CHAPTER 3

PROJECT CONTROL

A) MARKING SURVEY CONTROL POINTS

The monumenting of control points for highway and land surveys should be completed in a uniform manner as laid out in this chapter.

With the advancement of GPS survey equipment it is essential that the person in charge of setting control have a good understand of current geodetic surveying. This would include the understanding of Geiod models and the different types projections published by NGS.

The surveyor shall contact South Dakota One Call Notification Center prior to beginning any monument placement (1-800-781-7474). The surveyor should also check for any other possible utility companies not listed with the One Call.

The survey control points will be monumented with rebars and caps. The rebars should be 5 feet (1.5-meters) long and the caps are to be marked with "SDDOT Survey Point". Depending on the type or condition of the surface, the rebar and cap can be drilled and grouted into concrete and asphalt pavements. RR spikes can be used for control points only if it is not feasible to set rebars.

Complete notes are to be kept showing the location of all markers, names of the survey party personnel, and any other information, which may aid in future recovery of the points.

B) HORIZONTAL CONTROL

Horizontal Control for grading projects will be set under the guidance of the Region Surveyor. The control for all surveying and engineering work for each project is based on the South Dakota State Plane Coordinate System. Upon receiving a request for a survey, the assigned person will perform necessary research to establish project horizontal control. USGS topography maps can be used to plot control schematics. The National Geodetic Survey database is used to locate records for detailed descriptions and coordinates of control points in the vicinity of the project. These records should consist of GPS HARN stations with NAD 83/1996 or the most recent adjustment horizontal control and vertical control marks with NAVD 88 elevations. Laying out the survey to fit the needs of the project should be done well in advance of any survey observations.

Control points are **generally** set at approximate ½ mile intervals along the project. A fast and efficient way to establish a horizontal position on these points is accomplished by a Real Time Kinematic GPS survey. The horizontal control data, a project scale factor, and control point description will be made available to the Area Office survey crews for the use of the topographic survey.

C) VERTICAL CONTROL

Vertical control on most projects is sometimes established by the Region Surveyor while setting the Horizontal Control.   If the Region Surveyor does not set the elevation control for some reason, it becomes the responsibility of the Area Office survey crews. It is the Area Office's responsibility to set any additional bench marks that may be needed. Department policy is to reference all projects to Mean Sea Level through the use of the National Geodetic Survey (NGS) North American Vertical Datum of 1988 (NAVD 88). A complete record of all National Geodetic Survey benchmarks can be found on the NGS Internet site. (www.ngs.noaa.gov)

Preconstruction Bench Marks

Benchmarks are a series of permanent points of known elevation located within the limits of the project. Benchmarks are very important, since the gradeline, earthwork, structure work and drainage are all referenced to benchmarks for elevation.

Preconstruction benchmarks are to be placed where RTK GPS base stations setup locations or locations that convention surveys will be performed from this may be at locations approximately ¼ mile in areas not favorable for GPS surveying. Low wet areas where frost action may disturb the benchmarks should be avoided when possible. Benchmarks shall be established on some permanent object outside the construction limits and should be easily accessible for construction purposes. The monuments that were set for the horizontal control should also be used for the vertical control network. Additional monuments, five foot (1.5-meter) rebars with aluminum caps, need to be set to "fill in" the vertical control network on the project. Benchmarks should be set to avoid damage to equipment (i.e., mowers, tires, etc.) if accidentally hit.

Bench Mark Levels

Prior to running benchmark levels, the Survey Party Chief should make the following checks to insure necessary accuracy.

1.   Check and adjust, if necessary, the level being used. The necessary adjustment and methods are shown in various survey manuals. The level should be adjusted so that it reads accurately at a minimum of 200 feet (60 meters). It is a good policy to check the accuracy of the level each day. Also, the same level should be used for the entire work. The serial number of the level should be shown in the field notes along with the date adjusted.

2.   Check the condition of the level rod being used. The level rod should be in "like-new" condition. The length of the level rod along with the increment markers should be checked with a steel chain to insure accuracy. Rods with bad faces or inaccurate increments should not be used.

3.   Establish a procedure for the necessary turning points (T.P.'s). T.P.'s are temporary points of known elevation. While removable metal turning points may occasionally prove useful, the rod man should use spikes, wooden pegs, or stakes that are in place. Turning points may, of course, be established on any solid object. These objects should be marked so that if the rod is moved, it can be reset on the exact spot.

