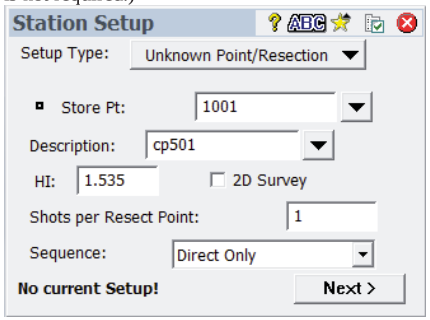


Step 1. The precise mode shall be used for all benchmark and control surveying, while Normal mode will be used to collect topographic data. Press the F1 button on the left side of the instrument dashboard.

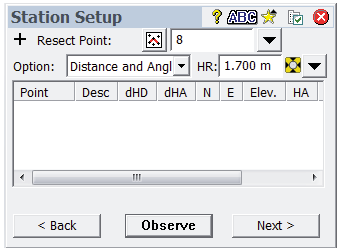
The Quick Shot window will open. Use the Electronic Distance Measurement drop-down to select precise mode.

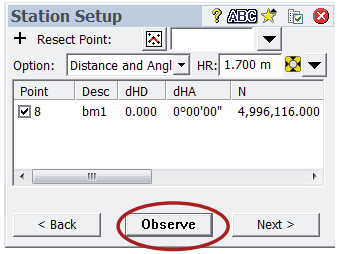


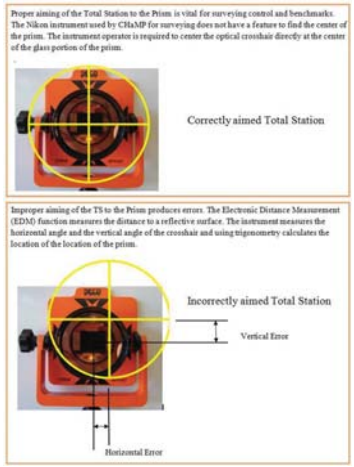
Step 2. Close the Quick Shot menu by pressing the F1 button. From the Main Menu select Survey → Station Setup. In the Setup Type pull-down select Unknown Point/Resection. Enter a point Number, Description (cp501) and HI. Confirm that 2D Survey box is unchecked. Shots per Resect Point =1 and Sequence: Direct only. Select Next.
(Note: Store Pt: in window below is set at 1001 to keep control points separate from topographic points in point sequence. This is used to allow surveyor to easily find CP and BM points when browsing point data. It is not required.)



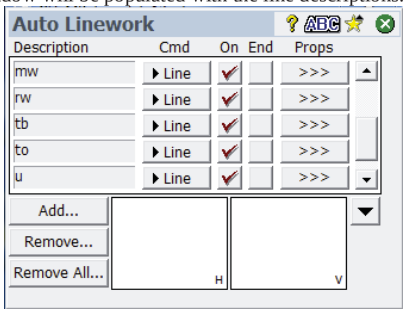
In the next Station Setup window, select the Resect Point using the dropdown. In the Option dropdown, select Distance and Angle. Enter the height of rod (HR), select the prism type (My Prism), aim the instrument at the prism and select "Observe".







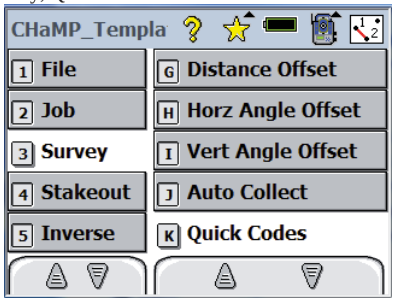
The Auto Linework window will be populated with the line descriptions.



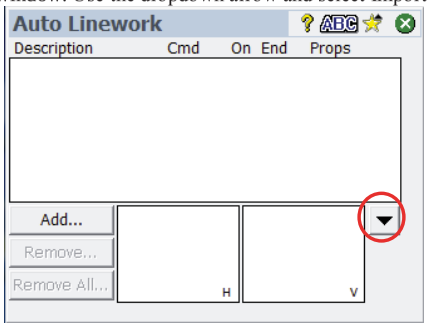
The **Cmd** column: should be Line.
The **On** Column: if this is checked every point collected using the corresponding description will be added to a line. If it is not checked every shot using the corresponding description will not be added to a line.
The **End** Column: If the box is grey, no line is currently being collected. If the open line symbol  is displayed a line is in progress.
This completes the Auto Linework Setup.

