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3.1. GENERAL SURVEY PROCEDURES

3.1.1. This chapter details the various activities involved in the survey process, including data requirements and procedures for gathering and presenting the data. Recent developments in surveying technology have made many methods obsolete. In general it is assumed that the surveyor is using total stations, data collectors, data reduction software and a computer aided drafting system. The requirements specified in this manual are intended to control the end product rather than intermediate activities, e.g., data collector formats. The required end product will be a complete survey in electronic format, certain check plots and required notes and documentation. This manual, instructions from the Regional Survey Supervisor, and, in the case of surveys performed by consultant firms, the contract, will define requirements for each separate project. Because of rapidly changing technology, data transfer methods will not be defined here. They will be a part of the Regional Survey Supervisor's instructions. A Survey Checklist (starting on page 7-64 of the Appendix) has been developed to insure completeness. It must be executed and turned in with the survey.

3.2. PROJECT CONTROL (GENERAL)

3.2.1. HORIZONTAL

3.2.1.1. All survey projects shall be tied to the Tennessee Geodetic Reference Network (TGRN). Section 5.1 will provide a more detailed discussion of the TGRN.

3.2.1.2. Ties shall consist of pairs of intervisible monuments along the length of the project. Spacing will depend on the type project, terrain, etc. and will be determined by the Regional Survey Supervisor (usually about 500 to 1000 ft).

3.2.1.3. Semi-permanent monuments will be used (reinforcing bars with metal caps or better). Also an adequate description and "to-reach" shall be prepared. (See FIGURE 7-3 in the Appendix for an example.) You should show a route description from a nearby landmark and a taped distance and azimuth to the witness post and at least two other reference points. Points along an existing route should be tied to the log mile.

3.2.1.4. TGRN ties will, in most cases, be supplied by TDOT Ground Control Crews.

3.2.1.5. Coordinate values for the monuments will be "Tennessee State Plane Grid Coordinates". These coordinates will be datum adjusted before being supplied to field crews for surveying and/or mapping. A more complete discussion of datum adjustment may be found in Section 5.1.

3.2.1.6. All ties to the TGRN will be made utilizing Global Positioning System (GPS) techniques. All GPS surveys will be according to the publication "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques", Version 5.0, May 1988, distributed by the Federal Geodetic Control Committee. GPS Surveys shall meet First Order (1:100000) accuracy standards as an absolute minimum. One part in one million closure for GPS control work is preferred.

3.2.1.7. Project control surveys will traverse the length of the project and shall originate and terminate at TGRN tied control points at the beginning, end, and, if appropriate, along the length of the project. Since these surveys originate and terminate at points with datum adjusted Tennessee State Plane Coordinates, all computed coordinates will be datum adjusted Tennessee State Plane Coordinates. No further datum adjustment is required.

3.2.1.8. Project control surveys shall meet Second Order Class II Standards (1:20000) or better, (See Section 5.2. and pages 7-27 and 7-28).

They may be performed by either of the following methods:

3.2.1.8.1. Total Station - Traverse

3.2.1.8.2. Global Positioning System, with prior approval from the Regional Survey Supervisor.

3.2.1.9. After the raw field data for project control has been compiled, computed and minimum standards met, traverses shall be adjusted by one of the following methods:

3.2.1.9.1. Least squares adjustment

3.2.1.9.2. Compass rule adjustment

3.2.1.10. Each leg of the project control survey (between adjacent pairs of TGRN tie points) shall be considered and adjusted independently.

3.2.1.11. All TGRN tie points (control pairs) and project control survey points shall be clearly shown and labeled in the planimetrics file (See Section 3.4.2). Any point which falls within the project limits shall be referenced (See Section 3.5.5, and FIGURE 7-4 of the Appendix for comments and examples).

3.2.1.12. Effective August 1, 1996, appropriate coordinate values for TGRN points are the NGS "re-observation project final adjustment" values. These are slightly different from the values previously used and necessitate a change in notation to differentiate between the two. The following notation will also allow for future upgrades as required:

3.2.1.12.1. Coordinates will be listed with current notation plus the year of the upgrade in parentheses, immediately following. Therefore, reference to current coordinate values will be NAD 83 (1995) for geographic coordinates and SPCS 83 (1995) for state plane coordinates.

3.2.1.13. The introduction of the final coordinate values, upon which all T.D.O.T. surveys will be referenced in the foreseeable future, necessitates a procedure to tie new survey projects to those referenced to NAD 27 coordinates, preliminary NAD 83 or NAD 83 (1990) TGRN values. The procedure will be as follows:

3.2.1.13.1. A pair of control points of the old project, at or near the point where the projects meet, will be used as beginning points for the new job. These reference points will be given two coordinate values (coordinate equation) and a notation that the two projects were referenced to different datums. The coordinate equations would be either NAD 27/NAD 83 (1995), NAD 83/NAD 83 (1995) or NAD 83 (1990)/NAD 83 (1995). In any case, coordinate values NAD 83 (1995) would then be carried forward for the new job.

3.2.2. VERTICAL

3.2.2.1. Global Positioning System (GPS) methods may be used for vertical control for projects provided approved procedures are followed.

3.2.2.2. The geoid model GEOID99 published by the National Geodetic Survey shall be used for height calculations.

3.2.2.3. Known third order or better NAVD 1988 benchmarks are occupied in the project control sessions and used for vertical ties and adjustment.

3.2.2.4. TDOT ground control crews will normally provide vertical control.

3.3. PROJECT CONTROL (G.P.S. PROCEDURES)

3.3.1. PRE-PLANNING

3.3.1.1. Assemble TVA/USGS quad maps, APR, photos, etc. for the project. Spot the project on the quad map and read approximate latitude and longitude of the project.

3.3.1.2. Based upon the map, you can get a rough idea of the number of points that will be required, and how long it might take to control the project. Estimate point placement, manpower needs, and potential problems with satellite blockage from this map also. You can also get an idea of how much of the project will be accessible by vehicle and where walking to the point will be required.

3.3.1.3. Check satellite predictions based upon satellite almanacs. Use this information to plan occupation times.

3.3.2. RECONNAISSANCE

3.3.2.1. Contact any property owners in accordance with requirements in chapter one.

3.3.2.2. Pick control point placement as follows:

3.3.2.2.1. Place points in the clear, away from trees, buildings and potential multi-path structures. Minimum obstruction angle shall be 20º.

3.3.2.2.2. Nominal control point spacing of 500ft to 1000 ft.

3.3.2.2.3. Points should be intervisible when possible. Exceptions will be large wooded areas. Note the example in Appendix FIGURE 7-34 shows a wooded area. You would simply skip this area and start placing points again on the other side.

3.3.2.2.4. Place points close to the projected centerline so that they will be of the most use to the surveyors who follow you (i.e. on hilltops). However, some thought should also be given to placing these points so that at least some of them will survive construction.

3.3.2.2.5. Document blockage problems on the site log. A site log form is shown in Appendix FIGURE 7-32. If you have blockage problems, place the control point to the south of the blockage since satellite path never crosses due north.

3.3.3. RECEIVER SETUP PROCEDURES

3.3.3.1. Improper instrument setup (human error) accounts for the most and the largest errors when performing GPS surveys. Therefore, care must be exercised during setup.

3.3.3.2. Use extra care to assure you are set up correctly on the point.

3.3.3.3. Make sure to properly focus the plummet and cross-hairs. Check to assure you are on the point during the session and before you break down the tripod to move. Triple checking the setup will greatly reduce the human error during the session.

3.3.3.4. Check and record your HI reading on the site log when you are set up. Check the HI again during the recording session and once more before you break down the instrument to move. This again aids in reducing human error during the session.

3.3.3.5. Set the tripod so that the receiver is at or above head height.

3.3.3.6. Set the tripod legs wide enough to prevent the tripod from being blown over.

3.3.3.7. Press the tripod feet firmly into the ground.

3.3.3.8. If you are sent to retrieve someone else's receiver, check their setup before you break it down.

3.3.3.9. Do not be afraid to report possible errors to the party chief. It is better to reoccupy the point while you are still in the field, than to try and determine what went wrong back in the office.

3.3.4. OBSERVATION METHODS

3.3.4.1. There are two basic methods used by TDOT to bring control into a project from the TGRN reference points. For this discussion we will refer to them as the **Traverse Method** and the **WING Point Method**. TABLE 3-1 shows advantages and disadvantages of each method.

3.3.4.2. A diagram of both methods is shown in the appendix, (FIGURE 7-33, FIGURE 7-34 and FIGURE 7-35).

TABLE 3-1 SUMMARY OF GPS METHODS

	Advantages	Disadvantages
Traverse Method	Uses similar leapfrog methodology as the conventional traverse. Is more efficient for projects with five or fewer control points.	Due to inherent possible errors in GPS baselines, error can accumulate rapidly. Requires high degree of coordination between survey crew. Requires higher degree of sophistication from **all** crew members.
Wing Point Method	Baselines are longer, minimizing error. Points are measured from two base points giving a check. Wing Points are likely to survive construction for later use. Less coordination is required between receiver operators. Base stations require little supervision for inexperienced operators. A true network is formed, giving stronger checks and adjustments. Wing points can be existing NGS benchmarks giving a vertical check on the network.	Time and effort are required to locate and set the wing points. Wing points are only useful for GPS work because they have no Azimuth points.

3.3.5. TRAVERSE METHOD

3.3.5.1. Use this method if the project requires five (5) points or less or if terrain conditions are non-conducive to the wing point method. See Appendix FIGURE 7-33 for an example.

3.3.5.2. Reconnoiter the project and set points at 500 ft to 1000 ft spacing.

3.3.5.3. Choose the **two** closest TGRN points for tie points. **Never tie back to the same point.**

3.3.5.4. On the first session occupy TGRN A, TGRN B and the first and last points on the project. Occupy these points for three (3) hours minimum using a 5-second epoch rate.

3.3.5.5. After the long line observations are complete, change the receivers to a 1-second epoch rate for the remaining short lines.

3.3.5.6. Short lines (lines less then 20 km (12 mi.) should be observed for 5 minutes plus 1 minute per km of baseline length. A minimum of 20 minutes of data is recommended on all lines, to allow for clipping bad segments of data. This allows for flexibility in computations during post processing when problems are discovered.

3.3.6. WING POINT METHOD

3.3.6.1. This is the preferred method for all projects because of the greater accuracy that can be obtained. See Appendix FIGURE 7-34 for an example.

3.3.6.2. Set the wing points about midway of the project, approx. 2 km (1 mi.) to 5 km (3 mi.) left and right of the proposed centerline. You want your maximum length of any measured line, from your wing points to your project control points, to be less than 10 km (6 mi.). You may need two or more pairs of wing points to accomplish this. Place wing points in the clear, away from trees, buildings and potential multi-path structures.