C) VERTICAL CONTROL (CONTINUED)

Bench level notes shall be recorded from the bottom of the page, up. On the left hand sheet of the notebook, shall be recorded the number of the bench mark and the turning point designation, the foresights and backsights, and the computed elevations of the heights of instrument, bench marks, and turning points. Turns should be recorded on every other line leaving a blank line between each turn.

On the right hand sheet of the notebook, shall be recorded the description and location of the benchmark. Bench level notes shall be carefully checked throughout from the original benchmark to the final bench. The notes should be checked to see that each benchmark has a description, and that there are no obvious errors.

Bench Mark Levels (continued)

The procedure for running single wire levels can be found in various survey books.   The following are items that should be observed during the process to insure accurate levels.

1.   Check accuracy on instrument daily.

2.   Use the same level and level rod for the entire run.

3.   Limit instrument setups to a maximum of 300 feet (100 meters). Insure that the instrument is firmly set and that turning points are solid points.

4.   Backsights and foresights should be approximately the same length. The rod should be accurately read and elevations figured to 0.01' (.005 meters). All benches should be used as turning points, because errors in side shots on benches may go undetected as they do not effect the accuracy of the level circuit.

5.   Bench levels should be run on calm overcast days.

6.   Avoid rod reading below 2 feet (0.6 meters) as heat waves, close to the ground, can cause difficulty in reading the rod accurately.

7.   Check that the instrument level bubble is correctly centered when the rod is read.

8.   Use a rod level, when available. When a rod level is not available, rock the rod slightly over center.

9.   Read the rod several times to insure a correct reading.

10.   Have the notekeeper repeat the rod reading to insure a correct reading.

11.   Reduce notes as you proceed and check notes with a calculator.

C) VERTICAL CONTROL (CONTINUED)

Bench Mark Check Levels

Check levels are to be run separate from bench levels and it is advisable to run check levels after one or two miles (1 ½ to 3 kilometers) of bench levels have been run.

In checking the original bench marks with the check levels, the difference in elevation between any two adjacent benchmarks must agree within the within the tolerance expressed by the following equation.

$$Tolerance = .035\sqrt{M}$$ (*M* is distance between two benches in miles.)
Note: Metric substitute *8.4mm* for *0.035 ft.* & use *K* in place of *M*

Example (English Units):

Bench Levels	Check Levels	Difference in Elevation
1715.30 BM2	1715.32	.02 <u>ft</u>

Bench Mark 1 is at Station 26+00 and Bench Mark 2 is at Station 49+00, which is 2300 feet or .4356 miles. Substituting these values into the formula and solving the result is .02 ft. Therefore, check levels are within tolerance.

The final elevation of benchmark Number 2 would be the average of the two runs.

Bench Level	1715.30
Check Level	<u>1715.32</u>
	3430.62 Divided by 2 = 1715.31

Once the elevation of bench mark Number 2 is established it is used as the correct elevation in establishing benchmark Number 3 and so on.

D) TOTAL STATION LEVELING

Bench marks will not be set from Total Station leveling, because of the accuracy required for the bench mark elevation. The accuracy required for benches, in most cases, cannot be met with the Total Station.

Robotic Total station leveling maybe done with properly calibrated robotic total station as long as observations are kept under 600 ft. It is recommendation that the measurements are taken in both faces.

E) CREATING CONTROL FILE DOCUMENTS

Control information needs to be saved as an .fwd file created in Microstation Inroads. The file name should be named PCEMREFMRK and stored in a folder named control in the project folder. Along with Northing, Easting and Elevation information the .fwd file needs to contain.

