SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

Pre-Construction Survey Manual

August 2003

PREFACE

The *Survey Manual* has been developed as a guide to provide uniform design practices for Department and consultant personnel conducting surveys and aerial mapping for Department projects. The designer/surveyor should attempt to meet all criteria and practices presented in the *Manual*.

The M*anual* presents most of the information normally required for preparation of survey requirements for a roadway project; however, it is impossible to address every situation that the designer will encounter. Additional survey requirements are also covered in the SCDOT Highway Design Manual, which outlines certain procedures and special cases. REF: HDM AS REQUIREMENT

A SCDOT task force under the direction of the Survey Section developed the *Survey Manual* with assistance from the engineering consultant firm of Civil Engineering Consulting Services, Inc. a sub consultant to Fluor on the CRM West program.

Table of Contents

AERIAL MAPPING PROCEDURES ____ *1*

1.1 Introduction ____ **1**

1.2 Aerial Photography & Mapping – General ____ **1**

1.3 Accuracy Requirements / CADD Standards ____ **3**

1.4 Camera Requirements/Calibration Report ____ **4**

1.5 Aerial Triangulation Report and Certification ____ **4**

1.6 2D Topo Files Deliverables ____ **5**

1.7 3D Topo and DTM Files Deliverables ____ **5**

1.8 Orthophoto Files ____ **6**

1.9 TIN Preparation ____ **6**

1.10 QA/QC ____ **11**

1.11 Aerial Mapping Deliverables ____ **11**

SURVEY DATA COLLECTION AND PROCEDURES ____ *13*

2.1 Survey / Controls / Benchmarks / Accuracy ____ **13**

2.2 Survey Monumentation ____ **21**

2.3 Shot Nomenclatures and Numbering ____ **24**

2.4 Break Lines / Spots / DTM Input ____ **42**

2.5 Introduction to GEOPAK Survey ____ **42**

2.6 Processing Survey File ____ **42**

2.7 TIN Generation ____ **62**

2.8 QA / QC Procedures ____ **66**

2.9 Survey Files Deliverables ____ **66**

APPENDIX A – PHOTOGRAMMETRIC CERTIFICATION PROJECT REPORT _ *67*

APPENDIX B – SCOPE OF WORK FOR TOPOGRAPHIC MAPPING PROJECT _ *69*

APPENDIX C – FGDC REQUIREMENTS ____ *74*

APPENDIX D - SUBSURFACE UTILITY FEATURE TABLE ____ *75*

APPENDIX E –SURVEY FEATURE TABLE ____ *78*

INDEX ____ *82*

Chapter 1

AERIAL MAPPING PROCEDURES

1.1 Introduction

Photogrammetry is the science and technology of obtaining reliable information about physical objects and the environment by interpreting, measuring, and recording aerial photographic imagery.

The SCDOT requirements for photogrammetry shall meet the FGDC standards and requirements as outlined in "Appendix A".

1.2 Aerial Photography & Mapping – General

The following are provided as general information and are subject to change, as the Department deems appropriate.

1.2.1 General

It is anticipated that work to be performed, unless specified otherwise, will be required to comply with applicable provisions of the FGDC requirements.

1.2.2 Aerial Vertical Photography

All aerial vertical photography will be obtained with a Wild RC20 or Jena LMK 1000 or equivalent camera systems employing both forward motion compensation and automatic exposure control.

Except for special cases, the photography will be acquired between January 1st and March 15th. Photography shall not be attempted when the ground is obscured by snow, haze, smoke, or dust, or when clouds or cloud shadows will appear on any photograph. In areas where water bodies are under tidal influence, photography shall

be acquired within a time not to vary by more than 2 hours from the time of low tide. Photography shall minimize shadows caused by trees or topographic relief and shall be taken when the suns inclination angle is greater than thirty (30) degrees.

1.2.3 Mapping and Digital Terrain Models

All mapping will be furnished by the consultant as Bentley 2D or 3D design files. Planimetric features will be furnished in a 2D design file. Topographic features will be furnished in 3D design file. Both planimetric and topographic features will be placed on separate, segregated levels as specified by the Department. Terrain model data will be submitted as Bentley 3D design files with spot elevations and break lines placed on separate levels. Break lines representing the Department's edges of pavement, curb and gutter, sidewalks or raised medians will be placed on a level separate from all other break lines.

All digital files will be fully compatible with the Department's Bentley system as well as Microstation and Geopak design software.

Design files shall be based on the following for metric working units:

1. Master Units: 1 m
2. Sub Units: mm
3. Sub Units per Master Unit: 1000 mm per m
4. Positional Units per Sub Unit: 10 pos. units per mm

This creates a design place that is 429,496 meters square. Since this plane is not large enough to encompass the entire state, the consultant may set the Global Origin of a design file to a position that will accommodate the project. All design files created and submitted for a project will have the Global Origin set to the same position.

Design files shall be based on the following for English working units:

1. Master Units: ft
2. Sub Units: in
3. Sub Units per Master Unit: 12 in per ft.
4. Positional Units per Sub Unit: 1000 Pos. Units per in.

This creates a design plane that is 357913 feet square.

NOTE: For the State of South Carolina, the official conversion factor to convert meters to feet is based on the International Foot (1 meter = 3.280839895 or 1 foot = 0.304800000 meter).

The Consultant will use the Department's specified level structure and cell library.

Digital terrain models will be a combination of cross section and critical point type. The DTM will be produced photogrammetrically using first order analytical

stereoplotters that automatically encode the data in digital form. Breaklines, ridges, drains, maximums, minimums, centerlines/edges of roadways, vertical faults, spot elevations, and points at regular intervals along parallel lines will be measured and recorded with sufficient density to produce the specified accuracy. Generation of DTM from previously collected contours will not be allowed. Obscured areas will be annotated and marked in the files by a unique line type.

1.3 Accuracy Requirements / CADD Standards

a) General Photogrammetric surveys are defined as the use of photogrammetry for obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting images and patterns of electromagnetic radiant energy and other phenomena. Minimum allowable photogrammetric production procedures and standards are hereby established for photogrammetric mapping and digital data production.
b) Production procedures for photogrammetric mapping surveys shall be in accordance with the standards established by the Federal Geographic Data Committee (FGDC) Geospatial Positioning Accuracy Standard and applicable extensions and revisions. These standards are incorporated by reference including subsequent amendments and editions.
c) Topographic maps, unless clearly marked as "Preliminary Map", shall meet FGDC Standards for horizontal and vertical accuracies. All orthophotos and planimetric maps, unless clearly marked as "Preliminary Orthophoto" or "Preliminary Map", shall be produced to meet FGDC Standards for horizontal accuracies.
d) When the resulting product is a digital (electronic) data set, or a map or document consists of more than one sheet, a project report will be certified and signed.
e) Ground control for photogrammetric projects shall be in South Carolina Grid coordinates and distances when the project is tied to Grid.
f) The project map or report shall contain applicable following information:
    1) Date of Photography or original data acquisition
    2) Scale of Photography
    3) Date of document or data set compilation
    4) If hard copy product is produced, the maps shall contain a north arrow, map legend, final document scale and contour interval, as applicable.
    5) Coordinate system for horizontal and vertical denoting SI or English units (i.e., NAD 83, assumed, etc.)
    6) A list or note showing the control points used for the project, x, y & z.
    7) If other data is included which was obtained by means other than photogrammetry, the source and accuracy of those items must be clearly indicated.
    8) A statement of accuracy complying with FGDC standards.
    9) For topographic maps or data sets, contours in areas obscured by man-made or natural features shall be uniquely identified or enclosed by a polygon clearly

identifying the obscured area. The accuracies of the contours or of the features in this obscured area should be noted to the extent they deviate from the general accuracy of the map or data set.

10) A vicinity map depicting the project location shall appear on the first sheet of all hard copy maps or in the report accompanying digital files.
11) Company name, address and phone number.
12) The name of the client for whom the project was conducted

g) A certificate, substantially in the following form, shall be affixed to all maps or reports (See sample report):
"I, _____, certify that this project was completed under my direct and responsible charge from an actual photogrammetric survey made under my supervision: that this photogrammetric survey was performed to meet Federal Geographic Data Committee Standards as applicable; that the imagery and/or original data was obtained on _____; that the photogrammetric survey was completed on _____; that contours shown as [broken lines] may not meet the stated standard; and all coordinates are based on _____.
h) An electronic copy of any digital data set delivered to the client shall be retained in the permanent files of the licensee.

1.4 Camera Requirements/Calibration Report

a) The aircraft shall be equipped with a precise aerial camera fitted with a 6" focal length and Forward Motion Compensation (FMC).
b) The photography shall be flown at 60% forward overlap and shall not contain any excessive tip, tilt, crab or cloud cover.
c) In areas where water bodies are under tidal influence, aerial photography shall be acquired within a time not to vary by more than 2 hours from the time of low tide.
d) Aerial photography shall be obtained when shadows are smallest and when the suns inclination angle is greater than 30?.
e) A current calibration report shall be supplied to the SCDOT.

1.5 Aerial Triangulation Report and Certification

The consultant shall use analytical aerotriangulation methods and procedures to extend and densify the ground control provided and establish the photo control required for photogrammetric map compilation as follows:

The analytical computations must result in a minimum root mean square (rms) error at the control points of one part in ten thousand (1:10,000) of the flight height (AMGL).

A minimum of nine precisely marked supplemental control points shall be established for each photograph, with six points located as near as possible to the corners and nadir point of the neat model.

All point marking of the film diapositives shall be accomplished using precision point transfer devices. All marks shall be drilled clearly through the emulsion of the diapositive, and excess waste material shall be removed carefully from the surface prior to the mensuration operation.

The locations of the supplemental and ground control points shall be measured using fully analytical instruments.

The computer software used shall contain a fully analytical block aerotriangulation program, and shall incorporate the capability to give appropriate weight factors to the control points on an individual basis, and to correct for film deformation, atmospheric refraction, Earth curvature and lens distortion.

Prior to the commencement of photogrammetric map compilation, the Consultant shall submit to SCDOT a Control Report detailing the results of the analytical aerotriangulation in the project area.

1.6 2D Topo Files Deliverables

The Topo 2D file should be saved from the original 3D file, where xyz coordinates represent all topographic features. Therefore, the seed file will be identical to the original 3D Topo file.

Also, DTM 2D file should be saved from the original 3D file, where the contours and triangles are represented on separate levels.

1.7 3D Topo and DTM Files Deliverables

The DTM 3D files should contain all spots, breaklines and the generated contours and triangles on separate levels.

1.8 Orthophoto Files

Digital orthophotos shall be developed from a perspective aerial photograph by differential rectification methods so that image displacements caused by camera tilt and terrain relief are removed.

Aerial negatives or diapositives shall be scanned using a precise image scanner. DTM or DEM may be used to rectify the images depending on the scope of the project by SCDOT.

The resampling of intensity values from the input image to the output one shall be accomplished using cubic algorithm or equivalent.

In case of multiple images, a mosaic shall be produced and image quality shall be uniform. All deliverables are to be in Tiff format accompanied by a TFW header.

1.9 TIN Preparation

The tin preparation is needed in order to be able to produce profiles and cross sections from the DTM file provided by the mapper. The design should adhere to the following procedures.

1. Do not extract points and breaks from the DTM File.
2. Extract only the triangles as breaks from the DTM.
3. Build the triangles from the .dat file and create the tin file.
4. Compare the GEOPAK triangle and contours to the mapper's triangle and contours.
5. If the triangles and contours match, the tin is verified and design work can proceed.

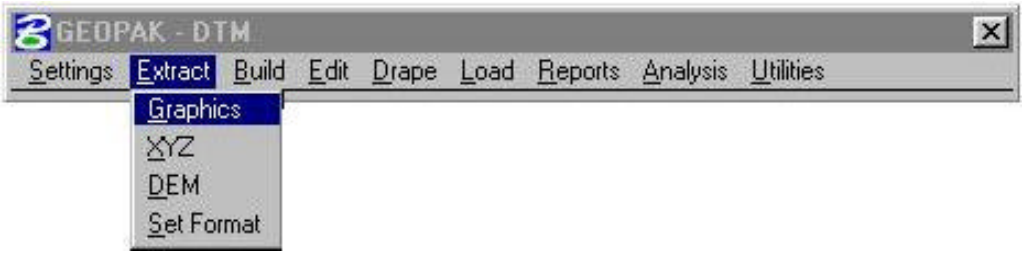
The following procedure outlines the steps needed to create the tin file.

1.9.1 Extraction from Mapping Triangles

Open the MicroStation file where the mapping data is located. In this case, open C:\Training**Mapdtm.dgn** and display triangles provided by the Mapper. Access the DTM menu by selecting **Applications > GEOPAK Road > DTM Tools** from the command bar. The DTM Tools dialog appears as shown below.

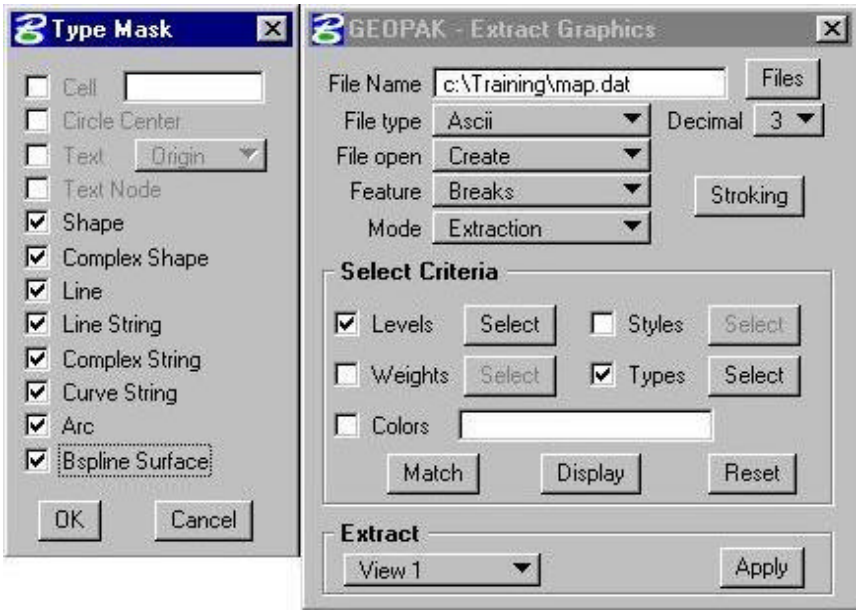
Open the DTM Menu by selecting the DTM Menu button on the palette.

From the DTM Menu tool bar, select the **Extract > Graphics** as shown below.



The **Extract Graphics** dialog box as shown below will be invoked. The File Name field identifies the DAT file that will be created. Key in the data as shown in the dialog below. We will extract the **Breaks** into **map.dat** file.

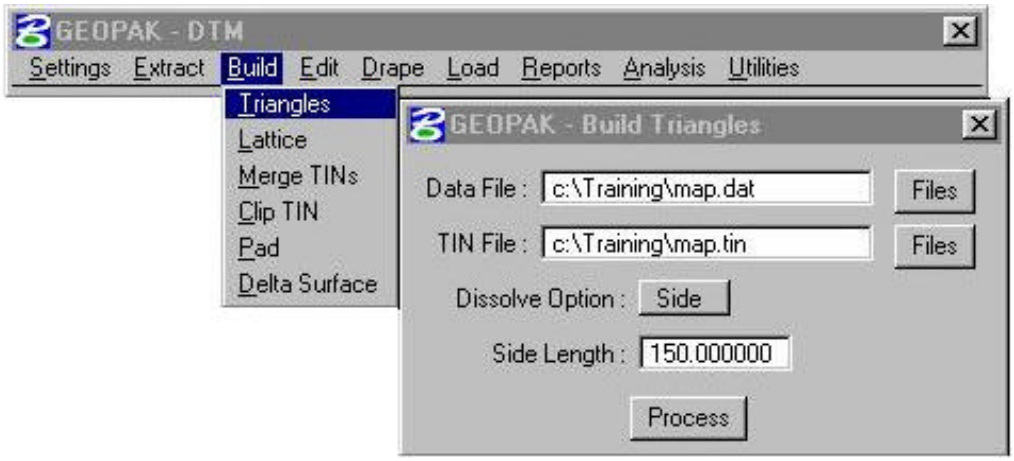
When one of the Select Criteria option boxes are tagged that Select button unghost and allows the setting of the mask. Refer to the Type Mask dialog box below. Since the feature option was set to extract the breaks, the type mask checked should match the attributes of the breaks as shown in the design file. Match the data as shown below and press **OK**.



The Type Mask dialog closes and returns the user to the Extract Graphics dialog. The graphics within the View indicated will be extracted and the *.dat file created. Make sure all the graphics have been fitted in the View and press the **Apply** button.

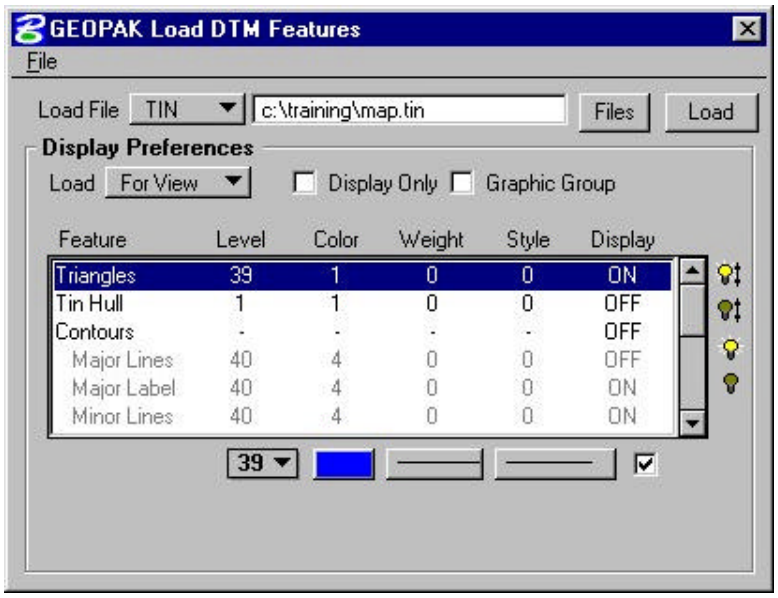
1.9.2 Building Triangles

Select the **Build Triangles** tool from the DTM 2000 tool bar as illustrated below, which invokes the dialog depicted below. The Data File and the TIN File are the files used as the source data from which the triangles are built. Match the dialog below and press the **Process** button.

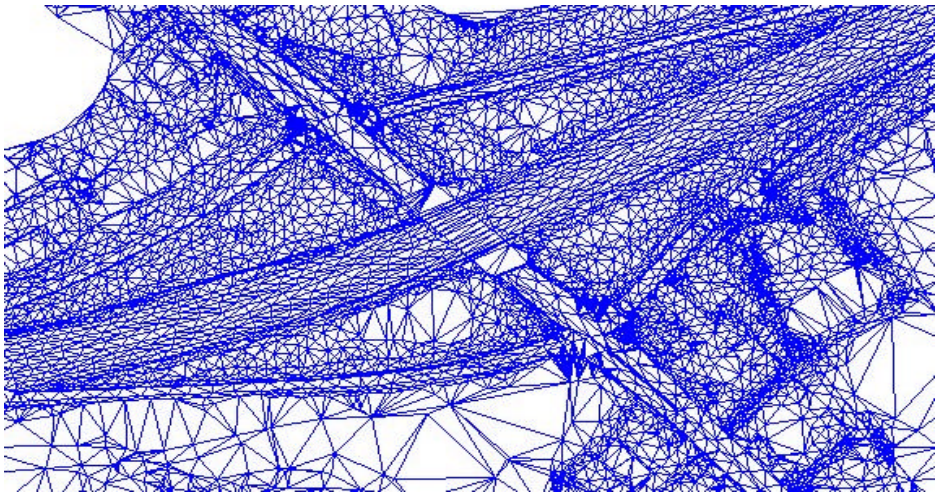


1.9.3 Drawing Triangles and Contours

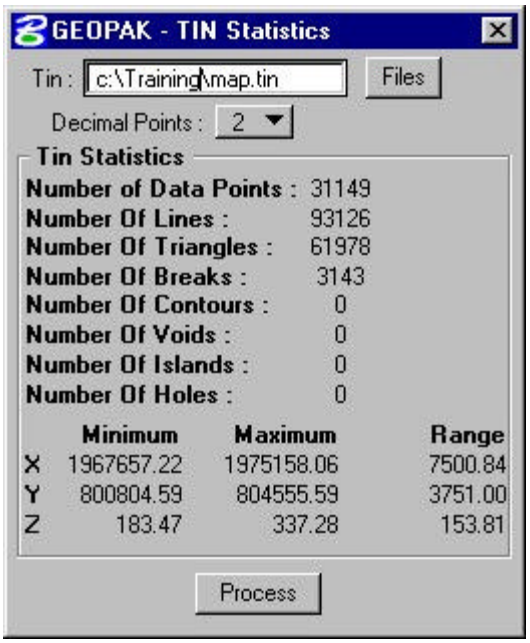
Select the **Load DTM Features** tool from the Survey DTM tool frame as illustrated above, which invokes the dialog depicted below.



