VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

SURVEY MANUAL 2002

APPROVED

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FOREWORD

This manual has been prepared for the guidance of all personnel engaged in securing and using survey data. Its purpose is to establish and put into practice, standard requirements which meet the most recent technical changes, methods and procedures that will enable its users to secure, prepare and submit accurate, complete and uniform data. It is not intended to be a textbook, but a guidance for organizational uniformity, functional methods and procedures, and to serve the need for consistent development of the changes in surveying technology. To minimize the scope and size of this manual, specifications and standards as referenced by this manual, and safety functions will be addressed by guidelines from the State Traffic Engineer and the State Safety and Health Engineer.

An employee of the Virginia Department of Transportation is a part of a large construction and service organization, the operating cost of which is paid directly by the people of the Commonwealth. The members of a survey party usually are the first to make direct contact with local citizens and the Department is judged by the survey party's actions, their integrity and courtesy, and their respect for public and private property. Because first impressions often are lasting ones, and because the entire Department is judged by the actions of its employees, it is imperative that all survey employees become familiar with the contents of this manual.

In preparing a manual such as this, all situations cannot be covered, nor is it the intent of this manual to do so. When unusual situations occur, it is the duty of the Survey Supervisor to secure the most complete and accurate information possible and to conform to this manual as closely as possible. The finest tool an engineer can have in designing a highway is a complete and accurate survey.

Anyone using this manual is encouraged to send any constructive criticism, useful suggestions or comments for improving it, to the State Location and Design Engineer.

For the distribution of this manual, issuance will be based on Departmental needs, with copies to all Department Administrators, governmental agencies and consultants under contract to the Virginia Department of Transportation. All other requests will be honored upon receipt of the current cost plus applicable sales tax made payable to the "Treasurer of Virginia", as manuals are available. Revisions will be issued as the need arises, and these will distributed to all assignees.

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Revisions: The following links contain references to most spot revisions and changes to this document since November 3, 2000, by occurrence.

11/30/01:

Ch. 1 – Sec. 1.02 Added PPMS activities & descriptions that apply to Survey.
Ch. 4 – Spot Revisions throughout chapter.
Ch. 4 – Sec. 4.07 Topography – Added "Wells, Springs, Septic Tanks &Drainfields" location specifications.
Ch. 4 – Sec. 4.08 Property Data – Updated sources for accurate acreage data.
Ch. 4 – Sec. 4.09 Procedures for Locating Existing Underground Utilities – Added form LD-430.
Ch. 5 – Photogrammetric Surveys – Major Additions & Spot Revisions
Ch. 5 – Sec. 5.09 Requesting Aerial Photography
Ch. 5 – Sec. 5.10 Requesting Photographic Products – New Section
Ch. 5 – Sec. 5.11 Field Responsibilities for Quality Photo Control (Replaces old Sources of Error Section).
Ch. 5 – Sec. 5.12 Field Responsibilities for Quality Control of Photogrammetric Data – New Section
Ch. 5 – Sec. 5.13 Aerial Photography Quality Control Procedures – New Section
Ch. 5 – Sec. 5.14 Photogrammetry Quality Control Procedures – New Section
Ch. 5 – Sec. 5.15 Photogrammetric Products Delivery Schedule – New Section
Ch. 5 – Sec. 5.16 Light Detection & Ranging (LIDAR) – New Section
Ch. 7 – Spot Revisions throughout the chapter.
Ch. 7 – Sec. 7.09.1 General Considerations – Remove verbiage regarding alignment revisions involving bridges.
Ch. 7 – Sec. 7.09.3 Site Surveys – Contours and topo plotted at 1"=10'
Ch. 8 – Figure 8-M "Special Provision for Section 105A – Section 105.10 Construction Stakes, Lines and Grades" remains the only section in draft form. Section 105C is the version issued by the Construction Division.
Ch. 10 GPS Surveys and the State Plane Coordinate System – Spot Revisions throughout the chapter
Ch. 10 Figure 10-O – General Specifications Chart
Ch. 12 – Quality Control Procedures – New Chapter added to manual

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GENERAL

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Sec. 1.01 **Legal Status of the Survey**

The State Highway Commissioner is authorized by the Revised Code of Virginia **§33.1-94** (see **Figure 1-A, page 1-5)** to make surveys for highway purposes. The code states, "The State Highway Commissioner, through his duly authorized officers, agents, or servants, may enter upon any land in the Commonwealth for the purposes of making examination and survey thereof, with a view to ascertainment of its suitability for highway purposes, or for any other purpose incidental thereto. Such officers, agents, of servants shall exercise care to protect any improvements, growing crops, or timber in making such examination or survey."

This authority should never be used arbitrarily, but should be thoroughly tempered with proper respect for private property and for the rights and feelings of the individual.

Sec. 1.02 **Authorization of Surveys**

All surveys for highways on all systems, including closed surveys for determination of ownership or for purchase, are to be authorized by the State Location and Design Engineer or his representative. This authorization will be in the form of a memorandum in which the scope of the project, length, type of survey required and any other pertinent data will be outlined. Supplemental data, made available to assist in performing the survey, will be furnished also.

Supplemental survey data, or information, shall include but is not limited to: National Geodetic Survey (NGS) field survey control, both horizontal and vertical, U.S. Geological Survey topographic maps, photographs of the area, existing road plans, and prints of adjacent projects in the planning stage. As schedules permit, the Global Positioning System, as initiated by the District Survey Engineer, shall be used to provide field survey control to the project based upon published government control.

After the location approval by the Commonwealth Transportation Board and the Federal Highway Administration, survey authorization for Interstates will be made in accordance with tentative construction schedules. Survey authorization for Principal-Minor Arterial System projects will be made in accordance with established construction or planning schedules. Prior approval must be given by the Federal Highway Administration on projects where Federal-Aid for preliminary engineering is requested.

Survey authorization for Urban projects will be made upon receipt of **Form U-9** **(see Figure 1-B, page 1-6)** from the Urban Division. Prior approval must be given by the Federal Highway Administration on projects where Federal-Aid is requested.

Survey authorization for the Secondary System (Arterial-Collector-Local Roads) will be made when requested by the Secondary Roads Division, in accordance with planning schedules and the Secondary System Contract Advertisement Schedule.

The Program/Project Management System (PPMS) is an on-line computer system operated through various programs maintained by VDOT's Information Technology Division (ITD) and the Commonwealth's Department of Information Technology (DIT). It provides direct managerial information on a large number of projects to 12 of the 20+ divisions of the Department, including the Central Office and all 9 Districts and their Residencies.

The two main goals of PPMS are:

- To assist managers in developing realistic and feasible work programs and schedules that are in reasonable balance with resources currently and expected to be available; and
- To assist managers in completing the work in accordance with approved programs and schedules.

Once a project is authorized to begin, the appropriate starting date must be entered in the PPMS database. All VDOT Survey Managers are responsible for the maintenance of starting and ending dates for the each of the survey-related PPMS codes that relate to each project. Please refer to **Figure 1-C, page 1-7** for all current survey-related codes and their descriptions.

The Department's policy is not to re-establish right-of-way lines for adjacent property owners or anyone else unless it is to serve the Department's needs. The Department will, however, assist others, such as property owners, engineers or surveyors in establishing right-of-way by providing plans and other available information. The surveying necessary to re-establish the lines is the responsibility of the one having the need for such information.

Section §33.1-222 (see **Figure 1-D, page 1-10**) of the Code of Virginia states that the Department is prohibited from making surveys for municipalities except in connection with highway projects or the establishment of right-of-way or street lines. Please refer all inquiries for work of this type to the State Location and Design Engineer.

All survey work performed by anyone other than members of the survey party must be supervised and checked by the District Survey Parties Engineer. This survey work includes and is not limited to any right-of-way stakeout, metes and bounds surveys, construction stakeout, etc., performed by inspectors in the Residencies. Previous experience in surveying does not eliminate the need for supervision and checking by the District Survey Parties Engineer.

Sec. 1.03 Working Hours

Unless otherwise approved by the District Administrator, normal VDOT survey personnel working hours are from 8:00 a.m. to 4:30 p.m., including one-half hour for lunch. These working hours may vary and be dependent upon extenuating circumstances in certain areas of the state. An example might be that survey personnel may be forbidden to work within the interstate right-of-way during rush hour traffic according to District policy for safety considerations.

The Survey Supervisor shall leave at the office in which he has his headquarters a note as to where he and the survey party will be working each day.

Sec. 1.04 **Daily Diary**

A complete diary, which shall be kept by the Survey Supervisor, should indicate the activities of all members of the party and the type and amount of work accomplished by the party. The diary will be checked frequently by the District Survey Parties Engineer to insure completeness and accuracy.

Sec. 1.05 **Refuse Disposal**

It is the responsibility of the person in charge of the party to see that the grounds are cleaned up after lunch and all refuse is disposed of, whether on private property or on the State's right-of-way. Under no circumstances shall the survey personnel leave waste paper or any miscellaneous debris on any job.

Sec. 1.06 **Specifications and Standards**

Each party will be furnished, according to its needs, one or more copies of the Road and Bridge Specifications, Road Designs and Standards, the Construction Manual, and Post Construction Operations Manual, and revisions or errata for same as they are issued. These will be charged to the Survey Supervisor and every member of the party must become familiar with the contents. Of particular importance should be the specifications covering the type of road for which the survey is being performed. Other standard plans, such as minor drainage structures and revisions thereto, will be issued from time to time as deemed necessary.

Sec. 1.07 **Accuracy of Surveys**

All Survey topographic information must comply with the *Model Virginia Map Accuracy Standards* and the *National Map Standards* for the scale of mapping. These standards are attached as Appendix D.

Sec. 1.08 **Completion of Surveys**

After all field work is completed, as outlined in **Chapter 4.00** of this manual, all surveys that are to be designed in the District will be retained by the District and the Assistant State Location and Design Engineer shall be notified by memorandum that the survey is complete. A copy of all survey, designated utilities, DTM, contour, and all update files shall be sent to the State Survey Parties Engineer for evaluation and archival. A copy of the **Survey Report** (see **Sec. 2.01**) and all other pertinent information shall be included with the memorandum.

For surveys in which all data has been secured except the utility designation, the survey shall not be shown complete nor shall the element for the Human Resources Planning System be closed out until the utility designation is complete.

Projects scheduled to be designed by the Central Office, or Consultants, are to be submitted to the Assistant State Location and Design Engineer by memorandum upon completion of the fieldwork. The memorandum should contain all data previously listed.

Bridge Site Plans, except for secondary projects, are to be transmitted to the Assistant Location and Design Engineer in accordance with established procedures. Secondary Bridge Site Plans are to be transmitted directly to the District Bridge Engineer, with the proper distribution of prints.

Sec. 1.09 **Safety**

All survey activities shall be governed by guidelines and instructions as issued by the State Traffic Engineer and the State Safety and Health Engineer. All survey personnel should be very familiar with and aware of the guidelines as specified in VDOT's "Virginia Work Area Protection Manual" and VDOT's "Work Zone Safety Guidelines for Temporary Traffic Control". All survey personnel, who will be in the roadway and are responsible for directing traffic in the work zone, shall have successfully completed and shall be certified as a flagman through VDOT's Flagging Certification Program. All survey personnel who are required to enter confined spaces (i.e. manholes, utility vaults, etc.) shall be certified through VDOT's Confined Space Certification Program. Any questions or information requests regarding VDOT's Certification Programs should be directed to the State Safety and Health Engineer.

Sec. 1.10 **Outside Requests for Data**

Time will not permit the practice of doing the necessary research and printing of control data for people outside VDOT. If a person would like to come to the appropriate office and copy the data himself, this would be satisfactory. If the data is on an approved plan sheet, it will be satisfactory to sell him a print of the plan sheet. This will apply to horizontal and vertical control.

National **G**eodetic **S**urvey (formerly U.S.C.& G.S.) data can be acquired from: The Director, National Geodetic Survey, 1315 East-West Highway, Silver Spring, Maryland 20910, or by visiting the NGS web site and using the searchable database for datasheet retrieval at http://www.ngs.noaa.gov/ .

Figure 1-A

§ 33.1-94. Right to enter on land to ascertain its suitability for highway purposes; damage resulting from such entry.

The Commonwealth Transportation Commissioner, through his duly authorized officers, agents, or servants, may enter upon any land in the Commonwealth for the purposes of making examination and survey thereof, with a view to ascertainment of its suitability for highway purposes, or for any other purpose incidental thereto. Such officers, agents, or servants shall exercise care to protect any improvements, growing crops, or timber in making such examination or survey.

In the event that the Commissioner and any landowner affected cannot agree as to the amount of damage, if any, sustained by reason of the entry upon land for the purposes herein stated, the Commissioner shall institute condemnation proceedings, as hereinafter provided in this chapter, for the purpose of determining the amount of such damage, if any.

Figure 1-B

Form U-9
(Rev. 2-10-95)

VIRGINIA DEPARTMENT OF TRANSPORTATION
URBAN DIVISION

To: Mr. G. A. Whirley, Sr.

PPMS NUMBER ______

Authorization is hereby approved for:
Prel. Engineering ☐
Right-of-Way ☐
Construction ☐

Date ______
R534 Data ______
(1) (2) (3) (4-5)
Street Name ______
State Project: ______

Town/City of ______ Route ______

Federal Project ______ Length ______

Description: ______

Character of Work: ______

Bridges: ______
Railroads: ______

Fiscal Manager's Funding Information

Ledger Code ______
Town/City Authority ______

CURRENT AUTHORIZATION				
ITEM	ESTIMATED COST	FEDERAL SHARE	STATE SHARE	CITY/TOWN SHARE
Preliminary Engineering				
Right-of-Way				
Construction				
Total				

REMARKS: ______

/aas
attachment

______
State Urban Engineer

cc: Chief Engineer
Assistant Commissioner - Finance
Location & Design
Right of Way
Structure & Bridge
Environmental Quality
Transportation Planning
Traffic Engineering
District Administrator
Resident Engineer
Mr. B. L. Campbell
Mrs. Christy Epps
Mr. W. D. Gilbert
Mr. E. Grajewski, Jr.
Central File
Urban File
Monthly File
U-9 File

Figure 1-C

Program/Project Management System (PPMS) Activity Codes

12 AUTHORIZE PE
Involves authorizing the expenditure of funds for preliminary engineering. Includes obtaining FHWA authorization on federal-aid projects.

Interstate, Primary & Urban Projects
Responsibility: Programming and Scheduling Division (Interstate and Primary Systems), Urban Division (Urban Systems). **Begins**: When request is received for PE to be authorized. **Ends**: When PE is authorized and proper divisions are notified. **Norms**: 1 Month.

Secondary Projects
Responsibility: Secondary Roads Division (Secondary Systems). **Begins**: When they receive the County budget. **Ends**: When the County Budget is reviewed, approved, and submitted to Fiscal Division, and PE for the individual project is open to charges.

NOTE: On those few Secondary projects which involve Federal funding in PE, the end date of Activity 12 would be when FHWA authorizes PE.

Norms: 2 ½ months.

22S DEV AERIAL PHOTO/MAPPING
Involves property research and preparing property owner letters; establishing alignment, collecting topography, DTM data, or cross sections; plans base preparation. **Responsibility**: Location and Design Division, Survey Section **Begins**: On approval of Six Year Plan, or special request. (After Activity 12 ends - Feb-Mar-Apr Only) **Ends**: When film has been processed and edited.

31S CONDUCT LOCATION SURVEY
Involves property research and preparing property owners letters; establishing alignment, collecting topography, DTM data, or cross sections; plan base preparation. **Responsibility**: Location and Design Division, Survey Section **Begin**s: When the survey is authorized. **Ends**: When survey is completed and all data, including cross sections/DTM's and utilities designations are transmitted to the Location & Design Manager.

Norms: 6 - 8 Months.

37S MAJOR STRUC/BRIDGE SURVEY
Involves establishing alignment, collecting topography, DTM data or contours, cross-sections; plan base preparation. **Responsibility**: Location and Design Division, Survey. **Begins**: As established during scoping or as requested by bridge engineer. (When Activity 31S ends) **Ends**: When all data has been collected and transmitted to appropriate bridge engineer. (1 month prior to end of Activity 46C/D)

NOTE: This activity is not automatically scheduled. It is added by request only.

56S SURVEY COMPENSATORY MITIGATION

Involves site survey, control and mapping for conceptual, preliminary and final plans for wetland/stream mitigation compensation sites for projects. **Responsibility**: Location and Design Division, Survey Section. **Begins**: Automatically scheduled when activity 56 is activated. **Ends**: When activity 56 ends.

Norms: 15 months. Dependent on activity 56. Activity 56 time frames will be utilized.

SURVEY REQUIREMENTS

Wetland mitigation surveys will conform to the current APELSCIDLA Board regulations as cited in the following:

18 VAC 10-20-370 "Minimum standards and procedures for land boundary survey practice"

18 VAC 10-20-390 "Geodetic Surveys"

DTM and contour survey (if requested). Location of swamps, marshes, ponds, streams, springs, rivers, physical objects, etc. (if requested) with survey ties to the external boundary of the parcel being surveyed. Use the same coordinate system of the adjoining or adjacent VDOT project. Plus and offset corner information shown on plat for all adjoining corners which abut a VDOT project. Use RM-2 monumentation for all boundary corners, unless RM-1-monuments are more practical. Provide at least one corner as a permanent bench mark. This corner to have a flat brass disc set in concrete with the following:

Punch mark at the corner point. Horizontal coordinates of corner point. Elevation and datum of corner point

57S RIGHT OF WAY STAKEOUT SURVEY

Involves establishing /re-establishing alignment, marking rights of way, construction and drainage easements. **Responsibility**: Location and Design Division, Survey Section. **Begins**: Upon receipt from R/W Section. (2 weeks into Activity 51) **Ends**: When request is satisfactorily completed. (Middle of 69C/D)

70S UTILITY STAKEOUT – SURVEY

Involves establishing/re-establishing alignment, marking utility easements. **Responsibility**: Location and Design Division, Survey Section or Contractor's Surveyors. **Begins**: When requested by Right of Way Division. (2 weeks into Activity 51). **Ends**: When request is satisfactorily completed. (Middle of Activity 67C/D)

77S CONSTRUCTION SURVEY

Involves setting slope stakes, grade hubs, moving control markers as needed. **Responsibility**: Location and Design Division, Survey Section or contractor's surveyors. **Begins**: When project is Awarded. (2 months after the end of Activity 80). **Ends**: When project is accepted as completed by the Department. (6 months later)

NOTE: This activity is not automatically scheduled. It is added by request only.

Figure 1-D

§ 33.1-222 Maps or plats prepared at request and expense of local governing bodies and other groups; Department of Mines, Minerals and Energy to seek other existing sources.

The Commonwealth Transportation Commissioner is hereby authorized in his discretion to have prepared photogrammetric maps or plats of specific sites or areas at the request of the governing bodies of counties, cities and towns of this Commonwealth, local nonprofit industrial development agencies, planning district commissions, soil and water conservation districts, metropolitan planning organizations, public service authorities and local chambers of commerce. The request shall have been first reviewed by the Department of Mines, Minerals, and Energy to determine whether suitable or alternate maps or plats are currently available, and the governing body, agency or chamber must agree to reimburse the Department of Transportation for the cost of producing the maps or plats.

CHAPTER 2.00

REPORTS

Chapter Contents

Sec. 2.01	The Survey Report
Sec. 2.02	Monthly Report of Surveying & Engineering Equipment
Sec. 2.03	Human Resources Planning System

Sec. 2.01 **The Survey Report**

Unless specified by the State or District Survey Parties Engineer, the Survey Report shall be submitted with all requested survey data upon completion of **each** survey assignment and shall be in a separate WORD document (*.doc) file format. The Survey Report will consist of two parts, a heading (or informational block) and a body. The heading shall contain the following: Route number/name, Project number, County/City, District, Project Length, Work Begin Date, Work End Date, Horizontal & Vertical Datum Basis, and Survey Personnel Involved. The body of the narrative will be a brief description of the project and shall include, but not be limited to, the following:

- the purpose of the assignment
- all traverse and level loop raw and adjusted closures
- a description of survey control and which points constrained the network
- utility owners and addresses
- possible locations of hazardous materials or contaminated soils
- conflicts with dissatisfied property owners
- general description of conflicts with record and field property data
- a list and description of each survey file and supporting data that is sent to the State Survey Parties Engineer's office
- general observations or recommendations regarding the field survey and completed survey files

This Survey Report will be archived with all project data for future reference and will be used and chronicled as an informational source for the life of the survey.

Sec. 2.02 **Monthly Report of Surveying and Engineering Equipment**

LD-910-DD **(SEE SAMPLE FORM, FIGURE 2-A, PAGE 2-3)**

The Monthly Report on Surveying and Engineering Equipment should be completed on the first of each month, and submitted to the State Location and Design Engineer's Office. This report will be run on the eleventh (11th) of each month. A report should be received each month from all Districts. The coding will be done as follows:

1. To update an existing record, code Columns 1 through 15 exactly as it is shown on the master file and the desired changes in other fields in Columns 16 through 80.
2. Column 1 must be coded with digits 1 through 8 (your District number, "A" for N. Va. and 0 for Central Office).
3. Columns 2 and 3 must be coded with digits 1 through 10.
4. Columns 4 and 5 must be coded with digits 1 through 46.
5. Column 16 must be coded with digits 1 through 3.
6. All coding in the fields in Columns 1 through 15 is right justified. (The last digit of the serial number must be in Column 15).

7. All coding in the fields in Columns 17 through 80 is left justified. (The first letter in "Assigned to" must be in Column 17, the first letter in "Location" must be coded in Column 35, and the first letter or digit in "Comments" must be coded in Column 52).

The person in the District who codes Form LD-910-DD will code only changes within the District, and never will delete a record. The Central Office shall handle all changes between the District and Central Office. This is necessary to prevent duplication of records.

The form LD-910-DD must be filled in with pencil so that the Central Office can make corrections before all the forms are transmitted to the Data Processing Division.

Sec. 2.03 **Human Resources Planning System**

The Human Resources Planning System was established in 1972 to enable the Department to determine personnel costs and manpower requirements related to the development of highway projects. This system records the hours expended for each element and provides a record for the project of the hours expended. From these records, "norms" are developed in order that manpower can be projected for new projects.

The Survey Supervisor shall become familiar with the system and properly educate his personnel regarding it. Time sheets should be reviewed carefully to assure that the element code is correct for the type of work performed and that the element is closed out when that element is completed.

The District Survey Parties Engineer shall have the responsibility of submitting budgets for projects and revising the budgets when necessary. The Workload Assessment System (WAS) should be used when budgeting a project. Any project changes, such as alignment miles and/or any other changes made due to additional data or change in the scope of the project are input directly into the Program/Project Management System (PPMS) after changes are approved. The District Survey Parties Engineer should review all changes before they are submitted to ensure the completeness and accuracy. Any questions regarding the work elements or project numbers, which are being charged to, should be directed to the District Survey Parties Engineer.

Figure 2-A

LD-910-DD
Rev. 4/89

VIRGINIA DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN DIVISION
SURVEYING AND ENGINEERING EQUIPMENT REPORT
INPUT FORM

INPUT
SUBMITTED BY ______________ ROOM: _________ PHONE: _____________ DATE: ______

COMMENTS:

D I S T R I C T	INSTRUMENT			ASSIGNED TO		LOCATION	COMMENTS
	T Y P E	M A K E	SERIAL NUMBER	C O D E			
1	2-3	4-5	6-15	16	17-34	35-51	52-80

CHAPTER 3.00

INSTRUMENTS AND SUPPLIES

Chapter Contents

Sec. 3.01	**Responsibility**
Sec. 3.02	**Care and Adjustment of Instruments**
Sec. 3.03	**Calculators**
Sec. 3.04	**Electronic Distance Meter (EDM) Reflector Constants**
Sec. 3.05	**Survey and Miscellaneous Supplies**
Sec. 3.06	**Periodic Checks of Electronic Total Stations and Accessories**

Sec. 3.01 **Responsibility**

It is the responsibility of the State Location and Design Engineer or his representative to secure, assign and keep in good working order all major surveying instruments and equipment. This does not preclude a mutually agreed upon purchase by the District should a specific item be required, or the purchase of such items as hand-held calculators paid for with District funds.

The assignment of instruments within a district is the responsibility of the District Survey Parties Engineer. This should be reported monthly to the State Location and Design Engineer in accordance with **Section 2.02**.

In the event a survey party is disbanded, all instruments and equipment should be kept in District Stock.

Sec. 3.02 **Care and Adjustment of Instruments**

Electronic Total Station and Data Collector

The electronic total station and the data collector are the most important instruments used by the survey party, each representing a considerable monetary investment. These are carefully adjusted scientific instruments constructed to a very fine degree of accuracy and precision. They are necessarily delicate, very sensitive to vibration and subject to being seriously damaged by careless handling. The realization of just what a survey instrument is and how it should be handled is an essential requirement of a competent instrument technician. Each Total Station and Data Collector has an operator's manual containing instructions on operating procedures. Every operator should read and become familiar with the procedures before attempting to operate these instruments.

The Survey Supervisor is responsible for all equipment and at no time shall a senior technician assign these instruments to the care of a junior technician unless authorized to do so.

When not in use, an instrument should be placed in its carrying case, even when it is necessary to suspend work. Before climbing a fence or similar obstacle, the instrument should be put in the carrying case and, along with the tripod, placed on the other side. **Under no circumstances should an instrument be carried on the tripod**, and under no circumstances should the equipment be positioned in a vehicle so that it can bounce around.

Transits and Levels

Many transits and levels are assigned to other V.D.O.T. Divisions and Departments. These instruments also are delicate, very sensitive to vibration and subject to serious damage by careless handling. The District Survey Parties Engineer should assign minor adjustments and cleaning when necessary. They never should be disassembled except as authorized by the District Survey Parties

Engineer. If these instruments have been exposed to inclement weather, they must be wiped dry as soon as possible, in any event, as soon as brought indoors.

Storage and Shipping

Under ordinary circumstances, instruments should not be shipped, but carried by box. Should circumstances require that an instrument be shipped, it should be clamped on its spindle and paper packed carefully and snugly into the box around it.

Careful consideration should be given to the location where instruments are stored when not in use, and every possible precaution should be taken to insure that they are not damaged, vandalized or stolen.

If an instrument is sent to the Central Office for reassignment, its tripod and all other accessories should accompany it. If it is sent in for repairs, **only** the instrument should be sent with a detailed report of why repairs are needed.

Sec. 3.03 **Calculators**

Since programmable calculators have become available, various programs have been developed which will solve most routine surveying calculations. This applies mainly to the alphanumeric programmable type calculators with continuous memory. Available programs can be obtained by contacting the State Survey Parties Engineer.

Sec. 3.04 **Electronic Distance Meter (EDM) Reflector Constants**

The constant for each reflector unit must be known before its use. If the refractive index of glass were the same index as air (1.00), there would be no corrective constant. Since the refractive index of glass is about 1.57, the thickness of the prism from the front of the apex to the back can be multiplied by 0.57, to get the reflector constant, that is always negative. Actually, it is not necessary to do this because the constant, which varies with the different types of reflectors, is usually noted in the specifications or corrected within the E.D.M. system. In any case, it must be taken into account, because failure to do so can result in serious errors.

Sec. 3.05 **Survey and Miscellaneous Supplies**

Surveying and miscellaneous supplies shall be obtained through the District Office, either from the District supply or by requisition.

Sec. 3.06 **Periodic Checks of Electronic Total Stations and Accessories**

A suitable range shall be established in each District to check the Electronic Distance Meters and accessories at three (3) month intervals. This shall include both horizontal and vertical checks and also shall include all tribrachs and range poles.

A record shall be prepared and retained by the District showing the date, instrument number, operator and the results of this testing, with a copy to the State Survey Parties Engineer. An example is shown in **Figure 3-A, Page 3-4**. Any major deficiencies should be reported immediately in order that corrective steps may be taken. Before adjusting the instrument, a check of the tribrachs should be made.

Figure 3-A

SURVEYING AND ENGINEERING EQUIPMENT – ELECTRONIC DISTANCE METER EVALUATION

LYNCHBURG DIST.
YEAR 1990

				1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		
Party	Type Instr.	Model	Serial No.	Date	Chkd. By	Date	Chkd. By	Date	Chkd. By	Date	Chkd. By	Remarks
12	TOPCON	ET 1	F 30988	3-2	D. G.	6-8	D.G.	8-24	D. G.	10-17	D. G.	No Adj.
		Accessories	3 Tribrach	3-2	D. G.	6-8	D.G	8-24	D. G.	10-17	D. G.	Needed
			2 RangePole	3-2	D. G.	6.8	D.G	8-24	D. G.	10-17	D. G.	
12	TOPCON	ET 2	P 70236	3-2	D. G.	6-8	D.G	8-24	D. G.	10-17	D. G.	Dist. OK
		Accessories	1 Tribrach	3-2	D. G.	6-8	D.G	8-24	D. G.	10-17	D. G.	Adj. Vert.
			0 RangePole									CrossHair
12	TOPCON	GTS 2	B 40525	3-2	D. G.	6-8	D. G.	8-24	D. G.	10-17	D. G.	
		Accessories	1 Tribrach	3-2	D. G.	6-8	D. G.	8-24	D. G.	10-17	D. G.	
			RangePole									
		Accessories										
		Accessories										
		Accessories										

CHAPTER 4.00

LOCATION SURVEYS

Chapter Contents

Sec. 4.01	General Remarks
Sec. 4.02	Survey Assignment
Sec. 4.03	Contacting Property Owners
Sec. 4.04	Horizontal Control Monumentation
Sec. 4.05	Alignment
Sec. 4.06	Field Data
Sec. 4.07	Topography
Sec. 4.08	Property Data
Sec. 4.09	Procedures for Locating Existing Underground Utilities
Sec. 4.10	Levels
Sec. 4.11	Cross-Sections & DTMs
Sec. 4.12	Bridge Site Plans - Streams
Sec. 4.13	Bridge Site Plans – Highways & Railroads
Sec. 4.14	Bridge Site Plans - Widening
Sec. 4.15	Minimum Plan Projects
Sec. 4.16	Additional Survey Data Requests
Sec. 4.17	Submission of the Survey Report

Sec. 4.01 **General Remarks**

In using these instructions, it must be realized that to write a set of rules so all-inclusive as to cover any and all situations encountered during the course of a survey would be impractical, if not impossible. Unusual situations will occur, and we depend on the skill and initiative of the Survey Supervisor to resolve, or have these situations resolved. With the implementation of the Total Survey Station System, the Survey Supervisor will make all location surveys, using current guidelines and instructions, from the Virginia Department of Transportation's "Survey Manual". This manual will cover almost all programs concurrent with a location survey.

Sec. 4.02 **Survey Assignment**

Upon receipt of a survey authorization, the District Survey Parties Engineer will assign the project to a Survey Supervisor in the district. During the progress of the survey, the District Survey Parties Engineer will review the work for conformance with current instructions and ascertain that the survey data is complete and covers the proposed project.

Sec. 4.03 **Contacting Property Owners**

In making surveys of any nature, survey party personnel usually are the first agents or representatives of the Department to encounter private property owners. Since first impressions often are lasting ones, it is of utmost importance that all contacts with private property owners be handled with integrity and in a courteous and business-like manner.

Every possible effort must be made by the survey party to contact property owners prior to entering their property. Although law prescribes our right of entry for making surveys, **(See Sec. 1.01)** courtesy demands that this right must not be abused. There can be no reasonable excuse for the failure to make these contacts, particularly when the owner lives on the property or in the vicinity.

Prior to any fieldwork involving private property or public utility property, the Survey Supervisor should visit the appropriate courthouse to view area real estate maps for the purpose of making a list of all property owners to be effected by the proposed survey. In areas where real estate maps are not available, other methods will be necessary to determine the effected properties.

This list should then be forwarded to the District Survey Parties Engineer, and the standard memorandum shown on **Figure 4-A, Page 4-19** of this manual prepared for each owner. This memorandum should be used statewide to insure uniformity. The brochure "Let's Take a Look" must be sent with this memorandum.

The Survey Supervisor either should deliver personally or mail a copy of this memorandum and brochure to each property owner affected. In either case, a copy should be furnished to the Resident Engineer with a list of all property owners for which a memorandum and brochure was prepared. This will enable the Resident Engineer to be better prepared to handle inquiries that may be made as the survey progresses.

The Survey Supervisor should also keep with him, or in his vehicles, while making a location survey, extra copies of this memorandum and brochure, if for any reason some property owner may have not received the memorandum and brochure.

Sec. 4.04 **Horizontal Control Monumentation**

Permanent Horizontal Control Monuments shall be set on all surveys for highways for all systems, including closed surveys. Data available for setting horizontal control will be sent with the survey authorization, or as schedules permit the Global Positioning System (GPS) will be initiated by the State Survey Parties Engineer with the authorization memorandum. The District Survey Parties Engineer will assure that the Survey Supervisor has sufficient data for control and/or will coordinate with the State Survey Parties Engineer or the GPS Engineer the scheduling for setting GPS datum and will provide sufficient personnel to assist the GPS Engineer when securing GPS datum.

Standard V.D.O.T. disks are to be set in concrete with re-bar or other metal added to assist in relocation with a metal detector (see **Figure 10-D, Page 10-14**). In addition to permanent monuments, additional swing ties to other objects should be obtained as evidence for re-establishment of a monument. A minimum of four (4) monuments should be set on each project regardless of the length of the project.

Monuments should be tied to the location centerline or baseline by right angle plus and distance and enough monuments placed that the alignment can be re-established readily, with plane or project coordinate values shown to the nearest one thousandth foot **(0.001-ft)** and vertical control to the nearest one hundredth foot **(0.01-ft)**. The maximum error for vertical control shall in no case be greater than plus or minus five hundredths foot **(±0.05-ft)** times the square root of the loop distance in miles.

Form LD-200 (Horizontal Control Reference Card) **(Figure 10-F, Page 10-16)** shall be completed for all permanent monuments set for horizontal control, for referencing purposes. When the cards have been completed, a copy will be sent to the State Location and Design Engineer. Copies of Form LD-200 completed by consultants will be sent to the appropriate District.

Sec. 4.05 **Alignment and Datum**

The survey centerline, baseline or traverse line should be established to be functional relative to the safety and geometric alignment of the survey corridor of the project.

Any new survey, that will not be tied into any existing VDOT survey projects, shall be tied to the **Virginia State Plane Coordinate System, North American Datum of 1983 (Current Published Adjustment) Metric Datum**, horizontally, and **North American Vertical Datum of 1988 (NAVD 88)** vertically**.** The **Global Positioning System (GPS)** should be utilized whenever it is practical to do so. Unless specifically directed by the State Survey Parties Engineer, any survey that is an extension of, or will tie into, an existing VDOT survey project will be constrained to the datum of the existing survey project. The State Survey Parties Engineer will furnish all N.G.S.

(formerly U.S.C.& G.S.) control data in the area of the survey when the survey is authorized. The use of assumed vertical datum should be avoided if possible.

In the establishment of the survey centerline or any necessary baseline, the distance and angular measurement methods or procedures shall be commensurate with the degree of accuracy required. All alignment computations (curve data) must be calculated to the fourth decimal place and shown to the nearest one-hundredth foot (**0.01-ft**). A single centerline or baseline for the measurement of cross-sections is desirable in the development of computerized design and earthwork. In proposed dual lane situations, the one centerline should be located so that readings may be obtained and full coverage of both lanes recorded.

Stationing for a new survey should begin with a station not less than **10+00** (Feet) and increase from the **South** to the **North** or from the **West** to the **East**. If the new stationing conflicts with the stationing of a previously constructed project within the limits of the new survey or if the survey is the extension of a previous survey, the old stationing shall be carried forward.

Minus stations and overlapping equalities are not to be used. Equalities in stations should be avoided wherever possible. If an overlapping equality occurs, the **AHD** (Ahead) station shall be increased by **1000**.

Alignment that will be included in a V.D.O.T. CADD Survey file will be entered according to the V.D.O.T. CADD Standards. The CADD Standards are included in **Chapter 11** and **Appendix A** of this manual. Every effort should be made to insure that all text, levels, weights and line styles entered into a survey file adhere to these standards. Plan element information presently being used by V.D.O.T. is shown as **Figure 4-B, Pages 4-20 & 4-21** in this manual.

When alternate lines are necessary, their stationing shall be a continuation of the stationing of the original line and a stationing equality shall be shown at the tie-in. Each alternate line shall be clearly designated if adopted. When a survey line intersects or is within a reasonable distance of a previous survey, the lines should be tied together at frequent intervals.

When terrain, property developments or other conditions make it desirable to parallel a right-of-way owned by any public utility company, special attention must be given to positioning the line so as to avoid encroachment of the proposed highway right-of-way on that owned by the utility company.

In making surveys from mosaics furnished by the Location and Design Division, any change in topography, or other features which do not show on the mosaic and which might have an adverse effect on the ultimate location, should be brought to the attention of the District Survey Parties Engineer. If a decision to change the proposed line is made, this should be fully explained in the Survey Report.

Alignments for all intersecting roads should be run out a sufficient distance from the survey centerline, depending upon the nature of the possible changes, to ensure the securing of all needed information. Complete survey information - topography, property lines, property owners, centerline levels, cross-sections, et cetera - should be secured for the full length of the connection. Where a large skew angle is encountered, consideration should be given to relocation at a more desirable intersecting angle.

Alignment for grade separation structures of railroads should cross the railroads at right angles whenever possible. When a skew crossing is necessary, the skew should be at even fifteen-degree **(15°)** skew angle increments, unless conditions make other angles necessary. When conditions warrant the use of other angles, the angles should be to the nearest even degree. The skew angle is not to exceed forty-five degrees **(45°)**. The distance between the P.C. or P.T. of a curve and the structure should be sufficient to permit using the standard length transition without overlapping the bridge where possible. A centerline tie must be made with the railroad by measuring the angle of intersection. Track alignment on the railroad shall be run for a distance of five hundred feet **(500 ft)** each side of the centerline, down the center of the tracks. When the railroad is on a curve, the track alignment should be run out as a regular traverse, with each chord point used as a point of intersection. These angular measurements must be taken and recorded to the nearest **thirty seconds (30″)**.

Alignment for survey centerlines, baselines or traverse lines shall be shown on all plan sheets, bridge situation and/or site plans, closed survey plats or any other surveys.

Generally, long easy curves that do not materially lengthen the route are preferred to continuous tangent alignment. Long curves that fit the topography of the country are preferable to shorter curves and longer tangents. Short, sharp curves and steep grades near the approach to a bridge and sharp curves at the foot of a steep descending grade are particularly hazardous and should be avoided.

A combination of horizontal and vertical curvature at a summit should be avoided. It is highly desirable for safety reasons to arrange groups of curves in orderly sequence form flat to sharp and back to flat, using the easiest possible curves at the ends of long tangents. Curvature should not be misleading to motorists by sudden variation of degree. At all times, the flattest curvature practical should be used.

On all location surveys, simple curves shall be located with sufficient distance between the P.T. of one curve and the P.C. of the next to permit the use of standard length transition spirals. Where it is impossible to meet this requirement, curves should be compounded or reversed and made as near the same degree as practicable.

For small angles, the curve must always be of sufficient length to avoid the appearance of a kink in the alignment.

When it is necessary to introduce curvature on the approach to a bridge, the P.C. or P.T. of such curves shall be located, if possible, so that the standard length transition spiral will not overlap the structure. If this is impossible, then consideration should be given to putting the structure entirely on the circular part of the curve.

Sec. 4.06 **Field Data**

All field data will be secured by Total Station Survey methods and processed in accordance with the procedures outlined in this manual. This information should be complete and will be used to prepare finished plan base.

Generally, the files turned in, as the completed survey, should contain the following information:

1) SPPMS#.doc - This file is the Survey Report **(see Sec.2.01)**. (Example: SPPMS#.DOC)

2) ".ALN" - This file contains the alignments for the survey being conducted. (Example: SPPMS#.ALN)

3) ".FLD" - This file contains the raw field data obtained by data collection. (Example: SPPMS#.FLD)

4) ".TOP" - This file is the formatted list of the ".FLD" file, this means that the ".FLD" file has been processed into an understandable context so editing is made easier. (Example: SPPMS#.TOP)

5) ".CVT" - This file is the converted ".TOP" file. It is formed when the ".ALN" and ".TOP" files are used together to compute coordinate values on the readings of the various topography codes taken in the field. (Example: SPPMS#.CVT)

6) ".ARC" or ".ZIP" - CAiCE Project Archive File. (Example: dtPPMS#.ARC) or ZIP CAiCE 2000 See Sec.11.07.1)

During the course of the survey there may be need to have more than one working file, as when a survey is extended or additional information is required.

Completed survey files and updates should be stored and archived as shown on **Figures 4-C & 4-D, Pages 4-22 & 4-23**. Extreme care should be taken so that the CDs or floppy disks are not lost, placed near a magnetic field, or exposed to heat or cold. It is also required that backup copies of the disk be made in case of loss or damage, thus, eliminating the need to re-survey an area or entire project. Please refer to **Section 11.07** for more information on files and the formats required for submission to the Department.

Sec. 4.07 **Topography**

All topography will be secured by the use of Total Survey Station methods and procedures. It is essential the total survey station method be used due to the advanced technical methods and procedures of V.D.O.T.'s CADD Section. The procedures for creating Survey CADD files are explained in **Chapter 11** of this manual. The V.D.O.T. CADD Standards for topography are included in **Chapter 11** of this manual. The Survey CADD Section has made a great effort in creating cells and line styles for topography and utilities that may be encountered by a survey party. Examples of these cells and linestyles are also included in **Appendix A** of this manual and it is required that these cells and line styles are used in V.D.O.T. survey files.

Topography (General)

The location of edges of pavement, shrubbery, walls, curbs, fire hydrants, water meters, right-of-way monuments and project markers shall be shown. Fences, streams, woods, outlet ditches, entrances, roads, bridges, culverts, pipes, end walls, et cetera will also be shown. Existing pipe sizes should be accurately measured.

The sizes of trees will be measured **4.5 feet** above the ground, or Diameter at Breast Height (DBH), to obtain the diameter of the tree. Isolated or cultivated trees should be located and described.

The outside limits of all automobile graveyards will be shown.

Types of fences, whether barbed wire, woven wire, rail, board, or other should be shown and noted.

The extremities of cemeteries must be shown. The graves closest to centerline must be shown and the approximate number of graves noted.

The width and type of pavement shall be shown. If concrete pavement has been overlaid with asphalt, this shall be noted along with the approximate depth of the overlay. All changes of pavement type must be referenced to survey stations.

Once an environmental scientist has marked the limits of wetland areas, the flags shall be located and stored in a separate file. The file will be named "sPPMS#wl.dgn". **This data will not be merged in the survey master file**. The data shall be shown in the wetland file on level 27, line weight of 3, the scale shall be the job scale, and the line code will be "wl". This information is listed in **Appendix A**.

Unusual circumstances such as standing water, sink holes, caves, outcrops, or any other condition which might need special attention from materials investigation should be noted by the District Survey Party Engineer in the Survey Report letter.

House & Building Location

Buildings are to be shown at the overhang and the type of construction should be noted (frame, brick, et cetera), the height (one story, two story, et cetera) and condition other than good, should also be noted. Porches, carports are also to be shown.

Individual house numbers, where assigned, are to be shown in lieu of block numbers in cities, towns, and built-up areas. Where house numbers have not been assigned, the block numbers should be prominently shown. The building number should be shown within the limits of the building, if possible. If this is not practical, the building number should be shown as close to the building as possible.

Utilities & Drainage Items

The location of utility poles and pedestals along with the number and utility owner initials (C&P#100, V.P.#200A) should be shown. Overhead utility lines, except for high voltage transmission lines, need not be shown unless requested by the utility engineer after the utility field inspection. Underground utilities such as water and gas lines, telephone cables, et cetera will be addressed in **Section 4.09** of this manual.

Storm and sanitary sewers are to be located with elevations secured on the tops of manholes or drop inlets and their inverts (or flowlines). The location of the next structure (manhole, etc.) outside of survey limits shall be included with elevations. Also, the open ends of pipes shall have their locations with invert elevations secured by the field parties.

The necessity for outlet ditches and channel changes should be investigated and appropriate recommendations made. Any lake or pond being affected by possible erosion should be shown.

Wells, Springs, Septic Tanks & Drain Fields

Except in areas where properties are served by municipally owned sewer and water systems, information shall be shown on each individually developed property regarding water supply and sewage disposal. If it is determined that the facilities will be impacted by future construction, it will be necessary to accurately locate these facilities, and a specific request, to do so, will be issued. If the facilities are a considerable distance from centerline, a note indicating how these properties are served will suffice. Most often, the location of the facilities should be shown in the survey file based upon the best data available. It should be noted that obtaining location information from the counties might need to be addressed via the Freedom of Information Act.

Historical Markers

Historical markers should be located and the identifying number recorded. In the securing of location survey data on any type of survey, special attention should be given to any site that is of historical or archeological significance. Some of these sites are well marked and are easily identifiable by markers placed by the Association for the Preservation of Virginia Antiquities, the Virginia Department of Conservation and Economic Development or by local governments. Some are not so well marked and require a knowledge of the area and local research on the part of the Survey Supervisor. If there is any possibility that a site of historical or archeological significance exists in the area of any survey, it should be conspicuously noted in the Survey Report.

Hazardous Material/Waste Sites

All hazardous material/waste (or potential) sites should be located and/or identified. Caution should be taken and at no time should Department employees touch, smell, move or otherwise be exposed directly to a potential hazardous material. The Survey Supervisor shall make a statement in the Survey Report indicating whether any hazardous materials were encountered or found, and if encountered or found, state the location of the possible hazard in the survey notes. Listed below are some sources, which have potential for hazardous material waste from underground tanks or associated sources.

Underground Tanks

Airports
Auto Dealers and Repair Shops
Banks
Car washes
Churches and/or cemeteries
Colleges/Schools/Education Facilities
Construction Companies
County and Local Government Services Offices
(Fire and Police Dept., Prisons, etc.)
Convenience Stores
Delivery Services(UPS, Emery, etc.)
Distribution Companies
Dry Cleaners
Engraving Firms
Farms
Federal and State Government
Home Owners
Hospitals and Nursing Homes
Hotels/Motels
Grocery Stores
Jobber Bulk Terminal
Manufacturing Plants
Marinas
Mining Companies
Recreational Facilities
Residential Apartment Buildings
Restaurants
Service Stations
Shopping Centers
Tire Stores
Transportation Services
Truck Stops
Trucking Firms
Utility Companies
Installations and Offices

Soils

The following sites have the potential of contaminating the surrounding soil:
·dumps ·waste water treatment sites ·abandoned lagoons ·landfills ·dry cleaners ·funeral homes ·service stations ·vehicle maintenance areas ·paint companies ·photography labs ·machine shops ·medical facilities ·printing companies ·pesticide operations ·fertilizer operations ·paper industries ·electric companies (storage yards) ·chemical manufacturing facilities ·electronic facilities ·wood treatment plants (creosote or salt)

Signs

The location and description of all special signs, such as overhead truss signs, electrical traffic signal lights, railroad protective devices, traffic light actuating treadles, et cetera, should be shown in detail. On all surveys, the survey party should show all outdoor advertising signs and indicate the O.A. license number, the size of the sign and the owner.

Government Control

All government benchmarks, triangulation stations, traverse stations, azimuth marks, reference marks, et cetera, must be located. If anticipated construction will disturb or destroy these control markers, the disk number should be recorded and the proper agency advised so a new disk can be furnished for replacement. The original of the new description and values are to be sent back to the agency concerned and a copy of the information needs to be sent to VDOT's Geodetic Surveys Engineer.

Railroads

When railroads parallel the survey, topography of the tracks shall be secured. The high-rail of the tracks shall be located with elevations by conventional survey methods. The location and elevation of the railroad bed may be secured by photogrammetric methods. All railroad switches, mileposts, signal equipment, right-of-way, size and type of all culverts under the railroad, et cetera, shall be located. On multiple track lines, the edge of all first rails and weights of all rails on all lines shall be secured.

Whenever a railroad is shown in the topography, it is imperative that the nearest railroad milepost be located and shown in reference to the survey centerline crossing. In the event there is no milepost, as may be true in the case of some spur tracks, the railroad should be run out or tied into the survey showing a clear and concise reference to the railroad evaluation maps, including the railroad stationing. A print of the railroad right-of-way map should be secured and submitted with the survey. If this is not possible, the drawing number and any other information available should be included in the Survey Report letter.

Political Boundaries & Road Names

The names of all cities, towns, villages (whether incorporated or unincorporated), and all post offices must be shown. Accurate tie-ins must be made for all corporate limits, county or state lines, et-cetera, showing stations and angular ties.

Road and street names in addition to Route numbers will be shown on plans and correspondence. If feasible, the name will be shown within the roadway limits. Otherwise, the name should appear in close proximity to the road or street. This procedure will be of assistance to field personnel and particularly to area citizens who can more easily identify existing roads and streets by names than numbers.

Should a question arise concerning the correct road name, the survey party will check with the current Traffic Engineering road name listing (available in each District and Residency Office) to obtain the correct information.

Surveys Near Airports

When a proposed location is within three (**3**) miles of an airport, the survey party should secure the following data so that the glide angle can be determined:

1) If the runway is perpendicular or skewed, the distance from the end of the runway to the survey centerline measured on line with the centerline of the runway (may be obtained from suitable map if clearances are not critical). When the runway generally parallels the survey centerline, locate the closest end of the runway and establish a bearing for the runway.
2) The pavement elevation at the end of the runway shall be secured.
3) Width of the landing area and runway number if available.
4) The airport property boundary shall be tied.
5) Class and type of service, such as private, secondary feeder, trunkline, express, continental, inter-continental, or Department of Defense Air Base shall be noted in the file.

Sec. 4.08 **Property Data**

All property data shall be secured by use of Total Survey Station methods and procedures.

All pertinent data from court records, such as subdivision plans, tract plans, deed book descriptions, etc., should be carefully checked for legibility when copies are made from the records. This also should apply for the names and addresses for public utilities and existing right-of-way data from old project files. It is imperative that any designer or right-of-way technician has the best data possible.

A memorandum from the State Location and Design Engineer, *Right-of-way Plans*, dated June 13, 1989, supplies a checklist helpful in securing property and right-of-way data. See **Figure 4-E, Pages 4-24 through 4-26**.

All property corners (monuments, stones, iron pins, trees, fence corners, etc.) shall be tied to the survey centerline/baseline by station and right angle offset or radial offset distance. Both station and distance shall be shown to the nearest one-hundredth foot **(0.01 ft)**.

Property lines shall have a calculated bearing in relation to the centerline/baseline bearing. The recorded deed or plat bearing and distance will be shown in parenthesis. When different plat bearings and distances are encountered on the same line of adjacent properties, both bearings and distances will be shown with care given to the placement of these bearings and distances on the appropriate side of the property line.

The names of all property owners shall be shown as recorded in the deed book, with the deed book and page number, and acreage or square footage. ***An acreage or square footage must be shown for all parcels, this acreage or square footage should be obtained from the most accurate and reliable records.*** Sufficient data shall be given so that the right-of-way take can be shown by a metes and bounds description on all parcels. The property data (owner, deed and map book reference & area) should be added to the survey file using the V.D.O.T. CADD Standards shown in **Section 11.02.4a.**

When subdivided land is encountered, prints of the subdivision, as well as the names and addresses of the affected owners should be secured. Using the prints, an accurate tie at a minimum of three points on the subdivision should be made. It will not be necessary to tie each individual lot.

In the case of small lots that are not part of a subdivision, the entire lot should be shown so that it can be determined how much of the lot will remain after the right-of-way is secured. The bearings (plat or survey) and distance on all property lines between corners, which fall within the proposed right-of-way, must be shown.

Prescriptive or statutory easements will NOT be shown as existing right-of-way. A note will be placed in the survey file indicating which parcels are affected by the prescriptive easement. Property lines will be extended into the prescriptive easement to their terminus according to record data or the center of the traveled way. These lot lines will not be connected along the center of the traveled way, unless described by metes and bounds in the deed of record.

When a metes and bounds survey is required, the survey party will make sufficient ties of the existing corners to the survey centerline. When property belonging to any agency of the United States Government is crossed by the centerline, the distance from the centerline crossing to the nearest tract corner measured along the Government's property line will be obtained.

Complete metes and bounds descriptions are required for the U.S. Government, the National Forest Service, all State Agency transfers, railroads and private firms, such as Virginia Power.

On all surveys where limited access right-of-way is proposed or anticipated, properties that will be landlocked due to the control of access are to be so noted at the time the location and width of the proposed right-of-way is determined. This should be addressed with the Survey Report.

Sec. 4.09 Procedures for Locating Existing Underground Utilities

Existing underground utilities will be secured as outlined by the current revision ***Location and Design Division Instructional and Information Memorandum, LD-95 (D) 140.6*** **(See Figure 4-F, Pages 4-28 through 4-36)**.

Interstate, Primary and Urban projects, requiring surveys, will have subsurface utilities designated by Consultant or by state survey personnel as determined by the State Location and Design Engineer. A determination will be made and indicated on Form LD-430 on Secondary projects as to the need to secure the underground utility designating service.

When the utility data is obtained under the consultant contract, the survey party will show all visible utility facilities such as water meters, cutoff valves, poles, etc. The survey party, as per *Sec. 4.07*, should locate sanitary sewers (except force mains) and storm sewers.

When the survey party obtains the utility data as determined by the State Location and Design Engineer or as indicated on LD-430 ***(See Figure 4-H)*** on secondary projects, the following procedures will be used. The District Survey Parties Engineer shall notify the District Utilities Engineer at the time of the survey authorization, that a survey party will be securing the designation on the project in the near future. The District Utilities Engineer will advise the local utility companies (including municipalities) accordingly, and will arrange to have someone knowledgeable of their underground facilities locations, with as-built plans and/or with locating equipment, to meet with the District Utilities Engineer and the Department's survey party to jointly locate their facilities. A copy of the letter to utility owners is to be sent to the District Survey Parties Engineer along with a list of the names, addresses and telephone numbers of the utility representatives. The utilities' representative can be contacted directly by the Survey Supervisor to arrange a specific date and time for the joint survey.

Under no circumstances should the survey party do any digging when securing utility designation. Once others uncover a utility, the survey party's function is to read any elevations.

All data for utility designation will be secured through total survey station methods and procedures. V.D.O.T. Utility CADD File Standards are located in **Section 11.03, Page 11-5**, of this manual.

Sec. 4.10 **Leveling and Securing Elevations**

All location survey leveling will be secured by the use of Total Survey Station methods and procedures. Elevations for all location surveys shall be based on GPS, U.S.G.S. or N.G.S. **U.S. Survey Feet** datum. This is important, and no departure from this rule is authorized unless so indicated in special instructions for the particular project. The kind and source of datum should always be included in the Survey Report.

When a survey is authorized, the Survey Supervisor will be furnished the location, description and elevation of any available government benchmarks.

Before running centerline or profile levels, a series of benchmarks must be established throughout the project at intervals of approximately one thousand feet **(1000 ft)**. A benchmark should be established also near all future structures (bridges, box culverts) and at all road intersections. These benchmarks must be as permanent as possible, located on solid structure bases or in the bases of trees not likely to be disturbed by construction. **A benchmark should never be set in a utility pole**. A complete description, including station plus and distance from centerline as well as accurate description of the object on which the benchmark is located, must be given. In all cases, any benchmark established must be turned on, in order to be properly tied to the line of levels.

Check levels must be run unless a permanent benchmark is convenient to both ends of the project. If a government benchmark is found near each end of the job and intermediate benchmarks are tied in by reason of turns, then a tie-in with the permanent benchmarks near each end of the project could serve as an adequate check. Elevations on *V.D.O.T. Control Monuments* should be read also when benchmark levels are being run.

The maximum error in differential leveling (benchmark levels) shall in no case be greater than plus or minus five-hundredths **(±0.05)** of a foot times the square root of the length of the level run in miles **(±0.05 ft X $\sqrt{M}$)**, where **M** is the loop length in miles. For profile leveling, the maximum error of a benchmark elevation previously established shall be no greater than plus or minus two hundredths of a foot **(±0.02 ft)** times the square root of the distance in stations from the preceding benchmark.

Levels on alternate lines will be based on the same datum as on the main survey.

Centerline elevations shall be determined at even stations, plus fifty **(+50)** stations, all equalities, and elsewhere as required to define the profile of centerline. When centerline crosses a different surface (i.e., soil to pavement), a reading is to be obtained at that point and noted. Each benchmark established as heretofore described shall be tied into as reached.

Elevations on all surveys shall be tied into the elevations of any adjacent surveys and surveys on intersecting roads. Where the location survey parallels an existing road, as in the case of a survey for a new lane of a dual lane road, a centerline profile of the existing road shall be taken.

Elevation of high, normal, and low water shall be obtained where the location crosses or parallels a stream. In tidal areas, mean low water and mean high water shall be obtained. In the case of a parallel stream, the elevation of normal and high water is required at frequent intervals. Where bridges are in place, the profile of the bridge floor as well as the streambed should be secured. The date and source of information is to be noted for all high water readings. Elevation data shall cover all alignments beyond the beginning and end of the project so suitable grades can be worked out at these points.

Elevations are required where the centerline intersects railroad rails and all other points that will influence or govern the final grade of the proposed highway. Where the utilization of an existing bridge is contemplated, the elevations of the bridge seats, top of footings, piers, and the bridge deck are to be obtained.

On some urban surveys, it will be necessary to obtain elevations on floors, porches, steps, etc. to determine the impact of the proposed design.

Sec. 4.11 **DTMs and Cross-Sections**

DTMs (Digital Terrain Models) or Cross-Sections are to be secured by the use of Total Survey Station methods in the required file formats. Cross-Sections are to be taken at right angles or radial to the survey centerline and must be referenced to one centerline, although base lines may be used. Where wide areas are cross-sectioned, such as Interstate locations, extreme care should be taken to assure that the cross-sections are taken at right angles.

DTMs or Cross-Sections shall be taken at normal intervals **(50 ft-Rural, 25 ft-Urban)**, at all equalities, at all breaks in the centerline profile, and elsewhere as necessary for volume computations.

DTM readings are to be collected in a manner as to define all existing ground breaks. The ground breaks shall be taken as either a line string or curve string readings. All other readings can be secured as spot readings. V.D.O.T. CADD DTM File Standards and CAiCE DTM .SRV File Format Standards are included in this manual in **Section 11.05 through 11.06, Pages 11-10 through 11-12.**

Either DTM readings or cross-sections shall be taken on all existing drainage ditches to show the profile of the ditch. The collection of data should begin at a centerline plus and extend beyond the inlet end of the structure a minimum of fifty feet **(50 ft)** upstream and extend beyond the outlet end (depending on the highway system), far enough to cover the area requiring an outlet ditch. The section shall follow along the flowline of the ditch regardless of its direction from centerline. The invert elevations shall be secured on all existing drainage structures or pipes. Entrance profiles shall be taken on all existing entrances their entire length. Where, due to excessive length, this would be impractical, the length should be restricted to an appropriate distance by the Survey Supervisor to provide adequate coverage for the Designer.

Sec. 4.12 **Bridge Site Plans - Streams**

Bridge Site Plans at streams shall be taken in accordance with **Chapter 7.00** of this manual. While this section may appear lengthy, each Survey Supervisor should be thoroughly familiar with all parts of it in order to prepare the most detailed Bridge Site Plan possible. Bridge situation CADD Standards are located in **Section 11.04,** of this manual.

Sec. 4.13 **Bridge Site Plans – Highways and Railroads**

For Bridge Site plans - Highways and Railroads, secured by Photogrammetric Surveys, see **Sec. 5.06** of this manual.

Contours are **NOT** to be secured on bridge site plans for grade separation, highway situations, or railroads unless specifically requested. The situation plan shall show a north arrow and bearings on the centerlines or baselines. Bridge situation CADD Standards are located in **Section 11.04** of this manual.

The alignments and topography for the situation plan area shall be plotted to a scale of one inch to ten feet **(1" = 10')**. The alignment for the situation plan area shall be plotted as it exists.

Normally, the topography covers an area fifty feet **(50 ft)** each side of the centerline of the situation plan area. However, in some cases, such as a proposed four-lane divided route, it may be necessary to extend the area more than fifty feet **(50 ft).**

Any topographic features that fall within the limits of the situation plan area shall be recorded on the situation plan. In addition, all underground utilities shall be shown, with elevations when they apply. All existing property, right of way and easement monumentation shall be referenced to the centerline by station plus and offset distance and recorded on the situation plan.

When the area covered is fifty feet **(50 ft)** each side of the centerline, profiles are to be taken on centerline, twenty-five feet **(25 ft)** left and right of centerline and fifty feet **(50 ft)** left and right of centerline. However, when it is necessary to extend the width of the situation plan area, profiles are to be taken at twenty-five feet **(25 ft)** intervals, seventy-five feet **(75 ft)**, left or right of centerline, etc.

These profiles are to be plotted, when possible, directly beneath the situation plan area (alignment and topography area) to a scale of one inch to ten feet **(1" = 10')** both vertically and horizontally. If the area is of extended width, the profiles may be offset to the right of the situation plan area and plotted in the usual matter.

Profiles for the road being crossed, railroad being crossed, railroad spurs, entrances, etc., are to be plotted to a convenient scale and shown after the site portion of the Bridge Site Plan.

The site portion of the site plan shall be plotted on the same roll, and shall follow the situation plan and profiles. This may be plotted at some convenient scale and cover two hundred feet **(200 feet)** each side of the situation plan area being covered. All information secured for the location survey shall be shown on the site portion, to include all property data, utility data, location and description of all adjacent drainage structures, bearings, north arrow, etc.

The elevation and description of each benchmark (or horizontal control monument if used) on which the bridge situation is based must be shown. The datum of the benchmarks shall be given, whether it is N.G.S., U.S.G.S., or other. In all cases, the location survey, the bridge site plan and the DTM data shall be based on the same datum.

Where the site plan is at a railroad crossing, instructions in **Sec. 4.05** and **Sec. 4.07** of this manual should be adhered to as they pertain to railroads. The weight of the rail should be shown prominently on the site plan.

Cross-sections shall be taken at twenty-five feet **(25 ft)** stations from the centerline or baseline of the road or railroad being crossed, only in the area of the situation plan. These cross-sections shall extend at right angles to cover the situation area also. In unusual situations it may be necessary to secure extra cross-sections as may be determined by conditions of the situation plan to cover an area that the existing road or railroad has both cut and fill areas. These cross-sections shall be stored in the usual manner and the Bridge Designer may obtain these sections by securing the job number and sequence number from the Road Designer.

Sec. 4.14 **Bridge Site Plans - Widening**

The bridge site plan for widening projects shall be secured and plotted in accordance with **Sec. 4.14** and **Chapter 7.00** of this manual. In the case of widening at streams, no upstream or downstream cross-sections are to be secured unless specifically requested at a given site, but the Bridge Data Sheet **(Figure 7-A, Pages 7-18 through 7-19)** must be completed.

When an existing bridge is close enough to the location centerline that the proposed structure might overlay the existing bridge, accurate stations and offsets shall be secured to all accessible outlines of the existing structure.

Where an existing bridge is to be widened and as-built plans are on file, measurements shall be secured and shown on a copy of as-built bridge plans as follows:

1. Stations and skew angles at beginning and end of bridge and at all piers.
2. Bridge seat elevations at exterior beams on both sides of the bridge.
3. Dimension from centerline to outside edge of deck.
4. Elevations of basic slab at gutter line at beginning and end of bridge and at centerline of piers.

This data will be incorporated on the file/disk with all other information.

On certain widening projects, the clearance is often critical, especially if the structure to be widened crosses a surfaced facility. In view of this, DTMs are to be secured along the centerline of the roadway beneath the bridge at ten feet **(10 ft)** intervals. DTMs are to be secured under the bridge at a distance of ten feet **(10 ft)** from the centerline of the exterior beam to a distance ten feet **(10 ft)** outside the proposed edge of the widened pavement. These DTMs shall extend to the top of the shoulder or the bottom of the ditch only, except at the regular station or fifty feet **(50 ft)** intervals, which are to be collected as usual. Elevations are to be secured for the bottom of beams at the supports for the exterior beams and any adjacent beams of greater depth.

For Bridge Site Plans - Widening, secured by Photogrammetric Surveys, see **Sec. 5.07** of this manual.

Sec. 4.15 **Minimum Plan Projects**

The fundamental objective of a "Minimum Plan" project is to provide a satisfactory basis for competitive bids without the development of fully detailed plans and cross-sections. In plain language, such projects will employ varying degrees of the "eyeball" concept of construction with special provisions in the bid proposal covering such items. The full extent and amount of survey information to accomplish this would be determined on the recommendations of the District Administrator or Resident Engineer, based upon the individual needs of each proposed project. Generally, the following could be used as a guideline:

1. Establish survey centerline and obtain essentially the normal topographic information such as property lines and property ownership, fences, utilities, property development and improvements. This topographic information is essentially the same as normally secured for any project but on a minimum width unless otherwise recommended or directed by the District Administrator.

2. Obtain centerline profiles but DTMs or cross-sections are not to be taken unless specifically designated or requested by the District Administrator and usually only at certain specified locations within a proposed project. One of the basic provisions of a "Minimum Plan" project provides for grading as a lump sum bid item. Earthwork quantities are not computed and generally the plans show the centerline profile and perhaps a spline grade line without specific elevations at each station.

See the current edition of VDOT's Road Design Manual, Appendix A, Section A-7, titled "Section A-7 – "No Plan" and "Minimum Plan" Projects". ***Excerpts are contained herein as Figure 8-J, pages 8-17.***

Sec. 4.16 **Additional Survey Data Requests**

Ideally, all survey information required should be secured in the initial survey, but from a practical standpoint, this will not happen. Some items, such as entrance profiles for new private entrances must be secured after the Field Inspection.

On projects being designed by the Districts, requests for additional data should be handled by memorandum within the District. Should the original survey be secured by Photogrammetric Survey methods and the capability to secure the additional data be available by this method, the request for this additional data should be forwarded to the Central Office, attention to the State Survey Parties Engineer.

The additional data is to be requested by Form LD-261, See **Figure 4-G, Page 4-36**, this request is to be reviewed by the District Survey Parties Engineer in the Districts or the State Survey Parties Engineer for projects designed by the Central Office.

It is important that the survey and utility master files (complete with survey control, baselines and topography) and well-marked B/W prints should be attached for topography and clarity of request. Construction baseline/alignment data should be made available also.

Requests for additional data should be handled on a priority basis according to current established schedules. Copies of letters transmitting additional data to the District Design Units should be sent to the appropriate individuals in the Central Office.

Sec. 4.17 Submission of Survey Report and Data

Before sending in the survey data, all information should be checked by the Survey Supervisor. He shall ascertain that the survey embodies all of the required information and that it is recorded and plotted in accordance with these instructions.

The Survey Supervisor should then write the Survey Report (a copy of which shall be titled "**sPPMS#.doc**" and shall be included on the disk turned in). The narrative will give a description of the survey and report all features and conditions not fully covered in the notes that will affect the location, design and construction of the road. Any part of the survey not conforming to the standards herein specified or generally accepted shall be fully explained.

It is the responsibility of the District Survey Parties Engineer to check each survey for correctness and completeness. The District Survey Parties Engineer will verify that the survey has been secured in accordance with the authorization and these instructions and all pertinent information such as subdivision plans, tract plats and deed book descriptions from court records are included.

In the continuing effort to supply quality survey products to our customers, VDOT has established a checklist of guidelines and procedures to be followed when producing and checking survey information and graphics files. The accuracy and quality of the survey information provided to engineers and designers is paramount because the survey information is the foundation of every design. VDOT's survey files conform to APELSCIDLA board minimum requirements and the data contained conforms to Virginia's Model Map Accuracy Standards. The field procedures utilized by VDOT's surveyors has built-in checks to minimize mistakes and maximize accuracy while saving time. A listing of procedures or quality checks for VDOT surveys is not provided here as each facet of each project is unique and measurement techniques will vary. **Chapter 12** lists quality control checks for survey information and graphics files. GPS field and office procedures are also contained therein. When a survey project is submitted, all applicable items on the checklist should be checked, initialed and signed to certify the completion of quality control process.

COMMONWEALTH *of* VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, 23219-2000

CHARLES D. NOTTINGHAM
COMMISSIONER

J. T. MILLS
STATE LOCATION AND DESIGN ENGINI

February 22, 1999

Project:	1002-072-154, C-501
From:	Emmanuel Church Rd.
To:	Rte. 1002, at the Intersection of Rte. 13 Powhatan County
PPMS	#19059

<<FirstName>> <<LastName>>
<<Address1>>
<<City>>, <<State>> <<PoatalCode>>

Dear : <<FirstName>> <<LastName>>

The Virginia Department of Transportation is considering improvement of intersection of Emmanuel Church Road and Rte. 13 as noted above. The purpose of this proposed improvement is to enhance safety and upgrade the roadway drainage system.

In order to plan improvements to existing highways, it is necessary for a location survey to be made to determine the safest and highest quality alternatives. The survey party may need to enter your property to locate physical features, property lines, etc. This survey work on your property does not indicate that a highway across your property is imminent or that a decision on an improvement has been made. It is simply for the purpose of gathering data and is one of the early steps toward determining possible improvements.

The attached booklet, "Let's Take A Look", will explain to you the reasons for this survey and attempt to answer any general questions you may have. If you still have other questions concerning the survey or the proposed improvements, you can contact our local Resident Engineer or Project Manager at the address listed below. We currently anticipate having drawings and other data outlining proposed improvements made available by the fall of 2000. Shortly before that time, we will again notify you of when and where this information will be available for your review and input.

Mr. Jim Smith
Resident Engineer
3301 Speeks Dr.
Midlothian, VA. 23112
(804) 674-2800

Marian Costin, EIT
Project Manager
P. O. Box 3402
2400 Pine Forest Drive
Colonial Heights, VA 23834
(804) 524-6154/ (800) 663-4188

Yours Truly,

Samuel W. Hayes, P.E.
District Location & Design Engineer

Figure 4-A

Figure 4-B

PLAN ELEMENT INFORMATION PRESENTLY RECOMMENDED BY VDOT

1. Sheet size will remain the same.

2. Stationing – 100 feet method.

3. Scales:

Plan Sheets

a) Rural - 1”=50’ (Plan sheet covers 1200 ft± along centerline)
b) Urban - 1”=25’ (Plan sheet covers 500 ft ± along centerline)

Profile Sheets

a) Rural - 1”=50’ Horizontal; 1”=10’ Vertical
b) Urban - 1”=25’ Horizontal; 1”=5’ Vertical

Cross-Sections

a) Rural - 1”=10’
b) Urban - 1”=5’

4. Pavement cross-slope –2%
   Shoulder cross-slope – 5% Paved; 6% Unpaved; 8% Unpaved Local

5. Degree of curve will be used. All horizontal curve data will be based on the radius in feet.

6. Degree-Minute-Second will be retained for angular measurement.

7. Computed spiral transitions will be used for Rural curves with pavement widening.

8. Cross-section interval – 50 feet (Rural)
   25 feet (Urban)

9. All survey information will be expressed in feet. Property data will be shown in units recorded in court records.

10. Hydraulic design will continue to be performed in English units along with descriptions of proposed structures.

11. Dual units will not be shown on plans with the probable exception of the R/W Data Sheet.

12. Chords rather than concentric curves will be used to describe proposed R/W where a spiral curve transition is used.

13. When converting meters to feet and extreme accuracy is needed, use the conversion factor for U.S. Survey Feet rather than the slightly different factor for the International Foot. The factors are as follows:

    U.S. Survey Feet

    For conversion of meters to U.S. Survey Feet, multiply the meters by 39.37 ÷ 12.0 which is 3.28083333333 to 12 significant figures.

    International Feet

    For conversion of meters to International Feet, multiply the meters by 100.0 ÷ 30.48 which is 3.28083989501 to 12 significant figures.

    The required accuracy for projects is as follows:

    All survey (horizontal and vertical) information will be obtained and processed to the nearest 0.01 ft. All proposed horizontal alignment information on the plans will be shown to the nearest 0.01 ft. All proposed elevations and horizontal location dimensions will be shown to the nearest 0.02 ft. One exception would be R/W monuments located at curve points such as PC's, PT's, etc. where the station of the R/W monument will be shown to the same accuracy as the curve point (0.01 ft.).

    Descriptions for hydraulic items shall be shown in accordance with the following:

    Pipe Culverts

    1. Length of culverts shall be shown to the nearest foot.
    2. Invert elevations shall be shown to the nearest 0.01 ft.

    Storm Sewer

    1. Length of culverts shall be shown to the nearest foot
    2. Invert elevations shall be shown to the nearest 0.01 ft.
    3. Heights of manholes and drop inlets shall be shown to nearest 0.01 ft.

    Channels & Ditches

    1. Show width and depth to the nearest 0.25 ft.

    Pipe Cover

    1. Pipe Cover shall be shown to the nearest 0.25 ft.

Note: This information is subject to change as further information is received.

Figure 4-C

11/15/99

TOTAL STATION FILE MANAGEMENT

[DATA COLLECTOR FILES]

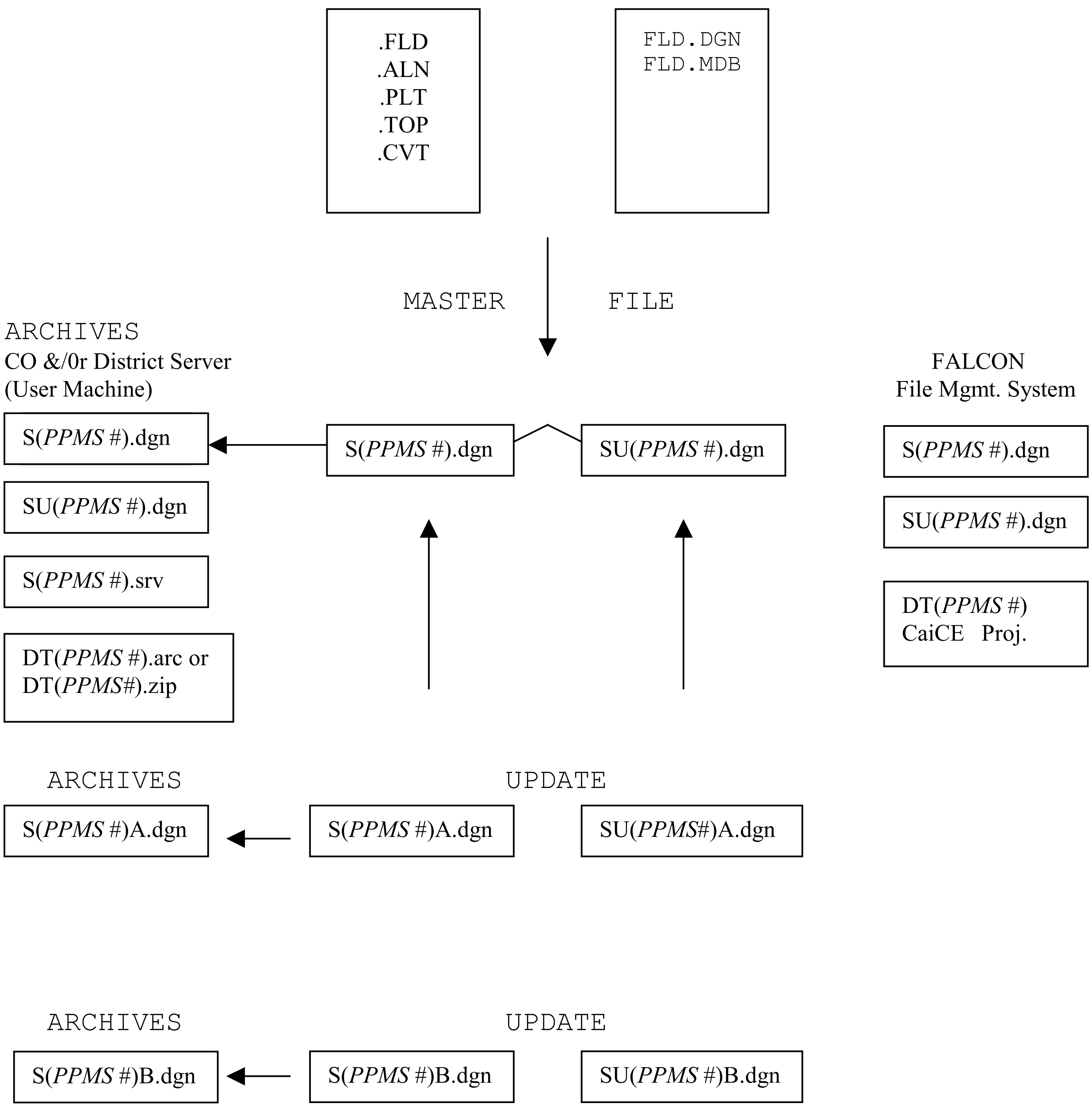


Figure 4-D

*** COMPLETED ITEMS ***

a) The latest version of the master survey file, utilities master file and CAiCE files will be stored in a folder on the Central Office survey server in: \501cosurvey\proj\Central Office\ppms#\ .

b) The latest version of the master survey files will be stored on the Central Office Falcon (file management system). In \ppms#\s(ppms#)\ the survey master file and utilities master file will be stored and in \ppms#\s(ppms#)\dt(ppms#)\ the CAiCE project files will be stored. These files will be maintained by Automated Engineering Support (AES). AES can give Designers controlled access to work in these files.

c) All completed survey master files, utilities master files and CAiCE project files should be stored in local archives.