3.3.6.3. Place the wing points on or near NGS NAVD 1988 benchmarks for a vertical tie.

3.3.6.4. Reconnoiter the project and set points at 500 ft to 1000 ft spacing.

3.3.6.5. Choose the **two** closest TGRN points for tie points. **Never tie back to the same point**.

3.3.6.6. In the first session occupy TGRN A, TGRN B and the two wing points. Occupy these points for three (3) hours minimum using a 5-second epoch rate.

If there are more than two wing points on the project, perform the above-mentioned procedure for each pair of wing points.

3.3.6.7. On subsequent missions set base stations on the wing points and two rovers on the project. The base units will run continuously. The rovers will collect a minimum of 20 minutes of data for each of the project points and also any photo control points. It is advised that each rover have a list of points that he will occupy rather than just going to whichever point is next. This will eliminate duplicate or omitted points.

3.3.6.8. **NOTE: Modified wing point method for small two point projects** – Often, on a two point project (bridge or intersection) you will have severe blockage on the site which makes collecting 3 hours of data very difficult. Using a modified wing point method, go up and down the road from the project a mile or two and chose a location with no blockages. Set one point up the road and one down the road from the actual project site. Occupy TGRN A, TGRN B, and these two modified wing points for a minimum of three (3) hours using a 5 second epoch rate. (See Appendix FIGURE 7-35.) Then you can use 1-sec data collection on a short line from the modified wing points into the project and choose the best 20 minutes of data.

3.3.6.9. POSSIBLE PROBLEMS AND REMEDIES IN THE FIELD

Problem	Remedy
GDOP goes above 6.0	Note the time in site log. Restart time count.
Loss of lock	Note in site log. If frequent, you may need to start over with a higher HI.
Cycle slips	Note in site log. If frequent, you may need to start over with a higher HI.
Thunderstorm or other atmospheric event	Note time and azimuth of event on site log.
Receiver is disturbed	Notify party chief. Restart point observation.
You forgot to press measure	Notify party chief. Restart point observation.

TABLE 3-2 GPS FIELD PROBLEMS AND REMEDIES

3.3.7. POST-PROCESSING

3.3.7.1. Check the field data as you insert into the post-processing software. Be sure to check HI, antenna offset and point names. Especially, be sure that reference point names are always **identical** or you will show two different points which cannot be combined.

3.3.7.2. Always calculate all lines for which you have sufficient data. This will make the network stronger.

3.3.7.3. Always check the log file for calculated lines for the items indicated in Appendix FIGURE 7-32.

3.3.7.4. Always check the log file for the network adjustment for the items listed in Appendix FIGURE 7-32.

3.3.7.5. See page 7-81 for possible solutions to processing problems.

3.3.7.6. When performing your network adjustment, be sure to fix benchmarks in height only. This is ellipsoid height not orthometric height.

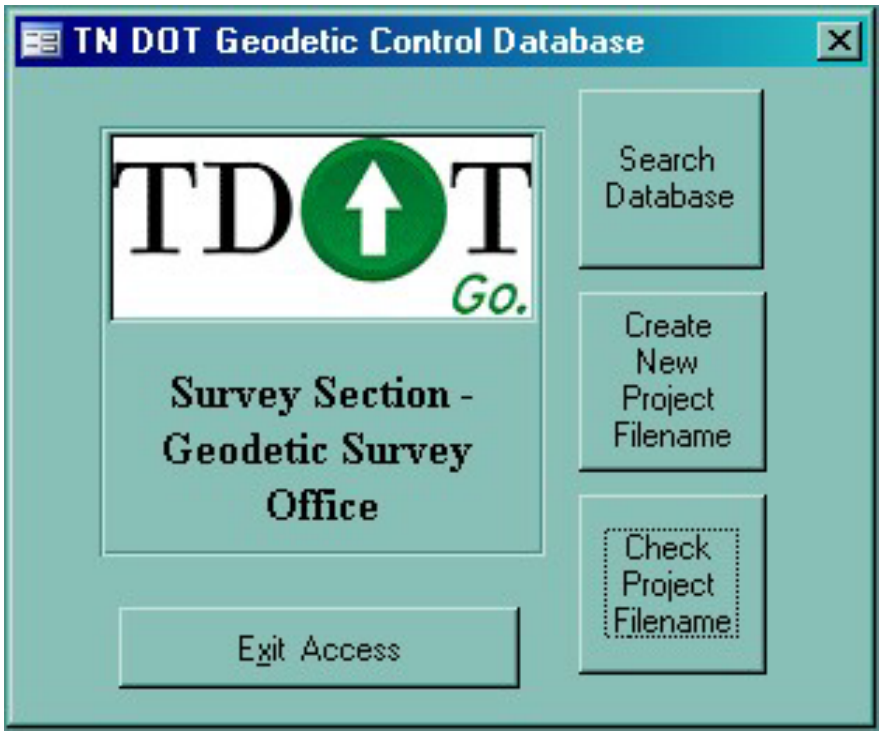
3.3.7.7. After network adjustment, process the final geographic coordinates to compute state plane coordinates and orthometric heights. Geoid model 1999 as published by the National Geodetic Survey is the only approved model for computing orthometric heights. TN Lambert map projection information is available in the appendix.

3.3.7.8. Process the state plane coordinates through an approved method to compute an average datum adjustment factor for the project. This factor will be applied to all project control points to compute final published coordinates. Control information shall be supplied to Regional Survey Supervisor in a suitable format for adding the information to the control point database maintained by TDOT. The geodetic control point database was created by TDOT using the Microsoft® Access© software.

3.3.8. TDOT CONTROL POINT DATABASE USE

3.3.8.1. Note: See the Appendix FIGURE 7-3 for a sample control point description sheet.

3.3.8.2. The following menu opens when the database is opened.



3.3.8.3. Search by point name returns a full description form like in the appendix. You are prompted for point name and county. A wildcard asterisk is allowed.

3.3.8.4. Manual Input brings up a blank form for inputting point information that only exists in paper form.

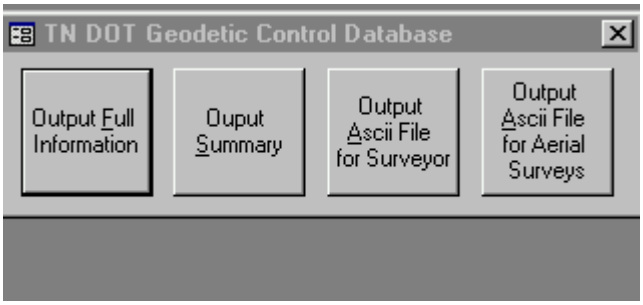
3.3.8.5. Search by Keyword searches the TO REACH field for the keyword you ask for. Be sure your search string is preceded by and followed by asterisks.

3.3.8.6. Search by Geographic Coordinates searches a 1.5 mi radius based upon LAT-LONG you input.

3.3.8.7. Search by State Plane Coordinates searches a 1.5 mi radius based on Northing and Easting you input.

3.3.8.8. Create Project Name is used by Regional Survey Supervisor in assigning project names but can be used by the database user to find the project name associated with a particular project. You are prompted for a county-route code. This is a two-character code for the county, followed by three numbers for the route. County codes are documented in the CADD Guidelines. Append an asterisk to find all projects in the database in the county, and on that route. Cycle through the choices to find the project you are interested in. You can then search for the control on this project as shown below.

3.3.8.9. Search by Project Name retrieves control for an entire project in either full description sheets, a summary or an ASCII file. Choosing this option opens another menu as shown below.



3.3.8.10. Output Full Information places the points on a description sheet, complete with all information, as shown in the sample in Appendix FIGURE 7-3.

3.3.8.11. Output Summary creates a summary report (see example below) which list all the points in a table (usually 1-2 sheets) including only coordinates (in feet) Datum Adjustment factor and scale factor.

Geodetic Survey Control Project Summary

Tennessee Dept. of Transportation - Geodetic Survey Section

Project Filename: EMORY
County KNOX

	North:	East:	Elev.:	D.A. Factor:	Scale Factor:
EM-1	630817.640	2559599.920	1030.067	1.00009538	0.99995545
EM-10	635349.803	2565915.102	1031.770	1.00009538	0.99995626
EM-11	636001.723	2566874.871	1048.722	1.00009538	0.99995638
EM-12	636399.105	2567305.443	1057.052	1.00009538	0.99995646
EM-13	637165.066	2568118.740	1057.915	1.00009538	0.99995660
EM-14	638059.989	2569209.452	1049.371	1.00009538	0.99995677
EM-15	638658.296	2569639.815	1054.886	1.00009538	0.99995689

3.3.8.12. Output ASCII file creates a text file for input into a CADD program to eliminate the need for retyping. The only difference in the surveyor and aerial options is the order of the information in the file.

3.4. DEVELOPMENT OF SURVEY CADD FILES

In the following discussion the surveyor is advised that CADD standards are maintained by the Design Division, CADD Section, and periodically revised. The surveyor is referred to the latest version of these standards, hereinafter referred to as the CADD Guidelines, for questions regarding colors, level structure, and other file format items. The CADD Section also maintains all files such as cell and font libraries that the surveyor may need. The Regional Survey Supervisor can direct you to the appropriate contact person. Note: All CADD files shall be in Microstation® format, shall conform to the standards set forth in the CADD Guidelines and shall be of manageable size as set by the Regional Survey Supervisor.

3.4.1. GENERAL

3.4.1.1. TDOT.smd

The TDOT.smd feature table file shall be used on all TDOT surveys. This file can downloaded from the DOT web site, this download also contains a list of these features.

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/survey.htm

3.4.1.2. The completed survey will consist, at a minimum, of the following items:

3.4.1.2.1. A Microstation® (.DGN) file containing all planimetrics

3.4.1.2.2. A Geopak® (*.TIN) file containing the digital terrain model (DTM)

3.4.1.2.3. A Geopak® (*.GPK) containing: points, lines, curves, spirals, chains, survey chains and parcels. See TDOT CADD Guidelines for naming conventions of COGO elements.

3.4.1.2.4. Other documentation or paper plots as set forth in the remainder of this manual

3.4.1.2.5. Other computer files or paperwork as required (See page 7-71)

3.4.2. THE PLANIMETRICS FILE

3.4.2.1. FILENAME

This file shall have the form 11222-33filetype.DGN where:

11 = the county code (See TABLE 7-7), and as shown in the CADD Guidelines

222 = the route number (if not a state route the surveyor's discretion is allowed.)

–33 = GPS project number (Contact the Regional Servey Supervisor for this number)

filetype = Survey (Survey Topography and Profile data)

Example: DV155-01Survey.DGN

Filetype = SurveySUE (Survey Subsurface Utility Engineering data)

Example: DV155-01SurveySUE.DGN

See Section 1.6 for project nameing procedure.