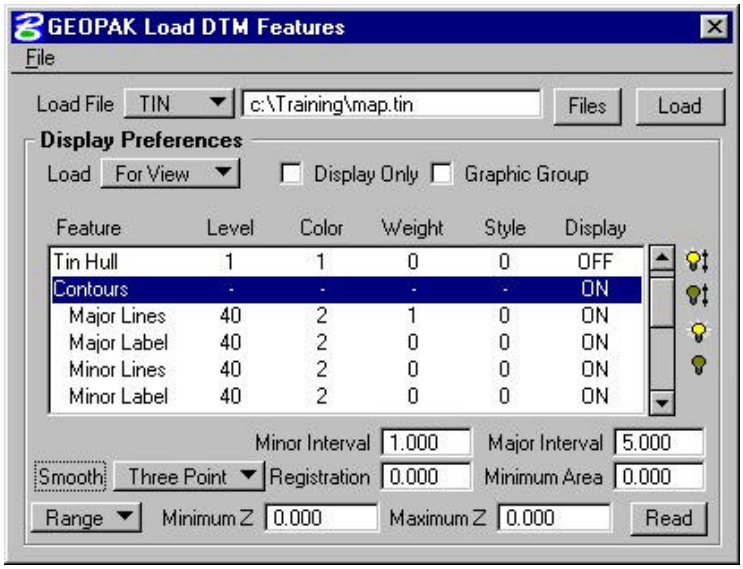
Change your settings to match those above and press the **Load** button in the upper right corner of the dialog. The Triangles will be drawn on level 39 in your MicroStation file.



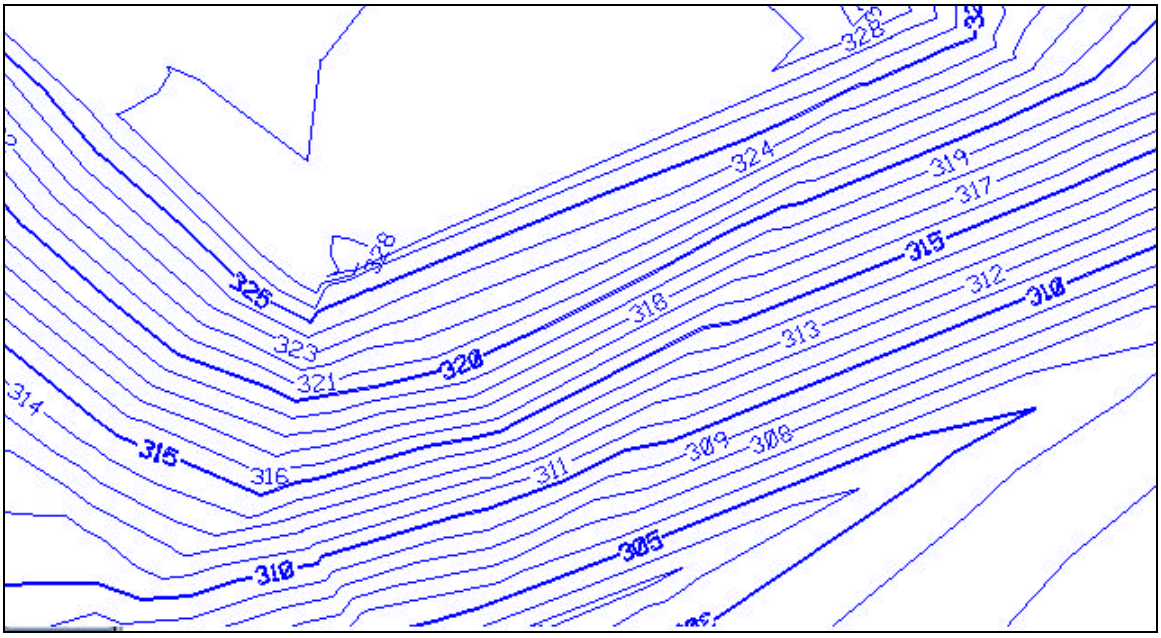
Select the **Triangles Statistics** tool from the **Reports** menu and the **TIN Statistics** dialog will display as depicted below. The Triangle Statistics tool displays the coordinate ranges of data points in a triangulation model as well as the total number of points, lines, and triangles, along with a plethora of other information about the model.



To draw the Contours in a design file, double click on **Contours**, **Major Lines**, **Major Label**, and **Minor Lines**, which dynamically changes the dialog as depicted below.



Press the **Load** button in the upper right corner of the dialog. Contours as depicted below are displayed.



1.10 QA/QC

The first QA/QC step is to ensure that the triangles and contours generated by GEOPAK Tin Match the ones provided by the mapper.

The second QA/QC step is to ensure that the DTM accurately represents the terrain. One way of checking this is to process a profile and association for a known baseline. Ensure that the profile on the centerline of the roadway and edge of pavement collected during the field surveys conducted during the mapping phase are accurately reflected in the Tin generated from the compiled DTM.

1.11 Aerial Mapping Deliverables

Preconstruction Surveying Consultants will deliver to the DOT files that are compatible with the Departments CADD and Plan Development Process. All Roadway Project within the Department are assigned a Project Pin Number. All files

submitted by the Consultant will be referenced to a Pin Number. The types of files and naming conventions are listed below and are examples of some of the files that might be requested by the Department. The examples shown assume a Pin Number of 123456.

123456.new

Primary Survey file containing all surveyed points. SMI format.

123456.alg

A file containing alignment points and is in a specific DOT format.

123456.txt

A GEOPAK alignment report of alignments created with GEOPAK. The GPK files are also required.

123456.dgn

A 2D Microstation Design file containing all project Planimetric Mapping.

123456prop.dgn

A 2D Microstation Design files containing all property boundaries. Also, all existing survey alignments with matching stationing from the latest SCDOT right of way files.

1234563d.dgn

A 3DMicrostation Design file containing all project Planimetric Mapping.

123456dtm.dgn

A 3D Microstation Design file containing all Breaklines, spot elevations, triangulation and contours.

123456op.tif

A Tiff format file containing the orthophoto files.

Note: Any additional surveys submitted for the same project will follow the same naming convention but will add an A, B, C, etc. Example: for the first additional survey the file name will be 123456a.new, the second additional survey will be 123456b.new etc.

* Other deliverables such as calibration report, aerial triangulation report will be submitted prior to commencing the mapping process. The photogrammetric certification project report should also be signed and certified by the responsible charge supervisor.

Chapter 2

SURVEY DATA COLLECTION AND PROCEDURES

2.1 Survey / Controls / Benchmarks / Accuracy

2.1.1 Preconstruction Surveying

2.1.1.1 General:

A South Carolina Registered Land Surveyor will be required to be directly responsible for the proper execution of the surveying work to be performed.

No survey work is to be performed on property from which right of way may be acquired without providing a public notification. This is to be done in accordance with the requirements of the Eminent Domain Procedures Act for the State of South Carolina. Other means of notification are needed if the work to be performed will be in areas that may cause concerns for security to residents and property owners.

The scope of the surveying work to be performed will be determined by the requirements for the design of the project and preparation of the right of way and detailed construction plans. The following is provided as supplemental information to other SCDOT requirements for the design and development of the project.

2.1.1.2 Aerial photography and mapping:

The general requirements for aerial photography and mapping from photography are provided in Chapter 1. The Preconstruction Surveys Engineer or the Assistant Preconstruction Surveys Engineer must approve any modifications.

Any mapping derived from aerial photography will be supplemented by ground surveying to insure that the mapping will provide sufficient information, detail, and accuracy needed for the project's design and development.

2.1.1.3 Surveying for right of ways:

A thorough search of the public record will be made to identify and review deeds and plats applicable to the boundaries of the properties that will be affected by the project. Instruments for easements and rights of way that are part of the public record will also be reviewed and identified. Where ground conditions indicate that there is a likelihood of the existence of easements or rights of way, sufficient contacts and research will be made to identify the easement or right of way.

An extensive search will be made to locate all property monuments on the ground that are referenced in deeds and/or survey plats that are part of the public record and will be within the limits of any new right of way or construction for the project. The monuments that are found will be located by survey and tied into the survey and mapping horizontal control.

Due to the large number of property parcels that are typically involved in acquisition of right of way for highway projects, a boundary survey is not normally performed for individual parcels. The property map for the project is generally developed by utilizing the position of the found monuments, the property boundary information in deeds and plats, ground evidence of ownership lines, information from property owners, and sources of information for right of way and easement lines.

Due to the practices and procedures used for developing the property map, breaks on any new right of way line for changes in width should be avoided at the parcel division property lines depicted on the right of way property map. In the event that this can not be avoided, the location of the property line by a boundary survey in accordance with the statutory requirements for land surveying will be necessary prior to physical location of any monument, fence, or other appurtenance whose location is controlled by this line.

The South Carolina State Board of Registration for Engineers and Surveyors has approached the SCDOT about making changes to its practices for right of way surveying. In response, SCDOT had reviewed these practices and submitted to the State Board the Department's recommendations. Upon agreement between SCDOT and the State Board, the changes will be incorporated into SCDOT's standard practice.

In preparation for the possible changes for right of way surveying, the Department may incorporate related requirements for right of way surveying into the scopes of work for selected projects.

2.1.1.4 Surveying for utilities:

The standard survey practice of accurately finding the location and elevation of all aboveground utility topography will be required for most projects. For other projects, where the location of underground utilities is considered critical to the design process, Subsurface Utility Engineering (SUE) services shall be used.

SUE is a method for identifying the location of subsurface utilities at various levels of quality. Each quality level is defined by the thoroughness, accuracy and methods used in gathering the subsurface utility information.

A representative of the Surveys/Utilities Office, working with the SUE firm as well as the Project Team, will determine the extent of utility delineation and appropriate quality levels needed based on the utility information available, utility risks and project budgetary constraints. Once the Department has contracted with the SUE firm for the required quality level(s), the SUE firm will be responsible for obtaining some or all of the following utility information in accordance with the current Department SUE Cadd standards, and will be responsible for the negligent errors of omissions in the data:

- ?? Utility ownership information for all utilities within the project limits,
- ?? Location of all underground utilities,
- ?? Location of all aboveground utility topography,
- ?? Location of all utility poles including identification number,
- ?? Location of all aerial utility facilities, and
- ?? Utility details as required by the standard utility data sheets.

The following are the four SUE quality levels as defined by the Federal Highway Administration (FHWA):

1. Quality Level D. This level information comes solely from existing utility records. It may provide an overall "feel" for the congestion of utilities, but it is often highly limited in terms of comprehensiveness and accuracy. Its usefulness should be confined to project planning and route selection activities.

2. Quality Level C. This level involves surveying visible aboveground utility facilities (e.g., manholes, valve boxes, posts) and correlating this information with existing utility records. When using this information, it is not unusual to find that many underground utilities have been either omitted or erroneously plotted. Its usefulness, therefore, should be confined to rural projects where utilities are not prevalent, or are not too expensive to repair or relocate.

3. Quality Level B. This level involves the use of surface geophysical techniques to determine the existence and horizontal position of underground utilities. This activity is called "designating." Two-dimensional mapping information is obtained. This information is usually sufficient to accomplish preliminary engineering goals. Decisions can be made on where to place storm drainage systems, footers, foundation and other design features in order to avoid conflicts with existing utilities. Slight adjustments in the design can produce substantial cost savings by eliminating utility relocations.

4. Quality Level A. This level involves the use of nondestructive digging equipment at critical points to determine the precise horizontal and vertical position of underground utilities, as well as type, size, condition, material and other characteristics. This activity is called "locating." It is the highest level presently available. When surveyed and mapped, precise plan and profile information are available for use in making final design decisions. By knowing exactly where a utility is positioned in three dimensions, the designer can often make small adjustments in elevations or horizontal locations and avoid the need to relocate utilities. Additional information (e.g., utility materials, condition, size, soil contamination, paving thickness) also assists the designer and utility owner in their decisions.

Refer to Appendix D for the SUE surveying codes.

2.1.1.5 Surveying for existing roadways:

On projects involving the improvements of existing roads, it is desirable to re-create the existing horizontal and vertical alignment. Existing stationing may be re-created or new stationing may be established. It may be advantageous to re-create existing stationing where feasible, thus making it easier to check plan data for "completion and correctness" from the final plans. Re-creation of the horizontal alignment will establish the exact position and limits of existing right of way, which is required in the development of final right of way plans. Should traffic create hazardous surveying conditions, offset baselines may be established and the roadway alignment and right of way may be compound with the aid of roadway centerline shots, property pins, right of way monuments, etc. If relocations are planned, alignments can be graphically depicted on prints of record plans with proposed horizontal curves and controls, as appropriate.

It is required to replace the existing Edge of Pavement (EOP) shots/breaks with ground surveys and delete the aerial mapping EOP breaklines.

2.1.2 Horizontal Control Survey Specifications

2.1.2.1 Primary control for the surveying and mapping

The surveying requirements for the horizontal and vertical control are provided below. These requirements may be modified if warranted by project conditions. The Preconstruction Surveys Engineer or the Assistant Preconstruction Surveys Engineer must approve any modifications.

2.1.2.2 Surveying Supervision and Responsibility

A South Carolina Registered Land Surveyor will be directly responsible for the proper execution of all surveying described in this scope of services to be provided by the consultant.

2.1.2.3 Surveying requirements for horizontal control

The most current Federal Geodetic Control Subcommittee (FGCS) standards for Geodetic Control Networks, unless otherwise specified in this scope, will apply to Level 1 and Level 2 horizontal control. All applicable requirements will apply, including those for instrumentation and field procedures. "Blue Book" format is not required for the data. The stated accuracy classification will be considered to apply to an equivalent or higher level of accuracy in any change that may occur in the FGCS classifications.

The most current FGCS specifications for "GPS Relative Positioning Techniques" will apply to control points established through the Global Positioning System (GPS).

2.1.2.4 Horizontal Control Accuracy

Level 1 – Second Order Class 1 or equivalent as defined by the FGCS.

Level 2 – Third Order Class 1 or equivalent as defined by the FGCS.

Level 3 – Supplemental horizontal control points whose position and azimuth orientation are constrained between the two control points classified as either Level 1 or 2 that are closest to the point being established. The maximum error of closure for a traverse between the constraining points will not exceed 1:10,000 of the traverse distance and 12 seconds in a closing azimuth to the next Level 1 or 2 point.

2.1.2.5 Horizontal Control Spacing

Level 1 – An intervisible pair of points, having a minimum horizontal distance of 1500 feet along their line of sight, will be established in the areas where the surveying and mapping for the project will begin and end. These intervisible pairs of points will then be established throughout the project at intervals not to exceed 10,000 feet.

Level 2 – Will be established throughout the project at sufficient locations whereby all design alignment change in direction or curvature points will be within a horizontal distance not to exceed 2000 feet from two control points classified as Level 1 or 2. Level 2 points will also be established at sufficient locations whereby the maximum horizontal distance between control points classified as either Level 1 or 2 will not exceed 2000 feet.

Level 3 – Will be established between points classified as either Level 1 or 2 whereby the horizontal distance between any 2 points classified as either Level 1, 2 or 3 does not exceed 600 feet.

2.1.2.6 Project Horizontal Datum and Ties to the National Geodetic Reference System

All surveying for Level 1 points will be tied to and constrained by points in the database for the National Geodetic Reference System that meet the requirements for First Order horizontal control points.

All surveying for Level 2 points will be constrained to the adjusted positions of points to Level 1 or higher accuracy.

All surveying for Level 3 points will be constrained to the adjusted positions of points to Level 2 or higher accuracy.

The final adjusted position of the Level 1, 2 and 3 control points will be determined by a Least Squares Adjustment, using only procedures and software that are known to provide reliable results compatible with the required survey accuracy.

Final coordinates for these control points will be South Carolina State Plane Coordinates on the NAD83 (86 adjustment) datum. The scale factor and convergence correction will be specific to the geodetic location of each measurement. A mean orthometric project elevation may be used, provided the ratio of the difference from the true elevation and the mean project elevation does not exceed 1:100,000.

An average combined scale and elevation factor will be determined from the Level 1 control points and may be used for coordinate determination of points surveyed from the Level 1, 2 or 3 control points.

2.1.2.7 Horizontal Control Markers

Level 1 Markers

Locations will be selected that are favorable to their future preservation for the purpose of locating the project right of way lines. Care needs to be taken to set these markers outside of the anticipated construction limits for the project.

These markers will consist of a 3.25-inch diameter aluminum survey cap anchored in concrete as illustrated by either the Option A or B schematic diagram. Caps will be stamped as illustrated by the "Survey Marker Cap – Horizontal Control (Level 1)".

Level 2 and 3 Markers

Will be marked at a minimum by a durable plastic survey cap stamped SCDOT and set flush with the ground on a 5/8 or 3/4 inch diameter rebar with a minimum length of 2 feet.

2.1.2.8 Documentation of Horizontal Control

All Level 1, 2 and 3 horizontal control points will be identified on the project design and right of way plan sheets. Each point will be identified by its level and a unique point number in the format of L1-4 where L1 designates the level and 4 is the point number unique to this Level 1 control point. A table of horizontal control points will be provided in the project plans with each point's identification, coordinates and combined scale and elevation factor. The table will include a heading that states the coordinates are South Carolina State Plane Coordinates on the NAD 83 (86) Datum.

In addition to the requirements covered under the SCDOT Highway Design Manual, a table of coordinates will be provided in the design plans for: all construction or right of way alignment (alignment to which the right of way line is referenced if different from the construction centerline) points where changes in direction or curvature occur, the PI and radius point of all curves and required POT points along alignment tangents. The table will provide a description of the point and in addition to the Northing and Easting coordinates, will include a column with the combined scale and elevation factor. The average project combined scale and elevation will be the average of the combined factors of the Level 1 horizontal control points.

The plan sheet that provides this information will include the Registered Land Surveyor's name, signature, and registration number; state the responsibility for surveying to establish the Level 1, Level 2, and/or Level 3 horizontal control; and certify that to the best of the surveyor's knowledge and belief, the data provided to locate the control and right of way alignment points by survey is correct.

2.1.3 VERTICAL CONTROL – BENCHMARKS

Elevation benchmarks will be established at intervals not to exceed 1,000 feet {English} or 300 meters {Metric} near the project alignments or baselines.

Level readings for benchmarks will be to the hundredth of a foot (0.01) {English} or to the millimeter (0.001) {Metric}.

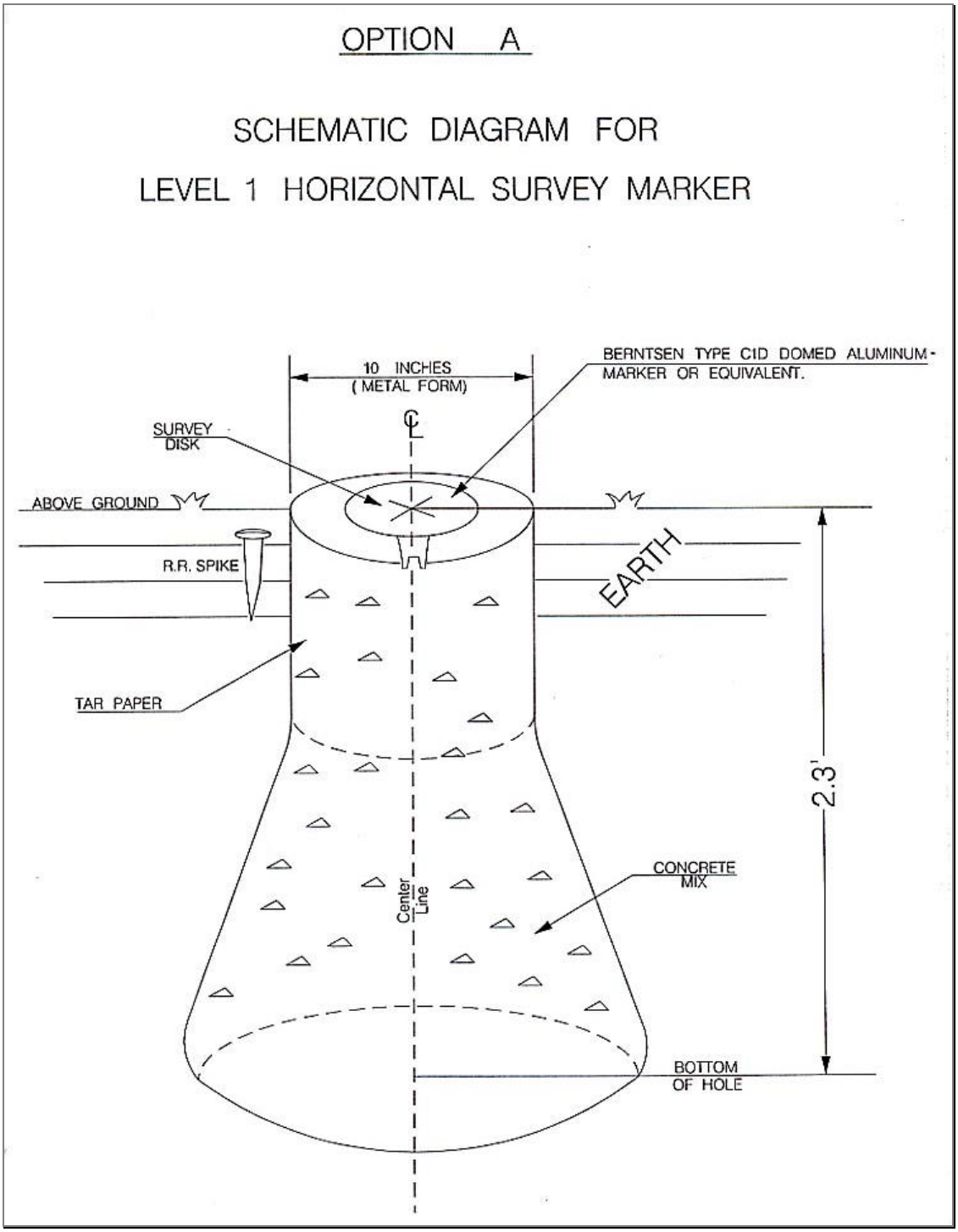
Level runs for the determination of benchmark elevations shall have third (3^{rd}) order closure: The maximum allowable error of closure for English unit surveys is 0.05 foot multiplied by the square root of the length of the level run in miles. The maximum allowable error of closure for Metric unit surveys is 12 millimeters multiplied by the square root of the length of the level run in kilometers.