*** PROJECT UPDATES ***

a) When updating a survey, use only the latest version of the Project Master file that is stored on Falcon.

b) Make the necessary changes to the Project Master file, moving only the necessary existing information.

c) Save the update information in a separate file. Name the update file properly.

d) Place the update file in local archives. Update files will be stored on the Central Office survey server.

e) Merge the update information with the Project Master file.

f) Place the updated Project Master file in the project directory on the Central Office survey server and on the Central Office Falcon.

Figure 4-E

Right-of-way Plans

This handout was prepared for all attendees at the Annual Consulting Engineering Forum May 25 and 26, 1989, at the Holiday Inn, (Koger Center) Richmond, VA.

The purpose of this handout is to focus your attention on the solutions to the problems the right-of-way division (statewide) has in trying to acquire right-of-way based on information or the lack of it on right-of-way plans.

On all plans prepared for right-of-way acquisition, please make sure that the surveyors, technicians and designers are aware of the problems and the recommended solutions presented herein.

1. Show existing right-of-way and label these lines often. Chances are good the state has acquired right-of-way somewhere on the project before, particularly at intersections. You need to research old project files to determine if and where right-of-way has been acquired before.

2. These plans are available on microfilm in each district office and I would encourage you to use this resource.

3. In most instances, there will be a right-of-way data sheet in each set of old plans. If the old plans show existing right-of-way, this should be checked out when you perform your courthouse research.

4. You should also check the court records and check with local planning officials to determine if there have been any right-of-way proffers or dedications to local governing bodies.

5. The same procedure should be used to determine existing easements to include utility easements. Contacting the affected utility companies would be a good source in checking the existing utility easements.

6. Show property lines accurately to include bearings and distances as they appear in the present property owner's deed descriptions and/or the latest recorded plats.

7. On each individual parcel, show the entire acreage of the parcel as reflected in the deed and/or plat. Check the court records for any out conveyances because they become separate parcels and the acreage must be deducted from the original acreage.

8. Show property owner's names exactly as they appear in the latest deeds at the courthouse.

9. Show recorded data on plans such as deed book and page and plat book and page.

10. Another good source in checking acreages and ownership is in the assessors' offices; these records are usually current and reliable.

11. Parcel numbers and "D" numbers will be assigned by the district right-of-way section.

12. Use standard labeling on plans and profiles such as "CL" for centerline and identify each centerline and profile line on the plans.

13. We need up-to-date topography showing features above and below the ground. Examples of underground topography include but are not limited to wells, septic tanks, drainfields, underground storage tanks and lines. Sizes and types of underground gas, water and sewer lines should be shown.

14. Examples of above-ground topography are buildings, landscaping, utility poles, walks, walls, driveways and field entrances, signs, property pins and billboards along with their owners' names.

15. In regard to proposed right-of-way lines, show clearly and label often. A right-of-way line should always have a terminus at an existing right-of-way line, property line or end of project.

16. All preliminary plans should show existing and proposed right-of-way lines throughout the entire project or the plans are of no benefit to this division in advancing right-of-way acquisition. The reason is real property appraisals are prepared from preliminary plans.

17. Show all right-of-way breaks with a plus and distance.

18. Clearly, show all proposed easements, label often and identify the type of easement needed and whether they are to be temporary or permanent. Generally, all permanent construction features that will be maintained by the state after construction should be located within a permanent easement. Such as drop inlets, signal poles, retaining wall footings etc.

19. A right-of-way data sheet should be included in each set of plans and the acreage within the proposed right-of-way and easements should be computed for each parcel shown on the plans.

20. Plans should contain other pertinent information such as invert elevations on manholes; particularly those not affected on side streets. We desperately need test hole data information on existing underground utilities.

21. Show on plans where and the amount of undercut required.

22. Please give us as much information as possible on proposed bridges, such as, the location of abutments, the type, sizes and spacing of pilings.

23. The right-of-way division needs to be copied with all plan revisions. These revisions may not require additional right-of-way, but they could have an impact on utility adjustments. For example, utilities could be affected by grade changed, changes in the typical section and relocation of drainage pipes and other drainage structures.

24. Any changes in design features within the proposed and even the existing right-of-way should always be brought to the attention of our utility section.

Figure 4-F

VIRGINIA DEPARTMENT OF TRANSPORTATION

LOCATION AND DESIGN DIVISION

INSTRUCTIONAL AND INFORMATIONAL MEMORANDUM

GENERAL SUBJECT: UTILITY CONFLICTS	NUMBER: **LD-95 (D) 140.6**
SPECIFIC SUBJECT: Procedure for Utility Field Inspection Plans, Utility Designation, and Utility Location (Test Hole) Contract	Date: February 1, 1995 SUPERSEDES: LD-90 (D) 140.5
SIGNATURE:	

Changes are shaded.

CURRENT REVISION

- Submitting Plans:
  - revised data required for submittal
- Non-Project Request:
  - revised to replace "one set of mylars and two sets of prints" with "A sketch showing the location with horizontal and vertical control".
- CONSTRUCTION PLANS:
  - added second paragraph referring to block added on UNDERGROUND UTILITIES TEST HOLE INFORMATION Sheet indicating utility adjustments (yes or no).

EFFECTIVE DATE

- This memorandum is effective upon receipt.

POLICY

- The Department has contracts statewide with Subsurface Utility Engineering (SUE) consultants to designate and locate utilities on projects selected by the Department. Utilities are designated by marking the presence of a subsurface utility using a geophysical prospecting technique. Accurate locations of subsurface utilities are obtained horizontally and vertically by digging test holes.

- All projects shall be designated by the Consultant or the survey party as determined by the State Location and Design Engineer. A determination will be made and indicated on Form LD-430 as to the need to secure the underground utility designating service. All projects with buried water, gas or sanitary sewer force mains should be designated. The letter of authorization will then indicate the manner in which this will be accomplished.

PROCEDURE

- The following procedure has been developed to identify and resolve utility conflicts at an early stage in plan design. A procedural flow chart is shown on Sheet 7 of 9 indicating the steps to be taken.

Utility Survey Data

- The project survey will show all visible utility facilities such as water meters, cutoff valves, poles, etc. and all sanitary (except force mains) and storm sewers including top and invert elevations. The next structure (manhole, etc.) outside of survey limits shall be included with elevations.

Submitting Plans

- The unit preparing the plan base shall submit a Microstation DGN file and three (3) sets of B/W prints of the <u>entire</u> project (including title sheet and/or location map). The file should clearly show the survey line that was established in the field along with sufficient references to locate and retrace the original line. Also submit one (1) print of the computer alignment printout of the survey line that was established in the field to the State Survey Parties Engineer via Form LD-261 (Request for Additional Survey).

Simultaneous Plotting

- Annotation, property data and any other information can be secured and plotted simultaneously with the designating of the subsurface utilities.

Designating

- The horizontal location of existing subsurface utilities will be designated by the consultant and the information returned to the Department in the format requested.

Preliminary Road Plan Development

- Upon receipt of the underground utility designation (horizontal) data, preliminary road plans, including hydraulic design, will be developed. The designer will request that the Structure and Bridge and Traffic Engineering Divisions submit preliminary bridge, sign, signal and lighting plans, including estimates, for detailed plan development prior to the roadway field inspection.
- A review is to be made with these divisions by the designer to determine if there are utility conflicts with bridges, signs, signals, etc. based on the horizontal location of the utilities.
- The design of the project drainage facilities, walls and other features are to avoid horizontal utility conflicts where feasible.
- Prints are to be resubmitted to Structure and Bridge and/or Traffic Engineering if the design is altered during plan development affecting their preliminary plans.

UTILITY LOCATING SERVICES

Determination

- Potential vertical utility conflicts shall be determined after all feasible horizontal design adjustments have been incorporated into the design. The designer shall, based on the magnitude of the underground utility involvement, determine whether locating services (test holes) provided under the consultant contract should be requested. This determination should be made after discussing the project with the District Utilities Engineer.

- When other Divisions need test holes, they are to submit their requests directly to the designer for inclusion in his submission.

Scheduling of requests for Test Holes

- The designer should request the Underground Utility Location (Test Holes) approximately 6 months prior to the scheduled Field Inspection in order for the evaluation of test hole data and necessary plan changes to be made before Field Inspection.
- It is expected that the request for test holes will be based upon preliminary hydraulic design and when the hydraulic design is finalized, additional test holes may be needed.
- Please see Flow Chart on sheet 7 of 9.

Requesting Locating (Test Hole) Information (when required)

- The designer shall submit the applicable mylar sheets on which the test holes are requested, two (2) sets of prints of the entire project (including title sheet and/or location map and sheets containing bench marks). The sheets should clearly show the survey line that was established in the field along with sufficient references to locate and retrace the original line. Also submit one (1) print of the computer alignment printout of the survey line that was established in the field to the State Survey Parties Engineer via Form LD-261 (Request for Additional Survey). The designer shall clearly mark in red pencil the location of test holes to be secured on one set of the prints. Prior to submitting the request for additional survey, the designer shall request that the District Utilities Engineer review the marked prints to assure that all necessary data will be secured with the initial request. The District Utility Engineer should advise the designer of any known utility relocations that are proposed which will negate the need for any test holes.
- Test holes should be secured on all underground facilities, i.e., water and gas lines larger than 75 mm (3”), telephone and electric lines in conduit systems and sanitary sewer force mains when there are potential conflicts. Direct buried telephone or electric cables normally should not require test holes. Service lines to properties should not be secured unless they are 150 mm (6”) or greater in size and test holes should not be requested for facilities where construction will require that the facility be relocated. Test holes should not be requested for gravity sanitary sewer facilities, unless the inverts of the manholes are not obtainable because of physical obstructions. In addition to the potential conflict sites where the utilities are crossed by the proposed storm drainage, consideration should be given to requesting data in locations:
    1. Where potential conflicts may exist with the project design (i.e., retaining walls, bridge footings, signal structures, ditches, entrance cuts, unsuitable material, etc.).
    2. Where cut to the subgrade line is 0.5 m (18”) or less. (Test holes should not be requested in cuts where the excavation would be expected to uncover the utility.)
- Requests from District design units are to be made through the respective Design Coordinators.

Non-Project Request

- There will be instances where the services furnished under this contract may not be related to a project being designed for construction. In these cases, a request, by memorandum, should be made to the State Survey Parties Engineer stating the need, an appropriate charge number and the date when the data is needed. A sketch should be furnished showing the location with horizontal and vertical control.

Data Distribution

- When the test hole data has been secured, it will be transmitted to the project designer for his evaluation and incorporation into the roadway plans distribution to others as requested.

Evaluating Test Hole Data

- The designer shall review the test hole data secured, and make an evaluation as to whether the facility is vertically in conflict or not. Should there be a conflict between the utility and the proposed structure, ditches, roadway or entrance cuts, etc., or wherever test holes are dug the designer shall determine if changes can be made to eliminate the utility conflict. If the design is changed, new test hold data may be required. Should such changes significantly increase the cost of the construction items, the designer shall advise the Utility Section and the Urban Division, if applicable, of the estimated cost for proper disposition.

  If the utility engineer determines that a utility adjustment would be warranted rather than a storm sewer change or if a utility relocation is proposed, the utility engineer shall advise the designer so that the storm drainage design can be finalized.

The results of this evaluation shall be shown on the UNDERGROUND UTILITIES TEST HOLE INFORMATION sheet (see sample, sheet 8 of 9) and a copy shall be sent to the Utility Section and the District Utilities Engineer.

ROADWAY AND UTILITY FIELD INSPECTIONS

Distribution of Prints

- After Roadway F.I. evaluation is complete and approval received, the appropriate changes must be incorporated in to the plans. The designer shall distribute prints for the Utility F.I. in accordance with IIM LD- (D) 68 and the Utility Field Inspection Form LD-428 (attached).

- Prints of manual or computer plotted cross sections are to be included.

- The Designer/Consultant is to be notified of the Utility Field Inspection on Intestate, Primary and Urban projects. Check the appropriate data on the Utility Field Inspection Form.

Utility Test Hole Data

- The underground utilities test hole information shall be shown on the Underground Utilities Test Hole Information Sheet, available in the CADD insertable sheet directory, (See sheet 8 of 9) or on a plan summary sheet. The information contained on the test hole information sheet shall include the utility owners, addresses, phone numbers and the legend for all known utilities.

CONSTRUCTION PLANS

- The Underground Utilities Test Hole Information sheet (see sample sheet) is to be included in the construction plans. The designer will specify the clearances (e.g. 0.35 m clear. over water line) and any action taken (e.g., water line relocated, water line sleeved through 1.8 m X 2.4 m box culvert, etc.) in the remarks column.

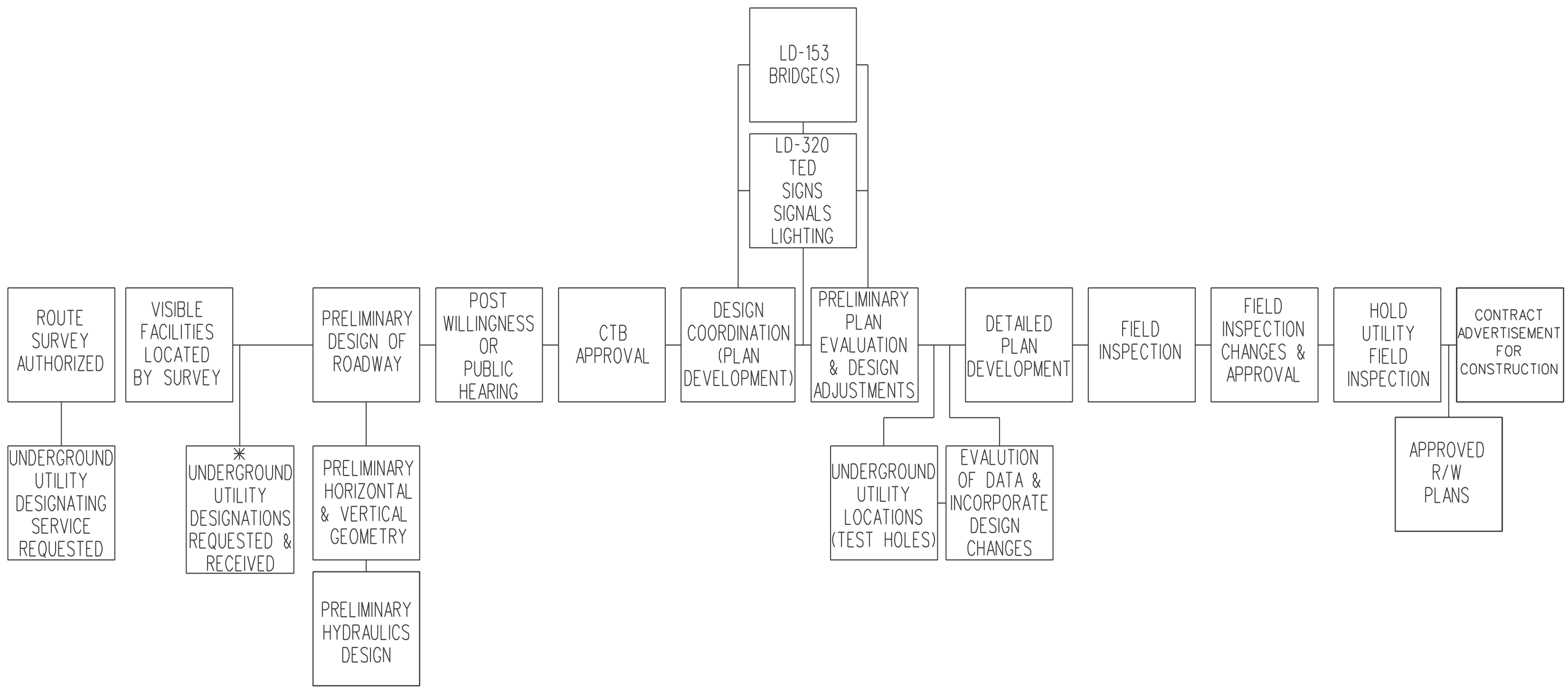
- Required utility adjustments will be determined by the Utility Engineer. The designer will indicate these utility adjustments (yes or no) on the Underground Utility Test Hole Information Sheet.

- The utility test hole information will not be shown on the construction plan sheets, but shall be included on the detail drawings for retaining walls, bridge footings, signal structures, special design items, etc. Include any utility information that may be beneficial to the Contractor, (i.e., 430 mm (17”) between top of waterline and retaining wall footing, top of utility elevation, etc.). Caution must be exercised to ensure that the data being shown applies to facilities that will still be in place during the construction of the highway project.

INSERTABLE SHEET

- An insertable sheet entitled “UNDERGROUND UTILITY TEST HOLE INFORMATION” (Metric or Imperial) is available through the CADD files for insertion into applicable plan assemblies.

PLAN DEVELOPMENT / UTILITY RESOLUTION PROCEDURES



SHADED BLOCKS DENOTE PROCEDURES WHEN UNDERGROUND UTILITY SERVICES ARE SECURED

✳ SURVEY DATA CAN BE SECURED & PLOTTED ON THE PLANS SIMULTANEOUSLY WITH THE DESIGNATING OF THE SUBSURFACE UTILITIES BY THE CONSULTANTS (SEE SUBMITTING PLANS 7 SIMULTANEOUS PLOTTING ON SHEET)

DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT.

REVISED	FHWA REGION	STATE	FEDERAL AID PROJECT	STATE ROUTE	STATE PROJECT	SHEET NO.
	3	VA.		U000	U000-152-103,C502	2D

SAMPLE

UNDERGROUND UTILITIES TEST HOLE INFORMATION

PLAN SHEET	TEST HOLE	DISTANCE (METRIC)	(1) STATION & ROADWAY	OWNER	TYPE OF FACILITY	(2) ELEV. (METERS)	(3) CONFLICT	(4) REMARKS	UTILITY (5) ADJUSTMENT REQUIRED
4	1	3.10 RT	318+93.20 RELOC. RTE. 168	2	450 mm W/STL GAS LINE	4.26	NO	0.32 m CLEAR OVER G.L.	NO
4	2	3.72 RT	321+70.40 ATLANTIC AVE.	1	225 mm C.I.WATER LINE	4.39	NO	0.02 m CLEAR OVER W.L.	YES
4	3	2.90 RT	321+90.40 ATLANTIC AVE.	2	600 mm STL CASING PIPE	4.40	NO	0.02 m CLEAR OVER G.L.	NO
4B	4	4.10 LT	324+10.20 ATLANTIC AVE.	1	225 mm BELL JOINT ON 200 mm C.I.WATER LINE	4.50	YES	ST.SEWER CANNOT BE RAISED TO MISS W.L.	YES
4C	5	6.00 LT	334+35.90 ATLANTIC AVE.	3	(1) 9 WAY TERRA COTTA TELEPHONE DUCT	4.80	YES	ST.SEWER CANNOT BE LOWERED TO MISS T.D.	YES
4C	6	1.50 LT	334+36.00 ATLANTIC AVE.	4	800 mm C.I.SAN.FORCE MAIN	4.00	NO	0.60 m CLEAR OVER S.F.M.	NO
5	7	21.30 RT.	325+98.00 RELOC.RTE.168	1	150 mm C.I.WATER LINE	4.50	NO	0.20 m CLEAR OVER W.L.	NO
6	8	0.30 LT	22+01.00 LIBERTY ST.CONN.	1	200 mm C.I.WATER LINE	4.90	YES	ST.SEWER CANNOT BE LOWERED TO MISS W.L.	YES
6B	9	3.40 LT	10+50.00 JEFFERSON ST.	1	175 mm A.C.WATER LINE	4.50	YES	ST.SEWER CANNOT BE ADJUSTED TO MISS W.L.	YES
6B	10	7.30 LT	19+57.00 LIBERTY ST.	1	400 mm STL CASING PIPE	4.80	NO	0.06 m CLEAR OVER W.L.CASING PIPE	YES

PLAN SHEETS	TEST HOLES	DISTANCE (METERS)	(1) STATION & ROADWAY	OWNER	TYPE OF FACILITY	(2) ELEV. (METERS)	(3) CONFLICT	(4) REMARKS	UTILITY (5) ADJUSTMENT REQUIRED

OWNER NUMBER	UTILITY OWNER
1	CHESAPEAKE PUBLIC UTILITIES P.O.BOX 15225 CHESAPEAKE, VA 23320 PHONE 804 925-5372
2	VIRGINIA NATURAL GAS 5100 EAST VIRGINIA BEACH BOULEVARD NORFOLK, VA 23502 PHONE 804 925-9822
3	CHESAPEAKE & POTOMAC TELEPHONE COMPANY 3757 EAST VIRGINIA BEACH BOULEVARD NORFOLK, VA 23502 PHONE 804 925-4490
4	HAMPTON ROADS SANITATION DISTRICT P.O.BOX 5000 VIRGINIA BEACH, VA 23455 PHONE 804 925-4106

LEGEND

W

T/Tg Duct

SFM

G

NOTES:

(1) ALL TEST HOLES ARE REFERENCED FROM THE SURVEY BASELINE UNLESS OTHERWISE NOTED.

(2) ELEVATIONS SHOWN HEREON ARE TO THE TOP OF THE FACILITY UNLESS OTHERWISE NOTED.

(3) YES OR NO; NO INDICATES NO DIRECT CONFLICT, HOWEVER, CLEARANCE MAY BE LESS THAN ACCEPTABLE TO UTILITY OWNER.

(4) REMARKS TO INCLUDE CLEARANCE DIMENSION (REGARDLESS OF DISTANCE).

(5) YES OR NO; INFORMATION TO BE PROVIDED BY THE VDOT DISTRICT UTILITY ENGINEER.

FOR ADDITIONAL INFORMATION SEE IIM LD- (D)140 .

SPECIAL DESIGN SECTION
DRAWING NO. A-41

SUPERVISED BY
DESIGNED BY
CADD OPERATOR
REVISED BY

PLAN
NOTE BOOK
NO.

PLAN NO.	PROJECT	FILE NO.	SHEET NO.
A	U000-152-103,C502		2D

*time

LD-428 (Rev. 9-99)

UTILITY FIELD INSPECTION FORM

MEMORANDUM

Date ____________________
Route ____________________
Proj. ____________________
PPMS ID# ____________________

To: District Administrator

Attn: District Utility Engineer

From: Location and Design Project Manager: ____________________

Enclosed are ______ prints of plans and _____ prints of x-sections on the above described project which are being sent to your for the Utility Field Inspection.

( ) 1 set of prints, including cross sections (plus 1 set of prints, 1 set of cross sections and 1 set of plan sheets only for each Utility Company).

( ) Underground Utility Test Hole Data has been included.

( ) Underground Utility Test Hole Data has been requested and will be evaluated and available on or about ____________________ .

( ) The Underground Utility Test Hole Data was not required.

Please schedule the Utility Field Inspection with the affected utility companies. Copies of the Utility Field Inspection Report (Form UT-3) are to be distributed in accordance with the requirements contained on the form.

( ) The Project Designer would like to attend the Utility Field Inspection. Please notify as to the time and location.

( ) The Hydraulic Designer would like to attend the Utility Field Inspection. Please notify as to the time and location.

( ) The Project Designer will attend the Utility Field Inspection if requested.

( ) The Hydraulic Designer will attend the Utility Field Inspection if requested.

If the Department is to obtain utility easements please provide sufficient data, as detailed in the Road Design Manual, to plot the utility easements on the plans.

( ) Utility Field Inspection prints include changes recommended at F.I.

( ) Utility Field Inspection prints do not include F.I. recommendation.

cc: Director of Right-of-way and Utilities (Utility Section) with 1 set of prints
Urban Engineer (if applicable)
Hydraulics Designer/Coordinator with 1 set of prints

Figure 4-G

LD – 261 (Rev. 10-00)

LOCATION AND DESIGN DIVISION
REQUEST FOR ADDITIONAL SURVEY INFORMATION

TO: State Survey Parties Engineer

PROJECT DESCRIPTION DATE: ____________________

From: ____________________ ROUTE ____________________

____________________ PROJECT ____________________

To: ____________________ ____________________

____________________ COUNTY ____________________

PPMS-ID ____________________

The following additional survey information is needed in preparing the plans on the above captioned project:

____

____

____

____

____

The following data is being handed you:

____

____

____

ALIGNMENT Listing of the project is attached ___ (yes) ___ (no)

DTM FILES of the project are attached ___ (yes) ___ (no)

Survey books, rolls and/or disks are in the District Drafting Room ___ (yes) ___ (no)

Survey information to be furnished to District Design Engineer ___ (yes) ___ (no)

Subsurface Utility Designation has been outlined on the prints ___ (yes) ___ (no)

Subsurface Utility Locating (Test Hole) has been reviewed by ____________, Utility Engineer

Requested by ____________________ Phone No. ____________________

Request has been reviewed by ____________________ Transportation Engineer or above

Remarks ____________________

____

____

____

____

PLEASE DO NOT WRITE BELOW THIS LINE

Survey authorized by ____________________ Date ____________________

VIRGINIA DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN DIVISION
INITIAL FIELD REVIEW AND SCOPING REPORT
PART A

Date of Review: ____________

Route ________ or Name of Facility ____________

Project ____________ PPMS ID ________

From: ____________ FHWA - 534 ________

To: ____________

County, City or Town ____________ , Virginia

District ________ 6 Year Plan(Year) ________ Page ____ Line ____

Type of Facility: (Interstate, Primary, Urban, Secondary, Bridge, Bicycle, Other) ________

PE Authorization Date ________ Type Plan Assembly (C,M,N) ________

Amount Authorized for PE ________

Type of Financing: State ________ Federal ________ Other ________

6 Yr. Plan Est.: PE ________ R/W ________ (Incl. Utilities) Const. ________ Total ________

Engineer's Est.: PE ________ R/W ________ (Incl. Utilities) Const. ________ Total ________

Description of Work: ____________

____

Design Speed ________ Functional Class. ________

Existing Traffic ________ ADT (Yr. ____) % Trucks ________

Design Year Traffic ________ (if available) ADT (Yr. ____) DHV ________

Project Length ________ Alignment Length ________ Should utilities be designated? ____

3R Guidelines Used? ____ If no, explain ____________

Are you aware of the need for any 3R waivers or design exceptions? ________ If yes, attach separate documentation for approval with this LD-430 form.

GEOMETRICS:	Existing	Proposed		Existing	Proposed
No. of Lanes			Lane Width, m/ft.		
Median Type			Curb &Gutter Location (one side, both)		
Fill Shoulder, m/ft.			Ditch Width, m/ft.		
Cut Shoulder, m/ft.			Median Shoulder, m/ft.		

Existing Pavement to be Used ____________

Widening Existing Pavement ________ (one side, both) Existing Pavement Width ________ m/ft

PART A (cont.)

Widening Lt. ____________ m/ft. Widening Rt. ____________ m/ft.

Does the locality have a biking or walking accommodations plan? ________

Sidewalk: Width ____________ Location ____________

Shared Use Paths: Width (10’ or 12’) ____________ Location ____________

Bicycle Lanes: (yes or no) ____________ Location ____________

Wide Outside Lane: Width (14’ or 15’) ________ Location ____________

No. Bridges Req’d. ____________ Suff. Rating Exist. Bridges ____________

R/W Width ____________ Purchase ____________ Donation ____________

Scheduled Advertisement Date ____________

Perform Recoverable Slope Study? (Y or N) ________ If no, explain ____________

List Necessary Design Exceptions: ____________

Should a value engineering study on this project or specific elements be facilitated by Management Services Division? ____________

Design services provided by (Central Office, District, Consultant or other)? ____________

Project Assigned to ____________ Phone No. ____________

Members of the Initial Field Review Team are as follows:

- District Utilities Engineer ____________
- Residency ____________
- Location and Design ____________
- Location and Design (Public Involvement) ____________
- Location and Design (Survey) ____________
- Location and Design (Hydraulics) ____________
- Locality (if applicable) ____________
- Urban (if applicable) ____________
- Secondary Roads (if applicable) ____________
- Environmental (address items found on Form EQ-429) ____________
- Right of Way and Utilities ____________
- Traffic Engineering ____________
- Transportation Planning ____________
- Structure and Bridge ____________
- Rail and Public Transportation (if applicable) ____________
- Construction Division ____________
- Area Maintenance Engineer ____________
- Materials ____________
- FHWA ____________

(continued on next page)

PART A (cont.)

Survey Information Required

Provide a letter size map or photo showing the location of project. If possible, please include a large scale photo (minimum plan ratio 1:2000 or scale 1" = 200') to show the scope of the project.

Average width of terrain information required ______________________________

List connections with length of survey needed ______________________________

____

____

____

Does this project tie to or cross any other existing projects that are now in the survey, design, R/W, or Construction phase Y _______ N _______

If yes, provide the following information:

Project ______________________________

From: ______________________________

To: ______________________________

Project Manager ______________________________ PPMS No. ______________

Project ______________________________

From: ______________________________

To: ______________________________

Project Manager ______________________________ PPMS No. ______________

Project ______________________________

From: ______________________________

To: ______________________________

Project Manager ______________________________ PPMS No. ______________

Any other information which should be included with survey request ______________________________

____

____

Survey Authorized by: ______________________________ Date ______________

District Administrator (Secondary Projects)

State L & D Engineer (other projects)

PART A (cont.)

Scope Approval

NOTE: The following signatures constitute Scope approval for those projects that the Project Manager concludes no further studies are required to determine Scope. Part C of this form will be completed for Final Scope approval of those more complex projects (including Secondaries) that the Project Manager determines survey is necessary to conduct concept studies and hold a Preliminary Plan Review before establishing Scope.

Will PART C be completed for this project? _______ Yes _______ No

Secondary System

Approved by: ______________________________ Date: ______________
Resident Engineer

Approved by: ______________________________ Date: ______________
District Administrator

Concurrence by: ______________________________ Date: ______________
Secondary Roads Engineer

Interstate, Primary or Urban Systems

Approved by: ______________________________ Date: ______________
District Administrator

Approved by: ______________________________ Date: ______________
State Location & Design Engineer

Approved by: ______________________________ Date: ______________
Programming & Scheduling or Urban Engineer

Comments: ____

____

____

After approval by Scoping Group please return completed form to:

______________________________ Project Manager

The Project Manager will distribute copies of this report to the following upon completion:

District Administrator
District Construction Engineer
State Construction Engineer
Assistant State Construction Engineer
Resident Engineer
State Location and Design Engineer
Programming and Scheduling Administrator (if applicable)
Urban Engineer (if applicable)
Secondary Roads Engineer (if applicable)
District Location and Design Engineer
State Survey Engineer
Value Engineering Program Manager
Management Services Officer
Initial Field Review Team Members
State Environmental Engineer
Director of Right of Way and Utilities
State Traffic Engineer
State Transportation Planning Engineer
State Bicycle Coordinator
State Structure and Bridge Engineer
State Materials Engineer
Director of Rail and Public Transportation
FHWA

PART B

This section of LD-430 should be completed to document information discussed at the Initial Field Review and should be included with information provided when project survey is requested.

Existing Conditions

Existing Posted Speed ________________

Surface of Facility ____

____

Width of Facility ________________________ Ditch Width ________________________

Cut Slope ________________________ Fill Slope ________________________

Are existing slopes holding up? ______ Yes ______ No

Average width of existing Right of Way ____

Businesses that may be taken ______ Yes ______ No. If yes, number __________

Homes that may be taken ______ Yes ______ No. If yes, number __________

Provide purpose and need for this project: ____

____

Is this improvement in a regional or local study _________ Yes _________ No

If yes, name of study ____

Major structures on this project

Give short description of major structures (replacement, rehabilitation or new structure)

____

Miscellaneous information

Is Railroad involved? ______ Yes ______ No. If yes, what type of crossing is present? At grade ____ or separated ________ .

Are proffers or other financial arrangements anticipated? ______ Yes ______ No. If yes, give source and amount ____

____

Environmental impacts that may accrue on this project ____

____

PART B (cont.)

Are major utility conflicts or problems anticipated? ______ Yes ______ No. If yes, please explain ____

Are utilities present that may be attached to bridges? _____ Yes ______ No

Would this project be affected by any other project? If yes, please explain ________________

Recommended Public Involvement for this project:

None ____________ Explain ______________________________

Information meeting (s) ______________________________

Post Willingness ______________________________

Public Hearing ______________________________

Will maintenance of traffic be necessary for this project? (Y or N) _______

Can a detour to another road be used? ______________________________

PART C

NOTE: Part C of Form 430 to be utilized for projects that will have the Scope approved after receipt of survey and holding of a Preliminary Plan Review.

Design Year Traffic (__________ Yr.) __________ ADT __________ DHV __________ % Trucks

Existing Level of Service __________ Proposed Level of Service __________

Describe any changes in geometric design since Initial Field Review ______________________________

____

Describe the proposed project (i.e. four lane divided, limited access, etc.) ______________________________

____

____

Were Alternate Designs Considered? ________ If so, why was this specific design selected? __________

____

Was a Recoverable Slope Study conducted? __________ (Yes or No). If Study was conducted will Recoverable Slopes be provided? __________ If not provided, explain why ______________________

Est. Cost: PE __________________ R/W ______________________ Const. ___________________

(incl. utilities)

Date of Preliminary Plan Review __________________________

Members of the Preliminary Plan Review Team are as follows:

District ____

Residency ____

Location and Design ____

Locality (if applicable) ____

Urban (if applicable) ____

Construction Division ____

Environmental (address items found on Form EQ-429) ______________________________

Right of Way and Utilities ____

Traffic Engineering ____

(continued on next page)

PART C (cont.)

Transportation and Planning ______________________

Structure and Bridge ______________________

Rail and Public Transportation (if applicable) ______________________

Area Maintenance Engineer ______________________

FHWA ______________________

Other ______________________

Scope Approval

Approved by: ______________________ Date ____________

Resident Engineer (Secondaries Only)

Approved by: ______________________ Date ____________

District Administrator

Approved by: ______________________ Date ____________

State Location and Design Engineer

Approved by: ______________________ Date ____________

Programming and Scheduling,
Urban or Secondary Roads Engineer

Comments: ______________________

____

____

After approval by Scoping Group please return completed form to:

______________________ Project Manager

The Project Manager will distribute copies of this report to the following upon completion:

District Administrator
District Construction Engineer
State Construction Engineer
Assistant State Construction Engineer
Resident Engineer
State Location and Design Engineer
Programming and Scheduling Administrator (if applicable)
Urban Engineer (if applicable)
Secondary Roads Engineer (if applicable)
District Location and Design Engineer
State Survey Engineer
Value Engineering Program Manager
State Environmental Engineer
Director of Right of Way and Utilities
State Traffic Engineer
State Transportation Planning Engineer
State Bicycle Coordinator
State Structure and Bridge Engineer
State Materials Engineer
Director of Rail and Public Transportation
Management Services Officer
Initial Field Review Team Members
FHWA

CHAPTER 5.00

PHOTOGRAMMETRIC SURVEYS

Chapter Contents

Sec. 5.01	**General**
Sec. 5.02	**Pre-Photography Control**
Sec. 5.03	**Targets**
Sec. 5.04	**Post-Photography Control**
Sec. 5.05	**Annotation of Control Points**
Sec. 5.06	**Delivery of Control Point Information**
Sec. 5.07	**Digital Terrain Models, Cross-Sections, Profiles, and Bridge Situations**
Sec. 5.08	**Helicopter Photography**
Sec. 5.09	**Requesting Aerial Photography**
Sec. 5.10	**Requesting Photographic Products (Photo Counter)**
Sec. 5.11	**Field Responsibility for Quality Photo Control**
Sec. 5.12	**Field Responsibility for Quality Control of Photogrammetric Data**
Sec. 5.13	**Aerial Photography Quality Control Procedures**
Sec. 5.14	**Photogrammetry Quality Control Procedures**
Sec. 5.15	**Photogrammetry Products Delivery Schedule**
Sec. 5.16	**Light Detection and Ranging (LIDAR)**

Sec. 5.01 General

When the location survey necessitates the gathering of a large amount of information, or where the construction centerline is likely to be situated in a location different from the survey centerline, photogrammetric surveys offer many advantages. Once the photography has been secured and controlled, visible features, and terrain information can be secured very rapidly, safely, and at very little additional expense.

Sec. 5.02 Pre-Photography Control

On surveys where photogrammetry is to be used, a quadrangle sheet will be marked by the Photogrammetry Section outlining the area to be mapped and suggesting the general location for the placement of aerial targets. This marked map, along with other pertinent data needed for securing the survey information, usually is sent with the survey authorization.

On projects where no centerline or traverse will be established, permanent horizontal control monuments will serve as control for securing all topography, property data, elevations, etc. which cannot be secured by photogrammetry. Care should be taken in the placement of the horizontal control monuments to facilitate securing items such as edges of pavement, property lines, etc. This field data shall be secured in accordance with **Chapter 4.00** of the Survey Manual.

On projects where survey centerlines and/or traverse lines are established on the ground, aerial targets are to be placed along the lines at approximately five hundred foot **(500 ft)** intervals, depending on the scale of the photography. When placing a target on a centerline or traverse station, a hole should be cut in the center of the target, and the target placed over the station as level with the ground as possible. It is important that care be given so that targets are not placed in heavy woods or in shaded areas if at all possible. Where the centerline or traverse runs for long intervals in woods, targets with legs should be used to increase the possibility that the targets can be seen on the photography. It is important that the targets be placed in open areas if possible. It is permissible to move a target two hundred to three hundred feet **(200-300 ft)** along the centerline or traverse to a station that is in an open area.

If a connection is more than one thousand feet **(1000 ft)** long, targets should be placed at intervals of approximately five hundred feet **(500 ft)**, depending on the scale of the photography.

As soon as practical after mainlines, connections and traverses have been targeted, a list of all the stations targeted, along with the alignment and control information should be submitted to the State Survey Engineer or his representative in accordance with **Section 4.17** of this manual.

Sec. 5.03 TARGETS

Aerial targets are the preferred means to mark control point locations for photogrammetry.

The best targets are made in the shape of a cross with the point to be measured, placed in the center of the cross. The legs of the cross should be straight and placed on level ground or ground having a regular slope. The target should have good contrast with its background, The standard, printed, forty inch by forty inch **(40 in x 40 in)** cloth target works well against any background, and may be used in open areas for **1 : 3600** scale and larger scale photography.

When placing targets in the woods, extension legs six inches **(6 in)** wide and five feet **(5 ft)** long or longer should be added. **Figure 5-A** provides standard specifications for target dimensions based on photo scale and existing site conditions. **Figure 5-B, Page 5-3** illustrates a typical target configuration.

Targets painted on the pavement or sidewalk should be in the form of a cross with an overall length of four feet **(4 ft)** and a width of four inches **(4 in)** for aerial photography scales **1 : 3600** (1”=300’) or larger. White paint on new asphalt or black paint on new concrete makes excellent targets. On worn and discolored surfaces, it is often necessary to outline a white target with black paint or vice versa.

Target Dimensions

	Open Areas		Wooded Areas	
	L	W	L	W
Photo Scale	Length (ft)	Width (in)	Length (ft)	Width (in)
1:3000 (1”=250’)	4	4	8	6
1:3600 (1”=300’)	4	4	8	6
1:4200 (1”=350’)	4	6	8	6
1:6000 (1”=500’)	10	9	12	9
1:8400 (1”=700’)	10	9	14	9
1:12000 (1”=1000’)	15	12	20	12
1:16800 (1”=1400’)	20	12	25	18
1:24000 (1”=2000’)	30	18	40	36

Figure 5-A

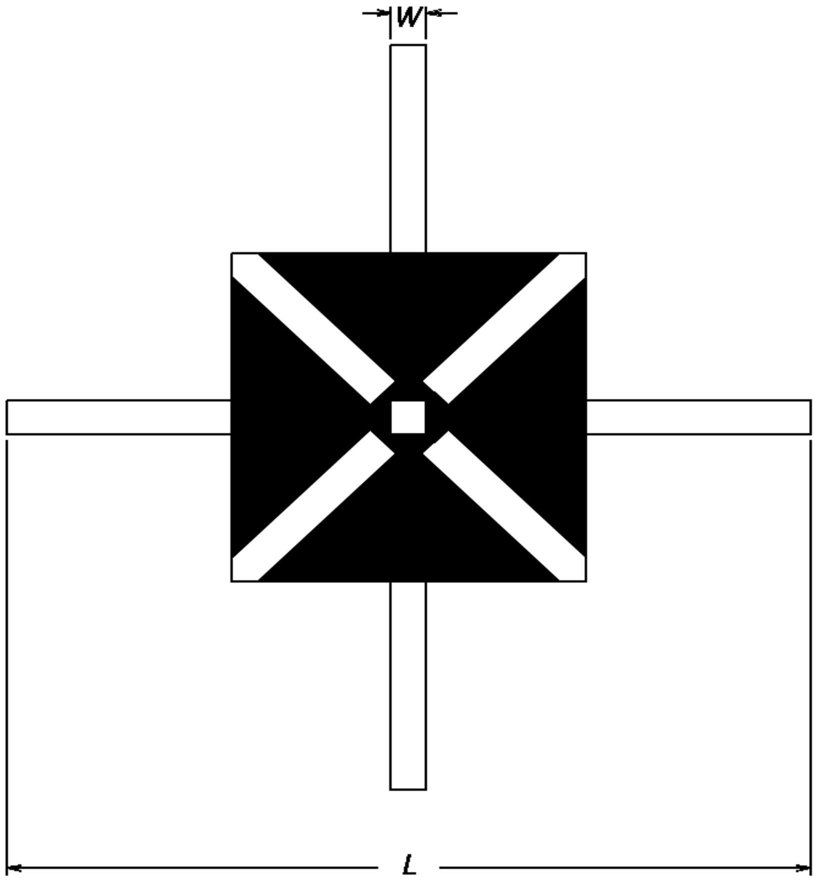


Figure 5-B

Sec. 5.04 **POST PHOTOGRAPHY CONTROL**

Often, on photogrammetric surveys, timing and other considerations do not allow for the placing of targets before the photography is secured. This necessitates the use of natural images, or "picture points", instead of targets for all control points. Natural image (picture point) locations must satisfy several conditions to insure an acceptable accuracy level:

- They must be sharp, well defined, and positively identifiable on all photos.
- They must lie in level, unobstructed locations.
- They must have thorough, accurate, and detailed descriptions written.

Natural images (picture points) are never as good as targets from the standpoint of precision and identification. However, they usually have more permanence than a targeted point. Good natural image points for **horizontal and vertical** control include, but are not limited to, intersection of parking lot markings, sidewalk corners and intersection of sidewalk edges, corners of drop inlet grates and concrete basins, painted traffic markings (points of turn lane arrows, corners of parking lot stripes, etc.), provided the traffic markings have not been changed or repainted between the time that the photography was taken, and the time of the control point survey.

Good natural image points for **vertical** control only include, but are not limited to, the center of manhole covers, intersections of roads and/or trails, on pavement at the end of islands, bases of utility poles, fence corners, and fence intersections. These all work well for **vertical** control only, provided the point locations are on level terrain. Building corners, rock outcrops, and around tree bases, should only be used in cases of extreme need when absolutely nothing else is available.

When selecting/reading any natural image (picture point), take extra care to insure that the photo image and the actual ground location are the exact same point. Also, verify that the actual ground location is sharp, well-defined, not covered by dirt, sand, or vegetation, not obscured by shadows, is on level terrain, and not hidden by image layover (relief displacement) on the photo(s).

In most instances, the field crew will receive a set of photography from the photogrammetry unit. This photography will typically have the natural image (picture points) pre-selected. In other instances, areas will be circled on the photos (usually in red grease pencil) for natural image (picture point) location by the field crew. These areas are the suggested, first-choice areas that would provide the best location for a natural image (picture point) from a photogrammetrists perspective. The field crew is not required to limit their point locations to these circled areas if they cannot locate a suitable point within the area. It is acceptable for the field crew to select a location outside of the circled area, but every effort should be made to stay as close to the circled area as possible.

When writing natural image (picture point) descriptions, be sure to indicate if the point was read "on the ground" or on a structure. Locating natural image points "on the ground" is generally preferred by the photogrammetrist, but does not always provide the best location.

ALWAYS use the direction of flight as "North" when describing control point locations (the "North" side of the photograph corresponds to the same side that contains the date, photo scale, and exposure number). See **Figure 5-C** below.

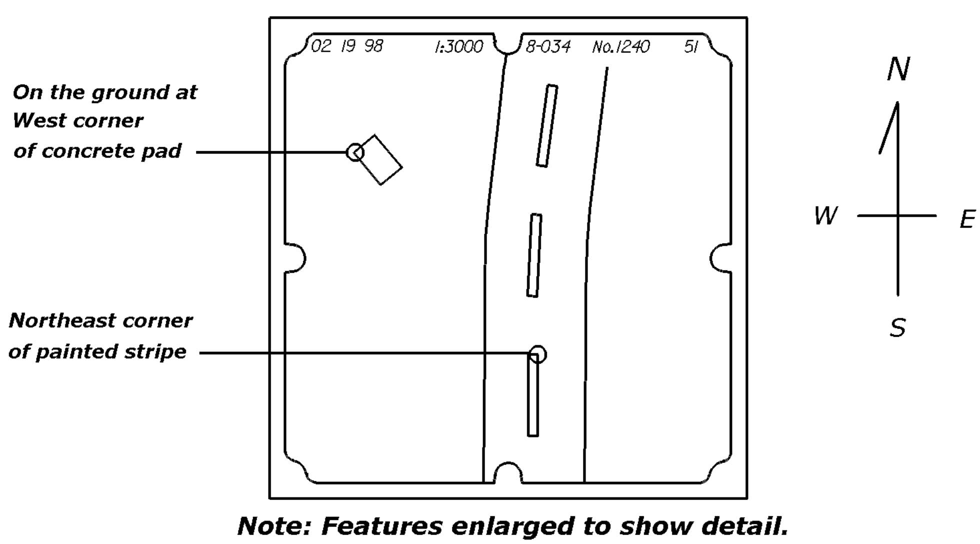


Figure 5-C

Sec. 5.05 ANNOTATION OF CONTROL POINTS

When annotating control points on the photography, please follow the conventions as outlined below. This method should replace all existing methods.

When targets or natural images (picture points) are used, the points will be numbered sequentially; beginning with 101 and increasing one at a time, until all control points are numbered (101, 102, 103, etc.).

The number assigned to a control point must be written beside that point's location on the photograph. Also, if the point lies on a centerline or a traverse line, that corresponding station should be written beside the control point on the photograph. All coordinate values of points should be annotated using the following format: **ID – X – Y – Z**. Control point ID numbers, coordinate values, and descriptions (where applicable), should be clearly written on the backs of the contact prints using permanent ink.

It is critical that only one number be used to designate each control point. Never assign different numbers to the same control point within a project, even if the point appears on different photos or strips. Also, it is unnecessary to annotate control points on every photograph. Choosing either odd or even photos is preferable for annotating control points. When marking control points on the photographs, use the following symbology:

Δ = Full Control Point (X,Y,Z)
❒ = Horizontal ONLY Control Point (X,Y)
❍ = Vertical ONLY Control Point (Z)

Remember: Clear, concise descriptions are extremely important for all picture points.

Sec. 5.06 DELIVERY OF CONTROL POINT INFORMATION

Once all control point values have been read and checked, and all contact prints annotated, the following items are to be delivered:

- Annotated contact prints
- 3.5" diskette containing the control values in ASCII format (ID-X-Y-Z separated with at least one blank space)
- Hardcopy of ASCII file

		ID	X	Y	Z
Example of	**:**	101	3660547.009	434232.333	81.789
ASCII File	**:**	102	3659553.271	434596.146	86.184
Format	**:**	103	3660667.354	432287.107	76.176
		104	3661443.659	432729.983	85.210

For projects having the photogrammetry performed by VDOT forces, return the control information to:

STATE PHOTOGRAMMETRY ENGINEER
VDOT
1401 EAST BROAD STREET, ROOM 915
RICHMOND, VA. 23219

Sec. 5.07 DIGITAL TERRAIN MODELS, CROSS-SECTIONS, PROFILES AND BRIDGE SITUATIONS

When digital terrain models (DTMs), or cross sections are being secured photogrammetrically, the survey party shall provide readings as specified by the engineer along or on all edges of pavement and concrete structures, such as curb and gutter, etc. in the required DTM format. Entrance profiles, storm water management areas and mitigation sites will be secured by photogrammetry using the DTM method unless specifically requested otherwise.

Note to survey parties-
For best feature definition, when collecting breaklines on curved structures (such as curb and gutter), the frequency of the readings should increase as the radius decreases.

On photogrammetric surveys, DTMs should be used wherever possible when securing drainage data. The survey party should secure drainage data only when requested. On most of these surveys, only streambed elevations will be required.

When cross-sections or DTMs are secured by the photogrammetric method, drainage ditch and outfall areas will be covered by contours. The survey party will secure DTM readings or cross sections necessary to cover the areas under water or otherwise obscured. On new alignment, the "drainage only" cross-section will extend left and right of the survey centerline. On existing alignment, the "drainage only" cross-section will extend left and right of centerline also and will show the invert elevations of the existing structure. The "drainage only" cross-section will extend at least one hundred feet **(100 ft)** from centerline and up to two hundred feet **(200 ft)** when a parallel lane is to be constructed. The distance should be measured along the existing ditch or swale and the resultant profile should accurately show the existing conditions. In the case of existing parallel highways with wide medians, the "drainage only" cross-section must extend at least one-hundred feet **(100 ft)** upstream and downstream form the existing structure.

In addition to streambeds, there will typically be other areas obscured to the photogrammetrist that the survey party will need to collect. Such areas do not facilitate accurate photogrammetric DTM collection due to heavy vegetation cover (wooded and brushy areas), large structures covering the ground (bridges), etc. When obscure areas need to be collected by the survey party, the photogrammetry section will furnish a list of the areas, and submit a marked set of photography or plots to the survey engineer. The data will then be secured by the survey party and combined with the photogrammetry data before the finished DTM is turned over to the design engineer.

When bridge situations are to be secured by photogrammetric methods, sufficient data shall be secured by the survey party to complete the situation plan in accordance with **Chapter 7.00** of this manual.

For Bridge Site Plans - Highways and Railroads, where there are no existing structures, only pavement and top of rail elevations are needed along with the connection alignment and/or railroad traverse.

For Bridge Site Plans - Widening, all data secured shall be in accordance with **Section 4.14** of this manual with the exception of the cross sections. In lieu of the cross sections, DTMs shall be secured covering the area under the structure, with sufficient data to cover the information needed to be merged with the data from the photogrammetry section.

Sec. 5.08 HELICOPTER PHOTOGRAPHY

VDOT has begun utilizing photography taken from a helicopter in an effort to promote safety for the survey personnel, and produce higher accuracy from photogrammetric DTMs. Helicopters can fly at lower altitudes, and hover over the ground, unlike fixed-wing aircraft that must maintain a minimum airspeed and altitude to avoid disaster.

The photography produced from helicopter flights increases the accuracy of photogrammetric measurements and data collection. Helicopter photography is typically taken from three hundred feet to eight hundred feet **(300-800 ft)** above the ground. This produces photo scales ranging from 1:600 to 1:1600. This scale range produces a theoretical measurement accuracy of .03’ to .08’ respectively.

The helicopter’s hovering capability allows it to hold position until the camera operator is ready to take the photo. This is particularly useful when working in areas of heavy traffic when vehicles are often driving across and obscuring the aerial targets.

Helicopter photography will not replace fixed-wing aircraft photography, nor will it replace the need for a field party, but it will provide a high-accuracy supplement for the survey data produced by traditional survey and photogrammetry methods.

Helicopter Photography Aerial Targets-

Targets must be used to mark all helicopter-photography photogrammetry control points. The aerial targets used for helicopter photography are smaller than traditional targets, and can be configured in the shape of an “X” like the larger targets, or a “V”. See **Figure 5-D, Page 5-8** for helicopter-photography target illustrations. See **Figure 5-E, Page 5-8** for recommended helicopter-photography target dimensions. A PK Nail should be set at the appropriate location as indicated in **Figure 5-D**. The photogrammetrist will actually be able to read the top of the nail, so careful attention must be made to place the nails at the appropriate location. The nails MUST be driven flush with the pavement. See **Figure 5-F, Page 5-8**. The surveyor must read the center of the top of the PK nail as the control point location.

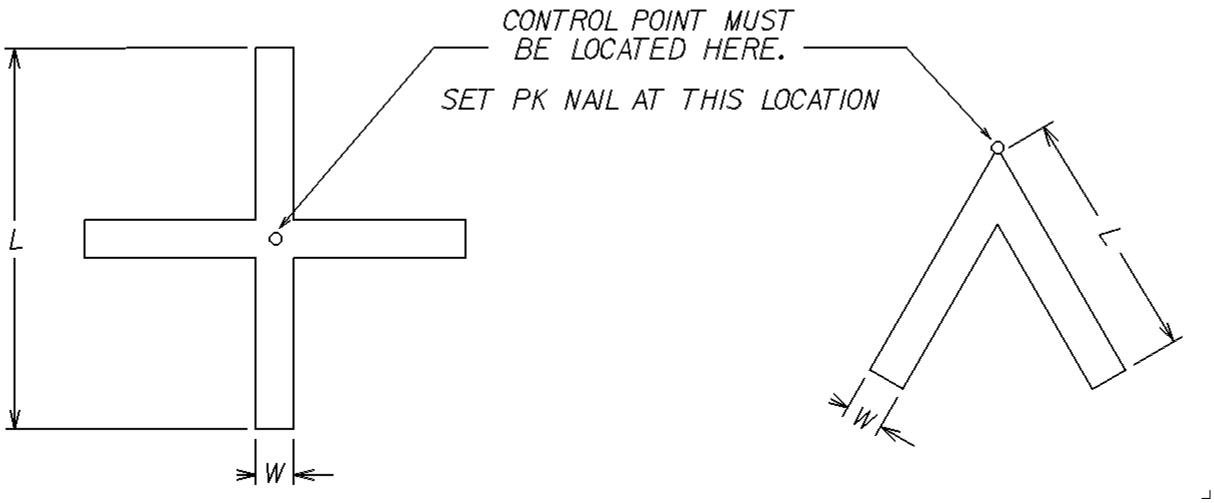
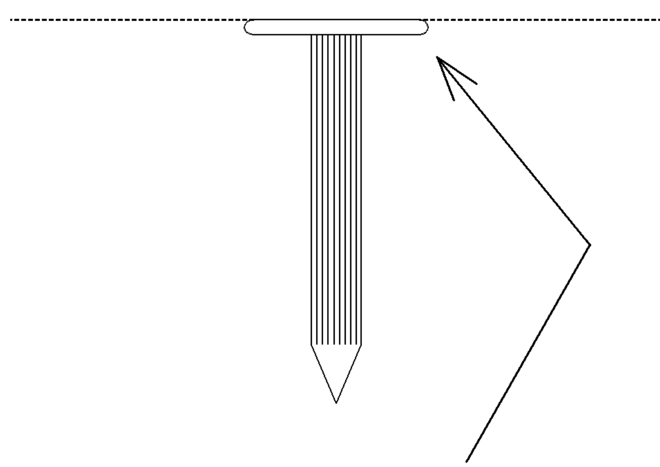


Figure 5-D

"X" Configuration Helicopter Target Dimensions

Photo Scale	L Length (in)	W Width (in)
1:800 (1"=67')	8"	1"
1:1000 (1"=83')	10"	1"
1:1200 (1"=100")	14"	2"
1:1500 (1"=125")	18"	2"

Figure 5-E



CRITICAL

Set PK Nail flush with pavement (ground)

Figure 5-F

Targets for helicopter photography can be set using either Method “A” or Method “B” below:

A: Set targets in pairs (one on the left shoulder or pavement edge, and the second, directly opposite the first, on the right shoulder or pavement edge), so that the target pair falls on approximately every other stereomodel. Target spacing along the shoulder or pavement edge should be from 400’–550’ for 1:800 – 1:1000 photo scales respectively. See **Figure 5-G** below.

B: Set a single target on approximately every other stereomodel along the left shoulder or pavement edge then set a single target on the right shoulder or pavement edge, staggering the targets so that one target will fall on approximately every stereomodel, alternating from the left shoulder or pavement edge, to the right shoulder or pavement edge. Target spacing along each shoulder or pavement edge should be 400’–550’ for 1:800 – 1:1000 photo scales respectively. See **Figure 5-H, Page 5-10**.

- Helicopter targets must be painted on a hard and level surface.
- PK nails set at the center of the target must be hammered flush with the surface.
- The point number should be painted next to the target using 6-inch high numbers.
- A digital level should be used for the vertical control to keep the vertical closures as accurate as possible.

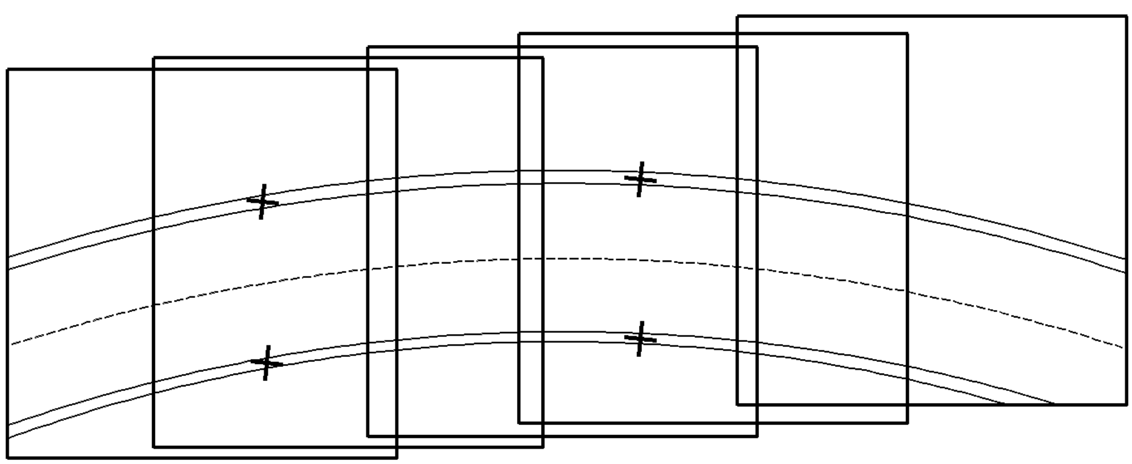


Figure 5-G

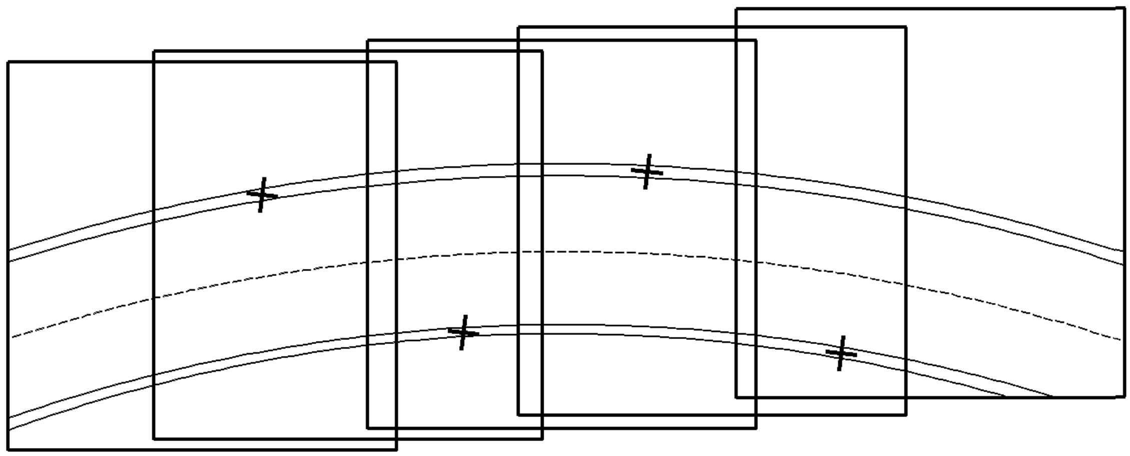


Figure 5-H

Sec. 5.09 **REQUESTING AERIAL PHOTOGRAPHY**

Requests for aerial photography may be submitted any time throughout the year. Photography that is to be used to generate photogrammetric mapping to supplement a location survey for base highway design, must be flown during leaf-off conditions, preferably in February and March. If this is the photography's intended use, the request needs to be submitted no later than the preceding January (the earlier the better for scheduling purposes). Requests for general aerial photography may be sent to the Senior Aerial Photographer. Requests that require targeting for photogrammetry should be directed to the State Photogrammetry Engineer. A copy of the request form is included on the next page. A copy is also located on the Central Office-Location and Design Division's intranet site, listed under the heading "L&D Forms". The form number is LD-392

Note: Be as specific as possible when filling out the form.

LD-392 (Rev. 10/00) LOCATION AND DESIGN DIVISION

WORK REQUEST

FOR AERIAL PHOTOGRAPHY AND MOSAICS

Date: ______________________
PPMS-ID: ______________________
Route: ______________________
State Project: ______________________
PPMS-ID Lineage: ______________________
From: ______________________
To: ______________________
County/City/Town: ______________________

Requested by: ______________________
Title: ______________________ Phone: ______________________
Intended use of photography: ______________________
Contact person if different than above: ______________________

Check items desired:

☐ Aerial Photography:
- Date Due: ______________
- Date Complete: ______________
- Targeting Required: ______________
- Photo Scale Desired: ______________

☐ Mosaic:
- Date Due: ______________
- Date Complete: ______________
- Targeting Required: ______________
- Mosaic Scale Desired: ______________

☐ Obliques:
- Date Due: ______________
- Date Complete: ______________

Notes: Please provide a map/diagram of desired coverage. Vertical photography will be flown using black and white film unless otherwise specified.

Remarks: ____

____

____

____

Sec. 5.10 REQUESTING PHOTOGRAPHIC PRODUCTS *(PHOTO COUNTER)*

Anyone requiring photographic products from VDOT's aerial photography archives, can order the products from VDOT's Photo Counter (*Telephone No. (804) 786-2575 or Telefax No. (804) 786-1788)*. Examples of products that can be provided include: contact prints, diapositives, and enlargements. Current pricing policies are in effect. Please contact the photo counter at the telephone number listed above for more information.

Any products ordered in support of a VDOT project must include the UPC number, the project number, and the activity number.

Consultants ordering photographic materials for VDOT projects that they are working on, should make the request through their VDOT survey or design coordinator, who will in turn place the order with the photo counter.

Note: Copyright laws are in effect for VDOT aerial photography.

Sec. 5.11 FIELD RESPONSIBILITY FOR QUALITY PHOTO CONTROL

Every effort must be taken to ensure the information supplied to the Photogrammetry Section is error free. Errors in elevation or horizontal position can adversely affect measurements made photogrammetrically as much as 1000 feet away from where the error occurs. For this reason, it is required that you **TURN on each vertical control station** when securing elevations. A special effort should be made to assure that the control values, both horizontal and vertical, are kept on the assigned project values. When assigning a number to a control station, **MAKE CERTAIN** that the assigned number is placed at the actual location of the control station to which it is assigned. When using GPS for photogrammetry control, make certain that you tie the GPS to existing monuments or other known points.

All work must meet or exceed National Map Accuracy Standards.

Sec. 5.12 FIELD RESPONSIBILITY FOR QUALITY CONTROL OF PHOTOGRAMMETRIC DATA

Upon receipt of the photogrammetric data files (planimetry and DTM), the survey manager will initiate a series of field checks to validate the quality and accuracy of the photogrammetric data. At a minimum, a selection of random features in the planimetric file should be verified for horizontal accuracy, and the file must be reviewed for completeness. DTM file checks will include verifying invert elevations, random spot heights, and miscellaneous other features, for horizontal and vertical accuracy and completeness. Field profiles may also be run to provide additional quality checks.

Sec. 5.13 AERIAL PHOTOGRAPHY QUALITY CONTROL PROCEDURES

This section is to be used by all internal personnel and consultants performing and providing aerial photography services for the Virginia Department of Transportation (VDOT). It defines the appropriate and necessary procedures to follow for performing quality control/quality assurance checks on all products, data, and services provided by, and to, VDOT. The procedures outlined herein are to be explicitly followed during the development of all aerial photography data.

Film processing-

The following steps will be taken to assure the quality of the film and film processing methods used by VDOT and contractors. In all cases it is expected that the film and film-processor manufacturer's instructions and recommendations will be strictly followed for proper processing procedures and equipment maintenance. The film shall be free of scratches, static marks or other blemishes. It shall be exposed and processed with a density range of 1.0 +/- 0.2 with a minimum density of 0.3 +/- 0.1 above base fog. Base fog shall not exceed 0.15. All fiducial marks shall be sharp and clear.

1. Each roll of film will be inspected visually for image quality.
2. If there is a question as to image quality then density readings will be taken of the affected exposures with a calibrated densitometer with a 0-3.0 range.
3. When the image quality does not meet standards, the aerial photography supervisor will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be re-flown.

Flight lines-

The following steps are used to determine whether the photography was taken at the correct location and if atmospheric conditions were suitable for the project. Each flight line shall be flown continuously across the project area. No actual flight line shall deviate horizontally from the specified flight line by more than 10 percent of the specified flight height.

1. Each flight line will be inspected visually to determine if the photography falls on the photo line and to insure that the desired area is covered.
2. Each flight line will be inspected visually for excessive haze, shadows, clouds and snow cover.
3. When the photo location and/or coverage area do not meet standards or if the atmospheric conditions were unsuitable at the time of photography, the aerial photography supervisor will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be re-flown.

Overlap-

The following steps are used to determine if there is adequate overlap to produce stereoscopic coverage. Overlap shall not be less than 55 percent or more than 65 percent and shall average 60 percent. Side-lap shall not be less than 20 percent or more than 40 percent and shall average 30 percent. Tri-lap of the mapping area shall be maintained across the project.

1. With the use of a template, the overlap of each flight line will be determined visually. Tri-lap (coverage on three consecutive exposures) will also be determined visually.
2. Side-lap for parallel flight lines will be checked visually.
3. When the overlap, side-lap and/or tri-lap do not meet specifications, the aerial photography supervisor will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be re-flown.

Crab-
The following steps are used to determine if the crab (wind correction angle) is within specifications. Crab shall not exceed 3 degrees for any photograph and shall average 1 degree for each flight line.

1. Each flight line will be visually inspected for excessive crabbing with the aid of a template.
2. If there is a question to the amount of crab then prints of the affected exposures will be made and the actual crab will be plotted on the prints.
3. When the amount of crab exceeds specifications, the aerial photography supervisor will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be re-flown.

Scale-
The following steps are used to determine if the scale is correct and within specifications for the project. Actual scale shall not deviate from the specified scale by more than 5 percent high or low.

1. Each flight line will be inspected visually for proper scale. A template is used to determine proper photo coverage for a given scale.
2. If there is a question of proper scale, then the actual photo scale will be calculated.
3. When the scale is incorrect or does not meet specifications, the aerial photography supervisor will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be re-flown.

Tip and Tilt-
The following steps are used to determine if the camera angle (level) is within specifications. The tip and tilt of the camera at the instant of exposure shall not exceed 5 degrees from vertical.

1. Each flight line will be visually inspected for proper tip and tilt.
2. If there is a question of proper tip and tilt then diapositives of the photography will be set up on a photogrammetric instrument to determine actual tip and tilt.
3. When the tip and tilt exceed specifications, the aerial photography supervisor will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be re-flown.

Additionally, flight logs will be reviewed for notes taken by the photographer during the flight. Also, the film frames are to be inspected for error codes produced by the camera.

Sec. 5.14 **PHOTOGRAMMETRY QUALITY CONTROL PROCEDURES**

This section is to be used by all internal personnel and consultants performing and providing photogrammetric services for the Virginia Department of Transportation (VDOT). It defines the appropriate and necessary procedures to follow for performing quality control/quality assurance checks on all products, data, and services provided by, and to, VDOT. The procedures outlined herein are to be explicitly followed during the development of all photogrammetric data.

Additionally, the "Quality Control Checklist for Photogrammetric Surveys" outlined in Chapter 12 must be completed for all VDOT projects requiring photogrammetry.

Project-Related Materials-
All project related materials, (flight/target maps, contact prints, diapositives, camera calibration report, control values, mapping scale, mapping units, mapping limits, scoping report, project specifications, adjoining project(s) and associated files, unusual circumstances, etc.) must be complete, and correct, and delivered to the internal or outsourced photogrammetry unit performing the work. The VDOT photogrammetry supervisor or manager will be responsible for validating the correctness and completeness of these materials. Each item must be verified, as correct by the manager or the supervisor.

Prior to project start-up by the photogrammetry unit, all diapositives are to be randomly checked to determine if any warping has occurred during the processing stage. A sample of 10%-15% of every project's diapositives is to have the interior orientations measured in a photogrammetric instrument. Interior orientation values of the diapositives must be 20 microns or less at each measured fiducial. Any value exceeding 20 microns must be brought to the attention of the shift supervisor, and a determination will be made to accept or reject the measurement and/or the corresponding diapositive. If the diapositive is rejected, then a new diapositive must be produced, and this quality control process repeated.

Scanning-
The following steps are to be used for quality assurance of the scanning process.

All equipment used for scanning aerial negative or positive film for the purpose of creating a digital image that will subsequently be used for aerotriangulation, stereo-compilation, or orthophoto generation, must be certified by the manufacturer to be in good working condition to produce scans according to the manufacturer's originally stated specifications. Scanner calibration certificates (where applicable) must be current and validated by the manufacturer or a representative thereof.
All scans generated by a scanner must be of good radiometric and geometric quality. Interior Orientation values should not exceed 20 microns. A senior technician or shift supervisor must verify these values and qualities.

1. The material(s) being scanned (negative film or diapositive) will be visually inspected prior to scanning. The material(s) will be inspected to check for scratches, blemishes, discoloration, unusually dark or light areas, etc., which may affect the quality of the scanned images. Any material(s) failing the visual inspection will be reproduced. Any reproduced material(s) will be inspected as outlined above.

2. Normalization or calibration of CCD camera responses will be performed within manufacturer's recommended calibration range. Unacceptable normalization residuals must be corrected by authorized service, software checks, etc., before scanning commences.
3. Fiducial mark quality must be checked. All 8 fiducials should be visible, clear and sharp in the scanned image. If fiducials are of questionable quality, the affected images will be rescanned, and the original material reviewed for clarity. If appropriate, the original material will be reproduced in an effort to improve fiducial clarity and quality.
4. The manufacturer's recommended input values for Transmissivity (Tmin and Tmax), Density, and Gamma Correction, will be followed for all VDOT project-related scanned imagery.
5. A test scan will be performed on the first diapositive/negative, prior to scanning the entire project. Scanner settings will be adjusted as necessary to produce the best quality possible, meeting the requirements of the project. The test image will be visually checked for quality before final scanning is done.
6. Final scans will be reviewed for correct scan resolution, required image output format, and compression. Visual checks will be performed on the images after each scan is complete.

Aerotriangulation-
The following steps are to be used for quality assurance of the aerotriangulation process.

1. Ground control delivered by the surveyor, will be assumed to be correct as verified by the quality control procedures used in the respective survey section. Input images/diapositives will be assumed to be quality-checked by the respective photogrammetry unit, and ready for use in the aerotriangulation process.
2. The photogrammetric technician performing aerotriangulation will verify that the correct camera calibration report is being utilized for the current project. Any discrepancies between the camera calibration report and the camera file utilized on the photogrammetric instrument must be resolved.
3. Interior orientation of the images/diapositives must be 20 microns or less at each measured fiducial. Any value exceeding 20 microns must be brought to the attention of the shift supervisor, and a determination will be made to accept or reject the measurement and/or the corresponding image/diapositive. If the image/diapositive is rejected, then a new image/diapositive will be produced, and the quality control process repeated.
4. Relative orientation of the images/diapositives must be 5 microns or less at each measured point. Any value exceeding 5 microns must be corrected. If the point cannot be corrected by subsequent measurements, the problem must be brought to the attention of the shift supervisor. The shift supervisor will make a determination to either accept or reject the measurement, and what course of action will be taken to resolve the problem.
5. Absolute orientation measurement residuals for each control point on the images/diapositves must be 0.1' vertical and 0.2' horizontal or less for imperial-unit at a photo scale of 1:3000. Any point measurement exceeding 0.1' vertical or 0.2' horizontal must be corrected. All points must be checked in stereo to assure consistency and accuracy. If the point cannot be corrected by subsequent measurements, the problem must be brought to the attention of the shift supervisor. The shift supervisor will make a determination to either accept or reject the measurement, and what course of action will be taken to resolve the problem.

6. The residuals of each control point listed on the photogrammetric adjustment will not exceed .1' vertical and .2' horizontal from their originally submitted values (for imperial-unit 1:3000 scale photography). Likewise, the mean residuals for all control points must not exceed .1' vertical and .2' horizontal. Any points exceeding .1' vertical or .2' horizontal must be investigated and corrected. If the point cannot be corrected by subsequent measurements or troubleshooting techniques, the problem must be brought to the attention of the shift supervisor. The shift supervisor will make a determination to either accept or reject the measurement, and what course of action will be taken to resolve the problem.
7. The final aerotriangulation adjustment must be reviewed and approved by the shift supervisor. This adjustment, which will include input and adjusted control values, will be printed onto hardcopy format. The shift supervisor will sign and date the first page of the hardcopy printout, and maintain this hardcopy record at VDOT-Central Office indefinitely.

Note: All consultants performing aerotriangulation on a VDOT project will submit the final, approved, signed and dated aerotriangulation adjustment report to the State Photogrammetry Engineer at VDOT.

Planimetry Compilation and Editing-

The following steps are to be used for quality assurance of the planimetry compilation and editing process.

1. Before starting planimetry compilation, the photogrammetry technician will verify the following project-specific items and set up their work procedures accordingly:
   - Mapping Limits – delineate in separate CADD file or outline on contact prints.
   - Map Scale – use appropriate feature tables, symbology, and resource files.
   - Units – Metric or Imperial.
   - Required Map Accuracy – review with shift supervisor.
   - Scheduled Due Date – verify/confirm with shift supervisor.
   - Special Project Circumstances – review with shift supervisor.

2. During planimetry compilation, the photogrammetry technician will perform continuous checks on the collected data.
3. Items to check include, but are not limited to:
   - Correct symbology and level structure as per the VDOT CADD and VDOT Survey manuals
   - Use of appropriate scales
   - Thoroughness of collected features
   - Adequate coverage of project area
   - Horizontal and vertical accuracy of collected features
   - Separation of utility information into a separate file
   - Compatible (appropriately-tied) data (between stereomodels, field data, and other photogrammetry data), and clean appearance of the data (fully edited)
4. Upon completion of the planimetry compilation for each stereomodel, the technician that collected the data will review all compiled data.
5. Upon completing the self-check and making any necessary edits, the photogrammetry technician will notify a senior level technician or shift-supervisor that they have

completed the stereomodel, and that they require a quality review of the data contained within that stereomodel.

6. The senior-level technician or shift supervisor will review and check the planimetry in the stereomodel following the criteria listed in #2 above. Any errors detected by the senior technician or shift-supervisor is to be noted to the technician collecting the data so that the technician may make any necessary revisions. The senior technician or shift-supervisor before final sign-off on the stereomodel will review the revisions. The date of the final sign-off will be indicated adjacent to the senior technician or shift-supervisor's endorsement.
7. The approved, final review must be signed-off and dated by the senior technician or shift supervisor performing the final review before the photogrammetry technician proceeds to the next stereomodel. Steps 2 – 7 must be repeated for each stereomodel within the project.
8. After the planimetry for the entire project has been compiled, edited, and checked as outlined above, the individual stereomodel files will be merged (if necessary), and the utility data will be separated (if necessary) into a unique "utility" file. Each file (planimetry and utility) will be reviewed one final time for completeness and correctness by the shift supervisor. If any errors or omissions are detected, the shift supervisors may at his/her discretion, correct the file(s) themselves or return the file(s) to the photogrammetry technician for correction.
9. The shift supervisor will notify the respective survey coordinator/survey technician/design technician by email or paper mail, when the files have been quality checked and approved. The shift supervisor will move the files to the appropriate location on the VDOT survey server, and maintain hardcopy records in the paper file of all correspondence relating to the files and the project.

Digital Terrain Model Compilation, Editing, and Processing-
The following steps are to be used for quality assurance of the digital terrain model (DTM) compilation, editing, and processing process.

1. Before starting digital terrain model compilation, the photogrammetry technician will verify the following project-specific items and set up their work procedures accordingly:
   - Mapping Limits – delineate in separate CADD file or outline on contact prints.
   - Map Scale – use appropriate feature tables, symbology, resource files; and use appropriate point spacing and DTM compilation techniques.
   - Units – Metric or Imperial.
   - Required Contour Interval – verify/confirm with shift supervisor.
   - Required Map Accuracy – review with shift supervisor.
   - Scheduled Due Date – verify/confirm with shift supervisor.
   - Special Project Circumstances – review with shift supervisor.