3.4.2.2. CONTENT

This file shall contain the following items within the limits of the projects as specified by the Regional Survey Supervisor or set forth in the survey contract.

3.4.2.3. A survey centerline (as required) (The centerline may be optionally stored in a file by itself in a filename as defined in the CADD Guidelines) (See Section 3.5)

3.4.2.4. All existing rights-of-way and property with owners shall be shown in the CADD file (See Section 3.6.6, 3.6.7 and 3.13). An EXCEL© file will be completed this file will be used to create the acquisition table. This EXCEL© file (RowAcqTable.EXE) can be downloaded from DOT web site:

http://www.tdot.state.tn.us/Chief_Engineer/assistant_engineer_design/design/survey.htm

3.4.2.5. All existing topography (See Section 3.6.)

3.4.2.6. Profiles of all survey centerlines with underground and overhead utilities shown (These may be in a separate CADD file of the form 11222-33filetype.DGN if technical considerations make this a more practical alternative.) (See Section 3.8)

3.4.2.7. Drainage Information as required (See Section 3.10, 3.11 and 3.12.)

3.4.2.8. Other survey data such as reference diagrams, various notes and other items as set forth elsewhere in this manual.

3.4.2.9. NOTES

See FIGURE 7-11 through FIGURE 7-18 and TABLE 7-3 in the Appendix for examples of the above information. Although these examples are shown in sheet form, the surveyor is advised that the survey will not consist of finished sheets but will be in a CADD file. The CADD file will consist of a single long map with coordinate integrity maintained. Also, the examples show only certain levels plotted in order to indicate the information required. The CADD file will actually contain all the information shown on all the examples on the levels as specified in the CADD Guidelines.

3.4.2.10. The surveyor shall make every effort to insure the readability and usability of the completed survey for design work. This shall include checking for text overlaps. The surveyor shall consider which data will be displayed simultaneously as the design process continues and make allowances for placement of text and other data. It is understood that all contingencies cannot possibly be considered, but a reasonable effort shall be required.

3.4.2.11. It shall be noted that any file format conversions required and any problems realized therefrom are the responsibility of the surveyor and that the end result of the turn-in files must be in a form in compliance with the CADD Guidelines.

3.4.3. THE DIGITAL TERRAIN MODEL

3.4.3.1. DEFINITIONS

The following definitions apply to all other discussions within this manual.

3.4.3.1.1. Digital Terrain Model (DTM) - a set of three dimensional random points and breaklines used to model the surface of the earth both horizontally and vertically.

3.4.3.1.2. Breakline - Also known as a fault line, is defined as a discontinuity in the earth's surface such as the edge of pavement or shoulders. Other examples are the top of a sharply defined stream channel or the bottom of a man-made ditch. Breaklines are generally indicated by a sharply defined line on the ground surface rather than a smooth or rolling appearance.

3.4.3.1.3. Random Point - Those points which are not connected with any breakline but stand alone.

3.4.3.1.4. Link Lines - Also known as triangle lines are the imaginary lines stored internally in a computer connecting the points used to interpolate information about the ground surface where no actual point exists.

3.4.3.1.5. Edge Lines – A line placed around the edge of data in an attempt to keep link lines from forming in areas where no data exists.

3.4.3.2. FILENAME

The DTM file shall be an ASCII *.TIN file in Geopak® format.

3.4.3.3. NOTES

A DTM is interpreted by the computer as a set of points connected by a series of link lines. The algorithms used to create the lines connect points to their nearest neighbor. However, in some instances the nearest point may not be the proper link connection. For example, the nearest point to a point on the top of a ditch cut may be a point on the opposite top. The proper link is in the bottom of the ditch, though, hence the need for breaklines. The computer algorithm will not allow a link line to cross a breakline. So a breakline in the bottom of the ditch forces the links into the bottom instead of short circuiting across the top.

3.4.3.4. It is pointed out that breaklines may be required even when the ground shows no obvious discontinuity. The surveyor shall show adequate random points and breaklines to insure that the DTM accurately reflects the surface of the earth. Great care shall be taken in the development of breaklines in the area of bridges or other structures, in a stream, under bridges, etc. At bridge abutments, wing walls, ends of pipes and culverts, curbs, retaining walls and any other vertical-type situation, breaklines at both the top and bottom of the feature shall be developed.

3.4.3.5. Random points are generally collected in a gridded manner with a nominal spacing of about 25 to 50 feet. This spacing can vary widely, however, from both much smaller or much larger, depending on the regularity of the surface being modeled. The spacing and placement of random points shall be such as to insure the accuracy of the DTM. See FIGURE 7-18 in the Appendix for an example of a DTM.

3.5. FINAL ALIGNMENT AND TOPOGRAPHY

3.5.1. ALIGNMENT

3.5.1.1. GENERAL

The final alignment shall be computed as nearly as possible to that specified in the Advance Planning Report. The Regional Survey Supervisor will furnish the Field Supervisor with all design criteria, the Advance Planning Report, any available preliminary maps, TVA quad maps, control monuments, etc., and provide any needed assistance to establish the final alignment. If it is discovered that the alignment falls close to a wetlands or “blue line stream” a line change shall be considered. Any significant deviation shall be approved by the Regional Survey Office. Alignments or portions thereof may or may not be field staked at the discretion of the Regional Survey Supervisor. If staked all route surveys shall meet Second Order, Class II accuracy standards, and be tied to the TGRN. (See Section 3.2) Also, the survey shall be tied at the beginning to existing log mile marker (if available) and the ties noted in the planimetrics file.

3.5.1.2. STATIONING

Stationing will always be shown in the direction of increasing log mile. If log miles are not available, stationing will be shown from South to North and West to East. Stationing shall always begin with a station large enough to avoid any minus stations if the survey is backed up for additional information. When tying to an existing road, the survey shall extend far enough past the proposed beginning and end of the project to provide information necessary for the designer to make a good vertical and horizontal tie. Cross roads shall be stationed left to right looking forward along the alignment. Stationing of cross roads shall be staggered to prevent any two cross roads from having the same or overlapping station value. State routes crossing the alignment shall be stationed with the existing log mile.

3.5.2. CURVES

3.5.2.1. All curves shall meet the standards illustrated in the Tennessee Standard Drawings RD-SE-2 and RD-SE-3. (See Appendix FIGURE 7-9 and FIGURE 7-10 for tables.) Also refer to the T.D.O.T. Design Guidelines. Exceptions shall be approved by the Regional Survey Office.

3.5.2.2. Circular Curves - All data is to be computed by the arc definition.

3.5.2.3. Curve data shall be rounded to three decimal places.

3.5.3. TANGENTS

All bearings are to be calculated from the initial bearing from PI to PI. PI coordinates shall be computed to four decimal places, then bearings re-computed to even seconds. Bearings and beginning coordinate point are then held constant and PI's and ending coordinates re-computed to four decimal places. These new coordinates and even bearings will be labeled on present layout sheets. Coordinates at the beginning and ending of all alignments, at all PI's, and at intersection station equations shall be labeled.

3.5.4. STAKING FINAL ALIGNMENT

3.5.4.1. ALIGNMENT POINTS

Iron pins, spikes, nails or other material that can be located with a metal detector shall be used for curve points and significant POT's. Other points may be marked with stakes. All alignment points in cultivated fields shall be buried below the depth of cultivation and all points in yards or pastures shall be driven flush with the ground. Alignment points shall be staked at the discretion of the Regional Survey Supervisor.

3.5.4.2. STAKING

The final alignment may be staked and marked at the discretion of the Regional Survey Supervisor, with the station number at least every 100 feet. Intervals for staking will be at the discretion of the Regional Survey Supervisor. When staking on existing pavement, all stations will be marked with a nail and the station painted on the pavement near the point. All stakes shall be removed from cultivated fields and hay fields when the survey is complete, or when requested by a property owner or tenant.

3.5.5. REFERENCE POINTS

Project control survey points (See Section 3.2) will serve as reference points for each project. They are to be referenced with permanent type material and documented in the planimetrics file. The method used for referencing shall be at the discretion of the Regional Survey Office. (See FIGURE 7-4 or TABLE 7-1 in the Appendix for examples).

3.6. TOPOGRAPHY

3.6.1. GENERAL

It is important that all topography likely to be affected by, or that will affect, the proposed road be accurately located, this shall include all houses on properties that are in some way affected by the project. It is the responsibility of the Field Supervisor to determine limits of the topography. The limits shall include the proposed width of R.O.W. and possible limits of construction. Occasionally a building or drainage structure outside the construction limits will affect or be affected by the project, these shall also be located.

3.6.2. TOTAL STATIONS

Topography may be accurately located with total stations using angle and distance method. A minimum of two points shall always be tied and all buildings measured so they can be accurately plotted. A minimum of two points shall be tied on each property line, preferably each corner if possible. This method insures that any point or property line can be calculated using coordinate geometry. There are different methods of recording field data from different instruments. A method approved by the Regional Survey Office shall be used.

3.6.3. PROPERTY OWNER CONTACT

As discussed in other sections of this manual, the first step of any survey involving private property shall be the personal contact of the property owner or tenant. At this meeting, the Field Supervisor shall request from the property owner information concerning the location of property lines, property corners, septic tanks, overflow fields and wells. In the case of commercial property an inquiry shall be made as to the existence of underground storage tanks. The Property Owner Contact Form (Appendix FIGURE 7-1) shall be used for this purpose. A completed form for each tract shall be submitted as part of the completed survey. This procedure will also be applied to all railroad property.

3.6.4. AT GRADE ROAD CROSSINGS

Alignment, DTM, topography and present R.O.W. shall be recorded for a minimum of 500 ft for State Routes and 300 ft for other roads. Exceptions to the minimum may be made at the discretion of the Regional Survey Office. The DTM shall be extended as necessary to insure proper information for grade ties of proposed to existing roadways. Bearings of centerlines and stations of the intersection shall also be shown.

3.6.5. AT GRADE RAILROAD CROSSINGS

3.6.5.1. General - A 90 degree crossing is desirable, and in no case shall tracks be skewed less than 70 degrees.

3.6.5.2. Field Data Required:

3.6.5.2.1. Plus and bearing of each set of rails

3.6.5.2.2. Alignment of all tracks, 600 ft each direction with curve information (if any) computed and recorded in the planimetrics file

3.6.5.2.3. Topography within the railroad R.O.W. for 600 ft each direction, including switching devices, signal devices, control boxes, and utilities (especially fiber optic cables)

3.6.5.2.4. Name of the railroad

3.6.5.2.5. Present railroad R.O.W. The term “Charter R.O.W.” does not indicate that the railroad owns the property and charter R.O.W. shall not be shown. Railroad R.O.W. shall include only the property owned by deed or being used and maintained

3.6.5.2.6. Distance and direction to the nearest mile post and description of same.

3.6.5.2.7. Profile of the top of rail 600 ft each direction; both rails if they are superelevated

3.6.5.2.8. Develop the DTM 200 ft in each direction along the tracks within the railroad R.O.W. If the road R.O.W. extends beyond 200 ft, the outermost limits of the DTM shall be taken at the limits of the R.O.W.