The elevations will be tied to a minimum of one benchmark in the National Geodetic Control Network that is classified for a third order or better vertical accuracy. Further ties will be made to all National Geodetic Control Network benchmarks in the vicinity of the project that can be recovered.

The National Geodetic Vertical Datum (NGVD) of 1988 will be used unless otherwise specified. Any data that might be used from any previous projects must be verified for accuracy and vertical datum. Historically, some projects have been oriented to the North American Vertical Datum of 1929 and some to assumed datums.

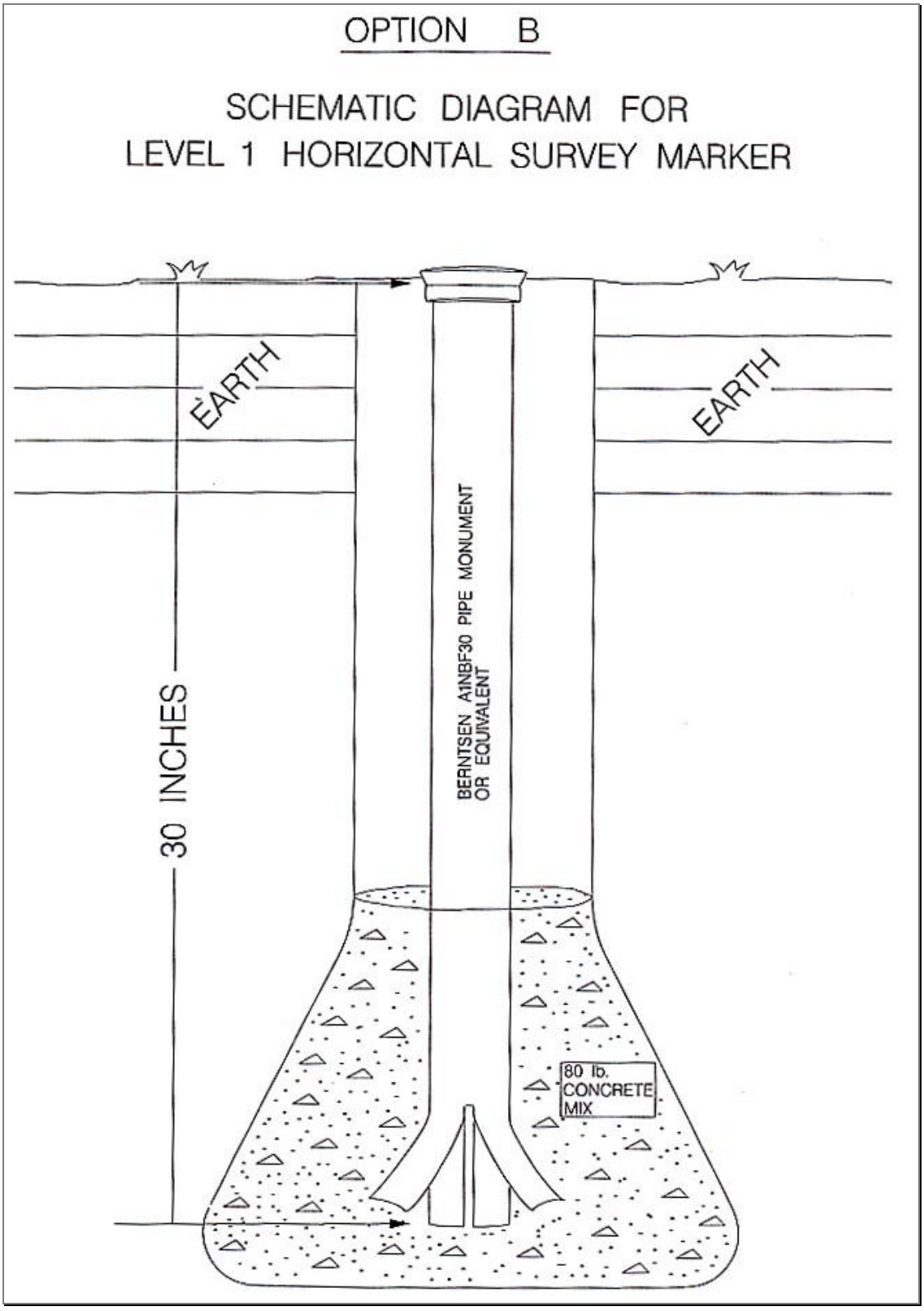
In addition to other requirements that may be specified under the SCDOT Highway Design Manual, a table will be provided within the design and construction plans, which lists all benchmarks set for the project. This table will state the vertical datum. For each benchmark, the following will be provided: an alignment or baseline station and offset reference, elevation, and description of the mark. Additionally, all elevations for National Geodetic Control Network benchmarks tied to will be documented.

2.2 Survey Monumentation



OPTION B

SCHEMATIC DIAGRAM FOR
LEVEL 1 HORIZONTAL SURVEY MARKER



SURVEY MARKER CAP

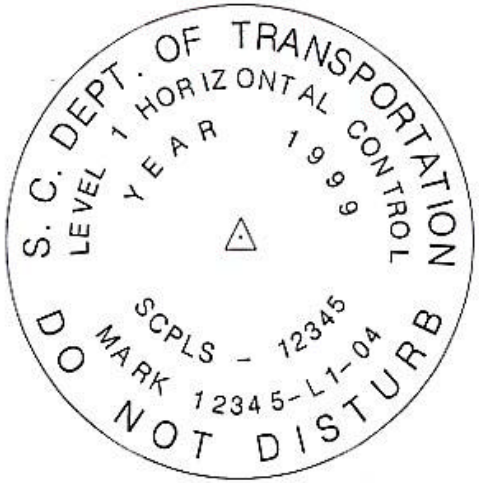
HORIZONTAL CONTROL (LEVEL 1)

82.5 MM (3.25") DIAMETER TOP

OUTSIDE ROW – 46 SPACES
4.8 MM (3/16") LETTERS

MIDDLE ROW– 35 SPACES
4.8 MM (3/16") LETTERS

INSIDE ROW– 35 SPACES
3.2 MM (1/8") LETTERS



TOP INSIDE ROW – YEAR MARK IS SET

BOTTOM INSIDE ROW – SCPLS REGISTRATION OF SURVEYOR IN CHARGE OF SURVEY

BOTTOM MIDDLE ROW – MARK ID NUMBER
(PIN NUMBER, DASH, L1, DASH, POINT NUMBER)

2.3 Shot Nomenclatures and Numbering

Electronic Survey Data Collection Feature Codes and Procedures

2.3.1 Section I

General Rules:

1) Features will be classified as either Single or Line.

   (A) Single is defined as a feature whose position can be defined by a single measurement or total station shot. For example, a tree would be in this classification.

   (B) Line is defined as a feature shown by a string or series of connected points. For this type of feature, the description, or code, of the first point should end with the letter A and the last point to designate the end of the line for the feature should end with the letter B. If the end of the feature cannot be located, such as an underground pipe, the letter Z along with a space is placed immediately after the B to note that the feature continues in the general direction of the shot given.

2) When taking shots and storing the data electronically, the shots applying to a particular line feature should be along a path where the order of the shots is the same as the order in which they would be graphically connected. When working with line features, think of the prism pole as a pen drawing a line on the plan sheet for the points that apply to that particular feature. Shots for different features can be intermixed. The rule for the order of shots applies only to the line feature.

   Example: The first shot of a segment of line to show the left edge of pavement would have the note EPLA. The next shot could then be a tree with the note T, or any other feature. Then if the next shot you wanted to take was again on the left edge of the pavement and an intermediate point along the line of EPL points to be connected starting at the preceding EPLA, the note should be EPL. You would continue this procedure until you get to the last EPL point that would end the line and the note EPLB would be used for this point. If you then need to store another segment of line to show the edge of pavement, follow the same procedure, starting with the EPLA note on the beginning point and EPLB for the ending point with EPL used in between.

3) For line items that continue beyond the last point being shot, the letter Z, separated by a space, following the B indicates that the feature continues, but this is the last shot provided in the survey data.

4) The codes used in the description for electronic data submitted to headquarters office must be identical to the codes described herein in order for the CADD system to recognize the applicable features. Except for use of the letters A, B, or Z for line features, nothing else can be in or immediately next to the feature code unless it is separated from the code by a space at the end of the code. Example: POT 123+86 where a space separates the Pot feature code from the station number.

5) Any additional description needed to describe the point can be placed after the feature code provided a delimiter separates it. This will include such information as size and type of a pipe, size and type of a tree, height and type of a fence etc.

2.3.2 Section II

Feature Codes:

Following is a list of features and codes by a general area that would characterize the feature, such as fences or vegetation. Also, the classification of the features as either single or line is given.

Special Notes

VOID	Ignore this Point	
MSP	Miscellaneous Point	Single
MSL	Miscellaneous Line	Line

Alignment and Control

POT	Point on Tangent	Single
POST	Point on Sub Tangent	Single
PC	Point of Curve	Single
PI	Point of Intersection	Single
PT	Point of Tangency	Single
RP	Radius Point Of Curve	Single
PRC	Point of Reverse Curve	Single
PCC	Point of Compound Curve	Single
ICL	Intersecting Road Centerline	Line
ODL	Outfall Drainage Line	Line
CP	Control Point	Single
BM	Bench Mark	Single

FEATURE CODE TABLE

Profile and Cross Sections

CLP	CL Profile (No Cross X-Section)	Single
CL	CL Profile (Will Have X-Section)	Single
X	Cross Section Shot	Single
XL	End of X-Section Left	Single
XR	End of X-Section Right	Single
OF	Outfall Drain Flow Line Profile	Single

Buildings

B	Building	Line
STP	Steps	Line

Drainage

Special Note: The letter Z and a space immediately after the end of line designation means the ending point is beyond the point being stored.

P	Pipe	Line
BRC	Bridge-Concrete	Line
BRW	Bridge-Wood	Line
CVL	Culvert	Line
HW	Headwall	Line
WW	Wingwall	Line
CBN	Catch Basin	Single
DI	Drop Inlet	Single
MHD	Man Hole-Drainage	Single
JB	Junction Box	Single

Fences

FL	Fence-Left	Line
FR	Fence-Right	Line

Sidewalks

SW	Sidewalk to the Road	Line
SWL	Sidewalk Left of C/L	Line
SWR	Sidewalk Right of C/L	Line

FEATURE CODE TABLE

Columns

C	Column	Single

Walls

W	Wall	Line

Utilities

MHU	Man Hole-Utility	Single
UGC	Underground Cable	Line
UGT	Underground Tank	Single
AGT	Above Ground Tank	Line
GPI	Gas Pump Island	Line
AC	Air Conditioner Unit	Single
TCW	Tower (Radio/TV) Residential	Single
PP	Power Pole	Single
TP	Telephone Pole	Single
LP	Light Pole	Single
GP	Guy Pole	Single
GW	Guy Wire	Single
TPP	Telephone Pedestal	Single
EPP	Electrical Pedestal	Single
TVP	Cable TV Pedestal	Single
SS	Sanitary Sewer	Line
MHS	Man Hole-Sanitary Sewer	Single
FH	Fire Hydrant	Single
WM	Water Meter	Single
WV	Water Valve	Single
WL	Water Line	Line
GL	Gas Line	Line
GV	Gas Valve	Single
GM	Gas Meter	Single
GLT	Gas Line Test Point	Single
ST	Septic Tank	Line
TG	Telegraph Pole	Single
TW	Perimeter of any Commercial Tower. Also Power Lines.	Line
SAT	Satellite Dish	Single

FEATURE CODE TABLE

Roads And Drives

EPL	Edge of Pavement Left	Line
EPR	Edge of Pavement Right	Line
ERL	Edge of Dirt Road Left	Line
ERR	Edge of Dirt Road Right	Line
CFL	Face of Curb Left	Line
CFR	Face of Curb Right	Line
D	Edge of Dirt Driveway	Line
DP	Edge of Paved (Asphalt) Driveway	Line
DC	Edge of Concrete Driveway	Line
MCL	Misc. Curb Left of C/L . A Sketch should be sent in to Detail this Item	Line
MCR	Misc. Curb Right Of C/L. A Sketch should be Sent in to Detail this Item	Line
VGL	Valley Gutter-Left	Line
VGR	Valley Gutter-Right	Line
MDC	Median-Concrete	Line

Property and Legal Lines

IP	Iron Pin Found	Single
PLC	Property Line Corner (Computed) or Ground Evidence	Single
PL	Property Line (shot on line)	Line
RWE	Right of Way Line Existing	Line
CMT	Concrete Monument	Single
RWM	Right of Way Monument	Single

Vegetation

T	Tree	Single
TL	Tree Line or Woods Line Left	Line
TR	Tree Line or Woods Line Right	Line
OT	Orchard Tree (Apple,Pecan,Etc.)	Single
OTL	Orchard Tree Line Left	Line
OTR	Orchard Tree Line Right	Line
S	Shrub	Single
SL	Line Row of Shrubs	Line
F	Flower Bed	Line
H	Hedge Row	Line

FEATURE CODE TABLE

Railroads

RR	Railroad Track	Line
RRS	Railroad Signal	Single
RRX	Railroad Crossing Arm	Single
RRM	Railroad Mile Post	Single
RRT	Railroad Trestle	Line

Other

GR	Guard Rail	Line
SN	Sign	Line
SP	Sign Post	Single
WEL	Well	Single
SPR	Spring	Single
CRR	Creek Bank Right	Line
CRL	Creek Bank Left	Line
DTR	Ditch Right	Line
DTL	Ditch Left	Line
BDR	Berm Ditch Right	Line
BDL	Berm Ditch Left	Line
DAM	Dam	Line
SWP	Swamp Line	Line
MAR	Marsh Line	Line
WE	Edge of Water	Line
WH	High Water Line or Mark	Single
GRV	Grave or Cemetery	Line
CEM	Cemetery	Line

FEATURE CODE TABLE

New Codes Added After January 1990

EP	Additional Edge of Pavement	Line
RR	Additional Railroad Track	Line
P	Additional Pipe	Line
MSL	Additional Misc. Line	Line
GRV	Grave	Line
XP	Edge of Pavement On X-Sect.	Single
ETB	Electric Transformer Box	Single
FOL	Fiber Optic Line	Line
TBX	Telephone Box	Single
SPL	Service/Meter Pole	Single
SSC	Sanitary Sewer Cleanout	Single
WTS	Utility Witness Marker	Single
GEO	Geodetic Survey Marker	Single
FLT	Flood/Ground Light	Single
SPK	Sprinkler	Single
SPG	Water Spiget	Single
PLT	Planter	Line
RSB	Railroad Signal Box	Single
WMW	Water Monitoring Well	Single
CNP	Canopy	Line
CPD	Concrete Pad	Line
FLAG	Flag Pole	Single
MP	Service / Meter Pole	Single
CAP	Fill Cap for Underground Tank	Single

Note: Please see code description of TCW, and TW under utilities. TCW will be used to locate any residential TV or radio tower as a single shot. The code TW will be used as a line code to show the perimeter of any commercial tower (Water, Electrical, Microwave Etc.). TW should also be used to show any high voltage power lines.

All line codes can have an additional 1,2,3,4 added to create four additional codes, if needed. Example: the code for pipe (P) can also be P1, P2, P3, P4.

FEATURE CODE TABLE

Breaklines: Added April , 2002

During the first quarter of 2002, preconstruction surveys felt it was time to move toward collecting breaklines and spot elevations as our standard method of providing ground data on our surveys. It was determined that given our current organization the best way to provide this data was to create two separate ASCII coordinate files. One file containing coordinates and codes that describe all the planimetric features on a project and a second file containing coordinates and codes that describe breaklines and spot elevations. In most cases planimetric line and single point codes have correct elevations that can be used in both ASCII files. A small number of additional breakline codes will be added to supplement existing codes. The following are new codes that will be used to describe breakline features.

CRW	Crown of Paved Road or Street	Line
TC	Top of Curb	Line
BSW	Back Edge of Sidewalk	Line
TS	Top of Slope	Line
BS	Bottom of Slope	Line
BL	Misc. Breakline	Line
ODL	An Existing Code that will be used for all Roadway and Outfall Ditch Flowlines.	Line
X	Code used in breakline surveys as a spot elevation.	Spot

Note: As With All Line Codes An Additional 1,2,3,4, Can Be Added.

FEATURE CODE TABLE

2.3.3 Section III

Application of Feature Codes, Field Procedures and Additional Information Needed

Special Notes

VOID: Instructs the data processing system to not use the point. This can be useful during the field survey to shoot back on control points when doing TOPO or cross sections to check for proper instrument orientation. For example, the note void CP11 indicates that the shot is a check shot back on control point number 11. This note should also be used to mark points with incorrect data rather than erasing the point from the file.

MSP: Miscellaneous Point can be used for any point for a feature not coded. MSP must be followed first by a space and then a sufficient description to identify the feature.

MSL: Miscellaneous Line can be used to define and locate a line feature not coded. Any MSL should begin with MSLA and end with MSLB. The starting MSLA must be followed by a space and then a sufficient description to identify the feature.

Alignment and Control

For a project with more than one alignment such as intersecting roads or interchange loops the different alignments should be numbered. The appropriate alignment number should follow the feature code separated by a space. Not necessary if project only has one alignment.

POT	Point on Tangent
PC	Point of Curve
POC	Point on Curve
PI	Point of Intersection
PT	Point of Tangency
RP	Radius Point of Curve
PRC	Point of Reverse Curve
PCC	Point of Compound Curve

ICL: Intersecting Road Centerline to define the alignment of an intersecting road without the establishment of horizontal curve points. Also used for 300 ft profile along intersecting roads.

ODL: Outfall Drainage Line. Used as a breakline to define the flow line of roadway and outfall ditches. It may be random shots along the drainage line as needed to show its alignment and fall.

CP: Control Point.

BM: Bench Mark. Should be followed by the BM number separated by space from code. BM ties and descriptions should still be submitted as hand field notes.

Profile And Cross Sections

CLP: CL Profile (No Cross X-Section)

CL: CL Profile (Will have X-Section). Give station number at least at 500 FT intervals in additional description.

X: Cross Section Shot.

XL: End of X-Section Left.

XR: End of X-Section Right.

Buildings

B: Building. After first shot BA, identify type of building in description after space. For example, the description "BA R" would designate the first point shot on a residence. Other shots on this particular building only need the Code B until you get to the last shot which would be BB. The following may be used to designate the type of building after the BA SPACE: R (Residence) BU (Business) STO (Storage) SH (Shed) HT (House Trailer) G (Garage). If the building is rectangular, you only need to get three corner shots.

STP: Steps. Need shot on each side of bottom step with number of risers in additional description.

Drainage

Special Note: The letter Z and a space following the letter B for the end of line designation means the ending point is beyond the point being stored.

P: Pipe. Should have type and size after space for first shot PA. For example PA 18RC designates the beginning shot on a line of 18 inch reinforced concrete pipe. All shots should be given on the flow line. If shot can't be on flow line, it should be designated with NFL in the additional description. The following may be used in the additional description after the first point coded PA to designate the type of pipe: RC (Reinforced Concrete Pipe), CM (Corrugated Metal Pipe), CI (Cast Iron Pipe), TC (Terra Cotta Pipe), AF (Asphalt Fiber Pipe), PVC (PVC Pipe).

BRC: Bridge-Concrete. Shot needed on each corner of the bridge.

BRW: Bridge-Wood. Shot needed on each corner of the bridge.

CVL: Culvert. Shot needed on each of four corners. Culvert sketches are still needed with hand written field notes.

HW: Headwall. Shot needed on each end.

WW: Wingwall. Shot needed on each end.

CBN: Catch Basin. If it has a manhole, give shot at center of manhole, if type 1, shot at center of face of hood at the gutter line. If no manhole and not type 1, shot at center of top. Type of catch basin should be given in additional description.

DI: Drop Inlet. Shot at center. Size in additional description.

MHD: Man Hole-Drainage. Shot at center.

JB: Junction Box. Since this cannot be located on the ground surface, this would normally be a calculated location. Typically the basis for giving this would be from information on plans of previous projects, or other maps showing existing drainage systems. Since the location is usually estimated, and the existence of a junction box can usually only be determined by excavation, a "?" should be placed in the additional description.

Fences

The FLA or FRA points designate the beginning of a fence line. Will need additional description to designate the type of fence. The remaining points along the line do not require additional description. For example "FRA C48" means the first shot on a line of 48-inch chain link fence right of the survey centerline. The following abbreviations may be used in additional description to designate the type of fence: C (Chain Link), B (Board), W (Barbed Wire), S (Split Rail), O (Other).

FL: Fence-Left.

FR: Fence-Right.

Sidewalks

SW: Sidewalk to the Road. For example, a sidewalk from a residence to the road. The first edge of the sidewalk in relation to the centerline stationing is the one to shoot. The width and type of material, if other than concrete, will be defined by additional description. SWA 48 would mean the first shot of a 48-inch wide concrete sidewalk to the road. SWA 48BR would indicate 48-inch wide brick.

SWL: Sidewalk Left of C/L. Designates sidewalk left of the road centerline following the direction of the road. Only need to shoot the closest edge. If sidewalk width is different than 54 in. (4.5 FT) and/or material is other than concrete, the width in inches and/or material should be given by additional description.

SWR: Sidewalk Right of C/L. Same rules as for SWL except sidewalk is right of the road centerline.

Columns

C: Column. One shot at the center of the face closest to the road. Additional description should give dimensions and type of material. For example, C 24X24BR would be a brick column 24 inches square.

Walls

W: Wall. First shot coded WA for beginning of wall line should give material and height. For example, WA BR48 will mean the first shot on a line of brick wall 48 inches tall. As long as the wall remains the same material and approximate height, remaining description only needs to be W until you get to the end, which will then be WB to end the line.

Utilities

MHU: Man Hole-Utility. Shot at center.