2. During DTM compilation, the photogrammetry technician will perform continuous checks on the collected data.
3. Items to check include, but are not limited to:
   - Correct symbology and level structure as per the VDOT CADD and VDOT Survey manuals
   - Horizontal and vertical accuracy of collected breaklines and spot readings
   - Appropriate point spacing and DTM collection technique

- Thoroughness of collected features
- Adequate coverage of project area
- Compatible (appropriately-tied) data (between stereomodels, field data, and other photogrammetry data), and clean appearance of the data (fully edited)

4. Upon completion of the DTM compilation for each stereomodel, the technician that collected the data will review all compiled data. Contours will be generated to check for high and low “spikes”, and any other data abnormalities.
5. Upon completing the self-check and making any necessary edits, the photogrammetry technician will notify a senior level technician or shift-supervisor that they have completed the stereomodel, and that they require a quality review of the data contained within that stereomodel.
6. The senior-level technician or shift supervisor will review and check the DTM in the stereomodel following the criteria listed in #2 above. Any errors detected by the senior technician or shift-supervisor are to be noted to the technician collecting the data so that the technician may make any necessary revisions. The senior technician or shift-supervisor before final sign-off on the stereomodel will review these revisions. The date of the final sign-off will be indicated adjacent to the senior technician or shift-supervisor’s endorsement.
7. The approved, final review must be signed-off and dated by the senior technician or shift supervisor performing the final review before the photogrammetry technician proceeds to the next stereomodel. Steps 2 – 7 must be repeated for each stereomodel within the project.
8. After the DTM for the entire project has been compiled, edited, and checked as outlined above, the individual stereomodel files will be merged (if necessary), and the entire DTM file will be reviewed one final time for completeness and correctness by the shift supervisor. Contours will be generated for the entire file to check for “spikes”, data compatibility problems, and other data abnormalities. If any errors or omissions are detected, the shift supervisors may at his/her discretion, correct the file(s) themselves or return the file(s) to the photogrammetry technician for correction.
9. The shift supervisor will notify the respective survey coordinator/survey technician/design technician by email or paper mail, when the DTM file has been quality checked and approved. The shift supervisor will move the file to the appropriate location on the VDOT survey server, and maintain hardcopy records in the paper file of all correspondence relating to the file and the project.

Orthophoto Generation-
The following steps are to be used for quality assurance of the orthophoto process.

1. The digital terrain model (DTM) file will be assumed to be correct as verified by the quality control procedures used in the respective photogrammetry unit. Scanned images and aerotriangulation adjustments will be assumed to be quality-checked by the respective photogrammetry unit, and ready for use in the orthophoto process.
2. Individual orthophoto images created from ortho-resampling process will be visually inspected using image display software. Images of poor quality will be ortho-resampled again.
3. Ortho-rectified images will be checked for proper geo-referencing and geometric quality, and any abnormalities to the ortho images. A problem with any of these indicates problems with scanned images, DTM elevation data, aerotriangulation data or the ortho-

resampling process. The problem must be investigated and a solution determined. A shift supervisor, or senior technician will approve final acceptance of the result.

4. The Digital Ortho Mosaic will be checked for image quality. Seam line areas are checked for acceptable feathering among all individual ortho images. When seam line feathering does not pass the quality review, mosaicking should be performed again with necessary adjustments applied. Seam lines should be placed in the least noticeable areas of image overlap.
5. The Digital Ortho Mosaic will be checked for a uniform tonal look across the image. Image enhancement software will be used to improve the Digital Ortho Mosaic and the individual ortho images, if necessary.
6. The Digital Ortho Mosaic lastly, will be checked for geometric accuracy. Input control values should be checked against the corresponding positions on the ortho-rectified image. The ortho mosaic will also be checked against DTM data or other available map data for proper Geo-referencing within the coordinate plane. The scale across the image will be checked for accuracy by measuring between two known points and comparing that distance to the same measurement across the ortho images. The accuracy of the digital orthophoto must meet or exceed the project requirements and specifications.

Delivery-
The following steps are to be used for appropriate notification and delivery of photogrammetry products.

Upon completion of the quality review process for each photogrammetric product (planimetry file, utility file, digital terrain model, orthophoto, etc.) the shift supervisor will copy the necessary files to the appropriate location on the survey server or other location as requested. The shift supervisor or unit manager will notify the respective central office survey coordinator, with a courtesy-copy to the appropriate district survey manager, stating that the work is complete and providing the location of the files. Such notification will be made by paper mail or email with a hardcopy maintained in the photogrammetry unit's paper files.

Sec. 5.15 PHOTOGRAMMETRY PRODUCTS DELIVERY SCHEDULE

The following schedules are to be observed for the various deliverables and procedures regarding consultant submittal of photogrammetry data and aerial photography for all VDOT projects. This applies to all photogrammetry and aerial photography work performed on any VDOT project regardless of the request origination.

Deliverable:	Processed Aerial Film, Flight Map, Current Aerial Camera Calibration Report
Send To:	Senior Aerial Photographer VDOT 1401 East Broad Street, Room 901 Richmond, VA 23219
Due:	30 calendar days after photo mission.
Notes:	Photogrammetry consultants are expected to send the processed aerial film to VDOT for inspection and annotation. The VDOT project manager will send any contact prints and diapositives necessary for completing the photogrammetry

work to the photogrammetry consultant upon request. When project circumstances and schedules dictate that there is insufficient time for the consultant to send the film to VDOT, then wait for contact prints and diapositives to be made and sent back to the consulting firm, the photogrammetry consultant will be permitted to produce all photographic products necessary (contact prints, diapositives, scans, etc.), to complete the required phase(s) of work before sending the film to VDOT. Prior approval will be required from the State Photogrammetry Engineer before any contact prints, diapositives, scans, etc. are generated under this exception. In this instance, the consulting firm will still be required to send the processed film to VDOT within 30 days of completing the photo mission.

One camera calibration report per camera/lens per year will be included with the first processed film submitted for each calendar year. Additional reports for the same camera/lens will not be required until the following calendar year or when the camera is recalibrated, whichever occurs first.

Deliverable: Aerotriangulation Report- Include Contact Prints with annotated control points (good-quality copies are acceptable). Contact Prints or copies should have the mapping limits annotated.

Send To: State Photogrammetry Engineer
VDOT
1401 East Broad Street, Room 915
Richmond, VA 23219

Due: Immediately following acceptance of the final adjustment (typically within 2 business days).

Notes: Photogrammetry consultants will be expected to submit the aerotriangulation report by regular mail, fax, or email. Contact prints or copies are to be sent by regular mail.

Aerotriangulation reports are to include the following information:

1) VDOT Project and PPMS Number
2) Units (English or Metric)
3) Input Ground Control List
4) Adjusted Point List
5) Standard Deviation Tolerances for horizontal and vertical control
6) Individual Control Point Residuals
7) RMSE values for X-Y-Z coordinates
8) Input control withheld from final adjustment (ID, X-Y-Z withheld)

VDOT staff will review the adjustment and respond accordingly.

Consultants are instructed to proceed with mapping activities after they have accepted the final adjustment. DO NOT WAIT for VDOT's approval of the aerotriangulation report to proceed with mapping. Any noted problems regarding the adjustments will prompt immediate communication from VDOT to the respective consultant firm.

Deliverable: Orthophotos and File Index
Send To: State Photogrammetry Engineer
VDOT
1401 East Broad Street, Room 915
Richmond, VA 23219
Due: 5 business days after generation and quality-review acceptance of the orthophotos are completed.

Notes: Photogrammetry consultants will be expected to submit the completed orthophotos on CD. All orthophotos are to be delivered in un-tiled GeoTif (.tif), or tiff (.tif) with tiff-world-file (.tfw) format. The file index is to be a 2D Microstation file containing vector-shape representations of each orthophoto with each orthophoto file name written within the vector shape. Orthophotos generated for highway design must be georeferenced to the same coordinate base established for the location survey. Orthophotos generated for corridor studies may be on an arbitrary coordinate base as instructed by VDOT, providing the units are compatible with the design project. VDOT staff will review the orthophotos for radiometric and geometric quality and respond accordingly. Consultants are instructed to proceed with other mapping activities after they have completed, reviewed, and accepted the orthophotos. DO NOT WAIT for VDOT's approval of the orthophotos to proceed with other mapping activities. Any noted problems regarding the orthophotos will prompt immediate communication from VDOT to the respective consultant firm.

Sec. 5.16 LIGHT DETECTION AND RANGING (LIDAR)

Light Detection and Ranging (LIDAR) data may be used for certain VDOT projects. Such projects include corridor location studies, and any other preliminary engineering projects that require a digital terrain model (DTM) at a lower level of accuracy than traditional location surveys. The use of LIDAR typically provides a faster delivery of data at a lower cost than conventional photogrammetry and survey methods. VDOT does not have LIDAR capabilities and relies on the consultant community for all LIDAR services. VDOT does demand that any consultant performing LIDAR work for the department have the necessary hardware, software, and experience that will provide a consistent, accurate, and reliable product. LIDAR procedures must include appropriate data filtering and editing to eliminate incorrect, non-surface readings, and reduce the file to a manageable size. Photogrammetry must be utilized to develop breaklines for the DTM and to provide a means for quality control of the LIDAR data. This has become a standard practice within the industry, and will be expected by VDOT. Breaklines are to be added by photogrammetry along all pavement, ditches, streams-of-water, ridges, valleys, and any other significant surface feature that would require a breakline for proper definition.

Note: **LIDAR data is *not* to be used for any location survey unless the State Survey Engineer or the State Photogrammetry Engineer gives written approval.**

As LIDAR technologies improve, the requirements listed in this section will be modified. Therefore, anyone providing LIDAR services to VDOT will be expected to check the online version of the survey manual for the updates or contact the State Survey Engineer or the State Photogrammetry Engineer.

The following list outlines a basic framework for executing LIDAR projects:

1. Approval/Notice to Proceed utilizing LIDAR.
2. Establish/set control for aerial photography.
3. Fly photography and LIDAR. LIDAR platform must include a fully functioning airborne global positioning system (ABGPS) and an inertial measurement unit (IMU). GPS base stations must also be utilized.
4. Aerotriangulation of aerial photography for subsequent breakline compilation, quality control of LIDAR data, orthophoto generation, and planimetry compilation.
5. Filtering/data-editing of LIDAR mass points.
6. Photogrammetric quality control of LIDAR data and addition of breaklines.
7. Orthophoto generation.
8. Quality review and assurance of all products.
9. Delivery of final products to VDOT.

The following table lists the deliverable, file format, and maximum file size for projects utilizing LIDAR. All VDOT projects utilizing LIDAR will be restricted to the following digital file formats and maximum sizes.

Deliverable	**File Format**	**Maximum File Size**
Digital Terrain Model	3D Microstation (Breaklines and points) Caice Database - Provide 200’ overlap between all “cut” Caice files	20MB 200MB (Uncompressed)
Contours	2D Microstation - Contour interval as required. - Provide edge-to-edge match between “cut” contour files, No Overlap!	15MB
Planimetry *(When required)*	2D Microstation - Provide edge-to-edge match between “cut” planimetry files, No Overlap!	15MB
Orthophotos *(When requested)*	Untiled GeoTiff (.tif and .tfw) <OR> Descartes (.hmr) - Provide edge-to-edge match between “cut” orthophoto files. No Overlap! - The project manager will determine the file format.	200MB
Index	2D Microstation - File indicating the area of coverage and filenames for all files/sheets in each deliverable category.	5MB

Note: When cutting data to meet file size specifications, use the same-sized “shape” throughout the project to create each block of cut data (i.e. rectangle, square, etc.).

CHAPTER 6.00

CLOSED SURVEYS

Chapter Contents

Sec. 6.01 Closed Surveys

Sec. 6.01 **Closed Surveys**

A closed survey will be required on parcels of land to be purchased for use as District or Residency offices or Maintenance Area Headquarters and may be requested by other State Agencies. When the acquisition of land involves a National Forest or other Federal Government Agency, or, in certain cases, private firms such as Virginia Power, etc., a closed survey may be required. These surveys may be prepared by computer-aided drafting techniques (CAD) or drafted by hand, using ink and plotted on plat book size mylar sheets, furnished by the Location and Design Division. Each sheet must contain a title block, filled out completely. The title block will contain the following information: county name, magisterial district, the name of the Survey Supervisor, date of survey, scale bar, the proposed use of the parcel of land and the name of the person or persons from whom it is to be acquired.

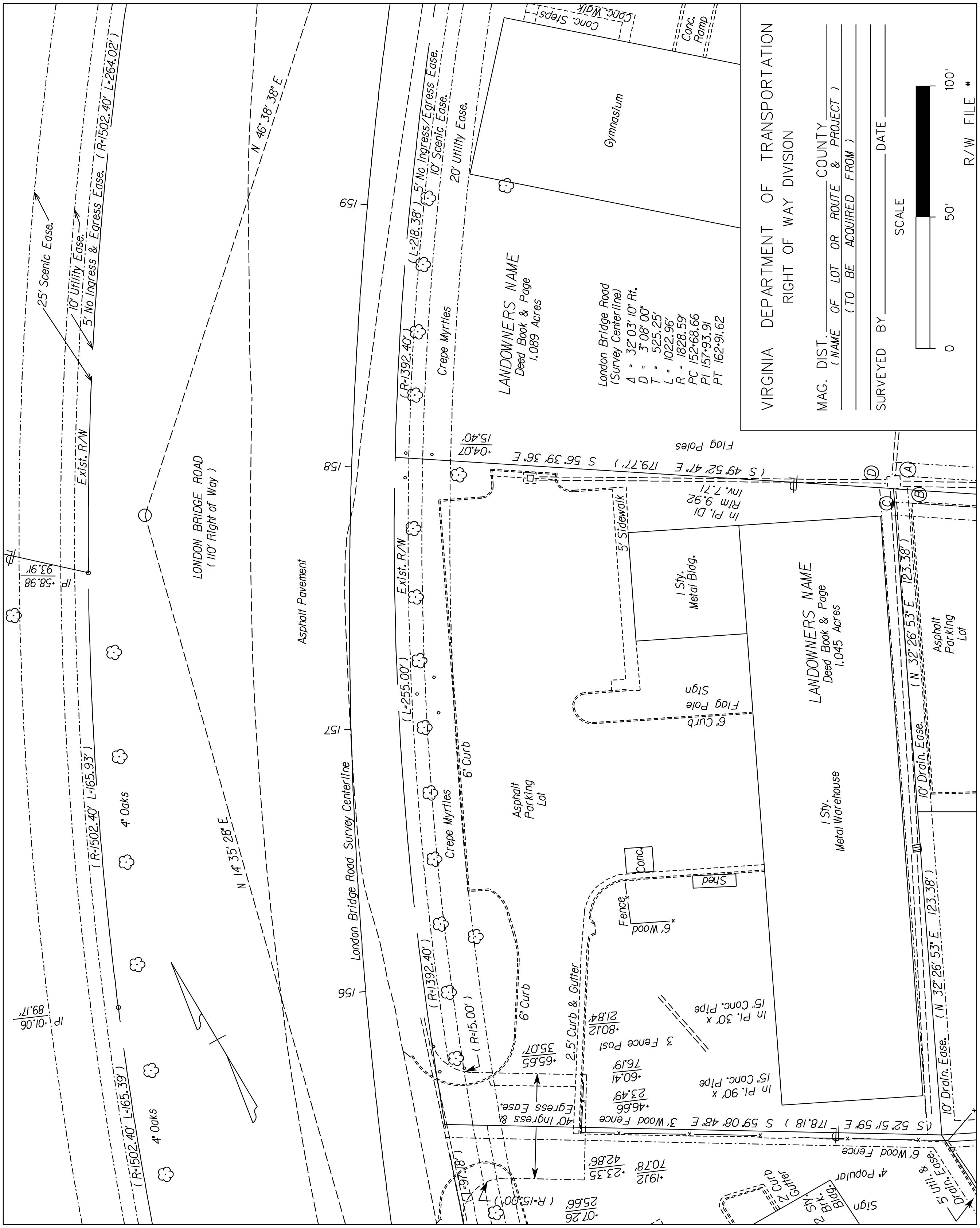
The survey must be tied into the survey centerline or baseline of adjoining or nearby projects and the existing right-of-way, whether owned in fee or as an easement or dedication, shown. Directions and distances to nearby towns as well as the adjacent route and project should be shown. Measure the angles and compute the bearings to the nearest second and measure distances between transit points to the nearest one-hundredth foot **(0.01-ft)**. The survey plat shall show all pertinent features such as streams, wooded areas, swamps, roads, buildings, fences, etc. The owner names and property lines of all adjoining properties must be shown.

An easily identified, unique point will be chosen as a point of beginning and the courses will run in a clockwise direction. The bearing and length of each course should be shown on the inside of the lot line and recorded bearings and length, if any, should be shown in parenthesis on the outside of the lot line **(Figure 6-A, Page 6-2)**. When a part of the boundary line is a curve, the central angle, length of chord, chord bearing, length of curve and radius of the curve must be shown on the plat book size mylar sheets. The area must be shown in acres to the nearest third decimal place.

A closed-loop traverse shall be field-run around the perimeter of the boundary. All angles and distances shall be entered, in sequence, into a Coordinate Geometry program. The "Compass rule" method of adjustment should be used, and a least squares adjustment is acceptable. The output data from the computer will be in two sections. The first section will contain the data just as it was entered from the field book, or data collector, and will give the bearing of the error, the length of the error and the ratio of the error. The second section will show the closed, adjusted data with the area of the traverse in acres and square feet. The traverse must have a zero error of closure in order to receive the correct area from the computer. However, the metes and bounds shown on the mylar sheet should be that of the closed data provided the error of closure does not exceed one in ten thousand (1:10,000). Should the closure exceed one in ten thousand, sufficient field checks should be made to correct any discrepancies.

A copy of both sections of the output form must be sent to the Central Office, along with the plat book size mylar sheets.

Figure 6-A



VIRGINIA DEPARTMENT OF TRANSPORTATION
RIGHT OF WAY DIVISION
MAG. DIST.
COUNTY
(NAME OF LOT OR ROUTE & PROJECT)
(TO BE ACQUIRED FROM)
SURVEYED BY
DATE
SCALE
0
50'
100'
R/W FILE #
LONDON BRIDGE ROAD
(110' Right of Way)
Asphalt Pavement
London Bridge Road Survey Centerline
LANDOWNERS NAME
Deed Book & Page
1.089 Acres
LANDOWNERS NAME
Deed Book & Page
1.045 Acres
London Bridge Road
(Survey Centerline)
Δ = 32° 03' 10" Rt.
D = 3° 08' 00"
T = 525.25'
L = 1022.96'
R = 1828.59'
PC 152+68.66
PI 157+93.91
PT 162+91.62
Gymnasium
1 Sty. Metal Bldg.
1 Sty. Metal Warehouse
Asphalt Parking Lot
Crepe Myrtles
4" Oaks
Exist. R/W
N 46° 38' 38" E
N 14° 35' 28" E
S 56° 39' 36" E
S 49° 52' 47" E
S 59° 08' 48" E
S 52° 51' 59" E
N 32° 26' 53" E
25' Scenic Ease.
10' Utility Ease.
5' No Ingress & Egress Ease.
10' Scenic Ease.
20' Utility Ease.
10' Drain. Ease.
40' Ingress & Egress Ease.
5' Sidewalk
6" Curb
2.5' Curb & Gutter
6' Wood Fence
3' Wood Fence
Flag Poles
Flag Pole
Sign
Shed
Conc.
Conc. Walk
Conc. Steps
Conc. Ramp
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CHAPTER 7.00

HYDRAULIC SURVEYS

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Sec. 7.12	Securing High Water Information

Sec. 7.01 **Introduction**

One of the most significant input parameters for any design activity is the survey data. The importance of complete information cannot be over emphasized. It is the responsibility of the District Survey Parties Engineer to insure that the data is complete and accurate when the initial survey data is sent into the Central Office or transmitted to the District Bridge Engineer.

The amount and detail of survey data to be collected should be commensurate with the complexity of the hydraulics of the site, stream stability and the importance and/or classification of the highway facility. The individual directing the field hydraulic survey should have a general knowledge of the design activity that will use the data. Surveys for unusual or complex situations and flood plain surveys for major structures shall be coordinated with the hydraulics designer.

For the purpose of this chapter, all facilities employed to convey or retain water will be classified as "hydraulic and drainage structures, or bridges". Culverts with a diameter less than three feet **(3 ft)** or clear span and ditches with a top width less than ten feet **(10 ft)** shall be considered "small drainage structures". Culverts with a diameter or clear span of three feet **(3 ft)** to twenty feet **(20 ft)** and channels with a top width equal to or greater than ten feet **(10 ft)** shall be considered "large drainage structures". Structures with a clear span or diameter greater than twenty feet **(20 ft)** shall be considered major drainage structures.

Sec. 7.02 **General**

Sufficient data shall be obtained to accurately determine the drainage requirements. Any existing structure if not built in accordance with a standard plan or for which there are no bridge plans on file, shall be carefully measured with details shown by sketches.

Where a structure in place is not functioning properly and/or is to be replaced, all data required for new sites shall be obtained.

Where the location parallels an existing road, as in the case of a survey for a dual lane road, locate all pipes and culverts under the existing road. Give accurate invert elevations at the inlet and outlet ends. Extend the profile of the streambed up and downstream beyond each respective lane a sufficient distance to determine the profile of the stream. This is most important as the pipes and culverts under the new lane must be designed to function with the existing structure. DTM readings or cross-sections should be extended a minimum of 50 feet beyond the construction limits of the existing road, at each existing culvert, to accurately define the terrain near the culvert.

At times survey data is secured only on one side of an existing road where a parallel lane is to be constructed. In these cases, it is necessary to secure complete drainage data on both sides of the existing lane.

In the case of a location paralleling a railroad, secure all information required above for a location paralleling an existing road.

At all ponds or lakes that will affect or may be affected by the proposed construction, the following is to be secured:

1. Outline (perimeter) of lake
2. Elevation of normal and high water
3. Detailed description at normal spillway works including dimensions and elevations
4. Detailed description of emergency spillway works including dimensions and elevations
5. Description of adjustable gates or other control devices
6. Profile along top of the dam and a typical cross-section of the dam
7. Determine the use of the pond, (stock water, fish, recreation, etc.)
8. Note the existing conditions of the pond as to turbidity and silt

Sec. 7.03 **Topographic Features**

The survey should provide sufficient information for the location engineer and the designer to select the location of the structure and make the necessary hydraulic and impact studies for all significant physical and cultural features that would be adversely affected by the construction. Features such as residences, commercial or industrial facilities, crop lands, roadways, railroads, utilities, wells and other facilities can influence design and their locations and elevations should be established by the survey.

Backwater above structures may extend a considerable distance upstream in streams with relatively flat slopes and features, which may be affected by the backwater, should be located.

The following survey data must be secured:

1. The location and elevation of pertinent points of all buildings and other valuable structures situated on the upstream side of a proposed or existing highway that would be flooded in the event high waters were to inundate the proposed or existing highway.

2. A description of all buildings, structures, land and activities in the area that would be flooded in the event the proposed or existing drainage structure caused the low point in the highway grade to become inundated.

3. Make note of any buildings or other property previously flooded or closely located to previously known flood stages.

Sec. 7.04 **Channel Characteristics**

The physical characteristics of existing channels, natural or man-made, can best be described by the field survey. The type of material in the bed and banks (i.e., clay, gravel, cobbles, etc.) should be noted as well as any evidence of erosion or deposition along the streambed and banks. **(See Table 7.1)** The type and extent of vegetal cover and classification of debris should be noted. **(See Table 7.2)**

Table 7.1

Particle Size (Mean Diameter)		*Standard Designation*
<0.0003 ft.		Silt
0.0003 ft.	to 0.0015 ft.	Fine Sand
0.0015 ft.	to 0.007 ft.	Course Sand
0.007 ft.	to 0.20 ft.	Gravel
0.20 ft.	to 0.80 ft.	Cobbles
	>0.80 ft.	Boulders

Table 7.2

Debris Classification	*Description*
Light floating debris	Small limbs, pruning and refuse
Medium floating debris	Limbs and large sticks
Heavy floating debris	Logs and trees

Sec. 7.05 **Water Level Information**

The survey should identify various water levels (i.e., normal water, high water, tide levels, etc.) as described in **Section 7.09.3**. This data is used to calibrate engineering calculations and is correlated with other sources of water data.

Normal water data should reflect the average water surface elevation the majority of the time. A line on the stream bank established by the fluctuations of the water or indicated by physical characteristics can be a good indicator of the high water mark elevation. Physical characteristics that indicate the high water mark can be a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris; or other appropriate means that consider the characteristics of the surrounding areas.

The frequency of high and low water is a "best estimate" and is not intended as a precise quantification that results from a detailed hydrologic analysis.

Reliable high water data can be invaluable information for establishing the stage and discharge of past floods, locating hydraulic controls and establishing highway profiles. Several high water marks along the traverse are required to compute the flood discharge by the slope area indirect method.

If possible, high water elevations for the same flood event should be obtained at points upstream, at the structure site and downstream of the site. When wide flood plains are encountered, elevations are desirable along the edge of the flood plain in addition to those along the stream. Most important, each high water elevation given should be a confirmed sighting, never obtained by paralleling a given elevation up or downstream. The exact location at which the elevation was taken should be referenced to the traverse because the water surface elevation is seldom flat or level either longitudinally or transversely.

Personnel experienced in identifying high water marks are extremely important because the apparent quality of evidence of high water can be deceiving. Evidence of high water on the upstream side of a tree or building will reflect a stage higher than the true high water and marks taken within the drawdown area of a structure or another obstruction will reflect a lower than normal stage than existed. Stages affected by ice, logjams, confluence, varying land use (such as forested areas subsequently cleared), aggrading or degrading channels, and railroad or highway structures can be misleading if the abnormal stage is not recognized.

Information on high water elevations can be obtained by observing seed and mud lines on tree trunks and bridge abutments, washlines and fine debris lines on banks, wisps of grass or hay lodged in tree limbs and fences, and evidence of erosion and scour. Interviews with residents, commercial and school bus drivers, mail carriers, law enforcement officers, highway and railroad maintenance personnel, and others who might have reason to observe unusual floods will yield additional information. The date of the flood occurrence, the name, address and phone number of the observer and the stage and location of the observation should be recorded. It is desirable to obtain high water marks from several sources for the same flood event as a cross-reference on the information. The observed frequency of occurrence should be noted since reliable information that a stream reaches a certain elevation every two or three years provides important frequency information for the designer. A few hours spent in interviewing several people who are familiar with the flood history of a stream can result in substantial savings in construction cost, liability, and future maintenance costs through improvements in the design.

The collection of high water data after any significant flood event is very important. The District Hydraulic Unit in each district is responsible for coordinating this data collection program.

A considerable period of time usually elapses between the initial survey for a highway project and actual construction. During this period, additional information should be collected if a reasonably large flood event occurs. This requires preparation in advance of the flood so that resources can be quickly mobilized when a flood occurs.

Correlation of stage at the structure site with discharge relationship by providing one or more known points on a rating curve that otherwise might be used entirely on computations. Data should be collected for as many past flood events as possible in order to aid both the hydrologic and hydraulic analysis.

Sec. 7.06 **Small Drainage Structures**

(Culverts less than 3 feet in diameter and ditches with top span less than 10 feet)

The following survey data is required for small drainage structures with the exception of roadside cut or toe ditches:

1. Stream traverse and profile taken a sufficient distance up and downstream of the anticipated construction area (not less than 100 feet beyond the construction area) to define the alignment and grade of the stream or swale (the traverse is not necessary on sites covered by aerial mapping).

2. Description of channel characteristics **(Sec. 7.04)**

3. Information pertaining to the past hydraulic performance of the existing stream, culvert, etc. to the extent practical. This may include maintenance observations by local citizens.

Sec. 7.07 **Large Drainage Structures**

(Culverts with diameter 3 feet to 20 feet and channel top width greater than 10 feet)

The following survey data is required for large drainage structures:

1. The stream DTMs and topo should be extended from the survey centerline 500 feet ± upstream and downstream of the anticipated right-of-way line. The DTM/cross-sections should be taken at intervals not to exceed 100 feet **(100 ft)** and should extend each way from the existing or proposed channel to points that are above known or anticipated high water levels. The stream traverse shall begin upstream of the structure and run downstream through the structure to the downstream limits of the survey.

2. Description of channel characteristics. **(Sec. 7.04)**

3. High water elevations, date, source of information, point of measurement. **(Sec. 7.05)**

4. Maximum elevation of headwater permissible at the proposed structure without causing flood damage to developed upstream property.

5. When structures are in place at the proposed site or within one thousand feet **(1000 ft)** up or downstream, the following information is required:

   a. Description of structure, date of construction
   b. Dates and high water elevations for major floods that have occurred since construction
   c. Performance during past floods
   d. Evidence of scour or erosion
   e. Location of overflow areas
   f. Appurtenance structures (i.e., energy dissipaters, rip rap, etc.)

6. Suggest a feasible location for the proposed structure, taking into consideration the proposed new grade and the meander of the stream or channel. This location, together with angle of skew and any necessary channel change, should be indicated in the notes and on the survey roll. The centerline of the existing or proposed channel for a distance of four hundred feet **(400 ft)** up and downstream from the survey centerline. The drainage designer will determine the final type, size and location of the structure.

7. Note significance, if any, of stream ecology and/or wildlife habitat.

Sec. 7.08 **Storm Sewers**

When the survey includes an existing storm sewer system, invert elevations should be determined on all pipes, drop inlets, catch basins, manholes, etc. It is essential that all utilities in the area of the existing or proposed storm sewer system be located and their elevations given in order to avoid conflicts between the existing utilities and future storm sewer system. This information should be extended well beyond the limits of the proposed project, both laterally and longitudinally, at least to the next access structure. The invert elevation of each pipe entering and leaving a drop inlet and/or manhole must be shown. The location of possible storm sewer outfalls should be determined. This data should conform to applicable items of **Sec. 7.06** and **Sec. 7.07**.

Sec. 7.09 **Major Structures Over Waterways and Major Flood Plain Surveys**

(Structures with clear span or diameter greater than 20 feet)

The purpose of a survey is to provide an accurate picture of the site conditions. The quality of the final design is heavily dependent on the accuracy and thoroughness of the survey data. This is particularly true in the case of major structures where the cost and the consequence of error can be quite significant.

All surveys for major structures must be coordinated with the District Hydraulic Unit. This will ensure that all needed data is obtained and, in many cases, will eliminate certain standard survey requirements that are not needed for the particular site.

Each item of requested information described in this section is needed for a specific reason. While the survey party must exercise some discretion in securing the requested information, they should endeavor to fully comply with the instructions in this section as modified through coordination with the District Hydraulic Unit.

Sec. 7.09.1 **General Considerations**

A reconnaissance of the stream should be made in order to select the most desirable structure site. The best location is a point where the flood plain is narrowest and where a reasonable foundation is available at a favorable elevation. Skewed crossings should be avoided when possible, but where skewed crossings are unavoidable, they should not exceed 45° unless conditions make other angles imperative.

Alignment should be adjusted to avoid horizontal curvature and transitions on bridges. When this cannot be done, it is usually preferable to place the entire structure on a horizontal curve with transitions beyond the end of the bridge. Structure locations that would involve a heavy gradient on the structure should also be avoided, when possible.

When crossings are necessary near bends and meanders, the trend of the meander should be noted. If erosion around the bend is evident, a comment so stating the conditions should be included in the survey notes.

Sec. 7.09.2 **Site Surveys**

When any project or design concept contains a major stream crossing or a longitudinal stream encroachment, the hydraulic design unit and the bridge design unit that will handle the design for the facilities shall be contacted to determine the type of site survey that will be required. These survey requirements shall be contained in the survey authorization at the time the site survey is begun.

There are three (3) classes of site surveys. Any deviation from or addition to these classes must be explained in the survey authorization.

Class I Site Survey - Standard Bridge Situation Survey

This class of survey is required for all bridge sites and major culvert installations where the data is needed to perform a detailed hydraulic analysis. All of the information described in **Section 7.09.3** "Survey Data" shall be obtained. The bridge design unit will specify its choice between contours (Option 1) at the site or profiles (Option 2) along each edge of shoulder. **It is imperative that consultation between the District Hydraulic Unit, the Bridge Design Unit and the Survey Manager prior to the survey taking place to identify the need for a full Class I Bridge Situation Survey. It may be necessary or beneficial to revert to a Modified Class I Site Survey.**

Modified Class I Site Survey

There are situations when only portions of the Class I Survey are required (i.e., only the flood plain cross-sections or only a single flood plain cross-section at the structure site). All requested data shall be obtained in accordance with **Section 7.09.3**. **It is imperative that consultation between the District Hydraulic Unit and the Survey Manager, prior to the survey taking place, occurs, to identify the special cases and the specific requirements for the particular survey.**

Class II Site Survey - Abbreviated Bridge Situation Survey

This class of survey is required for all bridge sites and major culvert installations where the data needed for a detailed hydraulic study is available from another source.

All of the information pertaining to the existing and proposed centerlines that is described in **Section 7.09.3** "Survey Data" shall be obtained. The stream profile, flood plain cross-sections and high water data are omitted. The bridge design unit will specify its choice between contours (Option 1) at the site or profiles (Option 2) along each edge of shoulder. The location of the stream channel shall be identified between a point two hundred feet **(200 ft)** downstream of the structure and a point two hundred feet **(200 ft)** upstream of the structure. **It is imperative that consultation between the District Hydraulic Unit and the Survey Manager prior to the survey to identify exactly what data is needed for the given situation.**

Class III Site Survey - Longitudinal Encroachments

Cross-sections shall be obtained for the full width of the flood plain. They shall be located at 200 feet ± intervals from a point 500 feet ± downstream of the anticipated encroachment to a point 500 feet ± upstream of the anticipated encroachment. A continuous channel bed profile is required through the area that is cross-sectioned.

Sec. 7.09.3 **Site Surveys**

Processing plans - All portions of the plans will be processed in accordance with procedures outlined in the V.D.O.T. Survey Manual 2000 referring to the Survey CADD Section in **Chapter 11**. It is essential the total survey station method be used due to the advanced technical methods and procedures of the V.D.O.T. CADD Section.

The CADD file should show the following from left to right:

1. Title Block - Route, Project, Date, Legend, Utility Owners, etc.
2. Situation Plan – Scale of one inch equals ten feet (1”=10’) with contours when they apply.
3. The profile or profiles of the situation area will be plotted under the situation plan unless modified, if modified the profiles will be plotted to the right of the situation plan.
4. The stream traverse (i.e. streambed, normal water, etc.), grade separation or railroad profiles will be plotted to the right of the profiles of the situation portion.
5. Flood plain cross-sections, when necessary, will be plotted to the right of the stream traverse and grade separation profiles.
6. Sketches, when needed, will be plotted to the right of the flood plain cross-sections and/or stream traverse profiles.
7. The site plan portion or sepia of a previously plotted plan sheet will follow to the right of the flood plain cross-sections, stream traverse profiles and sketches. Nothing is to be plotted to the right of the site plan portion, except the sketch of the existing structure containing field measurements for widening projects.

Contours (Option 1) - the contours for the bridge situation should be extended along the survey centerline to cover all of the area under high water, unless high water extends at rather shallow depths over a considerable area not likely to be bridged. Normally, the contours are extended to cover an area fifty feet (**50 ft**) each side of the edge of pavement at the proposed location. However, in some cases, such as a proposed four-lane divided route, it may be necessary to extend them more than fifty feet (**50 ft**).

The contours and topography shall be plotted to a scale of one inch equals ten feet (1”=10’). The contour interval is to be shown on the bridge situation plan by note at the beginning of the plan. The contours are to be labeled at sufficient intervals so that lower or higher elevations can be determined.

A north arrow, bearings on centerline or baseline, all topography within the area to contoured, the name of the stream and direction of flow are to be shown on the contour portion of the plan. The edges of the stream shall be designated by a dash and three-dot symbol (—— · · · ——). The high water line within the limits of the situation plan shall be designated by a dash and dot (– ·) symbol and obscured contours shall be shown as a broken line (— — —).

In this case, obscured contours are those that pass under a bridge or structure and are not visible when viewed in plan. No contour shall cross itself or another contour and no contour shall fork or split. The elevation and description on the benchmarks on which the bridge situation is based must be shown. The datum of the benchmarks should always be given whether it is that of the NGVD 29, NAVD 88, or assumed. The agency (N.G.S., U.S.G.S., VDOT or other) should also be noted. Most importantly, assumed vertical datum should be noted as such. **In all cases the elevation for bridge surveys must be referred to the datum used for the roadway survey.**

When the stream is of sufficient width and depth to prevent contours from being readily secured across its bed, three (3) profiles shall be taken across the stream, one on the centerline and one on each side of and parallel to the proposed location. These locations can be noted or written directly on the contour section of the plan.

Centerline profile - The profile must, in all cases, extend along the survey centerline to cover and define the high water spread area and, where practical, to cover an area at least two feet **(2 ft)** above high water. Where there is a nearby existing structure, the clear water way opening as well as the entire length of approach roadway inundated at high water must be defined by running levels and plotting a profile to delineate this area.

The profile on centerline shall, where possible, be plotted directly beneath the contours and topography to a scale of one inch equals ten feet (1"=10') both vertically and horizontally. The profile can be offset to the right and plotted in the usual manner if available space under the contour plot will not accommodate it.

The Materials Division will secure foundation determinations. The elevation of normal water, low water and extreme high water should be plotted with the profile. The month and year of high water and the name of the individual furnishing the information must be noted on the situation plan. High water data is of great importance in the hydraulic analysis. The Survey Supervisor should verify that the instructions in **Section 7.05** were followed in the acquisition and presentation of this data. Where tidal streams are encountered, the elevation of normal low tide, normal high tide, extreme low tide and extreme high tide should be determined. The month and year of extreme high tide and the name of the individual furnishing information must also be shown.

Edge of shoulder profiles (Option 2) - Profiles shall be plotted from cross-section data. These cross-sections shall be secured to cover the edge of shoulder left and right of the roadway centerline. For an existing structure these readings shall be located along the outer faces of the structure. For a proposed structure on new location these readings shall be located along the anticipated outer faces of the structure as supplied by the bridge design unit or 15 feet ± from the roadway centerline.

The length of the area cross-sectioned shall conform to the instructions, as described in the preceding subsection for the extent of contour coverage along the centerline. Where these cross-sections encounter an existing approach roadway embankment, readings shall be taken along the edge of shoulder and along the toe of the embankment.

Site Plan and Stream Traverse - The site plan portion of the situation plans shall be plotted or the sepia of a previously plotted plan sheet shall be attached to the same roll but shall follow the contours and profile. This can be plotted to some convenient scale of one to five hundred (1:500 is desirable.). The alignment and topography for 50 feet each side of the area being covered, as secured for the location survey, shall be shown on this plan. Property lines and owners, utility owners, location and description of all adjacent drainage structures, bearings, and a north arrow must be shown on the site plan portion. The location of all High Water Marks and all Flood Plain Cross-Sections shall be shown on the site plan. A traverse of the stream for a distance one thousand feet **(1000 ft)** minimum on each side of the location centerline shall be secured and shown so that its course can be determined. The traverse must be run from upstream to downstream to facilitate the direct transfer of data electronically from the data collector to engineering application software. Five hundred feet **(500 ft)** stations should be labeled clearly. A profile of the streambed and the normal water surface for a minimum distance of one thousand feet **(1000 ft)** each side of the location centerline shall be secured. This profile shall be continued until at least two feet **(2 ft)** above high water is reached, or until profile is run for a total of two thousand feet **(2000 ft)** on each side of the location centerline. If the proposed centerline is several hundred feet removed from an existing structure, the traverse shall extend from a point one thousand feet **(1000 ft)** from the downstream centerline to a point one thousand feet **(1000 ft)** from the upstream centerline.

For any dam located in the vicinity of the bridge situation, a profile should be secured along the top of the dam from the extreme edges of high water. A detailed description of all spillway arrangements should be obtained, similar to the outline in **Section 7.02** the dam should be located on the site plan.

On all surveys for navigable streams, the channel and bridge fender systems that are in place must be accurately located and shown on the situation plan as well as in the survey notes. The channel alignment is usually referenced to buoys or permanent markers on the shoreline. This information can be secured from the United States Coast Guard and must be tied into survey centerline and recorded in the notes.

On all surveys made for bridges in tidal areas, the Survey Supervisor should determine whether there are oyster beds in the vicinity of the proposed bridge, and, if so, accurately locate them on the continuous roll in the notes.

Existing Structures - Where an existing bridge is to be widened and as built plans are on file, field measurements shall be made of all accessible outlines of the substructure. Also, all outside dimensions of superstructure, complete layout dimensions and elevations of all bridge seats, top of basic floor, both immediately above the bridge seats and on top of the roadway surfacing, shall be field measured. These measurements shall be shown in a sketch following the site plan portion. When an existing bridge is close enough to the location centerline that the proposed structure might overlap the existing bridge, accurate outlines of the existing structure must be shown on plan views.

Structures near a proposed bridge may have experienced unusual historical floods or major flooding, large enough to provide useful information for the design of the proposed bridge. Information on historical floods or major flooding, which have occurred since construction of the existing bridge, may be obtained from highway agency personnel and maintenance files, residents of the area and from high water marks. This data should be noted on the Bridge Data Sheet.

Data at existing structures should include as much of the following as is available or can be obtained. (Note: Much of this information should be obtained from the District Bridge Office or the District Hydraulic Unit).

1. Date of construction
2. Location relative to proposed structure
3. Cross-section under bridge from as-built plans
4. Present cross-section under bridge

5. Type and size of materials in streambed and banks
6. Condition of structure
7. Scour, erosion and sediment deposits
8. Evidence of head cutting in stream
9. Major flood events since construction and dates of occurrence.
10. Flood elevation upstream and downstream of the bridge with horizontal location of such elevations
11. Observed differences in water surface elevations upstream and downstream of the embankment at as many locations as the information is available
12. Direction of flow relative to piers and the low water channel
13. Observed drift size and quantities
14. Clearance and freeboard
15. Duration of flooding
16. Damage of the high way, bridge and other property
17. The road profile should be carried to a point ± two feet **(2 ft)** above the high water elevation.
18. Photographs of the structure in flood events, stream, and any other feature that will aid in the design of the bridge

Flood Plain Cross-Sections - A cross-section shall be taken at right angles to the flood flow of the stream at the proposed bridge site and shall extend far enough to cover all the area under high water. And where practical, the stream cross-section shall extend to cover an area at least two feet **(2 ft)** above high water. The stream cross-section shall be plotted on the situation plan to the same scale as the centerline profile. A solid line representing the location of this cross-section shall be drawn on the site plan.

DTM readings or Cross-sections, which can provide a representative description of the flood plain, shall be taken throughout the area covered by the stream traverse. These sections should be located at points of major change in cross-sectional area of the flood plain. Major changes in cross-sectional area can be described as: narrowest point; widest point; points of major change in stream gradient (more than 5% change); the beginning and end of significant bends in the flood plain; points of confluence of two streams and at points that may cause a backwater effect (a dam, a road). As a general guideline, sections should be taken ± one hundred feet **(100 ft)** upstream and downstream of all structures (proposed and existing), ± one hundred feet **(100 ft)** and ± one thousand feet **(1000 ft)** downstream of the proposed roadway centerline, and ± five hundred feet **(500 ft)** and ± one thousand feet **(1000 ft)** upstream of the proposed roadway centerline. These cross-sections shall be taken, as nearly as practical, at right angles (90°) to the direction of flood flow. The cross-sections shall be collected left to right, as you are looking downstream. They shall extend far enough to cover the area under the high water elevation and, if practical, shall cover an area two feet **(2 ft)** above high water. In the case of wide flood plains, the precise definition of minor variations in elevation ± one foot **(1 ft)** may be omitted and average elevations over longer horizontal distances may be employed. **The Hydraulic Design Unit reserves the right to determine the spacing between the cross-sections.**

All flood plain cross-sections shall be referenced by station and angle to the stream traverse and shall be plotted on the site plan portion of the survey roll, unless the distance from the survey centerline makes this impractical. It is imperative that the location of these cross-sections be referenced to some base data. The left and right side of all cross-sections (looking downstream) shall be clearly referenced.

Cross-sections should be plotted at a scale that will permit realistic definition of detail without occupying excessive area on the situation survey roll. In all cases, the horizontal and vertical scale will be clearly indicated.

The location and description of the land cover for each subsection shall be shown for each cross-section. The description shall be in sufficient detail to permit the designer to differentiate between the degrees of cover within a given category, i.e., tall trees with dense undergrowth, light woods, dense woods - not just woods.

When flood plain cross-sections are obtained for a longitudinal encroachment, they shall span the entire flood plain below the high water elevation, and, when practical, shall be carried two feet **(2 ft)** above the high water elevation. They shall be carried horizontally and vertically to the centerline of the existing roadway or horizontally to the centerline of the proposed roadway if there is no existing roadway.

High water elevations and topographic data shall be obtained, as much as practical, conforming to the preceding flood plain cross-section instructions.

Station and angle to the roadway centerline or a traverse line shall reference cross-sections for a longitudinal encroachment. This survey data may be shown as part of the highway survey or it may be reported independently. If the latter course is taken, sufficient correlation with the highway survey should be indicated.

Sec. 7.10 **Environmental Data**

The need for environmental data in the engineering analysis of a stream crossing stems from the obligation to investigate and mitigate possible impacts due to specific design configurations. In those cases where an environmental assessment has been completed earlier in project development, part or all of this evaluation may already have been accomplished. Where an environmental assessment has not been made, the data developed for planning and location of the crossing is often of value in the engineering-environmental analysis.

While much of the information noted in the following paragraphs is not within the scope of V.D.O.T. field surveys, it is presented to (1) provide the survey party with an awareness of such data requirements and (2) to suggest that the survey party obtain any part of the required data that is accessible to them.

The designer needs information on existing water quality, present and future water uses and the water quality standards for the stream. Some of this information is available in the water quality standards and criteria published by the State Department of Environmental Quality in fulfilling part of the requirements of PL-92-500. Physical, chemical and biological data for many streams are also available from State and Federal water pollution control agencies, the U.S. Geological Survey and from municipalities, water districts and industries which use the stream as a source of supply.

A description of existing water circulation patterns and the definition of the types and extent of potentially affected wetlands is necessary for the designer to assess the effects of each structure-fill configuration. Data on circulation, tides, water velocity, water quality and wetlands is available from the National Geodetic Survey, the U.S. Coast Guard, the Army Corps of Engineers, universities, Marine institutes as well as other state, federal, and local agencies and organizations.

Information on fish and fish habitat is often necessary in order to evaluate proposed channel modifications and to design replacement habitat. Fish and fish habitat information is available from State and Federal Fish and Game Agencies.

Sediment analysis of the material in the streambed and banks as well as proposed fill materials may be essential data for projects in critical water use areas such as near municipal or industrial water supply intakes.

Information on sediment transport is also vital in defining the suitability of a stream for most beneficial uses including fish habitat, recreation and water supply. Potential changes in the sediment transport rate resulting from construction must be thoroughly investigated for environmental impacts as well as channel stability.

It may be necessary for the highway agency to collect data at critical sites, if the required information is unavailable from other sources.

Data needs may be summarized as follows:

1. Information necessary to define the environmental sensitivity of the crossing, e.g., water use, water quality and standards and wetlands information.

2. Information necessary to determine the most environmentally compatible design, e.g., circulation patterns and sediment transport data.

3. Information necessary to define the need for and design of mitigation measures, e.g., fish habitat sediment analysis and water use and quality standards.

Sec. 7.11 **Bridge Data Sheets** **(Form LD-23, See Figure 7-A, Pages 7-17 & 7-18)**

The bridge data sheet should be prepared on all proposed special design bridges and should be completed giving all of the pertinent information required on the sheet. Elevations of normal water and extreme high and low water should be given. The dates of extreme high water and sources of information are also required. For navigable streams the mean or average high and low tide should be determined, and care should be taken to ensure these levels check with the datum of the U.S. Geological or National Geodetic Survey. An estimate of the velocity of current in feet per second at high water and normal water should be made. In navigable streams, the velocity of current at mid flood and mid ebb tide should be obtained by the use of rods or floats. The character of the soil of the bed of the stream is often an index of the velocity during maximum flood conditions. This should always be noted.

Any evidence of erosion along the banks should be recorded, as such evidence affects the layout of the structure. The amount and character of drift and ice should be determined and noted. At locations over tidal streams, it is important to know the degree of brackishness of the water.

It will usually be necessary for the Survey Supervisor to have the assistance of the District Material Engineer in securing this data, but it should be shown in the "Remarks" at all tidal crossings. The "Remarks" should include a brief description of the current usage of the stream for navigation, by small boats, etc.

Emphasis should be placed on the importance of each and every item on the data sheet. This is often the only information available to design a costly structure and the time and effort expended to accurately determine all values is well spent.

Certain data required on bridge data sheets for stream and road crossings is superfluous for railroad grade separation structures and certain data for railroad crossings is needed that is not required on stream and road crossings. Only that portion applicable to the site plan being taken should be completed. This form is shown on **Figure A, Page 7-17**.

On all bridge site surveys for bridges over navigable waters, a statement must be included on the bridge situation roll as to whether the proposed bridge and approaches to the bridge will require the use of any land from a public park, recreation area, wildlife and waterfowl refuge or historical site.

Sec. 7.12 **Securing and Storing High Water Information**

The Department established a procedure during the 1960's and 70's for securing and storing high water data immediately after a flood event. This program was implemented to assist both the surveyor and the designer for use at a later date when a bridge site survey was needed. In some cases, it has eliminated the need for a bridge site survey.

It is imperative the survey parties retrieve any data in this program when a bridge site survey is needed. The Survey Supervisor will request this data from the District Hydraulic Unit prior making a bridge site survey.

The data can be requested and retrieved by the following systems:

1. District - All data for District
2. County - All data for County
3. Route - All data for Route in District
4. Route over called river - All data for route over river in District
5. River in called county - All data for river in County
6. River in called District - All data for river in District

All high water data will be submitted to the District Hydraulic Unit by memorandum, when the bridge site plans and data sheets are transmitted to the Central Office, or for secondary roads, when sent to the District Bridge Unit. The District Hydraulic Unit will then input the data into the program.

Figure 7-A

COMMONWEALTH OF VIRGINIA
DEPARTMENT OF TRANSPORTATION
STRUCTURE AND BRIDGE DATA SHEET

Project ______________________ County ______________________
Federal Route Base No. ____________ Situation data for design of bridge on Route ____________
over ____
Plane Coordinates or Latitude and Longitude from Transportation Department County Map

____
Date of Survey: ____________ Location (Nearest Town, etc. ____________

GENERAL INSTRUCTIONS

Fill out all blanks carefully, giving information on all points. High water data is especially important and should be thoroughly investigated. Comments on any item covered in Survey Instruction Manual which are not covered below should be noted on an attached sheet.

HYDRAULIC SURVEY

1. EXISTING STRUCTURE

Existing structure is any structure at, upstream, or downstream from the proposed site having comparable drainage area.
Date of original construction: ______________________
Was present bridge in place at time of extreme high water? ______________________
Has bridge ever been washed out? ________ Date ________ Mo. ________ Yr. ________
Explain what portion of bridge or approaches that have been washed out: ______________________

____
Elevation of maximum high water:
Upstream side of existing structure ______________________
Downstream side of existing structure ______________________
________ Ft. upstream of existing structure ______________________
________ Ft. downstream of existing structure ______________________
At other locations on the flood plain (describe)

____

____
Date of maximum high water: ________ Mo. ________ Yr. ________ Source of information

____

2. STREAM FLOW DATA AT PROPOSED SITE

Elevation of maximum high water of this stream at proposed location if different from data for existing site:
________ Ft. on upstream side of proposed ______________________
________ Ft. on downstream side of proposed ______________________
At other locations on the flood plain (describe) ______________________

____
Date: ________ Mo. ________ Yr. ________ Source of information ______________________

____
Elevations of highest backwater caused by another stream ______________________
Date: ____________ Stream Name ______________________
Source of information ______________________
Elev. of normal water: ____________ (Average) Elev. of extreme low water ____________
Date: ________ Mo. ________ Yr. ________
Source of information ______________________
Velocity of current at high water: ________ ft./sec. Velocity of current at normal
water ____________ ft./sec.

3. SITE CONDITIONS

Amount and character of drift during a freshet or flood:
Amount and character of ice: ______________________
Do banks or bed show scour? ______________________
Description and location of scour?

____

Bed of stream consists mainly of: mud, silt, clay, sand, gravel, cobbles, boulders, soft solid rock, stratified rock, hard rock, silt sedimentation, deposition of large stones. Is this material loose or well compacted?

____

Comments on stream ecology and wildlife habitat:

____

4. INFLUENCE AND CONTROL OF SITE

Location and condition of dams upstream or downstream that will affect high water or discharge at this site:

____

Location and description of any water-gaging stations in the immediate vicinity: ______________________

____

____

Elevation ______________ on gage corresponds to elev. ______________________
______________ on survey datum.
Extent to which sink-holes affect runoff, etc.: ______________________

____

Brief description of usage of stream for navigational purposes. By small boats, etc.

____

____

____

Railroad Grade Separation Structure Site Data

Railroad milepost ______________ No. of tracks ______________
Situation data for design of bridge on ______________ over ______________
Type of construction: ______________ New structure
______________ Replacement of existing structure
______________ Remodeling of existing structure
______________ Paralleling existing structure

Owner of existing structure ______________________.
Owner of grade crossing to be eliminated ______________________.

Date of original construction of any railroad structure being replaced or within approximately 500 feet of the site of proposed overpass ______________________.

Conditions of existing cut slopes, whether stable, eroded, et cetera.
Are ditches open, maintained, et cetera ______________________.
NOTE - Show cross-section of existing railroad bed at right angles to centerline crossing, with all dimensions, on bridge situation plan. This cross-section should extend from top of cut to toe of fill.

REMARKS -
(Information on significant features not listed, et cetera)

____

____

____

____

Survey by ______________________________

CHAPTER 8.00

CONSTRUCTION SURVEYS

Chapter Contents

Sec. 8.01	General
Sec. 8.02	Alignment
Sec. 8.03	Levels, Benchmarks & Project Elevations
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Sec. 8.06	Culvert Stakeout
Sec. 8.07	Bridge Stakeout
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Sec. 8.09	Fine Grade Stakes
Sec. 8.10	Right-of-way Stakes
Sec. 8.11	Federal Aid State Force Account Projects
Sec. 8.12	Non-Federal Aid State Force Account Projects
Sec. 8.13	Minimum Plan Projects
Sec. 8.14	Plan Quantity Projects
Sec. 8.15	Project Inspector's Staking Responsibilities
Sec. 8.16	Condemnation Staking
Sec. 8.17	As-built Plan of Right-of-way Monumentation
Sec. 8.18	Submitting Survey Data

Sec. 8.01 **General**

Construction surveys shall be made in accordance with the **Location and Design Division Instructional Memorandum LD-01 (D) 152.6** or latest revision, **Special Provision for Section 105.10** of the Specifications **(see Figure 8-M, page 8-24)** and the **Construction Manual** with its corresponding sections.

The Survey Supervisor should become familiar with the plans, Special Provisions and contract prior to the Pre-Construction Conference, to assist the Resident Engineer with proposed time schedules, special requirements, etc.

Unless specifically instructed by the District Survey Parties Engineer, the Survey Party is not to perform checks on any survey work performed by the contractor.

The Virginia Department of Transportation analyzes topographic information by using a Digital Terrain Model (DTM), or a triangulated network of 3-Dimensional points for representing existing terrain. Volumetric computations are performed are performed accurately and more cost-effectively using a DTM than by the traditional field cross-section methods. **In lieu of securing cross-section information, DTMs are also acceptable to VDOT for determining volumetric information.**

Sec. 8.02 **Alignment**

The construction centerline shown on the plans must be accurately established in the field and all control points on the construction centerline, such as PIs, PCs, PTs and POTs shall be referenced. If it becomes necessary to introduce equality in order to conform to the plan stationing, or if plan station equality is changed, these changes shall be clearly recorded in the field notes and so written and explained that there will be no misunderstanding their meaning. All notes relative to the retracing of the plan alignment shall be recorded in the transit or field book in the standard manner, and should be retained by the survey party for the use of retracing the line after construction, if needed **(Figures 8-B through 8-D, Page 8-9)**. For marking centerline and reference stakes, please see **Figure 8-I, Page 8-16**.

Sec. 8.03 **Levels, Benchmarks and Project Elevations**

After the centerline has been established and referenced, centerline elevations must be secured at all stations, intermediate cross-section intervals and at any other points where it will be necessary to secure DTM or cross-section data, by leveling methods. The DTMs will be secured to accurately cover all variations in the ground and insure the computation of accurate quantities. These levels shall be based on the plan datum and all benchmarks shown on the plans shall be checked. In case of an appreciable difference in elevation for any benchmarks from that shown on the plans, check levels shall be run and shown in the notes. The levels should be corrected to plan elevation at each benchmark where any difference occurs. This should be noted in the level book as a "pick up" **(Figures 8-F & 8-G, Pages 8-13 & 8-14)**. Where it is obvious that a plan benchmark has been disturbed or if, for any reason, it is not feasible to correct to plan elevation, a full explanation shall be made in the notes. The Project Inspector and Contractor should be furnished a list of benchmarks **(Figure 8-H, Page 8-15)**.

Sec. 8.04 **Cross-Sections**

All cross-section notes for construction surveying are to be kept in a large-size construction level notebook, number 1309. The following information will be shown on the first page of the book: route, state project number, county, district, an accurate description of the beginning and ending of the project, length of project, the name of the contractor and survey party personnel **(Figures 8-A & 8-E, Pages 8-8 & 8-12)**.

After centerline elevations have been secured and checked where necessary, cross-sections shall be secured at all stations, intermediate intervals and at all appreciable breaks in the ground. In all cases, the cross-sections shall be based on the plan construction centerline except where transition curves are used. Where curves are to be transitioned according to latest standards, the shifted centerline must be used as the centerline for levels and cross-sections.

In the event that there are two or more centerlines shown on the plans, as is often the case at intersections and in dual-lane construction, cross-sections may be taken from one of the plan lines. An independent base line may be established and used for this purpose. If an independent line is established for cross-sections, a diagrammatic sketch must be made and submitted with the cross-sections showing clearly the alignment ties between the random line and the plan alignment. At all road and street intersections the cross-sections shall be taken so as to cover all possible construction and in such a manner as to prevent any overlapping of quantities. In all cases an accurate sketch shall be shown either in the notes or on a plan sheet indicating clearly how the separator lines were established and how these sections were taken. These sketches should be sent to the Design Unit along with the books. Cross-sections at road intersections should be taken at sufficient intervals to insure computation of quantities.

Sec. 8.05 **Borrow Pits**

If borrow material is shown on the plans, the District Survey Parties Engineer should contact the Project Inspector in charge and ascertain the location of the pit(s) to be used. All borrow pits shall be cross-sectioned using the elevation of a benchmark shown on the plans if possible. A diagram of all borrow pits shall be shown in the borrow pit notebooks giving the number of each pit, property owner's name, property lines, the definite location, distance from centerline of the road and a tie-in with definite stations, if possible. The diagram also should show the properly referenced baseline, baseline bearing, cross-section limits and separator lines. If the quantities are to be run through the computer, the number of baselines and their intervals can be set up solely for the convenience of the survey party in taking cross-sections.

All references to the baseline and benchmarks are to be so placed that they will be entirely outside of the area likely to be disturbed by the operation in and around the borrow pits.

DTMs shall be secured at sufficient intervals to cover all breaks in the ground and insure accurate computations of quantities. In the event a borrow pit covers two or more properties, all property lines shall be clearly shown in the notes and on the diagrammatic sketch, in order that the amount of material removed from each property may be determined. It should be noted in the book whether the DTMs were secured before or after topsoil and/or rootmat was stripped and care should be exercised to see that the final sections are taken in the same way.

Sec. 8.06 **Culvert Stakeout**

All box culverts are to be staked, according to furnished alignment and grades. The Survey Supervisor should check that the dimensions given for the culvert are consistent with the typical section of the roadway, giving attention that the toe of the slope intersects with the proper point of the culvert. Should any major differences be found, the Survey Supervisor is to immediately notify the District Survey Parties Engineer so the differences can be resolved. For minor differences, such as the length of the culvert, the stakes for the proposed culvert should be adjusted to match the slope of the section, with notes made on the stakeout sketch and in red pencil on the contractor's and inspector's plans. **Figure 8-L, page 8-23** illiustrates a procedure for checking the stake out of a box culvert. **All culverts will be staked in accordance with Section 105.10 and Figure 1 as shown beginning on page 8-24.**

All pipe culverts, 48”and larger, are to be staked by the Survey Party. All pipe culverts less than 48” will be staked by project personnel.

All pipe culverts with design grades, such as storm sewers, regardless of size are to be staked by the Survey Party. All pipe culverts that are in critical locations will be staked by the Survey Party when specifically requested by the Project Engineer.

Sec. 8.07 **Bridge Stakeout**

On all projects, when the survey party stakes a bridge, the Survey Supervisor should check the consistency between the stations and the dimensions given on the bridge plans. If any difference is found, the Survey Supervisor should immediately notify the District Survey Parties Engineer and the District Bridge Engineer so that the differences can be resolved. This check is necessary on all grade separation structures to insure that the substructure is correctly located with respect to railroad tracks or under passing roads before construction is started.

The survey party is to set stakes at the intersection of the baseline of the bridge and the centerline of each pier. Also, set stakes on the baseline of the bridge at the intersection of the lines shown on the plans on the abutments from which dimensions are referenced. These intersection points will be shown on the sub-structure layout sheet of the bridge plans. Angles are to be turned to the centerline of all piers and the lines shown on the plans on the abutments from which dimensions are referenced and stakes set on either of the bridge baseline on these centerlines. **All bridge staking shall be in accordance with Section 105.10 and Figures 2 & 3 as shown beginning on page 8-24.**

All measurements of distances and angles are to be checked thoroughly by the Survey Party using a different method than that used initially. On more complicated structures, the District Survey Parties Engineer may elect to have the stakeout checked by a second survey party.

After completing the stakeout and thoroughly checking the same, the Survey Supervisor shall locate in red pencil on the layout sheet of the bridge plans used by the Project Inspector, Contractor's Superintendent and the Survey Party, all points which have been staked. This should be done in the presence of the Project Inspector and the Contractor's Superintendent or Engineer.

The Survey Party shall set an adequate number of stakes at 25' intervals or less to locate the position of the toe of fill (or cut) in front of the two abutments. The Survey Supervisor should be certain that the road and bridge plans agree as to dimensions, rates of slope and super-elevation on the abutment slopes.

Sec. 8.08 **Slope Stakes**

Slope stakes shall be set at all stations and intermediate cross-section intervals in accordance with the latest standards. The correct method of marking and setting slope stakes is shown in **Figure 8-K, Page 8-22**. For information on producing slope stakes notes, see **Figures 8-E through 8-G**. A careful examination should be made of the typical sections as shown, in regard to width of surfacing, width of shoulder and width of ditch, together with the cut or fill slopes or CS standards used. Also, a careful examination should be made of the summary sheets, plan sheets, profile sheets, special notes pertaining to the staking and construction of the project, and the plan cross-sections to determine the suggested slope to be used in special cases. In case of a conflict, the District Survey Parties Engineer will contact the Design Unit for clarification and when such clarification is given, staked accordingly. It is recommended that the slope stake listing from IGRDS is secured as considerable time and effort can be saved with its use.

Sec. 8.09 **Fine Grade Stakes**

Fine grade or other stakes, required for the construction of the project, are to be set as the work progresses, with the exception of secondary roads. Fine grade stakes should be set on all projects on which the plans show definite grade lines. On tangents, the fine grade hubs are to be set on one side with distances and grades referenced to the finished grade on centerline. On curves, fine grade hubs may be required on both sides with offsets and grades referenced to the edge of pavement. Clear, concise notes are to be kept on fine grade stakes showing dates, etc. Fine grade hubs are not to be set for rough grading, as the slope stakes should suffice in these instances.

In regard to secondary projects, fine grade stakes will be set only on those having curb and gutter, unless otherwise requested by the Resident Engineer.

On projects where grading and paving is done under the same contract, only one set of fine grade stakes is to be set. This one set of stakes is to be used for both cutting the fine grade and for paving. For marking fine grade stakes see **Figure 8-I**.

Sec. 8.10 **Right-of-Way Stakes**

Hub and tack points will be set for Standard RM-1 monuments by the Survey Party, as shown in the Road Design and Standards. Standard RM-2 monuments will be set by the Survey Party at the time of stakeout or after construction is completed, if pin location is within the construction limits. Intermediate stakes for fencing will be set only on curves, and then only as needed. There may be instances on curves in rough terrain where staking by the Survey Party will be required, but in many cases the fence line can be established by measuring from the centerline. See **Figure 8-I** for marking standard RM-1 stakes. **In all instances, the staking of all RM-1 & RM-2 monumentation shall be in accordance with Section 105.10 and Figure 4 as shown, beginning on page 8-24.**

Sec. 8.11 **Federal Aid State Force Account Projects**

Federal Aid State Force Account Projects are to be cross-sectioned and staked in the same manner as regular contract projects.

Sec. 8.12 **Non-Federal Aid State Force Account Projects**

Non-Federal Aid State Force Account Projects are to be staked out in the same manner as Regular Contract Projects, except as follows:

1. Where there is no change in the plan alignment and the slope stakes are set, there is no need to secure DTMs of the original ground. The original ground sections, or DTMs, secured at the time the location survey was made, are sufficiently accurate to be used in computing final quantities. The notes covering the running of centerline levels and setting slope stakes are to be recorded in level book number 1309 and sent to the District Engineer along with the final notes.

2. Where the alignment is changed during construction from that shown on the plans, complete DTMs of the original ground must be secured and recorded with the slope stake notes.

3. In the event borrow is necessary, all borrow pits must have DTM information secured, as outlined for contract work, as it is necessary in most cases to compute accurate quantities for settlement with the property owners.

4. In the event that the plans do not contain DTMs of the original ground, as is sometimes the case at intersections where quantities are estimated, DTMs shall be secured when the slope stakes are set.

Sec. 8.13 **Minimum Plan Projects**

Usually the only staking on a Minimum Plan Project should be locating the construction centerline and right-of-way stakes. If deemed necessary by the District Administrator or Resident Engineer, marked stakes shall be established showing the approximate depth at centerline of areas of major fills and cuts, which exceed four feet **(4 ft.)** and/or other areas, as required. Marked stakes shall be in place at the time of the Project Showing. The centerline is to be referenced so that the alignment can be retraced at future dates. Pipes, borrow pits when required, and structures shall be staked the same as any other project and distribution made.

See current edition of VDOT's Road Design Manual, Appendix A, Section A-7, titled "Section A-7 – "No Plan" and "Minimum Plan"Projects". Excerpts are contained herein as Figure 8-J , Page 8-17.

Sec. 8.14 **Plan Quantity Projects**

Plan Quantity Projects are to be staked in the same manner as regular contract projects with the exception of cross-sections, which will be governed as follows:

1. DTMs will not be secured during construction stakeout unless original location sections differ from existing conditions.

2. The Survey Supervisor will monitor the ground line to verify that original location sections are accurate. This is generally a matter of determining if the slope line intersection with the ground line conforms to the plans.

3. DTMs will be secured to cover areas that show changes from the original location sections, and final sections will be secured to coincide with these.

See current revision Location & Design Instructional and Informational Memorandum (D) 152.

Sec. 8.15 **Project Inspector's Staking Responsibilities**

1. Radius points for crossovers.
2. Radius points for connection flares.
3. Reset slope stakes when a minimal number are missing.
4. Reset fine grade hubs when a minimal number are missing.
5. Run levels to check grade hubs when they are to be used by the paving contractor.
6. Some survey parties set hubs at the slope stake point and drive another stake with data. This is done so the inspector can find the hub and reset all slope stakes.
7. Stake D.I.'s in median, etc. that do not fit into curbs. When C & G stakes are in place, curb D.I.'s could be staked also.
8. Set stakes for riprap.
9. Set stakes for pavement widening at run-on and run-off for bridge approaches.
10. Set stakes for bridge approach slab.
11. Check apparent errors in stakes by running levels from benchmarks.

Sec. 8.16 **Condemnation Staking**

On all condemnation stakeouts, the following color codes will be used:

Limited Access Line	Mark with Blue
Proposed Right-of-way	Mark with Red
Existing Right-of-way	Mark with White
Permanent Easement	Mark with Green
Temporary Easement	Mark with Orange
Utilities	Mark with Yellow

The above listed colors of tape are stocked at Fulton Supply Depot.

Sec. 8.17 **As-built Plan of Right-of-way Monumentation**

Once construction has been completed, all RM-1 and RM-2 monuments have been set, but prior to submission of all final survey reports, notebooks and computations, the Contract Surveyor shall verify the locations of all RM-1 and RM-2 monumentation, by measurement, that prescribes the right-of-way as depicted on the accepted construction plans. The surveyor shall prepare an "As-built" plan in accordance with the requirements of **Figure 4** in the **Special Provisions for both 105A & 105B - Section 105.10 "Construction Stakes, Lines and Grades"**. Copies of the special provisions are attached herein as **Figure 8-M, starting on page 8-24**.

Sec. 8.18 **Submitting Survey Data**

As soon as the project has been completely staked out, the notebooks marked "slope stakes" should be sent to the District Design Unit for the cross-section notes to be plotted. As soon as this is done, the notebooks will be returned to the Survey Supervisor for use in the field in securing the final sections. The cross-section sheets will be filed in the District Design Unit until the final comes in.

Figure 8-A

INDEX Page 2

Alignment Notes

Sta. 110 + 00 – 175 + 00 3 - 60

1

Route 19
Project 6019-092-102, C503
Tazwell County
Bristol County

From: 5. 224 mi. W. Va. - West Va. State Line
To: Va. – West Va. State Line
Length: 1. 456 mi.

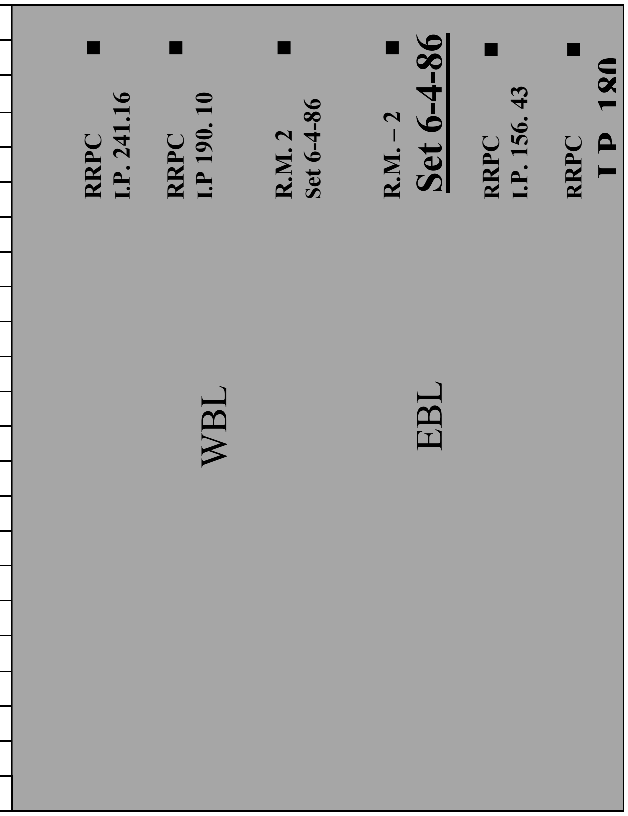
Contractor – H. B. Roane Co.
Mt. Airy, NC

J. C. Mort Survey Supervisor
J. C. Mays Eng. Tech VI
L. L. Speed Eng. Tech. IV
W. C. Clark Eng. Tech. IV
J. R. Stanley Eng. Tech. IV

Figure 8-B

4

+51.23	PC	2° 32’	07” Rt.	
+50				
163				
+50				
162				



3

+50				
161				
+50				
160				
		N 84°	39’ 01	E

Figure 8-C

6

+50	5° 03' 19"				
167	4°25'17"				
+50	3°47'15"				
166	3°09' 13"				

5

+50	2°31'11"				
165	1°53'09"				
	IC=1.05	Max			
+50	1°15'07"				
	IC=1.04				
164	0°37'05"				
	IC=0.93				

Figure 8-D

7

+50					
169	POC				
+50					
168	5°41'20"				
+73.30	PI				

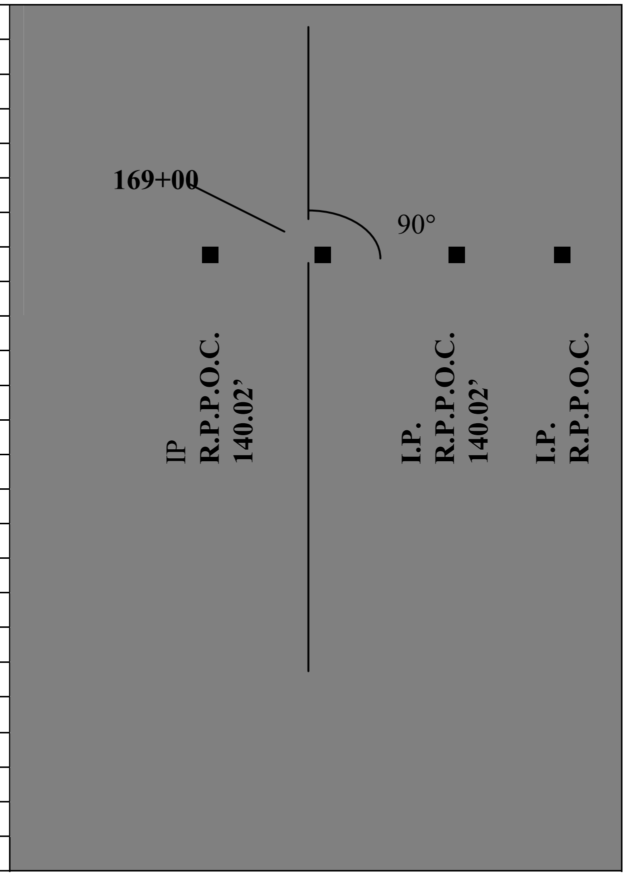


Figure 8-E

INDEX Page 2

						Level and Slope Stake Notes
						Sta. 112 + 50 Temp. Conn.
						Thru 189 + 00 4 - 80
						Road Beds 3 & 81

Page 1

						Route 19
						Project 6019-092-102, C503
						Tazwell County
						Bristol County
						From: 5. 224 mi. W. of Va. - West Va. State Line
						To: 3. 238 mi. W. of Va. - West Va. State Line
						Length: 1. 456 mi.
						Contractor – H. B. Rowe Co.
						Mt. Airy, NC
						Barry V. Woodford P.E.
						L. Randall Allison Chief
						A. W. Allison Levelman
						M. A. Price Chainman

Figure 8-F

1 ½: 1 C 20.2 2 : 1 Page 2

164	SOF = +0.4 SOC = +0.4 SIF = -1. 3 SIC = -1. 1			6. 5	2498.1	2477.88	C32.3 C32.7 10.6 86.2 ; C30.6 08.9 3.0 76.2 ; 11.9 +13.8 98.1 -0.8 ; 98.9 98.1 0. 8	C14.1 90. 1 8. 0 59. 2 ; C13.4 C12.36 90. 2 8. 7 69.2
B.M.	16.83	2504.5	15.35		2487.80	2487.75	Top R/W Pin 100' Rt. Sta. 163+51. 23 EBL	
+51.23	P.C.	2° 32' 07" Rt.					C20.7	2 : 1
+50	SOF = 0.0 SOC = +0. 1 SIC = -1. 0 Sh = 0. 5			4. 8	2498.4	2478.17	C29.9 08.2 7.0 75.2 ; 15.2 07.2 08.0 -1.2 ; 09.2 +10.8 98.4 -0.8 ; 99.2 98.4 +0.8	C15.0 92.2 7.0 61.0 ; C13.6 C12.6 CL 90.8 8.4 71 .0
							C31.2 C31.3 CL 09.5 5.7 85.2	
		2503.15						

1 ½ : 1 C 21. 4 2 : 1 Page 3

	Sh = 0. 1							
163	SOF = -0.04 SOC = -0. 2 SIF = -1. 0 SIC = - 0. 8			3.3	2499.9	2478.47	C 30. 0 C 29. 8 CL 08. 3 2. 2 83 . 2 ; C28. 6 06. 9 3. 6 73. 2 ; 10 . 5 + 10. 6 99. 9 - 0. 6 ; 00. 5 99. 9 0. 6	C 14. 8 92 . 5 8. 0 60. 6 ; C 13. 6 C 12. 8 CL 91 . 3 70. 6
	Sh = 0.0						STD	
+50	SOF = -0.6 SOC = -0.4 SIF = -1.0 SIC = - 0. 8			5.6	2497.6	2478.82	C 23. 9 02. 7 3. 1 78. 0 ; C 23. 3 02. 7 3. 7 68. 0 ; 05. 8 + 8. 2 97. 6 1. 2 ; 98. 8 97. 6 1. 2	C 12. 6 89. 9 7. 4 57. 7 ; C 11. 1 89. 9 8. 9 67. 7
+31.23	T.S.							
T. P.	8. 41	2503. 15	0. 72		2494.74			
		2495. 46						

Figure 8-G

1 ½ : 1 C 21. 4 2 : 1 Page 6

	Sh = 0. 1 SOF = -0. 4 SOC = -0. 2 SIF = -1. 0 SIC = - 0. 8						C 30. 0 C 29. 8 CL 08. 3 2. 2 83 . 2
163				3.3	2499.9	2478.47	C28. 6 06. 9 3. 6 73. 2
							10 . 5 + 10. 6 99. 9 - 0. 6
							00. 5 99. 9 0. 6
							C 14. 8 92 . 5 8. 0 60. 6
							C 13. 6 C 12. 8 CL 91 . 3 70. 6
	Sh = 0.0 SOF = -0.6 SOC = -0.4 SIF = -1.0 SIC = - 0. 8						C 18. 8 STD
+50				5.6	2497.6	2478.82	C 23. 9 02. 7 3. 1 78. 0
							C 23. 3 02 . 1 3. 7 68. 0
							05. 8 + 8. 2 97. 6 -1. 2
							98. 8 97. 6 1. 2
							C 12. 6 91 . 4 7. 4 57. 7
							C 11. 1 89. 9 8. 9 67. 7
+31.23	T.S.						
T. P.	8. 41	2503. 15	0. 72		2494.74		
		2495. 46					

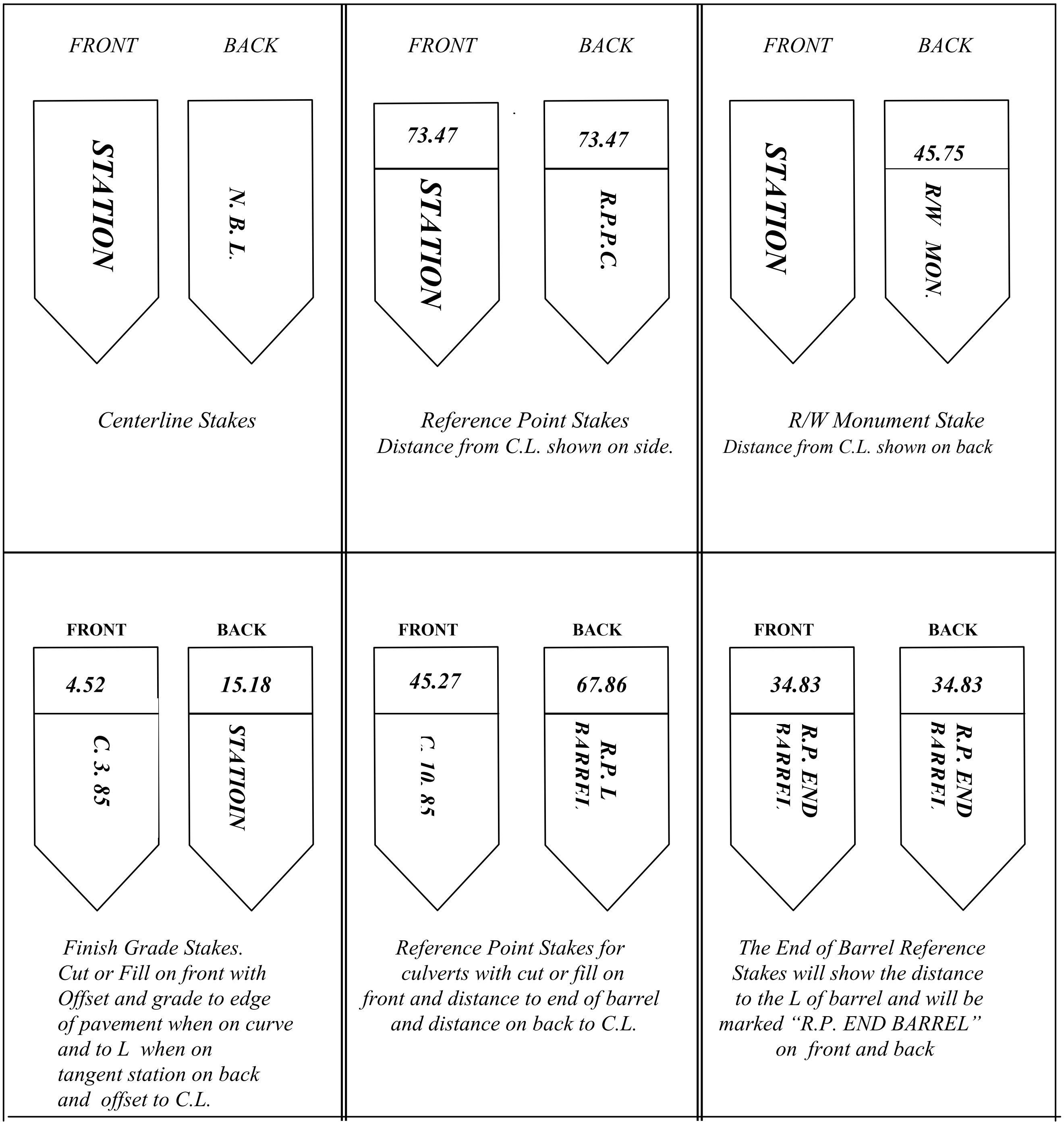
C 20. 1 Page 5

	Max **SF = 1. 9** **SC = 1. 6** **Sh = 1. 0**						07. 3 + 9. 9 97. 4 - 1 . 9
165				7. 2	2497. 4	2477.29	C23. 4 02. 3 5. 0 68. 0
							C 24. 0 C 25. 6 CL 02. 9 4. 4 78. 0
							99. 3 97. 4 1. 9
							C 15. 9 91. 6 7. 7 62. 8
							C 15. 6 C 14. 0 C. L. 91 . 3 8. 0 72. 8
							C 10. 9 C 9. 4 C. L. 89. 0 8. 6 65. 2
+50	Sh = 1. 0 SF = 1.7 SC = 1. 5			10.7	2493.9	2477.59	STD
							07. 6 + 4. 5 03. 1 - 2 . 5
							C 24. 0 03 . 1 2. 5 68. 0
							C 25. 3 C 26. 8 C. L. 04. 4 3. 2 78. 0
							05. 6 + 11 . 7 93. 9 -1. 7
							95.6 93. 9 1. 7
							C 12. 1 88. 2 7. 4 55. 2
		2504. 58					

Figure 8-H

				S.M.S.		
B. M	5. 06	148. 85	7. 48	143. 79	143. 79	Chiseled □ on Conc. Curb; 2' Lt. Sta. 23+40 Sur. B.L. 1st St.
B. M	1 . 32	151. 27	1 . 48	149. 95		Chiseled □ on Conc. Wall; 40' Lt. Sta. 28+25 Sur. B.L.Montiero
B. M	7. 64	151 . 43	2. 58	143. 79		Chiseled □ on Conc. Curb; 2' Lt. Sta. 23+40 Sur. B.L. 1st St.
T. P.	2. 64	146. 37	5. 09	143. 73		
T.P.	4. 96	148. 82	5. 01	143. 86		
B. M	5. 14	148. 87	7. 45	143. 73		Chiseled □ on Conc. Curb; 2' Lt. Sta. 14+70 Sur. B.L. 1st St.
T.P.	2. 27	151. 18	11. 15	148. 91		
B. M	1. 67	160. 06	3. 80	158. 39		Chiseled □ on Sidewalk; 2. 5' Rt. Sta. 8+35 Sur. B.L. 1st St.
		162. 19				

Figure 8-I



Centerline Stakes

Reference Point Stakes
Distance from C.L. shown on side.