1   NAD
2   NAVD
3   State Plane Zone
4   Geoid Model Used
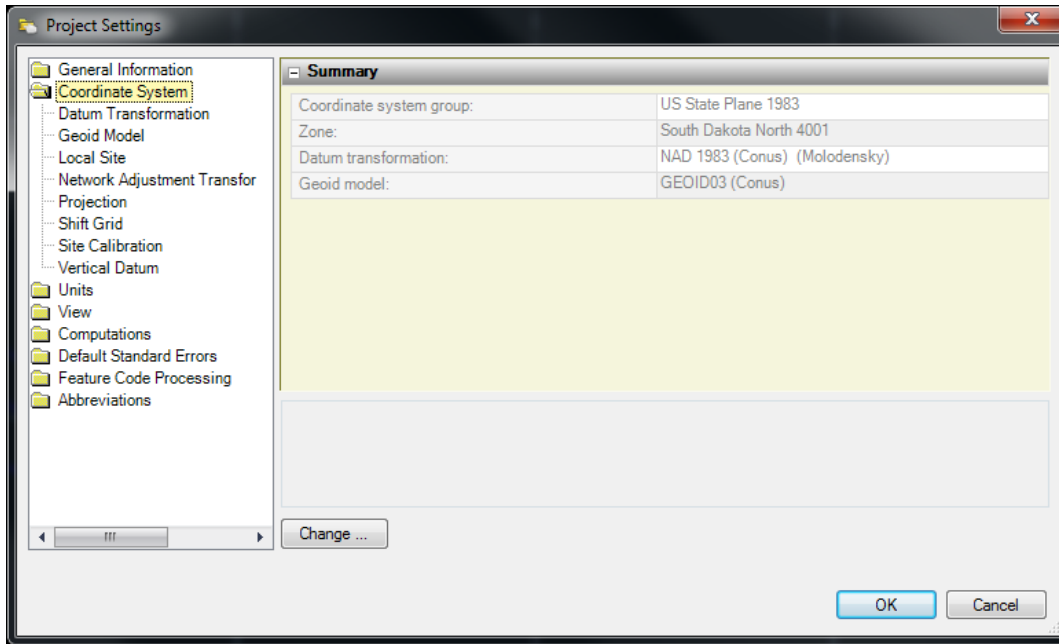5   Scale Factor.

Optional information can include.

1   Personal setting control
2   Project and location
3   County

An .alg file needs to be created using the same naming convention as the .fwd (PCEMREFMRK.alg) This file is be stored in the control file also.
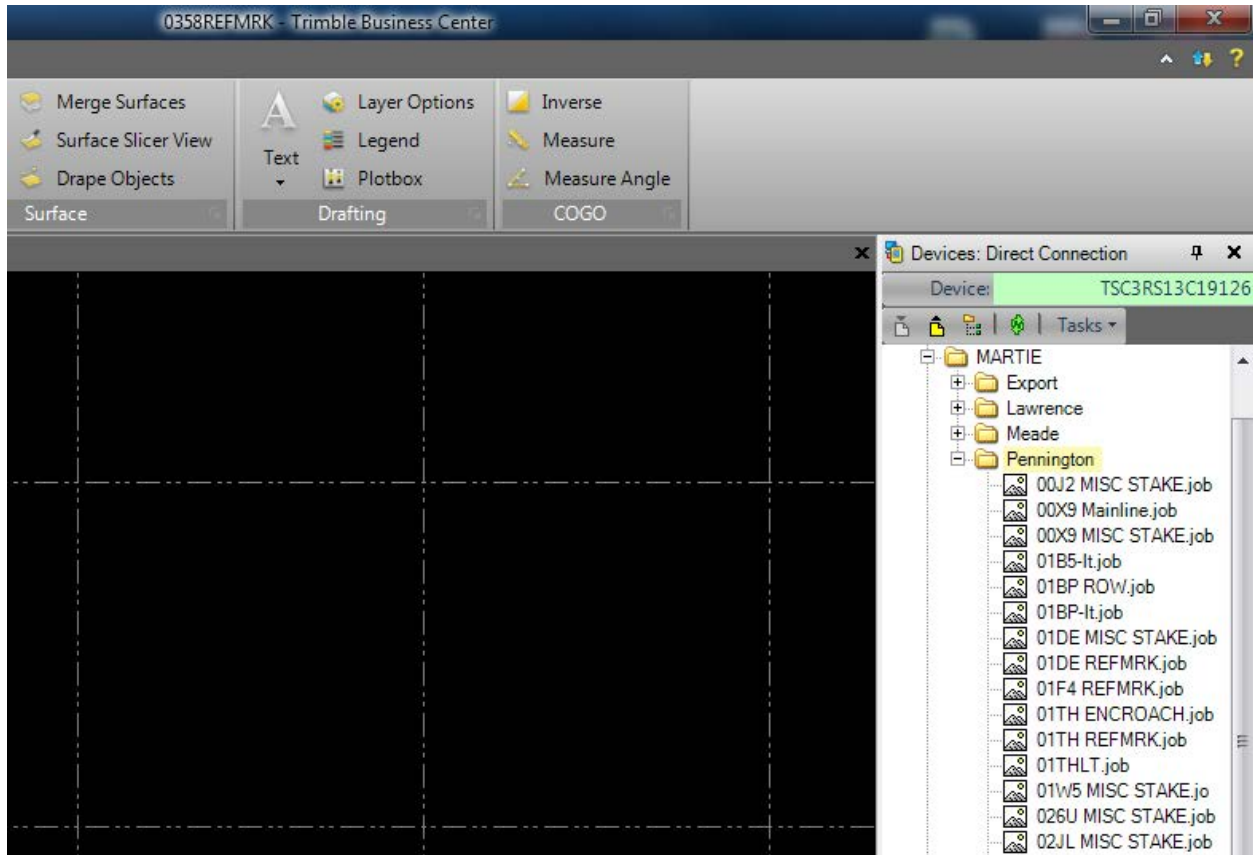
F) CALCULATING SCALE FACTORS.