UGC: Underground Cable. Shows the approximate location of a line of underground utility cable. First point to start the line (UGCA) should provide additional description. "UGCA ELEC" would identify it to be an electrical cable. "UGCA TEL" would identify it to be telephone cable.

UGT: Underground Tank. Give shot on the fill cap of the tank.

AGT: Above Ground Tank. Define by giving 4 shots, one at the horizontal position of each corner of a plane through the center of the tank.

GPI: Gas Pump Island. Need two shots, one at each end of the side facing the survey centerline. Provide width by additional description.

AC: Air Conditioner Unit. One shot at closest point to survey centerline.

TCW: Tower (Radio/TV). One shot at the point closest to the survey centerline.

PP: Power Pole. One shot at the point closest to the survey centerline. Give pole number if available in additional description.

TP: Telephone Pole. One shot at the point closest to the survey centerline. Give pole number if available in additional description.

LP: Light Pole. One shot at the point closest to survey centerline.

GP: Guy Pole. One shot at the point closest to the survey centerline.

GW: Guy Wire. Shot at the point where wire is fastened to ground.

TPP: Telephone Pedestal. Shot at the point closest to the survey centerline.

EPP: Electrical Pedestal. Shot at the point closest to the survey centerline.

TVP: Cable TV Pedestal. Shot at the point closest to the survey centerline.

SS: Sanitary Sewer. Give size, if known in additional information. If shot is at the flowline, designate by placing FL in additional information. For example, "SS 6FL" means a 6-inch diameter sanitary sewer line with the point elevation equal to the flow line.

MHS: Man Hole-Sanitary Sewer. Shot at center.

FH: Fire Hydrant. Shot at the point closest to the survey centerline.

WM: Water Meter. Shot at the center of the top cover.

WV: Water Valve. Shot at center of the top cover.

WL: Water Line. Shot on ground at approximate location of underground water line. First point on line should be WLA. If size of line is known, give in additional description after WLA. End of points shot to locate line should be WLB or WLB Z.

GL: Gas Line. Shot on ground at approximate location of underground gas line. First shot should be GLA and the last point to be shot should be GLB or GLB Z.

GV: Gas Valve. Shot at center of valve cover.

GM: Gas Meter. Shot at center of gas meter.

GLT: Gas Line Test Point. Shot at center.

ST: Septic Tank. Approximate outline of tank should be shot with four shots.

DF: Underground Drain Fields. Shot approximately at each end using DFA and DFB or DFB Z with DF given between as needed.

TG: Telegraph Pole. Shot at point nearest survey centerline.

TW: Power Line Transmission or Microwave Tower. Need point for each of four corners. Also, high voltage power lines.

SAT: Satellite Dish. One shot at point closest to survey centerline.

Roads and drives

EPL: Edge of Pavement Left.

EPR: Edge of Pavement Right.

ERL: Edge of Dirt Road Left.

ERR: Edge of Dirt Road Right.

CFLL: Face of Curb of Curb and Gutter along the Left Side of the Survey Centerline. Give shot at the gutter point of the face. Additional description with the first point CFLA should identify whether it is 18 inch or 24 inch wide type. This only needs to be given with the point to start the line.

CFR: Face of Curb of Curb and Gutter along the Right Side of the Survey Centerline. Location of shot and additional description same as CFL.

D: Edge of Dirt Driveway.

DP: Edge of Paved (Asphalt) Driveway.

DC: Edge of Concrete Driveway.

MCL: Misc. Curb Left of C/L. A sketch should be sent in to detail this item. If curb is ogee type, first point for line should be "MCL OGEE".

MCR: Misc. Curb Right of C/L. A sketch should be sent in to detail this item.

VGL: Valley Gutter-Left. Used for a paved ditch. Give shot at flow line point and provide additional description with VGLA to identify width and paving material. If width changes appreciably at other points, give different widths in additional description.

VGR: Valley Gutter-Right. Same as VGL except to the right of survey centerline.

MDC: Median-Concrete. Give shots around the perimeter with the last shot closing back at the first point.

Property and Legal Lines

The ability to determine the location of property corners and lines during the field survey is dependent upon varying ground evidence conditions, availability of recorded property plats, and availability of deeds and property descriptions that can readily be identified on the ground from available evidence. Due to the flexibility that must be afforded, the survey crew chief is to apply his judgment for the conditions that apply to each land parcel. Codes alone cannot be expected to fully describe property boundaries.

The following codes apply to coordinate points stored in the electronic data file. This data must still be accompanied by field drawings by the survey crew of property, copies of plats, tax maps, or other available documents that can relate property boundaries to the highway project. These drawings, plats, etc. should have the point numbers labeled on them at the points' corresponding location.

Due to this cross reference, placing the point number in the description as additional information after the feature code will provide assistance if the point number is changed from the number put on the drawing. The previous point number would still be retained in the description. It will probably be best to do this on the personal computer in the crew office by typing the point numbers at the end of the descriptions for any points cross referenced to drawings or documents by point number. This should be done in the as CII file prior to using the renumbering program.

IP: Iron Pin Found. This applies to any property corner monument found not specifically coded. If the monument is not an Iron Pin, it should be identified by additional description. For example, "IP RRSPIKE" would designate the monument to be a railroad spike, and "IP ROCK" would show a rock used as a property monument.

PLC: Property Line Corner (Computed). This is a point that has been computed from information on a plat, deed, etc. that relates boundary lines and can be tied to the survey datum. Computed by coordinate geometry and stored in survey coordinate database.

PL: Property Line (Shot on Line). Needs a minimum of two points with a PLA to start the line and a PLB or PLB Z to end. This will be useful for fence lines or other ground features that are used as the property line.

RWE: Right of Way Line Existing. A line feature starting with RWEA and ending with RWEB or RWEB Z.

CMT: Concrete Monument. Give shot at the center of the monument or at the point considered to be the boundary point.

RWM: Right of Way Monument. Give shot at the center.

Vegetation

Any Vegetation whose species, size, or other distinguishing characteristics are judged to have possible significance to the design of the road and/or to have particular interest to parties involved in right of way acquisition need to provide additional distinguishing information. For example, a 48-inch diameter oak tree in the possible construction area in front of a residence would have the description "T 48OAK"

T: Tree.

TL: Tree Line or Woods Line Left.

TR: Tree Line or Woods Line Right.

OT: Orchard Tree (Apple,Pecan,Etc.).

OTL: Orchard Tree Line Left.

OTR: Orchard Tree Line Right.

S: Shrub.

SL: Line Row of Shrubs.

F: Flower Bed.

H: Hedge Row.

Railroads

RR: Railroad Track. If track crosses the centerline, need to give shots on each rail for a distance of 300 feet or other specified distance left and right of the survey centerline. Each rail must be completed from beginning to end before another rail can be recorded. If the tracks are left or right and in the general direction of the survey centerline, shots are needed on the rail closest to the survey centerline only.

RRS: Railroad Signal. Shot on post at edge point closest to survey centerline.

RRX: Railroad Crossing Arm. Shot on post at edge point closest to survey centerline.

RRM: Railroad Mile Post. Give mile number in additional description.

RRT: Railroad Trestle. Give four shots to define the four corners of the trestle beginning with RRTA and ending with RRTB.

Other

GR: Guard Rail. Give shots along the edge of the guardrail closest to the survey centerline.

SN: Sign. Apply to a wide sign such as a billboard to define each end with SNA and SNB

SP: Sign Post.

WEL: Well. Give shot at point on ground closest to the survey centerline. Provide additional information as needed. For example "WEL PUMP" would designate a well with a pump and "WEL OPEN" would designate an open well. If the well has a pump house, a point is needed for the well and then the pump house needs to be shot as a building.

SPR: Spring. Will usually be used with a group of single points to define a spring.

CRR: Creek Bank Right. Shot at the top of the bank. This can apply to either edge of the creek bank and allows both edges of the creek bank to be surveyed without having to complete the survey for each edge line separately.

CRL: Creek Bank Left. Apply the same as CRR.

DTR: Ditch Right. May be used with the "ODL" (see alignment and control) to locate one of the edges of an existing ditch along the survey ODL. Start with DTRA and end with DTRB or DTRB Z.

DTL: Ditch Left. Used with ODL in conjunction with DTR to define the other edge of the ditch. Start with DTLA and end with DTLB or DTLB Z.

BDR: Berm Ditch Right. Generally applies to the top edge of a berm ditch to the right of the survey centerline. If the BDR line should cross the centerline to the left for such a case as where the centerline leaves an existing roadbed, you should continue using the same code to extend the line. The fact that it crosses over to the left will not be a problem. Should begin with BDRA and end with BDRB or BDRB Z.

BDL: Berm Ditch Left. Apply the same as BDR except for the case where the berm ditch starts off to the left of the survey centerline.

DAM: Dam. Used to define the toe of the embankment for a dam where water is impounded away from the survey centerline. If the centerline is on the dam, the shot should be given at the top edge of the embankment on the side of the centerline where water is impounded.

SWP: Swamp Line. Used to define the edge of a swamp. Begin with SWPA and end with SWPB or SWPB Z.

MAR: Marsh Line. Used to define the edge of a marsh. Begin with MARA and end with MARB or MARB Z.

WE: Edge of Water. Used to define the edge of a body of water. Begin with WEA and end with WEB or WEB Z.

WH: High Water. Single shot at a high water mark.

LC: Clothes Line. Begin with LCA and end with LCB.

GRV: Grave. Shot to locate a single grave. Give shot at the point that appears to be closest to the survey centerline. Should be used in conjunction with CEM (Cemetery) to show graves that may be affected by the project.

CEM: Cemetery. Defines the edge of a cemetery. Begin with CEMA and end with CEMB or CEMB Z. Use GRV (Grave) as needed.

2.4 Break Lines / Spots / DTM Input

The feature codes reference which shots are not included in the DTM, included as a spot in the DTM, included as a break in the DTM or included simply as a void in the DTM. These codes correspond to the SMD files prepared for the survey processing from the Raw ASCII files. Refer to "Appendix E" for the feature code table.

2.5 Introduction to GEOPAK Survey

2.5.1 Introduction

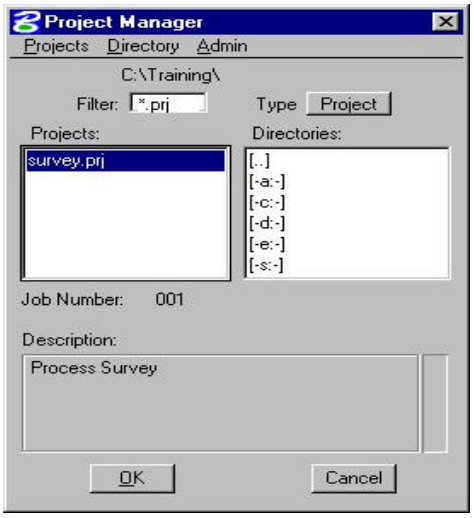
SCDOT uses SMI Survey Software for the collection, PC Survey for the processing of the survey data and GEOPAK for the mapping of the data. Refer to GEOPAK for more information on GEOPAK Survey Software.

2.6 Processing Survey File

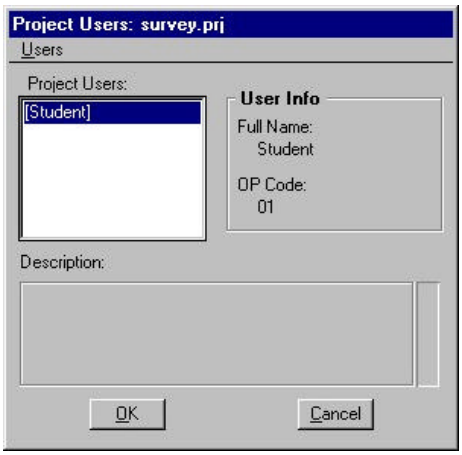
2.6.1 Processing Topographical Data in a 2d Design File

2.6.1.1 Accessing Project Manager

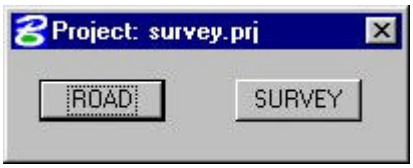
Open the MicroStation file C:\Training\228752d.dgn and access the Project Manager dialog by selecting Applications > GEOPAK Survey > Project Manager from the command bar. The Project Manager dialog appears as depicted below. Highlight survey.prj as shown in the dialog below and press the OK button.



Highlight user **Student** as shown in the dialog below and press the OK button.

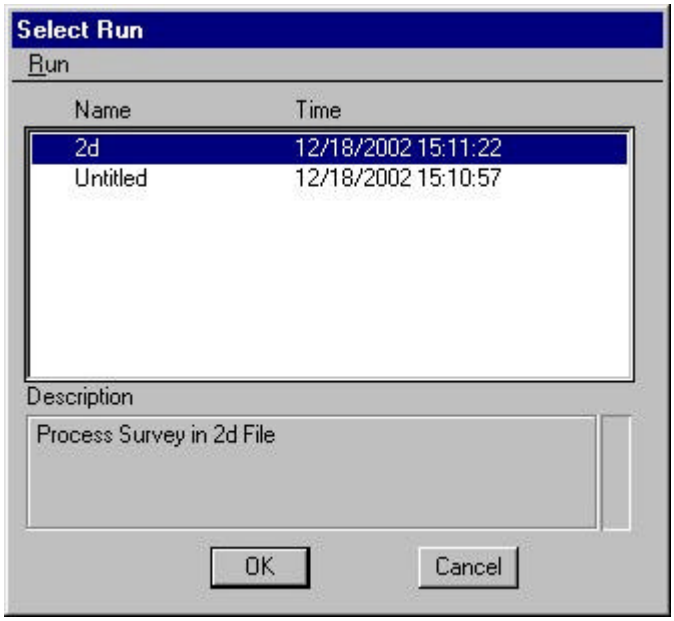


Once the user has been selected, the following project dialog box will open. Chose the Survey button to activate GEOPAK Survey.



To select the desired run, highlight 2d as shown in the dialog below and press the OK button. This will open two dialog boxes:

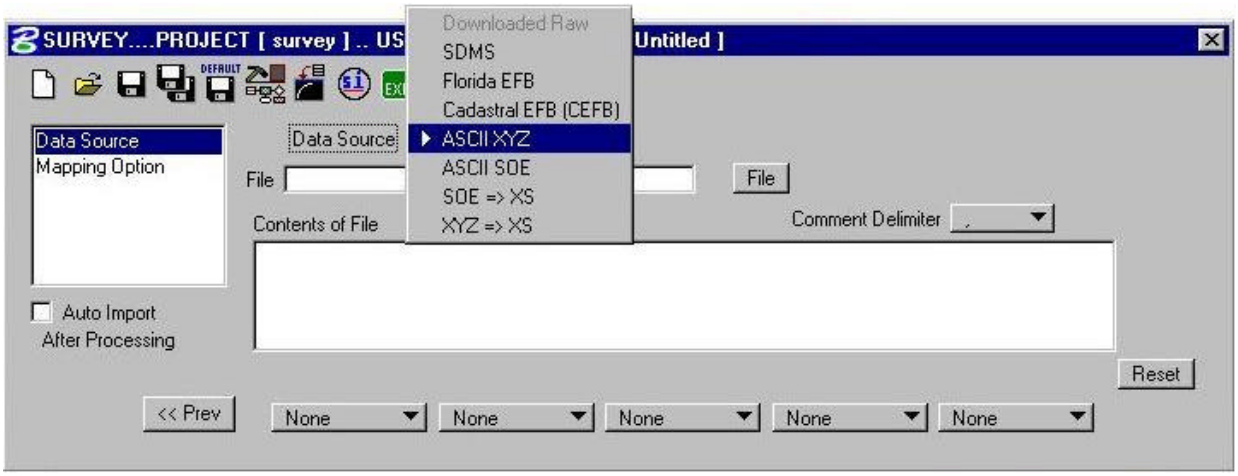
?? Survey … 2d
?? Survey Operations


Select Run
Run
Name
Time
2d
12/18/2002 15:11:22
Untitled
12/18/2002 15:10:57
Description
Process Survey in 2d File
OK
Cancel

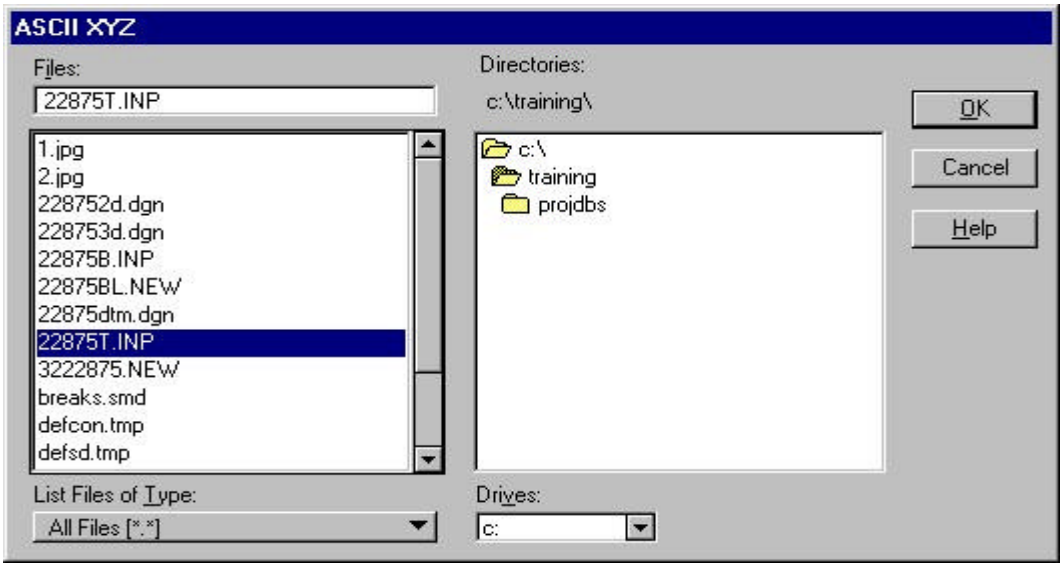
2.6.1.2 Processing Survey Data

The first step to processing the field data is to make the appropriate setting in the Survey/Project dialog. This entails selecting the desired raw field data file to be processed. In this case, we will be processing ASCII data that has already been reduced.

Step 1. Set the **Data Source** toggle **to ASCII XYZ**.



Step 2. After setting the **Data Source** to the ASCIIXYZ option, select the file to be processed by using the File push button. Select the **22875T.inp** file and press **OK**. A sample of the topo file is shown below.



Survey ASCII Data .new File

```
Point        Y             X              Z          Feature       Additional
 No.     Coordinate    Coordinate     Coordinate     Code          Comments

 4000, 758109.17256, 1949706.90227, 180.50404, CPD
 4001, 758120.96708, 1949708.75084, 180.50125, CPD
 4002, 758131.21262, 1949647.64679, 180.70467, CPDB
 4003, 758118.81590, 1949622.29043, 181.25145, PP
 4004, 758117.09923, 1949611.36914, 182.42432, T 18" OAK
 4005, 758138.49813, 1949605.14603, 183.11537, EPL
 4006, 758123.41500, 1949604.25092, 182.85166, EPL
 4007, 758109.14866, 1949610.47205, 182.41231, EPLB
 4008, 758109.14866, 1949610.47205, 182.41231, MCLA SLANT CURB
 4009, 758114.69400, 1949615.97935, 181.70657, SNA METAL
 4010, 758113.15347, 1949618.94764, 181.71265, SNB
 4011, 758099.95225, 1949645.32286, 181.44405, MCLB
 4012, 758099.95225, 1949645.32286, 181.44405, EPLA
 4013, 758090.32242, 1949673.84423, 181.27846, EPLB Z
 4014, 757989.16303, 1949823.13125, 179.33914, BA BU 1-S-BRK CHURCH
 4015, 758051.03527, 1949688.21023, 181.27527, B
 4016, 757827.58306, 1949587.74762, 180.60468, B
 4017, 757765.71082, 1949722.66864, 180.60468, B
 4018, 757989.16303, 1949823.13125, 179.33914, BB
 4019, 758016.93276, 1949597.20625, 182.27690, WEL
 4020, 758017.63016, 1949595.11151, 182.62682, WV
```

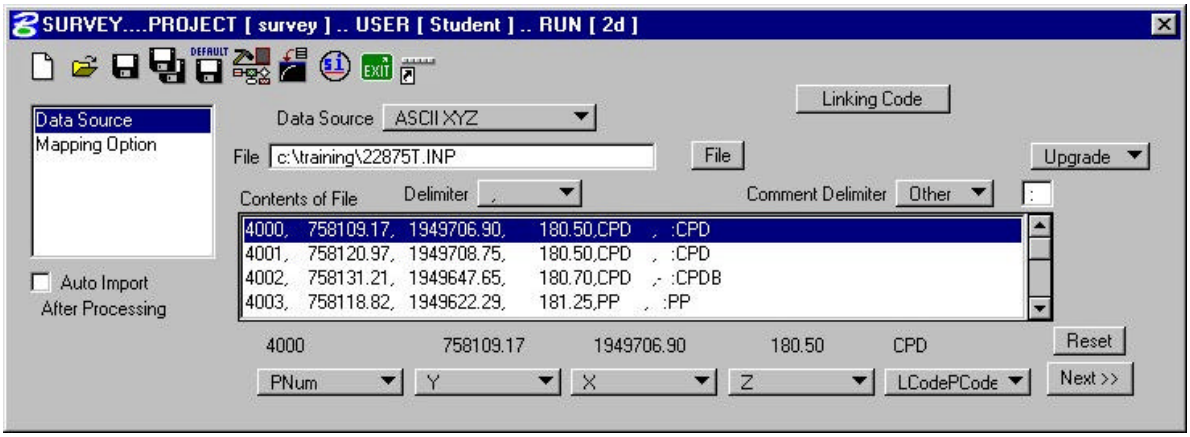
S (Single Shot)

A (Beginning of Line)

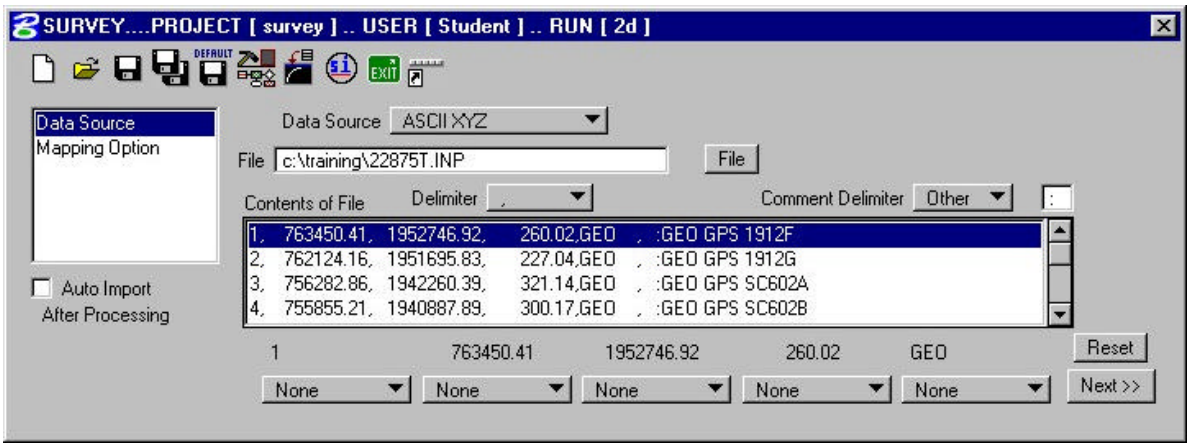
B (End of Line)

This ASCII file will be changed to .inp file by a program written by Road Design to convert the A & B as Beginning and End of line to a + and – respectively.