Collecting Line Data

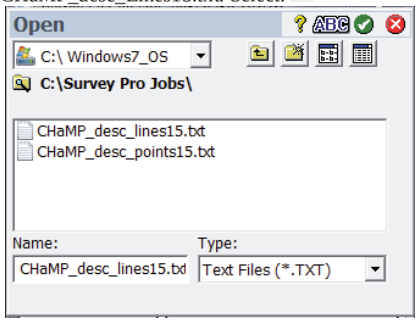
For this example the Quick Codes window is used. To open the Quick Codes window go to the the main menu, select Survey, Quick Codes.



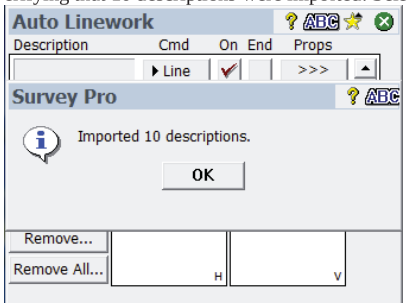
Select the Favorites Icon. Scroll to and select, Auto Linework.
In the Auto Linework window. Use the dropdown arrow and select Import Descriptions…



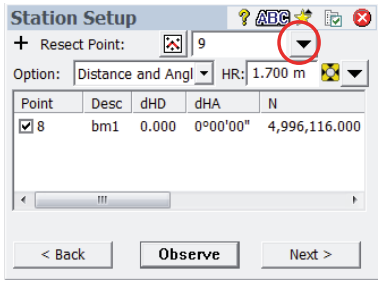
Scroll to and select the CHaMP_desc_Lines15.txt. Select.



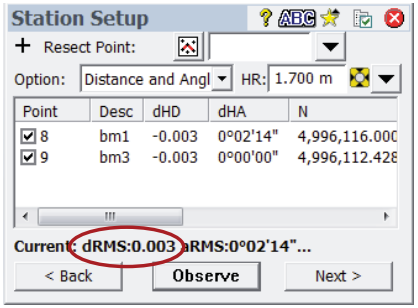
A message will appear verifying that 10 descriptions were imported. Select OK.



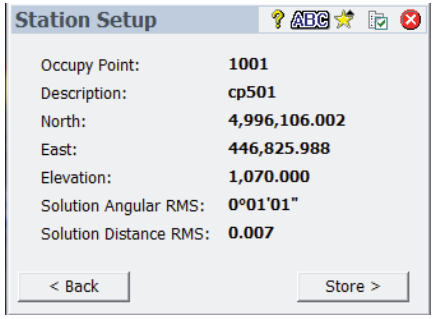
Step 3. Select the next Resect Point using the highlighted dropdown below. In the Option: dropdown select Distance and Angle. Enter the HR, select the prism type, aim the instrument at the prism and select "Observe".



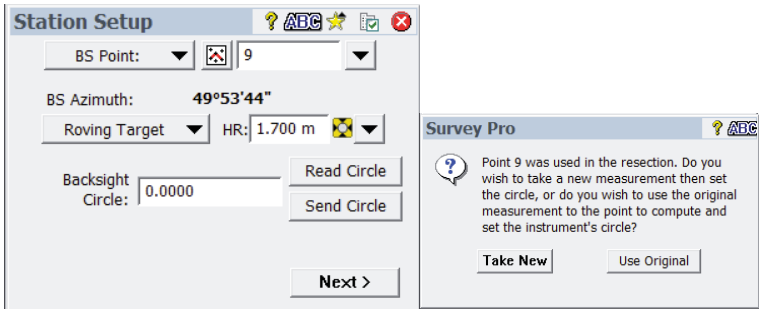
The measurement information is stored as shown below. After all available BMs or CPs are observed, the current distance RMS errors are displayed at the bottom of the window. For a successful resection, the dRMS must be < .07 m. If the dRMS limit is exceeded, check all setup information and repeat the resection.