R/W Monument Stake
Distance from C.L. shown on back

Finish Grade Stakes.
Cut or Fill on front with Offset and grade to edge of pavement when on curve and to L when on tangent station on back and offset to C.L.

Reference Point Stakes for culverts with cut or fill on front and distance to end of barrel and distance on back to C.L.

The End of Barrel Reference Stakes will show the distance to the L of barrel and will be marked "R.P. END BARREL" on front and back

Figure 8-J

Excerpts

SECTION A-7-“NO PLAN” AND “MINIMUM PLAN” PROJECTS

GENERAL CONCEPTS

Description

The “No Plan” and “Minimum Plan” concept provides for the accomplishment by contract of the type improvements that would not require complete and detailed surveys and plans, and where the use of modified specifications would be appropriate. Generally, the improvements will consist of widening, grading, draining and stabilizing primary and secondary roads with relatively low traffic volumes by using engineering judgment. “No Plan” and “Minimum Plan” concepts are to be used only for project where significant reductions in the cost of engineering and construction can be experienced by using these concepts to obtain the quality of improvement necessary for the particular situation. To optimize the usefulness of this concept, very careful initial study and project selection by the District and Residency staff is required. On secondary projects, this determination should be made in accordance with Mr. E. C. Cochran, Jr.’s memorandum dated December 1, 1994 concerning “Initial Field Review / Scoping Report – Revised Guidelines”. The Federal Highway Administration has concurred with the use of the “No Plan” and “Minimum Plan” concept on selected projects with Federal Oversight.

“No Plan” projects are used when no survey, engineering, hydraulic analysis or river mechanics studies are needed or when there will be no major structures with “B” or “D” designation numbers. Right of way may be acquired on “No Plan” projects provided it is acquired thru donations and no condemnation is required. A “No Plan” project is an assembly of letter size sketches showing the location of the project with a typical cross section and estimated quantities.

A “Minimum Plan” project differs in that limited survey is needed to provide the information necessary to secure right of way by the Right of Way and Utilities Division and a profile sheet is provided. In the establishment of such projects, attention should be given to determine that the project location and selection is in an area where disruption due to construction can be tolerated by the users of that particular roadway for a reasonable period of time.

PROCEDURES

GENERAL

Form C-99 (No Plan and Minimum Plan Quantity Support Report) and a Field Narrative (i.e., detailed description of proposed work in narrative or sketch form – See Page A-109) are to be completed by the Resident Engineer or the District Administrator's staff. They are to be submitted with the project assembly for the purpose of providing information concerning the general description of construction work from which to develop and support the construction cost estimate. Also provide a project specific erosion and sediment control plan (narrative or sketch) on projects disturbing more than 10,000 square feet of soil. Form C-99 and the Field Narrative should be reviewed and updated prior to the assembly being turned into the Construction Division for first submission to assure the data reflects existing conditions and supports the information to be used at the project showing. The Field Narrative will become part of the contract assembly.

Project Scoping & Initial Field Review

All projects are to be scoped and an Initial Field Review is to be held in accordance with IIM LD-(D) 210. These procedures will define the potential need for field and office engineering as well as right of way and environmental requirements.

"No Plan" Projects

The "No Plan" concept should be used when:

a) survey data is not required
b) *improvements to roadways do not involve major structures or special design items
c) *Hydraulic or River Mechanics Studies are not required.
d) rights of way are acquired thru donations and no condemnation is required
e) environmental permits will not normally be required
f) construction activities must be handled in an expeditious manner
g) detailed engineering is not required

*Exception – when a project requires an extensive study (survey, hydraulic or river mechanics study, etc.) for a major structure, the "No Plan" concept may be used only if the necessary studies for the structure design are performed. When a major structure is located on a long No Plan project, the site should be treated as a Minimum Plan exception to the No Plan Project.

The Resident Engineer normally obtains any donated right of way by use of the appropriate Right of Way Forms. When a "No Plan" project is to be constructed within existing right of way, a note must be placed on the title sheet indicating that "All construction is to be performed within existing right of way."

Metes and bounds plans are required for right of way from unique clients (e.g. Federal and State agencies, the national Forest, railroads, Virginia Power, etc.) – see VDOT's Road Design Manual Chapter 2D, Section 2D-8.

The construction baseline should generally follow the center of the existing roadway; however, minor relocation and alignment improvements (horizontal and vertical), roadway widening, and turn lanes may be accomplished. The geometrics should comply with the appropriate design standards. However, where it is impractical or not economical to obtain the minimum design and an exception is required, permission shall be secured from the State Location and Design Engineer and, if applicable, from the Federal Highway Administration.

The Resident Engineer is responsible for conducting the utility field inspections and preparing the field inspection reports, determining utility conflicts, method of adjustment, cost responsibility and for obtaining and forwarding all plans and estimates from utility owners to the District Administrator (District Utilities Engineer) for processing. The Resident Engineer is also responsible for advising the District Administrator (District) Utilities Engineer) in writing, no later than 60 days prior to the advertisement of the project, when all arrangements have been made with the utility owners to adjust the utilities prior to or in conjunction with project construction. The Central Office Right of Way and Utilities Division will obtain any necessary FHWA authorization for utility work and will furnish the usual utility clearances and estimates to the Construction Division for contract projects and State Force projects with Federal Oversight. If no known utilities and/or railroads are involved, the plans will contain a note so stating.

The responsibility for compliance with applicable regulations, policies and standards is assumed by the District Administrator for “No Plan” secondary projects. The State Location and Design Engineer is responsible for all other roadway classifications. This responsibility is evidenced by affixing the signature of the District Administrator or the State Location and Design Engineer in the appropriate plan signature space.

“Minimum Plan” Projects

Those sites that require an engineering evaluation should be designated as “minimum Plan” projects. This will permit the development of required engineering studies and will provide a vehicle for transmitting critical information to the contractor.

Projects that should be developed with the “Minimum Plan” concept include:

a) locations requiring survey
b) major stream crossing sites
c) locations that will require environmental evaluation and/or permits
d) all projects with “B” and “D” designation numbers
e) locations requiring Hydraulic or River Mechanics studies
f) locations that involve the acquisition of right of way and/or construction

The basic difference between the “Minimum Plan” and the “No Plan” project is the need for a limited survey and topo to provide sufficient right of way plans necessary to acquire right of way. Form RW-205 or individual deed forms are to be used. If any additional right of way or easements are necessary, the usual right of way certification letter and release for advertisement will be required. If additional right of way or easements are not required, the “Minimum Plan” title sheet is to contain a note indicating that “All construction is to be performed within existing right of way.”

“Minimum Plan” projects may include relocation or alignment improvements (horizontal or vertical), roadway widening, and the addition of turn lanes. The intent of the “Minimum Plan” project is for it to be constructed using engineering judgment; however, the complete project should not be required to be redesigned during construction. Special attention should be given to major drainage problems and the limits set for the proposed right of way. The geometrics should comply with the appropriate design standards. However, where it is impractical or not economical to obtain minimum design and an exception is required, permission must be secured from the State Location and Design Engineer and, if applicable, from the Federal Highway Administration.

Quantities computed by the project designer, typical sections, and other similar information generally should be shown on the initial plan and profile sheet. A grade line is required when the grade is to be different than that of the existing road.

When borrow material is anticipated, “Borrow Excavation” is to be set up as a separate bid item in accordance with Section 303 of VDOT’s Road and Bridge Specifications. Borrow sources should be located and designated, whenever possible, in accordance with VDOT’s Road Design Manual, Chapter 2D, Section 2D-16 – SOIL SURVEY AND PAVEMENT DEISGN.

A general description of work must be provided on Form C-99 and the field Narrative to denote additional work that is not covered on the plans.

SPECIFICATIONS

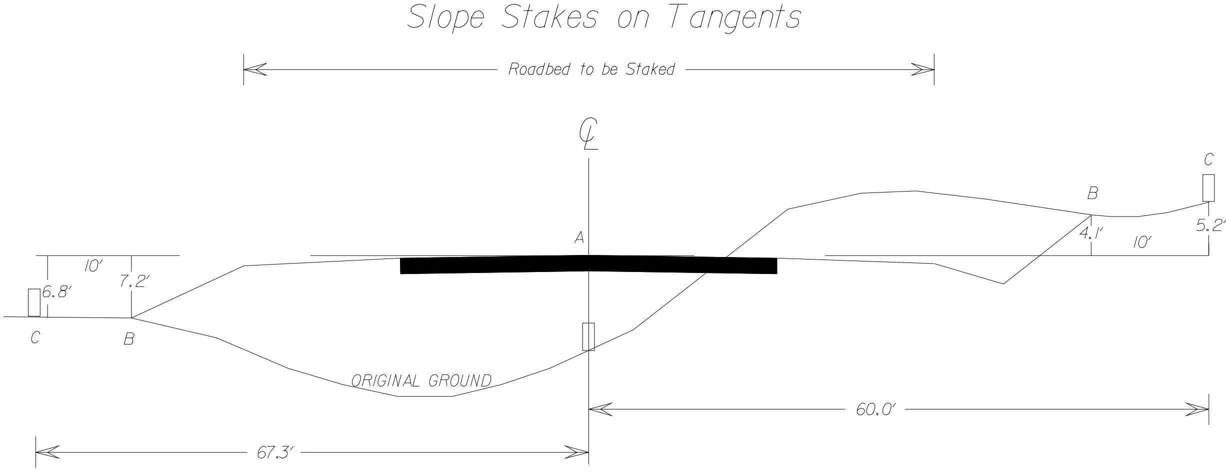
The Contractor shall perform all construction surveying on “No Plan” and “Minimum Plan” projects in accordance with the Special Provision “Copied Note” for Section 105.10 of VDOT’s (See IIM LD-92(D) 152) VDOT’s Road and Bridge Specifications.

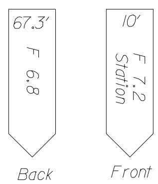
PROJECT LAYOUT

If deemed necessary by the District Administrator or Resident Engineer, marked stakes shall be established showing the approximate depth at centerline of major fills and cuts which exceed 4 feet and/or other areas as required. Marked stakes shall be in place at the time of the Project Showing.

Survey work for “Minimum Plan” projects should normally be performed in accordance with the VDOT Survey Instructions Manual or as otherwise determined by the District Administrator or Resident Engineer. The designer should determine in the early stages of the plan development where additional survey is needed in order to alleviate any major problem during construction. Normally, on “Minimum Plan” projects, entrance profiles are taken where right of way donations are not anticipated; however, they should not be plotted unless the need for condemnation is required.

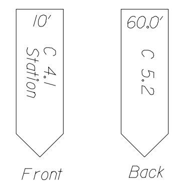
Figure 8-K

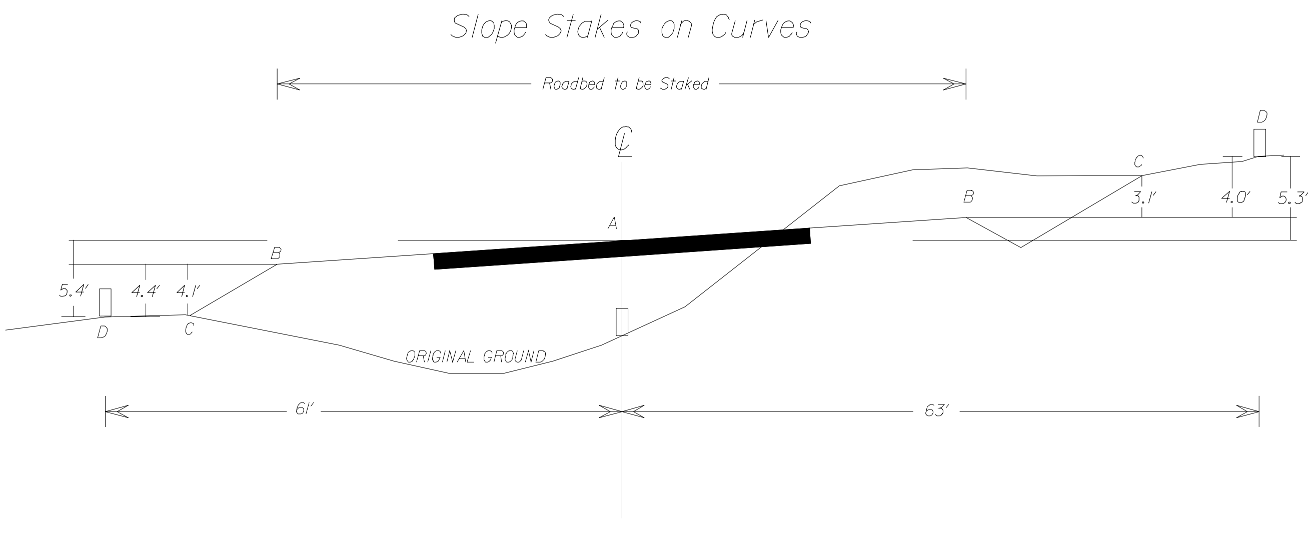


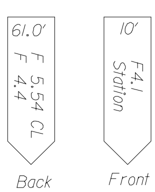


The front of the stake shall indicate the cut or fill to the slope intersection (vertical distance A to B), the offset distance (B to C), and the station.

The back of the stake shall indicate the cut or fill at the point where the stake is set (vertical distance A to C) and the distance to the centerline (A to C).







The front of the stake shall indicate the cut or fill to the slope intersection including superelevation (vertical distance B to C), the offset distance (C to D) and the station.

The back of the stake shall indicate the cut or fill to centerline at the point where the stake is set (vertical distance A to D), the cut or fill where the stake is set, including superelevation (vertical distance B to D), and the distance to centerline (A to D).

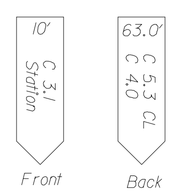
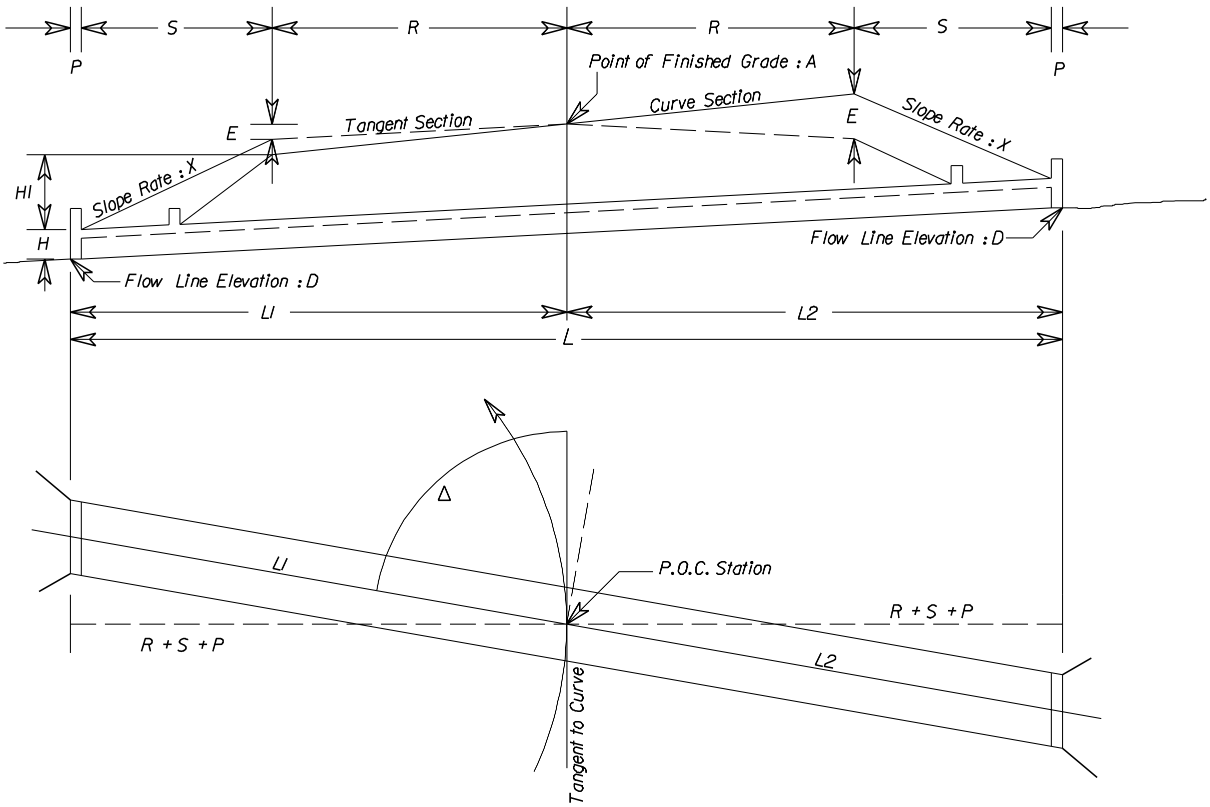


Figure 8-L

Sketch Showing Procedure for Checking Box Culvert



Given:

Box Length	*(L)*
Box Height	*(H)*
Station and Finished Grade	*(A)*
Super Elevation	*(E)*
Flow Line Elevation	*(D)*
Pavement and Shoulder Width	*(R)*
Slope Rate	*(X)*
Delta	*(Δ)*

Required: L1 and L2

Solution:

Elevation “A” ± “E” = Elevation “B”
Elevation Flow Line “D” + “H” = Elevation “C”
“B” – “C” = “HI”
“HI” x “X” = “S”
“R” + “S” + “P” = L1 or L2

For Shew Angles:

$$L1 \text{ or } L2 = \frac{\text{“R” + “S”}}{\sin \Delta} + \text{“P”}$$

Figure 8-M

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
105A – SECTION 105.10 CONSTRUCTION STAKES, LINES AND GRADES

DRAFT
June 13, 2001

SECTION 105.10 of the Specifications is replaced by the following:

Section 105.10 Construction Stakes, Lines and Grades – This work shall consist of providing all surveying and stakeout for the successful prosecution of work as indicated on the plans and as directed by the Engineer. Stakeout work shall be in accordance with the Department's current Survey Manual.

The location of any reference points, which may have been established by the Department, and any control data, which the Department may have, will be made available to the Contractor upon request. The Department will be responsible for the accuracy of such reference points and control data.

The following surveying work shall be performed by or under the direct control and personal supervision of a surveyor who is licensed in Virginia as a Land Surveyor and is experienced in highway construction stakeout: Right of way and boundaries affecting property ownership, horizontal and vertical control for bridges, horizontal and vertical control for box culverts and culverts having spans or openings larger than 48 inches, horizontal and vertical control for culverts with design grades, horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections.

All other surveying work may be performed by or under the direct supervision and control of the Contractor who is experienced in highway construction stakeout.

The Contractor shall provide the Engineer with a record copy of survey drawings, field notes and computations prior to the use of said stakeout information for construction. Survey record drawings shall be prepared and certified in accordance with the requirements of the attached sample figure drawings. Electronic data files may be submitted along with paper sketches and drawings, subject to the prior approval of the Engineer. All electronic copies submitted shall be in a format fully compatible with the Department's existing computer hardware and software. It shall be the responsibility of the Contractor to check all surveying work for correctness. Consideration will not be given for any delays to the project that are a result of inaccurate stakeout or time lost to correct elements of the defective survey work. Contractor shall bear all cost to correct all deficiencies resulting from defective survey work. Should a discrepancy arise during construction, the Contractor shall immediately provide oral and written notice to the Department, accurately describing and documenting the discrepancy. The Department will respond to the Contractor's notice and provide direction on how the work is to proceed.

Culvert construction: The Contractor shall stake box culverts and culverts having spans or openings larger than 48-inches and culverts with design grades. Stakeout work and record drawings shall be in accordance with the requirements of Sample Figure 1 herein. Certified record drawings, field notes, and computations shall be submitted to the Engineer.

Bridge construction: The Contractor shall stake all bridges. Stakeout work and record drawings shall be in accordance with the requirements of Sample Figures 2 and 3 herein. Certified record drawings, field notes, and computations shall be submitted to the Engineer.

Locating and setting right-of-way monuments: The Contractor shall set hub and tack points for RM-1 right-of-way monuments in accordance with the Road and Bridge Standards. The Contractor shall furnish RM-2 right-of-way monuments and locator posts. The Department will furnish the required caps for installation by the Contractor. Surveying work and drawings shall be in accordance with the requirements of Sample Figure 4 herein. Certified record drawings, field notes, and computations shall be submitted to the Engineer.

Measurement and Payment: Construction surveying will be paid for at the contract lump sum price, which price shall be full compensation for performing the work prescribed herein and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

Payment for construction surveying will be made upon written request by the Contractor. Such requests shall be submitted to the Engineer no earlier than five days, and no later than two days prior to the progress estimate date. Payment may be made in increments selected by the Contractor. However, payments will not exceed 60 percent of the contract unit price bid until the Contractor has provided the Engineer with surveying field notes, layouts, computations, sketches, and drawings in the format approved by the Engineer.

Locating and setting RM-1 and RM-2 right-of-way monuments will be measured and paid for in accordance with the requirements of Section 503 of the Specifications. No payment will be made until the Engineer has received certified documents from the Contractor.

Payment will be made under:

Pay Item	**Pay Unit**
Construction Surveying	Lump sum

CONTINUED ON THE NEXT PAGE

VIRGINIA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION FOR
105C - SECTION 105.10 CONSTRUCTION STAKES, LINES AND GRADES

February 1, 2001c

Section 105.10 of the Specifications is replaced by the following:

Section 105.10 Construction Stakes, Lines and Grades - This work shall consist of providing all surveying and stakeout for the successful prosecution of work as indicated on the plans and as directed by the Engineer. Stakeout work shall be in accordance with the Department's current Survey Manual.

The following surveying work shall be performed by or under the direct control and personal supervision of a surveyor who is licensed in Virginia as a Land Surveyor and is experienced in highway construction stakeout: Right of way and boundaries affecting property ownership, horizontal and vertical control for bridges, horizontal and vertical control for box culverts and culverts having spans or openings larger than 48 inches, horizontal and vertical control for culverts with design grades, horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections.

All other surveying work may be performed by or under the direct supervision and control of the Contractor who is experienced in highway construction stakeout.

The Contractor shall preserve Department furnished centerline or baseline control, references and location benchmarks. The Contractor shall provide all additional centerline stakes, such as additional lines, connections, ramps and loops, slope stakes, right-of-way markers, fine grade stakes, construction benchmarks and reference stakes as well as the locating of all drainage, roadway and bridge structures. All alignment established by the Contractor shall be referenced with a copy of the references furnished to the Engineer.

The Contractor shall provide the Engineer with a record copy of survey drawings, field notes and computations prior to the use of said stakeout information for construction. Survey record drawings shall be prepared and certified in accordance with the requirements of the attached sample figure drawings. Electronic data files may be submitted along with paper sketches and drawings, subject to the prior approval of the Engineer. All electronic copies submitted shall be in a format fully compatible with the Department’s existing computer hardware and software. It shall be the responsibility of the Contractor to check all surveying work for correctness. Consideration will not be given for any delays to the project that are a result of inaccurate stakeout or time lost to correct elements of the defective survey work. Contractor shall bear all cost to correct all deficiencies resulting from defective survey work. Should a discrepancy arise during construction, the Contractor shall immediately provide oral and written notice to the Department, accurately describing and documenting the discrepancy. The Department will respond to the Contractor’s notice and provide direction on how the work is to proceed.

Digital Terrain Model (DTM) and construction cross-sections: Original location Digital Terrain Model (DTM) or cross-sections will serve as a basis of payment for earthwork unless the DTM or sections differ from existing conditions. In such case, the Contractor shall be responsible for taking construction DTM or cross-sections to include only the areas that show changes from the original location DTM or sections. Contractor shall submit DTM to the Engineer for verification. All borrow pit DTM or cross-sections, both original and final, will be secured by the Engineer.

Culverts: The Contractor shall stake box culverts and culverts having spans or openings larger than 48-inches and culverts with design grades. Stakeout work and record drawings shall be in accordance with the requirements of Sample Figure 1 herein. Certified record drawings, field notes, and computations shall be submitted to the Engineer.

Bridge construction: The Contractor shall stake all bridges. Stakeout work and record drawings shall be in accordance with the requirements of Sample Figures 2 and 3 herein. Certified record drawings, field notes, and computations shall be submitted to the Engineer.

Grading and paving construction: Fine grade or other grade stakes required for the construction of the project shall be set as the work progresses. Fine grade stakes shall be set on all projects on which the plans show a definite grade line. Fine grade hubs shall be set on at least one side with distances and grades referenced to the finished centerline grade. On curves, fine grade hubs may be set on both sides with offsets and grades referenced to the edge of pavement.

On secondary projects, fine grade stakes will be required only on those projects having curb and gutter.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be required. Fine grade stakes may be used for fine grade and paving grade.

Locating and setting right-of-way monuments: The Contractor shall set hub and tack points for RM-1 right-of-way monuments in accordance with the Road and Bridge Standards. The Contractor shall furnish RM-2 right-of-way monuments and locator posts. The Department will furnish the required caps for installation by the Contractor. Surveying work and drawings shall be in accordance with the requirements of Sample Figure 4 herein. Certified record drawings, field notes, and computations shall be submitted to the Engineer.

Upon completion of the project, the Contractor shall provide the Engineer with all original surveying drawings, field notes, layouts, computations, sketches and drawings in the format approved by the Engineer. All electronic copies submitted shall be in a format fully compatible with the Department's existing computer hardware and software.

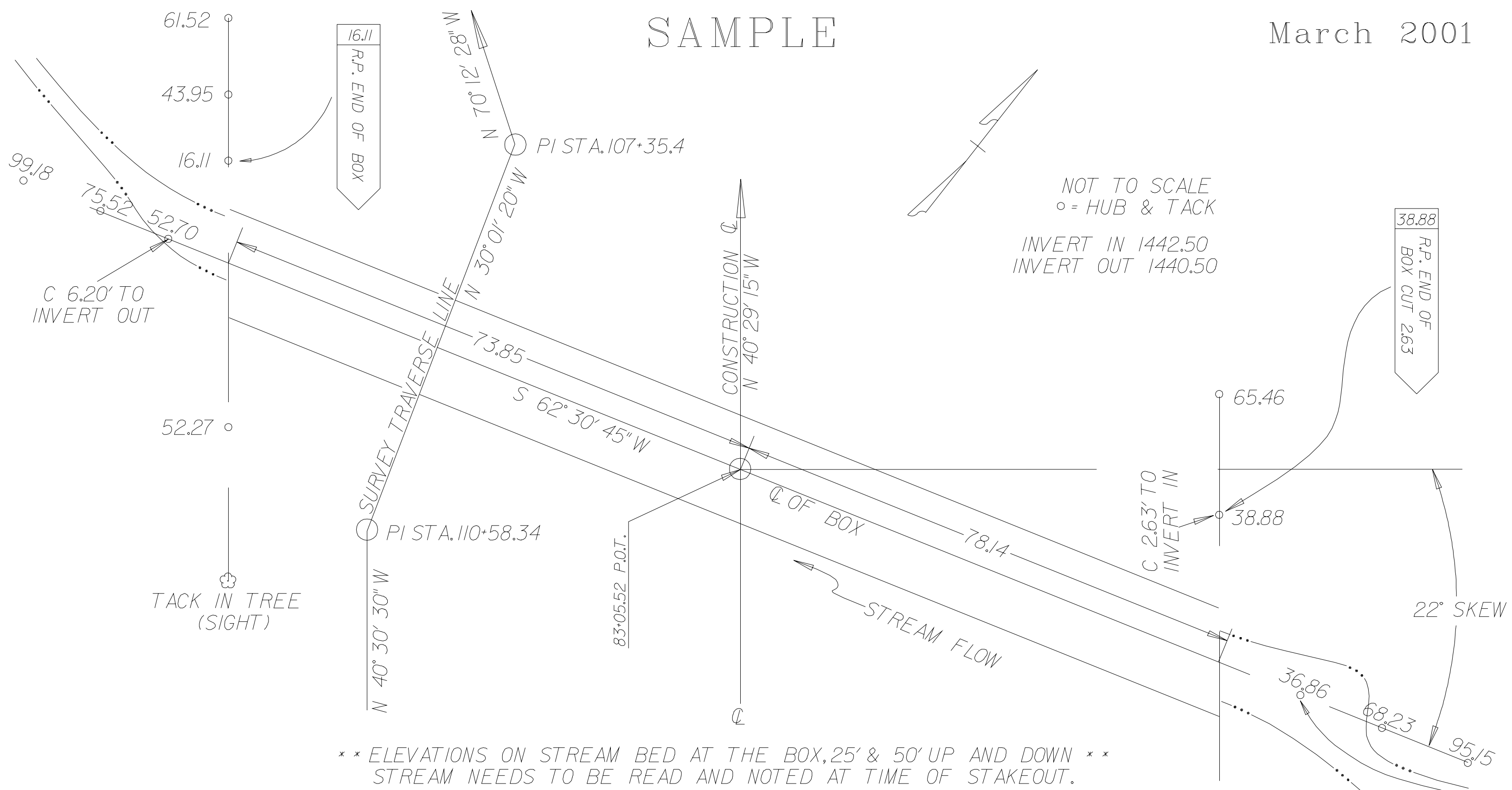
Measurement and payment: Construction surveying will be paid for at the contract lump sum price, which price shall be full compensation for performing the work prescribed herein, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

Payment for construction surveying will be made upon written request by the Contractor. Such request shall be submitted to the Engineer no earlier than five days, and no later than two days prior to the progress estimate date. Payment may be made in increments selected by the Contractor. However, payments will not exceed 60 percent of the contract unit price bid until the Contractor has provided the Engineer with surveying field notes, layouts, computations, sketches and drawings in the format approved by the Engineer.

Locating and setting RM-1 and RM-2 right-of-way monuments will be measured and paid for in accordance with the requirements of Section 503 of the Specifications. No payment will be made until the Engineer has received certified documents from the Contractor.

Payment will be made under:

Pay Item	**Pay Unit**
Construction surveying	Lump sum



Certification

I, Licensed Land Surveyor, Hereby State The Stake Out Of Box Culvert #________, Project# ____________ Was Conducted Under My Direct Control or Personal Supervision And This Sketch Correctly Represents The Location Of All Offset Points Staked In The Field.

Land Surveyor ____________ Reg.# ____________ Date ____________

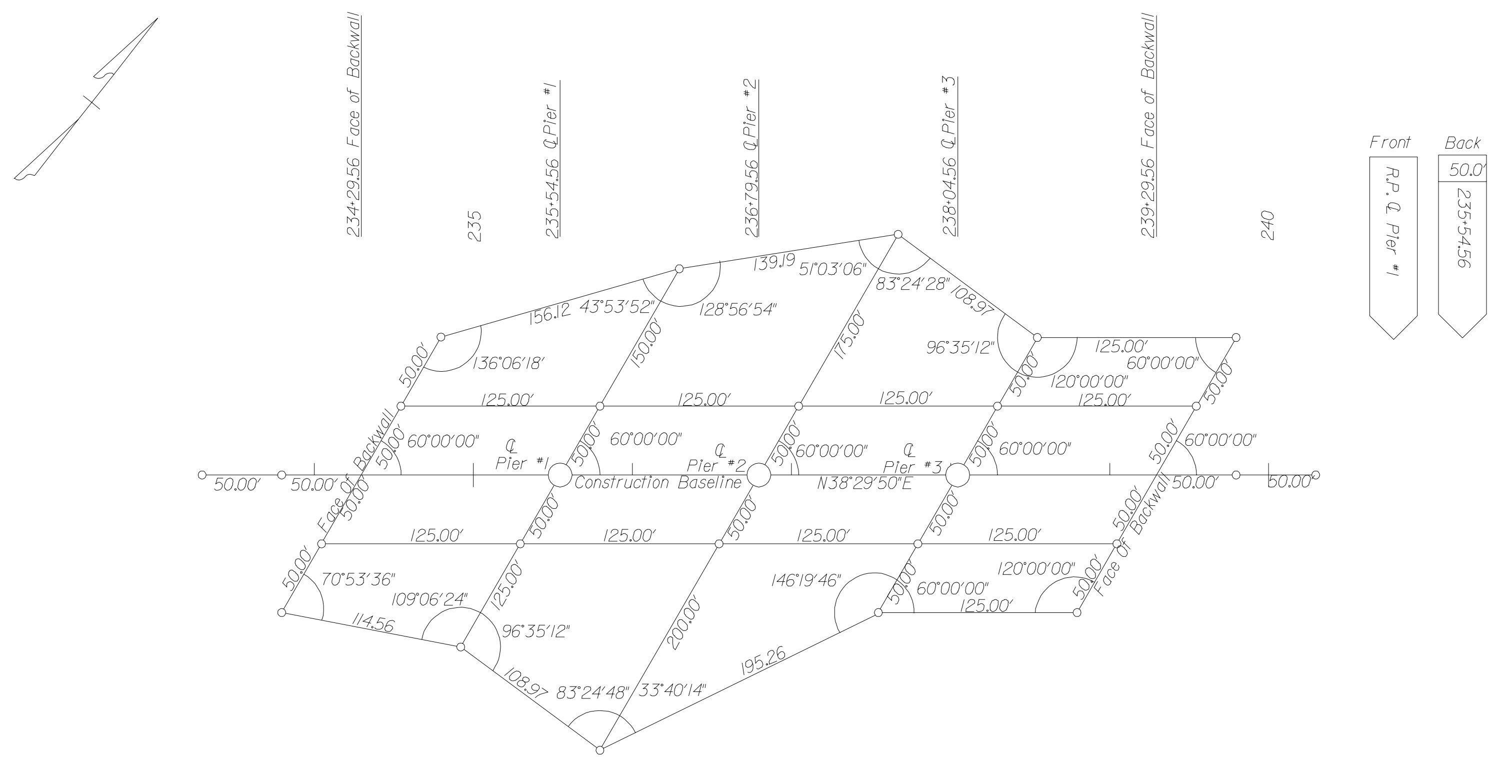
COMMONWEALTH OF VIRGINIA LAND SURVEYOR

1) Benchmark - 3 Nails Set In The Side Of A 36" Oak, 85' Lt. Sta. 84+30 Construction Baseline Elevation = 433.98
2) Reference Point End Of Box Stakes Are Marked R.P. End Of Box - With A Distance To CL Of Box (Front - Back).
3) CL Of Box Reference Stakes Are Marked R.P. CL Of Box On Front, With Offset To Ends Box, And Back Marked With CL Station And Offset To CL.

FIGURE 1

SAMPLE

March 2001



Certification

I, Licensed Land Surveyor, Hereby State The Stake Out Of Bridge #________, Project# ____________ Was Conducted Under My Direct Control or Personal Supervision And This Sketch Correctly Represents The Location Of All Offset Points Staked In The Field.

Land Surveyor ____________ Reg.# ________ Date ______

COMMONWEALTH OF VIRGINIA
LAND SURVEYOR

Benchmark #1 = 3 Nails Set In The Side Of A 36" Oak, 85' Lt.Sta.232+00 Construction Baseline
Elevation = 433.98

Benchmark #2 = Railroad Spike Set In The Top Of A 48" Stump, 105' Rt.Sta.240+50 Construction Baseline
Elevation = 429.22

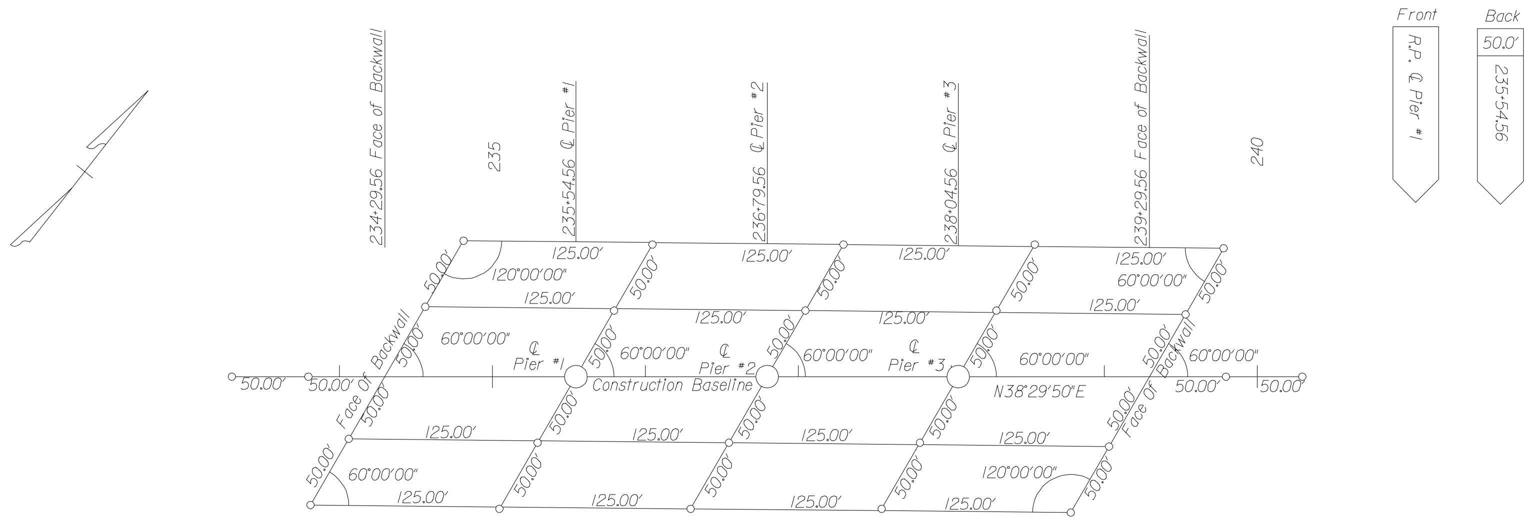
FIGURE 2

SAMPLE

March 2001

Benchmark #1 = 3 Nails Set In The Base Of A 36" Oak, 85' Lt.Of Sta.232+00 Construction Baseline
Elevation = 433.98

Benchmark #2 = Railroad Spike Set In The Top Of A 48" Stump, 105' Rt.Sta.240+50 Construction Baseline.
Elevation = 429.22



Note:

1. At Least Two Offset Points Shall Be Set On Each Side Of The Abutments And Piers.
2. Offsets When Possible Will Be Set Equal Distance From Backwall And Piers.
3. Angles And Distances Shall Be Checked At Ends Of All Offset Lines.
4. A Minimum Of Two Benchmarks Shall Be Set In The Immediate Vicinity Of The Bridge. The Descriptions And Station And Offset From The Construction Baseline Shall Be Shown On The Bridge Stake Out Sketch.
5. All Bridges Should Be Staked By One Field Crew And This Stake Out Verified By Another Field Crew Prior To Submittal Of This Sketch.
6. All Reestablishing Of Face Of Backwall And Centerlines Of Piers Will Be By Intersection Only. Distances Are Provided For Checking Purposes Only.

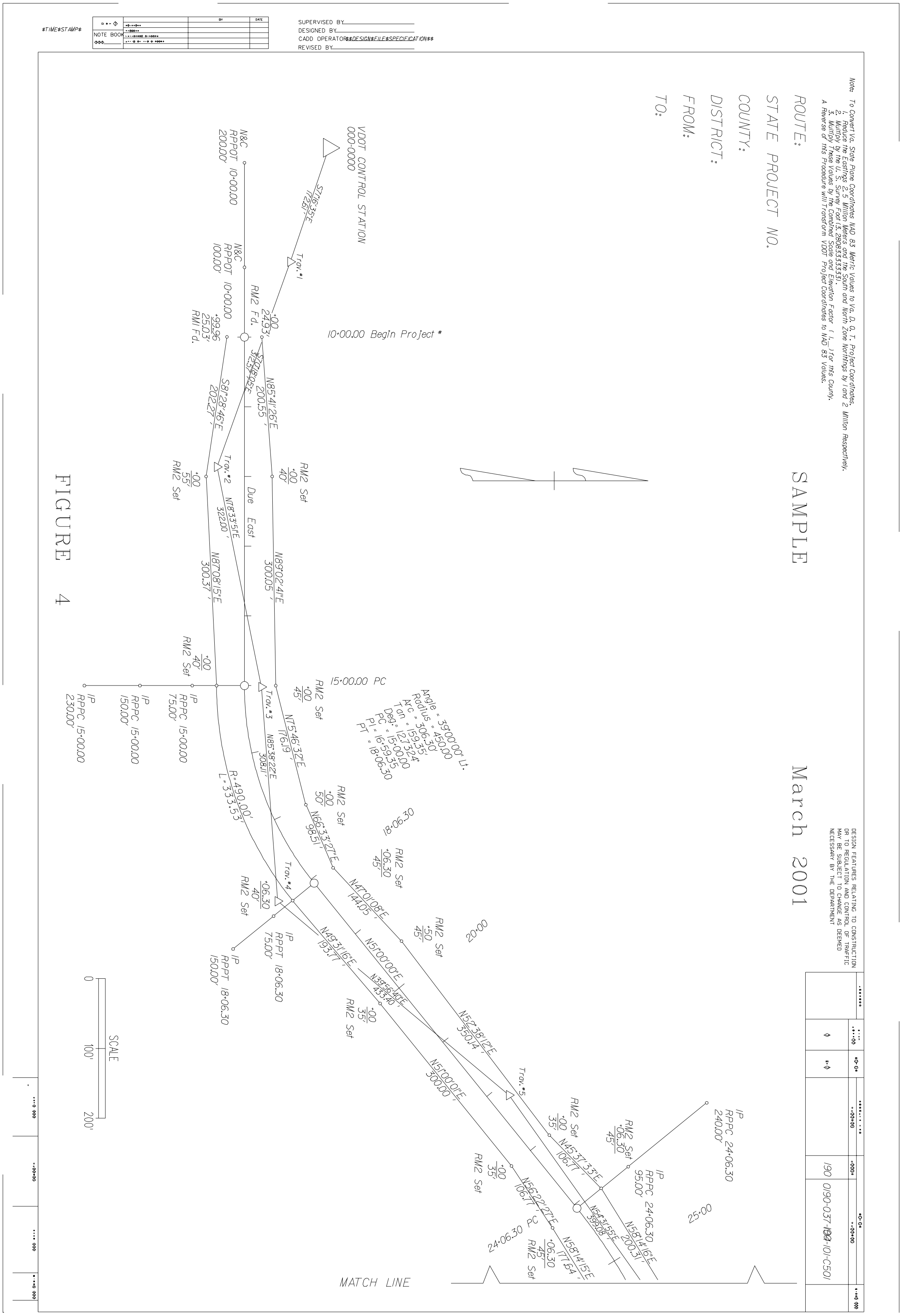
COMMONWEALTH OF VIRGINIA LAND SURVEYOR

Certification

I, Licensed Land Surveyor, Hereby State The Stake Out Of Bridge #________, Project# ____________ Was Conducted Under My Direct Control or Personal Supervision And This Sketch Correctly Represents The Location Of All Offset Points Staked In The Field.

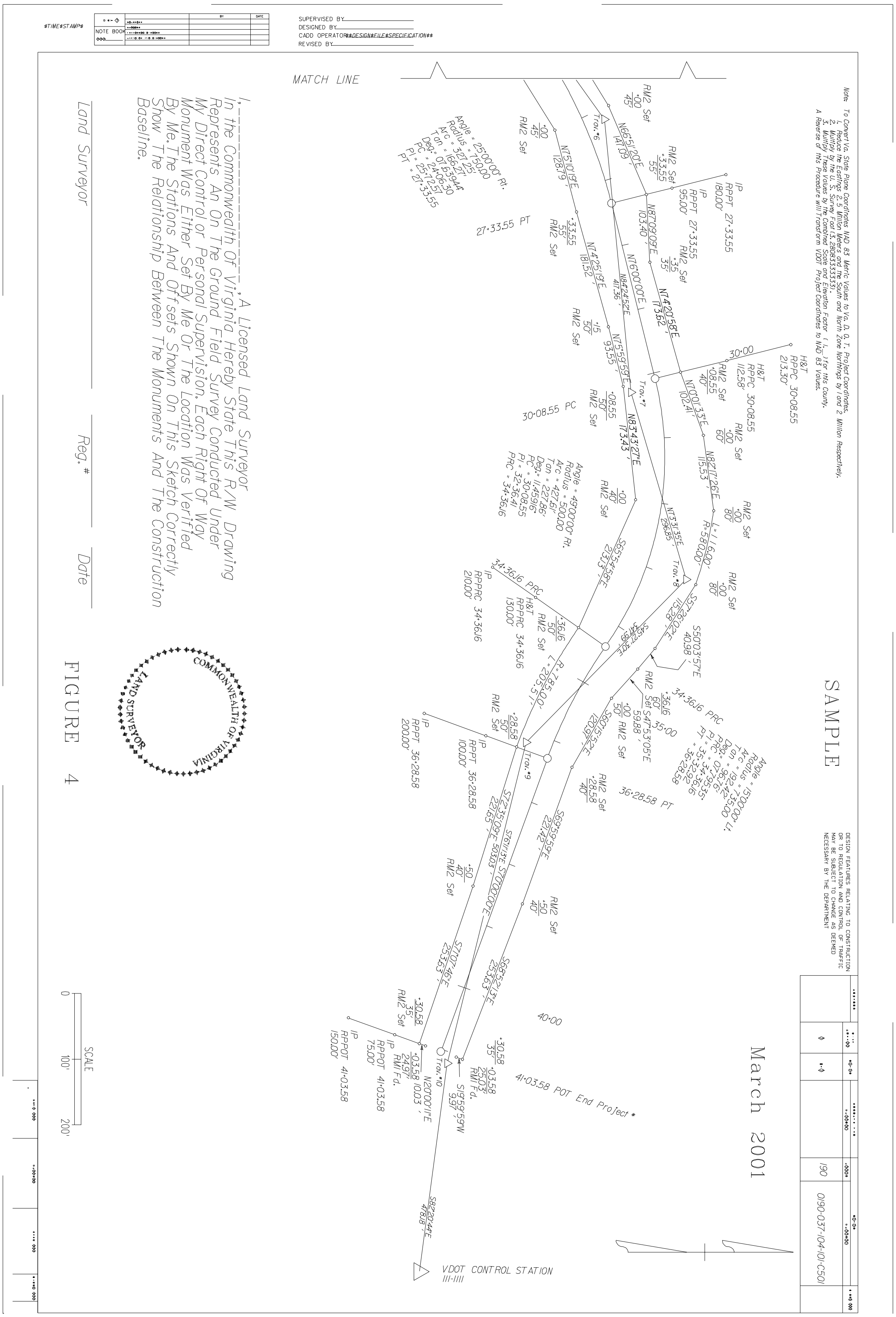
Land Surveyor ______ Reg.# ______ Date ______

FIGURE 3



SUPERVISED BY
DESIGNED BY
CADD OPERATOR
REVISED BY
NOTE BOOK
SAMPLE
March 2001
ROUTE:
STATE PROJECT NO.
COUNTY:
DISTRICT:
FROM:
TO:
DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT
VDOT CONTROL STATION 000-0000
10+00.00 Begin Project *
15+00.00 PC
Angle = 39°00'00" Lt.
Radius = 450.00
Arc = 306.30'
Tan = 159.35'
PC = 15+00.00
PI = 16+59.35
PT = 18+06.30
24+06.30 PC
Due East
MATCH LINE
SCALE
0
100'
200'

FIGURE 4


SAMPLE
March 2001
MATCH LINE
I,__________________, A Licensed Land Surveyor
In the Commonwealth Of Virginia Hereby State This R/W Drawing
Represents An On The Ground Field Survey Conducted Under
My Direct Control or Personal Supervision. Each Right Of Way
Monument Was Either Set By Me Or The Location Was Verified
By Me. The Stations And Offsets Shown On This Sketch Correctly
Show The Relationship Between The Monuments And The Construction
Baseline.
Land Surveyor
Reg. #
Date
COMMONWEALTH OF VIRGINIA
LAND SURVEYOR
FIGURE 4
SCALE
0
100'
200'
VDOT CONTROL STATION
III-IIII
41+03.58 POT End Project
0190-037-104-101-C501
DESIGN FEATURES RELATING TO CONSTRUCTION OR TO REGULATION AND CONTROL OF TRAFFIC MAY BE SUBJECT TO CHANGE AS DEEMED NECESSARY BY THE DEPARTMENT
SUPERVISED BY
DESIGNED BY
CADD OPERATOR
REVISED BY

CHAPTER 9.00

FINAL SURVEYS

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Sec. 9.02	Alignment
Sec. 9.03	Levels
Sec. 9.04	Cross-Sections
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Sec. 9.08	Non-Federal Aid State Force Account Projects
Sec. 9.09	Minimum Plan Projects
Sec. 9.10	Submitting Survey Data

Sec. 9.01 **General**

The district survey review and preparation procedures for final estimates shall be in accordance with the **Post Construction Manual**, or as directed by the District Construction Engineer. If finals are requested by the District Construction Engineer, the following sections should be used as guidelines. **Excerpts of the Post Construction Manual are attached as Figure 9-A, page 9-4.**

Sec. 9.02 **Alignment**

The centerline should be retraced accurately putting in all points where slope stake cross-sections were taken. In case the centerline can be retraced accurately without running a transit line over the project, a note conspicuously placed in the transit book should state that a transit line was not run as it was not necessary for the establishing of the centerline, and that the project was constructed according to plan alignment. When the line is retraced this is to be done in accordance with the procedures outlined in **Sec. 8.02**.

Sec. 9.03 **Levels**

After the centerline has been re-established, centerline levels are to be run taking elevations at all points where slope stake cross-sections were taken. These levels shall be run in accordance with the procedure outlined in **Sec. 8.03**.

Sec. 9.04 **Cross-Sections**

All final cross-section notes on contract construction are to be kept in a large construction level notebook number 1309 with the following information shown on the first page of the book: Route, state project number, county, district, accurate description of the beginning and ending of the project, length of project, name of the contractor, survey party personnel, date of beginning and completion of survey and the date construction was completed. An appropriate note should be placed conspicuously in the book to indicate whether the cross-sections were taken before or after topsoil was placed. **In lieu of securing cross-section information, DTMs are also acceptable to VDOT for determining final volumetric and final grading information.**

The next page is to contain a good, clear index, giving page numbers where information can be found.

Except in the case of Plan Quantity projects **Section 9.06**, final cross-sections, or DTMs, shall be secured as outlined below.

Final cross-sections shall be secured on even stations, plus fifties **(50')**, all points where slope stake sections were taken, and at any other points necessary to insure accurate quantities. If it is found necessary to secure a final cross-section at a point not covered by an original ground section, the survey party shall interpolate the proper ground cross-section and record it in its proper place in the slope stake notes. Final cross-sections are not needed in fill areas on projects where no borrow material is required and only cut yardage is computed.

On approaches to bridges and at all connections, a final cross-section shall be taken at any point where a slope stake cross-section was taken. The beginning and end of all cuts are to be recorded in the notes by giving the station and plus for it. In cases where it is necessary to take two or more separate sets of final cross-sections, as in the case of regrading or changes after grading is completed, these sections shall be fully explained in the notes and clearly designated as to the stage of grading represented. The edges of pavement must be located and marked in the cross-section notes.

Sec. 9.05 **Borrow Pits**

DTM readings or cross-sections must be secured on all borrow pits, prior to the removal of any topsoil from the borrow pit. The same benchmark elevation must be used when securing both the original and final ground elevations. If cross-sections are to be secured on the borrow pit a traverse or baseline must be established and referenced, and used when securing both the original and final cross-sections. DTM readings or cross-sections must be taken in a manner to ensure that an accurate computation of volume of material removed be obtained. If it becomes necessary to secure DTM readings or final cross-section for an area not covered by original ground elevations, the original ground elevation must be interpolated and placed in the same format as the originals. If cross-sections were taken, they must be recorded and placed in the original level notebook and so labeled. A cross-section must be taken at the actual beginning and end of excavation for each borrow pit. If DTM readings were secured, a breakline must be secured to define the beginning of excavation. In the case of more than one borrow pit, they must be numbered to correspond with the number used in staking them out.

Sec. 9.06 **Plan Quantity Projects**

A centerline profile at "Final" stage on plan quantity projects is not required. Spot checks will be made to assure that the vertical alignment is within required specifications. In some cases, a complete profile may be needed to provide proper assurance; but in most cases, this can be accomplished by use of reference stakes and benchmarks along the project.

Usually, final cross-sections will be omitted except where the following authorized tolerances between the plan grade and final profile are exceeded:

> On secondary roads having a daily traffic count of two hundred (200) or less, five-tenths **(0.5 ft.)** of a foot tolerance would be allowed provided such tolerances tend to equalize and are not to the detriment of the quality of the project.
>
> On Class IV primary roads and comparable secondary roads the allowable tolerance is three-tenths **(0.3 ft.)** of a foot. On Class I, II and III primary and on secondary roads comparable thereto, the allowable tolerance is two-tenths **(0.2 ft.)** of a foot

except in the case of Portland cement concrete surfaces where the tolerance is reduced to one-tenth **(0.1 ft.)** of a foot.

When setting slope stakes, in the event areas are found that show changes from the original location cross-sections, these areas will again be cross-sectioned to show the changes and final cross-sections taken to coincide with these sections.

Final cross-sections, or DTMs, are required on all borrow pits and material pits.

Sec. 9.07 Federal Aid State Force Account Projects

Finals on Federal Aid State Force Account Projects are to be taken up in the same manner as regular contract projects.

Sec. 9.08 Non-Federal Aid State Force Account Projects

If deemed necessary by the District Construction Engineer, finals can be taken on this type project and specific information obtained.

Sec. 9.09 Minimum Plan Projects

A Minimum Plan Project is to be handled the same as the Plan Quantity Project, except that cross-sections or DTMs are **not** necessary.

Sec. 9.10 Submitting Survey Data

As soon as the final survey is completed, the Survey Supervisor should send to the District Survey Parties Engineer all notebooks and Inspector's records which are in his possession. The District Survey Parties Engineer will then transmit these books to the District Design Unit.

Figure 9-A

VIRGINIA DEPARTMENT OF TRANSPORTATION

POST CONSTRUCTION MANUAL
(IMPERIAL & METRIC)

PREPARED IN THE OFFICE OF THE
STATE CONSTRUCTION ENGINEER

REVISED AND REISSUED
1997

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INTRODUCTION

Guidelines for the Review and Preparation of Final Estimates

INTRODUCTION:

The review and preparation of final estimates requires the coordinated effort of the Location and Design, Construction, Fiscal, Internal Audit, Structures and Bridge, and Materials Divisions. However, it is basically the responsibility of the District Administrator to utilize the District Design Units as the primary sources in completing Final Estimates. This responsibility was assigned to the District Engineers in a joint memorandum (dated May 7, 1964) by the Director of Engineering and the Director of Operations.

The objective in preparing a final Estimate is to determine that the records present a factual representation of the work done by the contractor on a project. It is necessary to determine that all work was done in accordance with the plans and specifications (including authorized changes), and that all required documentation of records is available and included in the final assembly.

It is the intent of these guidelines to establish uniformity in the review and preparation of these estimates. As in every operation of this nature, there exists some variation in district operational procedures; however, these differences should not vary from the basic principal and flow as presented herein.

In certain instances, the nature of the project (complexity, size, or an unusually large number of items included in the contract) will require some deviation from regular procedure in order to meet the date for final payment. Such deviations should occur only when the procedures outlined herein will cause an untimely delay, and then they must be evaluated to assure that the validity of the estimate will not be jeopardized. Any deviation from prescribed procedures must be documented and be included in the project files.

PRE PROJECT ACCEPTANCE:

Time becomes a critical factor in the final estimate and project review because final monies become due within ninety (90) days after project acceptance from the contractor. It is essential that every effort be made to complete as much work as possible prior to the Department's acceptance of the project.

Consideration is to be given to the following:

(A) EXCAVATION

(1) Payment on Plan Quantity Basis

Upon receipt of Slope Stake Notebooks, the District Design Unit should check the Levels and Cross-section Notes for those locations to be covered by Final Cross-sections (i.e., entrances, channel changes, borrow pits, etc). From there, the District Design Unit should plot and check sections and save the information for use when further data is available.

(2) Payment on final Cross-section Basis

Upon receipt of Slope Stake Notebooks, all centerline levels and cross-section notes (in addition to those items outlined in A(1) above) should be checked. Plot and check cross-sections and save the information for use when further data is available.

When possible, Final Cross-sections are to be taken as work on the project progresses and it shall be the responsibility of the Resident Engineer to assure that the field notes on all items are transmitted to the District Office for checking and incorporation into the Final Estimate.

(B) BRIDGES AND CULVERTS

"As-built" plans are needed for all bridge projects and special design box culverts. The project inspector shall prepare "as-built" plans or other records as designated, showing the dimensions of the parts of the structure that were changed during construction. This generally consists of excavation, pile lengths, footing depths, column lengths and reinforcing steel weight. The dimensions which differ from the plans should be converted into computed quantities (decrease or increase) by the Inspector. The district Structure and Bridge office will prepare "as built" plans from the information and "as-built" plans furnished by the inspector.

When bridges and box culverts are completed prior to other items of contract work, data should be promptly forwarded to the district office. Upon receipt of this data, the District Structures and

Bridge Engineer or Transportation Engineering Program Supervisor should proceed immediately to have these items verified in accordance with current directives listed within these guidelines.

(C) MISCELLANEOUS

While conditions and circumstances vary from project to project, the winter months often provide an opportunity for checking notebooks before final acceptance. For example, contract work may be complete, other than the final surface course or surface treatment, but is placed under shutdown for the winter while acceptance has already been made of the completed items of work. Bridges may be complete except for minor items of finish work not affecting the tabulation of quantities. In these situations, virtually all detail checking can be completed without having to be redone after acceptance. It will be the responsibility of the Resident Engineer to advise the District Administrator of any circumstance requiring accelerated operation.

DISTRICT PERSONNEL

DISTRICT SURVEY REVIEW AND PREPARATION PROCEDURES:

BORROW PITS

Borrow pits must be cross-sectioned, prior to topsoiling the borrow pit, using the same base line stations and benchmarks used in staking out the borrow pits. Cross-sections must be taken which insure an accurate computation of the volume of material removed. If it becomes necessary to take a final cross-section at a point not covered by an original ground section, an original ground section must be interpolated and shown in the proper space in the Original Level Notebook. Furthermore, the actual beginning and ending of excavation must be shown. In the case of more than one borrow pit, the pits must be numbered to correspondence with the number used in staking them out.

On projects requiring small quantities of borrow material and where actual measurements are difficult to obtain, payment may be made for as "load count measurement" as indicated in section 109.01 of the specifications. This applies, in particular, to "Minimum or No Plan" projects.

CONTRACT SURVEYING

The Contractor's field books as noted in the special provision, are to be turned in to the Project Inspector prior to making 100% payment for construction surveying.

DISTRICT DESIGN UNIT-REVIEW AND ESTIMATE PREPARATION PROCEDURES

An Engineer Technician Supervisor or Designer shall be assigned the direct responsibility for the preparation of a final estimate. This individual and subordinates or consultant shall review the construction plans, including all revisions, contract documents, special provisions, supplemental specifications, work orders, FHWA inspection reports, Material Division depth checks, and noncompliance of material reports, and any correspondence or other reports affecting payment for work and materials on the project. Particular note shall be made of the edition of specifications and standards governing project construction.

With guidance from the Engineer Technician Supervisor, or Designer, an Engineer Technician will generally function as a line supervisor, and they, with the assistance of technicians, will perform the necessary operations in the final review and estimated preparation process. Among the more significant are:

a) *Check survey level and cross-section notes. Check for completeness of coverage.

b) *Utilizing the electronic line plotter; plot cross-sections required by regular excavation projects. Check slopes for tolerances as required by the Road and Bridge Specifications, Section 303.

c) *Compute and check earthwork volumes. The most practical and advanced methods shall be used to determine areas and volumes, programmable computers, etc. However, when conditions dictate the use of planimeter, the areas shall be rechecked and any readings resulting in differences greater than one percent shall be rerun to insure that the area used will reflect the most accurate reading possible.

d) Check project records and "As-built plans against contract, plans, work orders, standards, Road and Bridge specifications, etc. for compliance in execution of work.

*Not applicable on "Minimum or no Plan" projects.

e) Review all geometric sketches shown in the work books, diaries, and/or "As-built" plans to assure that dimensions have been to achieve the desired degree of accuracy in computations of quantities.

f) Check all mathematical formulas and computations for correctness and accuracy.

g) Review diaries for content and sufficiency of records as outlined in Appendix C of the Construction Manual. (CIM)

h) Check the transfer of all items from diaries and/or "As-built- plans against the summaries or daily record of quantities. Check the totals of all summarized items.

i) Verify that documents of items paid for on a tonnage (metric ton) basis are in compliance with current procedures outlined in the CM-Appendix C and the Manual of Instruction Materials Division, Chapter VII, (MOI-MD, Ch. VIII).

j) Check the depth measurement Reports of pavement elements for compliance with specified tolerances. Verify deductions and adjustments in accordance with road and bridge specifications, Section 300, and CM-Div. III. Reports for non-compliance should be completed within two weeks of project acceptance.

k) Check reports for noncompliance of materials and then compute price adjustments for noncompliance in accordance with Road and Bridge specifications, MOI-MD-Ch II, and contract special provisions.

l) Verify that materials section has checked all materials notebooks for evidence of sufficient test quantities to cover all materials being shown for payment to the Contractor. Reference material covering this item can be found in the following: MOI-MD, road and bridge specifications, and the Construction Manual.

m) Check all notebooks and records, for certification by the inspector, verification by the Project Engineer or Resident Engineer, as required by CM-Appendix C and MOI-MD, Ch, VIII.

n) Check weigh sheets, Form C-79, (Summary of Time, theoretical and other measurements), loose leaf diaries, and "As-build" plans (as applicable) for signatures in compliance with CM-Appendix C, MOI-MD, Ch,VIII.

o) Prepare a draft of the final estimate.

p) Prepare the tabulation of final versus contract quantities, including work orders and revisions, and reasons for differences between the two. This only applies to projects not covered by the Certification Acceptance Program as indicated by letters from the Location and Design Engineer, dated August 28. 1969.

q) Prepare review of the Final Assembly by separate letter or other acceptable format advising the District Administrator of review findings on the project. This is to include a statement as to the general degree of project compliance with plans and specifications, a comparison of semi-final and final quantities and reasons for variations between the two, work orders and comments concerning the adequacy and accuracy of project records.

r) Assemble all data and supporting documents relative to the results shown on the final estimate voucher for an independent review and check.

s) Verify quantities of work performed by State Forces and make certain that items are clearly separated from those performed by the Contractor.

An independent review and recheck will be performed to assure the thoroughness and accuracy of the initial review. The Transportation Engineering Programs Supervisor will determine the depth and scope of recheck required to assure the validity of the final estimate preparation procedures and the results obtained therefrom.

Upon completion of the recheck, the contractor is to be notified that the Draft Final Estimate is available for review during the ten (10) day period specified in the Road and Bridge Specifications, Section 109. A copy of this notification should be forwarded to the Resident Engineer.

After review of the estimate by the Contractor or upon notification of intent not be review, the following data will normally be forwarded to the District Contract Administrator for assembly, review and signature by the District Administrator.

a) Draft Final Estimate as applicable.
b) Draft Final Assembly.
c) "As-built bridge plans." (Retain for future reference.)
d) Tabulation of price adjustments for noncompliance of materials, if not included in "Review of Final".
e) All materials notebooks, diaries and TL 102A's.

Numbering of records and/or "As-built Roadway Plans" and entry into master file log should be completed as soon as all records are available to the Design Unit. All numbering and log maintenance is to be in accordance with the letter from the State Location and Design Engineer, dated December 5, 1967. Identification of the review and initial check and recheck will be made by notations on all applicable records. Each individual performing a check or original notes, corrections, or a recheck shall note in colored pencil the function performed, the date and his initials. In no case should the same color pencil same color pencil be used for more than one purpose on a particular project. No summaries, sketches, or their records used for payment are to be filed without evidence that all entries and corrections have been checked. Adequate provisions shall be made to preserve and protect project records, "As-built" plans, and records while performing the final estimate and during the retention period thereafter.

Extreme care must be exercised in the time charged by Design Unit personnel to assure that only time actually spent performing activities directly related to the review and preparation of the final estimate is entered as a cost to the project. Unusual occurrences involving charges of time should be properly documented at the time of the occurrence and entered in the project file.

The retention and disposition of construction files have been reviewed with Department personnel and the Federal Highway Administration. It has been concluded that it is in our best interest to retain project records for five years following payment of the final voucher by FHWA. After the five year period, the records may automatically be disposed of by the residences, districts and central office. (Fiscal Division sends out a list of projects that have been vouchered by FHWA).

Based on the requirements of the comptroller and the regulations of the Federal Highway Administration, there are two exceptions which we are listing below:

A. Records required for pending, ongoing or unresolved litigation, audits, or claims. These records must be retained until completion, resolution or settlements.
B. Toll facilities and revenue bond project records must be retained for three years subsequent to the date when the facility becomes operational on a toll free basis.

Divisions, districts and residencies should take immediate steps to dispose of all project records which have been retained for the five year retention period.

Federal regulations will allow the five year retention period to be reduced to three years; however, the Department at this time wants to continue with the five year program. Alter all the records older than five years are disposed of, we will evaluate the desirability of changing the retention schedule to three years after payment of final voucher.

As built plans and materials test reports will continue to be microfilmed centrally and maintained in the central office, as well as the district offices.

In this manual, are many of the major items found on most contracts and which constitute the major portions of costs for most projects. The activities indicated should be performed.

To assist in the indexing of drainage structures for maintenance purposes, the design team assigned to a particular project will prepare a list of drainage structures having an opening of 36 square feet (3.3 square meters) or greater. This opening also applies to multi-lines of culverts, etc. This applies to structures that have been replaced, extended, or otherwise improved, and on which it becomes the Department's responsibility to maintain. Projects that will receive maintenance from cities are not to be assigned a structure number. The information supplied to the District Structures and Bridge Engineer should include the following; location, station and name of stream, street, length, square feet of opening, and type of opening, and type of structure; slab-span, special design, concrete pipe culvert, etc.

PROCEDURES FOR COMPUTING FINAL QUANTITY EXCAVATION BY DATA PROCESSING METHODS

1) Original cross-sections will be used in lieu of Slope Stake cross-sections whenever possible. However, when it is necessary to take Slope Stake cross-sections, the Transportation Engineer in charge of survey will make the notebooks available to the Transportation Engineering Programs Supervisor upon completion of the Slope Stake survey.

2) After reviewing the cross-sections for completeness, the data will then be processed by the District Design Unit.

3) *The District Designer will request edited cross-section data and a digital listing showing error indications.

4) The District Design Unit will correct the listing and resubmit any corrections or update of files. If applicable, survey files will at that time be returned to the Transportation Engineer.

5) *A corrected digital cross-section listing will be obtained. Should plotted original cross-sections be desired at this time, these will be requested by the District Design Unit and plotter information will be developed and supplied by the Richmond Central Office Information Systems Division. (This will be necessary for urban and certain other projects which will use these plotted sections for developing further final data by manual methods.

*Certain elements of these steps will be accomplished by means of on Line Remote Tele-processing terminals.

6) District design personnel will prepare electronic computer input data for the development of Theoretical Digital Roadway Design based on the Slope State survey. This will require either of the following:

    a) Reviewing and updating previously coded data which was used for original design purposes.

b) Complete coding of input data for projects which did not use computer methods in original design.

This work should be accomplished as soon as possible after the corrected cross-section information is available to the District Office.

7) *The District Design Unit will develop and maintain roadway design information in their computer files using Slope Stake survey and input controls as mentioned above.

8) When final survey is completed, the survey files will be received by district design personnel for processing and editing.

9) *The District Design Unit will process and edit final cross-section data and obtain a digital cross-section listing showing the errors.

10) The District Design Unit will make the necessary corrections to the cross-section listing.

11) *The District Design Unit will compute Earthwork Areas and Volumes using slope stake and final cross-section.

12) The Design Unit will prepare plotter data and furnish plotted cross-section information to the District Design Unit for the following:

    a) Original cross-section and/or slope stake cross-section (as applicable)

    b) Final "As Built" Survey

    c) Theoretical design

*In certain urban and other projects the theoretical design cannot be plotted by electronic means and must be added manually. Steps 10-12 above should be completed and data returned to the District Design Unit within 30 days of receipt of the final cross-section survey.

13) *Upon receipt of the data indicated in item 12, the final review unit will proceed to verify the actual final pay quantities as indicated.

*Certain elements of these steps will be accomplished by means of on Line Remote Tele-processing Terminals.

CHAPTER 10.00

GPS SURVEYS & THE STATE PLANE COORDINATE SYSTEM

Chapter Contents

Sec. 10.01	General
Sec. 10.02	GPS Equipment
Sec. 10.03	GPS Networks and Accuracy Standards
Sec. 10.04	General Specifications for GPS Surveys
Sec. 10.05	Quality Control Procedures
Sec. 10.06	Deliverables
Sec. 10.07	LD-200 Card (Rev. 8/00)
Sec. 10.08	Basis of the State Plane Coordinate System
Sec. 10.09	Depiction of Two Coordinate Zones
Sec. 10.10	Relation of Grid North and True North
Sec. 10.11	The VDOT Project Coordinate System

Sec. 10.01 **General**

Recent advances in Global Positioning Systems (GPS) technology have created a tool for surveying that is not only "smaller, lighter and faster" but has the ability to perform geodetic control surveying in a fraction of the time as compared to classical static GPS survey methods. GPS has enabled surveyors the ability to establish control for a project from known existing control that is miles away. Recently, VDOT has utilized GPS for securing control values for primary control as well as photo control. VDOT is exploring other uses of GPS specifically, the use of Real-Time Kinematic (RTK) GPS surveying for photo control, right-of-way and corridor baseline stakeout, and also topographic collection. Other divisions within VDOT are utilizing GPS in one form or another to collect data for their specific needs.

As with any surveying tool, certain guidelines, specifications and methodologies must be adhered to. The intent of this section of the survey manual is to assist the surveyor in the mission planning, collection and processing GPS data for VDOT survey projects. The surveyor should consult the publications, "**Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques, Version 5.0: May 11, 1988**" Reprinted with corrections: August 1, 1989, published by the Federal Geodetic Control Committee (FGCC) and also the "**Standards and Specifications for Geodetic Control Networks**" as published by the Federal Geodetic Control Committee (FGCC), Rockville MD, September 1984. This chapter was prepared heavily in parts, from these NGS publications. VDOT will continue its procedures to generate, via GPS survey techniques, metric state plane coordinates and metric orthometric heights for its Route Survey projects. These values shall be converted to the VDOT Project Coordinates, which are based on the U.S. Survey foot. For more on Project coordinates, see Section 10.07 regarding LD-200 cards in this chapter.

Sec. 10.02 **GPS Equipment**

The GPS geodetic receivers used for static survey operations shall receive both carrier frequencies transmitted by the current constellation of GPS satellites and shall have the capability of tracking a minimum of eight GPS satellites simultaneously. The receivers shall have the capability to receive and decode the C/A code and the P-code data on the L1 frequency and the P-code in the L2 frequency. The receivers should have the means to use the encrypted P-code.