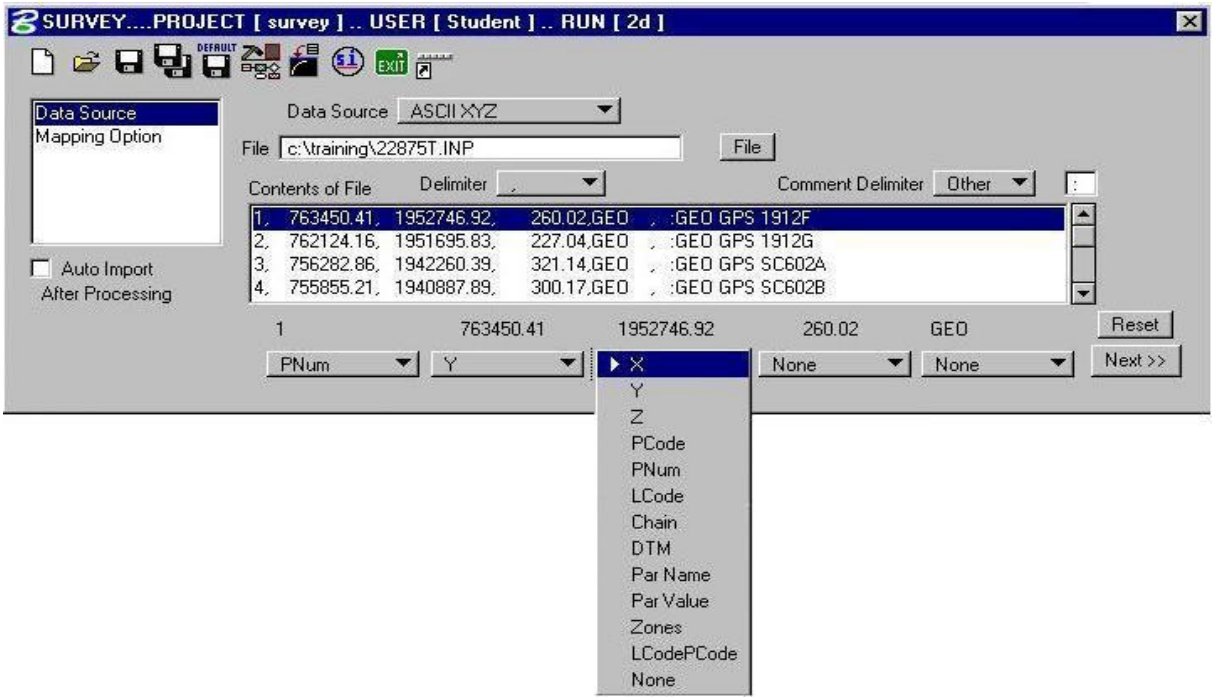
Step 3. Next we will need to set the **Delimiters** for the column delineation and also for the **Comments**. These two should be different so that the application can determine what data is read for processing and what data is simply a comment. In this case, a comma delimits the columns and the comment at the end of the line is delimited with a colon.



Step 4. Now we specify what information is located in each of the columns of the file to be processed. First select or highlight one of the lines within the display window of the dialog as shown below. Notice that when a line was selected in the display window the individual items fields will appear over the series of option buttons located beneath the list box. If this did not happen when you selected the line in the window then most likely the **Delimiter** is not set correctly. This will keep the application from being able to identify where a column starts and ends.



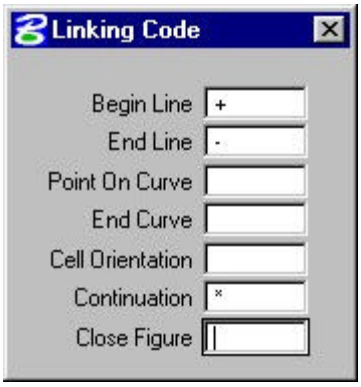
Step 5. The next step is to identify the individual fields in the ASCII file as representing either a point code, point number, x-coordinate, y-coordinate or z-coordinate. To accomplish this, adjust the option button to correctly identify the function of each field from the survey file.



Step 6. Proceed through each column, setting them by selecting the appropriate option on the toggle. The fields should be set in the following order: Point Number **(Pnum),** y-coordinate **(Y)**, x-coordinate **(X**), z-coordinate **(Z)**, Linking Code/Point Code **(LcodePCode)**, Linking Code **(Lcode)** and None (None).

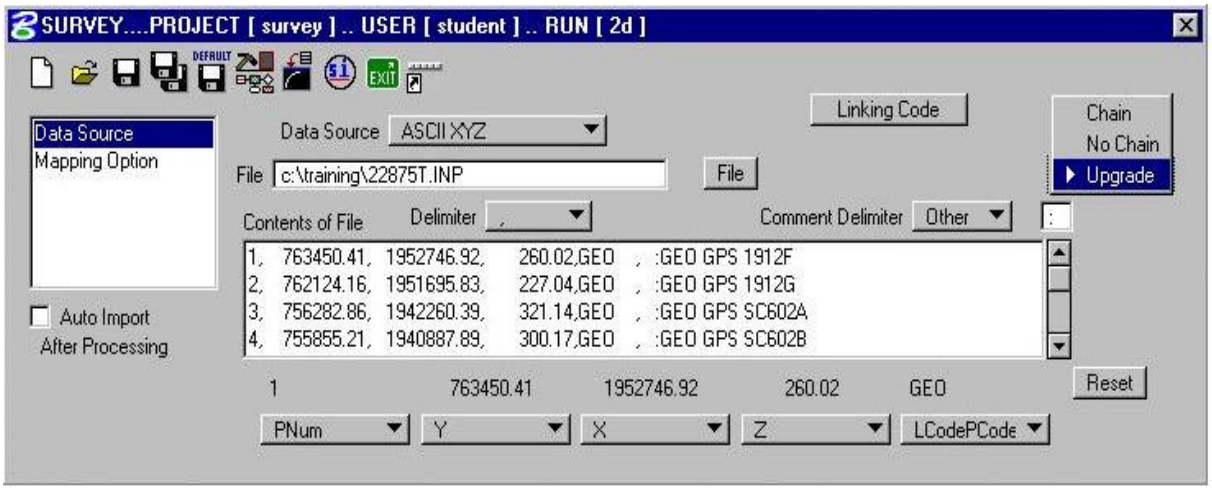
Note: Since the dialog permits the definition of only five fields at a time, we must use the **Previous** and **Next** push buttons to shift the fields right and left.

Step 7. When one of the options is set to Linking Code **(Lcode)**, the Linking Code button appears in the upper right portion of the dialog allowing the setting of the actual Linking Codes. Press the **Linking Code** button and the dialog depicted below appears. This determines the connectivity of the chains or linear elements. In our case the plus (+) is a begin line and minus (-) is an end line. Make the appropriate settings as shown below.



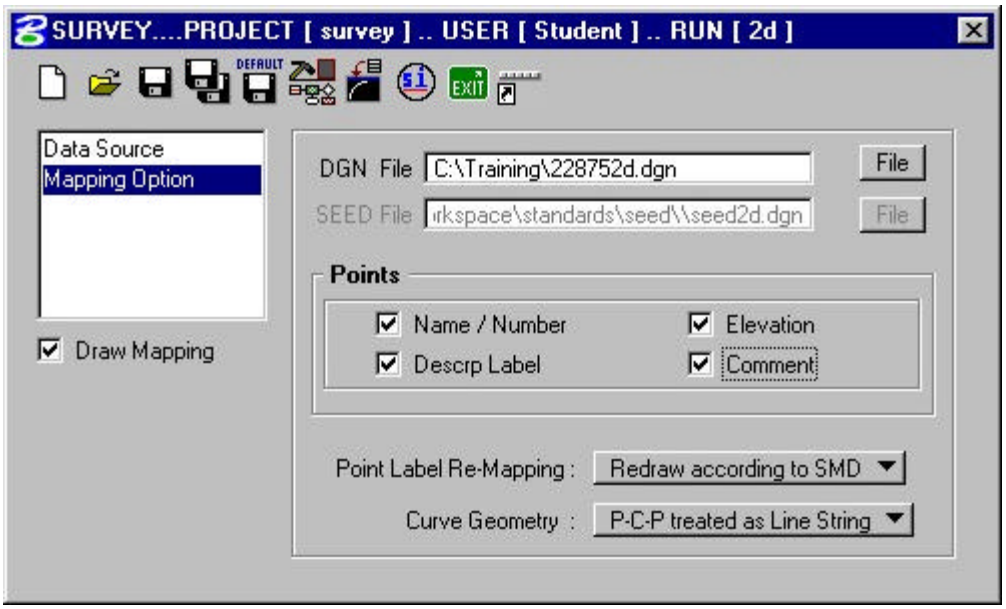
Close the frame by hitting the "X" in the upper right corner.

Step 8. Also be sure to set the chain processing toggle button to **Upgrade** as shown below.



2.6.1.3 Mapping Options

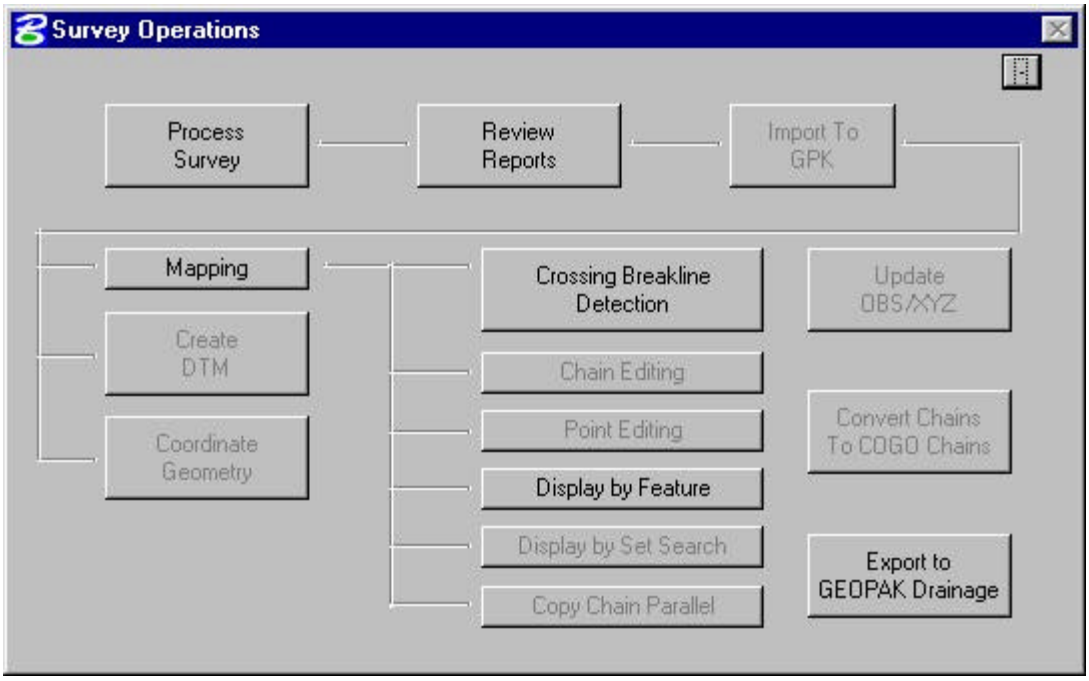
After making the settings for the ASCII data source, move to the next selection in the **Survey/Project** dialog for **Mapping Options**. The mapping option dialog defines the settings utilized when creating graphics from the source data.



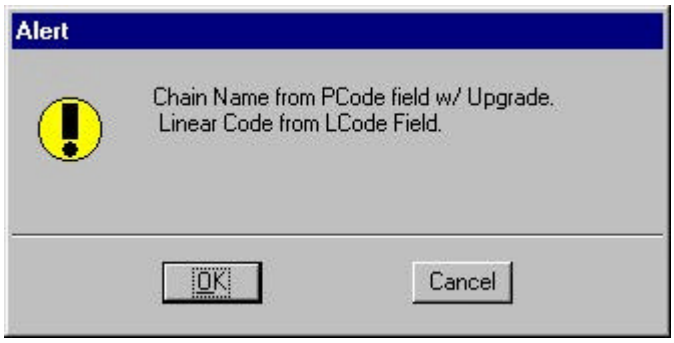
The **Draw Mapping** toggle dictates if any graphics will be drawn. If this toggle is off, then the input fields are ghosted out and are not available. The **DGN File** field denotes the path and name of the MicroStation 2d file where the graphics will be drawn.

2.6.1.4 Process Survey

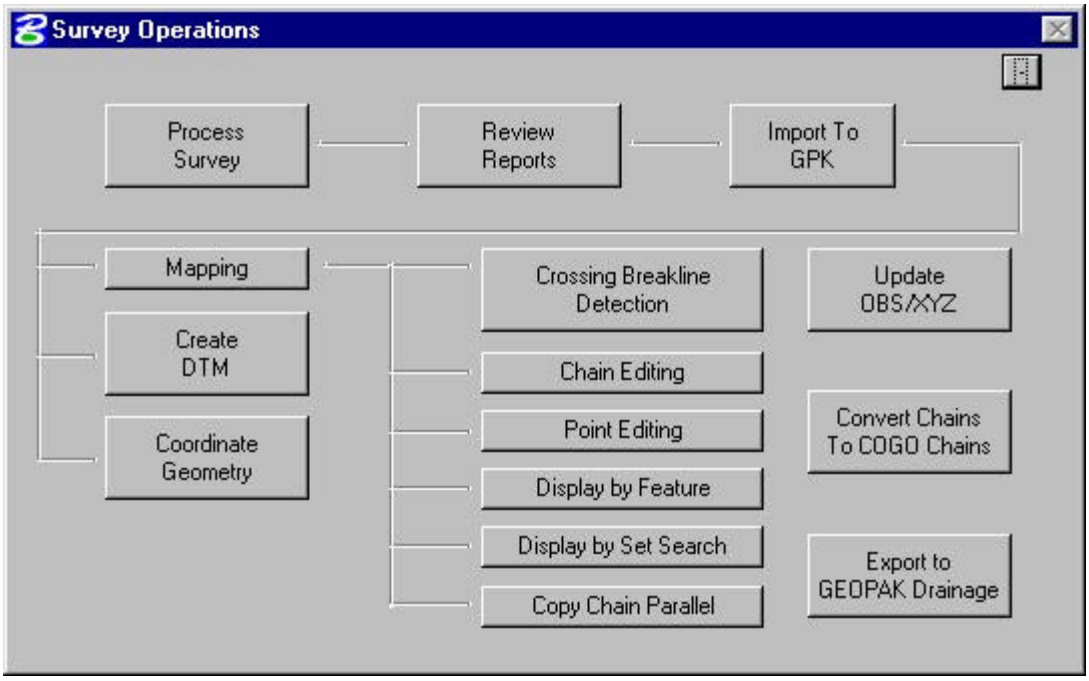
Step 1. When all of the settings have been made in the **Survey/Project** dialog then chose the **Survey Operations** dialog and process the survey. Select the **Process Survey button.**



Step 2. Once selected, the following dialog will appear as a confirmation of where certain information will be located. Simply select **OK** to continue.



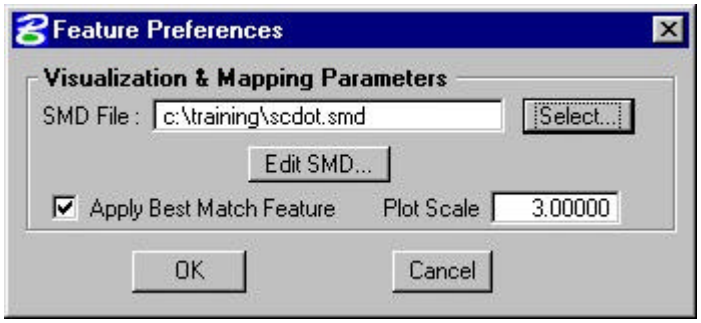
Step 3. Return to the **Survey Operations** menu and press the **Import to GPK** button. All data must be imported into the database before mapping, writing to DTM, etc. can be done.

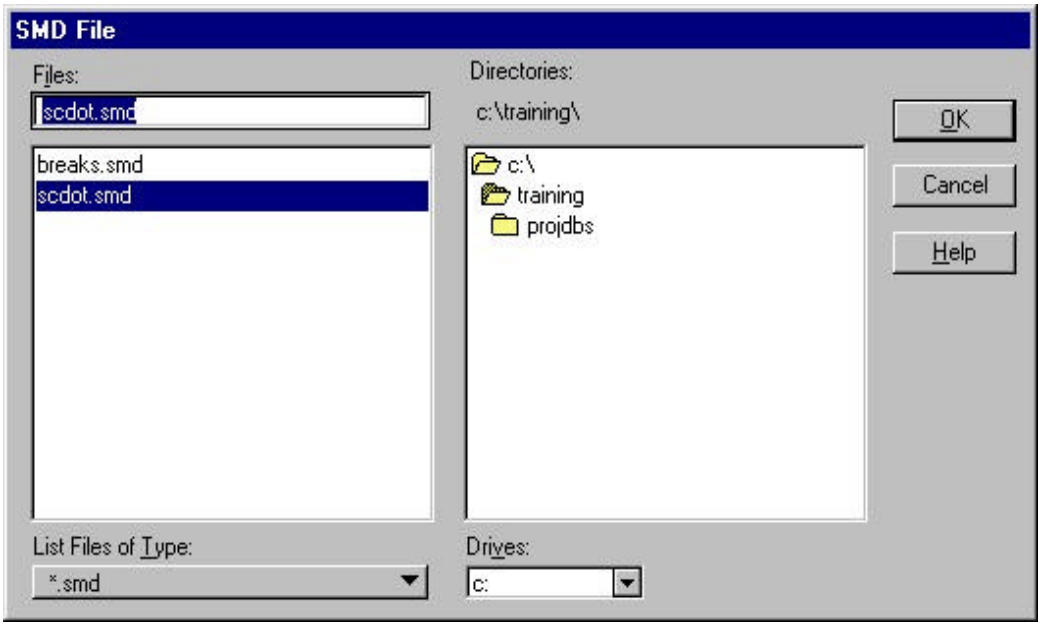


After processing, an Alert dialog opens if any unknown feature codes are found. The user has the option to save the list into an ASCII file for review.

2.6.2 Processing Topo Data in a 3d Design File

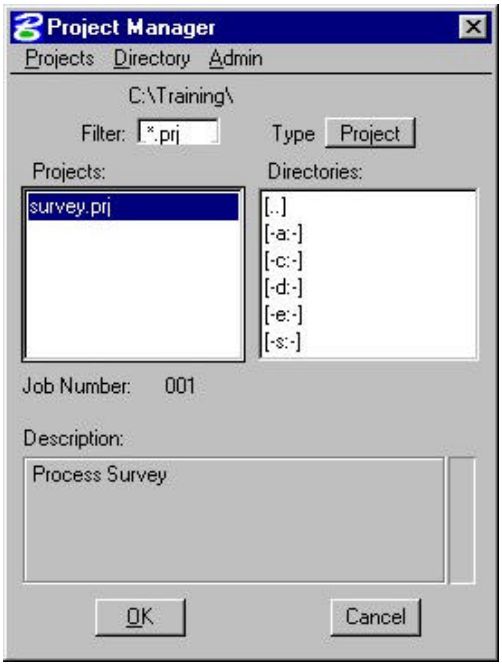
This manual allows the processing of two different 3d files, one for the purpose of plotting the Topo in a 3d file and the other for plotting the breaklines and the spots in a different 3d file. However, in order to control the level symbology, a separate SMD has bee created. One to process the Topo file (scdot.SMD) and the other to process the DTM file (breaks.SMD).