A scale factor is calculated in TBC. The procedure is as follow.

1   Open TBC
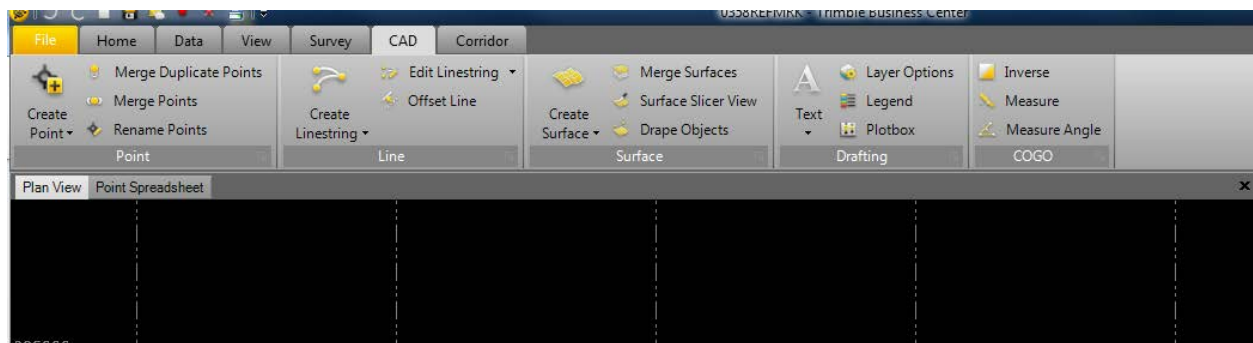2   Set up the project properties (State Plane coordinate system along with zone and Geoid Model Used)

F. CALCULATING SCALE FACTORS. (CONTINUED)

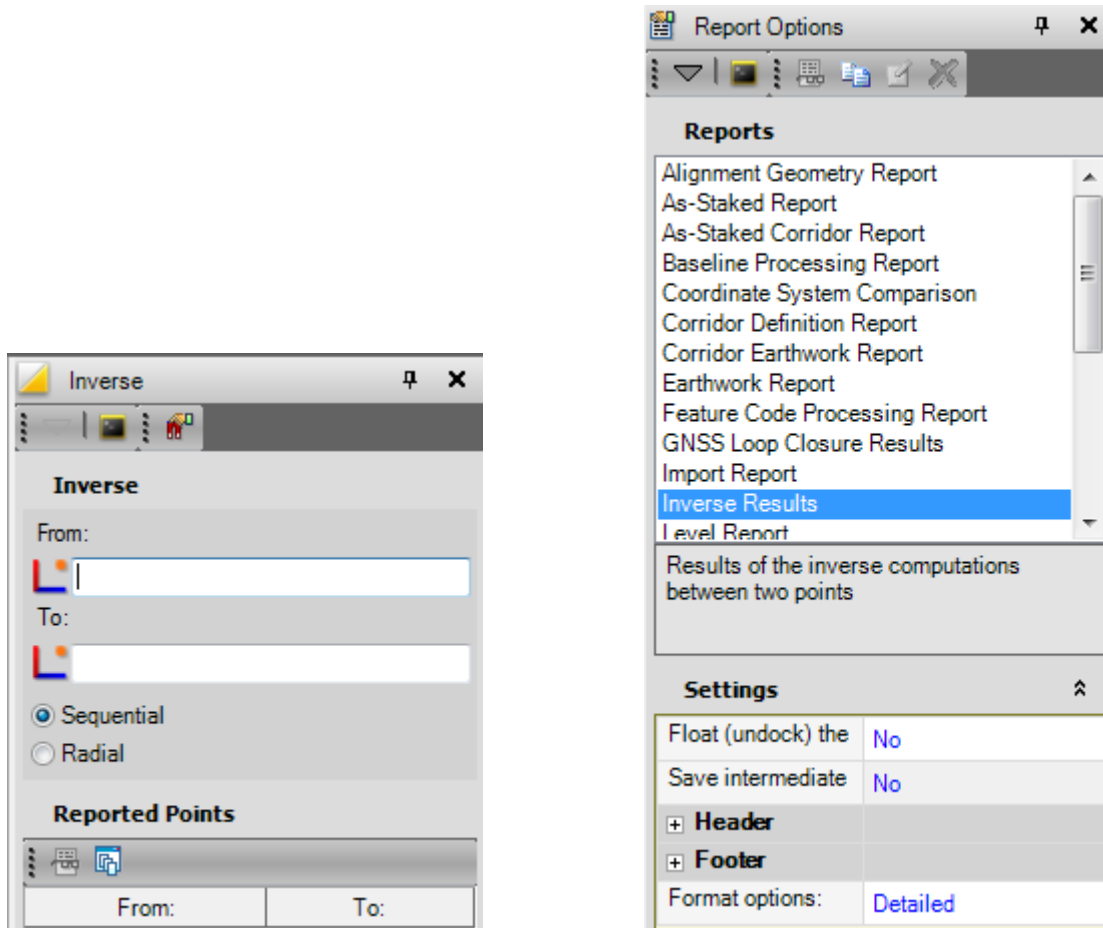3   Import the file from the data collector using the device pane.