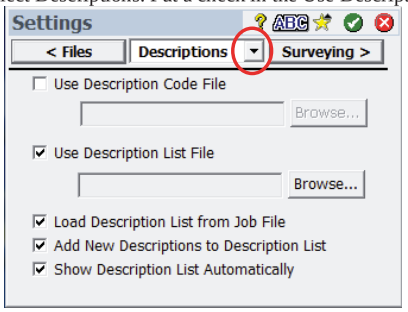
For a resection, three points are preferred but it can be completed using only two points. If only two point are available select “Next”. If three points are available for the resection, repeat the steps above with the third point. Select “Next”. The calculated Occupy coordinates and solution RMS errors are displayed. If the RMS errors are within CHaMP MAE (Max Acceptable Error), select ‘Store”.



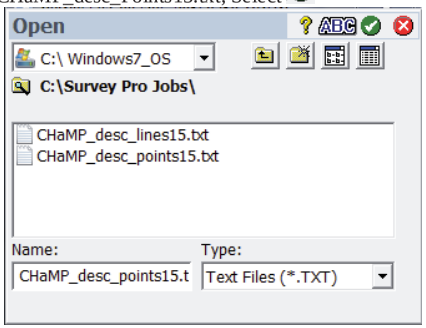
In the Station Setup window, select the backsight point. In this example bm3 is chosen as a backsight because it is farthest from the point of occupation (cp501). Aim TS at backsight and select Send Circle. In the popup window, select Take New and then select Next.



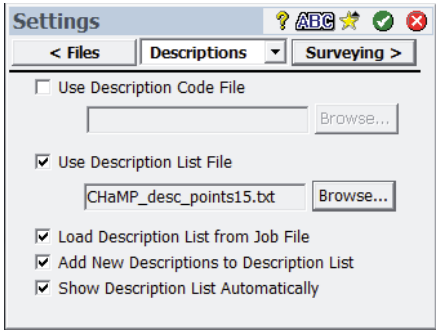
Use the drop down to select Descriptions. Put a check in the Use Description List File.



Browse and select the CHaMP_desc_Points15.txt, Select



The settings below are correct.



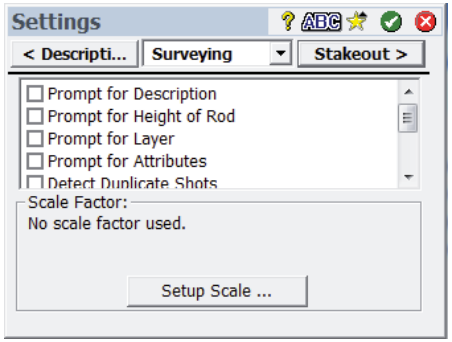
2.7 Line and Point Collection Settings

Collecting line data in the field is superior to drawing lines in the office. Collecting lines in the field allows the observers (the crew) to effectively communicate the field conditions to the office. SurveyPro has the capability of collecting many lines simultaneously if the lines have different descriptions. The required settings and procedures are described.
Data collection settings for descriptions of points and using AutoLinework require setting the path to text files. First the instrument must contain the files necessary.
Open Windows Mobile device Center. Select "Connect without setting up your device". Select "File Management". Select "Browse the contents of your device". Browse to the Nikon 100mb storage space and the Survey Pro Jobs folder. At a minimum there must be the following four files.

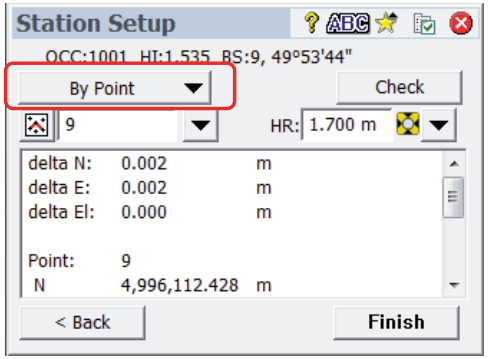
1) CHaMP_desc_Lines15.txt
2) CHaMP_desc_Points15.txt
3) CHaMP_Template15.raw
4) CHaMP_Template15.job

If these files are not present they should be downloaded from the field laptop to the TS.