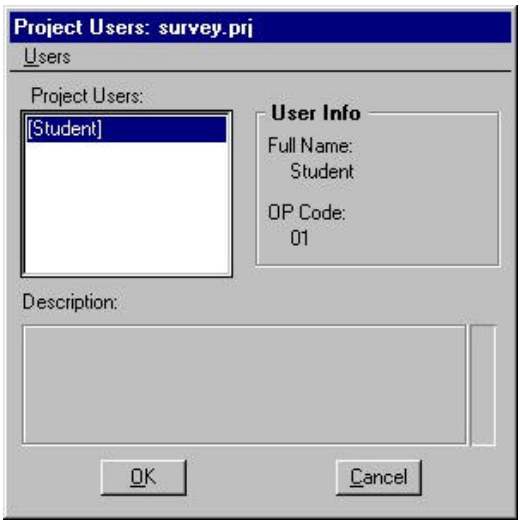


2.6.2.1 Accessing Project Manager

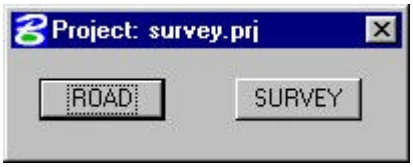
Open the MicroStation file C:\Training**228753d.dgn**. Access Project Manager by selecting **Applications > GEOPAK Survey > Project Manager** from the command bar. The Project Manager dialog appears as depicted below. Highlight **survey.prj** as shown and press the **OK** button.



Highlight user **Student** as shown in the dialog below and press the **OK** button.

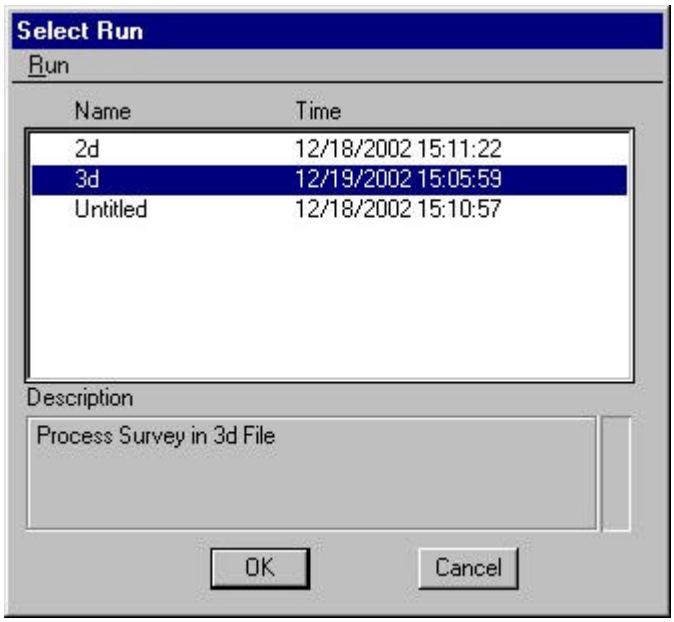


Once the user has been selected, the following project dialog box will open. Chose the **Survey** button to activate GEOPAK Survey.



To select the desired run, highlight the **3d** run as shown in the dialog below and press the **OK** button. This will invoke two dialog boxes:

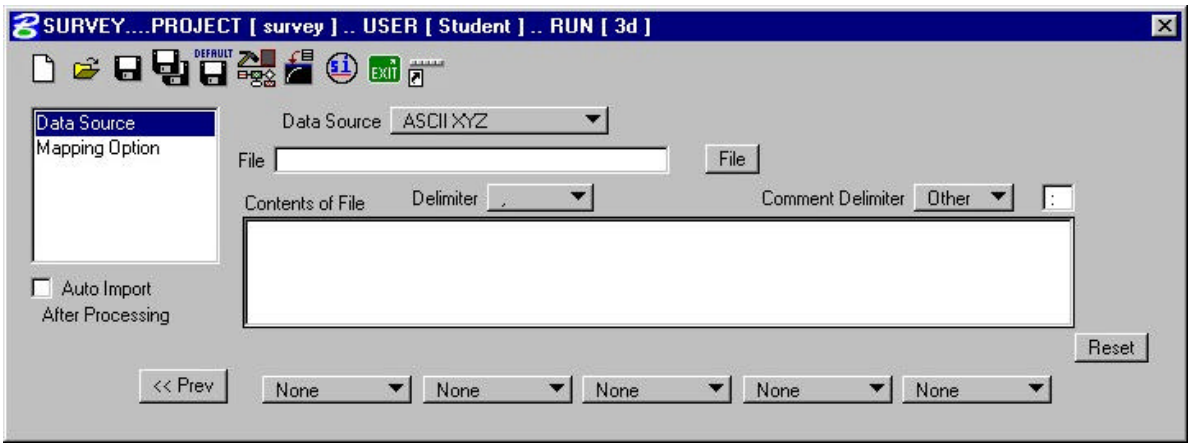
?? Survey … 3d
?? Survey Operations



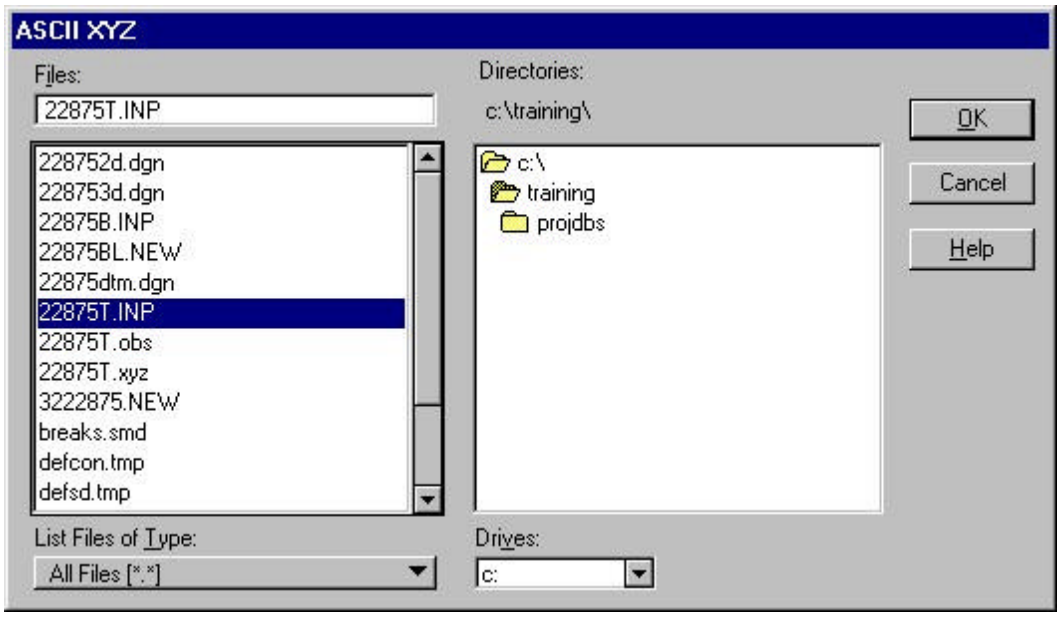
2.6.2.2 Processing Survey Data

The first step to processing the field data is to make the appropriate setting in the **Survey/Project** dialog. This entails selecting the desired raw field data file to be processed. In this case, we will be processing ASCII data that has already been reduced.

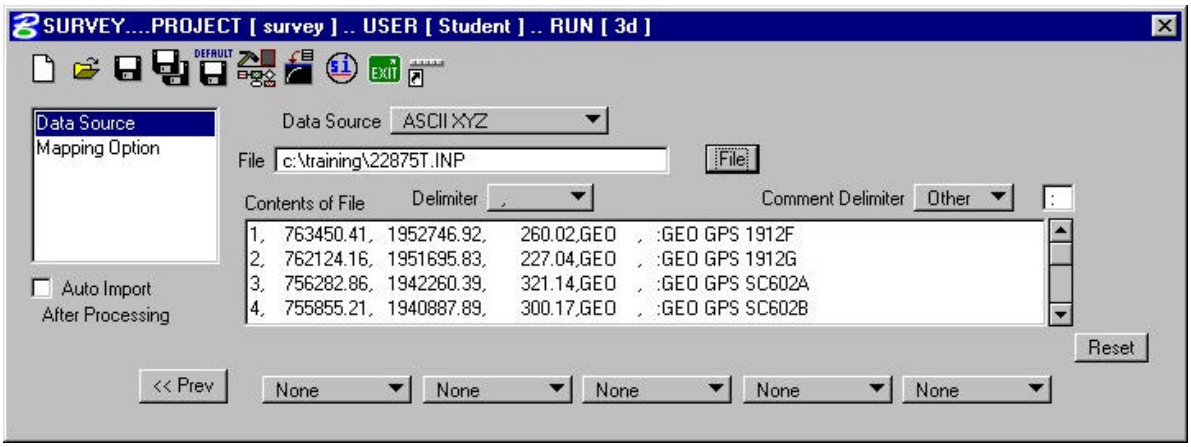
Step 1. Set the **Data Source** toggle to **ASCII XYZ**.



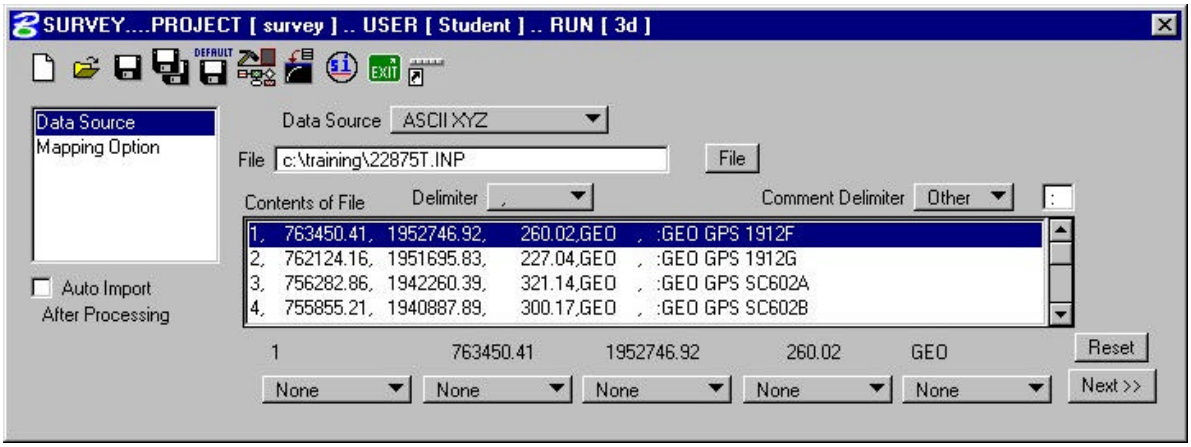
Step 2. After setting the **Data Source** option, select the file to be processed by using the **File** push button. Select the **22875T.inp** file and press **OK**.



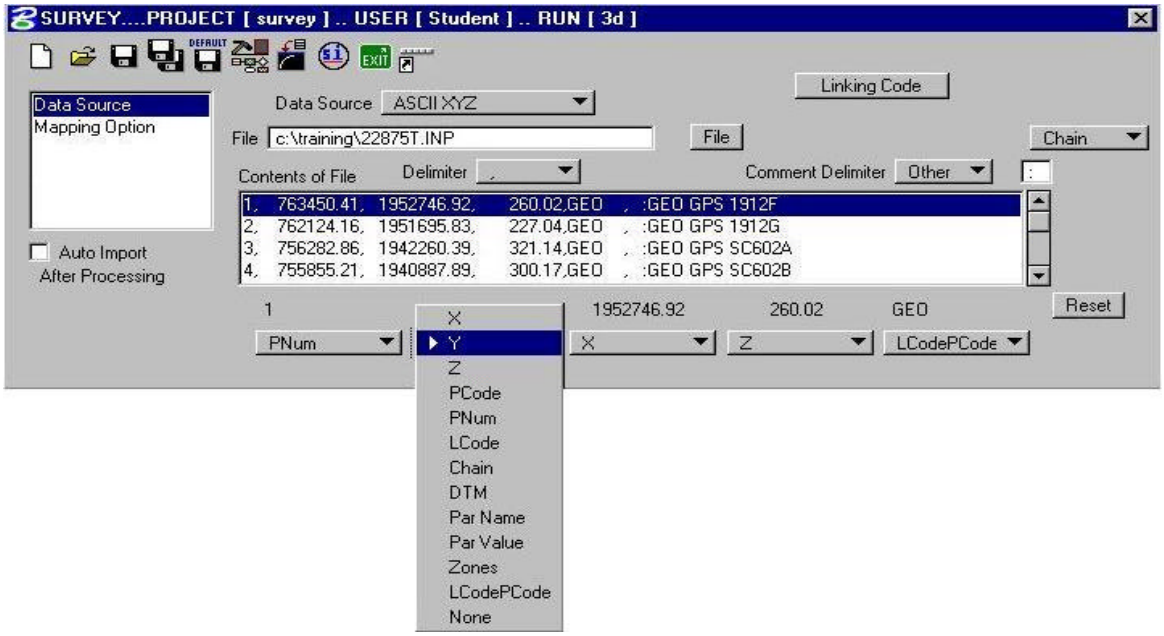
Step 3. Next we will need to set the **Delimiters** for the column delineation and also for the **Comments**. These two should be different so that the application can determine what data is read for processing and what data is simply a comment. In this case, a comma delimits the columns and the comment at the end of the line is delimited with a colon.



Step 4. Now we specify what information is located in each of the columns of the file to be processed. First select or highlight one of the lines within the display window of the dialog as shown below. Notice that when a line was selected in the display window the individual items fields will appear over the series of option buttons located beneath the list box. If this did not happen when you selected the line in the window then most likely the **Delimiter** is not set correctly. This will keep the application from being able to identify where a column starts and ends.

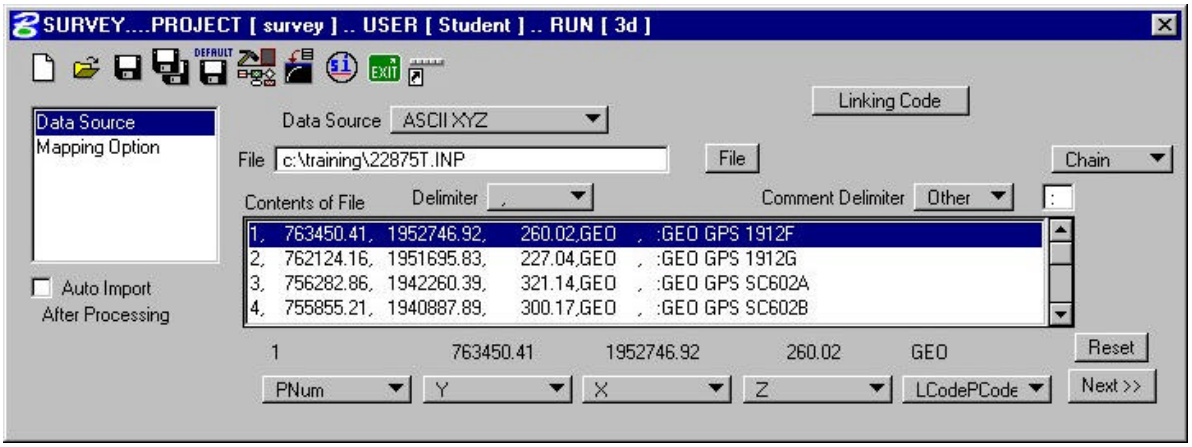


Step 5. The next step is to identify the individual fields in the ASCII file as representing either a point code, point number, x-coordinate, y-coordinate or z-coordinate. To accomplish this, adjust the option button to correctly identify the function of each field from the survey file.

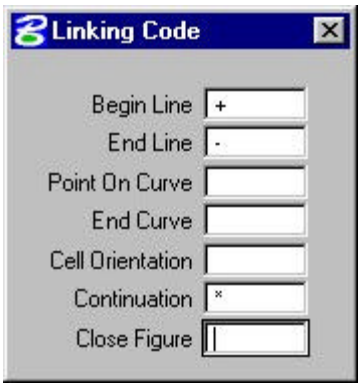


Step 6. Proceed through each column, setting them by selecting the appropriate option on the toggle. The fields should be set in the following order: Point Number **(Pnum)**, y-coordinate **(Y)**, x-coordinate **(X)**, z-coordinate **(Z)**, Linking Code/Point Code **(LcodePcode)**, Linking Code **(Lcode)** and None **(None)**.

Note: Since the dialog permits the definition of only five fields at a time, we must use the **Previous** and **Next** push buttons to shift the fields right and left.

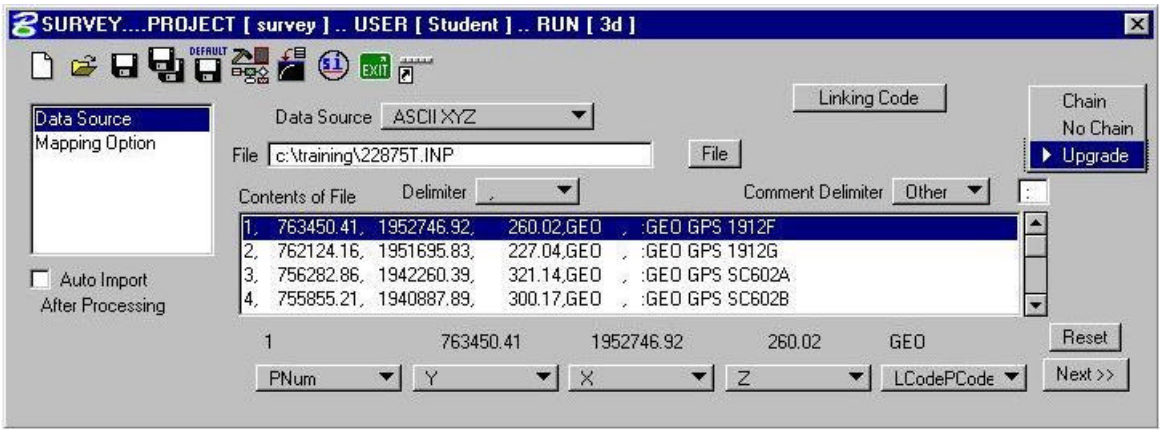


Step 7. When one of options is set to Linking Code **(Lcode)**, the Linking Code button appears in the upper right portion of the dialog allowing the setting of the actual Linking Codes. Press the **Linking Code** button and the dialog depicted below appears. This determines the connectivity of the chains or linear elements. In our case the plus (+) is a begin line and the minus (-) is an end line. Make the appropriate settings as shown below.



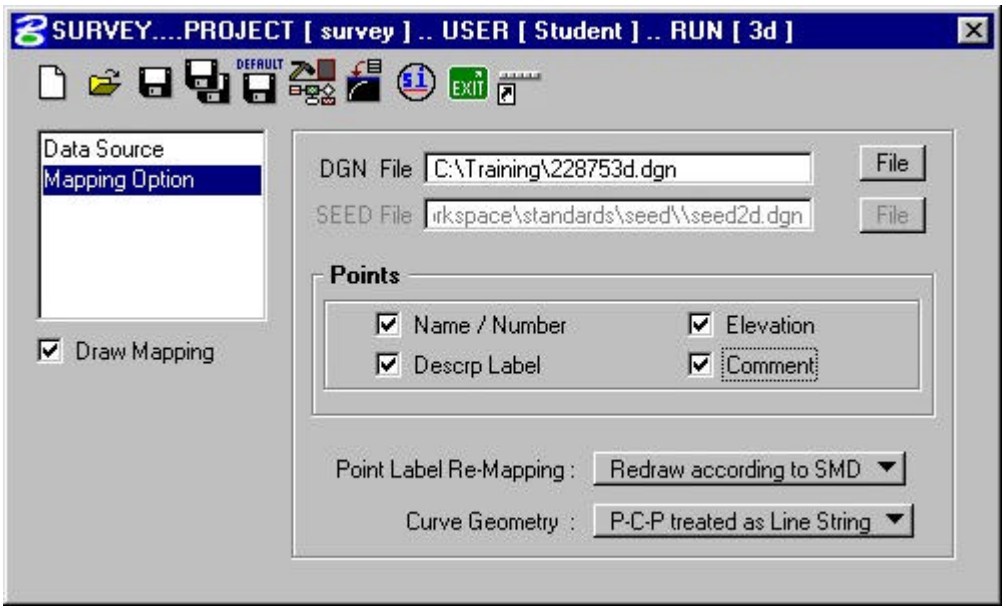
Close the frame by hitting the "X" in the upper right corner.

Step 8. Also be sure to set the chain processing toggle button to **Upgrade**.



2.6.2.3 Mapping Options

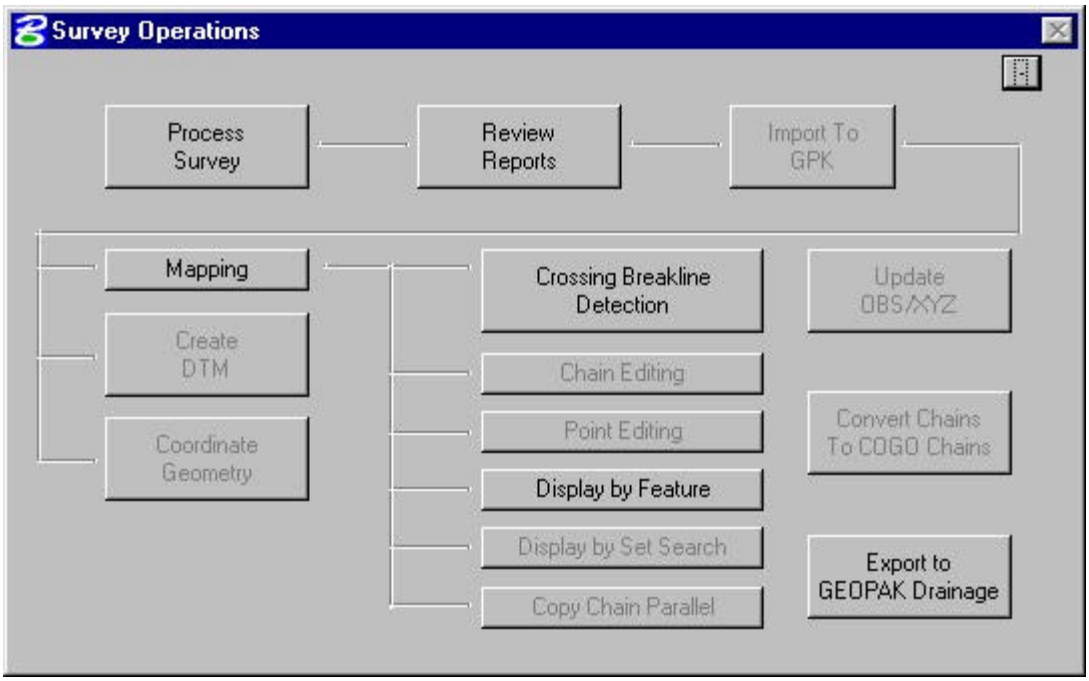
After making the settings for the ASCII data source, move to the next selection in the **Survey/Project** dialog for **Mapping Options**. The mapping option dialog defines the settings utilized when creating graphics from the source data.