3.6.5.2.9. Size, type, invert elevation and condition (if required) of existing drainage structures with the direction of flow in field drains and channels indicated by arrows.

3.6.5.2.10. Plotting - The data shall be plotted with the roadway topography detail. (See Section 3.6.14)

3.6.6. PROPERTY LINES

3.6.6.1. The bearing, distance and station of intersection shall be shown along each property line in the planimetrics file. If the property line does not cross the survey line, the right angle station and offset distance shall be shown for the property corner at the affected area. All angles to property lines will be tied with a total station, as directed in Section 3.6.2, and the bearings calculated from the survey line. Deed bearings shall not be shown.

3.6.6.2. Riparian Owners - Title to Stream Beds - Whether the stream is navigable or not determines how much of the stream bed a private individual can own. In Tennessee an individual can own to the ordinary low water lines, but no farther if the stream is navigable. Title to the stream bed that lies between the ordinary low water lines in a navigable stream is vested in the State for the use and enjoyment of the public at large. It is not susceptible to private ownership even when the deed calls for center of the stream. Title to stream beds in nonnavigable streams is vested in the adjacent riparian proprietors.

3.6.6.3. Navigability - Where the Corps of Engineers has declared certain waters to be “Navigable Waters of the United States” pursuant to the Rivers and Harbors Act of 1899, those will be accepted as navigable. A list of waters so designated by the Corps is shown on pages 7-8 through 7-11 of the Appendix. On all other streams, a determination of navigability must be made. The Tennessee Supreme Court has defined navigability this way: “A stream is navigable in a legal sense when it is capable, in the ordinary stage of water, of being navigated, both ascending and descending by such vessels as are usually employed for purposes of commerce.” Holbert vs. Edens, 73 Tenn. 204 (1880).

3.6.6.4. It is not navigable in a legal sense when: “as where, in certain stages of the water, it may have insufficient depth for flatboats, rafts, or small vessels of light draft.” Holbert vs. Edens, 73 Tenn. 204 (1880).

3.6.6.5. So, if a stream can float “flatboats, rafts, or small vessels of light draft” at all times of the year, it is navigable in the legal sense. But if it can float such vessels only during flood time, it is not navigable in the legal sense. The fact that a stream has never been used for navigation is no bar to navigability if the potential for navigation is present.

3.6.6.6. Property Lines on Navigable Waters - The Tennessee Supreme Court has said: “--the owners of land upon navigable streams have title to the ordinary low water mark--.” Martin vs. Nance, 40 Tenn. 649 (1859).

3.6.6.7. Ordinary low water mark was defined in another case: “The ordinary low water mark is the usual and common or ordinary stage of the river, when the volume of water is not increased by rains or freshets, occasioned by melted snow on one hand, or diminished below such usual stage or volume by long continued drought to extreme low water mark.” Goodall vs. Herbert & Sons, Inc., 8 Tenn. App. 265 (1928).

3.6.6.8. Property Lines on Nonnavigable Waters - When the stream is not navigable, private ownership extends to the center of the stream even if the deed calls for the edge or water line, unless there is a metes and bounds description or other intent not to extend to the center of stream.

3.6.6.9. Property Lines on TVA Lakes - TVA property extends to the "Maximum Shoreline Contour". (A list is given as TABLE 7-2 of the Appendix.) A "Flowage Easement" around lakes, such as Norris, Cherokee, and Douglas may also be owned and shall be indicated. Easements may be investigated at the TVA property office closest to the lake in question.

3.6.6.10. Surveying Riparian Property Lines - Enough data must be taken to enable the Designer to calculate the area of take. This means that the riparian property lines must be traversed, or located by offsets from base lines, by angle and distance with a total station or located by other suitable means.

3.6.6.11. Overlapping Deeds - Adjacent owners shall be consulted to determine if they can agree to a common line. If so, it shall be shown as an agreed property line. Discussions with the owners shall be documented on the Property Owner Contact Form (FIGURE 7-1.) If the owners cannot agree to a common line, both deed lines bounding the overlapped area shall be shown and the area labeled as "disputed" in the planimetric file.

3.6.6.12. Noncontiguous Deeds - If no one claims the area between the deeds, the deed lines shall be shown and the area labeled "owner unknown". Discussions with the owners shall be documented on the Property Owner Contact Form.

3.6.6.13. Deed Search - It is the responsibility of the surveyor to locate a deed for each piece of property affected by the project.

3.6.6.14. Subdivisions - The recorded plats provide information, but are not substitutes for locating property lines.

3.6.6.15. Evidence of Property Lines - Tennessee Courts will try to determine from a deed the land which the parties intended to include in the conveyance. Evidence is generally given this order of preference:

Agreed line between adjacent owners

Natural objects

Man-made objects

Boundary lines of abutting property

Courses and distances

Example: If a boundary is the center of a creek but the stream has naturally shifted, the boundary shifts with the creek unless the deed has metes and bounds calls that would otherwise show the intent of the parties.

Example: A deed calls for 350 ft to John Smith's eastern boundary, but the line measures 342 ft to Smith's boundary. The true distance is 342 ft, because a boundary line takes precedence over a course and distance. All physical evidence shall be recorded (iron pins, monuments, fences, etc.).

3.6.7. PRESENT RIGHT-OF-WAY

3.6.7.1. GENERAL

There are only six (6) situations in which the State can successfully claim ownership of present R.O.W.:

3.6.7.1.1. There is a recorded deed executed between the State, County or Municipality and the present or prior owner.

3.6.7.1.2. There is an unrecorded deed that can be located, executed between the State, County or Municipality and the present owner who is still living.

3.6.7.1.3. There is a plat recorded by the present or prior owner which shows a R.O.W. width.

3.6.7.1.4. There is an unrecorded petition between the present owner and the County.

3.6.7.1.5. There is a R.O.W. monument on the property.

3.6.7.1.6. Failing all five of the above, the State can only claim to the user's line, or if the User's line cannot be established, there is a presumption that the unascertained R.O.W. is 25 feet on either side of the centerline of the traveled portion of the road.

3.6.7.2. USER'S LINE

3.6.7.2.1. Determination will be a matter of judgment, and only property being used by the State may be claimed.

3.6.7.2.2. For rural sections, evidence shall be given the following order of preference:

Marked property corners

Fence paralleling the road

The widest of the following:

Limit of maintenance
A line of utility poles
Toe of slope and back of ditch
Edge of Shoulder
Edge of Pavement

3.6.7.2.3. For urban sections, evidence shall be given the following order of preference:

Marked property corners
Back of sidewalk
The widest of the following:
Limit of maintenance
A line of utilities
Toe of slope or back of ditch
Back of curb or edge of pavement

3.6.7.2.4. The orders of preference given above for the user's line can be disregarded only if there is good reason therefore.

3.6.7.2.5. When necessary, the Regional R.O.W Supervisor may be contacted for assistance in locating a user's line.

3.6.7.2.6. The user's line shall be labeled as "Pres. R.O.W." in the planimetrics file.

3.6.7.3. OLD R.O.W. PLANS

Old plans sometimes exist for which there are no R.O.W. deeds. In this case, without physical evidence, the old plans are only circumstantial evidence of present R.O.W. and only the user's line may be claimed. Areas to the user's line shall be calculated.

3.6.7.4. In the event that the present R.O.W. cannot be identified and a user's line cannot be established for a two (2) lane undivided public road, there shall be a presumption that the unascertained R.O.W. is 25 feet on either side of the centerline of the traveled portion of the road.

3.6.7.5. Information necessary for a complete description of R.O.W. lines (metes and bounds or coordinates) shall be recorded. All present R.O.W. metes and bounds, station and offset distances for all break points, the beginning and end of curve points, and property line intersection points along the present R.O.W. line shall be labeled in the planimetrics file.

3.6.8. UTILITIES

3.6.8.1. All existing utilities within the project area shall be shown.

3.6.8.2. OWNERS

The owner of each utility shall be shown. Include name, address, contact person and phone number.

3.6.8.3. LIMITS

When more than one utility company supplies the same service, the limits of each owner's service area shall be indicated.

3.6.8.4. LOCATION AND PROFILE

The location and depth of underground utilities shall be determined as best possible. Profiles on gas lines and gravity-flow sewer lines are especially critical. However, gas lines shall never be sounded with a steel rod.

3.6.8.5. UNDERGROUND

All underground utilities which may be affected by roadway or structure construction (as determined by the Regional Survey Supervisor) will be shown in the planimetrics file and plotted with present layout and profile. Other utilities within the proposed R.O.W. will be shown in the planimetrics file and plotted only with the present layout with approximate depth noted. In both cases the utility representative's name and the date the utility was located shall be recorded in the field book.

3.6.8.6. OVERHEAD

Overhead utility lines between poles will <u>not</u> be shown on present layout plots. The direction of the lines will be indicated by a short line through the square representing the pole. However, any wire, or low wire of a line group, crossing the centerline shall be shown with the station and elevation recorded and shown on the profile. A temperature reading shall be recorded and shown on the profile for all high-tension lines.

3.6.8.7. SIGNALS

At signalized intersections, the signal heads, span wires, poles and controller shall be recorded and shown on present layout plots.

3.6.8.8. POLE OR TOWER NUMBER

The pole or tower number shall be recorded, if available, for major transmission lines.

3.6.8.9. TYPE OF UTILITY

The type of service for each underground line and for each utility pole shall be noted using symbols shown on standard drawing RD-L-1 and RD-L-2 and RD-L-3. (See Appendix FIGURE 7-5 through FIGURE 7-7).

3.6.8.10. STORM SEWERS AND SANITARY SEWERS

Elevations shall be taken on the top and bottom of each manhole or catch basin and on the invert at each end of every pipe, including pipes that terminate in manholes. This information may be taken during development of the DTM or as part of a separate level run. It is advisable to develop a table of elevations and numbering system for the pipes of a sewer system.

3.6.8.11. SEPTIC TANKS AND DRAIN FIELDS

In areas where there are no municipally owned sewer and water systems, information shall be shown on all developed property regarding sewage disposal and water supply. All septic tanks and field lines near the proposed roadway shall also be located. However, a note indicating the location of facilities a considerable distance from the proposed roadway (or behind a building) will suffice.