4   Under the CAD tab in TBC, select the inverse option.

F. CALCULATING SCALE FACTORS. (CONTINUED)

5   Make sure that the report option is set to detailed and not concise.

6   Select the From box and the curser will appear in this box showing that is ready for you to select your first point.
7   Select the first point you what to use in your scale factor calculation
8   The curser will appear in the To window once you have selected the first point now you can select the other point.
9   The point will automatically move from the "To" window to the "From" window and the 2 points you selected will appear under reported points.
10   Select the show report option (Looks like a piece of paper with glasses)

F. CALCULATING SCALE FACTORS. (CONTINUED)

11 The report following report will be displayed.

Project Information		Coordinate System	
Name:	U:\regionRC\Misc\RC-Survey\Martie TBC\0358REFMRK.vce	Name:	US State Plane 1983
Size:	161 KB	Datum:	NAD 1983 (Conus)
Modified:	03/04/2013 2:40:24 PM (UTC:-7)	Zone:	South Dakota North 4001
Time zone:	Mountain Standard Time	Geoid:	GEOID03 (Conus)
Reference number:		Vertical datum:	
Description:			

Inverse Results

From	To	Grid Azimuth	Grid Distance	Δ Elevation
CP05	CP03	92°43'32"	5261.674	-43.268

Grid		Local (US State Plane 1983)		Cartesian (WGS-84)	
From: CP05					
Northing:	257187.514 ft	Latitude:	N44°28'32.20221"	X:	-3563060.622 ft
Easting:	982209.207 ft	Longitude:	W103°46'47.43401"	Y:	-14528246.876 ft
Elevation:	3912.467 ft	Height:	3864.827 ft	Z:	14589144.517 ft
Convergence:	-2°40'30.500660"				
Inverse:					
Grid Azimuth:	92°43'32"	NS Forward Azimuth:	90°03'02"	ΔX:	5117.938 ft
Grid Distance:	5261.674 ft	NS Back Azimuth:	270°03'53"	ΔY:	-1226.127 ft
ΔElevation:	-43.268 ft	Ellipsoid Distance:	5261.731 ft	ΔZ:	-34.214 ft
t-T Correction:	-0°00'00.258796"	Ground Distance:	5262.695 ft	Slope Distance:	5262.875 ft
Height Scale Factor:	0.9998166799	ΔHeight:	-43.442 ft		
Grid Scale Factor:	0.9999892308				
Combined Factor:	0.9998059127				
To: CP03					
Northing:	256937.302 ft	Latitude:	N44°28'32.14993"	X:	-3557942.683 ft
Easting:	987464.929 ft	Longitude:	W103°45'34.86736"	Y:	-14529473.003 ft
Elevation:	3869.198 ft	Height:	3821.385 ft	Z:	14589110.303 ft
Convergence:	-2°39'39.142465"				

12 Add the combined scale factor to the REFMRK.fwd file stored in the Control folder under the project folder.

13 Also saved created report in the Control folder. (This will show the parameters of how the scale factors was created.)

14 The Coordinate System Information is displayed on the header of the inverse report. This information should be the same as the information show on the header of the *PCEM*REFMRK.fwd file.