Chapter 8 – Scour Study Surveys

Policy Statement

Any survey performed for the purpose of collecting data for Scour Studies shall conform to the specifications as defined in this document.

Objective

The objective of a Scour Study survey is to determine the degree of sedimentation or scour (erosion) which has occurred within flood control facilities. Data is collected yearly or as directed by the requestor, typically OC Operations and Maintenance (O&M). Data points are usually collected in the form of cross sections at pre-determined stations. Volumes are computed by comparing cross sections to those from the previous survey, and a comparison is also made with the cross section templates from the original as-built drawings.

Accuracy Requirements

Data points should be located within the following tolerances, relative to project control ("local accuracy"):

- Data points should be located within +/- 0.10 feet horizontally and vertically.
- Data points should ideally be located within +/- 1 foot of the desired pre-determined station, with an occasional variance of up to +/- 5 feet accepted at the discretion of the Senior Land Surveyor

Field Methodology

This document establishes acceptable methodology for Scour Study surveys incorporating conventional instruments (total stations) and RTK GPS. See ***Chapter 9 – Hydrographic Surveys*** and ***Chapter 10 – Small Unmanned Aerial Vehicle (sUAV) Surveys*** for alternate methods of data collection.

See **"Establishing the Control Network"** below for details on the horizontal and vertical control network upon which the Scour Study survey is based.

General Methodology:

The following general notes relate to data collected from any source:

- Instrument set-up information, point ranges used, edits needed, etc. shall be logged on a ***"Data Collection Set-Up Sheet"*****.**
- Spacing of data points shall be such as is necessary to capture an accurate cross-sectional representation of the horizontal and vertical geometry of the flood control facility. Determination of point spacing is made in the field by the Party Chief.
- When capturing data points within any soft surface, e.g. sand or mud, the layout rod shall be equipped with a "shoe" or other blunt object designed to keep the rod from sinking beneath the surface.

Conventional Instruments:
The following notes are specific to data collected with a conventional instrument:

- After the instrument is oriented and the measurement to the backsight is recorded, a third control point is staked out, read, and recorded using the layout rod that will be used for collection of data points. This provides assurance that the prism offset and rod HI measurement are correct. Check shots should be coded with a unique numbering system which makes them easy to sort and verify. For example, a check shot on point #207 could be named "*CHK207*".
- In order to prevent degradation of the horizontal and vertical accuracy of data points, measurement distances should be limited to a maximum of **800 feet**.
- Prism rod HI may be extended to **25 feet**.

RTK GPS:
The following notes are specific to data collected with RTK GPS (RTK):

- Refer to ***Chapter 2 - RTK GPS*** for detailed policy on the use of RTK.
- For RTK surveys based on the Orange County Real Time Network (OCRTN), a 3D Site Calibration is required (see ***"Appendix B"*** for Site Calibration procedure). RTK surveys based on existing project control using a Base/Rover configuration do not require Site Calibration, provided that Base/Rover procedures defined in ***Chapter 2*** are followed.
- A known point shall be checked at the beginning and end of each session. Prudent practice would indicate additional checks, particularly after initialization is lost. Check shots should be coded with a unique numbering system which makes them easy to sort and verify. For example, a check shot on point #207 could be named "CHK207".
- Each topographic data point shall consist of a single measurement of at least **5 epochs**. Measurement duration of data points adjacent to steep embankments or tree canopy, or under any other circumstance which results in decreased precision, shall be prolonged so as to ensure the desired accuracy has been met.

Monumentation

Monuments set as control points during the course of a scours study survey shall meet the following criteria:

- Monuments which fall on concrete curbs or in the surface of concrete paving shall consist of a tag secured in a lead plug or set in epoxy.
- Monuments which fall on asphalt dikes or in the surface of asphalt paving shall consist of a spike or "MAG" nail with a washer.
- Monuments which fall in non-paved areas shall consist of an iron pipe with a tag or disk, or a rebar with an aluminum cap. Rebar must be set a minimum of 3 inches below the ground surface.
- All tags/washers/disks/caps referenced above shall be stamped with the agency name or the license number of the surveyor in responsible charge, and shall also be stamped "CP" or "CONTROL POINT".
- Tags set in iron pipes shall be of a diameter less than that of the inside diameter of the pipe. Disks affixed to iron pipes shall be of a diameter equal to that of the outside diameter of the pipe.