3.6.8.12. WELLS

Any drilled wells (gas, oil, or water) that will be inside the proposed roadway or that will be abandoned shall be shown. The name and address of the driller, the date drilled, the depth of the well and the name of the property owner at the time the well was drilled shall also be noted. If this information is available, it shall be listed in the planimetrics file adjacent to the well site.

3.6.8.13. LOCATION FOR PAY ITEM PURPOSE

Responsibility for payment (Utility Co. or State) to relocate a utility is determined by its location within or without of present R.O.W. When utilities are close to the present R.O.W. or user's line, care shall be taken when developing the planimetrics file to indicate whether the utility is inside or outside of the present R.O.W. The Regional Utility Engineer shall be consulted when there is confusion about information to be shown.

3.6.8.14. PROBLEMS

Occasionally problems are encountered in the coordinating of the location of underground utilities. Any such problems shall be recorded in the project field book.

3.6.9. LAND CHARACTER

The land character of rural areas such as pasture, second growth, cultivated, swampy, etc., shall be noted. There shall be no attempt to show boundaries of each character except for fences and tree lines.

3.6.9.1. STOCK AND EQUIPMENT PASSES

As implied in T.D.O.T. Design Guidelines, it is the responsibility of survey parties to recommend locations where stock and/or equipment passes shall be placed for proposed highways. The primary indicator for a stock pass is the dividing of a large area specifically used for pasture. Therefore, all pasture lands shall be carefully noted in the planimetrics file. Also, field personnel shall be cautioned against discussing possible locations with property owners. The assurance that a stock and/or equipment pass will be considered during the design process is usually the best response.

3.6.9.2. TREES

Trees which may be affected by construction shall be recorded. The edges of wooded areas shall also be identified.

3.6.10. EXISTING DRAINAGE STRUCTURES

3.6.10.1. The direction of flow shall always be shown.

3.6.10.2. The size, type, length, invert elevations, type of foundation material (if determinable) and condition (if required) of existing drainage structures shall be noted in the planimetrics file.

3.6.10.3. Channel Changes

3.6.10.4. The alignment shall be tied to the survey line.

3.6.10.5. The DTM shall encompass any area affected by a channel change.

3.6.10.6. Material used for channel lining shall be identified.

3.6.10.7. Storm Sewers - The size and location of all pipes shall be shown. A recommended method is to give each catch basin and manhole a number so that each pipe can be identified. Example: 71 in x 47 in from 3 to 4.

3.6.11. BUILDINGS

3.6.11.1. The number of stories shall be shown, such as:

1 F (one story frame)

2 B (two story brick)

Only the floors above ground shall be counted, and the abbreviations shown on Standard Drawing RD-A-1 (Appendix FIGURE 7-8) shall be used. Additional identification such as res., barn, shed, etc., shall be used. All commercial property shall be noted in the planimetrics file by name, e.g., “McDonald’s Restaurant”.

3.6.11.2. At least two corners on all buildings shall be located and buildings measured so they can be plotted accurately. In business districts all doors and loading docks shall be shown with floor elevations noted. Also the floor elevation shall be shown for all buildings near drainage structures in flood prone areas.

3.6.12. RAMPS AND DRIVEWAYS

All existing ramps and driveways shall be accurately located.

3.6.13. UNDERGROUND PETROLEUM STORAGE TANKS

The disposition of property containing underground petroleum storage tanks is of utmost importance to the T.D.O.T. Environmental requirements call for expensive procedures to insure that leakage does not occur during any activity affecting the property. Because of the expense involved, the T.D.O.T. must carefully consider such property when planning or constructing a roadway project. The ideal solution would be to avoid such property. This, however, is not always possible.

3.6.13.1. An attempt will be made to locate and identify all such property during development of the APR. Proposed alignments will then be located so that the property can be avoided if possible. All such tanks, currently in use, shall have a certificate (or tank identification) number issued by the State Department of Health and Environment.

3.6.13.2. In the event that such property is unavoidable, all tanks shall be located as accurately as possible and recorded in the planimetrics file. The Environment & Conservation Certificate Number shall also be shown. Accurate location of the underground tanks is often difficult. However, all possible sources of information shall be investigated (conversation with tenants, request for plans from owners, etc.). Environment & Conservation personnel can also be contacted and may be aware of additional information (including the certificate number) in their files. They may be reached at (615) 532-0945 in Nashville.

3.6.13.3. Occasionally property with tanks not identified in the APR will be encountered. This is more likely when the tanks are not in use. The property and existing tanks shall be brought to the attention of the Regional Survey Supervisor for consideration of moving the survey line to avoid the property. If this is not possible, the property and tanks shall be located as discussed above. If the tanks are in use the Environment & Conservation Office shall be contacted as mentioned above, for a Certificate Number.

3.6.13.4. OTHER TOPO FEATURES

Ornamentation on private properties such as signs, raised planters, etc. shall be shown and labeled in the planimetrics file. Parking lots and parking spaces (within or adjacent to proposed R.O.W.) shall also be located in the planimetrics file. These items affect the appraisal of the property.

3.6.14. FIELD NOTES

Field notes, as such, are not a required part of the survey. However, a field book shall be kept to record information which would be of use during data analysis and editing, development of plots and review of activities. Examples: conversations with property owners, utility company employees, etc.; sketches of unusual locations or situations; descriptions of potential problems or locations; descriptive data to be entered into files later.

3.6.15. PLOTTING

3.6.15.1. GENERAL

The alignment and topography shall be plotted to check the planimetrics file. Data displayed on bond paper (sheets or roll) shall be turned in with the survey. (See FIGURE 7-11 through FIGURE 7-13 of the Appendix for examples.)

3.6.15.2. SCALE

The Regional Survey Office will select the most convenient scale for each project. Usual scales are: 1in = 100 ft in rural areas and 1in = 50 ft in urban areas and short projects, such as bridge replacements. A scale of 1in = 20 ft, 1in = 50 ft or 1in = 100 ft could be used, but never a scale smaller than 1in = 100 ft.

3.6.15.3. HORIZONTAL AND VERTICAL DATUM

The horizontal and vertical datum used (See Sections 3.2, 3.7 and 5.1) shall be noted in the planimetrics file and on the check plot. Examples: “Coordinates are Datum Adjusted NAD/83 (1995) by the factor of 1.000XXX”. The “1995” refers to the year of the most recent adjustment of coordinate values in Tennessee and ”1.000XXX” refers to the actual datum adjustment factor used for the project. And, “All elevations are referenced to the NAVD 1988”. Datum adjustment factors will be accurate to at least six decimal places.

3.6.15.4. COORDINATE VALUES FOR PI’S

Coordinate values for all PI’s shall be shown in the planimetrics file as part of each curve data table. Coordinate values shall also be listed for the beginning and ending points of all alignments and intersection station equations.

3.6.15.5. COMPLETE NAMES

Complete names as shown on deed shall be used on present layout sheets and property tables. The term “ETUX” shall be avoided.

3.7. BENCH LEVELS AND CHECK LEVELS

3.7.1. VERTICAL DATUMS

All vertical datums shall be tied to monuments established by the National Geodetic Survey (NGS), United States Geological Survey (USGS), or Tennessee Valley Authority (TVA). NGS monument ties are preferred.

Note: Assumed datums or the use of GPS to establish vertical control will be used only when authorized by the Regional Survey Supervisor.

3.7.2. METHODS AND ACCURACY

Bench marks will be set and check levels run before they are used for development of the DTM. Third order accuracy shall be obtained before adjustments are made. (See page 7-28 in the Appendix for definition.) Check level calculations shall be shown in the notes of the field book. (See FIGURE 7-19 through FIGURE 7-22 in the Appendix for examples of field notes).

3.7.3. BENCH MARK LOCATION

Bench Marks shall be set at least every 1,000 ft along the survey and near all major structure sites and major intersections. All Bench Marks will be permanent in nature.

3.7.4. DESCRIPTIONS

All Bench Marks are to be fully described. Example: B.M. No. 35, elev. 594.68, Nail in side of 24 inch White Oak, 160 ft right, Sta. 24+45.00.

3.8. PROFILE AND CROSS SECTIONS

3.8.1. PROCEDURES

3.8.1.1. GENERAL

As a rule profiles, including drive and ramp profiles, are generated from the DTM and no separate procedures are required in the field. However, there may be an occasional situation for which the Regional Survey Supervisor would require a conventional profile. It is for that reason profile methods and procedures are outlined below. Many of the methods described below shall be observed when developing profile plots from the DTM. Cross sections are no longer used by T.D.O.T. as a method of gathering field data and they are not plotted as part of the survey function. Therefore, cross sections procedures are not considered in this manual.

3.8.1.2. REQUIREMENTS

Profile shots shall be taken at the beginning and ending stations, and at every 50 ft station. The profile shall also be taken at all breaks or abrupt changes in ground elevation.

3.8.1.3. METHODS

The Direct Rod Reading Method shall be used when taking a profile with a surveyor's level. Readings shall be made to the nearest 0.1ft on soil, rock, or gravel surfaces, and to the nearest 0.01 ft on asphalt or concrete surfaces.

3.8.1.4. DRIVEWAY AND RAMP PROFILES

Driveway and ramp profiles shall be taken at 25-foot intervals for a distance sufficient to accommodate ties to proposed grades. All profiles shall be tied to the centerline of survey, not some physical object such as edge of pavement.

3.8.1.5. SIDE ROADS

Profiles shall be taken for the limit of the alignment at 25-foot intervals with additional profile, if required to accommodate ties to existing grades.

3.8.1.6. TRIGONOMETRIC METHODS

Trigonometric profiling may be used when the terrain is rough or elevation differences are great. The field notes must be in such form that they are easily interpreted by others.

3.8.1.7. NOTES

An example of profile notes is included as FIGURE 7-22 in the Appendix. Notes must be checked and initialed in the field book.

3.8.1.8. DATA COLLECTORS

When field data collectors are used, a tabulated list of offsets and elevations must be produced.

3.8.2. PROFILE PLOTTING

See FIGURE 7-14 through FIGURE 7-16 in the Appendix for examples.

3.8.2.1. GENERAL

Profile plots shall be generated to check data in the planimetrics file and turned in with the survey. PROCEDURES

Standard metric profile paper, if available, (bond, roll or sheets) shall be used with the horizontal scale the same as that used for present layout plots. The desirable ratio is one (1) vertical to ten (10) horizontal.