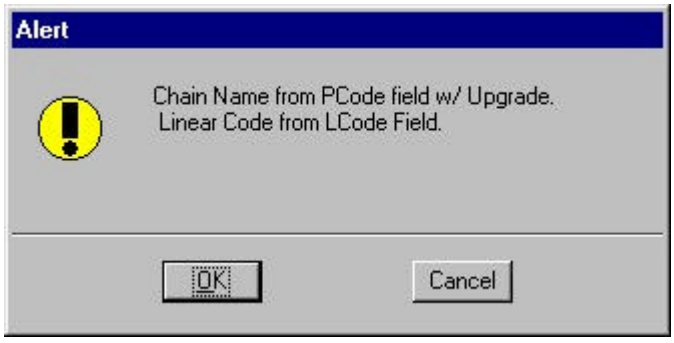
The **Draw Mapping** toggle dictates if any graphics will be drawn. If this toggle is off, then the input fields are ghosted out and are not available. The **DGN File** field denotes the path and name of the MicroStation 3d file where the graphics will be drawn.

2.6.2.4 Process Survey

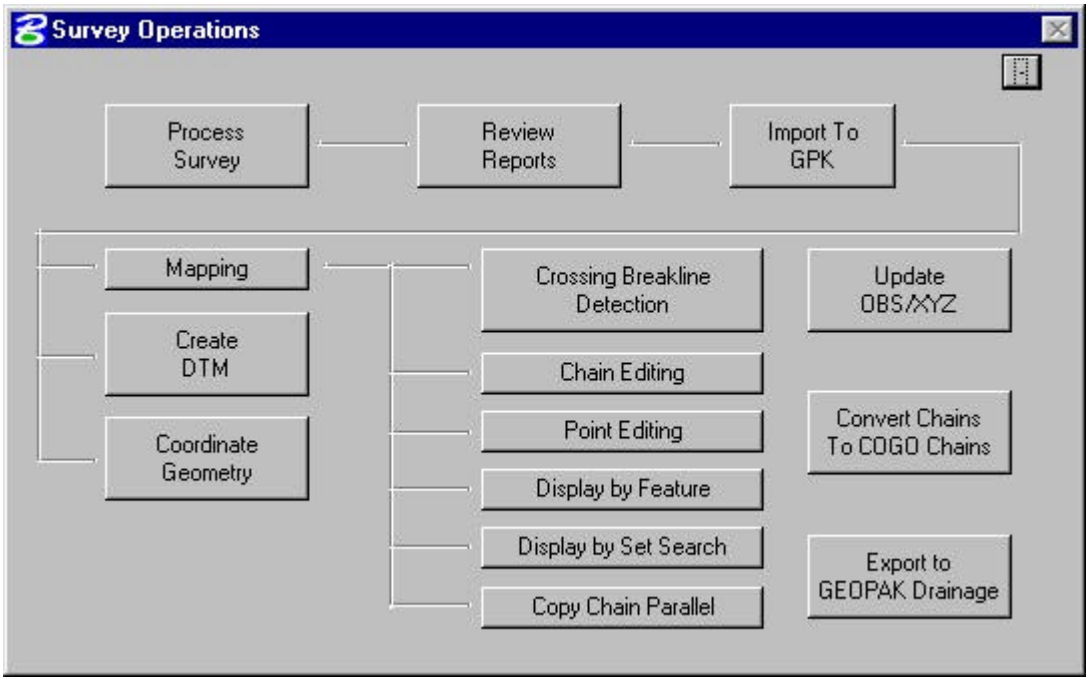
Step 1. When all of the settings have been made in the **Survey/Project** dialog return to the **Survey Operations** dialog and process the survey. Select the **Process Survey** button.



Step 2. Once selected the following dialog will appear as a confirmation of where certain information will be located. Simply select **OK** to continue.



Step 3. Return to the **Survey Operations** menu and press the **Import to GPK** button.



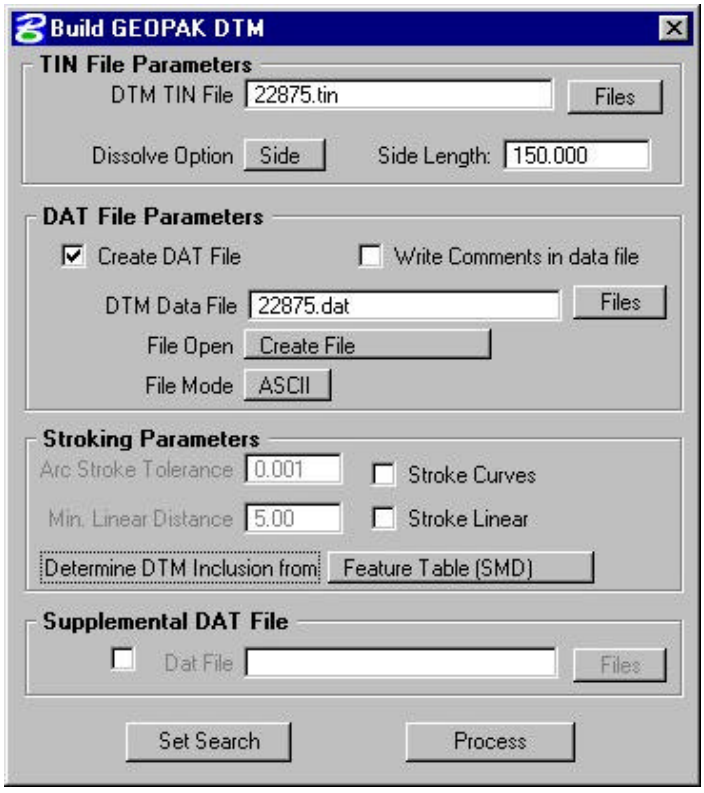
After processing, an Alert dialog box opens if any feature codes are detected in the survey data code that do not match a feature code in the **SMD** file. If this is encountered press the **OK** button to continue. The user has the option to save the unknown features as a list in an ASCII file that can be viewed later.

2.7 TIN Generation

2.7.1 Create DTM Input File

The Create **DTM** (Digital Terrain Model) button is unghosted once the Import to GPK processing is complete. This function creates the triangulation model.

Select the **Create DTM** button on the Survey Operations palette. The Build GEOPAK DTM dialog will be invoke as displayed below.



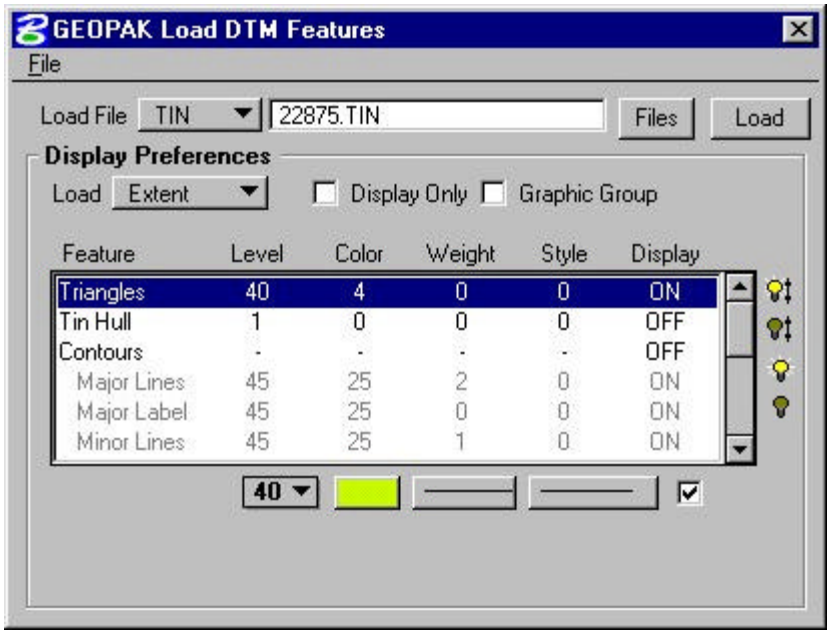
The **DTM TIN File** field identifies the name of the file that will be created or appended. The file may be created or appended to depending on the mode selected via the option button.

When the **Create DAT File** is active, the optional DAT file is created. Two File Modes are supported: **ASCII or Binary**.

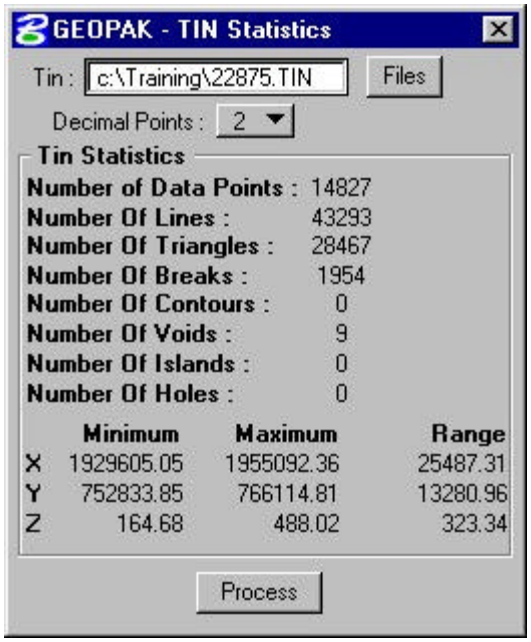
Key in the data as shown above and press the **Process** button.

Drawing Triangles and Contours

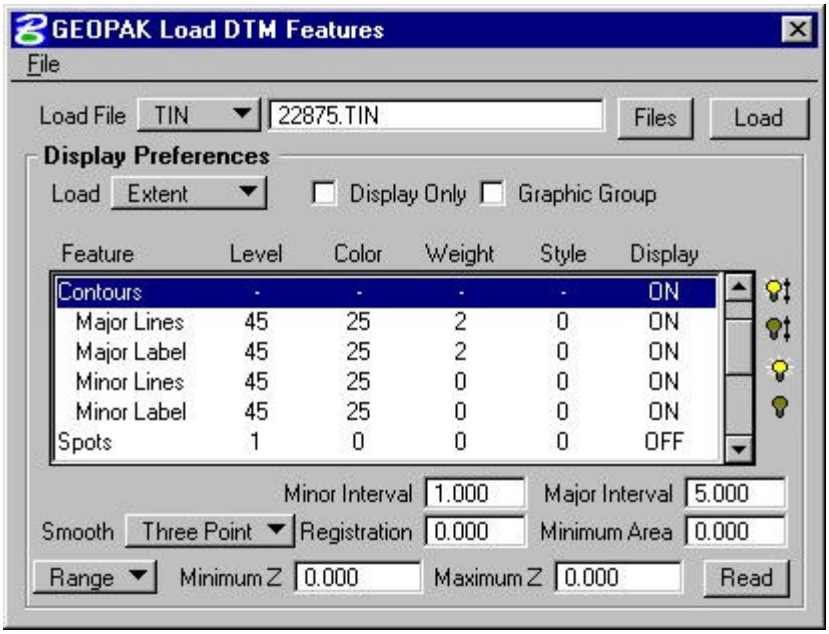
Select the **Load DTM Features** tool from the Survey DTM tool frame as illustrated above, which invokes the dialog depicted below.



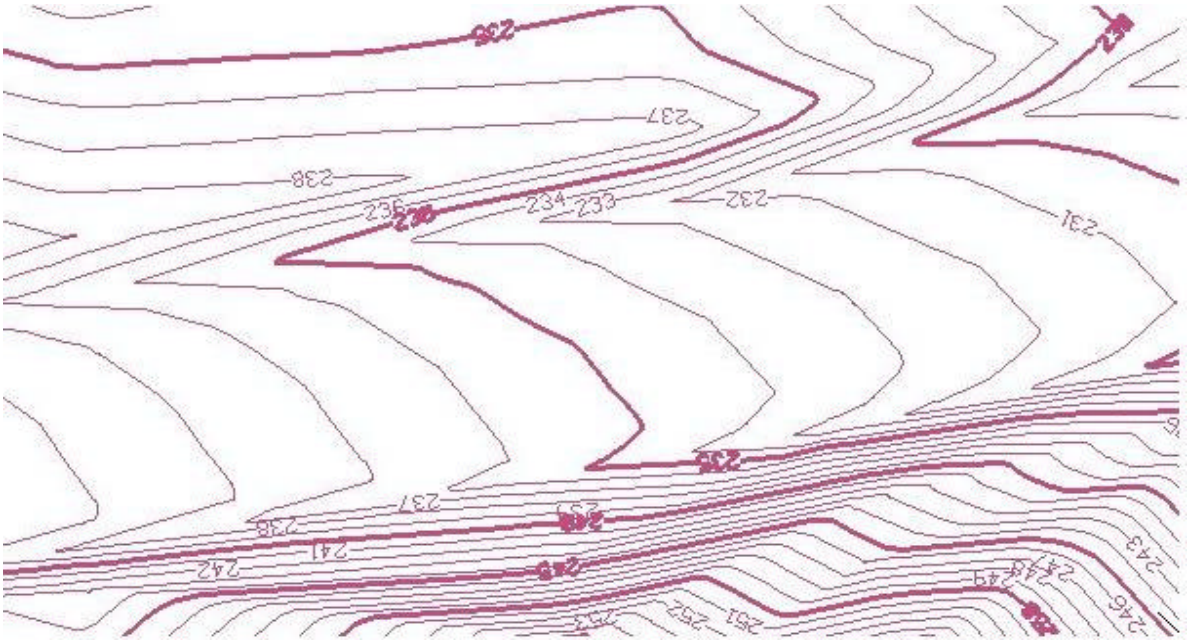
Change your settings to match those above and press the **Load** button in the upper right corner of the dialog. The Triangles will be drawn on level 20 in your MicroStation 3d file. Select the Triangles Statistics tool as depicted below.



To draw the Contours in a design file, double click on **Contours, Major Lines, Major Labe**l, and **Minor Lines**, which dynamically changes the dialog as depicted below.



Press the **Load** button in the upper right corner of the dialog. Contours as depicted below are displayed.



2.8 QA / QC Procedures

The tin generation can be generated by processing the Raw Data into a 3d file using the break line SMD file (breaks.SMD). Once the break lines and spots are plotted in a 3d design file the user can follow the creation of the tin as described in Section 1.9. The only difference is that the spots and break lines are extracted instead of the triangles in the "extract graphics" palette. The advantage of this method is that the designer may delete and change any graphics element, then produce the tin from the latest visual data.

2.9 Survey Files Deliverables

Preconstruction Surveying Consultants will deliver to the DOT files that are compatible with the Departments CADD and Plan Development Process. All Roadway Project within the Department are assigned a Project Pin Number. All files submitted by the Consultant will be referenced to a Pin Number. The types of files and naming conventions are listed below and are examples of some of the files that might be requested by the Department. The examples shown assume a Pin Number of 123456.

123456.new
Primary Survey file containing all surveyed points. SMI format.

123456.alg
A file containing alignment points and is in a specific DOT format.

123456.txt
A GEOPAK alignment report of alignments created with GEOPAK. The GPK files are also required.

123456.dgn
A 2D Microstation Design file containing all project Planimetric Mapping.

1234563d.dgn
A 3D Microstation Design file containing all project Planimetric Mapping.

123456dtm.dgn
A 3D Microstation Design file containing all breaklines, spot elevations, triangulation and contours.

123456prop.dgn
A 2D Microstation Design files containing all property boundaries. Also all existing survey alignments with matching stationing from the latest SCDOT right of way files.

Note: Any additional surveys submitted for the same project will follow the same naming convention but will add an A, B, C, etc. Example: for the first additional survey the file name will be 123456a.new, the second additional survey will be 123456b.new etc.

APPENDIX A – PHOTOGRAMMETRIC CERTIFICATION PROJECT REPORT

PHOTOGRAMMETRIC CERTIFICATION PROJECT REPORT

Date: _____

Project Number: _____

Client Name: _____
_____
_____
_____

I certify that this project was completed under my direct and responsible charge from an actual photogrammetric survey made under my supervision; that this photogrammetric survey was performed to meet Federal Geographic Data Committee Standards as applicable. I further certify:

That the _____ aerial photography was taken on _____ at a nominal scale of 1"= _____ using a Wild RC30 aerial camera.

That the data was compiled by standard photogrammetric means using a Wild BC2 analytical stereo plotter. The map was compiled on _____.

That this data was compiled to meet ___ feet horizontal accuracy at 95% confidence level and the vertical data was compiled to meet ____ feet accuracy at 95% confidence level.

That the data was compiled at 1"= ____ with a ____ contour interval. The area compiled as approximately _____ acres located in _____.

That all ground control was obtained by _____. Distances shown are grid lengths. To obtain horizontal ground distances, divide by a combined scale and sea factor of 0.9997756.

Horizontal datum: _____
Vertical datum: _____

All horizontal coordinates were referenced to the following marks:

NCGS Station Northing Easting Elevation

All vertical coordinates were referenced to the following marks:
NCGS Station Northing Easting Elevation

That all items compiled, except ground control points were obtained using photogrammetric methods.

That the data was compiled by: _____

_____
Signature Date

APPENDIX B – SCOPE OF WORK FOR TOPOGRAPHIC MAPPING PROJECT

General

The purpose of this Scope of Work is to provide topographic mapping, classifications and property information to preliminary mapping specifications, with an English or metric scale of _____, including DTM with _____contour interval, for the above noted project.

Project Limits

The mapping limits for this project are described as_____ _____. These limits are delineated on copies of portions of USGS Quadrangle maps and on contact prints if applicable.

Aerial Photography

Contractor shall obtain _____ aerial photography to cover the mapping area. The aircraft will be equipped with a precise aerial camera fitted with a 6" focal length and forward motion compensation (FMC). The photography will be flown at 60% forward overlap, and will not contain any excessive tip, tilt, crab or cloud cover. One set of 9"x9" contact paper prints and a recent camera calibration report will be supplied to the SCDOT.

Ground Control & Analytical Aerotriangulation

The SCDOT or other consultants will supply all horizontal and vertical ground control necessary for analytical aerotriangulation. The control supplied and all mapping carried out under this scope will be referenced horizontally to the South Carolina State Plane Coordinate Grid, North American Datum 1983/1995 (NAD83/95), and vertically to Mean Sea Level (MSL), National Geodetic Vertical Datum 1988 (NGVD88).

The Consultant will use analytical aerotriangulation methods and procedures to extend and densify the ground control provided and establish the photo control required for photogrammetric map compilation as follows:

The analytical computations must result in a minimum root mean square (rms) error at the control points of one part in ten thousand (1:10,000) of the flight height (AMGL).
A minimum of nine precisely marked supplemental control points will be established for each photograph, with six points located as near as possible to the corners and nadir point of the neat model.

All point marking of the film diapositives will be accomplished using precision point transfer devices. All marks will be drilled clearly through the emulsion of the diapositive, and excess waste material will be removed carefully from the surface prior to the mensuration operation. The locations of the supplemental and ground control points will be measured using fully analytical stereoplotters or soft copy stations.

The computer software used will contain a fully analytical block aerotriangulation program, and will incorporate the capability to give appropriate weight factors to the control to the control points on an individual basis, and to correct for film deformation, atmospheric refraction, Earth curvature and lens distortion.

Prior to the commencement of photogrammetric map compilation, the Consultant will submit to SCDOT, a Control Report detailing the results of the analytical aerotriangulation in the project area.

Map Compilation

The Consultant shall compile mapping at a scale of _____ within the project limits as specified above and noted on the attached USGS Quadrangle maps.

Planimetry

The digital map database and the final map sheet(s) shall include all physical and planimetric features discernible from the corresponding aerial photographs. All planimetric features will be compiled as specified by the SCDOT Mapping Manual.

Topographic Details

The digital map database and the final plotted map sheet(s) will contain all representable topographic features, which are identifiable on, or interpretable from, the corresponding aerial photographs. All topographic features will be compiled as specified by the SCDOT Mapping Manual.

Contours

Within the accuracy requirements, contours will be delineated to represent the exact shape of the ground, and its true elevation above Mean Sea Level (MSL). Solid line contours will be stored in the digital map database and delineated on the final map sheet(s) in all areas where the ground can be clearly seen on the three-dimensional (stereoscopic) model. When the ground is obscured, the Photogrammetrist will show the contours as dashed lines.

To render the index contours distinguishable from intermediate contours, every fifth contour shall be drawn as a heavier line, solid or dashed as appropriate. Each resulting index contour will be identified and labeled according to its actual elevation above Mean Sea Level (MSL).

When index contours are closer to each other less than 0.2 inches at map scale, and the ground between them is a uniform slope, intermediate contours should be omitted. Where the intermediate slope is not uniform, such an omission will not be permitted, unless the contours are shown at changes in ground slope.