- Under no circumstances are plastic plugs to be used with iron pipe or rebar.

Office Workflow

The following office workflow is to take place as the fieldwork progresses:

- Field data should be downloaded at the end of each day. Data shall be reviewed and edited by or under the supervision of the Party Chief. Care must be taken to resolve errors in rod heights and incomplete or inaccurate cross section lines.
- This edited data shall be delivered to the Mapping Unit (placed on the Field Survey Server) in blocks of no larger than three days of fieldwork.
- Note that the files themselves are not delivered by email. Files shall be copied to the Field Survey Server and organized as described in ***Chapter 13 – Preparation of the Field Note Package***. A link to the file location is emailed to the Mapping Unit.
- Data is delivered in Starnet **DAT** format (see **Adjustment of the Network** below for more details on generating the **DAT file**). The Starnet project file (**.SNPROJ**) containing all project settings is also delivered, and as new field data is collected, the Mapping Unit and the Party Chief will each maintain a running amended adjustment as an additional layer of QA/QC.
- Along with the Starnet data, the Party Chief shall deliver data collector job files (.JOB) and copies of the Data Collection Set-Up Sheets.
- After completion of the fieldwork and topo processing, the Mapping Unit will provide the Party Chief with a cross section plot of the entire project. The Party Chief shall walk the jobsite with the plot in hand, searching for errors or omissions, making corrections as needed. At the discretion of the Senior Land Surveyor, in lieu of a site visit the Party Chief may perform an office review of cross section plots.
- After final edits have been made, a plot is provided for the Senior Land Surveyor to review. Cross sections are delivered to the requestor in plot and tabular format, with quantities of cut or fill for each station and for the project as a whole.

Establishing the Control Network

In most cases, Scour Study surveys are performed using a control network established by a previous survey. If existing control is to be used as the basis of the survey, the integrity of the network shall be verified before the survey commences. This verification process must be documented in the form of a narrative, listing of stakeout deltas, and/or StarNet report. Any additional control points needed are then tied to this existing control and included within the project deliverables.

In the case of a new facility or a facility in which a substantial percentage of the original control has been destroyed, establishment of the new control network shall follow the procedures outlined below:

Horizontal control:

Horizontal control for Scour Study surveys shall conform to a minimum combined (relative) positional accuracy of **1:10,000** (at a 95% confidence level, or 2 sigma), or a combined distance error of **≤ 0.033 feet** for connection distances shorter than **330 feet**. Relative positional accuracy is a measure of the accuracy of point positions in relation to each other, and is not to be confused with the measure of traverse closure expressed as a ratio.

This **1:10,000** standard shall be met whether the survey is conducted by GPS (static or RTK), conventional traverse (total station), or any combination thereof.

The following are guidelines for GPS, conventional traverse, and differential leveling methodology:

Static GPS:
Control for a Scour Study survey may be established by static (or fast-static) GPS procedures. While a network adjustment *may* be performed using only GPS vectors (stand-alone), combining conventional traverse data with GPS vectors will result in a network with higher relative positional accuracy.

Design of the network and occupation scheme will be determined by the Party Chief in conformance with ***Chapter 1 – Static GPS*** When selecting points to be included in the static network, consideration must be given as to strength of figure and adequate spacing. The minimum allowable spacing for points in stand-alone networks shall be dictated by the following criteria:

- Trimble R10 receivers, rated for static surveys at 3mm + 0.5 ppm at 68% confidence level (1 sigma): a minimum spacing of **500 feet** when tied to CGPS stations at an average distance of 32,000 feet, and a minimum spacing of **300 feet** when tied to primary project control or legacy control at an average distance of 4,000 feet
- Minimum spacing for GPS receivers with static survey ratings different from those listed above can be computed using the formula shown in "**Appendix A, Section 1**"

RTK GPS:
RTK is generally not to be used as a stand-alone measurement tool when performing a control survey. RTK is best used to bolster the control network, not define it. In order to ensure realization of the **1:10,000** criteria, the network shall be adjusted using RTK measurements together with conventional traverse data.