3.8.2.3. ITEMS TO BE PLOTTED

3.8.2.3.1. Profile of the survey centerline or baseline

3.8.2.3.2. Profiles of all sideroad centerlines or baselines

3.8.2.3.3. Profiles of the tops of each rail for a railroad crossing for a minimum of 600 ft in each direction

3.8.2.3.4. Profiles of all ramps and driveways, if not included in the DTM

3.8.2.3.5. Profiles of storm and sanitary sewer lines within the roadway (back of shoulders or sidewalks)

3.8.2.3.6. Storm and sanitary sewers and major utilities, e.g., gas transmission lines which may be affected by roadway or structure construction

3.8.2.3.7. Bench Mark descriptions and elevations or control point descriptions and elevations, if they are used for vertical control

3.8.2.3.8. All intersection equations

3.8.2.3.9. Drainage information, including structure plotted, station, size of drainage area, skew and direction of flow

3.8.2.3.10. Low wire crossing information, including wire type, clearance, station, and temperature if a high tension line

3.8.2.3.11. High water marks and normal water marks at stream crossings or at intervals when the centerline parallels streams

3.8.2.3.12. Vertical datum and stationing properly shown

3.8.2.3.13. Labeling for each item shown

3.8.2.3.14. Profile plot labeled with project description

3.8.2.3.15. All profiles shall contain a statement, if indicated by field procedures, that depths to some utilities (indicate which) are approximate and profiles shall not be considered as accurate representations of their locations.

3.8.2.3.16. On occasion the surveyor may not be successful in arranging for the marking of underground utilities by the responsible company. In that case a note shall be entered in the planimetrics file and printed with the profile check plot. Following is an example:

NOTE: APEX PHONE COMPANY, AND ABC WATER WORKS WERE NOTIFIED THAT A SURVEY WAS BEING CONDUCTED BY T.D.O.T. FOR THIS PROJECT. THEY WERE REQUESTED TO MARK THEIR UNDERGROUND LINES IN THE FIELD, SO THE LINES COULD BE SURVEYED AND SHOWN ON THE PLANS. AFTER A REASONABLE AMOUNT OF TIME, THE LINES WERE NOT MARKED, OR INCOMPLETELY MARKED. AS A RESULT, SOME UNDERGROUND UTILITY LINES ARE NOT SHOWN ON THE SURVEY.

3.8.2.3.17. Identify the vertical datum - example: “All elevations are referenced to NAVD 1988”.

3.9. DRAINAGE SURVEYS

3.9.1. DRAINAGE MAP

An example is included as FIGURE 7-17 in the Appendix.

3.9.1.1. METHODS

A drainage map will be prepared for every project that has drainage crossing the survey centerline, unless instructed otherwise by the Regional Survey Office. Large areas may be run on quad sheets or aerial mapping. Smaller areas shall be surveyed in the field. Mapping shall be digitized and entered in the planimetrics file if possible. Any drainage structures which control flow into or away from the immediate project area (where flow crosses the centerline) shall be located and their size noted.

3.9.1.2. NOTES

Field notes shall be recorded in a standard field book, if a data collector is not used, and shall include the following information:

3.9.1.2.1. Any necessary traverse notes with ties to the centerline and other drainage areas.

3.9.1.2.2. Drainage area features such as ground cover, buildings, roads, etc. and any change in the drainage area that might effect the runoff, such as urban development or watershed projects.

3.9.1.3. PLOTTING

Drainage map check plots shall be developed on bond paper and submitted with the survey. The scale for maps (usually 1in = 200 ft) shall be determined by the Regional Survey Office (See page FIGURE 7-17 in the Appendix for an example.) The following information shall be shown on plots:

3.9.1.3.1. Centerline of survey with stationing

3.9.1.3.2. Each complete area and cross reference to other maps for large areas

3.9.1.3.3. North arrow, title block, area in acres, centerline ties, ground cover, buildings with floor elevations, roads, the elevation of and distance to the farthest point along the flow path, and the size, location and inlet and outlet invert elevations of existing drainage structures

3.9.1.3.4. In the event a TVA lake is shown on the drainage map the Full Pool Contour Elevation and the Maximum Shoreline Contour Elevation shall be noted. (See on page 7-11 in the Appendix.)

3.9.2. GENERAL REQUIREMENTS FOR BRIDGE AND CULVERT SURVEYS

3.9.2.1. SECTION 404 PERMIT INFORMATION

3.9.2.2. Under Section 404 of the Federal Water Pollution Control Act, the Survey and Design Office must provide certain information to the Corps of Engineers and obtain permits to dredge or fill in any channel conveying minimum constant average flows of 5 cfs. The requirement applies to any stream shown as a solid blue line on U.S.G.S. maps.

3.9.2.3. DEFINITIONS

EXTREME HIGH WATER: the highest elevation to which evidence can be found that water has ever risen [If the drainage basin has been altered, the highest elevation since that time]

NORMAL POOL: this elevation is identical to ordinary high water, but is applied to lakes and wetlands.

NORMAL WATER: the water surface elevation during normal weather conditions (no flood runoff).

3.9.2.4. FIELD DATA

The extreme high water, normal water, and low water elevations are required.

3.9.2.5. NAMES AND ADDRESSES

The names and addresses of property owners adjacent to streams that require 404 permits shall be recorded in the field book and in the planimetrics file.

3.9.2.6. SIZING DRAINAGE STRUCTURES

Sizing is not required by survey personnel. The size or type of structures is usually indicated in the Advance Planning Report, or will be determined by the Structures Division during the design.

3.10. DRAINAGE SITE SURVEYS

Unless directed otherwise by the Regional Survey Office, the following two (2) types of drainage site surveys will be made:

3.10.1. BRIDGE SURVEY: survey for sites with Q_{50} greater than 500 cfs or any structure whose length along the roadway is 20 feet or greater

3.10.2. PIPE AND BOX CULVERT SURVEYS: survey for sites with Q_{50} up to and including 500 cfs

3.10.3. The drainage area will be used in conjunction with the Hydrologic Areas Chart (Appendix FIGURE 7-36) to determine if a bridge or culvert survey is performed.

3.11. BRIDGE SURVEYS

(Q_{50}= GREATER THAN 500 CFS OR ANY STRUCTURE WHOSE LENGTH ALONG THE ROADWAY IS 20 FT OR GREATER) - Each bridge survey shall have a corresponding Bridge Survey Notes sheet submitted with the project data. A copy may be found on page 7-72 of the Appendix, which can be used for duplicating.

3.11.1. FLOOD PLAIN SECTIONS

3.11.1.1. A flood plain section perpendicular to flood flow shall be taken upstream and downstream. Each section shall be a distance from the proposed structure equal to four times the typical distance between top of banks. The flood plain section shall extend completely across the flood plain from extreme high water to extreme high water and be tied accurately to the centerline of survey.

3.11.1.2. Additional flood plain sections will be necessary at points where the valley constricts or significantly changes within the area of study (length of stream profile above or below the structure).

3.11.1.3. Flood plain sections at great distances from the structure may be located on a quad sheet or other mapping rather than the site plan. If it is determined from examination of topographic maps that a representative flood plain section can be observed closer to the survey centerline, the object of the survey will be met.

3.11.1.4. The flood plain section shall be described in segments as shown below (FIGURE 3-1). Land character shall be described using terms such as: pasture, no brush, high grass, cultivated area, row crops, heavy weeds, scattered brush, light brush and trees, heavy stand of timber, etc.

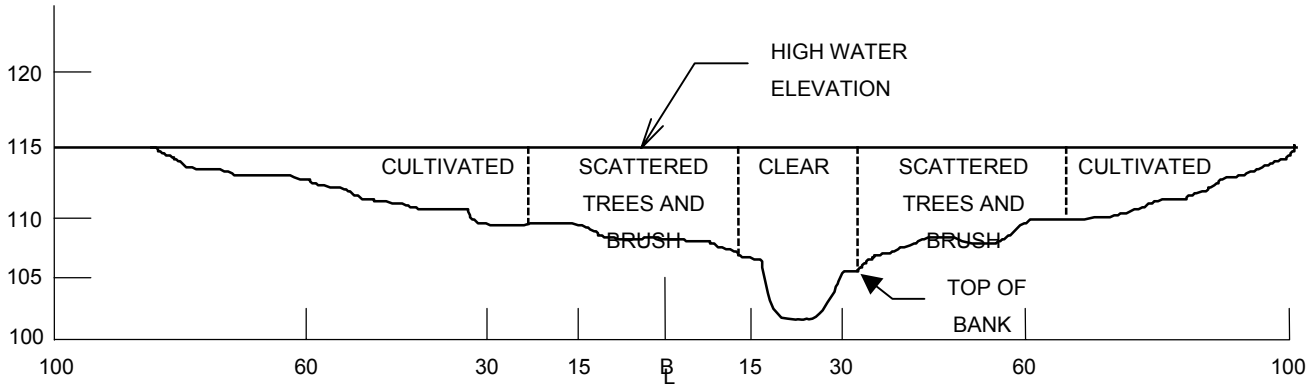


FIGURE 3-1 EXAMPLE FLOODPLAIN SECTION

3.11.2. STREAM PROFILE

The DTM shall be generated such that a stream bed, water surface and top of one bank profile can be developed for a distance equal to six times the typical distance between top of banks, upstream and downstream of the proposed structure. DTM shots shall be taken at regular intervals (depending on the size and uniformity of the stream) and at any point the water velocity changes. The type of material in the stream bed shall be described and it shall be noted if banks are subject to scour. Depth-finders may be used on major streams and rivers. The top of bank data is required only for those streams with well defined stream channels.

3.11.3. ROADWAY PROFILE

The DTM shall be generated such that a survey centerline profile can be developed completely through the flood plain. In the event that the survey centerline does not coincide with the existing road, (when the structure is to be relocated), the DTM shall include the existing road completely through the flood plain. The DTM shall also include any other road in the study area.

3.11.4. DTM DEVELOPMENT

In the immediate area of the structure the DTM shall be developed such that accurate 6-inch contours may be produced. The area must be wide enough to cover the limits of construction and long enough to cover the proposed structure and approaches. This will simplify design of slope protection for approach fills. Existing bridges and the Advance Planning Report may be used as a guide for length.

3.11.5. TOPOGRAPHY

3.11.5.1. Complete topography shall be taken to include stream meanders. Meanders of bank tops and bottom of banks or water surface shall be recorded and topography extended the greater of 300 ft, one structure length or the length of the stream profile upstream and downstream. On large flood plains, the topography can be spotted on USGS quadrangle sheets, aerial photographs, or other suitable mapping. Such maps will be submitted as part of the bridge survey. A stream baseline shall be shown generally following the stream meanders. This baseline shall be treated the same as a horizontal alignment except they are placed on CADD levels as noted for stream information. Alignments will also be shown for stream cross-sections.

3.11.5.2. BUILDINGS AND OTHER STRUCTURES SUBJECT TO FLOODING

The structure shall be located and floor elevation recorded.