Spot Elevations

Photogrammetrically ascertained spot elevations will be entered in the digital map database and be shown on the final map sheet(s) in proper position at water level on the shore lines of pertinent bodies of water, on hilltops, in saddles, at low point depressions, at-grade intersections of principal traveled ways such as highways, main streets and the like, and on the centerline at each end of bridges and other comparable structures.

Where contours are more than 3.0 inches apart at map scale, spot elevations will be shown at sufficient intervals so that they are not separated by more than 2.0 inches at map scale from the nearest spot elevation or contour.

Planimetric Classification & Supplemental Information If Applicable

The Consultant will input and incorporate, into the digital map database for delineation on plotted map sheets, the results of a field classification survey of surface features as performed by the Consultant. The results of the classification survey will be delineated and annotated on approximate scale 1:1500 aerial photo enlargements by the consultant, using SCDOT specifications.

Property boundaries, owner's name(s) and complete annotations will be included by the Consultant in the digital map database, and delineated on the plotted map sheets. The property information will be furnished by the SCDOT in the form of digital tax maps and digital owners names. All property boundaries that completely or partially lie within the mapping limits, shall be closed out on the final map. The consultant will enter and symbolize all features and data in accordance with the SCDOT specifications.

Map Accuracy

All mapping compiled under this scope will
comply with the Federal Geodetic Data Committee Standards, at the scale of compilation, as outlined in the Reference Guide Outline, "Specifications For Aerial Surveys And Mapping", published by the U.S. Department of Transportation, which states in part:

A. **Contours:** Ninety percent of the elevations determined from the solid-line contours of the topographic maps shall have an accuracy with respect to true elevation of one-half contour interval or better and the remaining ten percent of such elevations shall not be in error by more than one contour interval. This accuracy shall apply only to the contours, which are on each map. Thus, in each particular area where the intermediate contours have had to be omitted because of the steepness of the ground slopes and only the index contours are delineated on the maps, the accuracy stipulations apply to contour interval of the index contours. Wherever the intermediate contours are not

omitted, of course, the accuracies are applicable to the contour interval specified for the topographic maps. In densely wooded areas where heavy brush or tree cover fully obscures the ground and contours are shown as dashed lines, they shall be plotted as accurately as possible from the stereoscopic model, while making full use of spot elevations obtained during ground control surveys and all spot elevations measured photogrammetrically in places where the ground is visible.

B. **Coordinate Grid Lines:** The plotted position of each plane coordinate grid line shall not vary by more than one-hundred of an inch from true grid value on each map manuscript.

C. **Horizontal Control:** Each horizontal control point shall be plotted on the map manuscript within the coordinate grid in which it should lie to an accuracy of one-hundred of an inch of its true position as expressed by the plane coordinates computed for the point.

D. **Planimetric Features:** Ninety percent of all planimetric features which are well-defined on the photographs shall be plotted so that their position on the finished maps shall be accurate to within 2.5 hundreds of an inch of their true coordinate position, as determined by the test surveys, and none of the features tested shall be misplaced on the finished map by more than 5 hundreds of an inch from their true coordinate position. The true coordinate position shall be determined by making accurate measurements originating and closing on station markers of the project basic control survey, which shall have a closure accuracy conforming with the requirements for the basic control.

E. **Spot Elevations:** Ninety percent of all spot elevations placed on the maps shall have an accuracy of at least one-fourth the contour interval, and the remaining ten percent shall be not in error by more than one-half the contour interval.

DTM – Breaklines

The Consultant will input and digitize breaklines into the DTM files, all planimetric features, tops and bottoms of all cuts and fills, ridge lines, valleys, bodies of water, and all significant changes in slope, that will define and produce the best terrain model for contour generation. Breaklines must never cross, although they may intersect, in which case the elevation at this point must be the same on all breaklines.

Digital Data

All mapping, whether photogrammetrically compiled, resulting from field classification surveys, or inclusion of supplemental information, will be delivered in digital format in the form of MicroStation two-dimensional (2-D) Design (". DGN") Files, compatible with MicroStation Version SE. All mapping under this Scope will be based on the workspaces with the global origin and working units contained in the seed file (SEED.DGN) provided by SCDOT (also containing Font Library and Color Table files). All digital files will be accordance with the level structure, symbology and specifications as set forth by the SCDOT.

In addition to the two-dimensional (2-D) Design (".DGN") Files specified above, the Consultant will deliver three-dimensional Digital Terrain Model (DTM) files that will be based on the workspaces with the global origin and working units contained in the DTM seed file (SEED.DGN).

SCDOT Review

Following the Consultant's completion of all photogrammetric compilation, the incorporation of all field classification survey data and supplemental information, and subjection to in-house quality control procedures, the Consultant will submit the digital map files and Digital Terrain Model (DTM) file, to SCDOT for review.

Following receipt and incorporation of SCDOT final edit comments into the digital map database, and/or final approval from SCDOT, the Consultant will prepare and submit complete final digital map files and a complete Digital Terrain Model (DTM) file.

Deliverables

The following items will be deliverable to SCDOT during the course of, and at the completion of the project:

1. One set of 9"x9" contact prints.
2. Bound 8 ½" x 11" control report detailing the results of the analytical aerotriangulation for the project area with a digital file and a PE or PLS certification statement.
3. All field classification photos, property photos/tax assessments maps, ownership records, utility maps, etc. acquired by the consultant during the course of the project.
4. Pre-final submittal, the digital map data files in 2-D (two dimensional) and 3-D (three dimensional) format and the corresponding Digital Terrain Model (DTM) files for review by SCDOT.
5. Final digital map files in 2-D (two dimensional) and 3-D (three dimensional) format and final 3-D (three dimensional) Digital Terrain Model (DTM) file with a PE or PLS certification of the project information inclusive of all SCDOT final review and edit recommendations.

APPENDIX C – FGDC REQUIREMENTS

FGDC REQUIREMENTS

APPENDIX D - SUBSURFACE UTILITY FEATURE TABLE

LEVEL	DESCRIPTION	CO	CELL	SHOT	FEATURE CODE	DTM TYPE IN SMD
10	**ABOVE GROUND ELECTRIC**	3				
	Above Ground Electric			Line	E	Not Included
	Electric – Telephone			Line	ET	Not Included
	Electric – Television			Line	ETV	Not Included
	Electric – Telephone – Television			Line	ETTV	Not Included
	Power Pole		PP	Single	PP	Not Included
	Meter Pole		MP	Single	MP	Not Included
	Light Pole		LP	Single	LP	Not Included
	Guy Wire		GW	Single	GW	Not Included
	Guy Pole		GP	Single	GP	Not Included
	Power Line Tower		PLT	Single	PLT	Not Included
	Traffic Signal Junction Box		TSJ	Single	TSJ	Not Included
	Traffic Signal Pole		TSP	Single	TSP	Not Included
11	**ABOVE GROUND GAS**	4				
12	**ABOVE GROUND COMMUNICATION**	6				
	Telephone Line			Line	T	Not Included
	Telephone Cable TV			Line	TTV	Not Included
	Cable TV			Line	TV	Not Included
	Telephone Booth		TB	Single	TB	Not Included
	Telephone Pole		TP	Single	TP	Not Included
	Cell Phone Tower		CT	Single	CT	Not Included
13	**ABOVE GROUND WATER**	1				
14	**ABOVE GROUND SEWER**	2				
15	**MISCELLANEOUS ABOVE**	19				
	Other Use Pole		OP	Single	OP	Not Included
	End of Information		EOI	Single	EOI	Not Included

LEVEL	DESCRIPTION	CO	CELL	SHOT	FEATURE CODE	DTM TYPE IN SMD
16	**SWEEP LIMITS**	149				
20	**UNDERGROUND ELECTRIC**	3				
	Underground Electric (Recorded)			Line	UE	Not Included
	Underground Electric (Designated)			Line	UE	Not Included
	Electric Transformer Box		ETB	Single	ETB	Not Included
	Power Manhole		PMH	Single	PMH	Not Included
	Power Cable Hand Hold		PHH	Single	PHH	Not Included
21	**UNDERGROUND GAS**	4				
	Underground Gas (Recorded)			Line	G	Not Included
	Underground Gas (Designated)			Line	G	Not Included
	Gas Meter		GM	Single	GM	Not Included
	Gas Valve		GV	Single	GV	Not Included
	Gas Manhole		GMH	Single	GMH	Not Included
	Gas Vent		GVT	Single	GVT	Not Included
	Gas Pressure Regulator		GR	Single	GR	Not Included
22	**UNDERGROUND COMMUNICATION**	6				
	Telephone (Recorded)			Line	UT	Not Included
	Telephone (Designated)			Line	UT	Not Included
	Cable TV (Recorded)			Line	UTV	Not Included
	Cable TV (Designated)			Line	UTV	Not Included
	Fiber Direct Buried (Recorded)			Line	FDB	Not Included
	Fiber Direct Buried (Designated)			Line	FDB	Not Included
	Fiber Duct Run (Recorded)			Line	FDR	Not Included
	Fiber Duct Run (Designated)			Line	FDR	Not Included
	Cable TV Pedestal		TV	Single	TV	Not Included
	Telephone Pedestal		TPP	Single	TPP	Not Included
	Telephone Manhole		TM	Single	TM	Not Included
	Fiber Optic Hand Hold		FHH	Single	FHH	Not Included
	Telephone Hand Hold		THH	Single	THH	Not Included
	Cable TV Hand Hold		TVHH	Single	TVHH	Not Included
23	**UNDERGROUND WATER**	1				
	Water Line (Recorded)			Line	W	Not Included
	Water Line (Designated)			Line	W	Not Included
	Water Meter		WM	Single	WM	Not Included
	Water Valve		WV	Single	WV	Not Included
	Water Monitoring Well		WMW	Single	WMW	Not Included
	Well House		WELL	Single	WELL	Not Included
	Fire Hydrant		FH	Single	FH	Not Included

LEVEL	DESCRIPTION	CO	CELL	SHOT	FEATURE CODE	DTM TYPE IN SMD
	Water Manhole		WMH	Single	WMH	Not Included
	Water Air Release Valve		WAR	Single	WAR	Not Included
24	**UNDERGROUND SEWER**	2				
	Gravity Sanitary Sewer (Recorded)			Line	SS	Not Included
	Gravity Sanitary Sewer (Designated)			Line	SS	Not Included
	Forced Sanitary Sewer (Recorded)			Line	FSS	Not Included
	Forced Sanitary Sewer (Designated)			Line	FSS	Not Included
	Sewer Clean Out		SVC	Single	SVC	Not Included
	Sanitary Sewer Manhole		SMH	Single	SMH	Not Included
	Sewer Air Release Valve		SAR	Single	SAR	Not Included
25	**MISCELLANEOUS UNDERGROUND**	19				
	Unknown Utility			Line	?UTIL	Not Included
26	**TEST HOLE**	149				
	Test Hole		TH	Single	TH	Not Included
	Limits of SUE Sweep			Line	SUE	Not Included

APPENDIX E –SURVEY FEATURE TABLE

LEVEL	DESCRIPTION	CO	CELL	SHOT	FEATURE CODE	DTM TYPE IN SMD
1	**CENTERLINE**	149				
	Bench Mark Control Point			Single	BM	Not Included
	Control Point			Single	CP	Not Included
	Intersecting Road Centerline			Single	ICL	Not Included
	Point of Curve		PC	Single	PC	Not Included
	Point of Compound Curve		PC	Single	PCC	Not Included
	Point of Intersection		PI	Single	PI	Not Included
	Point on Curve		PC	Single	POC	Not Included
	Point on Sub Tangant		PC	Single	POST	Not Included
	Point on Tangant		PC	Single	POT	Not Included
	Radius Point on Curve		DP	Single	RP	Not Included
	Point of Reverse Curve		PC	Single	PRC	Not Included
	Point of Tangency		PC	Single	PT	Not Included
	Spot Shot CL Profile			Single	CL	Spot Shot
2	**MISCELLANEOUS FEATURES**	5				
	Misc. Line			Line	MSL	Not Included
	Misc. Points		MSP	Spot	MSP	Not Included
3	**ROADS, PAVEMENTS, CURB,& GUTTER**	14				
	Face of Curve Left			Line	CFL	Break Line
	Face of Curve Right			Line	CFR	Break Line
	Edge of Pavement Left			Line	EPL	Break Line
	Edge of Pavement Right			Line	EPR	Break Line
	Edge of Pavement			Line	EP	Break Line
	Edge of Dirt Road Left			Line	ERL	Break Line
	Edge of Dirt Road Right			Line	ERR	Break Line
	Miscellaneous Curb Left			Line	MCL	Break Line
	Miscellaneous Curb Right			Line	MCR	Break Line
	Median - Concrete			Line	MDC	Break Line
	Sidewalk Left of C/L			Line	SWL	Break Line
	Sidewalk Right of C/L			Line	SWR	Break Line
	Valley Gutter - Left			Line	VGL	Break Line
	Valley Gutter - Right			Line	VGR	Break Line
	Crown			Line	CRW	Break Line
	Top of Curb			Line	TC	Break Line
	Back Edge of Sidewalk			Line	BSW	Break Line
	Shoulder Break or Top of Slope			Line	TS	Break Line

LEVEL	DESCRIPTION	CO	CELL	SHOT	FEATURE CODE	DTM TYPE IN SMD
	Bottom of Slope			Line	BS	Break Line
	Breakline			Line	BL	Break Line
4	**RAILROADS**	7				
	Railroad Track		RRB	Line	RR	Break Line
	Railroad Signal Box		RRB	Single	RRB	Not Included
	Railroad Mile Post		RRM	Single	RRM	Not Included
	Railroad Signal		RRS	Single	RRS	Not Included
	Railroad Trestle		RRB	Line	RRT	Not Included
	Railroad Crossing Arm		RRX	Single	RRX	Not Included
5	**MAJOR DRAINAGE STRUCTURES [EXISTING]**	27				
	Bridge - Concrete			Line	BRC	Not Included
	Bridge - Wood			Line	BRW	Not Included
	Culvert			Line	CVL	Not Included
	Head Wall			Line	HW	Not Included
	Wing Wall			Line	WW	Not Included
6	**MINOR DRAINAGE STRUCTURES [EXISTING]**	106				
	Catch Basin		CB	Single	CBN	Not Included
	Drop Inlet		CB	Single	DI	Not Included
	Junction Box		JB	Single	JB	Not Included
	Man Hole Drainage		MH	Single	MHD	Not Included
	Outfall Ditch			Line	ODL	Break Line
	Existing RC Pipe			Line	P	Not Included
7	**EXISTING GUARD RAIL**	22				
	Guard Rail			Line	GR	Not Included
8	**BUILDINGS AND CULTURE**	6				
	Air Conditioner Units		AC	Single	AC	Not Included
	Above Ground Tank			Line	AGT	Not Included
	Building			Line	B	Void
	Column		COL	Single	C	Not Included
	Fill Cap for Underground Tank		CAP	Single	CAP	Not Included
	Cemetery			Line	CEM	Not Included
	Canopy / Overhang on Building			Line	CNP	Not Included
	Concrete Pads / Slabs			Line	CPD	Not Included
	Dam			Line	DAM	Break Line
	Dirt Drive			Line	D	Break Line
	Drive Paved Concrete			Line	DC	Break Line
	Drive Paved			Line	DP	Break Line
	Flood / Ground Light		FLT	Single	FLT	Not Included

LEVEL	DESCRIPTION	CO	CELL	SHOT	FEATURE CODE	DTM TYPE IN SMD
	Flag Pole		FLAG	Single	FLAG	Not Included
	Fence Left			Line	FL	Break Line
	Fence Right			Line	FR	Break Line
	Gas Pump Island			Line	GPI	Not Included
	Grave			Line	GRV	Not Included
	Clothes Line			Line	LC	Not Included
	Planter			Line	PLT	Not Included
	Satellite Dish		SAT	Single	SAT	Not Included
	Sign			Line	SN	Not Included
	Sign Post		SIGN	Single	SP	Not Included
	Water Spigot		SPG	Single	SPG	Not Included
	Water Sprinkler		SPK	Single	SPK	Not Included
	Steps			Line	STP	Void
	Sidewalk to the Road			Line	SW	Break Line
	Underground Tank & Septic			Single	UGT	Not Included
	Wall			Line	W	Not Included
	Well		WELL	Single	WEL	Not Included
	Water Monitoring Well			Single	WMW	Not Included
	Spot Shot			Single	X	Spot Shot
9	**PUBLIC UTILITIES**	3				
	Electrical Pedestal		EPP	Single	EPP	Not Included
	Electric Transformer / Box / Marker		ETB	Single	ETB	Not Included
	Fire Hydrant		FH	Single	FH	Not Included
	Fiber Optic Cable			Line	FOL	Not Included
	Gas Line			Line	GL	Not Included
	Gas Line Test Valve		GLT	Single	GLT	Not Included
	Guy Pole		GP	Single	GP	Not Included
	Gas Valve		GV	Single	GV	Not Included
	Guy Wire		GW	Single	GW	Not Included
	Light Pole		LP	Single	LP	Not Included
	Man Hole Sewer		MH	Single	MHS	Not Included
	Man Hole Utility		MH	Single	MHU	Not Included
	Service / Meter Pole		MP	Single	MP	Not Included
	Power Pole		PP	Single	PP	Not Included
	Sanitary Sewer			Line	SS	Not Included
	Sewer Cleanout Vent		SSC	Single	SSC	Not Included
	Telephone Box		TBX	Single	TBX	Not Included
	Telegraph Pole		TG	Single	TG	Not Included
	Telephone Pole		TP	Single	TP	Not Included
	Telephone Pedestal		TPP	Single	TPP	Not Included
	Cable TV Pedestal		TV	Single	TVP	Not Included
	Power Line / Microwave Tower			Line	TW	Not Included

LEVEL	DESCRIPTION	CO	CELL	SHOT	FEATURE CODE	DTM TYPE IN SMD
	Underground Cable			Line	UGC	Not Included
	Water Line			Line	WL	Not Included
	Water Meter		WM	Single	WM	Not Included
	Utility Witness Post		WTS	Single	WTS	Not Included
	Water Valve		WV	Single	WV	Not Included
10	**HYDROGRAPHY**	1				
	Berm Ditch Left			Line	BDL	Break Line
	Berm Ditch Right			Line	BDR	Break Line
	Creek Left			Line	CRL	Break Line
	Creek Right			Line	CRR	Break Line
	Ditch Left			Line	DTL	Break Line
	Ditch Right			Line	DTR	Break Line
	Marsh Line			Line	MAR	Void
	Spring		SPR	Single	SPR	Not Included
	Swamp Line			Line	SWP	Void
	Edge of Water / Ponds, ETC.			Line	WE	Void
11	**VEGETATION**	2				
	Flower Bed			Line	F	Not Included
	Hedge Row			Line	H	Not Included
	Orchard Tree		T1	Single	OT	Not Included
	Orchard Tree Line Left			Line	OTL	Not Included
	Orchard Tree Line Right			Line	OTR	Not Included
	Shrub		SB1	Single	S	Not Included
	Shrub Line			Line	SL	Not Included
	Tree		T1	Single	T	Not Included
	Tree Line Left			Line	TL	Not Included
	Tree Line Right			Line	TR	Not Included
12	**PROPERTY DATA**	0				
	Concrete Marker		CM	Single	CMT	Not Included
	Geodectic Marker		GEO	Single	GEO	Not Included
	Iron Pin		IP	Single	IP	Not Included
	Property Line		IP	Line	PL	Not Included
	Property Line Corner		DP	Single	PLC	Not Included
13	**RIGHT OF WAY**	4				
	Right of Way Line Existing		IP	Line	RWE	Not Included
	Right of Way Monument		RWM	Single	RWM	Not Included

INDEX

2

2D Topo Files Deliverables 5

3

3D Topo and DTM Files Deliverables 6

A

Accessing Project Manager 43, 54
Accuracy Requirements / CADD Standards 3
Aerial Mapping Procedures 1
Aerial Photography & Mapping – General 1
Aerial photography and mapping 14
Aerial Triangulation Report and Certification 5
Aerial Vertical Photography 1
Appendix A- Photogrammetric Certification Project Report 68
Appendix B – Scope of Work for Topographic Mapping project 70
Appendix C – FGDC Requirements 75
Appendix D - Subsurface Utility feature Table 76
Appendix E- Survey Feature Table 79

B

Break Lines / Spots / DTM Input 43
Building Triangles 8

C

Camera Requirements/Calibration Report 4
Create DTM Input File 63

D

Documentation of Horizontal Control 20
Drawing Triangles and Contours 9, 64

E

Extraction from Mapping Triangles 7

G

General 1, 14

H

Horizontal Control Accuracy 18
Horizontal Control Markers 19
Horizontal Control Spacing 18
Horizontal Control Survey Specifications 17

I

Introduction 1, 43
Introduction to GEOPAK Survey 43

M

Mapping And Digital Terrain Models 2
Mapping Options 51, 61

O

Orthophoto Files 6

P

Preconstruction Surveying 14
Primary control for the surveying and mapping 17
Process Survey 51, 62
Processing Survey Data 46, 57
Processing Survey File / Creating 2D and 3D.dgn Files 43
Processing Topo Data in a 3d Design File 53
Processing Topographical Data in a 2d Design File . 43
Project Horizontal Datum and Ties to the National Geodetic Reference System 19

Q

QA / QC Procedures 67
QA/QC 12

S

Shot Nomenclatures and Numbering 25
Survey / Controls / Benchmarks / Accuracy 14
Survey Data Collection and Procedures 14
Survey Monumentation 22
Surveying for right of ways 15, 17
Surveying requirements for horizontal control 18
Surveying Supervision and Responsibility 18

T

TIN Generation 63
TIN Preparation 6

V

Vertical Control – Benchmarks 21