RTK occupation points are selected in such a way as to maximize strength of figure, while leaving the bulk of the data to be captured by conventional traverse. The occupation scheme will be determined by the Party Chief in conformance with ***Chapter 2 – RTK GPS.***

The minimum recommended spacing for points in RTK surveys shall be dictated by the following criteria:

- Trimble R10 receivers, rated for RTK surveys at 8mm + 1 ppm at 68% confidence level (1 sigma): a minimum spacing of **1200 feet** when tied to OCRTN stations at an average distance of 32,000 feet; a minimum spacing of **700 feet** when tied to local project control in a base-rover configuration at an average distance of 4,000 feet
- Minimum spacing for GPS receivers with static survey ratings different from those listed above can be computed using the formula shown in "**Appendix A, Section 1**"

Conventional Traverse (Total Station):
Conventional traversing may be used either as a stand-alone method or in combination with GPS vectors when establishing control networks for Scour Study surveys.

Field measurements shall meet the following specifications:

- Horizontal Angles: Minimum of two direct (face 1) and two reverse (face 2) with a maximum residual of 5 seconds; exception granted for sights closer than 300 feet.
- Distances: Measured to backsight and foresight; minimum of two direct and two reverse with a maximum residual of 0.007 feet.

Vertical Control:
For Scour Study surveys, elevations of points within the primary control network shall be established using differential leveling procedures. Leveling shall be referenced to a minimum of two vertical control points (benchmarks) and be in conformance with ***Chapter 4 – Differential Leveling.***

Elevations of subsequent supplemental control may be derived by trigonometric principles, provided the points are traversed through, double determined, or set by two-point resection, with acceptable mathematical vertical closures observed.

Adjustment of the Network

Control Network:
All GPS and conventional data shall be adjusted by least squares adjustment software in conformance with ***Chapter 12 – Network Processing.***

Statistical analysis of the adjustment shall be performed to ensure that a minimum combined (relative) positional accuracy of **1:10,000** has been achieved for all connected monument pairs. Although this computation is automatically performed in most network adjustment software, the formula for this computation is shown in "**Appendix A, Section 2.**"

Connections of very short distances often will not meet this **1:10,000** standard. An alternative standard for distances of less than **330 feet** is shown in "**Appendix A, Section 3.**"

In the event one or more pairs of monuments fail to pass these relative positional accuracy criteria, the network adjustment shall be reviewed and a determination made by the Senior Land Surveyor (or Project Manager) as to whether or not additional observations will made in order to improve geometry, increase redundancy, or further isolate errors.

Topo Sideshots:
After the control network has been satisfactorily adjusted, Scour Study data points are added. Unique **DAT files** for each block of data (data representing 1 to 3 days of fieldwork) are created from the data collector files. Be sure to export data points in **sideshot** format. All necessary edits are made within the **DAT files**.

All sideshot **DAT files -** original and edited **-** are delivered to the Mapping Unit, along with **DAT file/s** representing the project horizontal and vertical control network, and the Starnet project file **(.SNPROJ)**.

Important Note:
Once a network has been adjusted and coordinates are reported to another entity (e.g.: Mapping Unit), these coordinates shall be deemed final. Should supplemental control or boundary ties be needed, the primary coordinates shall be fixed in subsequent adjustments. Only in the event that erroneous data is discovered will previously reported coordinate values be changed.