Dual frequency receivers are required for precision surveys to correct for the effects of ionospheric refraction where the magnitude of the error may range from 1 to 10 ppm. The receivers must record the phase of the satellite signals, the receiver clock times and the signal strength or quality of the signal. The phase center of the antenna, which is constant and unique to the antenna model, should be known from the manufacturer. It is best not to use different antenna models during a survey, as the phase center will create a bias in the elevations of survey points. If the receiver does not have a known phase center database relating to antenna type, the user should have the ability to enter the measurement components for the phase center height of the antenna. The measurement components are a measured height above a survey point to a mark on an adapter (or to a corner of the antenna) and the fixed constant distance from an adapter mark to the phase center of the antenna (provided by the manufacturer). **Figure 10-A, Page 10-11,** is an example from the NGS illustrating the different antenna measurements required for different antenna types. ***Fixed Height Tripods are recommended for use during GPS missions to avoid measurement or transcription errors.*** These GPS receivers should be programmable and have several I/O ports. The software should be able to be convert the data to RINEX-2 format for use with other GPS systems and software.

Sec. 10.03 GPS Networks and Accuracy Standards

In general, the GPS Network will consist of known points and all points to be surveyed, allowing loop closures to be calculated from processing procedures utilizing data from a minimum of two sessions that form a loop. A known point would be a point that has a known position and/or elevation. A HARN Station, a CORS site, a NGS vertical station, a USGS monument tied to NAVD88 datum or, especially in VDOT's case, an existing survey station from an existing project, would be considered a known point. A minimum of three known points shall be included in the observing scheme. The three known points should be based on or originate from a common datum. In some cases, it is acceptable to use available software to convert elevations to the NAVD88 datum. The location of the new control points shall depend on the optimum layout to carry out the required needs of the survey.

The "**Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques**", version 5.0 by the Federal Geodetic Control Committee (FGCC), is VDOT's source for the definition of accuracy standards and the specifications and procedures to achieve those standards. When requested, any surveyor performing a GPS survey for VDOT that must comply with an accuracy standard, shall adhere to the standards and specifications as published by the FGCC.

The accuracy standard for the survey will depend on several factors. These factors include, but are not limited to:

- number of receivers available for the project
- the "mission plan" or observation scheme
- satellite availability and geometry
- signal strength
- network geometry
- observation duration

Sec. 10.04 General Specifications for GPS Surveys

In general, this section is intended to be a guide for any surveyor who is providing VDOT with GPS data. These procedures are general minimum requirements that must be met by the surveyor in order for the GPS survey data to be accepted by VDOT. These procedures are for static and rapid static GPS observations and techniques. Please refer to "**Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques**" for more specific criteria not covered here.

1. **GPS Survey Project Datum.** Unless otherwise instructed, **ALL VDOT GPS CONTROL SURVEYS SHALL BE REFERENCED TO THE CURRENT PUBLISHED NATIONAL SPATIAL REFERENCE SYSTEM (NSRS) ADJUSTMENT AND THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) SHALL BE THE ELEVATION DATUM.** Only horizontal NAD 83 coordinates and control data observed by GPS methods from reference stations included in the NSRS will be accepted by VDOT. The NSRS contains GPS stations and data published from the following network observations: Continuously Operating Reference Stations (CORS), Federal Base Network (FBN) surveys, Cooperative Base Network (CBN) surveys, Area Navigation Approach (ANA) airport surveys, and "Blue-booked" User Densification Network (UDN) GPS surveys.

2. **GPS Network Control Procedures.** All GPS Network Control and Field Survey procedures will conform to the standards as defined in this section, for routine VDOT surveys, shown hereon as **2a** through **2o**. The intent of these procedures is to produce GPS surveys and data for the **Project Control Monumentation** that meets a geometric accuracy of 1:100,000 at the 68% confidence interval. A list of specifications is included as **Figure 10-O, page 10-25**, for easy reference.

2a. A minimum of three (3) GPS receivers shall be used simultaneously during all Static & Rapid Static GPS sessions.

2b. Existing or known points that will be used to control the survey shall be occupied simultaneously during the initial observation sessions. This is a check to ensure that existing, known or network control has not been disturbed and that the published values are, indeed correct. This is an integral part of the mission plan.

2c. Horizontal networks shall be connected to a minimum of two (2) NGS B-order (or higher) stations (see #1 of this section). At least one benchmark shall be used and held fixed for surveys where horizontal values will be paramount. The use of eccentric horizontal stations is not permitted.

2d. Vertical networks shall be connected to a minimum of three (3) third-order (or higher) bench marks. At least two of the benchmarks shall be near the project boundary to help determine the geoid separation of the project area.

2e. Sight (or station) pairs that are to be established by GPS methods to provide azimuths for the survey shall be inter-visible and spaced no less than 600 feet apart. Azimuth pairs that are to be established by GPS methods shall be spaced approximately one mile apart at a minimum and no more than 3 miles apart. Each sight (or station) pair and each azimuth pair shall be occupied at least **twice** simultaneously and separated by a minimum of one-half hour to create a redundant, direct connection between project control points. A sample network scheme is included as **Figure 10-B, Page 10-12**.

2f. For each session, a minimum of 5 satellites shall be observed simultaneously. The Geometry Dilution of Precision (GDOP), shall never be greater than 6 at any time during the observation session. The Position Dilution Precision (PDOP) shall never be greater than 4 at any time during the observation session. Acceptable GDOP & PDOP values can be achieved through good mission planning practices and utilization of mission planning software.

2g. For each session, data sampling shall have an epoch time interval of 5 seconds for Rapid Static survey procedures and 15 seconds for Static survey procedures. Satellite signals shall be observed from a minimum of 2 quadrants that are diagonally opposite from each other during Rapid Static survey missions. Satellite signals shall be observed from a minimum of 3 quadrants during a Static survey mission. This requirement shall be met while monitoring data collection in the field. It will also be verified by the GDOP value.

2h. Satellite receivers and processing software shall be programmed such that any satellite data below an elevation mask of 15 degrees shall not be used in the processing of baseline vectors. Any data below the 15-degree elevation mask would be questionable due to effects of atmospheric refraction.

2i. During reconnaissance and each observation session, careful notes or obstruction diagrams (see **Figure 10-C, Page 10-13**) shall be recorded for any obstructions that are 20 degrees or higher above the horizon. Proper mission planning can minimize the effects of any obstructions and maximize the opportunity for a productive observation session.

2j. The geoid model used shall be the **1999 Geoid Model**. This version shall be the model used for determining the geoid separation for each project control point and subsequent elevation.

2k. The ellipsoid model, used for determining elevation of the ellipsoid, shall be the **WGS 1984** ellipsoid model.

2l. VDOT requires that the final adjusted coordinates for the GPS project shall be the product of a three-dimensional least squares adjustment software package.

2m. Static observation procedures shall be required for all baselines with a length of 20 kilometers (km) or longer. For a baseline length between 20 and 50 kilometers, observation sessions shall be at a minimum, 2.5 hours plus one minutes per kilometer of baseline length for that session. For a baseline length between 50 and 100 kilometers, observation sessions shall be at a minimum, 3.5 hours plus one minute per kilometer of baseline length for that session. Proper mission planning and point site selections are vital to the success of the observing session.

2n. Rapid Static observation procedures shall be required for all baselines shorter than 20 kilometers (km) in length. Observation sessions shall be at a minimum, 10 minutes plus one minute per kilometer of baseline length for that session. Proper mission planning and point site selections are vital to the success of the observing session. From a conservative standpoint, it is strongly recommended to add additional time to minimize the effect of solar activity, atmospheric refraction and unhealthy satellites.

2o. Determination of observation duration will be a function of the spacing of known control, distance of known control to survey project control, and the length of the project corridor. Again, if control is farther than 20 kilometers from the project, static observation procedures will control.

3. **Securing Photogrammetry Control.** Securing control for photogrammetry will also follow the same guidelines as listed above. If control is nearby, the photogrammetry mission can be accomplished with rapid static observation procedures using "leap-frog" or traversing techniques through the control such that direct measurements are made between consecutive targets. Intermittent ties to the existing, known control and/or the monumented project control should be made during the mission. Proper mission planning techniques will develop the best results and checks for the mission. **The adjustment of photogrammetry control should be independent of the VDOT Project Control Monumentation adjustment.**

4. **Utilizing RTK GPS on VDOT Projects.** At the time of this revision to the Survey manual, VDOT is currently investigating the potential advantages and disadvantages in the use of Real-Time Kinematic (RTK) GPS surveying equipment, capable of achieving a 2-cm positional accuracy. Therefore, VDOT has not developed any guidelines or specifications for RTK GPS surveying procedures. RTK GPS survey techniques for securing photo control and topography will be acceptable to VDOT. Prior to securing photo control, the surveyor shall have a base unit set on known control and shall check the values at another control point with the roving unit. The surveyor must provide proof of photo control points being measured at least twice by RTK methods, spot-checked by conventional survey methods, and that the positional differences are insignificant. The surveyor shall verify that the positional accuracy meets or exceeds the survey specifications. Any questions regarding field procedures may be directed to VDOT's Geodetic Surveys Engineer.

Sec. 10.05 Quality Control Procedures

This section of the Survey Manual will assist the surveyor with the minimum field practices to ensure quality GPS survey data for VDOT. As with any high-tech measuring device, certain standards of care should be enforced in the use and maintenance of the equipment. The following are a few of the procedures that are followed by VDOT surveyors to help minimize positioning and field errors and ensure a good quality with the field collected data.

a. The tribrach, for each unit, should periodically be checked so that the antenna is being centered accurately over the point. This can usually involve adjustment of the optical plummet and, in the worst case, the spirit level.

b. Care should be taken when setting a control monument or station, (see **Figure 10-D, Page 10-14**) so that the effect of obstructions or canopy can be minimized. The monument and disk, or iron pin should be set according to normal VDOT procedures.

c. A site log form (see **Figure 10-E, Page 10-15**) has been developed by VDOT for VDOT surveyors to corroborate data entered into the receiver. One site-log form shall be filled out for each receiver for each occupation. The pertinent data includes: the date, observer, receiver #, station occupied (name), beginning antenna height, the antenna offset, session start time, start intermediate and end minimum QI & satellite number, end session time, end antenna height and comments. The form is self-explanatory. It is the responsibility of the surveyor operating the receiver to complete each form. The QI is the Quality Index of the satellite signal being received from each satellite. Regarding VDOT's equipment, Leica System 300, a value of 99 is best. Regarding Leica's System 500, a QI of 99 is best and anything below 92 is unacceptable. The norm for this system is either 99 or 92. VDOT requires knowledge of which value is lowest and from which satellite. This knowledge will assist with processing baselines later on. The comment section is for the surveyor operating the receiver to describe any problems affecting the satellite data or satellite signal received.

d. The antenna height will be measured in meters. Measurements for antenna height shall be taken at the beginning and end of each session. If a station is to be occupied simultaneously through more than one session. The antenna will be reset over the station and a new antenna height at the beginning and end of each session will be measured. **It is the responsibility of the surveyor to insure that the antenna height measured in the field is recorded correctly on the site log form and entered correctly into the receiver.** Please refer to **Figure 10-A, Page 10-11**, for assistance with the components of the antenna height measurements.

e. Prior to every new project, the memory card of the receiver should be formatted (or cleared) once it has been definitely proven that the data has been downloaded and saved. It shall be the priority of the person who downloads the mission data to clear the cards of data only after a successful download and back up has been verified. Verification of a successful download will consist of examining mission data for session times, antenna height, and baseline quality and saving the data to another source or location.

f. Two-way radios shall not be used within 25 feet of the GPS receiver. Vehicles will be parked a minimum of 50 feet away from the GPS receiver.

g. Every member of the GPS survey mission should know his or her responsibilities, session starting and ending times, station locations and basic operation of the GPS equipment.

Sec. 10.06 **Deliverables**

All GPS “subject data” for VDOT contracted surveys (either primary control or photogrammetric control) shall be delivered to VDOT’s Geodetic Surveys Engineer for a quality control check and evaluation. This information will be delivered to the Geodetic Surveys Engineer **<u>before</u>** the entire VDOT survey is due.

The subject data that is to be delivered to the Geodetic Surveys Engineer shall include, at a minimum, every item on the list depicted below.

a. A sketch, on 8 ½” X 11” sheet of paper, containing the known network control points (NGS, USGS, etc.) and the project control, with ID’s.

b. A copy of data sheets published for each known network control point used in the adjustment. This data sheet shall include station name, Geographic Coordinates, ellipsoidal heights, orthometric heights, published state plane coordinates, “how to reach” descriptions and point description. A copy of an NGS data sheet is acceptable for the known control points. The same format is acceptable for the project control points. Photogrammetric control points shall be identified on the project control sketch **only**. Descriptions or measured swing-ties for photo control **shall not** be included or delivered to VDOT’s Geodetic Surveys Engineer.

c. A constrained three-dimensional adjustment report showing the latitude and longitude of all horizontal points, all benchmarks, and all ellipsoidal heights held fixed shall be delivered to VDOT’s Geodetic Surveys Engineer. The report should depict how the adjustment affects each point and the residuals of each baseline vector.

d. A listing of final adjusted geographic coordinates, ellipsoidal heights, and geoid separations for each station, including stations held fixed. The final adjusted geographic coordinates shall be listed with their respective positional error.

e. A listing of final adjusted metric state plane coordinates with orthometric heights, including stations held fixed.

f. All copies of site log forms, either VDOT's **OR** a similar form, as prepared by field surveyors.

g. All copies of any obstruction diagrams **(Figure 10-C, Page 10-13)**, if not included with site logs.

h. A copy of the mission plan. This mission plan will include session times, occupation duration and types of receivers used with manufacturer's standard antenna phase-center offset included.

i. A one-page summary of the GPS mission. The report should include:

- reasons for fixing and floating stations,
- evaluation of adjustment results,
- total man-hours spent by crew and processor and overall assessment of the mission and performance of equipment.

j. All completed LD-200 cards (latest version, see **Figure 10-F, Page 10-16**).

k. One copy of original GPS raw data (either on 3 ½" HD diskette or CD) in Leica or RINEX-2 format.

Sec. 10.07 **LD-200 Card (Rev. 8/00)**

As of 7/01/99, VDOT reverted to preparing surveys and design plans in imperial units, using the **U.S. Survey Foot**. This meant revisions to the survey manual. It also meant revising the LD-200 card. GPS has become a major tool for surveyors. The old LD-200 card did not have enough supporting data for a surveyor to use. Some new revisions include: adding Latitude and Longitude (out to 5 decimal places), the Geoid and ellipsoid heights, control station or VDOT project station that adjusted values are based on, horizontal closure and the sketch and detailed description (on back of printed version, below on electronic version). This new LD-200 Horizontal Control card (see **Figure 10-F, Page 10-16**) will help the surveyor by giving more background knowledge of the coordinate origin and inspire more surveyors to turn in an electronic version of the card and data. The card is a cell in the Microstation cell library (see **Appendix A**).

Sec. 10.08 **Basis of the State Plane Coordinate System**

To make full use of the State Plane Coordinate System, one must understand how the plane coordinates of any given point are directly related to the geodetic coordinates (latitude and longitude) of that point. First, it should be understood that the latitude of a point is the angular difference between that point and the equator. The longitude of a point is the angular difference between that point and the zero meridian, which arbitrarily passes through Greenwich, England. Virginia is divided into two (2) Lambert Conformal Conic Projection zones, North and South. The dividing line runs along latitude of 38˚. **The Code**

of Virginia §55-288.1 divides the zones along the county lines, as listed on **Figure 10-G, Page 10-17**. A point is positioned using GPS methods and the position is referenced to a geodetic coordinate system, latitude and longitude. The Geodetic Coordinates are directly related to the Virginia State Plane Coordinate System by definition in **The Code of Virginia §55-292** (see **Figure 10-H, Page 10-18**).

For example, if we need to define a point in Louisa, Virginia, the latitude can be defined as the angular difference between that point and the equator as shown in **Figure 10-I, Page 10-19**. Similarly, the longitude can be defined as the angular difference from Greenwich, England, as shown in **Figure 10-J, Page 10-20**. This point would be defined as 38^{O} North latitude and 78^{O} West longitude. This would relate our point in Louisa, Virginia to any other point on the surface of the earth. This is a very precise and universally accepted method of defining positions on the surface of the earth. However, while the system of geodetic coordinates is precise, the computations associated with them are unnecessarily complex when one is dealing with a relatively small area on the face of the earth, and it becomes expedient to establish a simpler model of the earth while still maintaining acceptable accuracy. This can be accomplished by utilizing the VDOT State Plane Coordinate System, which is based on NAD83 coordinate values.

This plane coordinate system allows the use of relatively simple theories and formulae of plane geometry and trigonometry used by surveyors since the beginning of history for the measurement of land and structures on the earth's surface.

The interstate highway system that we enjoy today is one of the prime contributing factors to the establishment of the Virginia State Plane Coordinate System and similar systems employed by all the other states in the United States. State and Federal engineers agreed that plane coordinate systems would be established to allow accurate surveys to be performed, which with the proper corrections applied, would be accurate, nationwide. In addition, the various zones in these systems would be small enough so that if no corrections were applied, positional accuracy within the respective zones would exceed 1 part in 10,000.

Sec. 10.09 Depiction of Two Coordinate Zones

Figure 10-K, Page 10-21 is a graphic representation of the State of Virginia showing the two coordinate systems. Refer to the Virginia South Zone and note that the line intersects the surface of the earth at two points similar to the to the way the long chord of a curve intersects the P. C. and P. T. of that curve. Likewise, the distance along the line from 36^{O} 46' to Point A would be shorter than the distance along the arc from 36^{O} 46' to Point A. The relationship between these two distances would give us a scale factor to apply to distances measured along the arc to reduce them to distances along the line. At 36^{O} 46' and 37^{O} 58' these corrections would be expressed as 1.0000000 multiplied by the distance measured. As you move to the center of the zone this factor decreased to 0.9999454. As you proceed South from 36^{O} 46' to the North Carolina line, the correction increased to about 1.0000464. You will note that this variation from high to low gives a possible difference in 1000 feet of 0.10 feet, which was the required accuracy for the coordinate system. This basic idea holds true for the Virginia North Zone.

Sec. 10.10 **Relation of Grid North and True North**

All lines or meridians of longitude run through the North and South Pole. Therefore, they cannot be parallel. The central meridian for the State of Virginia is 78^{O} 30' West longitude for both the North and South Zones. This means that throughout both zones grid north is exactly parallel to the 78^{O} 30' West longitude, central meridian. The angular difference between the true north and grid north is called the θ (theta) angle. **Figure 10-L, Page 10-22)** shows this graphically.

Sec. 10.11 **The VDOT Project Coordinate System**

The VDOT Coordinate System is based on **NAD83 METRIC values** as defined in **The Code of Virginia §55-292** (see **Figure 10-H, Page 10-18**). To convert NAD83 METRIC to VDOT Project coordinates (Imperial Units), first depending on the zone you are working in, subtract 1,000,000 meters from the South Zone Northing value (or 2,000,000 meters from the North Zone Northing value). Next, subtract 2,500,000 meters from the Easting value. Next, multiply the Northing and Easting values by 3.28083333333 (the conversion for the U. S. Survey Foot as defined in **The Code of Virginia §55-290,** see **Figure 10-M, Page 10-23**). Last, multiply the Northing and Easting values by the Combined County Scale & Elevation Factor. **Figure 10-N, Page 10-24** is a list of the combined scale and elevation factor for the counties. This produces VDOT Project Coordinates (in Imperial Units) for a given project. A reverse of this procedure will transform VDOT Project Coordinates back the original NAD83 METRIC values. See **Figure F, Page 10-16,** showing the use of the above procedures as depicted on a LD-200 Horizontal Control Station Reference Card.

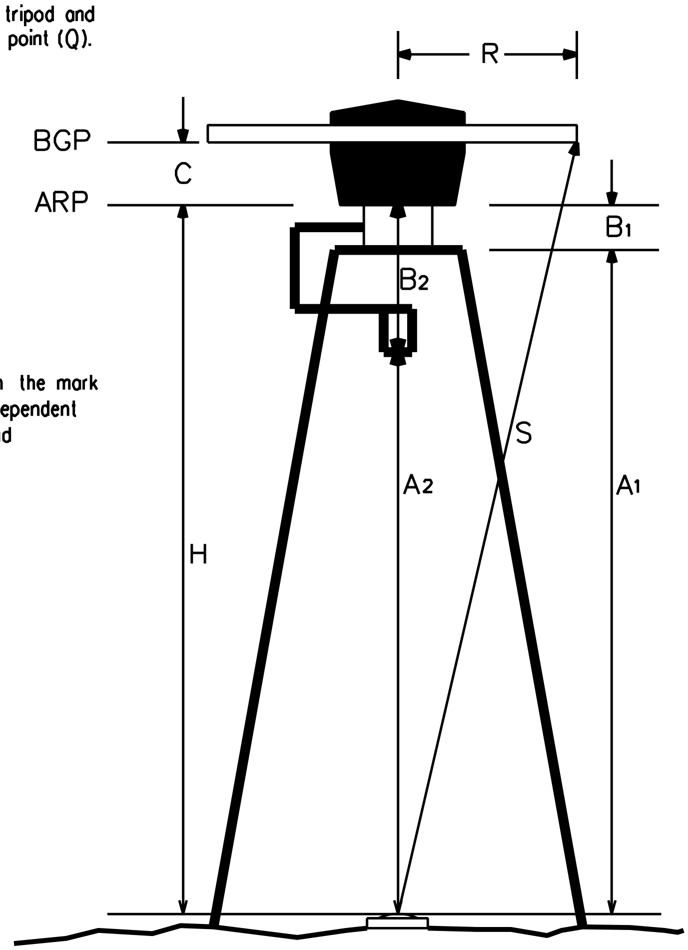
Figure 10-A

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:

I. Instructions for Fixed-Height Tripods:

Measure & record the length (A) and other offsets, if any, between the tripod and Antenna Reference Point (ARP) (B) and/or between the tripod and datum point (Q).

Antenna Height = $H = A_1 + B_1 - Q$



II. Instructions for Slip-Leg Tripod:

NOTE: For Leica measuring hooks, use the instructions below.

Leica Measuring Hook = $H = A_2 + B_2$

1. Measure the Slant Height

Before and after the observation session, measure the slope distance from the mark at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g. metric and imperial). Record measurments in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm				
Before, inch				
After, cm				
After, inch				
Note: cm = 1inch x (2.54)		Overall average, cm		

S = ______________ cm

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius is the horizontal distance from the Antenna Reference Point (ARP) to the measurment notch. The antenna constant is the vertical distance from the ARP to the BGP. See your Antenna specification manual for exact measurments.

R = ______________ cm

C = ______________ cm

3. Compute Antenna Height (H)

Use the following Pythagorean formula:

$$\text{Antenna Height } H = ((\sqrt{S^2 - R^2}) - C) - Q$$

Detail of Mark

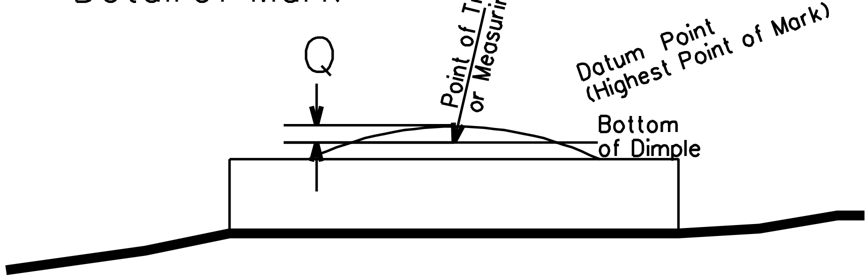
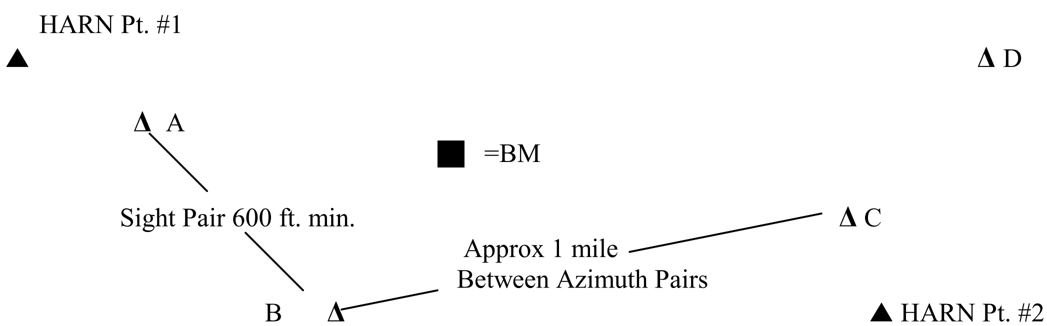


Figure 10-B



A,B,C,D = VDOT Route Survey Control Points; Coordinates to be Determined
HARN #1 to HARN #2 = 17 km ■ = BM on NAVD88 datum; GDOP = 2.5; 6 Satellites
HARN Points Have Known X, Y & Z Values

Observation Session #1, 4 Receivers, Duration 30 Minutes Minimum, Use Rapid Static Procedures, Occupy HARN #1, HARN#2, BM & A.

Observation Session #2, 4 Receivers, A-C = 3 km, Duration 15 Minutes Minimum, Use Rapid Static Procedures, Occupy BM, A, B & C.

Observation Session #3, 4 Receivers, B-D = 3 km, Duration 15 Minutes Minimum, Use Rapid Static Procedures, Occupy B, C, D & BM.

Observation Session #4, 4 Receivers, Duration 30 Minutes Minimum, Use Rapid Static Procedures, Occupy HARN #1, HARN#2, BM & D.

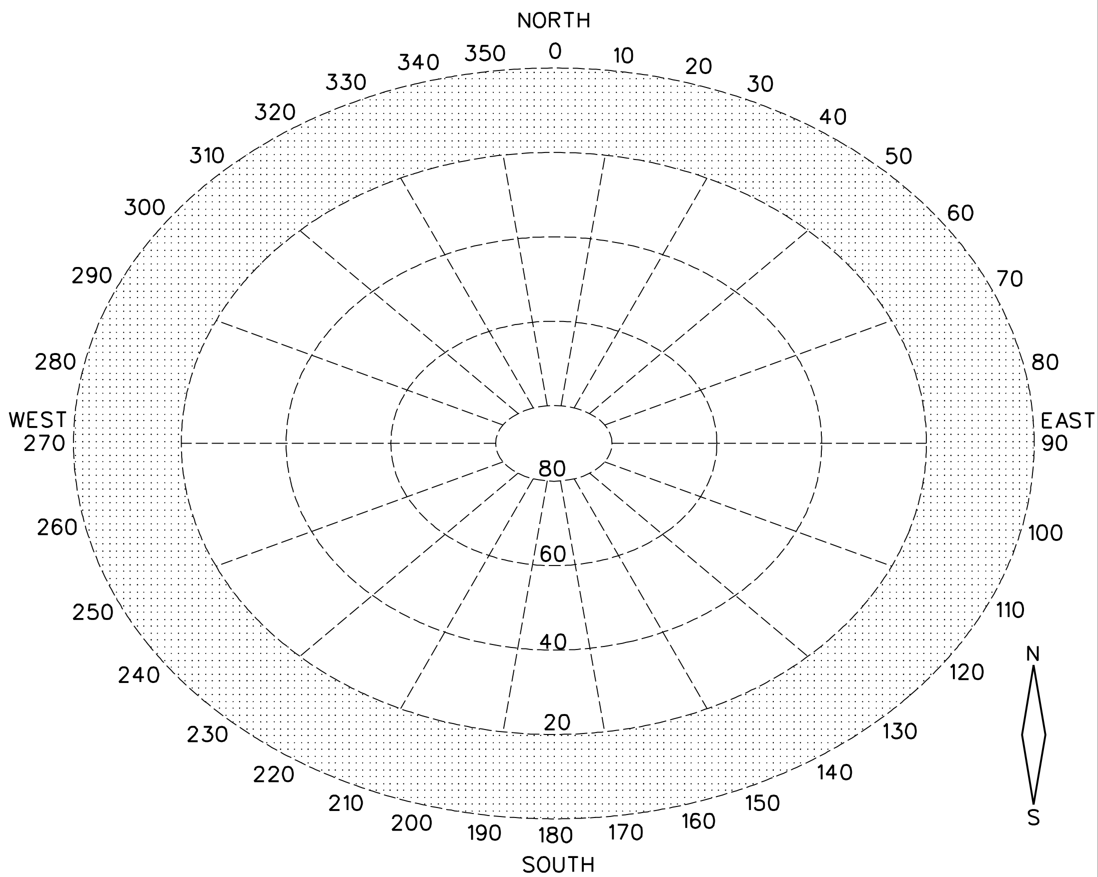
Observation Session #5, 4 Receivers, Duration 15 Minutes Minimum, Use Rapid Static Procedures, Occupy A, B, C & D.

Figure 10-B is an example of one observing session scheme. This illustrates one way to design a mission, but a mission is not limited to one scheme to accomplish the same results. An observing scheme should be developed to meet your specific accuracy standard criteria. The best source of information to develop observing session scheme or mission plan is "**Geometric Geodetic Accuracy Standard and Specifications for Using GPS Relative Positioning Techniques**". FGCC ver. 5.0 8/19/89.

Figure 10-C

GPS 610

GPS SATELLITE VISIBILITY OBSTRUCTION DATA SHEET



ACRN ____________________

OLD\OSN ____________________

ELEVATION ____________________ m / f

LATITUDE ____________________ N / S NAD27

LONGITUDE ____________________ E / W NAD83

STATION NAME ____________________

____________________ DATE

____________________ ORGANIZATION

____________________ MAP SCALE

____________________ MAP SHEET

____________________ OBSERVER

Observer's height at time of observation ________ ft. / in. / m

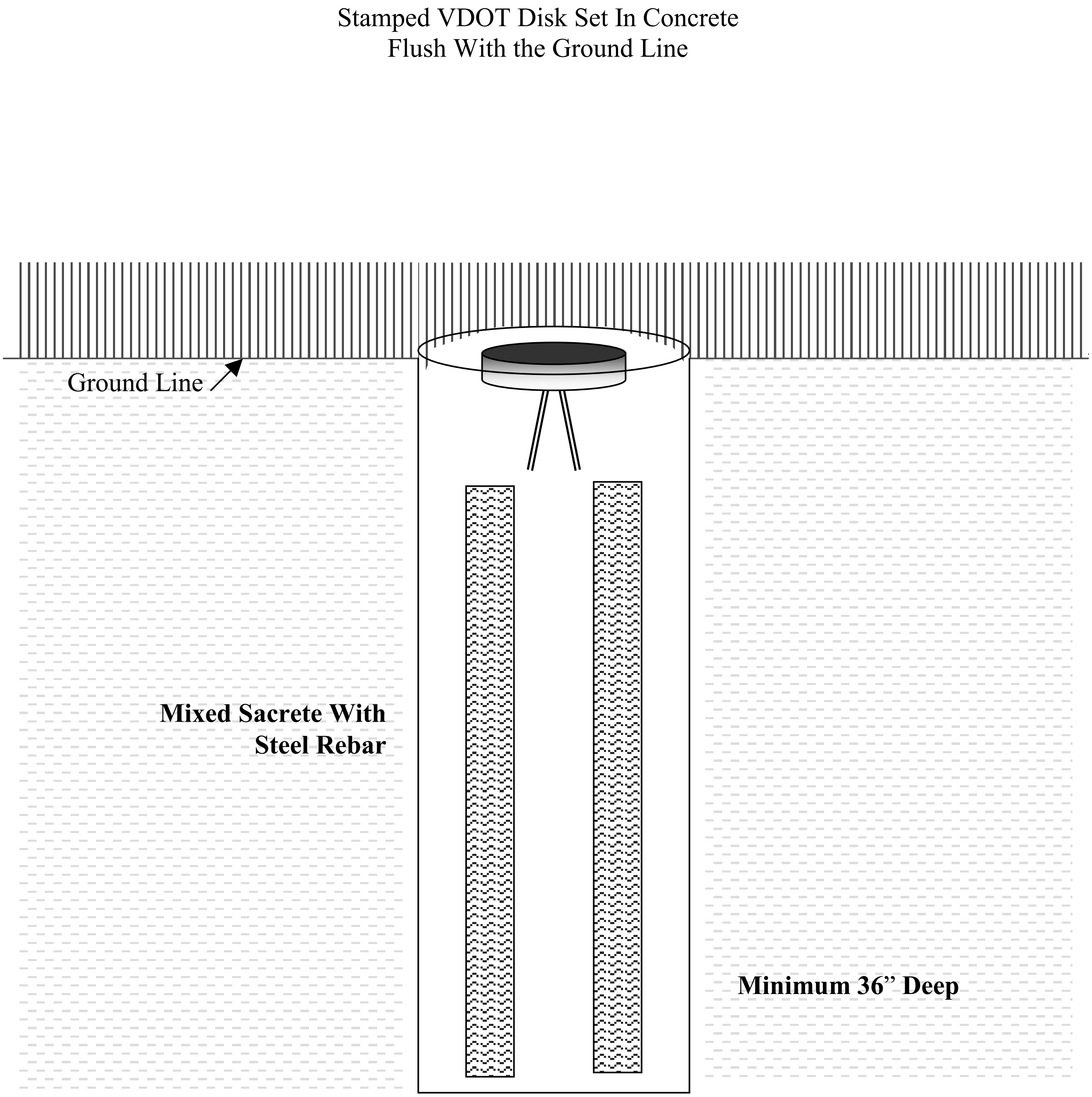
NOTES:

Indicate distance, direction, frequency, and power of known RF sources.

Show peripheral marks and required ties.

Show the distance to the nearest edge of all obstructions over 20° and\or indicate antenna height needed to clear obstructions at 20°.

Figure 10-D



Stamped VDOT Disk Set In Concrete
Flush With the Ground Line
Ground Line
Mixed Sacrete With
Steel Rebar
Minimum 36" Deep

Figure 10-E

VDOT GPS SITE LOG

DATE: ________________ **OBSERVER:** ________________________________

RECEIVER NUMBER: A B C D ( )

STATION NUMBER (NAME): ______________________________________

BEGINNING ANTENNA HEIGHT: _________________________ m
(Check Using Imperial Measurement): ___________________ ft

ANTENNA OFFSET: 0.441 m
(If sensor is not Leica SR399) ANTENNA OFFSET: ____________________ m

START SESSION TIME: ____________________________

START MINIMUM Q. I. READING: ____________ **Sat. Number** _________

INTERMEDIATE MINIMUM Q. I. READING: _____________ **Sat. Number** _________

END MINIMUM Q. I. READING: ________________ **Sat. Number** ___________

END SESSION TIME: ________________________________

END ANTENNA HEIGHT: ____________________________ m
(Check Using Imperial Measurement): ___________________ ft

COMMENTS

Figure 10-F

LD-200 (Rev. 8 / 2000)

Virginia Department of Transportation Horizontal Control

Control Station ID _____ Project _____

Route _____ City/County _____

Established By _____ Date _____-_____-_____

Vertical Datum Based On _____ Geoid ☐ 96 or ☐ 99

Horizontal Datum Based On _____

Azimuth to Station _____

Latitude: _____ N (5 decimal places)

Longitude: _____ W (5 decimal places)

Geoid separation (N): _____ Ellipsoid Height (h): _____ (WGS 84)

Control Based on: Station (name or PID) _____ or

Project (monument no.): _____ Order: _____

Virginia State Plane Coordinates > NAD 83 Metric Values

East (X) _____m

North (Y) _____m

Ortho. Elev. _____m

V. D. O. T. Project Coordinates

☐ **English** ☐ **Metric** (check one)

East (X) _____

North (Y) _____

Elevation _____

Zone **North** ☐ **South** ☐

Horizontal Closure _____

To convert state plane metric units to VDOT project values, use the following formula:

1. Reduce the Easting Metric Values By 2. 5 Million Meters. The South and North Zone Northing Metric Values By 1 and 2 Million Respectively
2. Multiply These Values by the U. S. Foot (3. 2808333333)
3. Multiply These Values by Combined Scale and Elevation Factor (1._____) for the county.

A Reverse of this Procedure will Transform VDOT Project Coordinates to NAD 83 Values.

Sketch and Detailed Description on Other Side

Detailed Description:

Sample Horizontal Control Card "LD-200"

Figure 10-G

§ 55-288.1. North and South Zones.

For the purpose of the use of these systems, the Commonwealth is divided into a "North Zone" and a "South Zone."

The area now included in the following counties and cities shall constitute the North Zone: the Counties of Arlington, Augusta, Bath, Caroline, Clarke, Culpeper, Fairfax, Fauquier, Frederick, Greene, Highland, King George, Loudoun, Madison, Orange, Page, Prince William, Rappahannock, Rockingham, Shenandoah, Spotsylvania, Stafford, Warren and Westmoreland; and the Cities of Alexandria, Fairfax, Falls Church, Fredericksburg, Harrisonburg, Manassas, Manassas Park, Staunton, Waynesboro, and Winchester.

The area now included in the following counties and cities shall constitute the South Zone: the Counties of Accomack, Albemarle, Alleghany, Amelia, Amherst, Appomattox, Bedford, Bland, Botetourt, Brunswick, Buchanan, Buckingham, Campbell, Carroll, Charles City, Charlotte, Cheterfield, Craig, Cumberland, Dickenson, Dinwiddie, Essex, Floyd, Fluvanna, Franklin, Giles, Gloucester, Goochland, Grayson, Greensville, Halifax, Hanover, Henrico, Henry, Isle of Wight, James City, King and Queen, King William, Lancaster, Lee, Louisa, Lunenburg, Mathews, Mecklenburg, Middlesex, Montgomery, Nelson, New Kent, Northampton, Northumberland, Nottoway, Patrick, Pittsylvania, Powhatan, Prince Edward, Prince George, Pulaski, Richmond, Roanoke, Rockbridge, Russell, Scott, Smyth, Southampton, Surry, Sussex, Tazewell, Washington, Wise, Wythe, and York; and the Cities of Bedford, Bristol, Buena Vista, Charlottesville, Chesapeake, Clifton Forge, Colonial Heights, Covington, Danville, Emporia, Franklin, Galax, Hampton, Hopewell, Lexington, Lynchburg, Martinsville, Newport News, Norfolk, Norton, Petersburg, Poquoson, Portsmouth, Radford, Richmond, Roanoke, Salem, South Boston, Suffolk, Virginia Beach, and Williamsburg.

Figure 10-H

§ 55-292. Definition of Systems by National Ocean Survey/National Geodetic Survey; adopted.

For purposes of more precisely defining the Virginia Coordinate System of 1927, the following definition by the National Ocean Survey/National Geodetic Survey is adopted:

The Virginia Coordinate System of 1927, North Zone, is a Lambert conformal projection of the Clarke spheroid of 1896, having standard parallels at north latitudes 38º02' and 39º12', along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 78º30' west of Greenwich with the parallel 37º40' north latitude, such origin being given the coordinates: x = 2,000,000', and y = 0'.

The Virginia Coordinate System of 1927, South Zone, is a Lambert conformal projection of the Clarke spheroid of 1896, having standard parallels at north latitudes 36º46' and 37º58', along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 78º30' west of Greenwich with the parallel 36º20' north latitude, such origin being given the coordinates: x = 2,000,000'and y = 0'.

For purposes of more precisely defining the Virginia Coordinate System of 1983, the following definition by the National Ocean Survey/National Geodetic Survey is adopted:

The Virginia Coordinate System of 1983, North Zone, is a Lambert conformal conic projection based on the North American Datum of 1983, having standard parallels at north latitudes 38º02' and 39º12', along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 78º30' west of Greenwich and the parallel 37º40' north latitude. The origin being given the coordinates: x = 3,500,000 meters and y = 2,000,000 meters.

The Virginia Coordinate System of 1983, South Zone, is a Lambert conformal conic projection based on the North American Datum of 1983, having standard parallels at north latitudes 36º46' and 37º58', along which parallels the scale shall be exact. The origin of coordinates is at the intersection of the meridian 78º30' west of Greenwich and the parallel 36º20' north latitude. This origin is given the coordinates: x = 3,500,000 meters and y = 1,000,000 meters.

Figure 10-I

VERTICAL PLANE THROUGH THE CENTER OF THE EARTH
LATITUDE

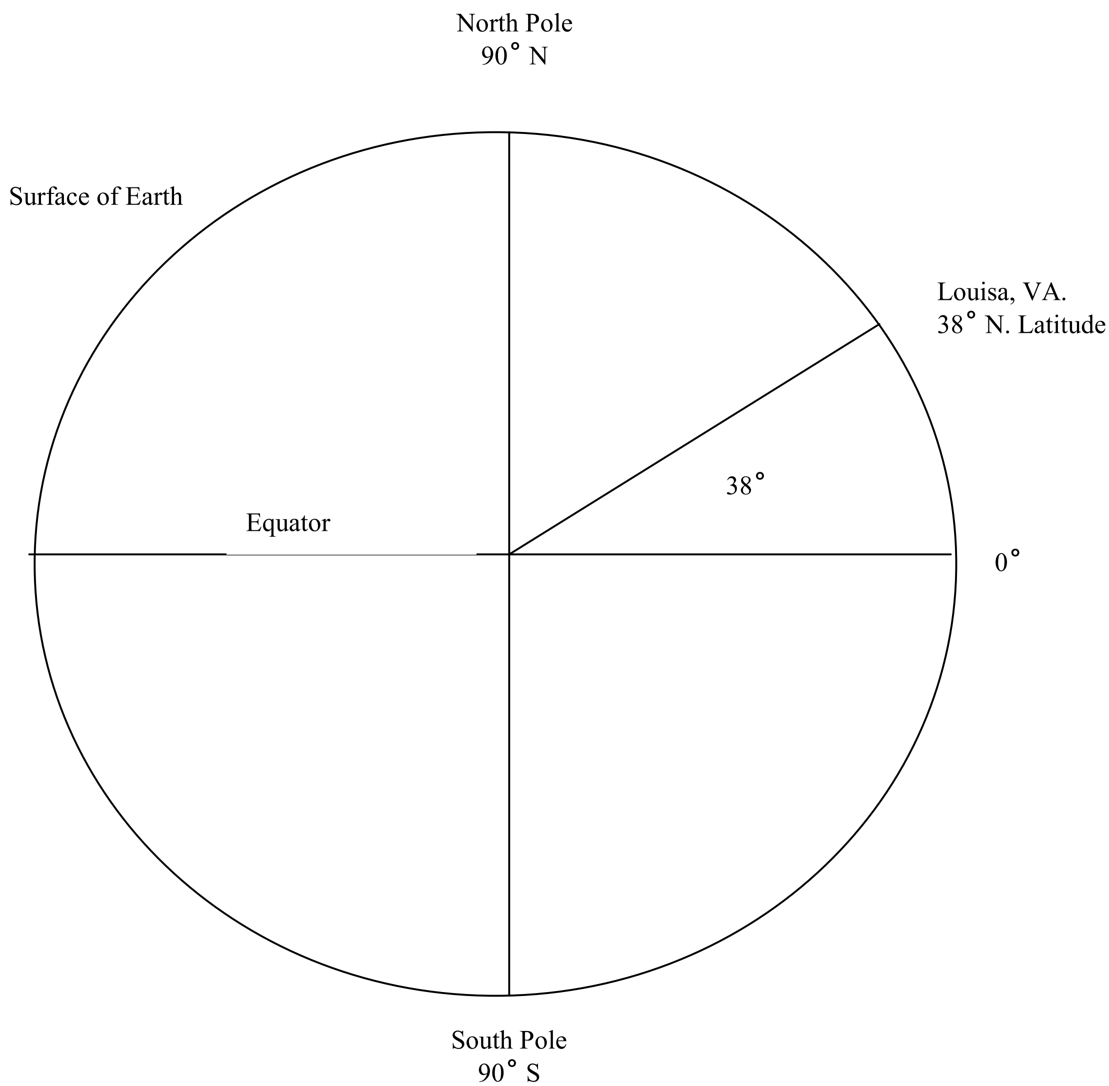


Figure 10-J

HORIZONTAL PLANE THROUGH THE CENTER OF THE EARTH
LONGITUDE

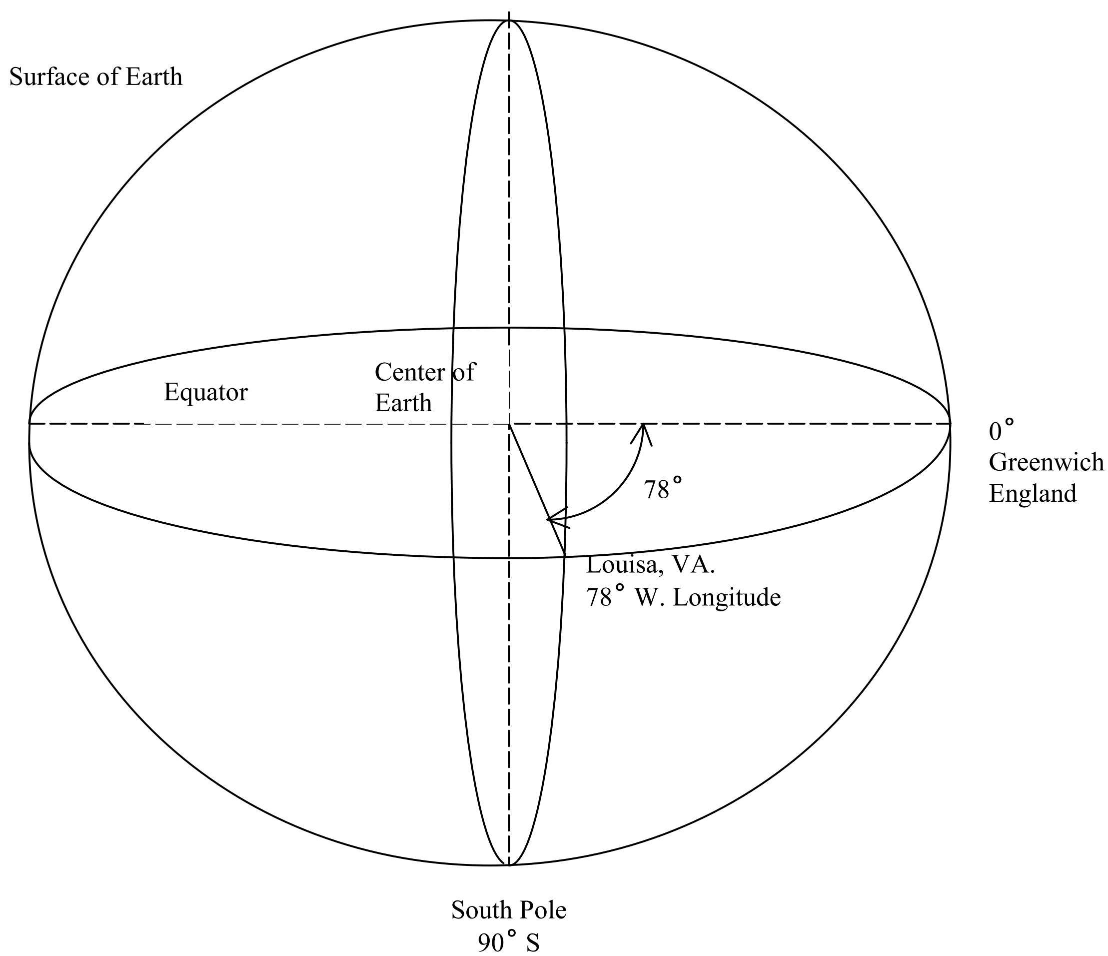


Figure 10-K

PROFILE VIEW
VIRGINIA STATE PLANE COORDINATE SYSTEM

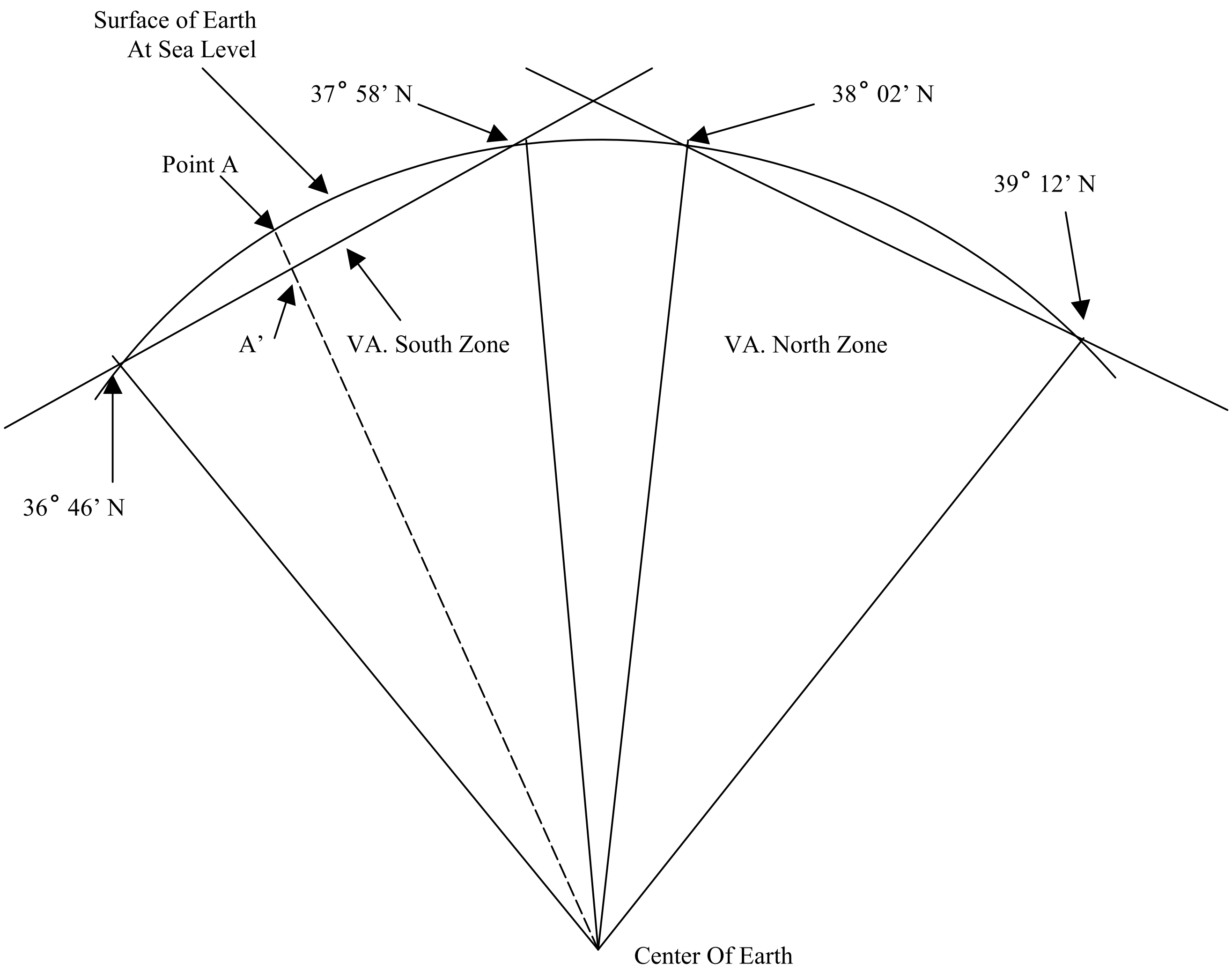


Figure 10-L

RELATIONSHIP BETWEEN TRUE NORTH &
GRID NORTH

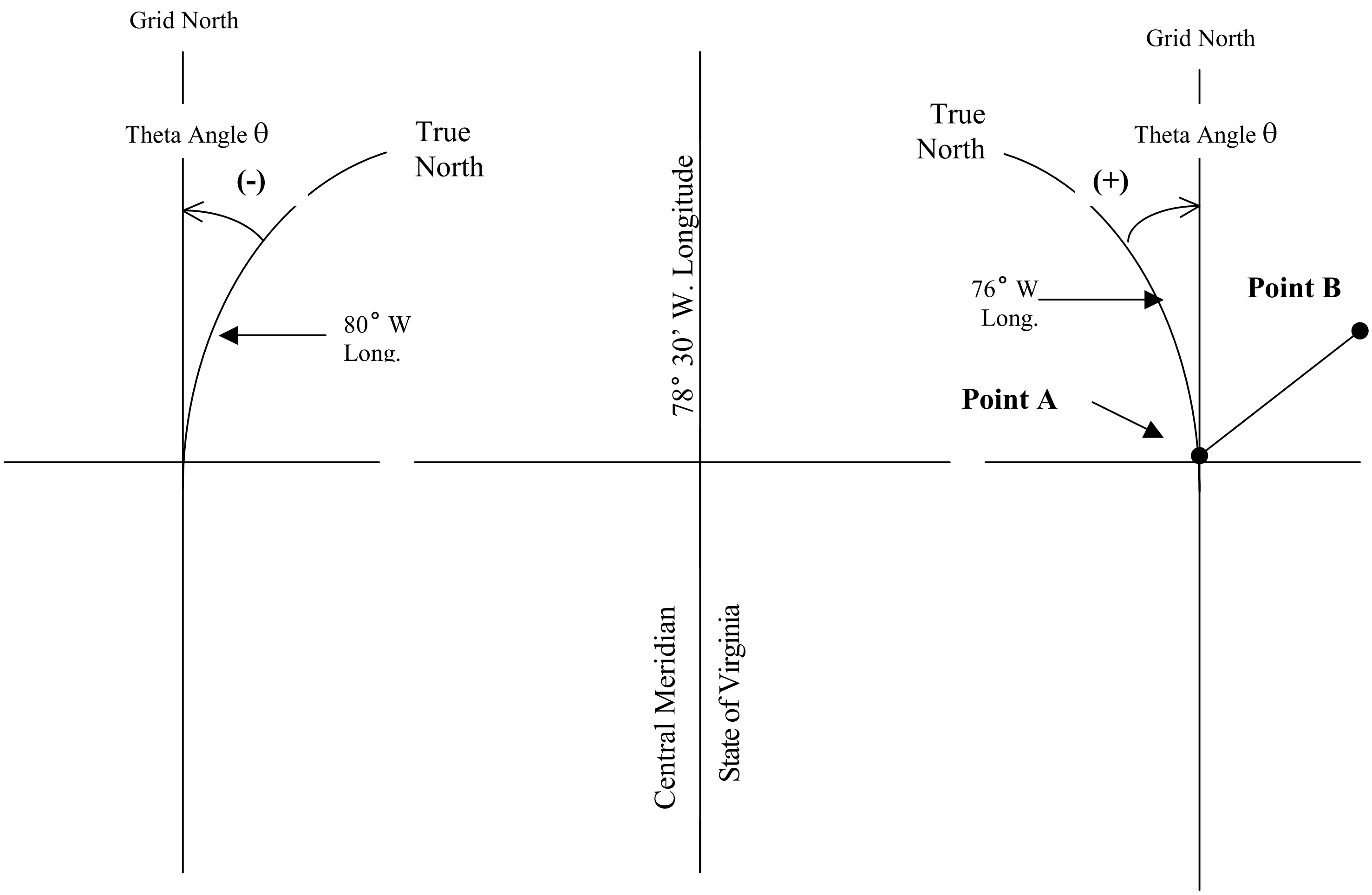


Figure 10-M

§ 55-290. Plane Coordinates used in Systems.

The plane coordinates of a point on the earth's surface, to be used in expressing the position or location of such point in the appropriate zone of these systems, shall be expressed in U.S. survey feet and decimals of a foot. One of these distances, to be known as the "x-coordinate," shall give the position in an east-and-west direction; the other, to be known as the "y-coordinate," shall give the position in a north-and-south direction. These coordinates shall be made to depend upon and conform to the coordinate values for the monumented points of the North American Horizontal Geodetic Control Network as published by the National Ocean Survey/National Geodetic Survey, or its successors, and whose plane coordinates have been computed on the systems defined in this chapter. Any such station may be used for establishing a survey connection to either Virginia Coordinate System.

When converting coordinates in the Virginia Coordinate System of 1983 from meters and decimals of a meter to feet and decimals of a foot, the U.S. survey foot factor (one foot equals 1200/3937 meters) shall be used. This requirement does not preclude the continued use of the International foot conversion factor (one foot equals 0.3048 meters) in those counties and cities where this factor was in use prior to July 1, 1992. The plat or plan shall contain a statement of the conversion factor used and the coordinate values of a minimum of two project points in feet.

Figure 10-N

COMBINED SCALE AND ELEVATION FACTOR FOR THE COUNTY

000	1.00006	Arlington
001	1.00004	Accomack
002	1.00002	Albemarle
003	1.00015	Alleghany
004	1.00007	Amelia
005	1.00009	Amherst
006	1.00008	Appomattox
007	1.00009	Augusta
008	1.00012	Bath
009	1.00009	Bedford
010	1.00017	Bland
011	1.00011	Botetourt
012	1.00001	Brunswick
013	1.00015	Buchanan
014	1.00007	Buckingham
015	1.00007	Campbell
016	1.00001	Caroline
017	1.00011	Carroll
018	1.00006	Charles City
019	1.00006	Charlotte
020	1.00006	Chesterfield
021	1.00004	Clarke
022	1.00017	Craig
023	1.00007	Culpeper
024	1.00007	Cumberland
025	1.00014	Dickenson
026	1.00005	Dinwiddie
027	1.00004	City of Hampton
028	1.00001	Essex
029	1.00006	Fairfax
030	1.00008	Fauquier
031	1.00012	Floyd
032	1.00004	Fluvanna
033	1.00009	Franklin
034	1.00004	Frederick
035	1.00017	Giles
036	1.00005	Gloucester
037	1.00005	Goochland
038	1.00011	Grayson
039	1.00007	Greene
040	1.00000	Greensville
041	1.00002	Halifax
042	1.00004	Hanover
043	1.00006	Henrico
044	1.00003	Henry
045	1.00016	Highland
046	1.00002	Isle of Wight
047	1.00005	James City
048	1.00004	King George
049	1.00004	King & Queen
050	1.00004	King William
051	1.00003	Lancaster
052	1.00006	Lee
053	1.00005	Loudoun
054	1.00002	Louisa
055	1.00005	Lunenburg
056	1.00007	Madison
057	1.00005	Mathews
058	1.00000	Mecklenburg
059	1.00005	Middlesex
060	1.00015	Montgomery
061	1.00000	City of Suffolk
062	1.00007	Nelson
063	1.00005	New Kent
064	1.00000	Nor. Ches. Ports.
065	1.00004	Northampton
066	1.00002	Northumberland
067	1.00007	Nottoway
068	1.00006	Orange
069	1.00010	Page
070	1.00004	Patrick
071	1.00002	Pittsylvania
072	1.00006	Powhatan
073	1.00007	Prince Edward
074	1.00006	Prince George
075	1.00000	City of VA Beach
076	1.00006	Prince William
077	1.00014	Pulaski
078	1.00009	Rappahannock
079	1.00001	Richmond
080	1.00013	Roanoke
081	1.00008	Rockbridge
082	1.00011	Rockingham
083	1.00012	Russell
084	1.00011	Scott
085	1.00009	Shenandoah
086	1.00015	Smyth
087	1.00000	Southampton
088	1.00004	Spotsylvania
089	1.00006	Stafford
090	1.00005	Surry
091	1.00003	Sussex
092	1.00019	Tazewell
093	1.00007	Warren
094	1.00004	City of Newport News
095	1.00009	Washington
096	1.00002	Westmoreland
097	1.00015	Wise
098	1.00014	Wythe
099	1.00005	York

Figure 10-O
GPS Survey Specifications for Project Monumentation

Specification	Static	Rapid (or Fast) Static
General Specifications		
Minimum number of reference stations used to control the survey - Minimum Order of station	Horz. - 2 NSRS B-order Vert. - 3 NSRS 3rd-order	Horz. - 2 NSRS B-order Vert. - 3 NSRS 3rd-order
Maximum distance from survey boundary to reference stations	50 km	20 km
Minimum number of dual frequency GPS receivers used simultaneously	3	3
Mission Planning & Field Observation Specifications		
Minimum number of satellites observed simultaneously at all stations	5	5
Maximum GDOP / PDOP during observation session	6 / 4	6 / 4
Minimum number of simultaneous occupations of reference stations	2	2
Minimum number of simultaneous occupations of sight pairs	2	2
Minimum number of simultaneous occupations of azimuth pairs	2	2
Minimum time between sight and azimuth pair repeat observations	30 minutes	30 minutes
Minimum Spacing of Sight Pairs / Azimuth Pairs	600 ft. / 1 mile	600 ft. / 1 mile
Epoch interval for data sampling during observation session	15 seconds	5 seconds
Minimum satellite mask angle above the horizon for collection and processing	15 degrees	15 degrees
Satellite signals received from minimum number of quadrants	3	2 diagonally opposite
Obstruction diagrams completed for obstructions higher than	20 deg. above horizon	20 deg. above horizon
Minimum observation time at station	2.5 hours	10 minutes
Antenna height measurement in meters at beginning and end of session?	YES	YES
Processing and Adjustment Specifications		
Fixed Integer solution required for all baselines?	YES	YES
Ephemeris used for processing	Broadcast or Precise	Broadcast or Precise
Maximum misclosure per loop in any one component (x,y,z) not to exceed	5 cm	5 cm
Maximum misclosure per loop in terms of loop length not to exceed	30 ppm	30 ppm
Maximum allowable residual in any one component (x,y,z) in a properly constrained least squares network adjustment not to exceed	3 cm	3 cm
Maximum baseline length misclosure allowable in a properly constrained least squares network adjustment	30 ppm	30 ppm

CHAPTER 11.00

SURVEY
CADD

CHAPTER CONTENTS

Sec. 11.01	General Description of Survey File
Sec. 11.02	Contents of Survey Planimetric Master File
Sec. 11.03	Contents of Survey Utility Master File
Sec. 11.04	Contents of Survey Bridge Situation File
Sec. 11.05	Contents of DTM MicroStation File (3D)
Sec. 11.06	Contents of a CAiCE Project
Sec. 11.07	Survey File Naming & Files Required for Submission to VDOT

Sec. 11.01 General Description of Survey File

The survey CADD files will be in MicroStation (dgn) format. The files will contain all information pertaining to the survey project. The required Digital Terrain information will be in a 3D MicroStation file (dtm) format, a CAiCE project **(Sec. 11.06)** format and an SRV file. The survey CADD files that pertain to information collected prior to 1995 will be in one MicroStation file and will contain the planimetric data and the utility information according to the standards set in Appendix A (1986). Topography collected from 1995 to present will be stored in two files, one file will contain the planimetric data and the other will contain the utility information **(See Sec. 11.02 and 11.03)**. The Survey Support Section in the Central Office will maintain all standards for survey files. Please contact the Manager of the Survey Support Section in the Central Office, with suggestions for changes for standards.

Sec. 11.02 Contents of Survey Planimetric Master File

In July of 1995, VDOT created the Survey Planimetric Master File separately from the Survey Utility Master File, mainly to permit the planimetric data to be displayed separately from the utility data. The Survey Planimetric Master File will contain all of the following information:

1) Coordinate Plan Sheet

The Coordinate Plan Sheet is very important in illustrating the survey alignment information and the coordinate values of the project. This sheet is also used by the Designers to show construction alignments. The Coordinate Plan Sheet is created in Microstation by selecting the cell named "CORPLA". The cell is placed to the left of the survey file at the scale of the project. The Plan Sheet lists all survey alignment data and will be arranged in a table format containing the following information in the order shown **(Figure 11-A, page 11-13)**.

- i) Station ID's - PI's, PC's, PT's, etc.
- ii) Stations
- iii) Tangent Bearings
- iv) Curve data
- v) Station Coordinates

2) Horizontal Control Plan Sheet

The Horizontal Control Plan Sheet **(Figure 11-B, page 11-14)** depicts both Horizontal and Vertical datum and all references that where used to control the survey. Accurate descriptions and detailed sketches are important when referencing control points, as surveyors will use these references to locate field survey control. The Horizontal Control Plan Sheet is placed to the right of the Coordinate Plan Sheet and at the scale of the job. This Plan Sheet will contain all control and datum information for the survey. All control monuments will be verified. The following types of field survey control will be shown on this Plan sheet.

LD-200 cards (A cell in surv95.cel library called "hc" (metric "mhc"))**(See sec.10.07, page 10-8)**

(1) Federal government monuments
(2) VDOT control monuments
(3) Control monuments established by the survey party
(4) Local government monuments

ii) Bench marks
iii) Reference points

3) Title Block

The Title Block **(Figure 11-C, page 11-15)** gives a great deal of useful information for surveyors and engineers involved in the project. The cell called "tb" (metric mtb) is a cell inside of MicroStation and is a standard Title Block that will be used to describe the survey. The Title Block, will be at the scale for the project as shown in **Figure 11-F, page 11-4**, is placed to the right of the Horizontal Control Plan Sheet and centered with the beginning of the survey baseline as shown in **Figure 11-C, page 11-15**. To add text to this cell, while in MicroStation, drop the status on it and place the text at the size and line spacing for the scale of the project as shown in **Figure 11-D, page 11-3**. The following fields are included in the Title Block and must be accurately completed.

a) Project Number: (VDOT Project Number)
b) District:
c) County:
d) From: (Where project starts)
e) To: (Where project ends)
f) Horizontal Datum Based On:
g) Vertical Datum Based On:
h) Surveyed By: (Name of the surveyor)
i) Operator: (Name of the CADD operator)
j) Date :
k) Scale :
l) PPMS# :
m) Notes: (hazardous waste, etc.)

4) Planimetric Data (Standards are defined in **Appendix A**)

The Planimetric Data, or "Topo Data", is collected by Surveyors and used to create an accurate set of base plans for a project. The field information is collected in many ways but must be created in a Microstation (dgn) format. The level structure and weights are defined in **Appendix A**. Planimetrics collected and shown in a Survey file will fall into one of four categories listed below.

- All natural topographic features.
- All manmade structures not associated with Utilities (excluding concrete pads for Power, Telephone, Traffic and Television).
- All wetlands located by a Wetland Delineation Specialist.
- All hazardous waste sites will be located and noted.

[Structures associated with utilities will **always** be shown in the Survey Utility File. **(Sec. 11.03.3, page 11-5)**]

a) Annotation

All Annotation will be placed in the survey file according to the project scale standards **(Figure 11-D),** first letter uppercase and the rest lower case (Example Curb & Gutter). The one exception, property owner names will be shown in ALL capital letters (ex. JOHN Q. PUBLIC). The annotation is placed so as to read left to right and bottom to top the way the centerline runs. When placing annotation in the file it is good practice to reference the utility file to make sure annotation is not written on top of anything in the utility file.

ENGLISH						
	ANNOTATION & C/L TEXT			**PROPERTY OWNERS**		
Scale	**Text Size**	**Weight**	**Line Spacing**	**Text Size**	**Weight**	**Line Spacing**
1" = 25'	3’	3	1.5	4’	**7**	2
1" = 50'	6’	3	3	8’	**7**	4
1" = 100'	12’	3	6	16’	7	8

METRIC						
	ANNOTATION & C/L TEXT			**PROPERTY OWNERS**		
Scale	**Text Size**	**Weight**	**Line Spacing**	**Text Size**	**Weight**	**Line Spacing**
1 : 250 m	0.75 m	3	0.375	1 m	**7**	0.5
1 : 500 m	1.5 m	3	0.75	2 m	**7**	1
1 : 1000 m	3.0 m	3	1.5	4 m	7	2

Note: When placing text in a file there is to be 1 space after a decimal point and two space after a period. (ex.: decimal point - 123.[1 space]45, period - JOHN Q.[2 spaces] PUBLIC

Figure 11-D

b) Centerline

All Centerlines, (survey, stream traverse) will be placed in the survey file according to the standards shown in **Figure 11-E, page 11-4** and the annotation on the centerline will be according to the standards shown in **Figure 11-D**.

LINE & LABELING

	Weight	Line Code
Line	5	0
Control Points	3	0
Labeling	3	0
Sub Tangent Lines	3	3
Ticks	5	0

STATION INCREMENT & CONTROL POINTS

Scale	Control Point Radius	Equality Line Length	Station Ticks Every	Station Label Every	Examples
1" = 25'	2.34375'	8'	100	100	290, 291, 292
1" = 50'	4.6875'	16'	100	500	290, 295, 300
1" = 100'	9.375'	32'	100	500	290, 295, 300
1 : 250 m	0.714375 m	2.3225 m	20	100	290, 291, 292
1 : 500 m	1.472875 m	4.645 m	20	100	290, 291, 292
1 : 1000 m	2.94575 m	9.29 m	20	100	290, 291, 292

Figure 11-E

c) Cells

All cells will be placed at a weight of 0 and at the scale for the project as shown in **Figure 11-F**. Please note the exceptions listed at the bottom of **Figure 11-F** and place them at a scale of 1.

d) Line Styles

All line styles will be placed by weight as described in **Appendix A** for the scale of the project as shown in **Figure 11-F**. Please note the exceptions listed at the bottom of **Figure 11-F** and place them at a scale of 1.

Active Scales:

English	Metric	Scale
1" = 25'	1 : 250 m	0.25
1" = 50'	1 : 500 m	0.5
1" = 100'	1 : 1000 m	1.0

EXCEPTIONS: Railroad Tracks, Right-of-way lines, Curb, Curb & Gutter, Pipe Culverts, Sidewalks, Walks, Graves, Paved Ditches, Jersey Barriers, State Lines, County Lines, City Lines, and Town Corporate Limits should always be placed using a **SCALE of 1** regardless of the file scale.

Figure 11-F

Sec. 11.03 **Contents of Survey Utility Master File**

In July of 1995, VDOT began creating the Survey Utility Master File separately from the Survey Planimetric Master File, enabling the utility data to be displayed separately from the planimetric data. The Survey Utility Master File will contain all of the following information:

1) Utility Owners

The Utility Owner information **(Figure 11-C, page 11-15)** is used as a reference for anyone who may need to contact a Utility Company on a project. The Utility Owners information is at the text size for the scale of the project **(Figure 11-D, page 11-3)**, a line spacing for the scale of the project **(Figure 11-D, page 11-3)**, and a weight of 3.0, and is placed above Title Block as shown in **Figure 11-C, page 11-15**.

a) List each utility owner complete with address and phone number.
   i) Gas
   ii) Electric
   iii) Sanitary Sewer
   iv) Telephone (Including fiber optic)
   v) Cable Television
   vi) Traffic Control
   vii) Water

2) The Utility Key

The Utility Key **(Figure 11-C, page 11-15)** is a cell called "uk" inside of MicroStation and gives a standard Key that will be used in all surveys in describing the utilities. The Utility Key is placed below the Title Block and at the scale for the project as shown in **Figure 11-F, page 11-4**. To add text to this cell, while in MicroStation, drop the status on it and place the text at the size and line spacing for the scale of the project as shown in **Figure 11-D, page 11-3**.

3) The Utility Topography (Standards are defined in **Appendix A**)

The Utility Topography is collected by Surveyors and used to create an accurate set of base plans for a project. The field information is collected in many ways but must be created in a MicroStation (dgn) format. The level structure and weights are defined in **Appendix A**. The following items listed below will be shown in the utility topography file.

- All utility structures above and below ground within the project's defined area.
- All Miscellaneous Utility Notes are placed on level (62).
- Planimetric Data will not be included in this file. See section **Sec. 11.02.4**

a) Annotation

All annotation will be placed in the survey utility file according to the standards in **Figure 11-D, page 11-3** with the first letter uppercase the rest lower case (ex. 12" Oak). The annotation is read left to right and bottom to top the way the centerline runs. When placing annotation in the survey utility file, it is a good practice to reference the survey planimetric file to make sure annotation is not written on top of anything in the survey planimetric file.

b) Cells

All cells will be placed at a weight of 0 and at the scale of the project as shown in **Figure 11-F, page 11-4**. Please note the exceptions listed at the bottom of **Figure 11-F, page 11-4** and place them at a scale of 1.

c) Line Styles

All line styles will be placed by weight as described in **Appendix A** and at the scale of the project as shown in **Figure 11-F, page 11-4**. Please note the exceptions listed at the bottom of **Figure 11-F, page 11-4** and place them at a scale of 1.

Sec. 11.04 **Contents of Survey Bridge Situation File**

The Bridge Situation Survey should provide sufficient information for the location engineer and the designer to design a structure and make the necessary hydraulic and impact studies for all significant physical and cultural features that would be adversely affected by the construction. The following will explain what is needed to create the Bridge Situation and how to compile it in a MicroStation (dgn) format.

1) Title Block

The Title Block **(Figure 11-G, page 11-16)** gives countless amounts of useful information. The cell called “tb” (metric "mtb") inside of MicroStation is a standard Title Block that will be used in all bridge situations to describe the survey. The Title Block is a cell in MicroStation, at the active scale of 0.125 is placed in the top left corner of the bridge situation as shown in **Figure 11-G, page 11-16**. To add text to this cell, while in MicroStation, drop the status on it and place the text at text size of 1.5 (metric 0.375), a line spacing of 0.75 (metric 0.1875), and at a weight of 5.0. The following fields are included in the Title Block and must be accurately completed.

a) Project Number: (VDOT Project Number)
b) District:
c) County:
d) From: (Where project starts)
e) To: (Where project ends)
f) Horizontal Datum Based On:
g) Vertical Datum Based On:
h) Surveyed By: (Name of the surveyor)
i) Operator : (Name of the CADD operator)

(Continued)

j) Date :
k) Scale:
l) PPMS#:
m) Bridge # (Construction Bridge Number)

2) Utility Owners

The Utility Owner information is used as a reference for anyone who may need to contact a Utility Company on a project. The Utility Owners, at the text size of 1.5 (metric 0.375), a line spacing of 0.75 (metric 0.1875), and a weight of 5.0, is placed below the Title Block and above the LD-23 Bridge Data Sheet as shown in **Figure 11-G, page 11-16**. Each utility owner should be listed according to standards as shown in **section 11.03.1**.

3) Note:

The note **(Figure 11-G, page 11-16)** is to inform the designer that the bridge portion of the bridge situation file is based on the project coordinates and for the plan portion refer to at the master file for the project coordinates. The note is placed, at the text size of 1.5 (metric 0.375), a line spacing of 1.0 (metric 0.1875), and a weight of 5.0, below the utility owners and above the **LD-23 Bridge Data Sheet** as shown in **Figure 11-G, page 11-16**.

The note for an English project will read as follows:
Note: Coordinate Values for bridge portion Scale: 1" = 10'
For the plan portion see master survey file. (Give survey master file name and location)

The note for a Metric project would read as follows:
Note: Coordinate Values for bridge portion Scale: 1 : 100 m
For the plan portion see master survey file. (Give survey master file name and location)

4) LD-23 Bridge Data Sheet

The Bridge Data Sheet has been designed to give as much pertinent data on the bridge as well as current information and conditions such as the needed information like existing structure data, stream flow data at proposed site, site conditions, influence and control of site, and railroad grade separation structure site data. The LD-23 Bridge Data Sheet is a cell in the surv95.cel library called "ld23" (metric mld23). The Bridge Data Sheet will be prepared on all proposed design bridges by the Surveyor in charge, see **Sec. 7.11 Bridge Data Sheets (Form LD-23 Rev. 11/15/77)**. The cell "ld23" (metric "mld23") contains text fields for data entry and will be placed, at a scale of 0.75 (metric 0.19), and in the lower left corner of the grid as shown in **Figure 11-G, page 11-16**. Note: The grid is to be removed from the bridge data sheets area.

5) Bridge Portion

The Bridge Portion **(Figure 11-G, page 11-16)** provides an accurate picture of the existing site conditions. The quality of the final design is heavily dependent on the accuracy and thoroughness of the survey data. The bridge portion is a section of the master survey file, including the master utility file and contour file, starting and ending on a station 50' or more from each end of the proposed bridge and 200' wide. The Bridge Portion is copied into the bridge situation file and will remain in the same position so the coordinates of any point will remain true to the project. All cells and patterns should be at an active scale of 0.25 unless listed in the exception box in **Figure 11-F, page 11-4,** then the cells and patterns will be at a scale of 1. Line styles will be at a scale of 0.25, unless listed in the exception box in **Figure 11-F, page 11-4,** then the line styles will be at a scale of 1. Topo annotation text will be at a text size of 1.5 (metric 0.375) and the property owner text will be at a text size of 2.0 (metric 0.5). Next, increase the weight of all elements by a weight factor of 2 in the bridge portion (ex. annotation with a weight of 3 will now be a weight of 5), so that when bridge situation is plotted everything will stand out over the grid. Obscured contours are those that pass under a bridge or structure and are not visible when viewed in plan. All obscured contours will be shown as a broken line with a line style of 3.