On the Instrument open SurveyPro
In the Main window select Job, Settings. The Settings window will open.



In the Station Check window click the "By Distance" tab and change it to "By Point" input the BS point number. Input the correct height of rod. Aim TS at Backsight prism and select "Check". Record errors in field notebook. Verify the information and select Finish.



Use the Stake Point Procedure (Section 2.3) to check resection horizontal and vertical errors to the backsight and all other BMs or CPs that are visible from setup location. Upon evaluation and acceptance of the errors it is time to begin survey or the move setup/Traverse to new location for better view of site. .

2.5 Traverse Procedures

Reference: Section 5.3, Columbia Habitat Monitoring Program protocol

Equipment: Total station, tape measure, tripod, prism, prism pole, backsight setup (i.e., tribrach with riser/prism adapter, tripod, and prism or bipod, prism, and prism pole), pencils, field notebook.

Objective: The traverse procedures will occur when moving the Total Station setup location. The Traverse mode propagates the coordinate system, remembers important information, and promotes the crew to follow the proper survey methodology. A traverse requires a normal Station Setup with two points (current setup location and backsight), and a new point which is referred to as a Foresight. When traversing, set up a tripod/bipod over the foresight and measure the height of the prism.

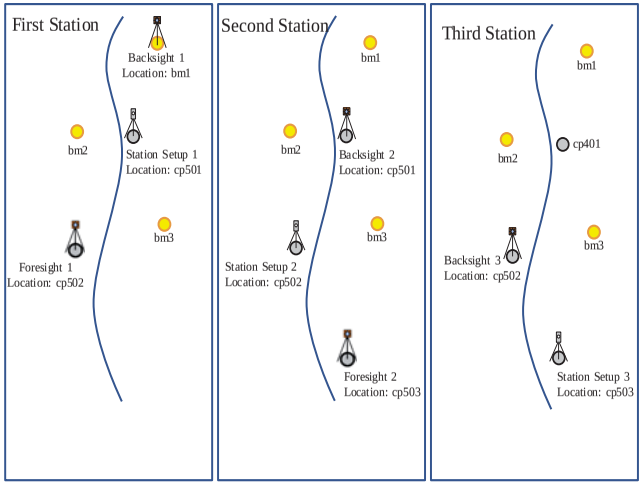


Illustration depicting station setup, backsight, and foresight locations for the first station setup, after traversing to the second station setup, and after traversing to the third station setup.

2.6 Backsight Checks Procedures

Reference: Section 5.4, Columbia Habitat Monitoring Program protocol

Checking the backsight is a method used to validate the status of the horizontal, vertical and distance measurements of the instrument or to validate the orientation within the coordinate system. Performing regular backsight checks also limits the total number of points that need to be resurveyed should a problem arise.

Backsight checks are to be performed in the following instances:

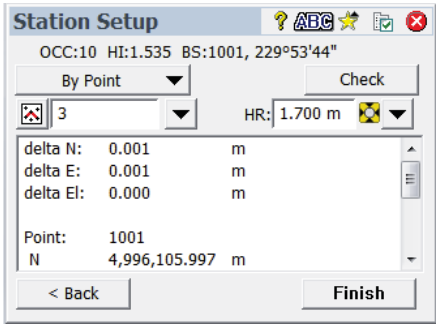
1. After a Station Setup.
2. After a Resection is performed.
3. Before Traversing.
4. Before Staking control or benchmarks.
5. During topographic survey, for every 50 to 100 points.
6. After completing topographic survey.
7. Anytime the Instrument or Tripod is bumped.
8. Anytime the need should arise to validate the condition of the survey.
9. If the instrument has been exposed to noticeable change in temperature.
10. If the ground has been exposed to noticeable change in temperature (thawing).

The Stake Points procedure is used to check the backsight and evaluate the errors. The Stake Points procedure is available in Section 2.3. The backsight check data should always be stored in the instrument and written in the field notebook. The description “ck” (check) can be used.

Maximum Acceptable Errors

Initial survey H= <0.03m and V= <0.015m
Revisit survey H= <0.05m and V= <0.03m

Step 4. Check that the Traverse was successfully within the error tolerance limits (H < 0.03, V <0.015) in Check screen.