Appendix A – Formulas

1. Minimum spacing for new control points to be positioned using GPS can be computed using the following formula:

   $D = 10{,}000 \times \sqrt{(2 \times \{ [(1.96)(a)]^2 + [(1.96)(b)]^2 + c^2 \})}$
   where:

   - D = minimum spacing (in feet) between static or RTK occupation stations
   - a = manufacturer's millimeter rating at a 68% confidence level, (converted to feet)
   - b = manufacturer's ppm rating at a 68% confidence level, times the average distance (in feet) from legacy control stations, and divided by 1,000,000
   - c = estimated receiver positioning error (rod plumb or tribrach errors), commonly estimated to be 0.007 feet
   - 1.96 = the multiplier from a 68% confidence level (1 sigma) to a 95% confidence level (2 sigma)

2. All connected monument pairs shall pass the following mathematical test:

   $D \div \sqrt{(x^2 + y^2)} \geq 10{,}000$ (or $\geq$ 20,000 where required above)
   where:
   - D = distance (in feet) between the pair of monuments being examined
   - x = error ellipse semi-major axis for monument #1 (at 95% confidence)
   - y = error ellipse semi-major axis for monument #2 (at 95% confidence)

3. Connections of very short distances often will not meet the **1:10,000** standard defined by the formula in Section 2 above. An alternative standard for distances of less than 330 feet follows:

   $\sqrt{(x^2 + y^2)} \leq 0.033$ feet
   where:
   - x = error ellipse semi-major axis for monument #1 (at 95% confidence)
   - y = error ellipse semi-major axis for monument #2 (at 95% confidence)

Appendix B - Site Calibration Procedure

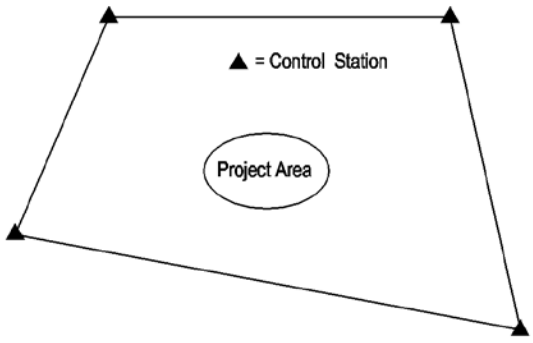
A Site Calibration establishes a relationship between the observed WGS84 coordinates and the local grid coordinates.

The procedures detailed below are specific to topographic survey projects. See ***Chapter 2 – RTK GPS*** for more general uses and procedures for Site Calibrations.

General Requirements:

- The control stations shall be selected so as to create a polygon which fully encompasses the project area (see ***Figure 1***). Selected control stations shall be located no more than six miles from the RTN station or base station.
- Conditions which may generate multipath or obstruct view of the satellites, such as overhead power lines, nearby trees, or adjacent buildings, should be avoided.
- Elevation mask shall be set to 15 degrees.
- Each occupation shall consist of either one measurement of 180 epochs, or three sequential measurements of 60 epochs each.
- Upon computation of the Site Calibration, a control station with residual values greater than those defined below shall be discarded and another control station shall be used in place of this outlier.
- All subsequent measurements and staking activities shall use the same RTN base station or base position as was used to generate the Site Calibration.

Figure 1 – Control Station Selection



2D Site Calibration:

- A minimum of 4 horizontal control stations shall be included in a 2D Site Calibration.
- Each horizontal control station shall be measured with 2 independent occupations, with a minimum time differential (time of day) of 2 hours. These time differentials are required in order to ensure significantly different satellite geometry.
- The stations in a 2D Site Calibration shall not exceed a horizontal residual of 0.07 feet

3D Site Calibration:

In addition to the requirements described above for a 2D Site Calibration, the following requirements shall be met for a 3D Site Calibration:

- A minimum of 5 vertical (or 3D) control stations shall be included in a 3D Site Calibration. To avoid creation of a distorted or tipped plane, the stations selected must have been tied together with one common leveling circuit. An alternative to this requirement is to collect data on these 5 vertical control stations but include just one of them in the Site Calibration. Analysis of the data will determine which vertical control station represents a best-fit solution for the project. This may be a better alternative when working with vertical control that has not been recently tied together (OC Survey Benchmarks).
- Each vertical control station shall be measured with 2 independent occupations, with a minimum time differential (time of day) of 4 hours.
- The stations in a 3D Site Calibration shall not exceed a vertical residual of 0.10 feet.