6) Profiles and Cross-Sections:

a) Centerline Profile

The Centerline Profile **(Figure 11-G, page 11-16)** of existing & proposed bridges must in all cases extend along the survey centerline to cover and define the high water spread area and, where practical, to cover an area at least two feet above high water. High water data is of great importance to the engineer for the hydraulic analysis. The centerline profile text size will be 1.5 (metric 0.375). The description and elevation of the benchmark on which the bridge situation is based must be shown above the centerline profile. The centerline profile shall, where possible, be plotted directly beneath the bridge portion to a scale of one inch to ten feet 1" = 10' (metric 1 : 100 m) both vertically and horizontally. The profile can be offset to the right and plotted in the usual manner if available space under the bridge portion will not accommodate it. The elevation of normal water, low water and extreme high water will be plotted with the profile. The month and year of high water and the name of the individual furnishing the information must be noted above the high water line on the Centerline profile.

b) Road Profile

The Road Profile under the existing bridge or at the proposed bridge will be along the high point of the road, 100' each side of centerline of the existing bridge or at the proposed bridge. The profile reading needs to be tied to the centerline of the road. The road profile text size will be 1.5 (metric 0.375). The road profile shall be plotted beneath the centerline profile to a scale of one inch equals ten feet 1" = 10' (metric 1 : 100 m) for vertical and one inch equal to *project scale* for horizontal. The road data is used to determine many things such as the height of the bridge when it ties into the existing pavement.

c) Railroad Profile

The Railroad Profile will be along the high rail 300' each side of centerline. The profile reading needs to be tied to the centerline of the railroad. The railroad profile text size will be 1.5 (metric 0.375). The railroad profile shall be plotted beneath the centerline profile to a scale of one inch equals ten feet 1" = 10' (metric 1 : 100 m) for vertical and one inch equal to *project scale* for horizontal. Railroad track elevation information is crucial for the need to determine the clearance for trains passing under the new bridge.

d) Stream Profile

The Stream Profile will be collected at 1000' each side of the centerline (streambed, normal water, etc.). The stream flow and flood information is very important to the height and placement of the new bridge as hydraulic engineers use this information to determine potential flood problems. The Stream profile will be plotted to the right of the bridge plan, or in the case of a grade separation or railroad, the Stream profile will follow. The stream profile shall be plotted to a scale of one inch equals ten feet 1" = 10' (metric 1 : 100 m) for vertical and one inch equal to *project scale* for horizontal.

e) Flood Plain Cross-Sections

The Flood Plain Cross-Sections when necessary, will be plotted to the right of the stream traverse profile. The cross-section information is very important to the height and placement of the new bridge as hydraulic engineers use this information to determine potential flood problems. Cross-sections will be secured at right angles (90°) to the flow of the stream at the proposed bridge site and will extend far enough to cover all the area under high water and where practical, shall extend to cover an area at least two (2) feet above high water. Cross-sections will be secured 100', 500' & 1,000' (metric 30 m, 150 m, 300 m) downstream and 100', 500' & 1,000' (metric 30 m, 150 m, 300 m) upstream of all proposed and existing structures. Intermediate cross-sections will be secured at areas obstructing stream flow and where the engineer designates. The stream profile and flood plain cross-section text size will be 1.5 (metric 0.375). The flood plain cross-section shall be plotted to a scale of one inch equals ten feet 1" = 10' (metric 1 : 100 m) for vertical and one inch equal to *project scale* for horizontal.

7) Bridge Plan Portion

The Bridge Plan Portion **(Figure 11-G, page 11-16)** is used as an overview of the survey planimetric master file and survey utilities master file in the area around the bridge site. To determine the size of the area that needs to be scaled down; multiply the project scale by the width of the grid to get the width of the area to be scaled down **(Figure 11-H, page 11-10)**. Multiply the project scale by the length of a plan sheet to get the length of the area to be scaled down **(Figure 11-H, page 11-10)**. This will give the overall size of the area that needs to be scaled down and moved. This area of the survey planimetric master file and the survey utility file will be cut out and merged according to the size calculated above. The contours will NOT be shown in this portion, contours will be shown only in the bridge portion. Before it is scaled down, a reference for a horizontal control card is to be placed in the upper right corner and a scale bar in lower right corner using the *project scale*. The Bridge Plan portion area will be scaled down by a factor depending on the scale of the project, see **Figure 11-I, page 11-10**. The Bridge Plan text size will scale to 1.2 to meet standards for the plan portion. Line styles will not scale down when using this method. For line styles that have a scale factor of 1.0, change the scale factor to 0.20 and for line styles with scale factor of the *project scale* set the scale factor to 0.10. When the bridge situation is completed and plotted at the scale 1” = 10’ (metric 1 : 100 m), the plan portion will be plotted at the project scale.

	Width		Length	
Scale	Grid	Equals	Grid	Equals
1" = 25'	22"	550'	35"	875'
1" = 50'	22"	1100'	35"	1750'
1 : 250 m	0.6 m	150 m	0.889 m	222.5 m
1 : 500 m	0.6 m	300 m	0.889 m	444.0 m

Figure 11-H

Scale	Scale Factor
1" = 25'	0.4
1" = 50'	0.2
1 : 250 m	0.4
1 : 500 m	0.2

Figure 11-I

8) Bridge Situation Grid

The Bridge Situation Grid is used as an overlay for plotting profiles and cross-sections. It is centered over the bridge situation after all the parts are complete and in place. The grid is then merged with the bridge situation. The grid can be initiated by selecting the grid tool on the Survey tool palette or running the mdl graph.ma from within MicroStation. The Survey tool palette and the graph.ma were developed at VDOT and are available from the Manager of the Survey Support Section in the Central Office.

9) Plotting The Bridge Situation

The Bridge Situation file will be plotted at a scale of 1" = 10' (metric 1 : 100 m).

Sec. 11.05 Contents of DTM MicroStation File (3D)

The 3-Dimensional MicroStation file or DTM file is used to create a detailed triangulated surface in the CAiCE software. The designer uses the surface to create cross-sections and profiles for the proposed project plans. The file contains the x, y and z values for each point that is placed in the file. Points are either spot elevation points or connecting points along a breakline. **Figure 11-J, page 11-11** shows the proper setting for Areas, Points and Breaklines in the DTM file.

VDOT CADD DTM FILE STANDARDS			
EXISTING FEATURES	LEVEL	WEIGHT	LINE TYPE
Obscured Areas	12		
Spot Points	13	5	Line 0 length
Breaklines	14	1	Line String
BRIDGE DECK (FOR FIELD USE ONLY)			
EXISTING FEATURES	LEVEL	WEIGHT	LINE TYPE
Bridge Deck Breaklines	40	1	Line String
Bridge Deck Points	41	5	Line 0 length
CONTOURS			
EXISTING FEATURES	LEVEL	TEXT	LINE WEIGHT
Intermediate Contour	9		4
Index Contour	10	10	5
Spots Elevations	11	11	5

Figure 11-J

NOTE! Place all Contours in a separate MicroStation (dgn) file.

It is important to check your DTM files for cells, text, shapes and complex strings before importing it into CAiCE because CAiCE can not process these items. Remove cells, text, shapes and complex strings or drop status on them to make them either points or lines.

Sec. 11.06 Contents of a CAiCE Project

The Virginia Department of Transportation selected the software CAiCE to use when working on digital terrain files and data, and is the only software approved for creating these files. The basic concept is to create a triangulated surface that best represents the actual ground surface. In the past, cross-sections were used to show the ground surface. CAiCE allows us the ability to create a surface that can be used for many design and engineering applications.

CAiCE allows the surveyor or designer to perform several powerful functions as listed below:

1) Cross-sections can be generated anywhere in the file.
2) Profiles can be generated for an alignment, entrance or even a stream.
3) An original or pre-excavation surface and a final or post-excavation surface can be used to calculate borrow pit information.

The following required information is needed for submitting in a completed CAiCE Project to the Department for review.

1) The CAiCE ARC or ZIP File

The CAiCE ARC file contains all of the project's information such as the length of the triangles used in your database, raw data, edited data and information about the survey datum. Once you have created an arc or zip file in CAiCE, do not rename it. It is important to create the project with the correct name dt(ppms#) so the arc file will be named correctly. The naming of the DTM database will be s(ppms#).

2) CAiCE (SRV) File Format

The method for creating a corrected SRV file is illustrated in **Appendix C** of this manual. The srv file can be used to restore the project if the arc file has become corrupt, or lost.

A CAiCE manual has been created and is updated by the Central Office Survey Support Section. This manual explains the procedures used in the creation of your project and the contents of your final product. The manual is included as **Appendix C**.

Figure 11-K, page 11-17 shows an example of a SRV file created by VDOT. The format and data structure will be similar for most SRV files created using the standards shown in VDOT's Survey CAiCE Manual **(see, Appendix C)**.

Sec. 11.07 Survey File Naming & Files Required for Submission to VDOT

All file names will contain the PPMS# of the project you are working on. Examples of the naming convention for electronic survey files are listed below.

File Name	Containing	Format
s(PPMS#).dgn	Master planimetric data	MicroStation
su(PPMS#).dgn	Master utility data	MicroStation
s(PPMS#)a.dgn	Update planimetric data	MicroStation
su(PPMS#)a.dgn	Update utility data	MicroStation
s(PPMS#)b(bridge#).dgn	Bridge situation data	MicroStation
s(PPMS#).dtm	Master 3D points and breaklines data	MicroStation
s(PPMS#)a.dtm	Update 3D points and breaklines data	MicroStation
dt(PPMS#).srv	Master XYZ data	ASCII
dt(PPMS#).arc or zip	Master 3D archive	CAiCE

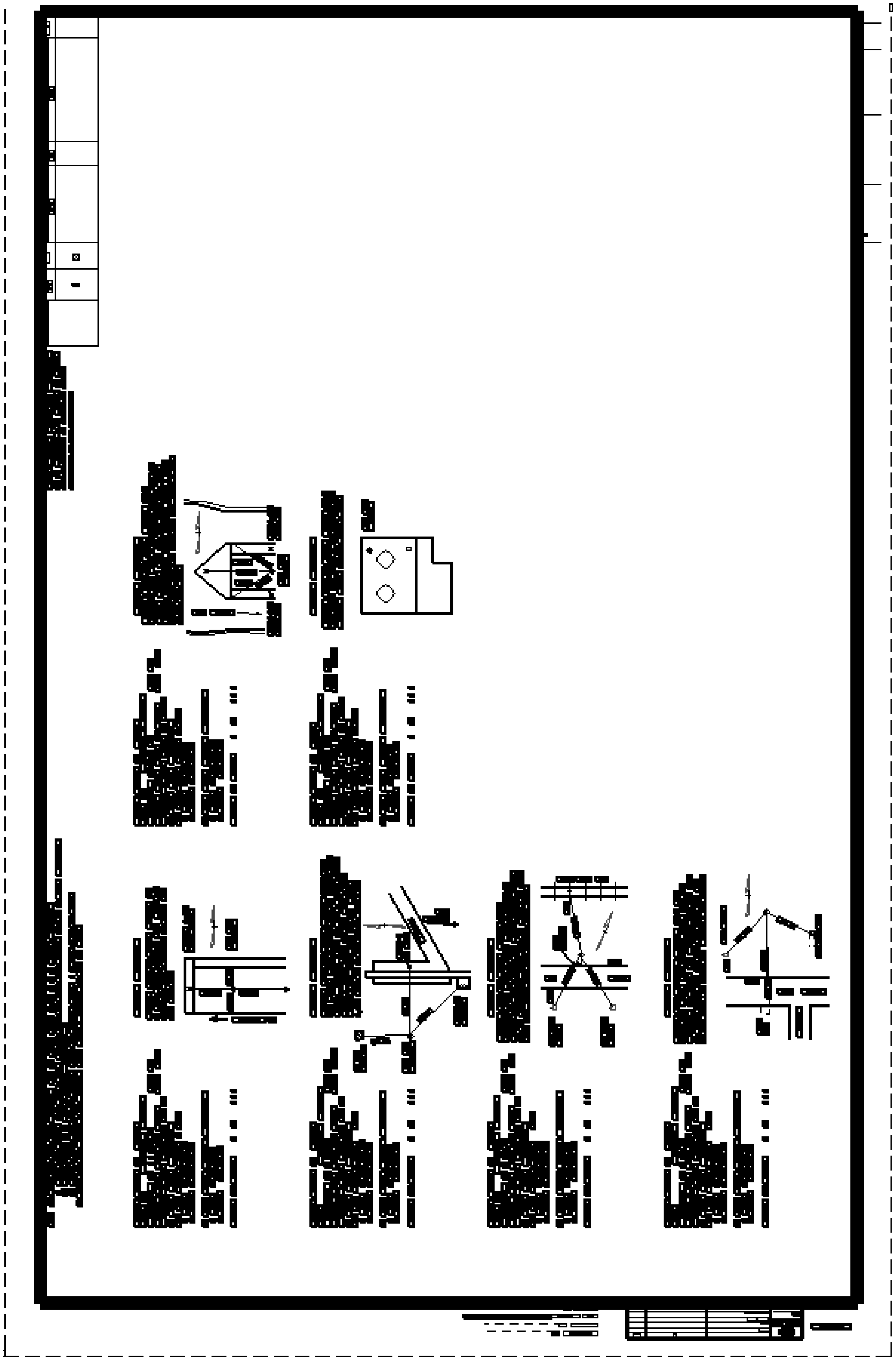
When submitting a project, ALL master files will be turned in along with any update files. The master file will also contain the update file information.

SURVEY ALIGNMENTS

POINT ID.	STATION	BEARING	PROJECT COORDINATES NORTH(Y)	EAST(X)
	ULTIMATE MEDIAN CENTERLINE			
SS	101+43.390		196,904.719	3,912,965.010
		S 78° 55' 43" W		
PC	101+43.385		196,904.720	3,912,965.014
PI	108+90.890		196,761.175	3,912,231.421
	Δ = 42° 45' 00" Rt.	D = 3.0000	T = 747.505'	
	L = 1,424.999'		R = 1,909.859'	
PT	115+68.385		197,153.730	3,911,595.290
		N 58° 19' 17" W		
PI	115+68.390		197,153.733	3,911,595.286

Sample Coordinate Plan Sheet Print Out

Figure 11-A



Sample Horizontal Control Plan Sheet
Figure 11-B

UTILITY OWNERS

Water & Sewer: City Of Portsmouth
P.O.Box 490
Portsmouth, Va. 23705

Gas: Commonwealth Gas Services, Inc.
P.O.Box 7189
Portsmouth, Va. 23707

Electric: Virginia Power
P.O.Box 329
Norfolk, Va. 23501

Cable T.V.: CDX Cable Television
4585 Village Avenue
Norfolk, Va. 23502

Telephone: Chesapeake & Potomac Telephone Co.
3757 East Virginia Beach Blvd.
Norfolk, Va. 23502

Sanitary Force Main: Hampton Roads Sanitation District Commission
P.O.Box 5000
Virginia Beach, Va. 23455

Utility Owners

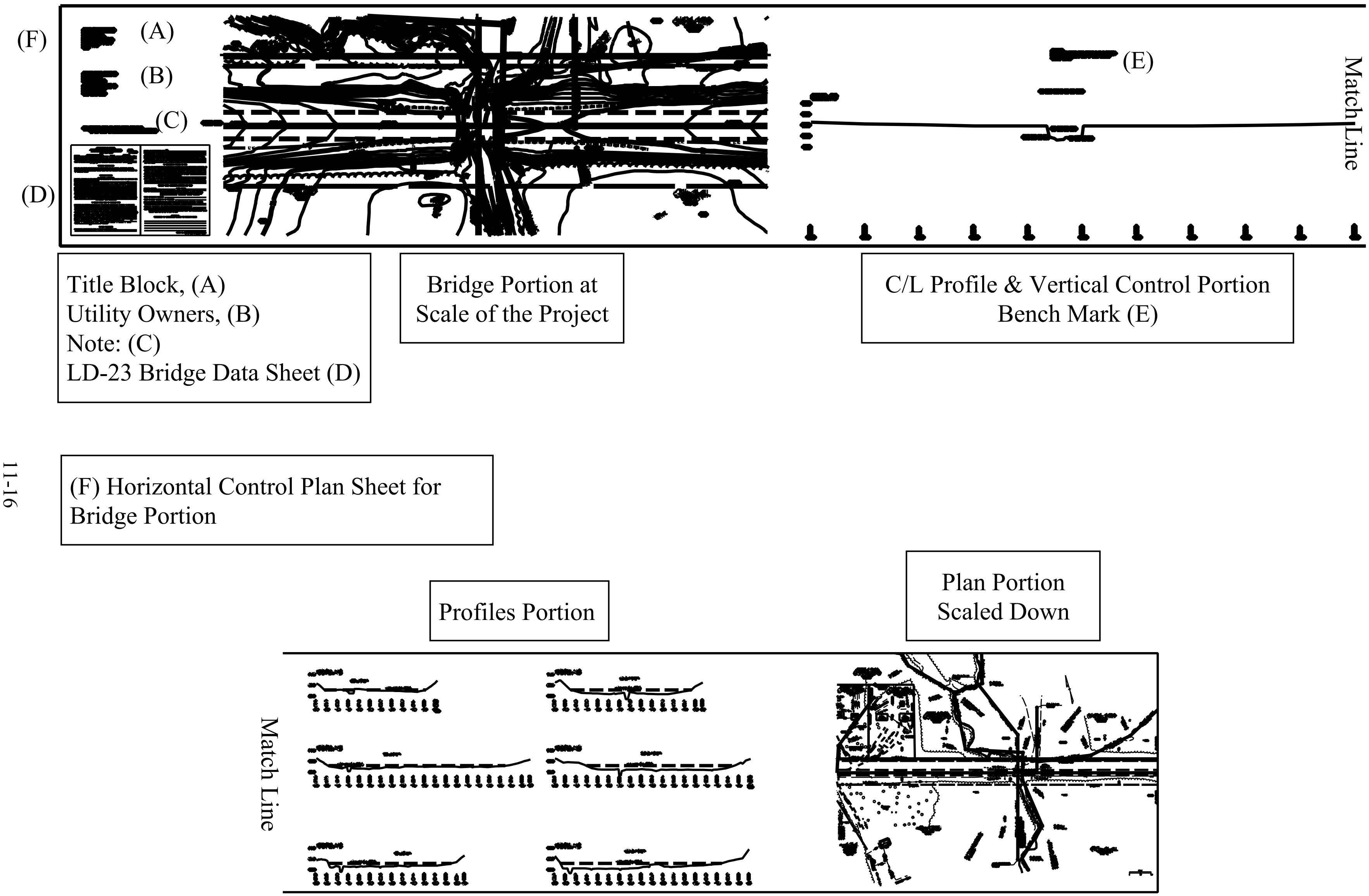
PINNERS POINT INTERCHANGE
PROJECT 0164 - 124 - F04, PE101
SUFFOLK DISTRICT
CITY OF PORTSMOUTH
FROM: E. END OF WEST NORFOLK BRIDGE
TO: 0.985 MI. N. ROUTES 337 & 17
VERTICAL DATUM BASED ON U.S.C.& G.S. DATUM
HORIZONTAL DATUM BASED ON N.A.D. 83 DATUM
SURVEYED BY F. H. WALTERS, JR.
PLOTTED BY T. E. GLASS
DATE 2 - 16 - 94
SCALE: 1" = 25'
PPMS #11750

Title Block Survey C/L

—— W ——	Water Line	City Of Portsmouth
	Water Valve	
	Water Meter	
	Water Manhole	
—— CATV ——	Underground Television Cable	Cox Cable Television
	Television Pedestal	
—— T/Tg ——	Underground Telephone Cable	C & P Telephone Co.
	Telephone Pedestal	
	Telephone Manhole	
	Telephone Pole	
—— E ——	Underground Power Cable	Virginia Power
	Power Pole	
	Electric Box	
	Combination Pole	C & P Telephone Co. & Virginia Power
—— G ——	Gas Line	Commonwealth Gas Services, Inc.
	Gas Valve	
- - - SFM - - -	Sanitary Force Main	Hampton Roads Sanitation District Commission
- - - S - - -	Gravity Sewer	City Of Portsmouth
	Sanitary Manhole	
	Sewer Clean Out	
	Storm Manhole	
- - - Unk - - -	Unknown	
- - (DATUR) - -	Depicted According To Utility Records	
- - (AATUR) - -	Abandoned According To Utility Records	
	Utility End Point	
E.O.I.	End Of Electronic Designating Information	

Utility Key

Sample Utility Owner, Title Block, Utility Key Related to Survey Centerline
Figure 11-C



Sample Bridge Situation Without Grid
Figure 11-G

<<< CAiCE SRV FILE FORMAT >>>

```
123456789X123456789X123456789X123456789X123456789X123456789X

           East         North        Elev.
            (X)          (Y)          (Y)
         Line Type
               Feature Type
                                 ?
                                                     Feature Code
                                                     Feature ID
BEGIN  PPC 17                                        Begin EP Chain
 P G 1 3099914.411 1049864.450 1080.992  17 EP
 P G 1 3099750.753 1049864.190 1073.748  17 EP
 P G 1 3099650.176 1049864.847 1067.612  17 EP   EP = Edge of Pavement
 P G 1 3099501.074 1049864.716 1057.480  17 EP      (Point to Point)
 P G 1 3099250.593 1049864.607 1039.688  17 EP
END                                                  End EP Chain
BEGIN WO 11                                          Begin Wood Chain
 P G 1 3099247.356 1049818.812 1043.101  11 WO
 P G 1 3099424.605 1049855.597 1054.858  11 WO   WO = Begin wood Chain
 P G 1 3099599.752 1049853.138 1083.436  11 WO       (Point to Point)
 P G 1 3099740.775 1049853.401 1078.366  11 WO
 P G 1 3099973.578 1049858.790 1099.770  11 WO
END                                                  End Wood Chain
 P G 1 3099981.826 1049844.647 1107.585  66 UT
 P G 1 3099685.839 1049844.865 1088.742  66 UT   PP = Power Pole
 P G 1 3099261.108 1049854.729 1038.412  69 UT      (Points)
BEGIN  PSS 18                                        Begin EP Chain (PC)
 P G 1 3099640.491 1049891.268 1065.437  18 EP
 P G 1 3099661.993 1049891.171 1067.036  18 EP   PC = Point To Curve
 C G 1 3099692.627 1049895.145 1069.190  18 EP   EP = Edge of pavement
 C G 1 3099710.937 1049898.191 1070.618  18 EP       (Point to Curve)
 P G 1 3099776.724 1049913.234 1076.770  18 EP
 P G 1 3099800.403 1049920.859 1079.478  18 EP
END                                                  End EP Chain
```

Sample CAiCE SRV File Format
Figure 11-K

CHAPTER 12.00

QUALITY CONTROL

Chapter Contents

Sec. 12.01	Introduction
Sec. 12.02	Quality Control Process
Sec. 12.03	Quality Control Responsibilities by Survey Category
Sec. 12.04	Quality Control Checklists
	12.04a Survey Master Files
	12.04b GPS Surveys
	12.04c Photogrammetric Surveys

Sec. 12.01 **Introduction**

The old saying "*any building is only as strong as the foundation it's built upon*" could not apply more to the intent of this section. Every route and bridge design at VDOT has as its very foundation, survey data. The success of every design effort at VDOT begins and ends with survey information. A tremendous emphasis has always been placed on providing the highest quality survey data and plan base for the development of the project design and construction plans. In the survey and plan development process, the Survey Office Manager is responsible for the survey project and the compilation of all survey data into the survey base. The District Survey Manager is responsible for both the executive criteria for all survey projects in the District and the final quality review before survey projects are submitted. All Survey Managers are responsible and accountable for the quality of the projects under their assign. The Program Manager is responsible and accountable for the overall quality of all survey projects statewide.

Sec. 12.02 **Quality Control Process**

All surveys, either topographical, boundary construction, etc., have inherent and built-in steps, too numerous and variable to list in this chapter, that are performed routinely to insure quality of field collected data. The intent of this chapter and the following Quality Control Checklist is to identify stages where checking and review of calculations, annotations and compilation should be made. The checklist is a guide or "tool" to facilitate this review effort during the survey project and plan base development process. It is not intended to be an all-inclusive list and covers a broad spectrum of the effort that should be completed at this stage. It is **required** that the Survey Office Manager maintain a current copy of this checklist for **each** survey project, in each survey project file, for checking and review at the appropriate stages during the survey project and plan base development process. The Quality Control Checklist covers the areas of Survey Plan Base Assembly, GPS Surveys and Photogrammetric Surveys. It is the responsibility of the Survey Manager to insure that the consultants that have been assigned work, per their request, are complying with and completing this checklist.

Sec. 12.03 **Quality Control Responsibilities by Survey Category**

ROUTE LOCATION SURVEYS:

The following procedures are used to determine acceptability of route location surveys acquired by VDOT or survey consultants.

1. All projects are to be reviewed at each of the four stages during development. The stages for QC Review are: Project Control, Photogrammetry, Collecting of Field information and Plan Preparation.
2. A list is to be kept in the project folder that advises: when the review was made, by whom and a reference to any comments/recommendations made.
3. The Survey Manager is responsible to insure that all projects are sufficiently reviewed.
4. The District Survey Manager is responsible for notifying the Survey Manager when the plans are due for the QC Review.

In-House Survey Projects -

1. The Survey Manager will review the project or assign the review to be made by the most appropriate resource.
2. The District Survey Manager will review 10% of the projects after the regular QC Review has been made.

Consultant Survey Projects -

1. The Survey Engineer responsible for the project will conduct the QC Review. If necessary for time constraints, the Survey Manager will assign the QC Review to the most appropriate resource.
2. The District Survey Manager will review 10% of the projects that have been reviewed by his staff.
3. The Program Manager will review 10% of the projects after the regular QC Review has been made.

Survey Reviews for Bridge Projects -

1. The Survey engineer responsible for the project will review surveys performed by consultants. If necessary for time constraints, the Survey Manager will assign the QC Review to the most appropriate resource.
2. Survey's performed by in house staff will be reviewed by the Section Manager.
3. The Program Manager will review 10% of the projects after the regular QC Review has been made.
4. A memo is to be placed in the file that advises when the review was made, by whom and a reference to any comments/recommendations made.

GEODETIC & LEVELING SURVEYS:

The following procedures are used to determine the acceptability of geodetic surveys acquired by VDOT or survey consultants.

1. All GPS and leveling projects are to be reviewed during development. The stages for QC Review are: Reconnaissance, Network Design, Observation Session Development, Downloading of Field Information, Final Adjustment Statistics and Final Coordinates.
2. A list is to be kept in the project folder that advises when the review was made, by whom and a reference to any comments/recommendations made as specified in the Survey Manual.
3. The Geodetic Surveys Engineer is responsible to insure that all projects are sufficiently reviewed.
4. The State Geodetic Surveys Manager is responsible for notifying the State Surveys Engineer or District Surveys Manager when the coordinates have been reviewed and deemed acceptable for use.

In-House Survey Projects -

1. The Geodetic Surveys Engineer will review the project or assign the review to be made by the most appropriate resource.
2. The State Geodetic Surveys Manager will review 10% of the projects after the regular QC Review has been made.

Consultant Survey Projects -

1. The Geodetic Surveys Engineer responsible for the project will conduct the QC Review. The consultant will prepare information to be reviewed in the appropriate format according to VDOT's Survey Manual. If necessary for time constraints, the Geodetic Surveys Engineer will assign the QC Review to the most appropriate resource.
2. The State Geodetic Surveys Engineer will review 10% of the projects that have been reviewed by his staff.
3. The Program Manager will review 10% of the projects after the regular QC Review has been made.

Survey Reviews for Geodetic Leveling Projects -

1. The Geodetic Surveys Engineer responsible for the project will review surveys performed by consultants. If necessary for time constraints, the Geodetic Surveys Engineer will assign the QC Review to the most appropriate resource.
2. Surveys performed by in house staff will be reviewed by the State Geodetic Surveys Engineer.
3. The Program Manager will review 10% of the projects after the regular QC Review has been made.
4. A memo is to be placed in the file that advises when the review was made, by whom and a reference to any comments/recommendations made in the format prescribed in VDOT's Survey Manual.

AERIAL PHOTOGRAPHY:

The following procedures are used to determine acceptability of aerial photography acquired by VDOT or aerial photography contractors.

1. All projects are to be reviewed at each of the four stages during development. The stages for QC Review are: Photography Request, Flight Map Preparation, Photo Acquisition and Film Processing and Editing. Quality control guidelines for aerial photography are outlined in Chapter 5 of the Survey Manual.
2. A list is to be kept in the aerial photography projects folder that advises: when the review was performed and by whom and a reference to any comments/recommendations made.
3. The Senior Aerial Photographer is responsible to insure that all projects are sufficiently reviewed.

In-House Aerial Photography Projects -

1. The Aerial Photographer will review the project or the Senior Aerial Photographer will assign the review to be made by the most appropriate resource.
2. The Senior Aerial Photographer will review 10% of the projects after the regular QC Review has been made.
3. The State Photogrammetry Engineer will insure that an appropriate QC review program is in-place and maintained for in-house aerial photography, and may review a sample of the projects after the normal QC Review has been made.

Consultant Aerial Photography Projects -

1. The Aerial Photographer will conduct the QC Review. If necessary for time constraints, the Senior Aerial Photographer will assign the QC Review to the most appropriate resource.
2. The Senior Aerial Photographer will review 10% of the projects that have been reviewed by his staff.
3. The State Photogrammetry Engineer will insure that an appropriate QC review program is in-place and maintained for consultant aerial photography, and may review a sample of the projects after the normal QC Review has been made.

PHOTOGRAMMETRY:

The following procedures are used to determine the acceptability of photogrammetric services acquired by VDOT or photogrammetric consultants.

1. All projects are to be reviewed at each relevant stage during development. The stages for QC Review are: Aerotriangulation, Photogrammetric Data Compilation, Incorporation of Field and Other Outside Data Sources, and Orthophoto/Imagery Generation. Detailed Photogrammetry QC review procedures are outlined in Chapter 5 of the Survey Manual.
2. A list is to be kept in the project folder that advises: when the review was made, by whom, and a reference to any comments/recommendations made.
3. The Photogrammetry Supervisor is responsible to insure that all projects are sufficiently reviewed. The State Photogrammetry Engineer is responsible for the administration of the QC procedures for photogrammetry data.
4. The Photogrammetry Supervisor is responsible for notifying the appropriate Engineer or Manager when the photogrammetry data has been QC reviewed and is available for use.

In-House Photogrammetry Projects -

1. The Photogrammetry Supervisor will review the project or assign the review to be made by the most appropriate resource. The detailed Photogrammetry QC review procedures outlined in Chapter 5 of the Survey Manual, are to be followed for in-house photogrammetry projects.
2. The State Photogrammetry Engineer will be responsible for the administration and maintenance of the in-house QC review program, and may review a sample of the projects after the regular QC Review has been made.

Consultant Photogrammetry Projects -

1. The respective VDOT Engineer is responsible for the submittal of photogrammetry projects and related data to the Photogrammetry Supervisor to conduct or assign the QC Review. The detailed Photogrammetry QC review procedures outlined in Chapter 5 of the Survey Manual, are to be followed for consultant photogrammetry projects. If necessary for time constraints, the State Photogrammetry Engineer or Photogrammetry Supervisor will assign the QC Review to the most appropriate resource.
2. The Photogrammetry Supervisor will review 10% of the projects that have been reviewed by the staff.
3. The State Photogrammetry Engineer will be responsible for the administration and maintenance of the consultant QC review program, and may review a sample of the projects after the regular QC Review has been made.

Survey Reviews for Photogrammetry Projects -

1. The Survey engineer responsible for the project will field check photogrammetry performed by consultants. If necessary for time constraints, the Survey Manager will assign the QC Review to the most appropriate resource.
2. Photogrammetry performed by in house staff will be field checked by the respective district Survey Manager. If necessary for time constraints, the Survey Manager will assign the QC Review to the most appropriate resource.
3. A memo is to be placed in the file that advises when the review was made, by whom, and a reference to any comments/recommendations made.

Quality Control Checklist for Survey Master Files

Route:
Project:
PPMS #

Survey File

I. Title Block

	DATE	INITIAL	
1.	________	_________	Route Number
2.	________	_________	Project Number
3.	________	_________	District & County
4.	________	_________	From & To
5.	________	_________	PPMS Number
6.	________	_________	Vertical Datum Based On
7.	________	_________	Horizontal Datum Based On
8.	________	_________	Surveyed By
9.	________	_________	CADD Operator
10.	________	_________	Date
11.	________	_________	Scale

II. Coordinate Plan Sheet

1.	________	_________	Alignment Datum On All Centerlines is Correct
2.	________	_________	Alignment Datum Is Located Within A Plan Sheet
3.	________	_________	VDOT Monuments (Coordinates, Diagram, Description Etc.) In the LD200 Cards.
4.	________	_________	N.G.S. or U.S.G.S. Benchmarks and Project Benchmarks
5.	________	_________	Check Coordinate Plan Sheet Survey Alignment Against ".HWY" Printout to Insure Correctness

III. Alignment

1. ________ _________ English or Metric input
2. ________ _________ All pluses and curve data to 3 decimal places
3. ________ _________ Alignments labeled correctly (alignment label, bearings, etc.)
4. ________ _________ 500' labels or 100m labels
5. ________ _________ Check for alignment overlaps (P.C.'s & P.T.'s)
6. ________ _________ Intersection pluses and angles where all alignments Intersect with circles at point of intersection and Delta Symbol in Place
7. ________ _________ Edit S.S. (starting station) to Begin Survey
8. ________ _________ Edit last P.I. (last station) to End Survey
9. ________ _________ Edit double text (at PCC's & PRC's)
10. ________ _________ North arrow Corresponds with Alignment.
11. ________ _________ Names of streets, RR, Rivers, Conn.'s, Route #'s, etc.
12. ________ _________ Mark equalities with flag

IV. Topography

1. ________ _________ Check annotation for spelling, first letter capital, Following letters lower case
2. ________ _________ Annotation for each topo item should be moved away From and perpendicular to C.L.
3. ________ _________ Topography and annotation should be correct and also on correct level and line styles
4. ________ _________ Symbology for topo items should be correct
5. ________ _________ "TO" nearest town or route at beginning and end of survey
6. ________ _________ RR mile post
7. ________ _________ County, state and corporate limits
8. ________ _________ Houses need to be located if within 250' of existing Road, a plus and distance shown to center of house if over 250' but less than 500' away, or a note that house is over 500' away from existing road.
9. ________ _________ If property is "Unimproved" a note stating this should be placed under the property owner's name and deed book reference.
10. ________ _________ Septic systems and wells shall be located if within 250' of existing road and a note of there location if over 250' away from the existing road.
11. ________ _________ Street Address or 911 # is given for each building

V. Property

1. ________ _________ Copy of property owners names and address and a copy of tax map(s) should be filed in designer's project folder
2. ________ _________ Property lines and annotation should be on correct level
3. ________ _________ Plat bearings and distances should be placed on all property and in parenthesis.
4. ________ _________ PL or lot line cell should be placed on property
5. ________ _________ Property owners name and deed book reference should be in place
6. ________ _________ Survey bearing and distance should be in place where applicable
7. ________ _________ Plus and distance should be on all property ties
8. ________ _________ Easements should be in place and labeled
9. ________ _________ Existing R/W should be labeled with reference to project or deed book where it was acquired
10. ________ _________ Convert property lines to existing R/W where needed
11. ________ _________ Right of Way, Property, Lot Lines & Easements Are the Proper Line Styles

VI. Drainage

1. ________ _________ Flow directional arrows should be shown on all drainage and streams along with name if applicable
2. ________ _________ All existing structures shall be labeled "In Pl." (in place) and the Condition.
3. ________ _________ Number structures and pipes annotation and move if area is congested
4. ________ _________ Check elevations of drainage structures for Correctness
5. ________ _________ Plot all permanent drainage easements
6. ________ _________ Need structure number on applicable structures
7. ________ _________ Box Culverts Are Described Properly
8. ________ _________ Bridge Plan Number is Noted in Survey File

Utility File

I. General

DATE INITIAL

1. ________ __________ Designated utilities should be referenced to topography to check for completeness i.e. double items, ties to houses
2. _________ __________ Orient underground utility ID's to alignment
3. _________ __________ Utility File is the same scale as the master file.
4. _________ __________ All utility files will have a legend, utility key, and list of utility owners; which include addresses.
5. _________ __________ The utility key (UK) cell will be used and completed on all files.

II. Electric

1. _________ __________ All underground electric lines will be shown using the (UP) custom lines style.
2. _________ __________ The (PP) cell will be used to represent a power pole
3. _________ __________ Electric pedestals will be shown with the (EPED) Cell. ID necessary if applicable.
4. _________ __________ The (EMH) cell will be used for all electric manholes.
5. _________ __________ All Light Poles will be shown using the (LP) cell and ID's when applicable.
6. _________ __________ All Power Poles will have an ID, which include the Company and pole number. Ex. (VP #768)
7. _________ __________ All satellite dishes shown will use the (SATDIS) cell.

III. Telephone

1. _________ __________ Make sure to use the telephone custom line style when Showing underground lines.
2. _________ __________ The (TP) cell will be used to represent a telephone pole.
3. _________ __________ Telephone pedestals will be shown with the (TPED) cell. ID is required. Ex. (GTE #HG-21)
4. _________ __________ The TMH cell will be used for all telephone manholes
5 _________ __________ All Telephone Poles will have an ID, which includes the Company and Pole number (C&P #47)
6. _________ __________ All Fiber Optic markers will be shown along with the fiber Optic custom line style.

Utilities (continued)

IV. Traffic Control

	DATE	INITIAL	
1.	________	_________	All traffic control poles will use the TCLP cell and will Have ID's if applicable.
2.	________	_________	All traffic control manholes will be shown using the TCMH cell.
3.	________	_________	All traffic control hand holes will be shown using the TCHH cell.

V. Water

1. ________ _________ All water lines will use the custom line styles For the correlating size.
2. ________ _________ All fire hydrants shown will use the FH cell.
3. ________ _________ All water valves shown will use the WV cell.
4. ________ _________ All water meters shown will use the WM cell.
5. ________ _________ All water manholes shown will use the WMH cell.
6. ________ _________ All end of water lines shown will use the WSTUB cell.

VI. Gas

1. ________ _________ All gas lines will be shown using the appropriate Custom line style.
2. ________ _________ All gas valves or meters shown will use the GV cell.
3. ________ _________ All ends of gas lines shown will use the GSTUB cell.
4. ________ _________ All gas manholes shown will use the GMH cell.

VII. Sanitary Sewer

1. ________ _________ All sewer lines will be shown using the appropriate Custom line style; Sanitary Force Main and Gravity Sewer.
2. ________ _________ All sewer manholes shown will use the SMH cell.
3. ________ _________ All sewer clean outs shown will use the SCO cell.

VIII. Cable Television

1. ________ _________ All cable TV lines will be shown using the appropriate Custom line style.
2. ________ _________ All cable TV manholes shown will use the TVMH cell.
3. ________ _________ Cable TV pedestals will be shown with the TVPED cell ID necessary if applicable.

Contour File

I. DTM's

DATE	INITIAL	
1. ________	_________	Microstation 3D file shall be created for editing and reviewing for accuracy.
2. ________	_________	Topography should be referenced to 3D file when reviewing for accuracy.
3. ________	_________	Breaklines should be reviewed at walls, abutments, etc. to insure vertical drops are correct.
4. ________	_________	High/Low points should be shown in contour file
5. ________	_________	Contours should be generated at 1' intervals, 5' index for imperial projects; .5m intervals, 2.5m index for metric projects.
6. ________	_________	Appropriate levels, weights, and text size should be meet

Property Owner File

I. Property Owner Information

1. ________	_________	The Property Owner Names, Deed Book References and Acreage Will Be Stored In a Separate File. Ex. (sPOPPMS#.dgn)
2. ________	_________	Names of Owners as Shown in Deed (wt. = 7)
3. ________	_________	Deed Book, Will Book or Plat Book Number and Page Number.
4. ________	_________	Area of Property as Shown in Plat.
5. ________	_________	Tax Maps, Insert Numbers and Parcel Numbers.
6. ________	_________	A Box with Letter Symbology Will Be Used In Survey Files To Avoid Congestion and Property Owner Information Should Be Placed To The Side as Needed.

Bridge Situations

I. Title Block

	DATE	INITIAL	
1.	_________	__________	AS = .125, Line Sp. =1, Weight =5
2.	_________	__________	Project Number
3.	_________	__________	District & County
4.	_________	__________	From & To
5.	_________	__________	Vertical Datum Based On
6.	_________	__________	Horizontal Datum Based On
7.	_________	__________	Surveyed By
8.	_________	__________	CADD Operator
9.	_________	__________	Date
10.	_________	__________	PPMS Number
11.	_________	__________	Bridge Number
12.	_________	__________	Cut grid lines out of title block

II. Utility Owners & Address

1.	_________	__________	Place to right of Title Block
2.	_________	__________	Sanitary Force Main
3.	_________	__________	Gas
4.	_________	__________	Electric
5.	_________	__________	Sanitary Sewer
6.	_________	__________	Telephone
7.	_________	__________	Cable TV
8.	_________	__________	Traffic Control
9.	_________	__________	Water
10.	_________	__________	Cut grid lines out of utility owner block

III. Scale Notes

1.	_________	__________	Place to right of Utility Block
2.	_________	__________	Note all scales for each portion of bridge situation, i.e. bridge portion, profiles, cross sections
3.	_________	__________	Cut grid lines out of Scale Notes

IV. LD-23 Bridge Data Sheet

1.	_________	__________	Use LD-23 cell (AS=.75)
2.	_________	__________	Fill in all text fields
3.	_________	__________	Place LD-23 in lower left corner of grid
4.	_________	__________	No grid lines on the LD-23

Bridge Situations (continued)

V. Bridge Portion

DATE	INITIAL	
1. ________	__________	Establish grid for bridge situation by establishing construction centerline in the area of coverage.
2. ________	__________	Area is survey master file, master utility file, and contour file merged together, 50' wide from each end of bridge, and 200' wide.
3. ________	__________	Active scale = .25 for cells, patterns, and line styles
4. ________	__________	If Active Scale = 1 check cells, patterns, and line styles for accuracy.
5. ________	__________	Text scale factor =.125 for line styles
6. ________	__________	Property owner text = 1.5
7. ________	__________	Weight on everything increased by 2
8. ________	__________	Obscured contours shown with a line style 3

VI. Profiles and Cross Sections

Centerline Profile of Bridge Portion

1. ________	__________	Place below the bridge portion if space is available, if space is not available then plot directly to the right of bridge portion.
2. ________	__________	Text size = 1.5
3. ________	__________	Description and elevation of benchmark or horizontal control monument.
4. ________	__________	Scale 1"=10' both vertically and horizontally
5. ________	__________	Month and year of high water, plus individual furnishing information.
6. ________	__________	Elevation of low, normal, and high water shown.

Roadway Profile

1. ________	__________	Place to the right of bridge portion.100' each side of centerline shown
2. ________	__________	500' each side of proposed centerline.
3. ________	__________	Text size = 1.5
4. ________	__________	Road profile scale 1"=10' for vertical, project scale for horizontal

Railroad Profile

1. ________	__________	Place to the right of bridge portion.
2. ________	__________	1000' collected each side of centerline
3. ________	__________	Text size = 1.5
4. ________	__________	Railroad profile scale 1"=10' for vertical, project scale for horizontal

Bridge Situations (continued)

Stream Profile

	DATE	INITIAL	
1.	________	_________	Place to the right of bridge portion.
2.	________	_________	1000’ collected each side of centerline
3.	________	_________	Text size = 1.5
4.	________	_________	Scale 1”=10’ for vertical, project scale for horizontal.

High-water Cross Sections

1.	________	_________	Place to the right of bridge portion and above Profile.
2.	________	_________	Coverage to two feet above high-water elevation
3.	________	_________	Cross sections taken perpendicular to flood flow
4.	________	_________	Cross sections to be taken 100’, 500’, 1000’ up and down stream from centerline
5.	________	_________	Text size = 1.5
6.	________	_________	Scale 1”=10’ for vertical, project scale for horizontal.

VII. Plan Portion

1.	________	_________	Area is survey master file, master utility file, and contour file merged together, just use topography for plan portion.
2.	________	_________	After scaling down to 35”X22”, verify the project scale and list.
3.	________	_________	Text size 1.2
4.	________	_________	Verify line styles for proper scale

Quality Control/Quality Assurance on Survey Items Unrelated to Microstation Files

I. Photogrammetric Control

DATE	INITIAL	
1. ________	__________	Computations on horizontal and vertical control points Have been checked
2. ________	__________	Picture points have been numbered (with no duplicate numbers)
3. ________	__________	Picture points have correct symbology on photography. (Square on horizontal, Circle on vertical, and Triangle on both horizontal and vertical)
4. ________	__________	All picture points have a complete description as to their location
5. ________	__________	Topography should be verified (new or destroyed) when Performing annotation
6. ________	__________	"Spot-check" photo points that were collected by GPS procedures.

II. Final Quality Control

1. ________	__________	Overlay plots of topography, breaklines and contours to Insure correctness of ground elevations
2. ________	__________	Take final plot of survey plan base to field for Quality review
3. ________	__________	Check level accuracy by examining each level Individually for correctness

III. Information Transmitted

1. ________	__________	Plot of survey plan base with contours
2. ________	__________	In Transfer file sPPMS#.dgn (topography), sPPMS#CR.dgn (contours), suPPMS#.dgn (utilities), sPPMS#.arc (CAiCE) files, spoPPMS#.dgn (property owners), sPPMS#3D (DTM's)
3. ________	__________	Property information in binder or folder.

IV. Completion Letter

1. ________	__________	Route, Project, Description, County/City and PPMS #
2. ________	__________	List any unusual circumstances that may affect design
3. ________	__________	Note whether or not any hazardous waste areas were Encountered
4. ________	__________	List information being turned in e.g. hard copies, Property information, In Transfer File; (listing each file by name), control monument cards

The survey files for this project have been reviewed and checked for quality and accuracy in accordance with this checklist.

Office Manager ________________________ Date _________

CADD Technician ________________________ Date _________

Survey Manager _________________________ Date _________

Quality Control Checklist Involving GPS Surveys

Route:
Project:
PPMS #

General GPS Survey Procedures

I. Project Information

DATE	INITIAL	
1. ________	__________	District & County:
2. ________	__________	From & To:
3. ________	__________	Vertical Datum Based On:
4. ________	__________	Horizontal Datum Based On:
5. ________	__________	Mission Planned By:
6. ________	__________	GPS Survey Party:
7. ________	__________	Mission Processed By:
8. ________	__________	Begin Date/ End Date:

II. Survey Control Reconnaissance

1. ________	__________	Control Research (online database, existing project control)
2. ________	__________	Recover Control (Note obstructions > 20° on diagram)
3. ________	__________	Map out control points and project points. Maximize network geometry. Plan a "Dummy" Point, if necessary.
4. ________	__________	Set project control monuments as intervisible pairs and minimize obstructions.
5. ________	__________	Reference monuments and produce descriptions.

III. Planning the GPS Survey Mission

1. ________	__________	Obtain most recent almanac.
2. ________	__________	Determine feasible observation time from almanac and planning software. If control has obstructions, plan these observations first. Avoid DOP Spikes!
3. ________	__________	Maximize network geometry (Add "Dummy" Point if necessary).
4. ________	__________	Minimize travel time between stations.
5. ________	__________	Produce observation schedule for each observer.
6. ________	__________	Verify that each observer has enough log sheets and obstruction diagrams.
7. ________	__________	Verify that each observer knows where each station is and knows the station naming convention.

IV. GPS Field Observations
(See Sec. 10.05 Quality Control Procedures)

A. Before Leaving the Office

DATE	INITIAL	
1. ________	__________	Verify all batteries are charged. Bring charger and adapters.
2. ________	__________	Verify survey Data Card is properly formatted.
3. ________	__________	Verify all necessary components of equipment are in the suitcase.
4. ________	__________	Each Party should verify the observation schedule. Each Party should have all schedules, forms and station descriptions.
5. ________	__________	Each Party should have cell phones/radios, charged batteries for each and verify phone numbers/channels for communications.

B. Observing At The Station

1. ________	__________	Equipment should be up and running, waiting to measure, at least 5 Minutes Prior to scheduled start time.
2. ________	__________	Measure the antenna height, record data on Site Log and enter data into receiver. Begin measuring.
3. ________	__________	Locate and depict any new obstructions on diagram.
4. ________	__________	Note any Cycle Slips or Anomalies with observation session on Site Log.
5. ________	__________	Measure the antenna height, record data on Site Log and Check data previously entered into receiver. Pack Up.

V. Processing GPS Data

1. ________	__________	Download data from collector or data card. Check antenna height, GDOP and Station Naming and edit if necessary. Once correct, Assign Data to Project.
2. ________	__________	Set Project Parameters, then Process Data.
3. ________	__________	Check Loop and Triangle Misclosures. Verify Criteria for GPS Positioning are met **(See Sec. 10.04)**
4. ________	__________	Perform and check ellipsoid height calculations for published control.
5. ________	__________	Fix Project Control. Adjust Project. Verify Criteria for Control Point Positioning are met **(See Sec. 10.04)**
6. ________	__________	Export Three-Dimensional Geodetic and Metric State Plane Coordinates in ASCII format for archival. Point Coordinate List should also include Ellipsoid Heights, Geoid Separations, and Orthometric Heights.
7. ________	__________	Export Log File from Final Adjustment to Project Folder.

VI. GPS Survey Report To Central Office
(See Sec. 10.06 Deliverables)

	DATE	INITIAL	
1.	________	_________	Copy of GPS Mission Report (One Page).
2.	________	_________	Copy of the Mission Plan
3.	________	_________	Copy of Survey Network and Project Points Sketch.
4.	________	_________	Copy of All Datasheets for Published Survey Control.
5.	________	_________	Copy of Log File and Results from Final Network Adjustment.
6.	________	_________	Copy of Point List including Geographic Coordinates, Ellipsoidal Heights, Geoid Separations, Orthometric Heights, Metric State Plane Coordinates. This includes stations held fixed.
7.	________	_________	All Copies of Site Log Forms and Obstruction Diagrams.
8.	________	_________	Copies of Completed LD-200 Cards.
9.	________	_________	Copy of Leica Raw Data or RINEX-2 Files for Project.

The GPS survey procedures and data for this project have been reviewed and checked for quality and accuracy in accordance with this checklist, and approved procedures established by VDOT and/or the NGS.

Office Manager ________________________ Date _________

GPS Processor ________________________ Date _________

Survey Manager ________________________ Date _________

Sec. 12.04c Quality Control Checklist for Photogrammetric Surveys

This checklist is to be used by VDOT Photogrammetry staff to insure that the appropriate procedures have been followed and verified for quality control and assurance.

Route: ________________________________
Project: _______________________________
PPMS #_______________________________

Photogrammetric Project Folder

I. Photogrammetry Project Status Sheet

(Sample "Project Status Sheet" available at the end of this checklist)

	DATE	INITIAL	
1.	________	_________	Project Number
2.	________	_________	PPMS Number
3.	________	_________	Description
4.	________	_________	English or Metric
5.	________	_________	Targets or Picture Points
6.	________	_________	"Photograph Information" Complete
7.	________	_________	"Survey Information" Complete
8.	________	_________	"Aerotriangulation Information" Complete
9.	________	_________	Camera Calibration Report Available
10.	________	_________	"Mapping Information" Complete
11.	________	_________	"Project Manager" name and telephone number
12.	________	_________	All Individual Planimetric Models Checked, Initialed, Dated
13.	________	_________	All Individual DTM Models Checked, Initialed, Dated

II. Aerotriangulation

1.	________	_________	Photography with annotated control.
2.	________	_________	Target Map Included
3.	________	_________	Control coordinate listing.
4.	________	_________	Aerotriangulation adjustment report.
5.	________	_________	Residual report reviewed by senior personnel.
6.	________	_________	Model orientation files stored.
7.	________	_________	Diapositives / images stored.

III. Photogrammetry Planimetric Master File

	DATE	INITIAL	
1.	________	_________	Planimetry reviewed/checked in "stereo" for accuracy and completeness.
2.	________	_________	Checked for correct levels and line styles.
3.	________	_________	Checked for correct scale for cells and line styles.
4.	________	_________	Checked for correct symbology for planimetric items.
5.	________	_________	Planimetry edited correctly (lines snapped, intersections cleaned, buildings squared, etc.).
6.	________	_________	File converted to 2D (if necessary).

IV. Photogrammetry Utility File

1.	________	_________	Utility data referenced to planimetry and reviewed/checked in "stereo" for accuracy and completeness (duplicate items, etc.).
2.	________	_________	Utility file has the same scale and symbology as the Photogrammetry planimetric file.
3.	________	_________	Utilities on correct levels.
4.	________	_________	Correct cells used for all utilities.

V. Photogrammetry DTM File

1.	________	_________	DTM file reviewed/checked in "stereo" for completeness, and horizontal and vertical accuracy.
2.	________	_________	DTM data checked for appropriate point grid spacing and sufficient breakline definition.
3.	________	_________	Planimetry referenced to DTM file when reviewing accuracy.
4.	________	_________	Breaklines reviewed at walls, abutments, etc. to insure vertical drops are correct.
5.	________	_________	Appropriate levels, weights, and colors.
6.	________	_________	Contours generated for reviewing DTM data problems.
7.	________	_________	Duplicate point and crossing breaklines processed and removed.

Final Quality Control/Quality Assurance for Photogrammetry

I. Final Quality Control

	DATE	INITIAL	
1.	________	_________	Reference planimetrics, DTM and contour files to insure proper registration of collected data and a final edit check.
2.	________	_________	Check level accuracy by examining each level individually for correctness.

II. Information Transmitted

1.	________	_________	Transfer file sPPMS#. dgn (planimetry), suPPMS#.dgn (utilities), and sPPMS#.dtm (DTM's.)

III. Completion Letter

1.	________	_________	Route, Project, Description, County/City and PPMS #
2.	________	_________	List any unusual circumstances that may affect design.
3.	________	_________	List information being turned in e.g. hard copy materials, files, other data, etc. (List each file by name and location on survey server, CD, FTP site, etc.)

The photogrammetry files for this project have been reviewed and checked for quality and accuracy in accordance with this checklist.

Photogrammetry Technician(s) ________________________
Date _________

Photogrammetry Supervisor ___________________________
Date _________

Photogrammetry Manager ____________________________
Date _________

(Rev 11/01)

PHOTOGRAMMETRY PROJECT STATUS SHEET

Project Number ______________________________ PPMS __________ Description: ____________________

From: ____________________

To: ____________________

English ☐ Targets ☐

Metric ☐ Picture Points ☐

Photograph Information - Aerial Camera: Owner________________ Serial No.________ Lens No.________ CFL_________

District Number/Name ____________________ Locality Number/Name ____________________ Roll Number ___________

Date Flown _______________ Photo Scale ________________ Flying Height _______________

Survey Information - Datum: Horizontal__________ Vertical__________ Other__________ Field Control Point Closure: ________

Control Set VDOT ☐ *Field Crew* ______________________ *Party Chief:* ______________________ *Telephone:* __________

By: Consultant ☐ *Name* ______________________ *Contact name:* ______________________ *Telephone:* __________

Aerotriangulation Information - AT # _______________ Camera Calibration ID: ____________________

Total Number of Strips _________ Total Number of Models _________

Read by: ______________ Instrument: _______________ Adjustment Used: _______________ Ran by: ______________

Std. Dev. Tolerance XY=_______ Z=_______ RMSE: XY=________ Z=________

Date of Final Aerotriangulation Run: ______________ Additional Runs? ______________________________

Mapping Information - Map Scale ______________ Adjoining (tie) Projects (by PPMS#): ____________________

Survey Master File: ______________________________ Survey Utility File: ______________________________

DTM Master File: ______________________________ Centerline File: ______________________________

Surface Files Generated by: ______________________________ Date: __________________

Project Manager -

Contact name ____ *Telephone:* ____________________

Notes: ____

____

____

(Rev. 11/01)

PHOTOGRAMMETRY PROJECT STATUS SHEET *continued*

Page ____ of ____

Project Number ______________________________ PPMS _____________ Description _____________________________

Compilation Record -

Model Number	Planimetry Compiled By:	Date Compiled	Planimetry Checked By:	Date Checked	DTM Compiled By:	Date Compiled	DTM Checked By:	Date Checked	Contours Reviewed By:	Date Contours Reviewed

Notes : ____

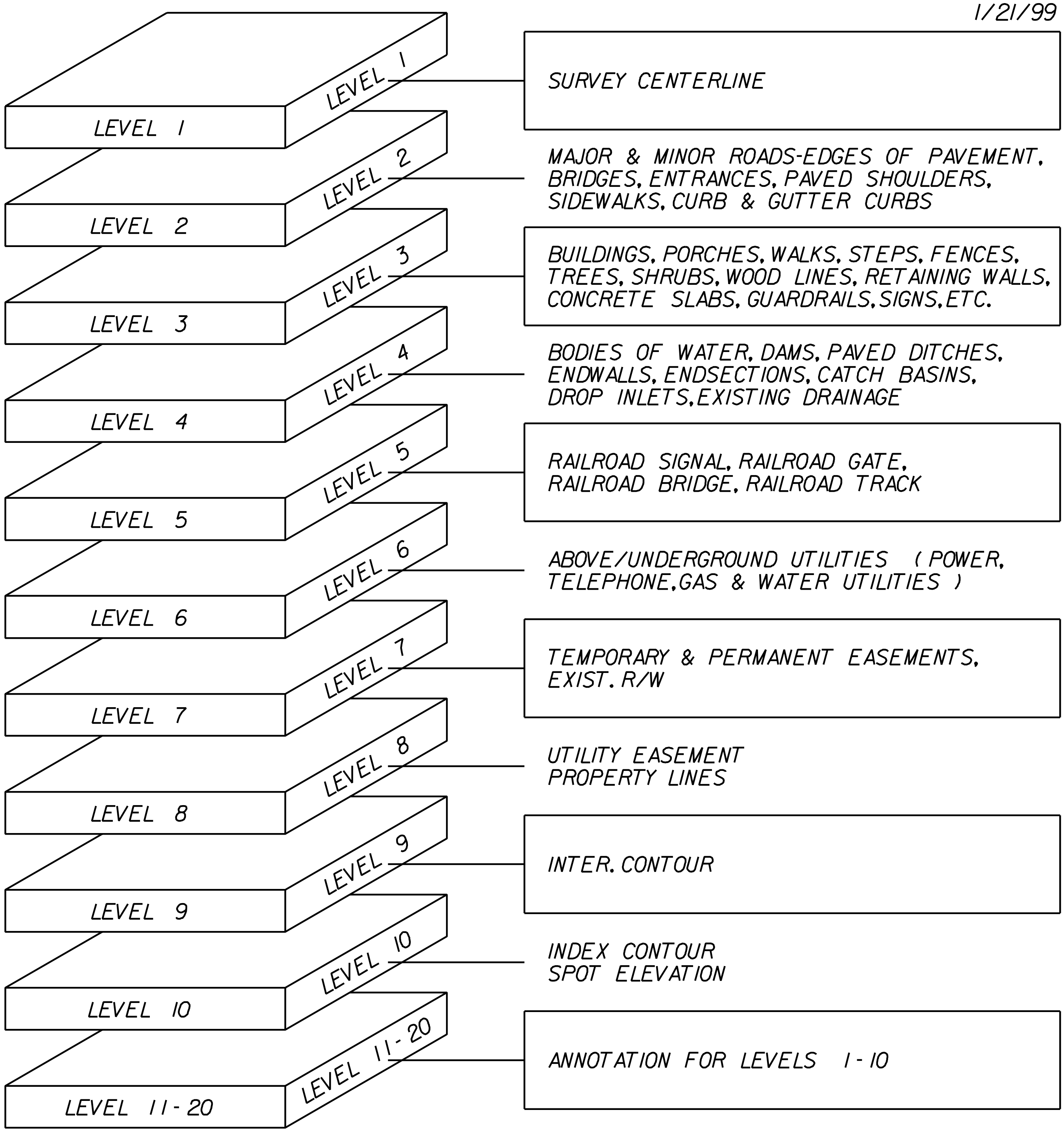
____

APPENDIX A

V.D.O.T.
LEVEL STRUCTURES,
LINE STYLES
&
CELL LIBRARIES

1986 SURVEY LEVEL STRUCTURE

1/21/99



1995 SURVEY TOPO LEVEL STRUCTURE

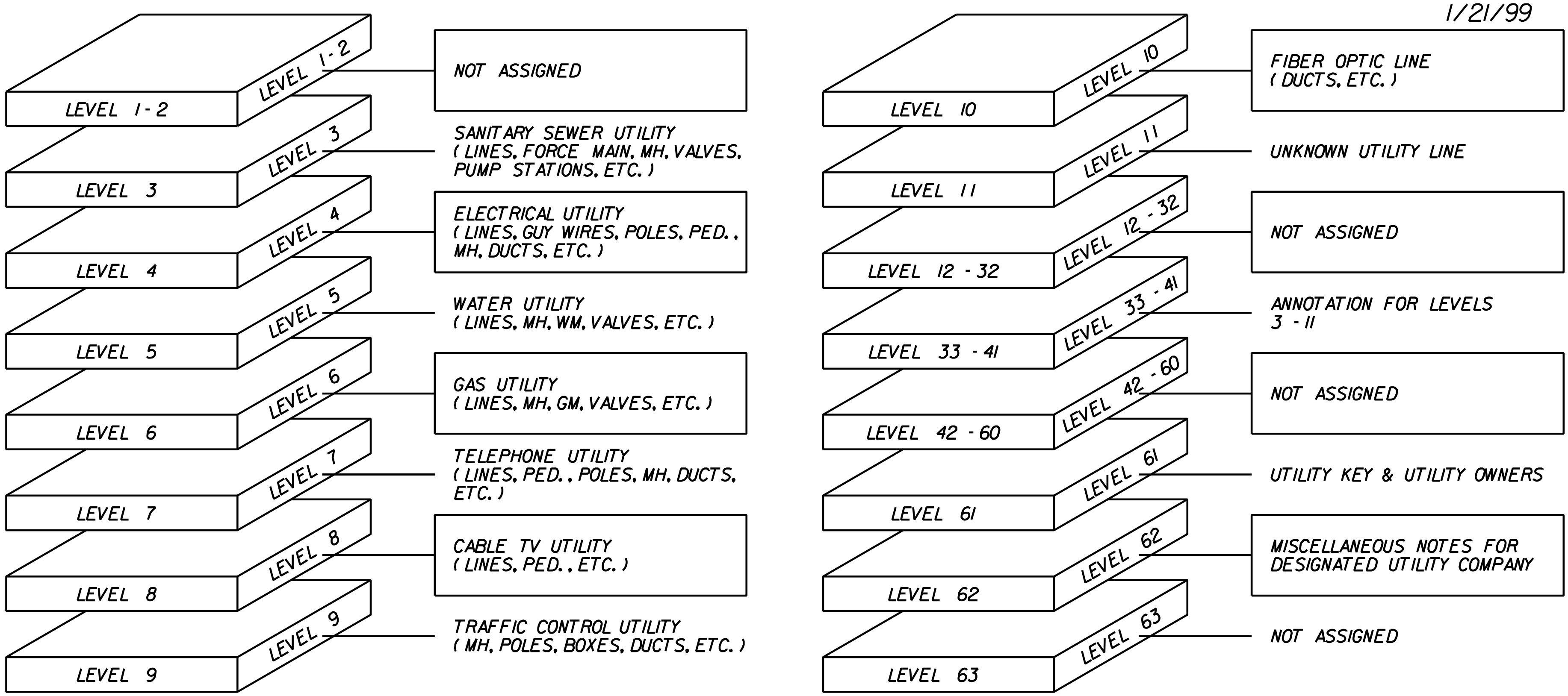
1/21/99

Level	Description	Level	Description
LEVEL 1	CENTERLINE, TRAVERSE, CONTROL STATION	LEVEL 17	BODIES OF WATER
LEVEL 2	BRIDGES	LEVEL 18	PAVED DITCHES
LEVEL 3	EDGE OF PAVEMENT, GRAVEL, CONC., ASPHALT	LEVEL 19	DRAINAGE ITEMS, DAMS, ENDWALLS, CATCH BASINS, DROP INLETS, CULVERT PIPES, DI MANHOLES
LEVEL 4	CURB AND GUTTER	LEVEL 20	RAILROADS, ETC.
LEVEL 5	CURB	LEVEL 21	SEPTIC TANKS, DRAIN FIELDS, WELLS
LEVEL 6	PAVED AND GRAVEL SHOULDER	LEVEL 22	CEMETERIES
LEVEL 7	SIDEWALK (ALONG ROADS)	LEVEL 23	RIGHT OF WAY AND RIGHT OF WAY MONUMENTS
LEVEL 8	BUILDINGS, PORCHES, DECKS, PATIOS, SWIMMING POOLS	LEVEL 24	PROPERTY LINES, PROPERTY PINS, AND PROPERTY EASEMENTS
LEVEL 9	WALKS (AROUND HOUSES) (AND BUILDINGS)	LEVEL 25	STATE, COUNTY AND CITY BOUNDARY LINES
LEVEL 10	STEPS	LEVEL 26	UTILITY EASEMENTS
LEVEL 11	FENCES, GATES	LEVEL 27	WET LANDS
LEVEL 12	WOOD LINE, TREES, SHRUBS, HEDGEROWS	LEVEL 28 - 30	NOT ASSIGNED
LEVEL 13	RETAINING WALLS	LEVEL 31 - 57	ANNOTATION FOR LEVELS 1 - 27
LEVEL 14	CONCRETE SLABS, COLUMNS, GAS ISLANDS, SIGNS, POSTS., RR TIES	LEVEL 58 - 60	NOT ASSIGNED
LEVEL 15	TANKS, DUMPSTERS, GAS PUMPS, FILLER CAPS, MONITORING WELLS, VENT PIPES	LEVEL 61	PLAN SHEET, NORTH ARROW SCALE BAR, ETC.
LEVEL 16	GUARDRAILS, JERSEY BARRIERS	LEVEL 62	GRID AND LABELS
		LEVEL 63	NOT ASSIGNED

NOTE :
Survey Contour, DTM, Topo, & Utility information will be in separate files.

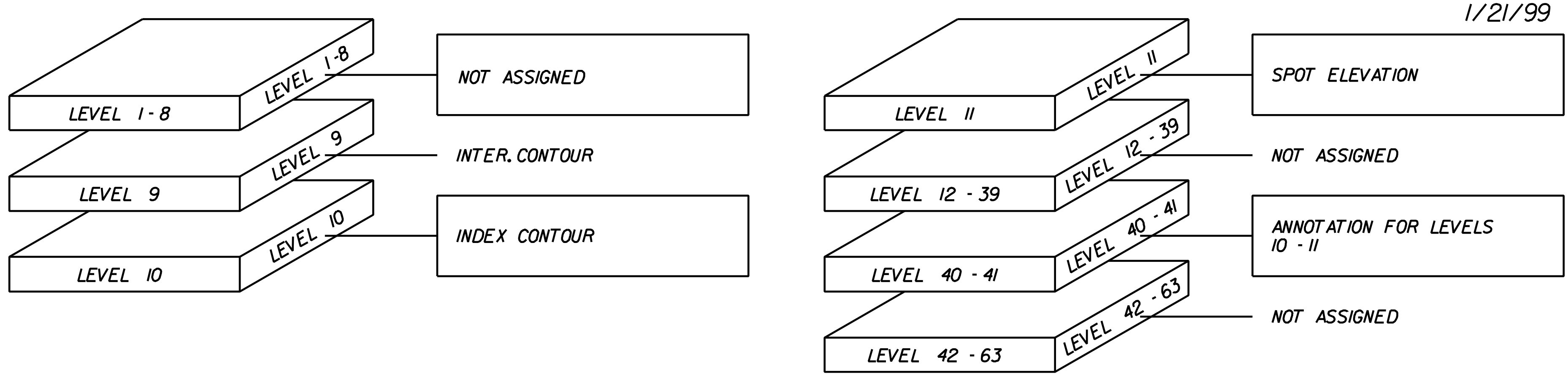
1995 SURVEY UTILITIES LEVEL STRUCTURE

1/21/99

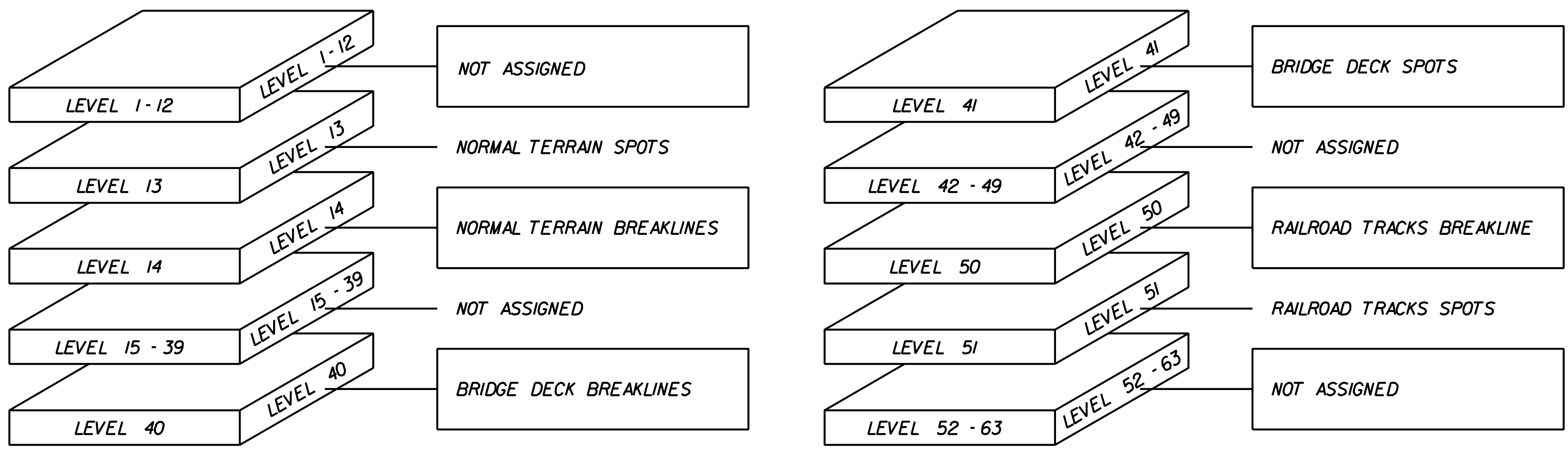


1995 SURVEY CONTOUR LEVEL STRUCTURE

1/21/99



1995 SURVEY DTM LEVEL STRUCTURE



1986 English Line Styles

1/21/99

Pipe wt-0 as-1 lv-4 lc-c
12" Pipe wt=0 as=1 lv=4 lc=c12
15" Pipe wt=0 as=1 lv=4 lc=c15
18" Pipe wt-0 as-1 lv-4 lc-c18
21" Pipe wt=0 as=1 lv=4 lc=c21
24" Pipe wt=0 as=1 lv=4 lc=c24
27" Pipe wt-0 as-1 lv-4 lc-c27
30" Pipe wt=0 as=1 lv=4 lc=c30
33" Pipe wt-0 as-1 lv-4 lc-c33
36" Pipe wt=0 as=1 lv=4 lc=c36
42" Pipe wt=0 as=1 lv=4 lc=c42
48" Pipe wt-0 as-1 lv-4 lc-c48
54" Pipe wt=0 as=1 lv=4 lc=c54
60" Pipe wt=0 as=1 lv=4 lc=c60
66" Pipe wt-0 as-1 lv-4 lc-c66
72" Pipe wt=0 as=1 lv=4 lc=c72
78" Pipe wt=0 as=1 lv=4 lc=c78
84" Pipe wt-0 as-1 lv-4 lc-c84
90" Pipe wt=0 as=1 lv=4 lc=c90
96" Pipe wt-0 as-1 lv-4 lc-c96
102" Pipe wt=0 as=1 lv=4 lc=c102
108" Pipe wt=0 as=1 lv=4 lc=c108
114" Pipe wt-0 as-1 lv-4 lc-c114
120" Pipe wt=0 as=1 lv=4 lc=c120
City Line wt=6 as=1 lv=7 lc=cl1
County Line wt-6 as-1 lv-7 lc-col
0.5' Curb wt=2 as=1 lv=2 lc=ecc.5
0.5' Curb Right wt=2 as=1 lv=2 lc=ecg.5right
C&G wt-2 as-1 lv-2 lc-ecg
C&G Right wt=2 as=1 lv=2 lc=ecg-right

1.0' C&G wt-2 as-1 lv-2 lc-ecg1
1.5' C&G wt=2 as=1 lv=2 lc=ecg1.5
1.5' C&G Right wt=2 as=1 lv=2 lc=ecg1.5-right
2.0' C&G wt-2 as-1 lv-2 lc-ecg2
2.0' C&G Right wt=2 as=1 lv=2 lc=ecg2-right
2.5' C&G wt=2 as=1 lv=2 lc=ecg2.5
2.5' C&G Right wt-2 as-1 lv-2 lc-ecg2.5-right
Fence wt=0 as=job lv=3 lc=fe
Gas wt-0 as-job lv-6 lc-g
3/4" Gas wt=0 as=job lv=6 lc=g.75
1" Gas wt=0 as=job lv=6 lc=g1
1 1/4" Gas wt-0 as-job lv-6 lc-g1.25
1 1/2" Gas wt=0 as=job lv=6 lc=g1.5
1 3/4" Gas wt=0 as=job lv=6 lc=g1.75
2" Gas wt-0 as-job lv-6 lc-g2
3" Gas wt=0 as=job lv=6 lc=g3
4" Gas wt=0 as=job lv=6 lc=g4
6" Gas wt-0 as-job lv-6 lc-g6
8" Gas wt=0 as=job lv=6 lc=g8
10" Gas wt-0 as-job lv-6 lc-g10
12" Gas wt=0 as=job lv=6 lc=g12
14" Gas wt=0 as=job lv=6 lc=g14
16" Gas wt-0 as-job lv-6 lc-g16
18" Gas wt=0 as=job lv=6 lc=g18
24" Gas wt=0 as=job lv=6 lc=g24
Gas Duct wt-0 as-job lv-6 lc-gduct
Guard Rail wt=1 as=job lv=3 lc=gr
Guard Rail Right wt=1 as=job lv=3 lc=gr-right
Hedge Row wt-0 as-job lv-3 lc-hr
Jersey Barrier wt=1 as=1 lv=3 lc=jb

NOT TO SCALE

1986 English Line Styles

1/21/99

Line Style	Sample Label
Paved Ditch wt=2 as=l lv=4 lc=pd	
4' Paved Ditch wt=2 as=l lv=4 lc=pd4	
5' Paved Ditch wt=2 as=l lv=4 lc=pd5	
Railroad wt=0 as=l lv=5 lc=rr	
Railroad Left wt=0 as=l lv=5 lc=rr-left	
Right Of Way wt=2 as=l lv=7 lc=rw	
Sanitary Sewer wt=0 as=job lv=6 lc=s	SAN
2" San Sewer wt=0 as=job lv=6 lc=s2	2 "SAN
2 1/2" San Sewer wt=0 as=job lv=6 lc=s2.5	2 1/2" SAN
3" San Sewer wt=0 as=job lv=6 lc=s3	3 "SAN
4" San Sewer wt=0 as=job lv=6 lc=s4	4 "SAN
6" San Sewer wt=0 as=job lv=6 lc=s6	6 "SAN
8" San Sewer wt=0 as=job lv=6 lc=s8	8 "SAN
10" San Sewer wt=0 as=job lv=6 lc=s10	10 "SAN
12" San Sewer wt=0 as=job lv=6 lc=s12	12 "SAN
14" San Sewer wt=0 as=job lv=6 lc=s14	14 "SAN
15" San Sewer wt=0 as=job lv=6 lc=s15	15 "SAN
16" San Sewer wt=0 as=job lv=6 lc=s16	16 "SAN
18" San Sewer wt=0 as=job lv=6 lc=s18	18 "SAN
20" San Sewer wt=0 as=job lv=6 lc=s20	20 "SAN
21" San Sewer wt=0 as=job lv=6 lc=s21	21 "SAN
22" San Sewer wt=0 as=job lv=6 lc=s22	22 "SAN
24" San Sewer wt=0 as=job lv=6 lc=s24	24 "SAN
27" San Sewer wt=0 as=job lv=6 lc=s27	27 "SAN
30" San Sewer wt=0 as=job lv=6 lc=s30	30 "SAN
33" San Sewer wt=0 as=job lv=6 lc=s33	33 "SAN
36" San Sewer wt=0 as=job lv=6 lc=s36	36 "SAN
42" San Sewer wt=0 as=job lv=6 lc=s42	42 "SAN
48" San Sewer wt=0 as=job lv=6 lc=s48	48 "SAN
54" San Sewer wt=0 as=job lv=6 lc=s54	54 "SAN

Line Style	Sample Label
Sanitary SFM wt=0 as=job lv=6 lc=sfm	SFM
2" San SFM wt=0 as=job lv=6 lc=sfm2	2 "SFM
2 1/2"San SFM wt=0 as=job lv=6 lc=sfm2.5	2 1/2" SFM
3" San SFM wt=0 as=job lv=6 lc=sfm3	3 "SFM
4" San SFM wt=0 as=job lv=6 lc=sfm4	4 "SFM
6" San SFM wt=0 as=job lv=6 lc=sfm6	6 "SFM
8" San SFM wt=0 as=job lv=6 lc=sfm8	8 "SFM
10" San SFM wt=0 as=job lv=6 lc=sfm10	10 "SFM
12" San SFM wt=0 as=job lv=6 lc=sfm12	12 "SFM
14" San SFM wt=0 as=job lv=6 lc=sfm14	14 "SFM
16" San SFM wt=0 as=job lv=6 lc=sfm16	16 "SFM
18" San SFM wt=0 as=job lv=6 lc=sfm18	18 "SFM
20" San SFM wt=0 as=job lv=6 lc=sfm20	20 "SFM
21" San SFM wt=0 as=job lv=6 lc=sfm21	21 "SFM
22" San SFM wt=0 as=job lv=6 lc=sfm22	22 "SFM
24" San SFM wt=0 as=job lv=6 lc=sfm24	24 "SFM
27" San SFM wt=0 as=job lv=6 lc=sfm27	27 "SFM
30" San SFM wt=0 as=job lv=6 lc=sfm30	30 "SFM
32" San SFM wt=0 as=job lv=6 lc=sfm32	32 "SFM
36" San SFM wt=0 as=job lv=6 lc=sfm36	36 "SFM
42" San SFM wt=0 as=job lv=6 lc=sfm42	42 "SFM
48" San SFM wt=0 as=job lv=6 lc=sfm48	48 "SFM
54" San SFM wt=0 as=job lv=6 lc=sfm54	54 "SFM
State Line wt=9 as=l lv=7 lc=stl	
Fiber Optic wt=0 as=job lv=6 lc=ufo	FO
Unknown Utility wt=0 as=job lv=6 lc=unk	Unk
Underground Elec wt=0 as=job lv=6 lc=up	E
U/G Elec. Duct wt=0 as=job lv=6 lc=upduct	T/Tg
Underground Tele wt=0 as=job lv=6 lc=ut	T/Tg
Traffic Control wt=0 as=job lv=6 lc=utc	TC