Change from "By Distance" to "By Point" input BS point number and height of rod Select "Check" and record error values in Field notebook. Select "Finish". If errors exceed tolerance limits, check the TS and backsight heights. If Traverse cannot be completed without exceeding tolerance limits, reset TS back up at original point, backsight to previous backsight point and attempt the Traverse again.

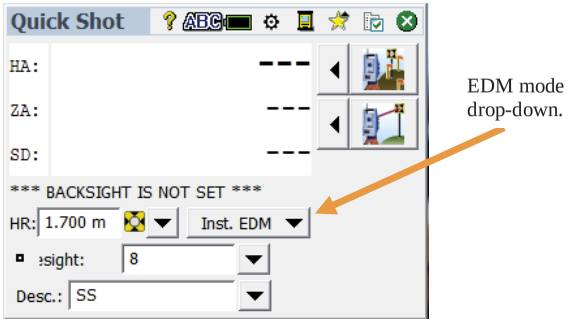
You have completed the Station Setup using the Traverse method.

Check all BMs and CPs that are visible from the new location using the Stake Points method. Continue with topographic surveying.

Step 1. Turn on the Precise EDM

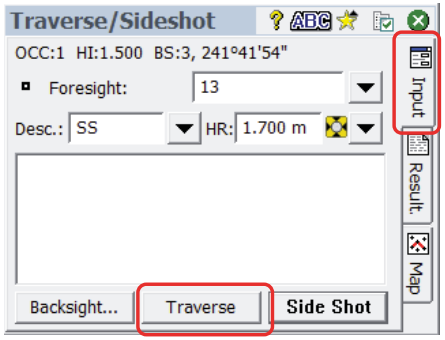
The precise mode is used when surveying all benchmark and control points, while Normal mode will be used to collect topographic data. On the left side of the instrument dashboard, press the F1 button.

The Quick Shot window will open. Use the Electronic Distance Measurement drop-down to select the precise mode.

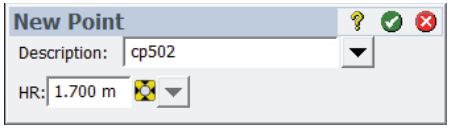


Once precise mode has been selected, close the Quick Shot window by pressing the green circle with an x in upper right corner of screen. Do a Station Setup outlined in Section (2.3), or if you have been conducting a topographic survey, check the BS then proceed.

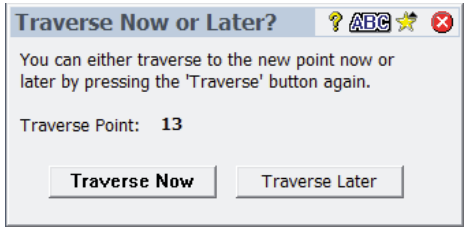
Step 2. From the Main Menu select Survey →Traverse/Sideshot. In the Traverse/Sideshot window select the input tab. At the top of the window check the Station Setup information. Enter the HR and the prism type (My Prism). Aim the TS at the prism located at the next desired setup location (Foresight) and select the "Traverse" button.



In the New Point window, check and if necessary enter the correct description (e.g., cp502). When done, select the green circle with the checkmark.



The Traverse Now or Later window will be displayed. Select Traverse Now.



The Station Setup window appears. The height of instrument (HI) field in this setup window represents the height of instrument when occupying the new setup location. The height of rod (HR) field represents the height of prism leveled over the previous setup location. Information will be inputted into these fields AFTER the surveyor has moved the TS to new location. Do not close this window. This window contains the information of the next point of occupation. On the dashboard push the red power button and select **Standby**. **Do not Close the below station setup window or shutdown instrument.**

Step 3. Move to the next station setup by unlocking TS and Prism from their respective Tribrachs. Secure TS on tripod previously occupied by prism and secure prism on tripod previously occupied by TS. Turn on the instrument using the power button. Select F2 to open the level bubble window, and center and level the instrument. Close the level bubble window. The Station Setup window will appear. Enter the height of the instrument (HI) from the current setup location, the HR from the previously occupied point (now your backsight), and the prism type (My Prism). Aim the TS at the backsight prism. Select Send Circle and then select "Next".