3.11.5.3. It will be necessary to document any structure that is replaced. The existing structure shall be located and described with dimensions of waterway openings shown. Also, wingwall geometry, retaining walls, rock ledges or previously abandoned structures in the area shall be located and defined.

3.11.5.4. CONSTRUCTION CLEARANCE FOR BRIDGE PROJECTS

When the proposed bridge will be located near the present structure, the offset distance shall be noted from the proposed centerline to the corners of the existing structure. Offsets shall be recorded to the nearest 0.1 ft. Also, an offset line or any method that will show the designer his working clearances, may be used.

3.11.5.5. EXISTING STRUCTURES

Each bridge or culvert along the existing route within the flood plain shall be located with beginning and ending stations shown for the bridges. An elevation view sketch of each shall also be developed and may be in the planimetrics file or a paper plot. (See FIGURE 7-28 through FIGURE 7-31 in the Appendix.) They shall be drawn to scale or have all dimensions of the waterway opening shown. The low beam elevation shall be recorded for bridges and the inlet and outlet invert elevations for culverts. Pier and deck elevations may also be required.

3.11.5.6. HIGH WATER AND NORMAL WATER

The elevations of high water and normal water levels shall be recorded with a description of how the high water was determined (including date). If the high water level is backwater the name of the river or lake shall also be noted.

3.11.5.7. Any significant collected material on the upstream entrance to the structure shall be noted in the planimetrics file.

3.11.5.8. QUESTIONS

Questions concerning a particular bridge survey shall be directed to the Regional Survey Office.

3.11.6. PLOTTING

Information must be provided, in the planimetrics file, DTM and on paper plots such that a plotted bridge survey complete within itself can be produced. The Road Designer will develop the following plots and forward them to the structures Division, Hydraulics Design Section.

3.11.6.1. TOPOGRAPHY

3.11.6.1.1. Text - Project name, stream name, comments and descriptive data.

3.11.6.1.2. Data - present layout, 6-inch contours in the immediate area of the structure, stream meanders with top and bottom of banks shown, survey centerline, location of flood plain sections if practical, existing structures, buildings subject to flooding with floor elevations.

3.11.6.2. PROFILES

Generated from DTM

3.11.6.2.1. Text - normal water elevation, high water elevation with a description of how it was determined, vertical datum used and description of channel bottom material.

3.11.6.2.2. Data - profiles of centerline, other existing roads, bottom of stream, water surface, top of bank and flood plain sections with type vegetation shown.

3.11.6.3. SKETCHES

Drawings of existing structures may be shown separately or with the topography plot. They shall include all data described in Section 3.11.5.5 (See FIGURE 7-28 through FIGURE 7-31 in the Appendix for examples.)

3.11.6.4. DRAINAGE MAP

The drainage map shall be provided as described in Section 3.9.1 (See FIGURE 7-17 in the Appendix for an example.)

3.11.6.5. QUAD SHEET

If required as noted earlier.

3.12. PIPE CULVERT AND CONCRETE BOX CULVERT SURVEYS

(Q_{50}= 0 cfs to 500 cfs) Separate surveys for these structures are not required. However, certain data must be gathered during the topographic survey and measures taken during DTM development to insure information is provided to allow for proper design.

3.12.1. TOPOGRAPHIC SURVEYS

Data gathered during topographic surveys will be shown in the planimetrics file and includes: stream and/or ditch meanders, and existing structure details such as endwalls, wingwalls, etc.

3.12.2. DTM

The DTM shall be developed in greater detail in the area of the existing structure and flow. Spot elevation shots and breaklines shall be recorded at the bottom of ditches or center of stream and the DTM shall be extended far enough to determine the natural profile of the stream or ditch.

3.12.3. TEXT

Certain descriptive information shall be recorded in the area of the pipe or structure, to include: condition and other comments, foundation material, invert elevations, extreme high water and normal water elevations.

3.12.4. EROSION CONTROL

Retention ponds and other special drainage features will be designated by the designer and may require additional field information at the time of design. Other data shall be provided as part of usual drainage surveys. A contour map of the area (scale no smaller than 1:5000) will supply required drainage information and is the designer's best source of information for erosion control (See Section 3.10).

3.13. PROPERTY MAP

3.13.1. PROCEDURES

Information will be gathered and shown in the planimetrics file such that a property map can be prepared for every project which requires R.O.W. and/or easement acquisition.

3.13.2. SOURCES OF INFORMATION

Deeds and plats

Field Information (See Section 3.6.6.)

Tax maps

Aerial mapping

Planning commissions, agency engineer

Private survey firms

3.13.3. MAP LIMITS

Each affected property shall be shown in its entirety, including all access roads. However, very large tracts do not need the entire boundary surveyed in the field. A field survey shall be performed and labeled with metes and bounds on the property to a width that will show on the present layout sheet. Outside this width, the area may be scaled or digitized from tax maps or deeds and shall not be labeled.

3.13.4. TRACT NUMBERS

Each tract shall be numbered consecutively from the beginning of the project, crisscrossing the road as necessary.

3.13.5. R.O.W. ACQUISITION TABLE

3.13.5.1. The table shall be as shown in TABLE 7-3 (consistent with the Acquisition Table in Design Guidelines), and as called for in Section 3.4.2.4.

3.13.5.2. The following will be recorded unless the Regional Survey Office directs otherwise:

Calculated area right and left of survey centerline

Areas under 0.1 acres to the nearest square foot

Areas over 0.1 acres in acres (to three decimal places)

Total calculated area

Deed book and page number

Tax Map and Parcel Numbers

3.14. GRADE SEPARATIONS (Roadway)

When it is proposed to construct, widen or replace a bridge over a road the following procedures apply:

3.14.1. FIELD DATA REQUIRED

3.14.1.1. The station of intersection and bearing shall be noted.

3.14.1.2. Alignment and topography shall be taken 500 ft right and left on rural roads and 1,000 ft right and left on state routes. Deviation from these limits shall be approved by the Regional Survey Office.

3.14.1.3. The DTM of crossroads shall be recorded for the limits of the alignment.

3.14.1.4. A detailed DTM suitable for development of an 8-inch contour map for separation structures shall be taken.

3.14.1.5. When the proposed bridge will be located near the present structure, the vertical clearance and offset distance from the proposed centerline to the existing structure shall be recorded to the nearest 0.1 ft.

3.14.2. PLOTTING

Data shall be recorded in the planimetrics and DTM files necessary to prepare the following plots:

3.14.2.1. Proposed roadway and crossroad profile

3.14.2.2. Ground line contour map (6-inch intervals)

3.14.2.3. As built survey if needed

3.14.2.4. Topography and alignment of bridge approaches, crossroad approach with any drainage structures and flowline elevations

3.15. GRADE SEPARATIONS (Railroad)

When it is proposed to construct, widen, or replace a bridge over a railroad the following procedures apply:

3.15.1. FIELD DATA REQUIRED

3.15.1.1. Station of intersection of each set of rails and spacing between tracks

3.15.1.2. Alignment of tracks, 600 ft each direction with curve information if the rails are curved

3.15.1.3. All topography within the railroad R.O.W. for 600 ft each direction, including switching devices, signal devices, control boxes, and utilities (especially fiber optic cables)

3.15.1.4. Name of the railroad

3.15.1.5. Present railroad R.O.W.; the term “Charter R.O.W.” does not indicate that the railroad owns the property and charter R.O.W. shall not be shown. Railroad R.O.W. shall include only the property owned by deed or being used and maintained.

3.15.1.6. Distance and direction to the nearest milepost and description of same

3.15.1.7. Profile of a rail 600 ft each direction, both rails if they are superelevated

3.15.1.8. DTM data necessary to develop a roadway profile

3.15.1.9. DTM data required to develop a contour map (6-inch intervals) in the area of the proposed structure

3.15.1.10. Size, type, flowline elevations and condition (if required) of all existing drainage structures

3.15.1.11. When the proposed bridge will be located near the present structure, the offset distance from the proposed centerline to the existing structure (to nearest 0.1 ft) and the location and vertical clearance from top of rail to bottom of beam

3.15.2. PLOTTING

Data shall be recorded in the planimetrics and DTM files necessary to prepare the following plots:

3.15.2.1.1. Roadway profile

3.15.2.1.2. Ground line contour map (6-inch intervals)

3.15.2.1.3. As built survey, if needed

3.15.2.1.4. Profile of the tracks 600 ft each direction

3.15.2.1.5. Topography and alignment of proposed centerline of bridge approaches and tracks 600 ft each direction including any drainage structures (with flowline elevation), distance and direction to the nearest milepost and description of same, and present railroad R.O.W.

3.16. BRIDGE WIDENING

3.16.1. BRIDGE WIDENING PROJECTS

In the event a structure is to be widened the following information will be required in addition to that indicated in Section 3.14 or 3.15 above: An as built survey is needed for the existing structure. Dimensions and elevations shall be recorded to the nearest 0.01 ft, since new concrete must be tied to old. Attention shall be given to details of elevation on low girder, top of footings, abutments, piers and beam seats. Also, the thickness of paving added to the structure shall be estimated. Existing plans or sketches prepared by bridge inspection teams shall be requested (if available) and may be used for checking and/or recording as built dimensions. Specific requests for survey information may be made by Structures Division personnel.

3.17. SPECIAL SURVEYS

3.17.1. STAKING RIGHT-OF-WAY

R.O.W. staking is usually requested by Regional R.O.W. Offices and is used by appraisers and buyers to field locate property parcels.

3.17.1.1. Stakes shall be set so that an observer can easily see from one stake to the other. When an obstruction is encountered (building, large tree, boulder, etc.), a stake shall be set adjacent to and on each side.

3.17.1.2. When possible, a standard 1” x 2” x 36” stake with the top 12” painted red shall be used. When a R.O.W. corner falls on pavement, a nail shall be set and painted. Since these points can be expected to be semi-permanent the same degree of accuracy used on the survey will apply.

3.17.1.3. The method used to establish R.O.W. shall be based on sound engineering principles.

3.17.1.4. Iron pins and/or R.O.W. stakes will be set as follows:

At R.O.W. angle points (stakes and pins)

At the beginning and end of each radius (stakes and pins)

At the intersection of property lines and R.O.W. lines (stakes only)

Near all structures which are positioned close to the margin, so that the relationship of the R.O.W. limit to the object can be determined visually (stakes only)

When stakes are hidden by vegetation (e.g., cultivated areas, weed cover, thicket, etc.), they shall be marked with a witness flag which will protrude above the expected growth of vegetation.