NOT TO SCALE

Traff.Con.Duct wt=0 as=job lv=6 lc=utcduct
TC Duct
U/G Tele. Duct wt=0 as=job lv=6 lc=utduct
T/Tg Duct
Cable TV wt=0 as=job lv=6 lc=utv
CATV
Cable TV Duct wt=0 as=job lv=6 lc=utvduct
CATV Duct
Water wt=0 as=job lv=6 lc=w
W
¾" Water wt=0 as=job lv=6 lc=w.75
¾"W
1" Water wt=0 as=job lv=6 lc=w1
1"W
1½" Water wt=0 as=job lv=6 lc=w1.5
1½"W
2" Water wt=0 as=job lv=6 lc=w2
2 "W
3" Water wt=0 as=job lv=6 lc=w3
3 "W
4" Water wt=0 as=job lv=6 lc=w4
4 "W
6" Water wt=0 as=job lv=6 lc=w6
6 "W
8" Water wt=0 as=job lv=6 lc=w8
8 "W
9" Water wt=0 as=job lv=6 lc=w9
9 "W
10" Water wt=0 as=job lv=6 lc=w10
10 "W
12" Water wt=0 as=job lv=6 lc=w12
12 "W
14" Water wt=0 as=job lv=6 lc=w14
14 "W
16" Water wt=0 as=job lv=6 lc=w16
16 "W
18" Water wt=0 as=job lv=6 lc=w18
18 "W
20" Water wt=0 as=job lv=6 lc=w20
20 "W
24" Water wt=0 as=job lv=6 lc=w24
24 "W
30" Water wt=0 as=job lv=6 lc=w30
30 "W
36" Water wt=0 as=job lv=6 lc=w36
36 "W
Water Edge wt=0 as=job lv=4 lc=wa
Water Duct wt=0 as=job lv=6 lc=wduct
W Duct
Walk wt=2 as=1 lv=3 lc=wk
Walk Left wt=2 as=1 lv=3 lc=wk-left
3' Walk wt=2 as=1 lv=3 lc=wk3
3' Walk Left wt=2 as=1 lv=3 lc=wk3-left
4' Walk wt=2 as=1 lv=3 lc=wk4

4' Walk Left wt=2 as=1 lv=3 lc=wk4-left
5' Walk wt=2 as=1 lv=3 lc=wk5
5' Walk Left wt=2 as=1 lv=3 lc=wk5-left
Wet Lands wt=3 as=job lv=4 lc=wl
WL- -WL-
Woods wt=0 as=job lv=3 lc=wo
Woods Left wt=0 as=job lv=3 lc=wo-left

Survey Centerline wt=5 lv=1 lc=0
Major Roads wt=2 lv=2 lc=3
Bridges wt=3 lv=2 lc=3
Minor Roads; Edge Of Pav.; Entrances; Paved Shoulder wt=2 lv=2 lc=2
Buildings wt=4 lv=3 lc=0
Porches wt=3 lv=3 lc=0
Retaining Walls wt=2 lv=3 lc=2
Steps; Concrete Slabs; Tanks; Columns; Signs; Posts wt=1 lv=3 lc=0
Dams; Endwalls; Endsections wt=1 lv=4 lc=0
Catch Basins; Drop Inlets wt=2 lv=4 lc=5
Railroad Gate,& Signal wt=2 lv=5 lc=0
Railroad Bridge wt=3 lv=5 lc=3
Drain Field; Septic Tank wt=1 lv=6 lc=2
Data According To Util.Record wt=0 lv=6 lc=3 DATUR (what it is)
Transmission Towers wt=2 lv=6 lc=2
Overhead Lines wt=1 lv=6 lc=1
Temporary Easement wt=2 lv=7 lc=6
Permanent Easement wt=2 lv=7 lc=4
Utility Easement wt=2 lv=8 lc=4
Property Line wt=3 lv=8 lc=0
Inter. Contour wt=1 lv=9 lc=0
Index Contour wt=3 lv=10 lc=0

NOT TO SCALE

1986 Metric Line Styles

1/21/99

m Pipe wt=0 as=1 lv=4 lc=mc

0.30 m Pipe wt=0 as=1 lv=4 lc=mc.30

0.38 m Pipe wt=0 as=1 lv=4 lc=mc.38

0.46 m Pipe wt=0 as=1 lv=4 lc=mc.46

0.53 m Pipe wt=0 as=1 lv=4 lc=mc.53

0.61 m Pipe wt=0 as=1 lv=4 lc=mc.61

0.69 m Pipe wt=0 as=1 lv=4 lc=mc.69

0.76 m Pipe wt=0 as=1 lv=4 lc=mc.76

0.84 m Pipe wt=0 as=1 lv=4 lc=mc.84

0.91 m Pipe wt=0 as=1 lv=4 lc=mc.91

1.07 m Pipe wt=0 as=1 lv=4 lc=mc1.07

1.22 m Pipe wt=0 as=1 lv=4 lc=mc1.22

1.37 m Pipe wt=0 as=1 lv=4 lc=mc1.37

1.52 m Pipe wt=0 as=1 lv=4 lc=mc1.52

1.68 m Pipe wt=0 as=1 lv=4 lc=mc1.68

1.83 m Pipe wt=0 as=1 lv=4 lc=mc1.83

1.98 m Pipe wt=0 as=1 lv=4 lc=mc1.98

2.13 m Pipe wt=0 as=1 lv=4 lc=mc2.13

2.29 m Pipe wt=0 as=1 lv=4 lc=mc2.29

2.44 m Pipe wt=0 as=1 lv=4 lc=mc2.44

2.59 m Pipe wt=0 as=1 lv=4 lc=mc2.59

2.74 m Pipe wt=0 as=1 lv=4 lc=mc2.74

2.90 m Pipe wt=0 as=1 lv=4 lc=mc2.90

3.05 m Pipe wt=0 as=1 lv=4 lc=mc3.05

City Line wt=6 as=1 lv=7 lc=mcil

County Line wt=6 as=1 lv=7 lc=mcol

0.15 m Curb wt=2 as=1 lv=2 lc=mecc.15

0.15 m Curb Right wt=2 as=1 lv=2 lc=mecc.15-right

m C&G wt=2 as=1 lv=2 lc=mecg

m C&G Right wt=2 as=1 lv=2 lc=mecg-right

0.30 m C&G wt=2 as=1 lv=2 lc=mecg.30

0.46 m C&G wt=2 as=1 lv=2 lc=mecg.46

0.46m C&G Right wt=2 as=1 lv=2 lc=mecg.46-right

0.61 m C&G wt=2 as=1 lv=2 lc=mecg.61

0.61m C&G Right wt=2 as=1 lv=2 lc=mecg.61-right

0.76 m C&G wt=2 as=1 lv=2 lc=mecg.76

0.76m C&G Right wt=2 as=1 lv=2 lc=mecg.76-right

Fence wt=0 as=job lv=3 lc=mfe

m Gas wt=0 as=job lv=6 lc=mg

G

0.02 m Gas wt=0 as=job lv=6 lc=mg.02

.02 m G

0.03 m Gas wt=0 as=job lv=6 lc=mg.03

.03 m G

0.04 m Gas wt=0 as=job lv=6 lc=mg.04

.04 m G

0.05 m Gas wt=0 as=job lv=6 lc=mg.05

.05 m G

0.08 m Gas wt=0 as=job lv=6 lc=mg.08

.08 m G

0.10 m Gas wt=0 as=job lv=6 lc=mg.10

.10 m G

0.15 m Gas wt=0 as=job lv=6 lc=mg.15

.15 m G

0.20 m Gas wt=0 as=job lv=6 lc=mg.20

.20 m G

0.25 m Gas wt=0 as=job lv=6 lc=mg.25

.25 m G

0.30 m Gas wt=0 as=job lv=6 lc=mg.30

.30 m G

0.36 m Gas wt=0 as=job lv=6 lc=mg.36

.36 m G

0.41 m Gas wt=0 as=job lv=6 lc=mg.41

.41 m G

0.46 m Gas wt=0 as=job lv=6 lc=mg.46

.46 m G

0.51 m Gas wt=0 as=job lv=6 lc=mg.51

.51 m G

0.56 m Gas wt=0 as=job lv=6 lc=mg.56

.56 m G

0.61 m Gas wt=0 as=job lv=6 lc=mg.61

.61 m G

Gas Duct wt=0 as=job lv=6 lc=mgduct

G Duct

Guard Rail wt=1 as=job lv=3 lc=mgr

Guard Rail Right wt=1 as=job lv=3 lc=mgr-right

Hedge Row wt=0 as=job lv=3 lc=mhr

Jersey Barrier wt=1 as=1 lv=3 lc=mjb

NOT TO SCALE

1986 Metric Line Styles

1/21/99

Paved Ditch wt=2 as=1 lv=4 lc=mpd

1.22 m Pav. Ditch wt=2 as=1 lv=4 lc=mpd1.22

1.52 m Pav. Ditch wt=2 as=1 lv=4 lc=mpd1.52

Rail Road wt=0 as=1 lv=5 lc=mrr

Rail Road Left wt=0 as=1 lv=5 lc=mrr-left

Right Of Way wt=2 as=1 lv=7 lc=mrw

m San wt=0 as=job lv=6 lc=ms

SAN

0.05 m San wt=0 as=job lv=6 lc=ms.05

.05 m SAN

0.06 m San wt=0 as=job lv=6 lc=ms.06

.06 m SAN

0.08 m San wt=0 as=job lv=6 lc=ms.08

.08 m SAN

0.10 m San wt=0 as=job lv=6 lc=ms.10

.10 m SAN

0.15 m San wt=0 as=job lv=6 lc=ms.15

.15 m SAN

0.20 m San wt=0 as=job lv=6 lc=ms.20

.20 m SAN

0.25 m San wt=0 as=job lv=6 lc=ms.25

.25 m SAN

0.30 m San wt=0 as=job lv=6 lc=ms.30

.30 m SAN

0.36 m San wt=0 as=job lv=6 lc=ms.36

.36 m SAN

0.38 m San wt=0 as=job lv=6 lc=ms.38

.38 m SAN

0.41 m San wt=0 as=job lv=6 lc=ms.41

.41 m SAN

0.46 m San wt=0 as=job lv=6 lc=ms.46

.46 m SAN

0.51 m San wt=0 as=job lv=6 lc=ms.51

.51 m SAN

0.53 m San wt=0 as=job lv=6 lc=ms.53

.53 m SAN

0.56 m San wt=0 as=job lv=6 lc=ms.56

.56 m SAN

0.61 m San wt=0 as=job lv=6 lc=ms.61

.61 m SAN

0.69 m San wt=0 as=job lv=6 lc=ms.69

.69 m SAN

0.76 m San wt=0 as=job lv=6 lc=ms.76

.76 m SAN

0.83 m San wt=0 as=job lv=6 lc=ms.83

.83 m SAN

0.91 m San wt=0 as=job lv=6 lc=ms.91

.91 m SAN

1.07 m San wt=0 as=job lv=6 lc=ms1.07

1.07 m SAN

1.22 m San wt=0 as=job lv=6 lc=ms1.22

1.22 m SAN

1.37 m San wt=0 as=job lv=6 lc=ms1.37

1.37 m SAN

m SFM wt=0 as=job lv=6 lc=msf

SFM

0.05 m SFM wt=0 as=job lv=6 lc=msf.05

.05 m SFM

0.06 m SFM wt=0 as=job lv=6 lc=msf.06

.06 m SFM

0.08 m SFM wt=0 as=job lv=6 lc=msf.08

.08 m SFM

0.10 m SFM wt=0 as=job lv=6 lc=msf.10

.10 m SFM

0.15 m SFM wt=0 as=job lv=6 lc=msf.15

.15 m SFM

0.20 m SFM wt=0 as=job lv=6 lc=msf.20

.20 m SFM

0.25 m SFM wt=0 as=job lv=6 lc=msf.25

.25 m SFM

0.30 m SFM wt=0 as=job lv=6 lc=msf.30

.30 m SFM

0.36 m SFM wt=0 as=job lv=6 lc=msf.36

.36 m SFM

0.38 m SFM wt=0 as=job lv=6 lc=msf.38

.38 m SFM

0.41 m SFM wt=0 as=job lv=6 lc=msf.41

.41 m SFM

0.46 m SFM wt=0 as=job lv=6 lc=msf.46

.46 m SFM

0.51 m SFM wt=0 as=job lv=6 lc=msf.51

.51 m SFM

0.53 m SFM wt=0 as=job lv=6 lc=msf.53

.53 m SFM

0.56 m SFM wt=0 as=job lv=6 lc=msf.56

.56 m SFM

0.61 m SFM wt=0 as=job lv=6 lc=msf.61

.61 m SFM

0.69 m SFM wt=0 as=job lv=6 lc=msf.69

.69 m SFM

0.76 m SFM wt=0 as=job lv=6 lc=msf.76

.76 m SFM

0.83 m SFM wt=0 as=job lv=6 lc=msf.83

.83 m SFM

0.91 m SFM wt=0 as=job lv=6 lc=msf.91

.91 m SFM

1.07 m SFM wt=0 as=job lv=6 lc=msf1.07

1.07 m SFM

1.22 m SFM wt=0 as=job lv=6 lc=msf1.22

1.22 m SFM

1.37 m SFM wt=0 as=job lv=6 lc=msf1.37

1.37 m SFM

State Line wt=9 as=1 lv=7 lc=mstl

Fiber Optic wt=0 as=job lv=6 lc=mufo

FO

Unknown Utility wt=0 as=job lv=6 lc=munk

Unk Unk

U/G Elec wt=0 as=job lv=6 lc=mup

E

U/G Elec Duct wt=0 as=job lv=6 lc=mupduct

E Duct

Underground Tele wt=0 as=job lv=6 lc=mut

T/Tg

NOT TO SCALE

1986 Metric Line Styles

04/10/00

- Traffic Control wt=0 as=job lv=6 lc=mutc — TC
- Traff. Con. Duct wt=0 as=job lv=6 lc=mutcduct — TC Duct
- Tele Duct wt=0 as=job lv=6 lc=mutduct — T/Tg Duct
- Cable TV wt=0 as=job lv=6 lc=mutv — CATV
- Cable TV Duct wt=0 as=job lv=6 lc=mutvduct — CATV Duct
- m Water wt=0 as=job lv=6 lc=mw — W — W
- 0.02 m Water wt=0 as=job lv=6 lc=mw.02 — .02 m W
- 0.03 m Water wt=0 as=job lv=6 lc=mw.03 — .03 m W
- 0.04 m Water wt=0 as=job lv=6 lc=mw.04 — .04 m W
- 0.05 m Water wt=0 as=job lv=6 lc=mw.05 — .05 m W
- 0.08 m Water wt=0 as=job lv=6 lc=mw.08 — .08 m W
- 0.10 m Water wt=0 as=job lv=6 lc=mw.10 — .10 m W
- 0.15 m Water wt=0 as=job lv=6 lc=mw.15 — .15 m W
- 0.20 m Water wt=0 as=job lv=6 lc=mw.20 — .20 m W
- 0.23 m Water wt=0 as=job lv=6 lc=mw.23 — .23 m W
- 0.25 m Water wt=0 as=job lv=6 lc=mw.25 — .25 m W
- 0.30 m Water wt=0 as=job lv=6 lc=mw.30 — .30 m W
- 0.36 m Water wt=0 as=job lv=6 lc=mw.36 — .36 m W
- 0.41 m Water wt=0 as=job lv=6 lc=mw.41 — .41 m W
- 0.46 m Water wt=0 as=job lv=6 lc=mw.46 — .46 m W
- 0.51 m Water wt=0 as=job lv=6 lc=mw.51 — .51 m W
- 0.61 m Water wt=0 as=job lv=6 lc=mw.61 — .61 m W
- 0.76 m Water wt=0 as=job lv=6 lc=mw.76 — .76 m W
- 0.91 m Water wt=0 as=job lv=6 lc=mw.91 — .91 m W
- Water Edge wt=0 as=job lv=4 lc=mwa
- Water Duct wt=0 as=job lv=6 lc=mwduct — W Duct
- m Walk wt=2 as=1 lv=3 lc=mwk
- m Walk Left wt=2 as=1 lv=3 lc=mwk-left
- 0.91 m Walk wt=2 as=1 lv=3 lc=mwk.91
- 0.91m Walk Left wt=2 as=1 lv=3 lc=mwk.91-left
- 1.22 m Walk wt=2 as=1 lv=3 lc=mwk1.22
- 1.22m Walk Left wt=2 as=1 lv=3 lc=mwk1.22-left
- 1.52 m Walk wt=2 as=1 lv=3 lc=mwk1.52
- 1.52m Walk Left wt=2 as=1 lv=3 lc=mwk1.52-left
- Wet Lands wt=3 as=job lv=4 lc=mwl — -WL- — -WL-
- Woods wt=0 as=job lv=3 lc=mwo
- Woods Left wt=0 as=job lv=3 lc=mwo-left
- Survey Centerline wt=5 lv=1 lc=0
- Major Roads wt=2 lv=2 lc=3
- Bridges wt=3 lv=2 lc=3
- Minor Roads; Edge Of Pav.; Entrances; Paved Shoulder wt=2 lv=2 lc=2
- Buildings wt=4 lv=3 lc=0
- Porches wt=3 lv=3 lc=0
- Retaining Walls wt=2 lv=3 lc=2
- Steps; Concrete Slabs; Tanks; Columns; Signs; Posts wt=1 lv=3 lc=0
- Dams; Endwalls; Endsections wt=1 lv=4 lc=0
- Catch Basins; Drop Inlets wt=2 lv=4 lc=5
- Railroad Gate, & Signal wt=2 lv=5 lc=0
- Railroad Bridge wt=3 lv=5 lc=3
- Drain Field; Septic Tank wt=1 lv=6 lc=2
- Data According To Util. Records (DATUR) wt=0 lv=6 lc=3 (what it is)
- Transmission Towers wt=2 lv=6 lc=2
- Overhead Lines wt=1 lv=6 lc=1
- Temporary Easement wt=2 lv=7 lc=6
- Permanent Easement wt=2 lv=7 lc=4
- Utility Easement wt=2 lv=8 lc=4
- Property Line wt=3 lv=8 lc=0
- Inter. Contour wt=1 lv=9 lc=0
- Index Contour wt=3 lv=10 lc=0

NOT TO SCALE

1995 English Line Styles

04/10/00

Pipe wt=0 as=1 lv=19 lc=c

12" Pipe wt=0 as=1 lv=19 lc=c12

15" Pipe wt=0 as=1 lv=19 lc=c15

18" Pipe wt=0 as=1 lv=19 lc=c18

21" Pipe wt=0 as=1 lv=19 lc=c21

24" Pipe wt=0 as=1 lv=19 lc=c24

27" Pipe wt=0 as=1 lv=19 lc=c27

30" Pipe wt=0 as=1 lv=19 lc=c30

33" Pipe wt=0 as=1 lv=19 lc=c33

36" Pipe wt=0 as=1 lv=19 lc=c36

42" Pipe wt=0 as=1 lv=19 lc=c42

48" Pipe wt=0 as=1 lv=19 lc=c48

54" Pipe wt=0 as=1 lv=19 lc=c54

60" Pipe wt=0 as=1 lv=19 lc=c60

66" Pipe wt=0 as=1 lv=19 lc=c66

72" Pipe wt=0 as=1 lv=19 lc=c72

78" Pipe wt=0 as=1 lv=19 lc=c78

84" Pipe wt=0 as=1 lv=19 lc=c84

90" Pipe wt=0 as=1 lv=19 lc=c90

96" Pipe wt=0 as=1 lv=19 lc=c96

102" Pipe wt=0 as=1 lv=19 lc=c102

108" Pipe wt=0 as=1 lv=19 lc=c108

114" Pipe wt=0 as=1 lv=19 lc=c114

120" Pipe wt=0 as=1 lv=19 lc=c120

City Line wt=6 as=1 lv=25 lc=cil

County Line wt=6 as=1 lv=25 lc=col

0.5' Curb wt=2 as=1 lv=5 lc=ecc.5

0.5' Curb Right wt=2 as=1 lv=5 lc=ecc.5-right

C&G wt=2 as=1 lv=4 lc=ecg

C&G wt=2 as=1 lv=4 lc=ecg-right

1.0' C&G wt=2 as=1 lv=4 lc=ecg1

1.5' C&G wt=2 as=1 lv=4 lc=ecg1.5

1.5' C&G Rightwt=2 as=1 lv=4 lc=ecg1.5-right

2.0' C&G wt=2 as=1 lv=4 lc=ecg2

2.0' C&G Right wt=2 as=1 lv=4 lc=ecg2-right

2.5' C&G wt=2 as=1 lv=4 lc=ecg2.5

2.5' C&G Right wt=2 as=1 lv=4 lc=ecg2.5-right

Fence wt=0 as=job lv=11 lc=fe

Gas wt=0 as=job lv=6 lc=g

G

¾" Gas wt=0 as=job lv=6 lc=g.75

¾"G

1" Gas wt=0 as=job lv=6 lc=g1

1"G

1 ¼" Gas wt=0 as=job lv=6 lc=g1.25

1¼"G

1 ½" Gas wt=0 as=job lv=6 lc=g1.5

1½"G

1 ¾" Gas wt=0 as=job lv=6 lc=g1.75

1¾"G

2" Gas wt=0 as=job lv=6 lc=g2

2"G

3" Gas wt=0 as=job lv=6 lc=g3

3"G

4" Gas wt=0 as=job lv=6 lc=g4

4"G

6" Gas wt=0 as=job lv=6 lc=g6

6"G

8" Gas wt=0 as=job lv=6 lc=g8

8"G

10" Gas wt=0 as=job lv=6 lc=g10

10"G

12" Gas wt=0 as=job lv=6 lc=g12

12"G

14" Gas wt=0 as=job lv=6 lc=g14

14"G

16" Gas wt=0 as=job lv=6 lc=g16

16"G

18" Gas wt=0 as=job lv=6 lc=g18

18"G

24" Gas wt=0 as=job lv=6 lc=g24

24"G

Gas Duct wt=0 as=job lv=6 lc=gduct

G Duct

Guard Rail wt=1 as=job lv=16 lc=gr

Guard Rail Right wt=1 as=job lv=16 lc=gr-right

Hedge Row wt=0 as=job lv=12 lc=hr

Jersey Barrier wt=1 as=1 lv=16 lc=jb

NOT TO SCALE

1995 English Line Styles

1/21/99

Paved Ditch wt=2 as=1 lv=18 lc=pd

4' Paved Ditch wt=2 as=1 lv=18 lc=pd4

5' Paved Ditch wt=2 as=1 lv=18 lc=pd5

Railroad wt=0 as=1 lv=20 lc=rr

Railroad Left wt=0 as=1 lv=20 lc=rr-left

Right Of Way wt=2 as=1 lv=23 lc=rw

Sanitary Sewer wt=0 as=job lv=3 lc=s
SAN

2" San Sewer wt=0 as=job lv=3 lc=s2
2 " SFM

2 1/2" San Sewer wt=0 as=job lv=3 lc=s2.5
2 1/2" SFM

3" San Sewer wt=0 as=job lv=3 lc=s3
3 " SFM

4" San Sewer wt=0 as=job lv=3 lc=s4
4 " SAN

6" San Sewer wt=0 as=job lv=3 lc=s6
6 " SAN

8" San Sewer wt=0 as=job lv=3 lc=s8
8 " SAN

10" San Sewer wt=0 as=job lv=3 lc=s10
10 " SAN

12" San Sewer wt=0 as=job lv=3 lc=s12
12 " SAN

14" San Sewer wt=0 as=job lv=3 lc=s14
14 " SAN

15" San Sewer wt=0 as=job lv=3 lc=s15
15 " SAN

16" San Sewer wt=0 as=job lv=3 lc=s16
16 " SAN

18" San Sewer wt=0 as=job lv=3 lc=s18
18 " SAN

20" San Sewer wt=0 as=job lv=3 lc=s20
20 " SAN

21" San Sewer wt=0 as=job lv=3 lc=s21
21 " SAN

22" San Sewer wt=0 as=job lv=3 lc=s22
22 " SFM

24" San Sewer wt=0 as=job lv=3 lc=s24
24 " SAN

27" San Sewer wt=0 as=job lv=3 lc=s27
27 " SAN

30" San Sewer wt=0 as=job lv=3 lc=s30
30 " SAN

33" San Sewer wt=0 as=job lv=3 lc=s33
33 " SAN

36" San Sewer wt=0 as=job lv=3 lc=s36
36 " SAN

42" San Sewer wt=0 as=job lv=3 lc=s42
42 " SAN

48" San Sewer wt=0 as=job lv=3 lc=s48
48 " SAN

54" San Sewer wt=0 as=job lv=3 lc=s54
54 " SAN

Sanitary SFM wt=0 as=job lv=3 lc=sfm
SFM

2" San SFM wt=0 as=job lv=3 lc=sfm2
2 " SFM

2 1/2"San SFM wt=0 as=job lv=3 lc=sfm2.5
2 1/2" SFM

3" San SFM wt=0 as=job lv=3 lc=sfm3
3 " SFM

4" San SFM wt=0 as=job lv=3 lc=sfm4
4 " SFM

6" San SFM wt=0 as=job lv=3 lc=sfm6
6 " SFM

8" San SFM wt=0 as=job lv=3 lc=sfm8
8 " SFM

10" San SFM wt=0 as=job lv=3 lc=sfm10
10 " SFM

12" San SFM wt=0 as=job lv=3 lc=sfm12
12 " SFM

14" San SFM wt=0 as=job lv=3 lc=sfm14
14 " SFM

16" San SFM wt=0 as=job lv=3 lc=sfm16
16 " SFM

18" San SFM wt=0 as=job lv=3 lc=sfm18
18 " SFM

20" San SFM wt=0 as=job lv=3 lc=sfm20
20 " SFM

21" San SFM wt=0 as=job lv=3 lc=sfm21
21 " SFM

22" San SFM wt=0 as=job lv=3 lc=sfm22
22 " SFM

24" San SFM wt=0 as=job lv=3 lc=sfm24
24 " SFM

27" San SFM wt=0 as=job lv=3 lc=sfm27
27 " SFM

30" San SFM wt=0 as=job lv=3 lc=sfm30
30 " SFM

32" San SFM wt=0 as=job lv=3 lc=sfm32
32 " SFM

36" San SFM wt=0 as=job lv=3 lc=sfm36
36 " SFM

42" San SFM wt=0 as=job lv=3 lc=sfm42
42 " SFM

48" San SFM wt=0 as=job lv=3 lc=sfm48
48 " SFM

54" San SFM wt=0 as=job lv=3 lc=sfm54
54 " SFM

State Line wt=9 as=1 lv=25 lc=stl

Fiber Optic wt=0 as=job lv=10 lc=ufo
FO

Unknown Utility wt=0 as=job lv=11 lc=unk
Unk

Underground Elec. wt=0 as=job lv=4 lc=up
E

U/G Elec. Duct wt=0 as=job lv=4 lc=upduct
E Duct

Underground Tele wt=0 as=job lv=7 lc=ut
T/Tg

Traffic Control wt=0 as=job lv=9 lc=utc
TC

NOT TO SCALE

1995 English Line Styles

04/10/00

Traff.Con.Duct wt=0 as=job lv=9 lc=utcduct
TC Duct

U/G Tele. Duct wt=0 as=job lv=7 lc=utduct
T/Tg Duct

Cable TV wt=0 as=job lv=8 lc=utv
CATV

Cable TV Ductwt=0 as=job lv=8 lc=utvduct
CATV Duct

Water wt=0 as=job lv=5 lc=w
W

3/4" Water wt=0 as=job lv=5 lc=w.75
3/4"W

1" Water wt=0 as=job lv=5 lc=w1
1"W

1 1/2" Water wt=0 as=job lv=5 lc=w1.5
1 1/2"W

2" Water wt=0 as=job lv=5 lc=w2
2 "W

3" Water wt=0 as=job lv=5 lc=w3
3 "W

4" Water wt=0 as=job lv=5 lc=w4
4 "W

6" Water wt=0 as=job lv=5 lc=w6
6 "W

8" Water wt=0 as=job lv=5 lc=w8
8 "W

9" Water wt=0 as=job lv=5 lc=w9
9 "W

10" Water wt=0 as=job lv=5 lc=w10
10 "W

12" Water wt=0 as=job lv=5 lc=w12
12 "W

14" Water wt=0 as=job lv=5 lc=w14
14 "W

16" Water wt=0 as=job lv=5 lc=w16
16 "W

18" Water wt=0 as=job lv=5 lc=w18
18 "W

20" Water wt=0 as=job lv=5 lc=w20
20 "W

24" Water wt=0 as=job lv=5 lc=w24
24 "W

30" Water wt=0 as=job lv=5 lc=w30
30 "W

36" Water wt=0 as=job lv=5 lc=w36
36 "W

Water Edge wt=0 as=job lv=17 lc=wa

Water Duct wt=0 as=job lv=5 lc=wduct
W Duct

Walk wt=2 as=1 lv=7, 9 lc=wk

Walk Left wt=2 as=1 lv=7, 9 lc=wk-left

3' Walk wt=2 as=1 lv=7, 9 lc=wk3

3' Walk Left wt=2 as=1 lv=7, 9 lc=wk3-left

4' Walk wt=2 as=1 lv=7, 9 lc=wk4

4' Walk Left wt=2 as=1 lv=7, 9 lc=wk4-left

5' Walk wt=2 as=1 lv=7, 9 lc=wk5

5' Walk Left wt=2 as=1 lv=7, 9 lc=wk5-left

Wet Lands wt=3 as=job lv=27 lc=wl
WL- -WL-

Woods wt=0 as=job lv=12 lc=wo

Woods Left wt=0 as=job lv=12 lc=wo-left

Survey Centerline wt=5 lv=1 lc=0

Bridges wt=2 lv=2 lc=3

Edge Of Pavement wt=2 lv=3 lc=3

Paved Shoulder wt=2 lv=6 lc=2

Buildings wt=4 lv=8 lc=0

Porches wt=3 lv=8 lc=0

Steps wt=1 lv=10 lc=0

Retaining Walls wt=2 lv=13 lc=2

Conc.Slab; Column; Sign; Post wt=1 lv=14 lc=0

Tanks wt=1 lv=15 lc=0

Dams; Endwalls; Endsections wt=1 lv=19 lc=0

Catch Basins; Drop Inlets wt=2 lv=19 lc=5

Railroad Gate,& Signal wt=2 lv=20 lc=0

Railroad Bridge wt=3 lv=20 lc=3

Drain Field; Septic Tank wt=1 lv=21 lc=2

Property Line wt=3 lv=24 lc=0

Temporary Easement wt=2 lv=24 lc=6

Permanent Easement wt=2 lv=24 lc=4

Utility Easement wt=2 lv=26 lc=4

Data According To Util.Record
wt=0 lv=(utility level) lc=3 DATUR (what it is)

Transmission Towers wt=2 lv=4 lc=2

Overhead Lines wt=1 lv=4 lc=1

Inter. Contour wt=1 lv=9 lc=0

Index Contour wt=3 lv=10 lc=0

NOT TO SCALE

1995 Metric Line Styles

1/21/99

m Pipe wt=0 as=1 lv=19 lc=mc

0.30 m Pipe wt=0 as=1 lv=19 lc=mc.30

0.38 m Pipe wt=0 as=1 lv=19 lc=mc.38

0.46 m Pipe wt=0 as=1 lv=19 lc=mc.46

0.53 m Pipe wt=0 as=1 lv=19 lc=mc.53

0.61 m Pipe wt=0 as=1 lv=19 lc=mc.61

0.69 m Pipe wt=0 as=1 lv=19 lc=mc.69

0.76 m Pipe wt=0 as=1 lv=19 lc=mc.76

0.84 m Pipe wt=0 as=1 lv=19 lc=mc.84

0.91 m Pipe wt=0 as=1 lv=19 lc=mc.91

1.07 m Pipe wt=0 as=1 lv=19 lc=mc1.07

1.22 m Pipe wt=0 as=1 lv=19 lc=mc1.22

1.37 m Pipe wt=0 as=1 lv=19 lc=mc1.37

1.52 m Pipe wt=0 as=1 lv=19 lc=mc1.52

1.68 m Pipe wt=0 as=1 lv=19 lc=mc1.68

1.83 m Pipe wt=0 as=1 lv=19 lc=mc1.83

1.98 m Pipe wt=0 as=1 lv=19 lc=mc1.98

2.13 m Pipe wt=0 as=1 lv=19 lc=mc2.13

2.29 m Pipe wt=0 as=1 lv=19 lc=mc2.29

2.44 m Pipe wt=0 as=1 lv=19 lc=mc2.44

2.59 m Pipe wt=0 as=1 lv=19 lc=mc2.59

2.74 m Pipe wt=0 as=1 lv=19 lc=mc2.74

2.90 m Pipe wt=0 as=1 lv=19 lc=mc2.90

3.05 m Pipe wt=0 as=1 lv=19 lc=mc3.05

City Line wt=6 as=1 lv=25 lc=mcil

County Line wt=6 as=1 lv=25 lc=mcol

0.15 m Curb wt=2 as=1 lv=5 lc=mecc.15

0.15 m Curb Right wt=2 as=1 lv=5 lc=mecc.15-right

m C&G wt=2 as=1 lv=4 lc=mecg

m C&G Right wt=2 as=1 lv=4 lc=mecg-right

0.30 m C&G wt=2 as=1 lv=4 lc=mecg.30

0.46 m C&G wt=2 as=1 lv=4 lc=mecg.46

0.46m C&G Right wt=2 as=1 lv=4 lc=mecg.46-right

0.61 m C&G wt=2 as=1 lv=4 lc=mecg.61

0.61m C&G Right wt=2 as=1 lv=4 lc=mecg.61-right

0.76 m C&G wt=2 as=1 lv=4 lc=mecg.76

0.76m C&G Right wt=2 as=1 lv=4 lc=mecg.76-right

Fence wt=0 as=job lv=11 lc=mfe

m Gas wt=0 as=job lv=6 lc=mg

0.02 m Gas wt=0 as=job lv=6 lc=mg.02

0.03 m Gas wt=0 as=job lv=6 lc=mg.03

0.04 m Gas wt=0 as=job lv=6 lc=mg.04

0.05 m Gas wt=0 as=job lv=6 lc=mg.05

0.08 m Gas wt=0 as=job lv=6 lc=mg.08

0.10 m Gas wt=0 as=job lv=6 lc=mg.10

0.15 m Gas wt=0 as=job lv=6 lc=mg.15

0.20 m Gas wt=0 as=job lv=6 lc=mg.20

0.25 m Gas wt=0 as=job lv=6 lc=mg.25

0.30 m Gas wt=0 as=job lv=6 lc=mg.30

0.36 m Gas wt=0 as=job lv=6 lc=mg.36

0.41 m Gas wt=0 as=job lv=6 lc=mg.41

0.46 m Gas wt=0 as=job lv=6 lc=mg.46

0.51 m Gas wt=0 as=job lv=6 lc=mg.51

0.56 m Gas wt=0 as=job lv=6 lc=mg.56

0.61 m Gas wt=0 as=job lv=6 lc=mg.61

Gas Duct wt=0 as=job lv=6 lc=mgduct

Guard Rail wt=1 as=job lv=16 lc=mgr

Guard Rail Right wt=1 as=job lv=16 lc=mgr-right

Hedge Row wt=0 as=job lv=12 lc=mhr

Jersey Barrier wt=1 as=1 lv=16 lc=mjb

NOT TO SCALE

1995 Metric Line Styles

1/21/99

Paved Ditch wt=2 as=1 lv=18 lc=mpd

1.22 m Pav. Ditch wt=2 as=1 lv=18 lc=mpdl.22

1.52 m Pav. Ditch wt=2 as=1 lv=18 lc=mpdl.52

Railroad wt=0 as=1 lv=20 lc=mrr

Railroad Left wt=0 as=1 lv=20 lc=mrr-left

Right Of Way wt=2 as=1 lv=23 lc=mrw

m San wt=0 as=job lv=3 lc=ms

0.05 m San wt=0 as=job lv=3 lc=ms.05

0.06 m San wt=0 as=job lv=3 lc=ms.06

0.08 m San wt=0 as=job lv=3 lc=ms.08

0.10 m San wt=0 as=job lv=3 lc=ms.10

0.15 m San wt=0 as=job lv=3 lc=ms.15

0.20 m San wt=0 as=job lv=3 lc=ms.20

0.25 m San wt=0 as=job lv=3 lc=ms.25

0.30 m San wt=0 as=job lv=3 lc=ms.30

0.36 m San wt=0 as=job lv=3 lc=ms.36

0.38 m San wt=0 as=job lv=3 lc=ms.38

0.41 m San wt=0 as=job lv=3 lc=ms.41

0.46 m San wt=0 as=job lv=3 lc=ms.46

0.51 m San wt=0 as=job lv=3 lc=ms.51

0.53 m San wt=0 as=job lv=3 lc=ms.53

0.56 m San wt=0 as=job lv=3 lc=ms.56

0.61 m San wt=0 as=job lv=3 lc=ms.61

0.69 m San wt=0 as=job lv=3 lc=ms.69

0.76 m San wt=0 as=job lv=3 lc=ms.76

0.83 m San wt=0 as=job lv=3 lc=ms.83

0.91 m San wt=0 as=job lv=3 lc=ms.91

1.07 m San wt=0 as=job lv=3 lc=msl.07

1.22 m San wt=0 as=job lv=3 lc=msl.22

1.37 m San wt=0 as=job lv=3 lc=msl.37

m SFM wt=0 as=job lv=3 lc=msf

0.05m SFM wt=0 as=job lv=3 lc=msf.05

0.06m SFM wt=0 as=job lv=3 lc=msf.06

0.08m SFM wt=0 as=job lv=3 lc=msf.08

0.10m SFM wt=0 as=job lv=3 lc=msf.10

0.15m SFM wt=0 as=job lv=3 lc=msf.15

0.20m SFM wt=0 as=job lv=3 lc=msf.20

0.25m SFM wt=0 as=job lv=3 lc=msf.25

0.30m SFM wt=0 as=job lv=3 lc=msf.30

0.36m SFM wt=0 as=job lv=3 lc=msf.36

0.38m SFM wt=0 as=job lv=3 lc=msf.38

0.41m SFM wt=0 as=job lv=3 lc=msf.41

0.46m SFM wt=0 as=job lv=3 lc=msf.46

0.51m SFM wt=0 as=job lv=3 lc=msf.51

0.53m SFM wt=0 as=job lv=3 lc=msf.53

0.56m SFM wt=0 as=job lv=3 lc=msf.56

0.61m SFM wt=0 as=job lv=3 lc=msf.61

0.69m SFM wt=0 as=job lv=3 lc=msf.69

0.76m SFM wt=0 as=job lv=3 lc=msf.76

0.83m SFM wt=0 as=job lv=3 lc=msf.83

0.91m SFM wt=0 as=job lv=3 lc=msf.91

1.07m SFM wt=0 as=job lv=3 lc=msf1.07

1.22m SFM wt=0 as=job lv=3 lc=msf1.22

1.37m SFM wt=0 as=job lv=3 lc=msf1.37

State Line wt=9 as=1 lv=25 lc=mstl

Fiber Optic wt=0 as=job lv=10 lc=mfo

Unknown Utility wt=0 as=job lv=11 lc=muko

U/G Elec wt=0 as=job lv=4 lc=mup

U/G Elec Duct wt=0 as=job lv=4 lc=mupduct

Underground Tele wt=0 as=job lv=7 lc=mut

NOT TO SCALE

1995 Metric Line Styles

04/10/00

Traffic Control wt=0 as=job lv=9 lc=mutc

TC

Traff. Con. Duct wt=0 as=job lv=9 lc=mutcduct

TC Duct

Tele Duct wt=0 as=job lv=7 lc=mutduct

T/Tg Duct

Cable TV wt=0 as=job lv=8 lc=mutv

CATV

Cable TV Duct wt=0 as=job lv=8 lc=mutvduct

CATV Duct

m Water wt=0 as=job lv=5 lc=mw

W

0.02 m Water wt=0 as=job lv=5 lc=mw.02

.02 m W

0.03 m Water wt=0 as=job lv=5 lc=mw.03

.03 m W

0.04 m Water wt=0 as=job lv=5 lc=mw.04

.04 m W

0.05 m Water wt=0 as=job lv=5 lc=mw.05

.05 m W

0.08 m Water wt=0 as=job lv=5 lc=mw.08

.08 m W

0.10 m Water wt=0 as=job lv=5 lc=mw.10

.10 m W

0.15 m Water wt=0 as=job lv=5 lc=mw.15

.15 m W

0.20 m Water wt=0 as=job lv=5 lc=mw.20

.20 m W

0.23 m Water wt=0 as=job lv=5 lc=mw.23

.23 m W

0.25 m Water wt=0 as=job lv=5 lc=mw.25

.25 m W

0.30 m Water wt=0 as=job lv=5 lc=mw.30

.30 m W

0.36 m Water wt=0 as=job lv=5 lc=mw.36

.36 m W

0.41 m Water wt=0 as=job lv=5 lc=mw.41

.41 m W

0.46 m Water wt=0 as=job lv=5 lc=mw.46

.46 m W

0.51 m Water wt=0 as=job lv=5 lc=mw.51

.51 m W

0.61 m Water wt=0 as=job lv=5 lc=mw.61

.61 m W

0.76 m Water wt=0 as=job lv=5 lc=mw.76

.76 m W

0.91 m Water wt=0 as=job lv=5 lc=mw.91

.91 m W

Water Edge wt=0 as=job lv=17 lc=mwa

Water Duct wt=0 as=job lv=5 lc=mwduct

W Duct

m Walk wt=2 as=1 lv=7,9 lc=mwk

m Walk Left wt=2 as=1 lv=7,9 lc=mwk-left

0.91 m Walk wt=2 as=1 lv=7,9 lc=mwk.91

0.91m Walk Left wt=2 as=1 lv=7,9 lc=mwk.91-left

NOT TO SCALE

1.22m Walk wt=2 as=1 lv=7,9 lc=mwk1.22

1.22m Walk Left wt=2 as=1 lv=7,9 lc=mwk1.22-left

1.52m Walk wt=2 as=1 lv=7,9 lc=mwk1.52

1.52m Walk Left wt=2 as=1 lv=7,9 lc=mwk1.52-left

Wet Lands wt=3 as=job lv=27 lc=mwl

WL

Woods wt=0 as=job lv=12 lc=mwo

Woods Left wt=0 as=job lv=12 lc=mwo-left

Survey Centerline wt=5 lv=1 lc=0

Bridges wt=2 lv=2 lc=3

Edge Of Pavement wt=2 lv=3 lc=3

Paved Shoulder wt=2 lv=6 lc=2

Buildings wt=4 lv=8 lc=0

Porches wt=3 lv=8 lc=0

Steps wt=1 lv=10 lc=0

Retaining Walls wt=2 lv=13 lc=2

Conc. Slab; Column; Sign; Post wt=1 lv=14 lc=0

Tanks wt=1 lv=15 lc=0

Dams; Endwalls; Endsections wt=1 lv=19 lc=0

Catch Basins; Drop Inlets wt=2 lv=19 lc=5

Railroad Gate, & Signal wt=2 lv=20 lc=0

Railroad Bridge wt=3 lv=20 lc=3

Drain Field; Septic Tank wt=1 lv=21 lc=2

Property Line wt=3 lv=24 lc=0

Temporary Easement wt=2 lv=24 lc=6

Permanent Easement wt=2 lv=24 lc=4

Utility Easement wt=2 lv=26 lc=4

Data According To Util. Records wt=0 lv=(utility level) lc=3 DATUR (what it is)

Transmission Towers wt=2 lv=4 lc=2

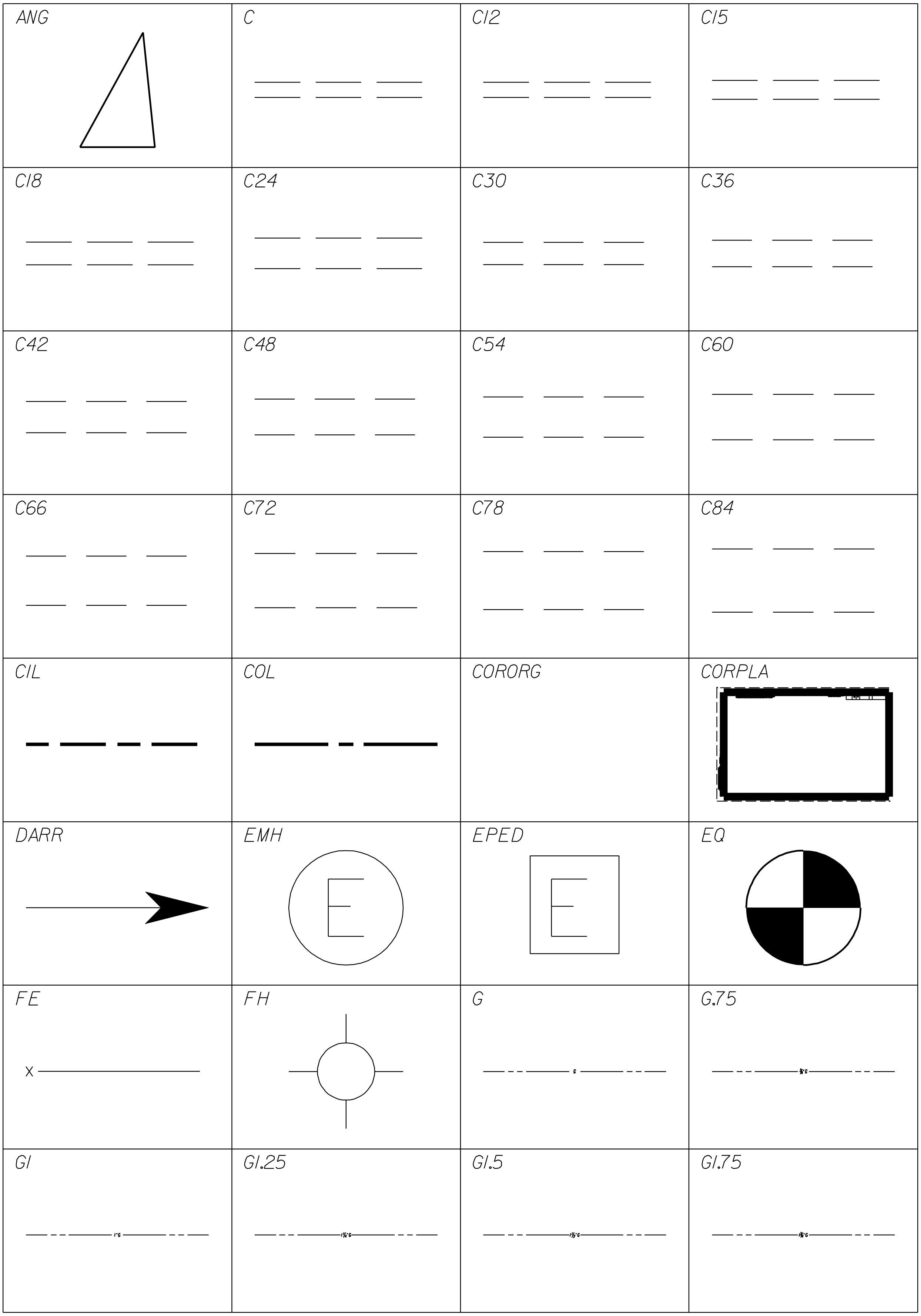
Overhead Lines wt=1 lv=4 lc=1

Inter. Contour wt=1 lv=9 lc=0

Index Contour wt=3 lv=10 lc=0

Cell Library: survey.cel

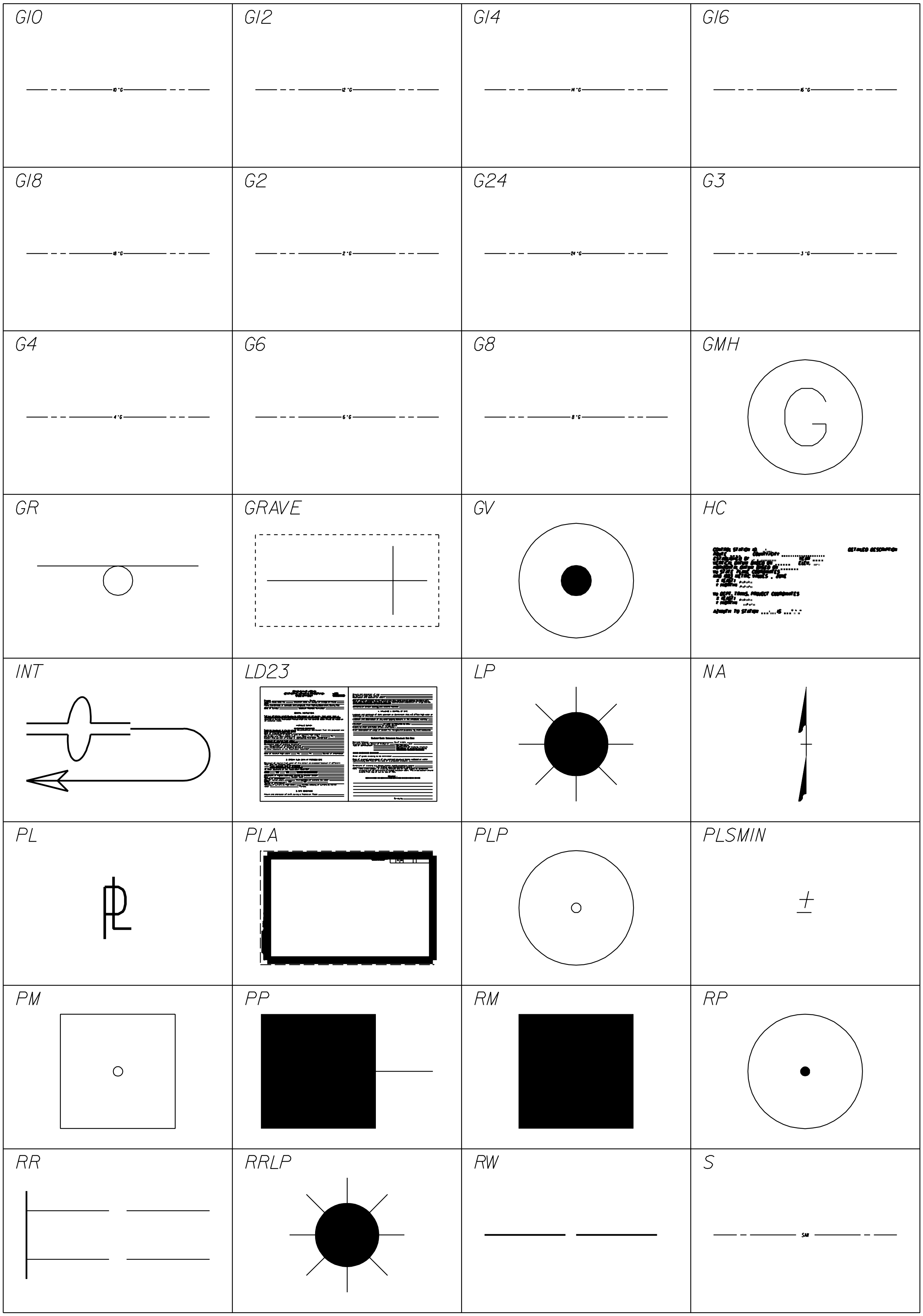
1/21/99



NOT TO SCALE

Cell Library: survey.cel

1/21/99



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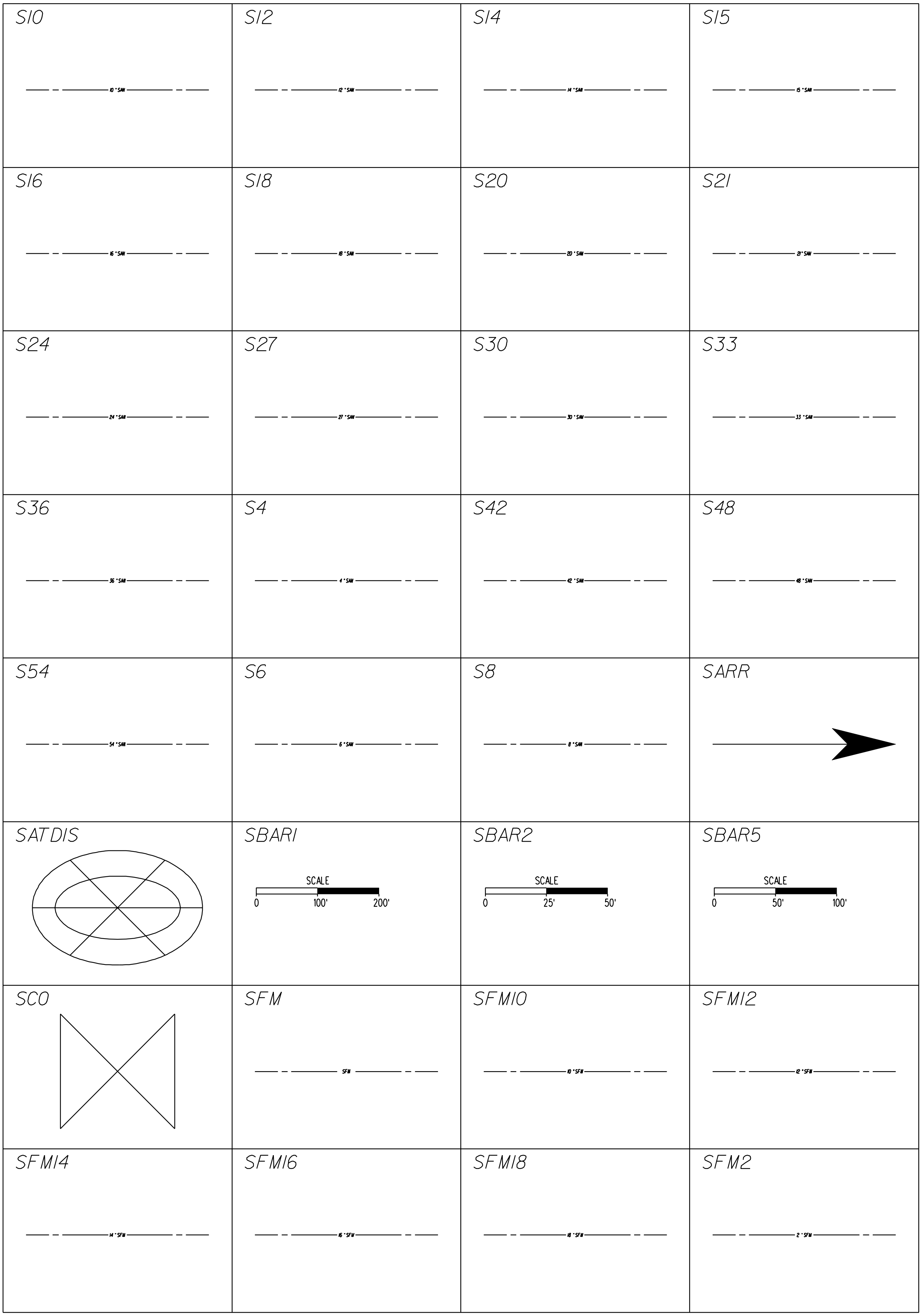
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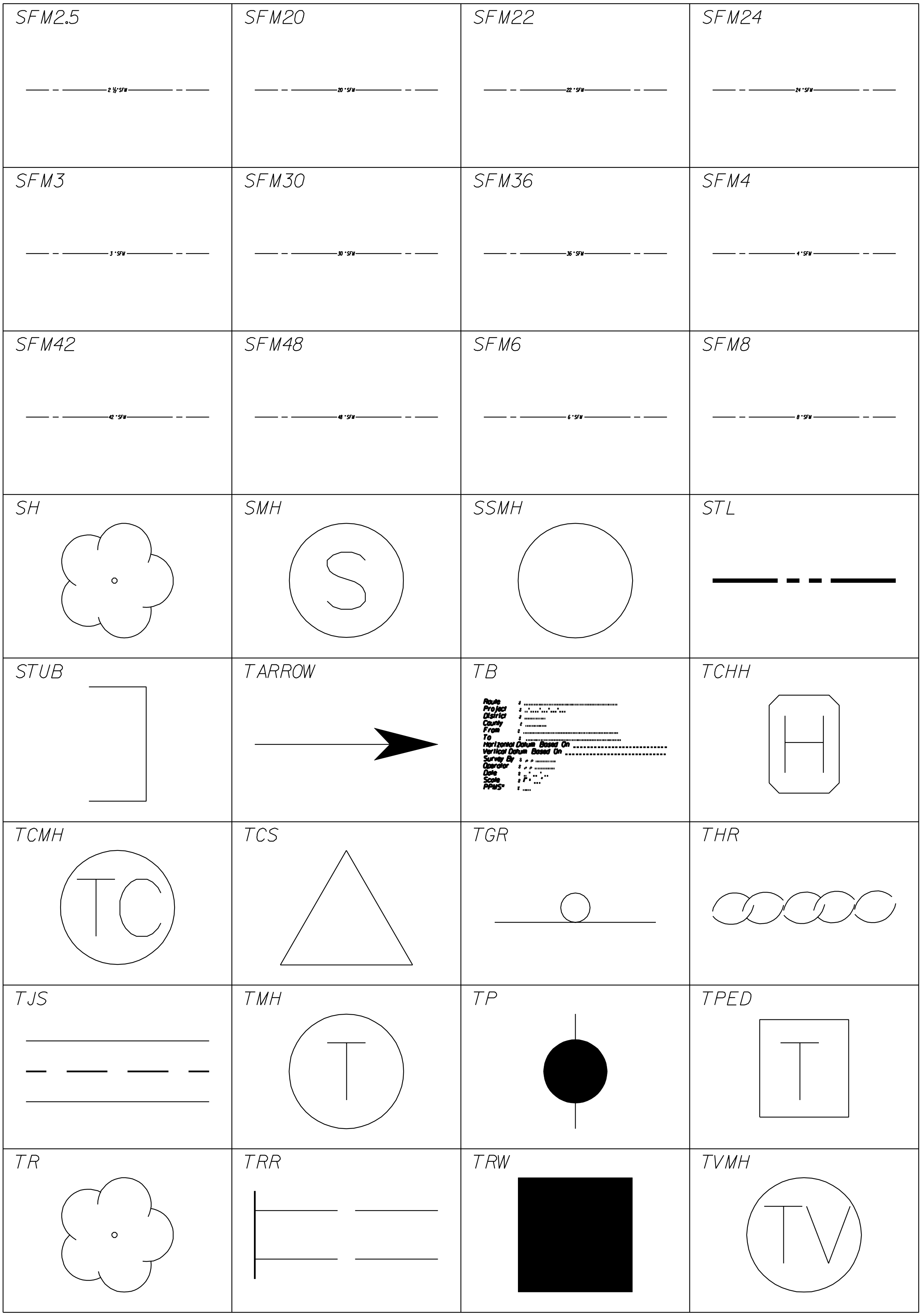
S12
S14
S15
S16
S18
S20
S21
S24
S27
S30
S33
S36
S4
S42
S48
S54
S6
S8
SARR
SATDIS
SBAR1
SCALE
0 100' 200'
SBAR2
SCALE
0 25' 50'
SBAR5
SCALE
0 50' 100'
SCO
SFM
SFM10
SFM12
SFM14
SFM16
SFM18
SFM2

NOT TO SCALE

Cell Library: survey.cel

1/21/99



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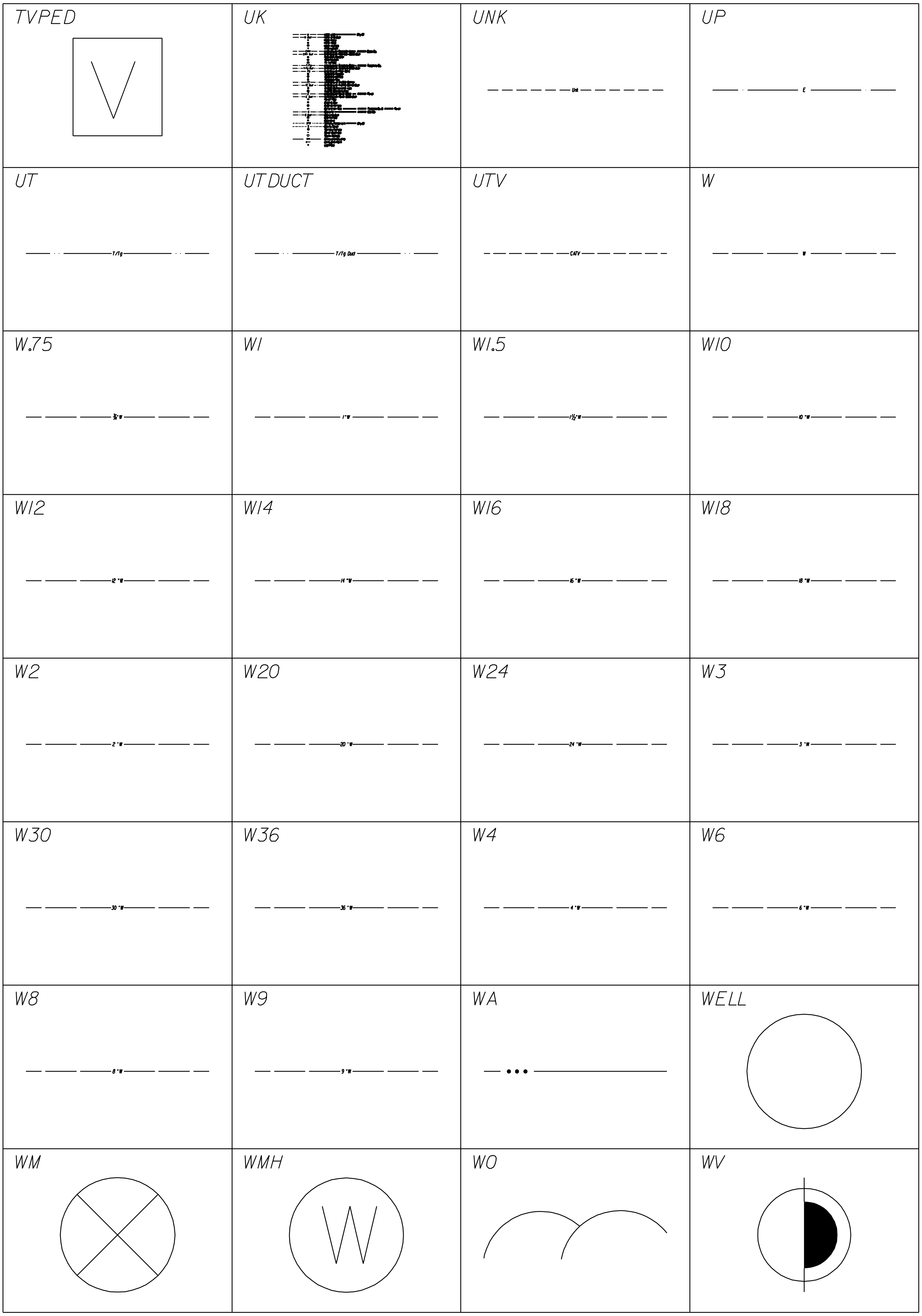
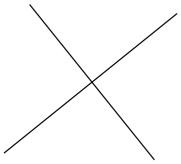
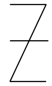

TVPED
UK
UNK
UP
UT
UTDUCT
UTV
W
W.75
W1
W1.5
W10
W12
W14
W16
W18
W2
W20
W24
W3
W30
W36
W4
W6
W8
W9
WA
WELL
WM
WMH
WO
WV

NOT TO SCALE

X 	XSECT 	Z 	

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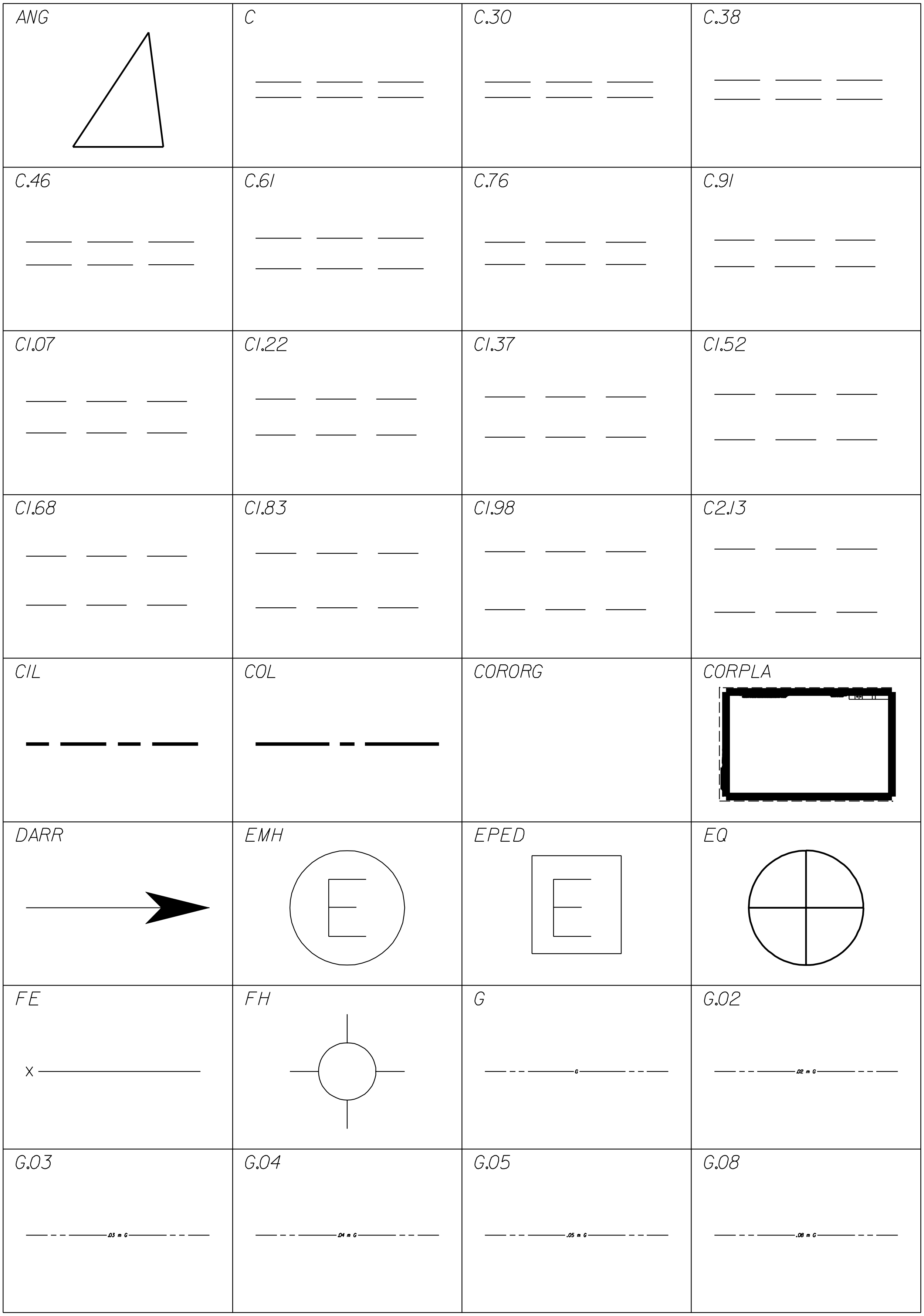
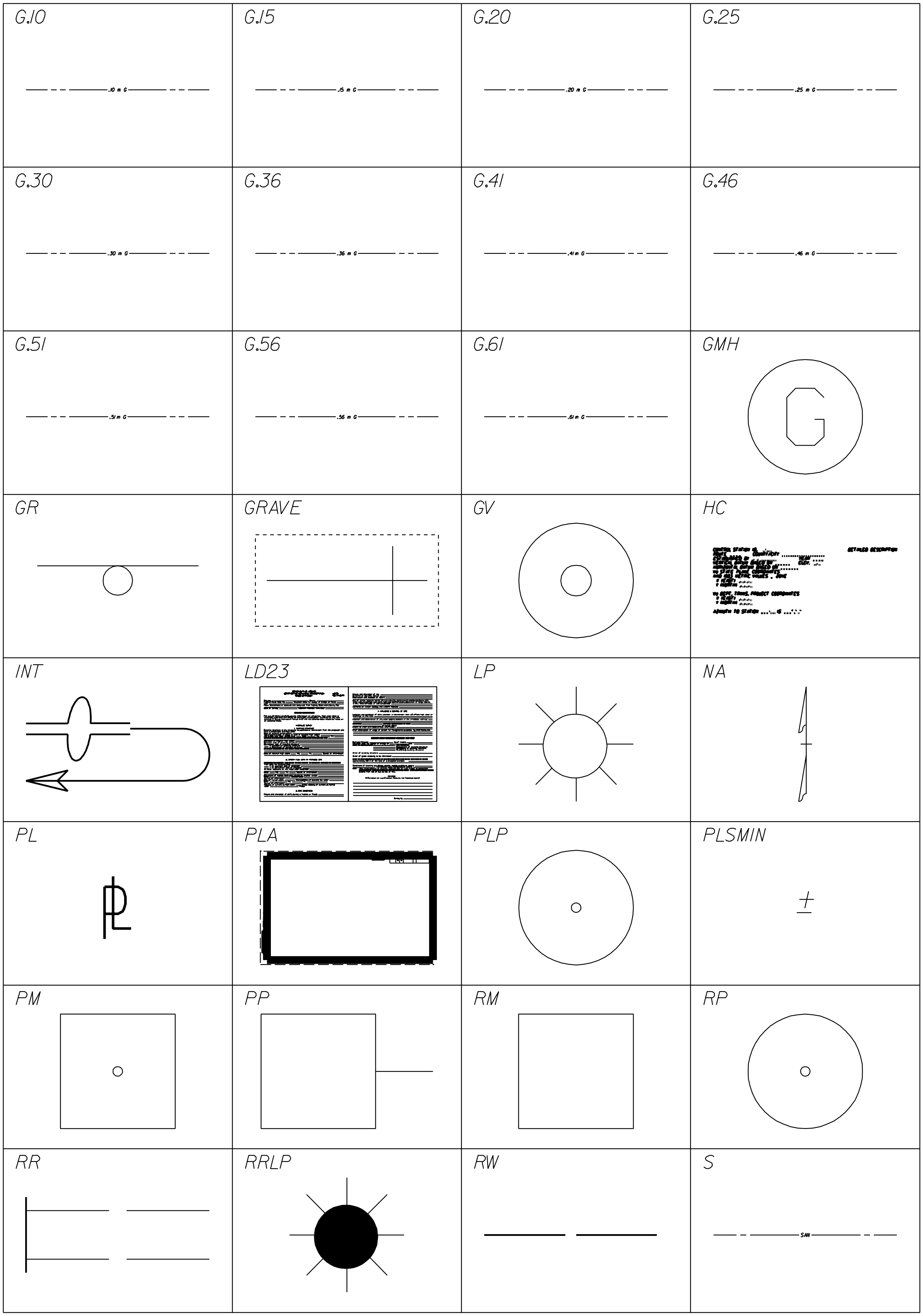

ANG
C
C.30
C.38
C.46
C.61
C.76
C.91
C1.07
C1.22
C1.37
C1.52
C1.68
C1.83
C1.98
C2.13
CIL
COL
CORORG
CORPLA
DARR
EMH
EPED
EQ
FE
FH
G
G.02
G.03
G.04
G.05
G.08

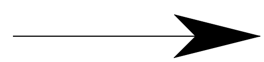
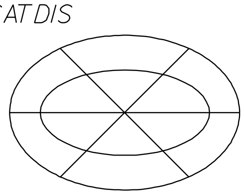
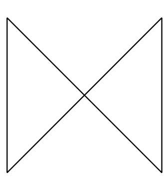
NOT TO SCALE

Cell Library: msurv.cel

1/21/99



NOT TO SCALE

S.05 .05 m SAN	S.06 .06 m SAN	S.08 .08 m SAN	S.10 .10 m SAN
S.15 .15 m SAN	S.20 .20 m SAN	S.25 .25 m SAN	S.30 .30 m SAN
S.36 .36 m SAN	S.38 .38 m SAN	S.41 .41 m SAN	S.46 .46 m SAN
S.51 .51 m SAN	S.53 .53 m SAN	S.56 .56 m SAN	S.61 .61 m SAN
S.69 .69 m SAN	S.76 .76 m SAN	S.83 .83 m SAN	S.91 .91 m SAN
S1.07 1.07 m SAN	S1.22 1.22 m SAN	S1.37 1.37 m SAN	SARR 
SATDIS 	SBAR1 METRIC SCALE 1:1000 0 20 m 40 m	SBAR2 METRIC SCALE 1:250 0 5 m 10 m	SBAR5 METRIC SCALE 1:500 0 10 m 20 m
SCO 	SF SFM	SF.05 .05 m SFM	SF.06 .06 m SFM

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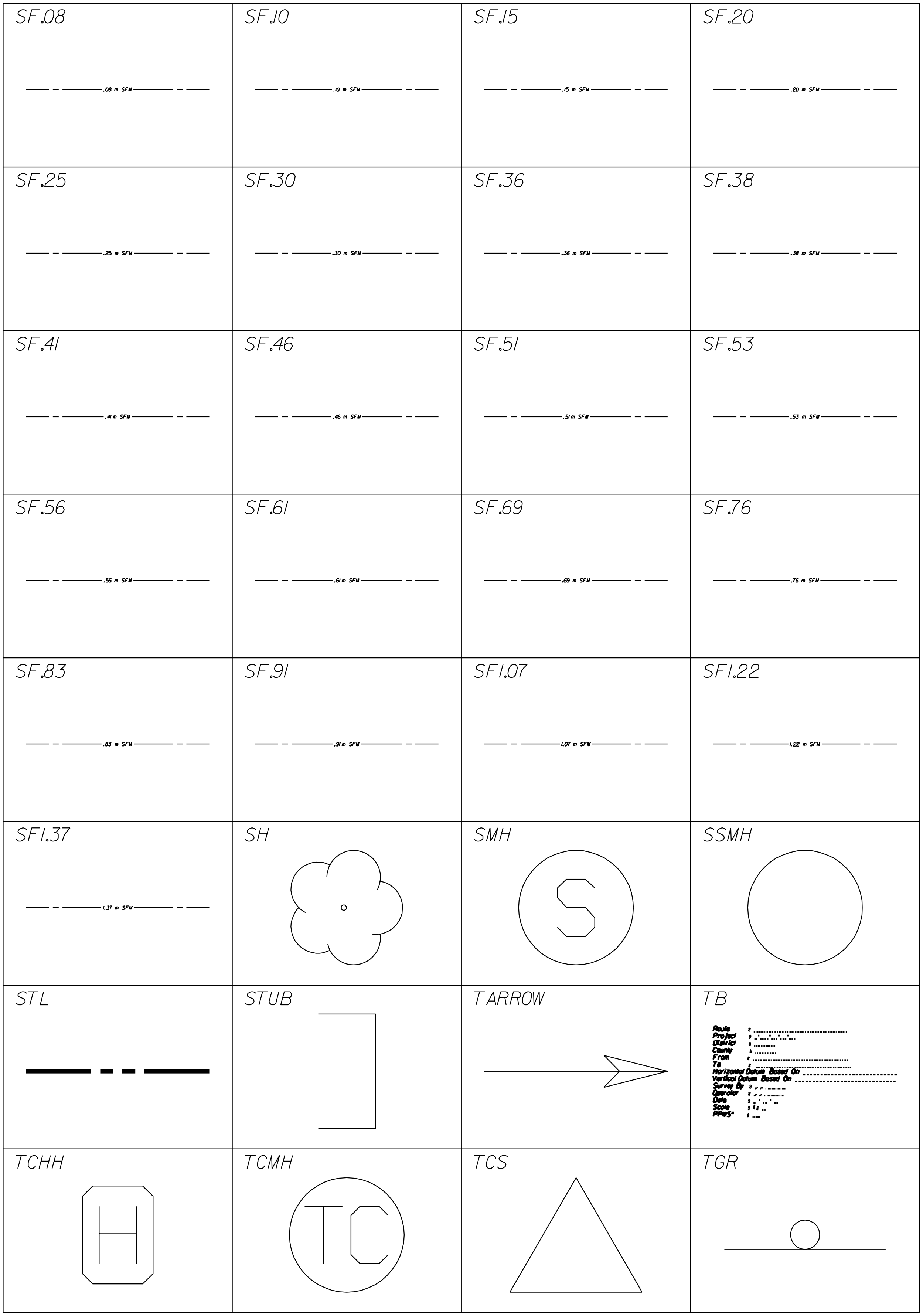
SF.08
.08 m SFM
SF.10
.10 m SFM
SF.15
.15 m SFM
SF.20
.20 m SFM
SF.25
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.41 m SFM
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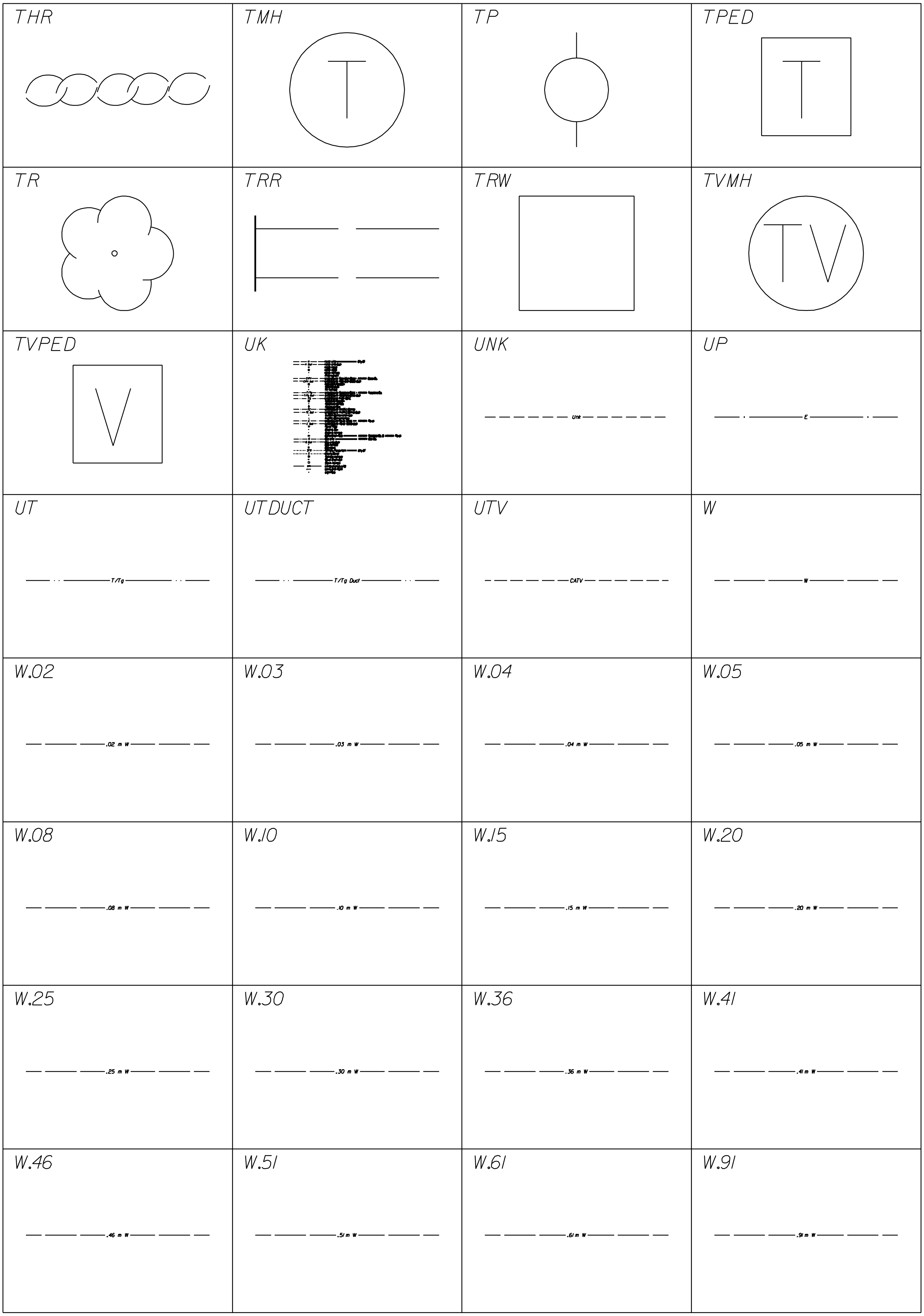
.56 m SFM
SF.61
.61 m SFM
SF.69
.69 m SFM
SF.76
.76 m SFM
SF.83
.83 m SFM
SF.91
.91 m SFM
SF1.07
1.07 m SFM
SF1.22
1.22 m SFM
SF1.37
1.37 m SFM
SH
SMH
S
SSMH
STL
STUB
TARROW
TB
Route
Project
District
County
From
To
Horizontal Datum Based On
Vertical Datum Based On
Survey By
Operator
Date
Scale
TCHH
H
TCMH
TC
TCS
TGR