3.17.1.5. R.O.W. stakes will be marked with description/station/offset. The following standard abbreviations shall be used. (Reference Standard Drawing RD-A-1 in FIGURE 7-8 in the Appendix)

PRES - Present
PROP - Proposed
R.O.W. or R/W - Right-of-Way
ESMT - Easement
BEG R - Begin Radius
END R - End Radius
PERM - Permanent
COR – Corner

3.17.1.6. Present R.O.W. shall not be staked unless so directed by the Regional Survey Office.

3.17.1.7. The point at which the centerlines of the proposed alignment and any existing roads cross shall be marked when staking R.O.W. The marking shall consist of a pavement nail, with flagging, circled by pavement marking paint with the centerline station painted on the pavement nearby.

3.17.1.8. Easements - Permanent easements shall be staked using the same procedures used in R.O.W. staking. Temporary easements shall be staked as accurately as supplied information permits (stakes only).

3.17.2. STAKING SOUNDING HOLES

3.17.2.1. The location for soil samples is selected by the Geotechnical Operations Section. Two copies of the proposed Layout Sheet will be sent with the desired drilling site marked in red and labeled numerically. All field work necessary to obtain ground elevations will be recorded on one of these sheets and maintained in the project file. The other will be returned to the Geotechnical Operation Section with the elevation of the ground shown at each hole site. (See FIGURE 7-26 and FIGURE 7-27 in the Appendix for examples.)

3.17.2.2. The actual field staking may be done with a cloth tape or other method giving similar or greater accuracy and marked with a standard 1” x 2” x 36” stake. The identifying labels on the stakes shall agree with those shown on the layout sheets.

3.17.2.3. Points which fall in water too deep to wade shall be referenced so drill crews can locate them with tape or chain. An appropriate sketch shall be recorded on the sounding hole sheet showing reference points and reference elevation. (See FIGURE 7-26 and FIGURE 7-27 in the Appendix for examples.)

3.17.3. ADDITIONAL INFORMATION

The methods and procedures used for gathering, recording, editing and transmitting additional information are generally the same as those used for the original survey. The primary problem encountered is the difficulty in separating additional data from original data. If possible the surveyor shall develop an end product which consists of files containing only additional information. One possible procedure for addressing the problem follows. If the surveyors CADD system has the capability, change all elements of the original file (copy) to one color. Additional information could then be recorded in a different color and selected for transmitting to the designer.

3.17.4. UPDATES

The old survey shall be carefully checked to determine where changes have occurred and new data exist. If changes are minor, plans can be marked. Otherwise, procedures would be the same as for additional information in Section 3.17.3 above.

3.17.5. NOISE ANALYSIS SURVEYS

3.17.5.1. NOISE SENSITIVE AREAS

3.17.5.1.1. Exterior - These are areas which have frequent human use and where noise levels affecting communication or aesthetic quality are undesirable (yards, playgrounds, sports areas, recreation areas, hospital grounds, church grounds, etc.).

3.17.5.1.2. Interior - These buildings house areas where noise levels affecting communication, aesthetic quality, or sleep are undesirable (schools, churches, hospitals, motels, hotels, nursing homes, residency, office buildings, libraries, etc.).

3.17.5.2. CRITICAL DISTANCES

The critical distance from the proposed centerline to a noise sensitive external area (D_E) and to a noise sensitive interior area (D_I) are determined by the Environmental Planning Office and are based on projected traffic. D_E and D_I are provided prior to the survey.

3.17.5.3. SURVEY

A noise analysis survey involves extending the DTM and topography to any noise sensitive area that falls within $4D_E$ or $4D_I$. See FIGURE 3-2 and FIGURE 3-3 for examples.

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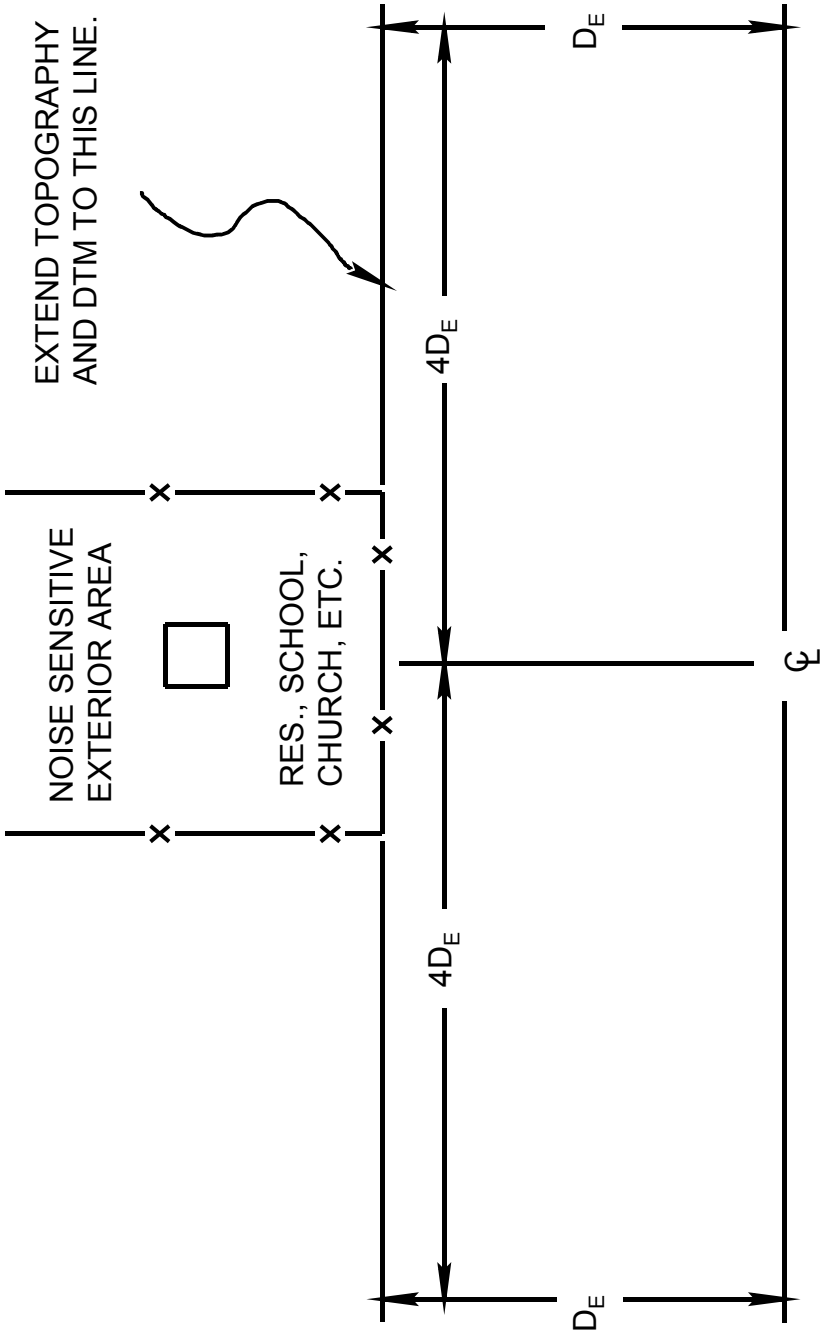

FIGURE 3-2 NOISE SURVEY INFORMATION

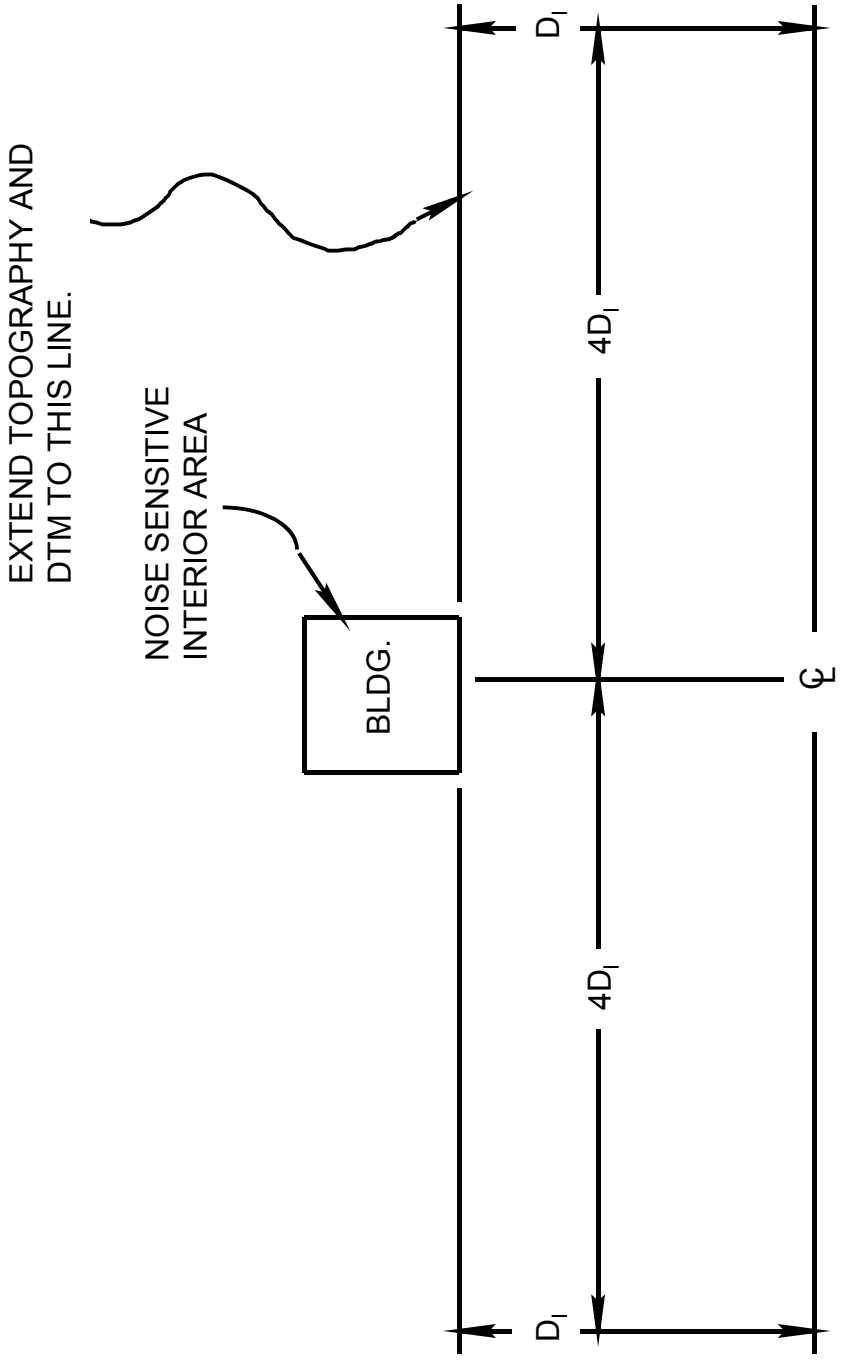

FIGURE 3-3 NOISE SURVEY INFORMATION