NOT TO SCALE



THR
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TPED
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TRR
TRW
TVMH
TV
TVPED
V
UK
UNK
Unk
UP
E
UT
T/Tg
UTDUCT
T/Tg Duct
UTV
CATV
W
W
W.02
.02 m W
W.03
.03 m W
W.04
.04 m W
W.05
.05 m W
W.08
.08 m W
W.10
.10 m W
W.15
.15 m W
W.20
.20 m W
W.25
.25 m W
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.30 m W
W.36
.36 m W
W.41
.41 m W
W.46
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W.51
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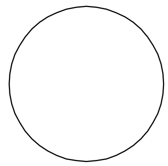
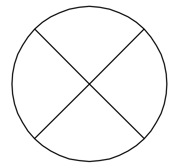
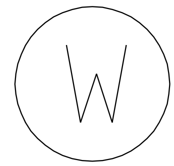
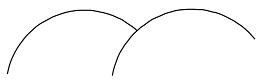
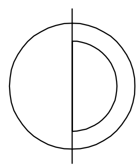
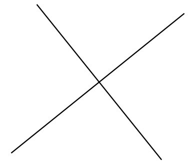
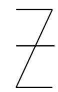
W.61
.61 m W
W.91
.91 m W

NOT TO SCALE

WA	WELL 	WM 	WMH 
WO 	WV 	X 	Z 

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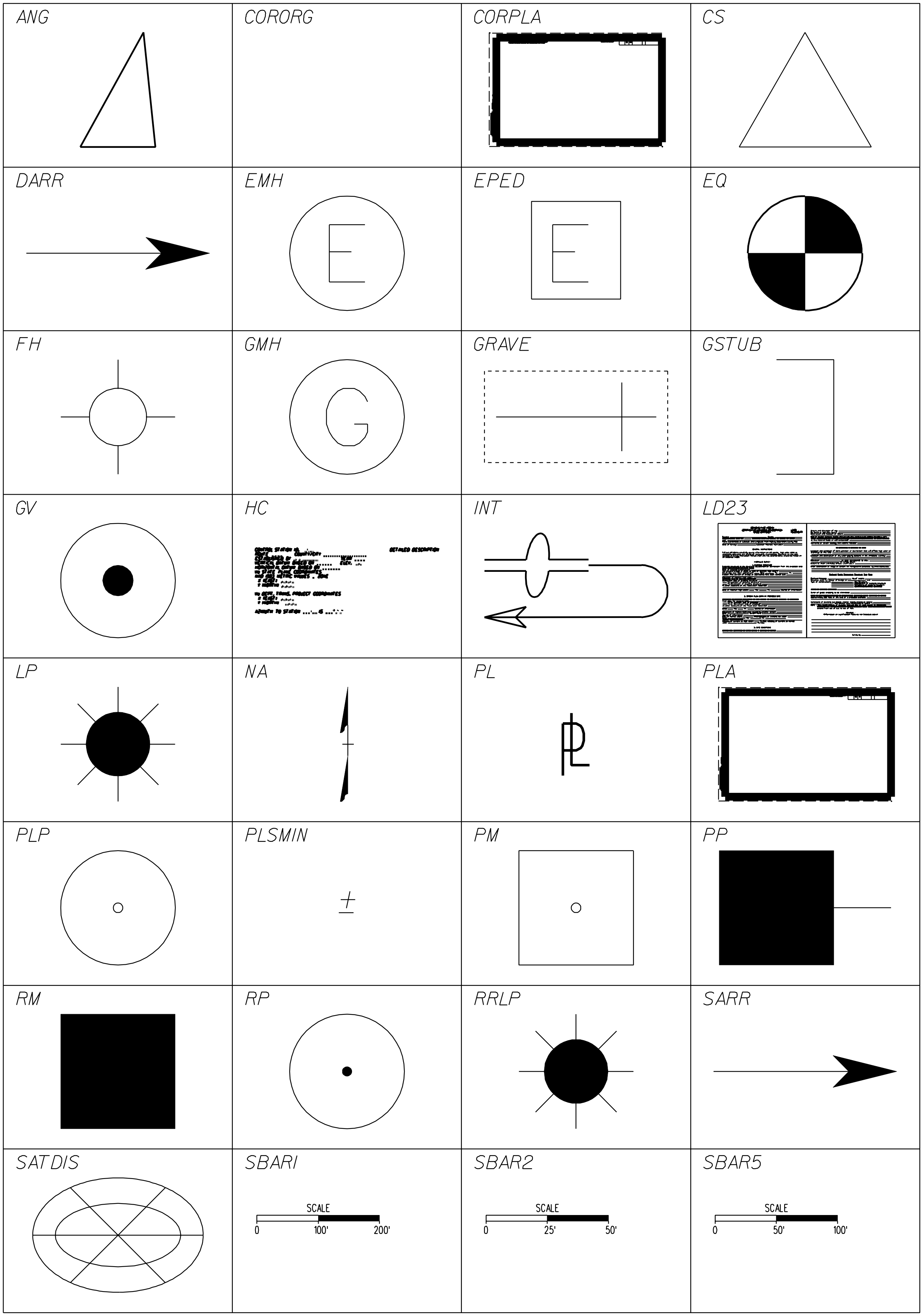
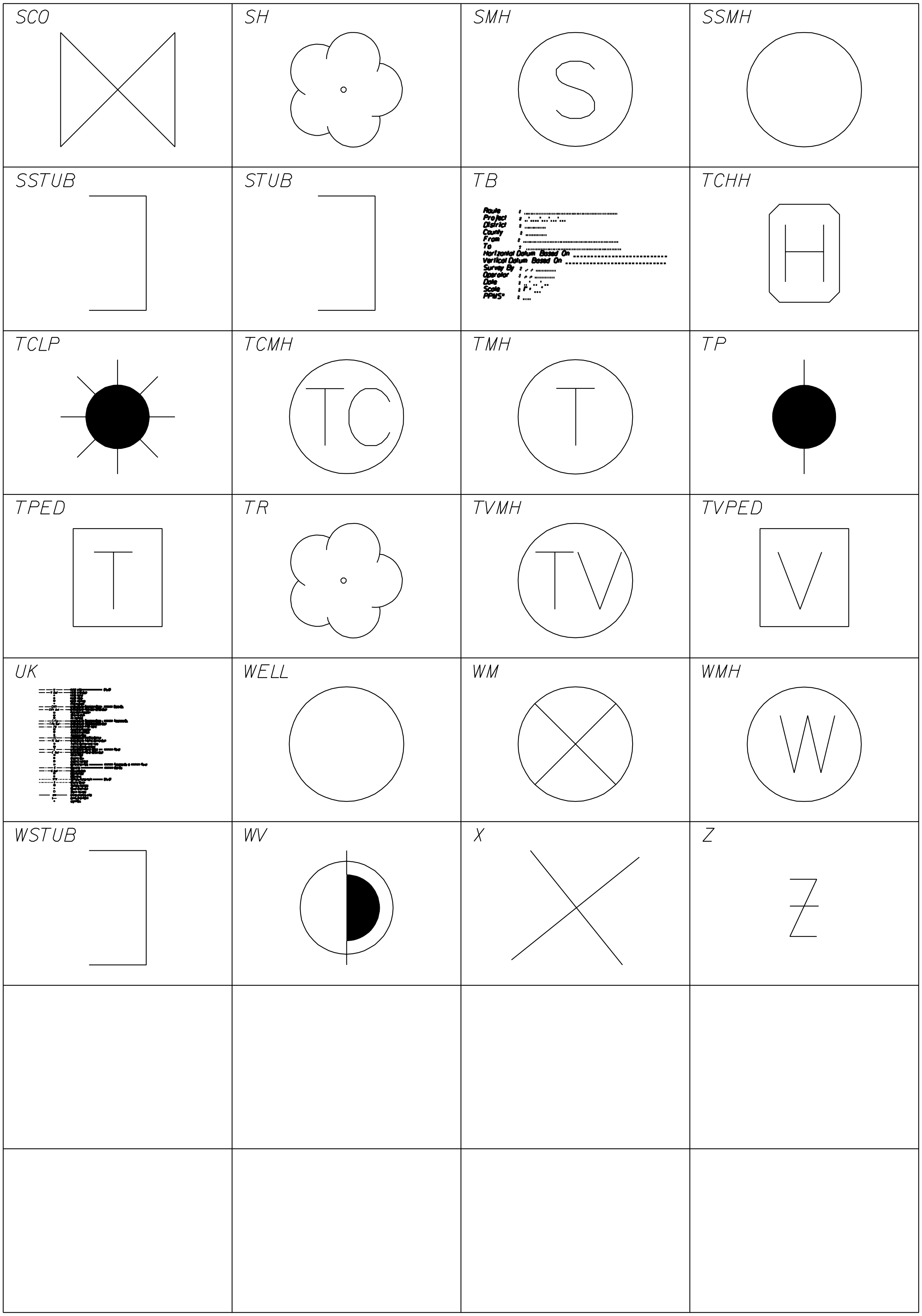

ANG
CORORG
CORPLA
CS
DARR
EMH
EPED
EQ
FH
GMH
GRAVE
GSTUB
GV
HC
INT
LD23
LP
NA
PL
PLA
PLP
PLSMIN
±
PM
PP
RM
RP
RRLP
SARR
SATDIS
SBAR1
SCALE
0 100' 200'
SBAR2
SCALE
0 25' 50'
SBAR5
SCALE
0 50' 100'

NOT TO SCALE

Cell Library: surv95.cel

1/21/99



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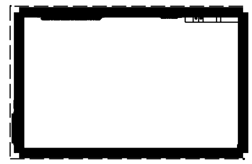
Cell Library: msurv95.cel

1/21/99

CORORG

CORPLA



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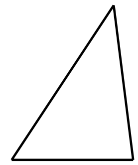

MCORPL

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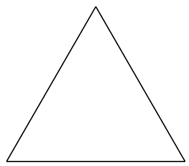

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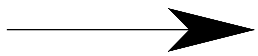

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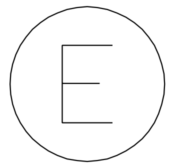

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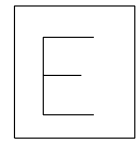

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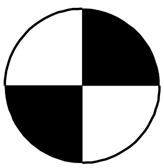

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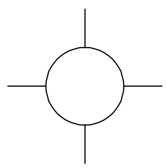

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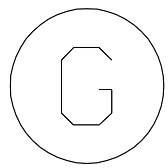

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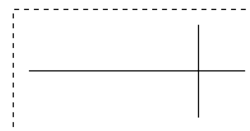

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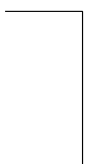
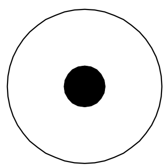
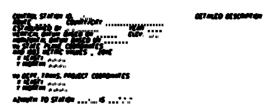


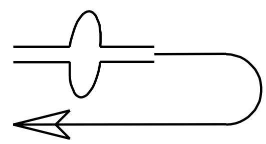
MGV



MHC



MINT



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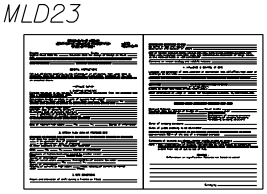

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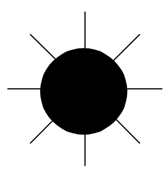

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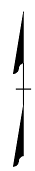

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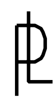

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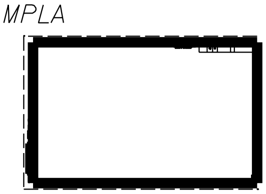

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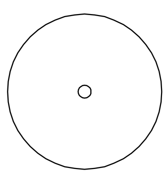

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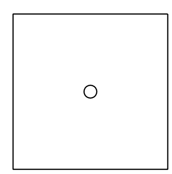

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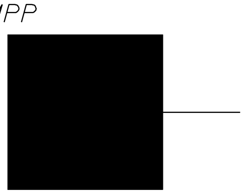

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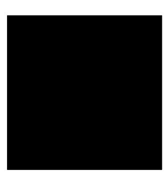

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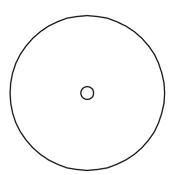

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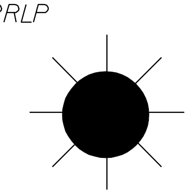

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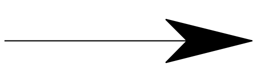

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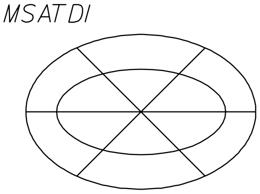

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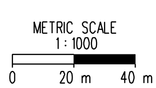
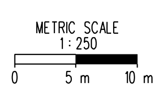
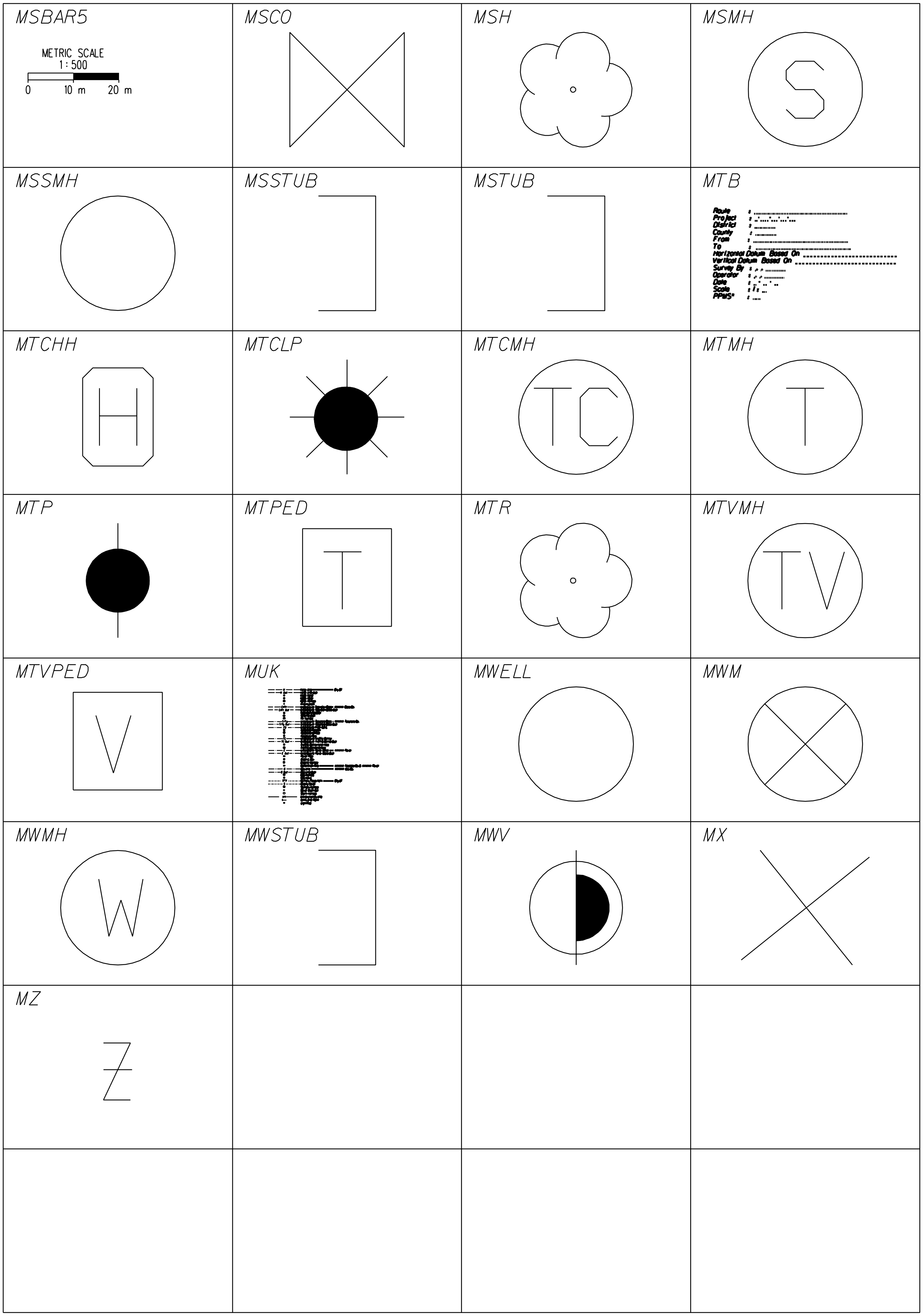


MSBAR2



NOT TO SCALE


MSBAR5
METRIC SCALE
1 : 500
0
10 m
20 m
MSCO
MSH
MSMH
MSSMH
MSSTUB
MSTUB
MTB
Route
Project
District
County
From
To
Horizontal Datum Based On
Vertical Datum Based On
Survey By
Operator
Date
Scale
MTCHH
MTCLP
MTCMH
MTMH
MTP
MTPED
MTR
MTVMH
MTVPED
MUK
MWELL
MWM
MWMH
MWSTUB
MWV
MX
MZ

NOT TO SCALE

APPENDIX B

Appendix Contents

B-1	Metric Conversion Chart & Precision of Measurements
B-2	Inches, Decimal of Inches and Metric Conversions
B-3	Minutes and Seconds to Decimal of Degree
B-4	Triangle Formulae
B-5	Right Triangle Formulae
B-6	Horizontal Curve Formulae
B-7	Compound Curve Formulae
B-8	Vertical Curve Formulae
B-9	Spiral Curve Formulae
B-10	More Spiral Curve Formulae

METRIC CONVERSIONS

*	1 meter (m)	=	39.37 inches (U. S. Survey Foot)
	1 meter (m)	=	3.280833333333 feet (U. S. Survey Foot)
	1 kilometer (km)	=	0.62137 miles
	1 hectare (ha)	=	2.471 acres
*	1 meter (m)	=	1,000 millimeters (mm)
*	1 kilometer (km)	=	1,000 meters (m)
*	1 hectare (ha)	=	10,000 sq. meters (m^2)

ADDITIONAL CONVERSIONS

*	1 vara	=	33 1/3 inches
*	36 varas	=	100 feet
*	1 rod, pole, perch	=	16½ feet
*	1 chain (Gunter's)	=	66 feet
*	1 link	=	7.92 inches
*	1 mile	=	5,280 feet
*	1 acre	=	43,560 $feet^2$
*	1 station	=	100 feet (ft) or 100 meters (m)
*	1 staking interval	=	50 feet (ft) or 20 meters (m)

*** Denotes exact conversion values. All others correct to figures shown.**

PRECISION OF INDIVIDUAL MEASUREMENTS

Horizontal Measurements	-	nearest 0.005 feet with EDM/Total Station nearest 0.01 feet with steel chain nearest 0.02 feet with cloth/fiberglass tape
Vertical Measurements	-	nearest 0.01 feet on bridges nearest 0.01 feet on existing pavement nearest 0.05 feet on natural ground
Trig Leveling/DTM	-	nearest 0.01 feet for H.I and target height

NOTE: All surveying measurements will be made in feet and decimals of a foot.

Conversion Chart

decimal inches	(in) inches	(cm) centimeters		(ft) feet	(cm) centimeters	(m) meters	(km) kilometer
0.0313	1/32	0.079		1	30.48	0.3048	0.000304
0.0625	1/16	0.159		2	40.96	0.4096	0.000409
0.0938	3/32	0.238		3	91.44	0.9144	0.000914
0.1250	1/8	0.318		4	121.92	1.2192	0.001219
0.1563	5/32	0.397		5	152.40	1.5240	0.001524
0.1875	3/16	0.476		6	182.88	1.8288	0.001829
0.2188	7/32	0.556		7	213.36	2.1336	0.002134
0.2500	1/4	0.635		8	243.84	2.4384	0.002438
0.2813	9/32	0.714		9	274.32	2.7432	0.002743
0.3125	5/16	0.794		10	304.80	3.0480	0.003048
0.3438	11/32	0.873		20	609.60	6.0960	0.006096
0.3750	3/8	0.953		30	914.40	9.1440	0.009144
0.4063	13/32	1.032		40	1219.20	12.1920	0.012192
0.4375	7/16	1.111		50	1524.00	15.2400	0.015240
0.4688	15/32	1.191		60	1828.80	18.2880	0.018288
0.5000	1/2	1.270		70	2133.60	21.3360	0.021336
0.5313	17/32	1.349		80	2438.40	24.3840	0.024384
0.5625	9/16	1.429		90	2743.20	27.4320	0.027432
0.5938	19/32	1.508		100	3048.00	30.4800	0.030480
0.6250	5/8	1.588		200	6096.00	60.9600	0.060960
0.6563	21/32	1.667		300	9144.00	91.4400	0.091440
0.6875	11/16	1.746		400	12192.00	121.9200	0.121920
0.7188	23/32	1.826		500	15240.00	152.4000	0.152400
0.7500	3/4	1.905		600	18288.00	182.8800	0.182880
0.7813	25/32	1.984		700	21336.00	213.3600	0.213360
0.8125	13/16	2.064		800	24384.00	243.8400	0.243840
0.8438	17/32	2.143		900	27432.00	274.3200	0.274320
0.8750	7/8	2.223		1000	30480.00	304.80	0.3048
0.9063	29/32	2.302		2000	60960.00	609.60	0.6096
0.9375	15/16	2.381		3000	91440.00	914.40	0.9144
0.9688	31/32	2.461		4000	121920.00	1219.20	1.2192
1.0000	1	2.540		5000	152400.00	1524.00	1.5240
2.0000	2	5.080		6000	182880.00	1828.80	1.8288
3.0000	3	7.620		7000	213360.00	2133.60	2.1336
4.0000	4	10.160		8000	243840.00	2438.40	2.4384
5.0000	5	12.700		9000	274320.00	2743.20	2.7432
6.0000	6	15.240		10000	304800.00	3048.00	3.0480
7.0000	7	17.780					
8.0000	8	20.320					
9.0000	9	22.860					
10.0000	10	25.400					
11.0000	11	27.940					
12.0000	12	30.480					

<u>Minutes & Seconds to Decimals of a Degree</u>

	Minutes	Seconds			Minutes	Seconds
1	0.016667	0.000278		31	0.516667	0.008611
2	0.033333	0.000556		32	0.533333	0.008889
3	0.050000	0.000833		33	0.550000	0.009167
4	0.066667	0.001111		34	0.566667	0.009444
5	0.083333	0.001389		35	0.583333	0.009722
6	0.100000	0.001667		36	0.600000	0.010000
7	0.116667	0.001944		37	0.616667	0.010278
8	0.133333	0.002222		38	0.633333	0.010556
9	0.150000	0.002500		39	0.650000	0.010833
10	0.166667	0.002778		40	0.666667	0.011111
11	0.183333	0.003056		41	0.683333	0.011389
12	0.200000	0.003333		42	0.700000	0.011667
13	0.216667	0.003611		43	0.716667	0.011944
14	0.233333	0.003889		44	0.733333	0.012222
15	0.250000	0.004167		45	0.750000	0.012500
16	0.266667	0.004444		46	0.766667	0.012778
17	0.283333	0.004722		47	0.783333	0.013056
18	0.300000	0.005000		48	0.800000	0.013333
19	0.316667	0.005278		49	0.816667	0.013611
20	0.333333	0.005556		50	0.833333	0.013889
21	0.350000	0.005833		51	0.850000	0.014167
22	0.366667	0.006111		52	0.866667	0.014444
23	0.383333	0.006389		53	0.883333	0.014722
24	0.400000	0.006667		54	0.900000	0.015000
25	0.416667	0.006944		55	0.916667	0.015278
26	0.433333	0.007222		56	0.933333	0.015556
27	0.450000	0.007500		57	0.950000	0.015833
28	0.466667	0.007778		58	0.966667	0.016111
29	0.483333	0.008056		59	0.983333	0.016389
30	0.500000	0.008333				

Example: To convert 8° 49’ 27” to decimal of a degree.

Using the chart above:

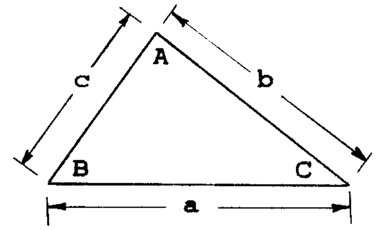
8° = 8.000000
49’ = 0.816667
27” = <u>0.007500</u>

Add the three numbers to get the result…..<u>8.824167°</u>

Example: To convert 8.824167° to degrees, minutes and seconds.

First, we know 8.00000 = 8° and 0.824167 degree
Next multiply: (0.824167 degree) * (60 minutes/degree) = 49.45020 minutes.
Now, we know we have 49 minutes and 0.450020 minute.
Next multiply: (0.450020 minute) * (60 seconds/minute) = 27.0012 seconds
For the result: <u>8° 49’ 27”</u>

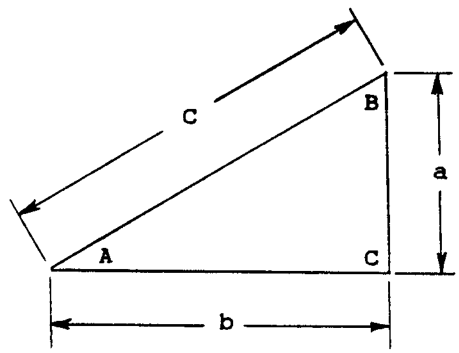
Law of sines	$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$
Law of cosines	$a^2 = b^2 + c^2 - 2bc \cos A$ $b^2 = a^2 + c^2 - 2ac \cos B$ $c^2 = a^2 + b^2 - 2ab \cos C$
Law of tangents	$\frac{a - b}{a + b} = \frac{\tan 1/2\ (A-B)}{\tan 1/2\ (A+B)}$



Find	Given	Formula
A	BC	$180^\circ - (B+C)$
sin A	acC	$\frac{a \times \sin C}{c}$
sin A	abB	$\frac{a \times \sin B}{b}$
cos A	abc	$\frac{b^2 + c^2 - a^2}{2bc}$
tan A	acB	$\frac{a \times \sin B}{c-(a \times \cos B)}$
tan A	abC	$\frac{a \times \sin C}{b-(a \times \cos C)}$
B	AC	$180^\circ - (A + C)$
sin B	abA	$\frac{b \times \sin A}{a}$
sin B	bcC	$\frac{b \times \sin C}{c}$
cos B	abc	$\frac{c^2 + a^2 - b^2}{2ac}$
tan B	bcA	$\frac{b \times \sin A}{c - (b \times \cos A)}$
C	AB	$180^\circ - (A + B)$
sin C	acA	$\frac{c \times \sin A}{a}$

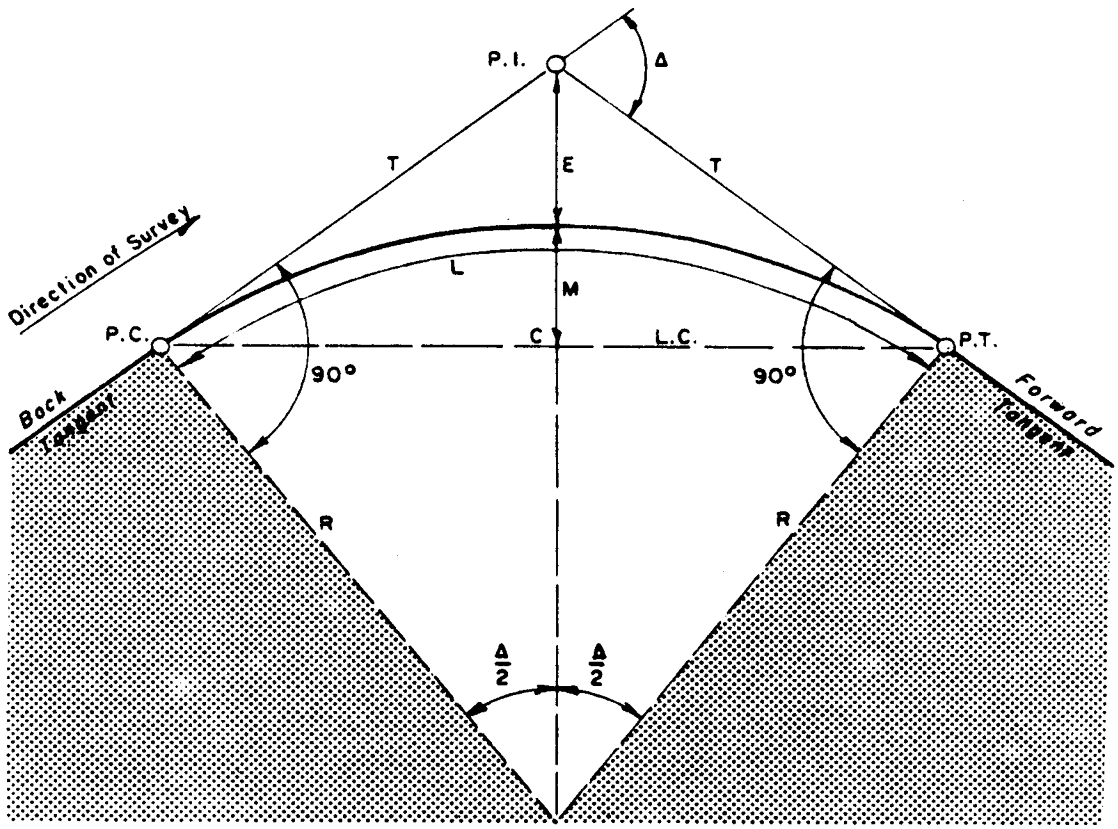
Find	Given	Formula
sin C	bcB	$\frac{c \times \sin B}{b}$
cos C	abc	$\frac{a^2 + b^2 - c^2}{2ab}$
tan C	bca	$\frac{c \times \sin A}{b - (c \times \cos A)}$
tan C	acB	$\frac{c \times \sin B}{a - (c \times \cos B)}$
a	cAC	$\frac{c \times \sin A}{\sin C}$
a	bAB	$\frac{b \times \sin A}{\sin B}$
a	bcA	$\sqrt{b^2 + c^2 - (2bc \times \cos A)}$
b	aAB	$\frac{a \times \sin B}{\sin A}$
b	cBC	$\frac{c \times \sin B}{\sin C}$
b	acB	$\sqrt{a^2 + c^2 - (2bc \times \cos B)}$
c	aAC	$\frac{a \times \sin C}{\sin A}$
c	bBC	$\frac{b \times \sin C}{\sin B}$
c	abC	$\sqrt{a^2 + b^2 - (2ab \times \cos C)}$

SIN = $\frac{\text{Opposite Side}}{\text{Hypotenuse}}$	TAN = $\frac{\text{Opposite Side}}{\text{Adjacent Side}}$	SEC = $\frac{\text{Hypotenuse}}{\text{Adjacent Side}}$
COS = $\frac{\text{Adjacent Side}}{\text{Hypotenuse}}$	COT = $\frac{\text{Adjacent Side}}{\text{Opposite Side}}$	CSC = $\frac{\text{Hypotenuse}}{\text{Opposite Side}}$



Find	Given	Formula
SIN A	Sides a, c	$\frac{a}{c}$
SIN A	Cos A, Tan A	Cos A Tan A
SIN A	Cos A	$\sqrt{1 - \cos^2 A}$
COS A	Sides b, c	$\frac{b}{c}$
COS A	Sin A, Tan A	$\frac{\sin A}{\tan A}$
COS A	Sin A	$\sqrt{1 - \sin^2 A}$
SIDE a	Sides b, c	$\sqrt{c^2 - b^2}$
SIDE a	Side c, Sin A	c Sin A
SIDE a	Side b, Tan A	b Tan A
SIDE b	Sides a, c	$\sqrt{c^2 - a^2}$
SIDE b	Side c, Cos A	c Cos A
SIDE b	Side a, Tan A	$\frac{a}{\tan A}$
SIDE c	Sides a, b	$\sqrt{a^2 + b^2}$
SIDE c	Side a, Sin A	$\frac{a}{\sin A}$
SIDE c	Side b, Cos A	$\frac{b}{\cos A}$
TAN A	Sin A, Cos A	$\frac{\sin A}{\cos A}$
TAN A	Sides a, b	$\frac{a}{b}$
ANGLE A	Angles B, C	C - B
ANGLE B	Angles A, C	C - A
ANGLE C	Angles A, B	A + B

FIGURE E-4
REFERENCE FORMULAS-90° TRIANGLE



FORMULAS FOR ARC DEFINITION

$\Delta = \frac{DL}{100}$

$D = \frac{5729.58}{R}$

$T = R \text{ Tan } \frac{\Delta}{2}$

$L = \frac{100\Delta}{D}$

$R = \frac{5729.58}{D}$

$E = T \text{ Tan } \frac{\Delta}{4} = R \text{ Sec } \frac{\Delta}{2} - R = R \text{ Exsec } \frac{\Delta}{2}$

$M = R \text{ Vers } \frac{\Delta}{2}$

$L.C. = 2 R \text{ Sin } \frac{\Delta}{2}$

Locating the P.C. and P.T.

Sta. P.C. = Sta. P.I. - T

Sta. P.T. = Sta. P.C. + L

LEGEND

P.I. – Point of Intersection

P.C. – Point of Curvature

P.T. – Point of Tangency

Δ – Deflection Angle Between the Tangents

T – Tangent Distance

E – External Distance

R – Radius of the Circular Arc

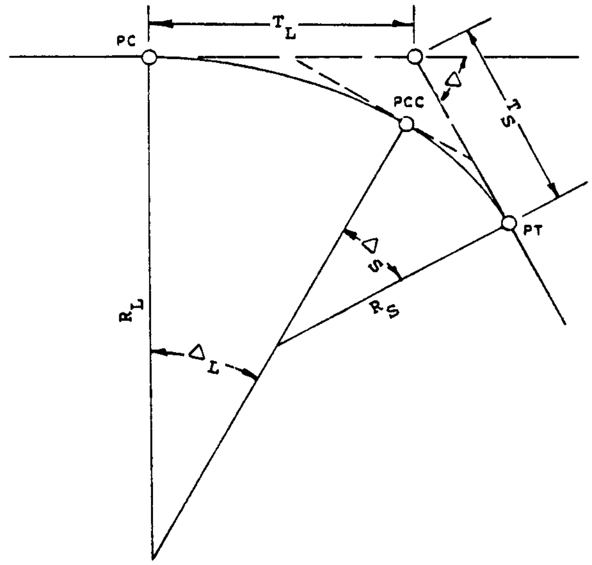
M – Middle Ordinate

L.C. – Long Chord (Distance Between P.C. and P.T.)

C – Midpoint of Long Chord

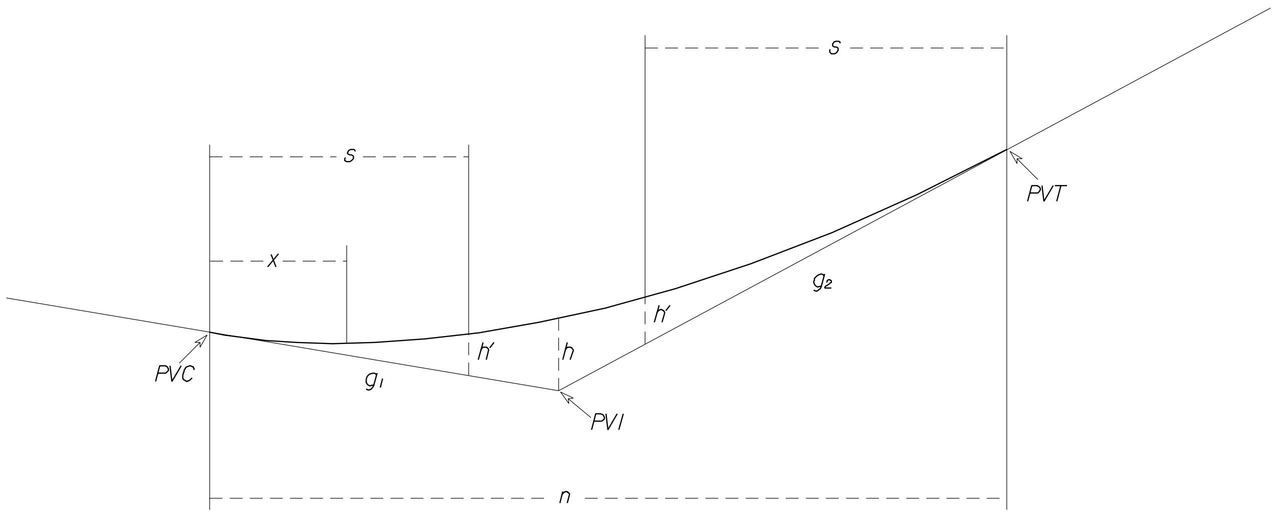
D – Degree of Curvature

L – Length of Curve



GIVEN	SOLUTION	LEGEND
$\Delta_L, \Delta_S, T_S, R_S$	$R_L = \dfrac{T_S \sin\Delta - R_S \operatorname{Vers}\Delta + RS}{\operatorname{Vers}\Delta_L}$	P.C. - Point of Curvature
$\Delta_L, \Delta_S, T_L, R_L$	$R_S = \dfrac{T_L \sin\Delta - R_L \operatorname{Vers}\Delta + R_L}{\operatorname{Vers}\Delta_S}$	P.C.C. - Point of Compound Curvature
$\Delta_L, \Delta_S, R_L, R_S$	$T_L = \dfrac{R_L \operatorname{Vers}\Delta - (R_L - R_S)\operatorname{Vers}\Delta_S}{\sin\Delta}$	P.T. - Point of Tangency
$\Delta_L, \Delta_S, T_S, R_L$	$R_S = \dfrac{T_S \sin\Delta - R_L \operatorname{Vers}\Delta_L}{\operatorname{Vers}\Delta - \operatorname{Vers}\Delta_L}$	R_L - Radius of Major Curve
$\Delta_L, \Delta_S, T_L, R_S$	$R_L = \dfrac{R_S \operatorname{Vers}\Delta_S - T_L \sin\Delta}{\operatorname{Vers}\Delta_S - \operatorname{Vers}\Delta}$	R_S - Radius of Minor Curve
$\Delta_L, \Delta_S, T_L, T_S$	$R_S = \dfrac{T_S \sin\Delta - \tan 1/2\Delta_L (T_L + T_S \cos\Delta)}{\operatorname{Vers}\Delta - \sin\Delta \tan 1/2\Delta_L}$	T_L - Long Tangent
Δ, T_L, T_S, R_S	$\tan 1/2\Delta_L = \dfrac{T_S \sin\Delta - R_S \operatorname{Vers}\Delta}{T_L + T_S \cos\Delta - R_S \sin\Delta}$	T_S - Short Tangent
Δ, T_L, T_S, R_L	$\tan 1/2\Delta_S = \dfrac{R_L \operatorname{Vers}\Delta - T_L \sin\Delta}{R_L \sin\Delta - T_L \cos\Delta - T_S}$	Δ - Total Deflection Angle of the Compound Curve $= \Delta_L + \Delta_S$
Δ, T_S, R_L, R_S	$\cos\Delta_L = \dfrac{R_L - T_S \sin\Delta - R_S \cos\Delta}{R_L - R_S}$	Δ_L - Deflection Angle of Major Curve
Δ, T_L, R_L, R_S	$\operatorname{Vers}\Delta_S = \dfrac{R_L \operatorname{Vers}\Delta - T_L \sin\Delta}{R_L - R_S}$	Δ_S - Deflection Angle of Minor Curve

VERTICAL CURVE FORMULAE



h = center orientation
h' - correction at any point on curve
n = length of vertical curve in feet
g_1 = grade in expressed as feet per foot. For example, 2% would be expressed as 0.02.
g_2 = grade out expressed the same as grade in.
s = horizontal distance, on curve measured from nearest end of curve, in feet.
x = horizontal distance, in feet, messurse from PVC to point on curve
y = elevation of any point on vertical curve in feet
y° = elevation at PVC, in feet

1) $h = \frac{n}{8}(g_1 - g_2)$

2) $h' = h\left(\frac{2s}{n}\right)^2$

Elevation Equation for any point on curve: $y = y^\circ + g(x) + \left(\frac{g_2 - g_1}{2n}\right)(x)^2$

Equation for Low or High Point of Curve: $x = \left(\frac{-gn}{g_2 - g_1}\right)$

SPIRAL CURVES

In order to approximate the path a vehicle makes when entering or leaving a circular horizontal curve, a spiral transition curve will be provided for horizontal curves with a radius less than or equal to 850 meters, except for interchange ramps and loops.

The spiral to be used is known as the Talbot Transition Spiral and has the following characteristics:

1. - The radius of the spiral at any point is inversely proportional to its length. The radius at the TS (beginning of the spiral) is infinite and at the SC (end of the spiral) is equal to the radius of the circular curve R.

R	radius of the circular curve
r	radius at the distance L_x from TS
LS	length of spiral

   $R \div r = L_x \div LS$

2. - The central angle of a spiral curve is exactly 1/2 of a circular curve with the same radius and length.

   DE = central angle of spiral

   $DE = (28.6479 \times LS) \div R$

3. - Spiral angles are directly proportional to the squares of their lengths from the TS.

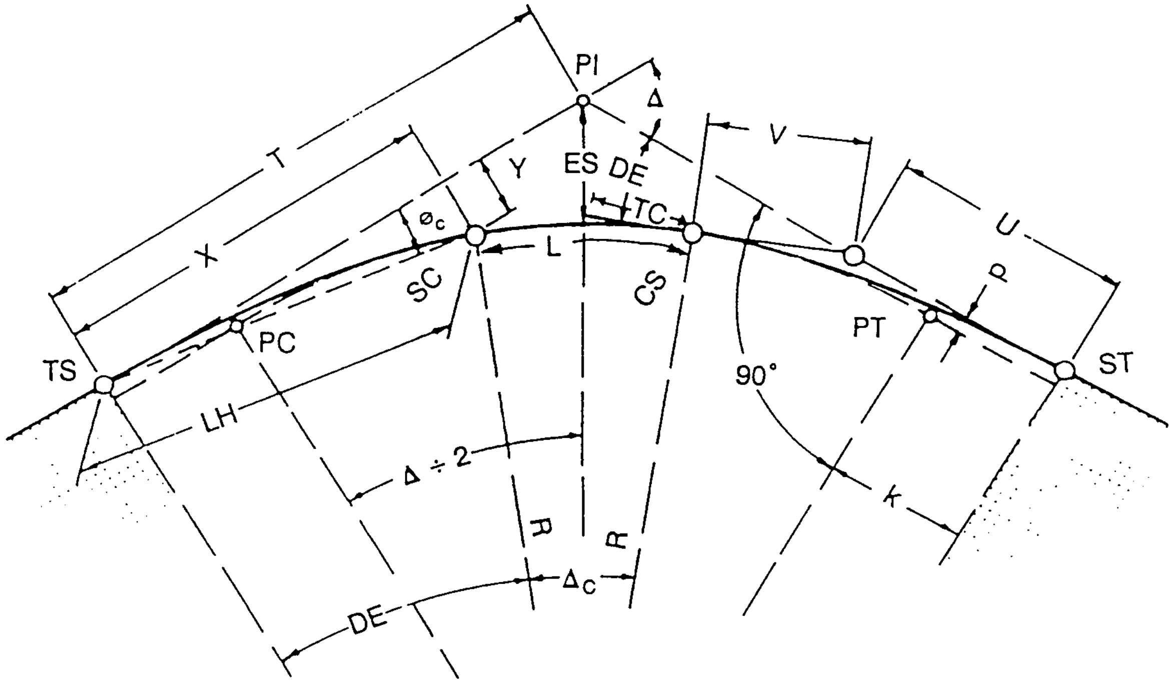
   Δ_L central angle for spiral for a length

   L_x from TS

   $\Delta_L = (L_x \div LS)^2 \times DE$

Formulas for computing spiral curve information is shown on the following page.

TRANSITION SPIRAL)CURVES



LS = Length of Spiral
L = Length of Circular Curve
R = Radius of Circular Curve
TC = Tangent of Circular Curve
T = Tangent Distance
Δ = Deflection Angle Between the Tangents
DE = Spiral Angle
Δ_C = Central Angle Between the SC and CS
ES = External Distance
LH = Long Chord
U = Long Tangent

V = Short Tangent
X = Tangent Distance for SC
Y = Tangent Offset of the SC
k = Simple Curve Coordinate(Abscissa)
p = Simple Curve Coordinate(Ordinate)
$\varnothing_C$ = Deflection Angle of Spiral Curve
TS = Tangent to Spiral
SC = Spiral to Circular Curve
CS = Circular Curve to Spiral
ST = Spiral to Tangent

SPIRAL CURVE FORMULAS

DE = $(28.6479 \times LS) \div R$
Z = $0.01745 \times DE$
X = $LS \times [1 - (Z^2 \div 10) + (Z^4 \div 216)]$
Y = $LS \times [(Z \div 3) - (Z^3 \div 42) + (Z^5 \div 1320)]$
L = $(R \times \Delta_C) \div 57.2958$

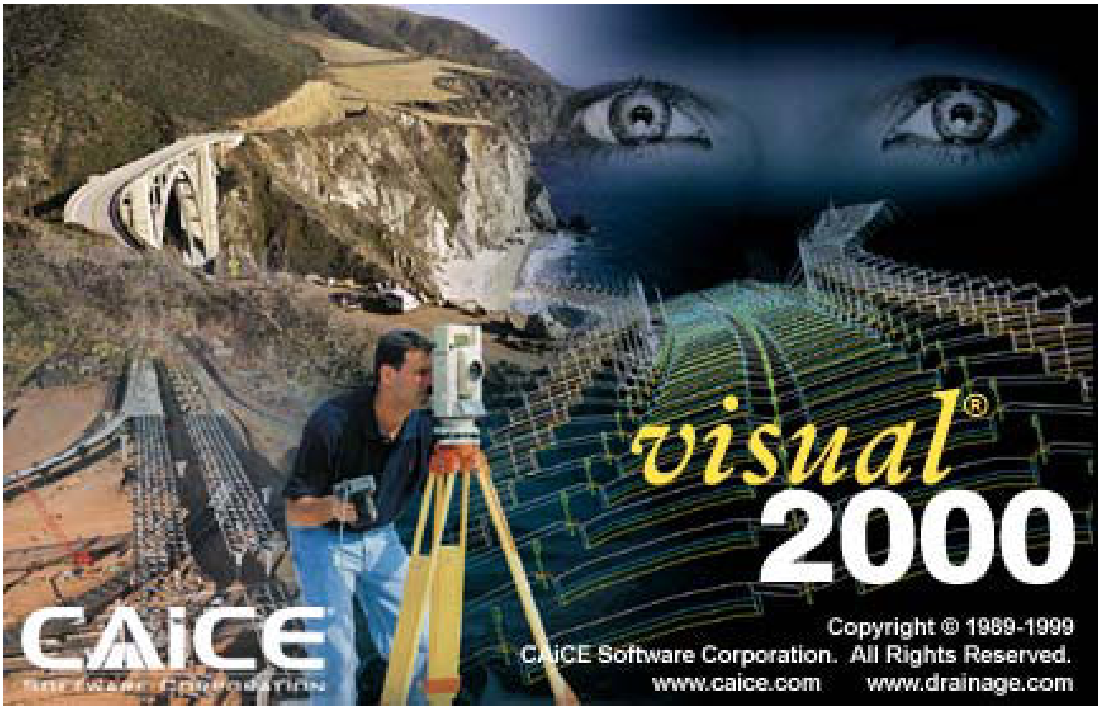
TC = $R \times [\text{Tan}\ (\Delta_C \div 2)]$
Δ_C = $\Delta - (2 \times DE)$
p = $Y - [R \times (1 - \cos(DE)]$
k = $X - [R \times (\sin(DE)]$

TO CALCULATE T AND ES OF A SIMPLE CURVE WITH EQUAL SPIRALS

T = $[(R + p) \times \text{Tan}\ (\Delta \div 2)] + k$
ES = $[(R + p) \times \text{exsec}\ (\Delta \div 2)] + p$
ES = $[(R + p) \div \cos\ (\Delta \div 2)] - R$

TO CALCULATE THE TANGENT DISTANCES OF A SIMPLE CURVE WITH UNEQUAL SPIRALS

Ti_{in} = $[(R + P)_2 \div \sin \Delta] - [(R + p)_1 \times \cot\Delta] + k_1$
T_{out} $[(R + p)_1 \div \sin \Delta] - [(R + p)_2 \times \cot \Delta l + k$



Computer Aided Civil Engineering

The Survey Support Section in Central Office is available for any questions or Training that you may need. The contacts are listed below:

Survey Support Personnel

Terry Glass	**Engineer Tech. III**	**(804) 786-4432**
Stephen Greenwood	**Engineer Tech. III**	**(804) 225-4200**
James Fultz	**Engineer Tech. III**	**(804) 786-1573**
Fred Harris	**Engineer Tech. III**	**(804) 786-9726**
William Elliott	**Engineer Tech. III**	**(804) 786-9727**
Chris Marston	**Engineer Tech. III**	**(804) 786-9728**

NOTE: This manual has been created to hopefully follow the normal work flow for State Survey Parties. The manual is not intended to be the only way to do a project but instead as a guide to help you.

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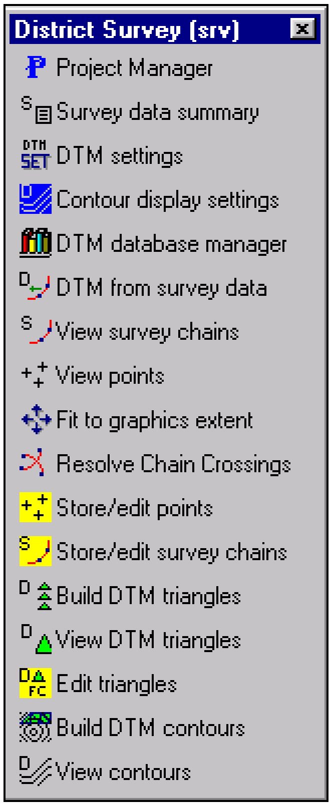
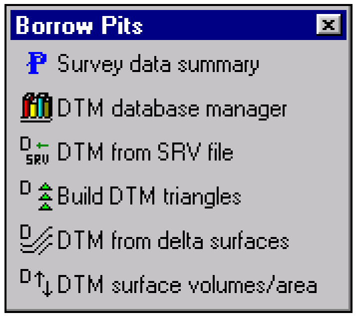
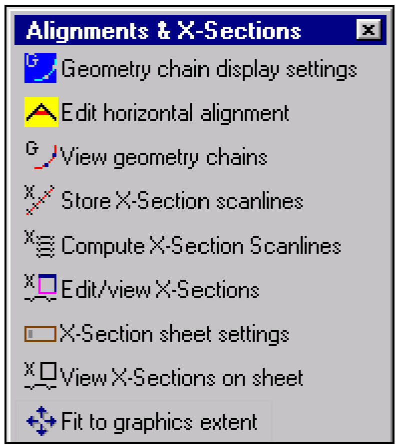
New Survey Toolbars

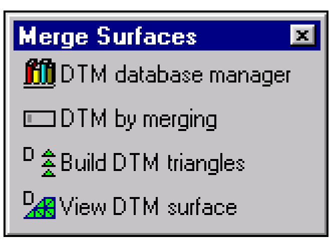
The toolbars below have been created to help you work through a normal project. In some cases you may have to modify the settings to meet your special needs. In order to use the toolbars below, use your mouse and click on ***Settings*** then ***Toolbars***. The **Toolbars Manager** box will appear, look to the left side of this box and click on the **Toolbar** icon. Now in the center of this box you will see all the toolbars listed. To use one just click in the box next to the toolbar you want and it will appear on your screen. Then click ***OK***.





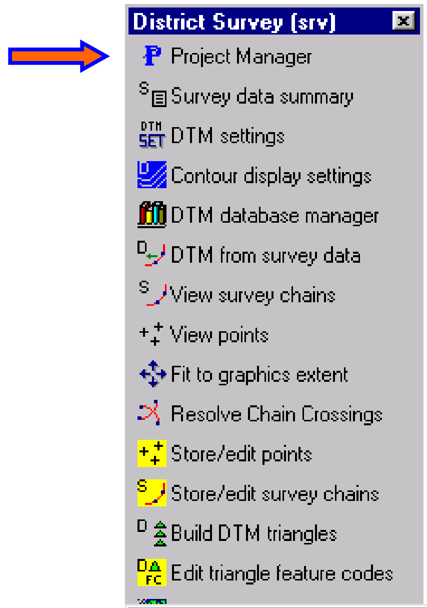


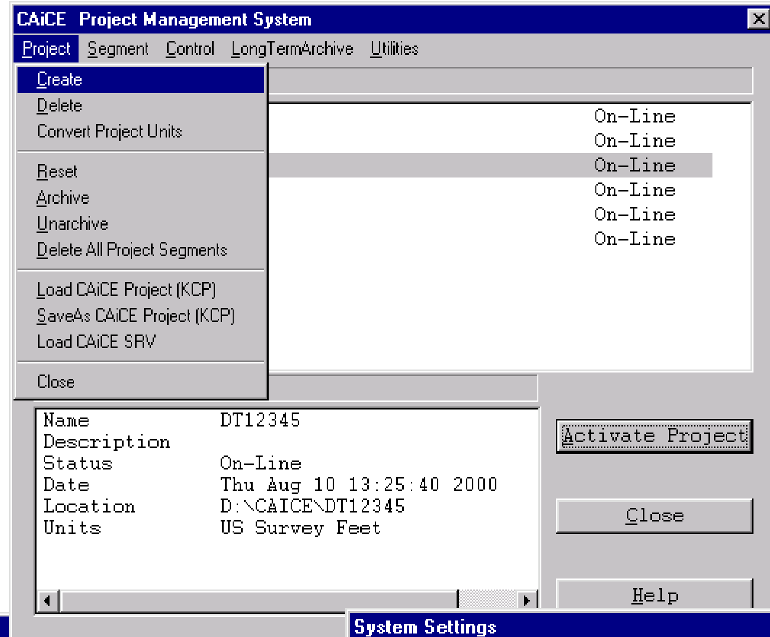
Design Toolbar

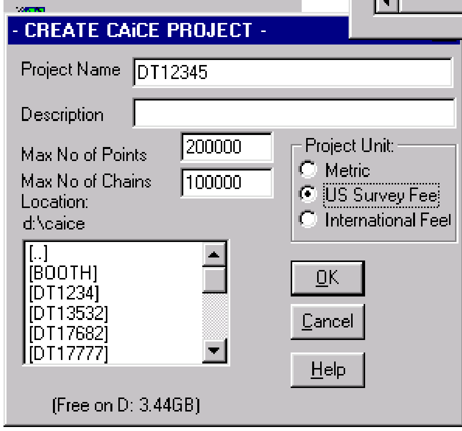


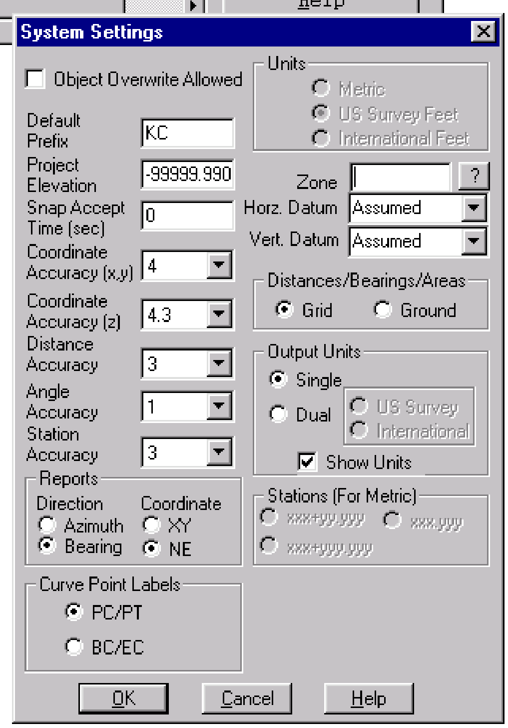
Creating A New Project In CAiCE

This version of CAiCE gives you the ability to use Toolbars instead of drop downs from the menu bar. The Toolbar that has been created for you will hopefully follow your workflow. Select **Project Manager** from the Toolbar. When the ***CAiCE Project Management System*** Box appears click on **Project tab** then the press the Create tab.





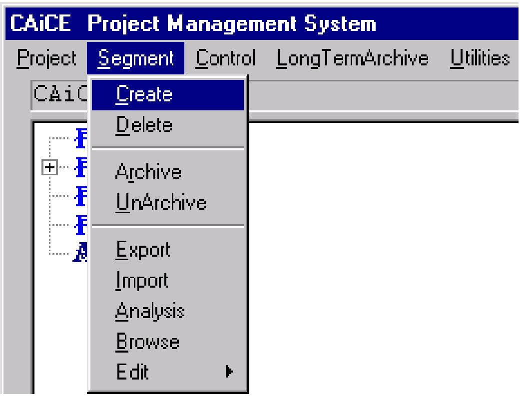


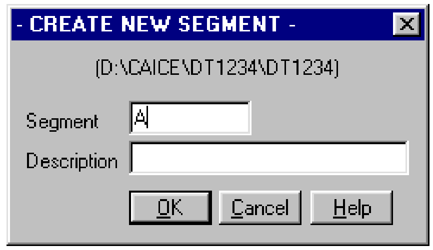


The **Project name** should always start with (**DT**) then the PPMS#. You will then need to select **US Survey Feet** or **Metric**. Once you have selected **OK** the ***System Settings*** box will appear. Here the **Coordinate Accuracy** (z) value should be set to (4.3); this is needed for elevations that are in the thousands of feet.

Creating and Importing Segments

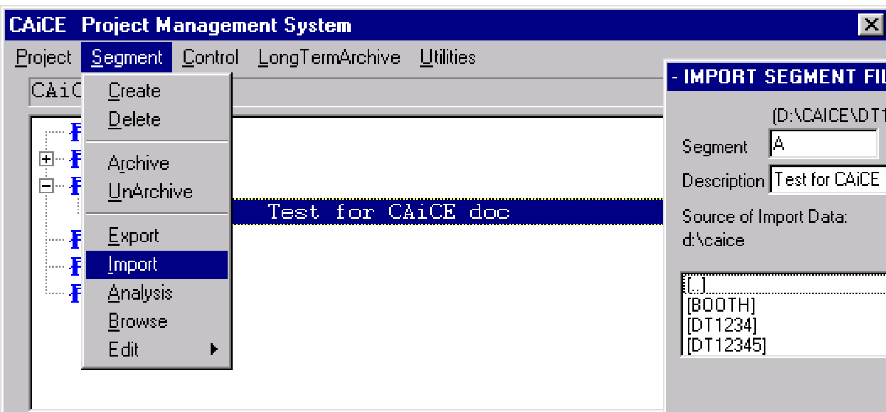
If the ***CAiCE Project Management System*** box is not still on the screen select **Project Manager** from the Toolbar. Click on the **Segment Tab** then **Create** to begin creating your Segment.

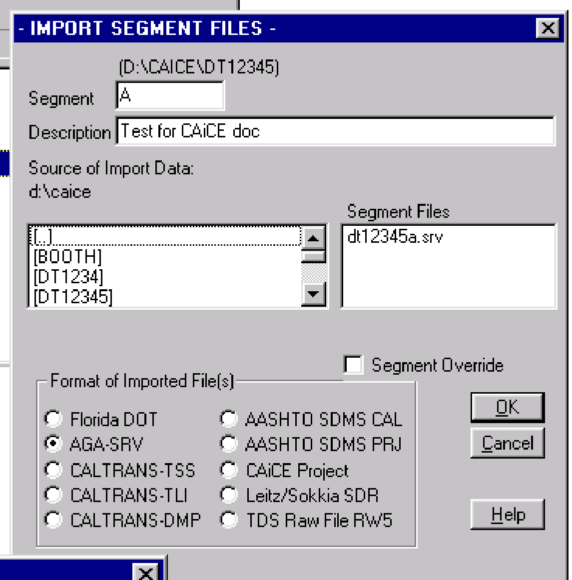




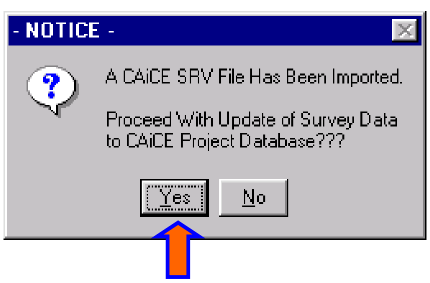
It's important to remember that your **.srv** file should be named **DTPPMS#A.srv.** This will give CAiCE the ability to recognize your srv file. Select **OK.**

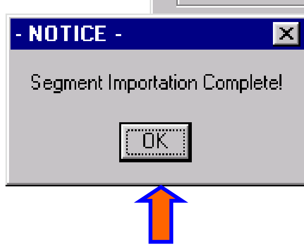
When the **CAiCE Project Management System** box reappears make sure you select the segment so that it becomes highlighted. At this time select the **Segment** tab then **Import.**





The **IMPORT SEGMENT FILES** box will appear, if necessary change your directory, select your segment and click **OK.** You will need to answer the two **NOTICE** boxes below.

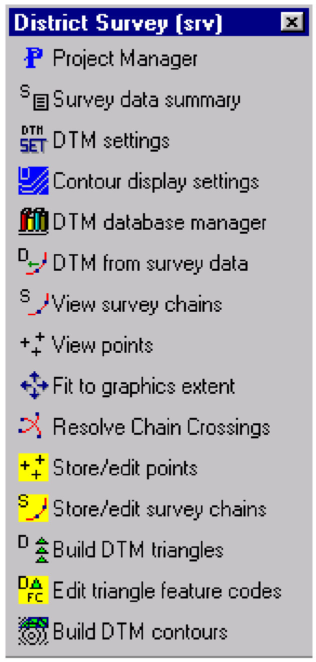


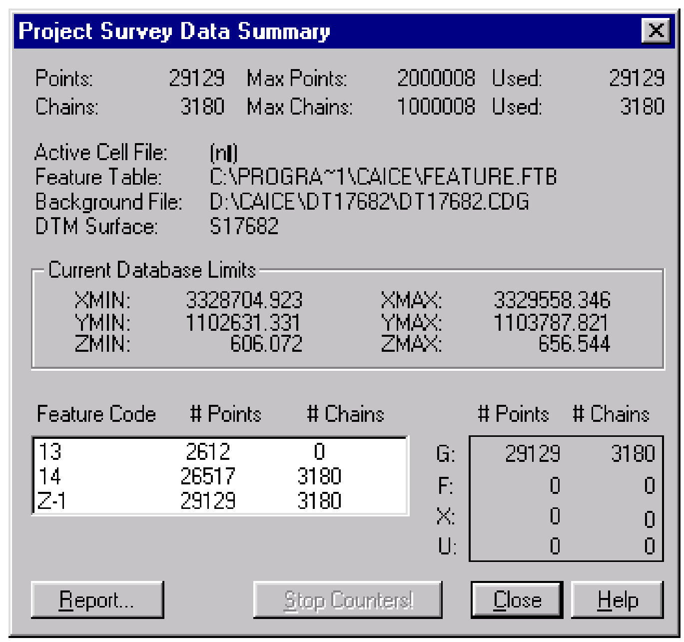


When the **CAiCE Project Management System** box reappears make sure your project is highlighted then click on **Close**

Survey Data Summary

This new feature will allow you to check your (srv) or (dtm) file before you create a DTM Database in CAiCE. You should run this program after you import your segment or load your DTM file. This will check your min & max z-value and min & max XY. When you select **Survey data summary** from the toolbar the picture to the right will appear.

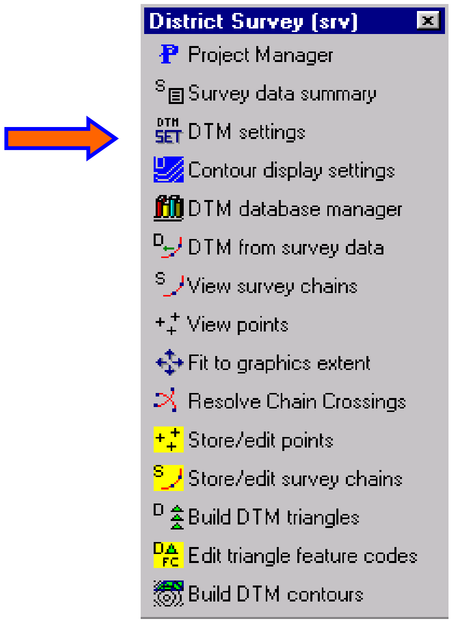




After the program completes its action, you can click on the **Report** button and CAiCE will create a report and you can open a note pad so that you can view or print the file.

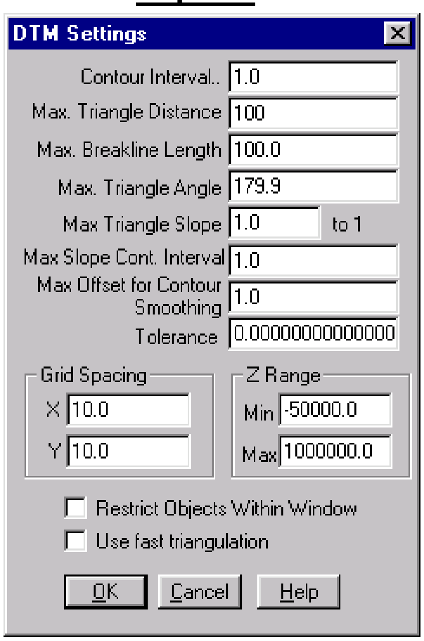
DTM Display Settings

These settings will be used to help you control the length of your triangles and spacing between your contours. Select **DTM settings** from the Toolbar.

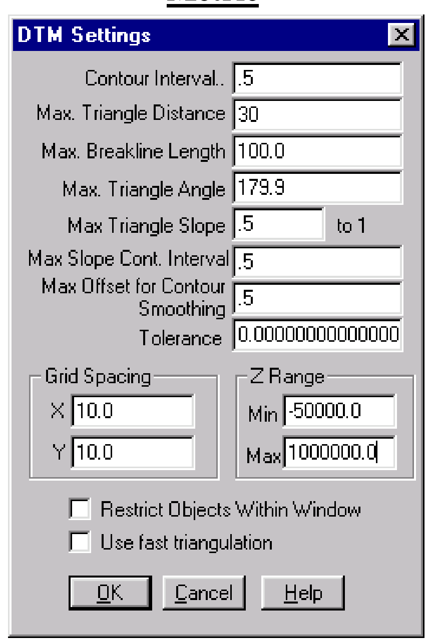


The settings shown below are for your reference and may need to be adjusted for some projects.

Imperial

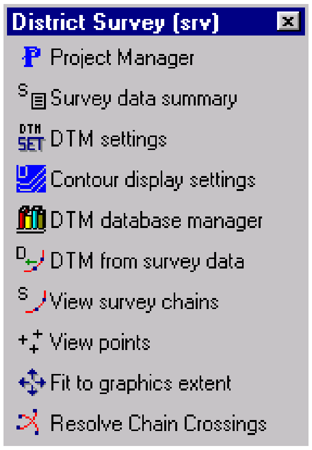


Metric

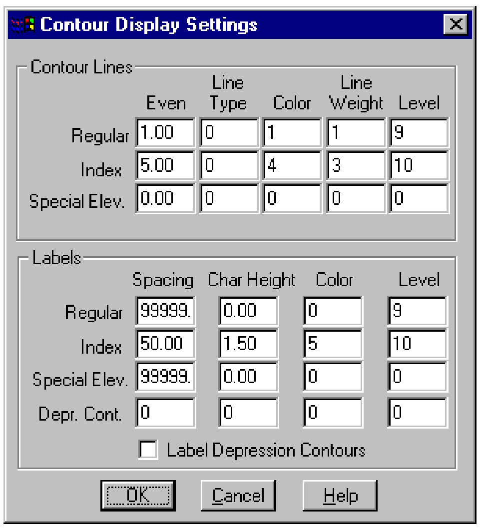


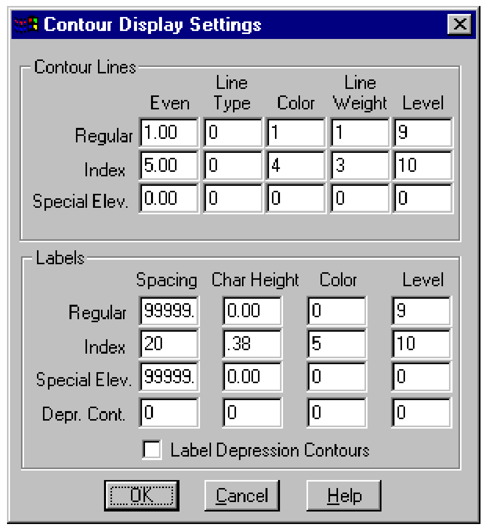
Contour Display Settings

These settings will be used to help you control the way your contours are displayed. Select **Contours Display Settings** from your Toolbar.



The examples shown below will help you for the most commonly used scales. The Index line under **Labels** is where all of the changes will be made.





Imperial Settings

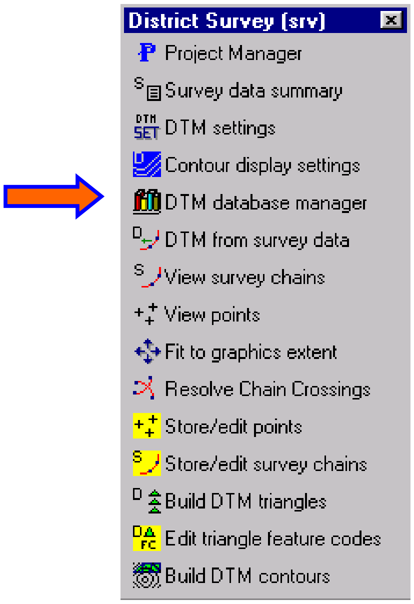
1” to 10’	(Shown above)	
1” to 25’	Spacing 200 / Char. Height	3
1” to 50’	Spacing 300 / Char. Height	6

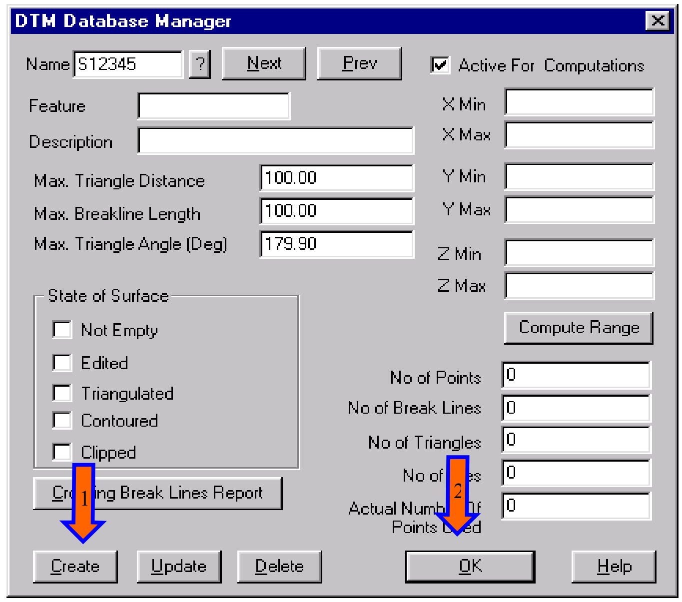
Metric Settings

1m to 100m	(Shown above)	
1m to 250m	Spacing 60 / Char. Height	.75
1m to 500m	Spacing 90 / Char. Height	1.5

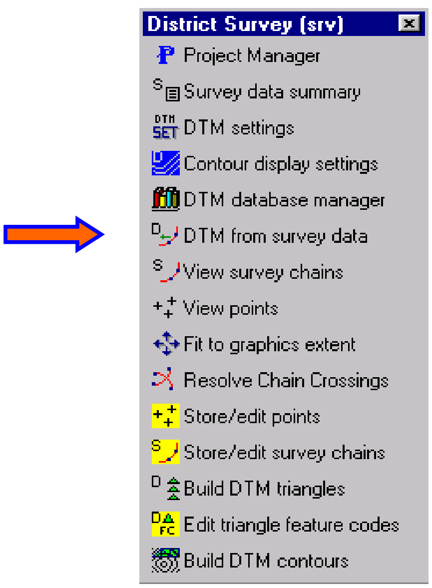
DTM Database Manger & DTM Data Load

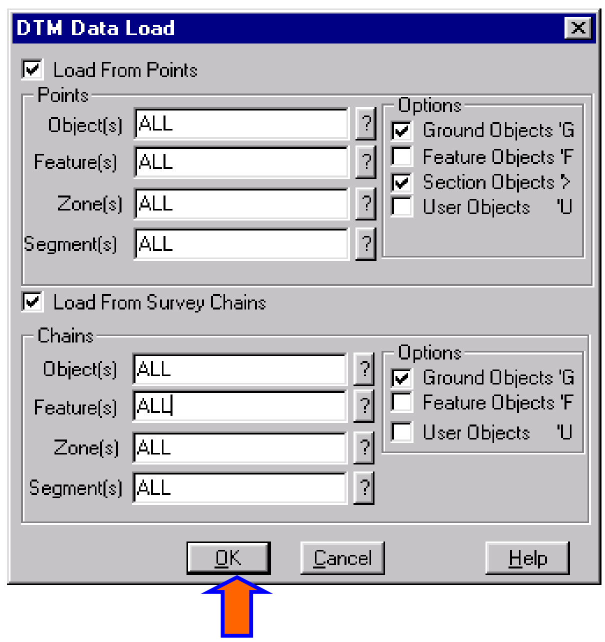
Select **DTM database manager** from your Toolbar. The picture to the right will appear. This should reflect some settings you made earlier in the project. Type in (sppms#) at the *Name* prompt then click the **Create** button. Then Click **OK**.





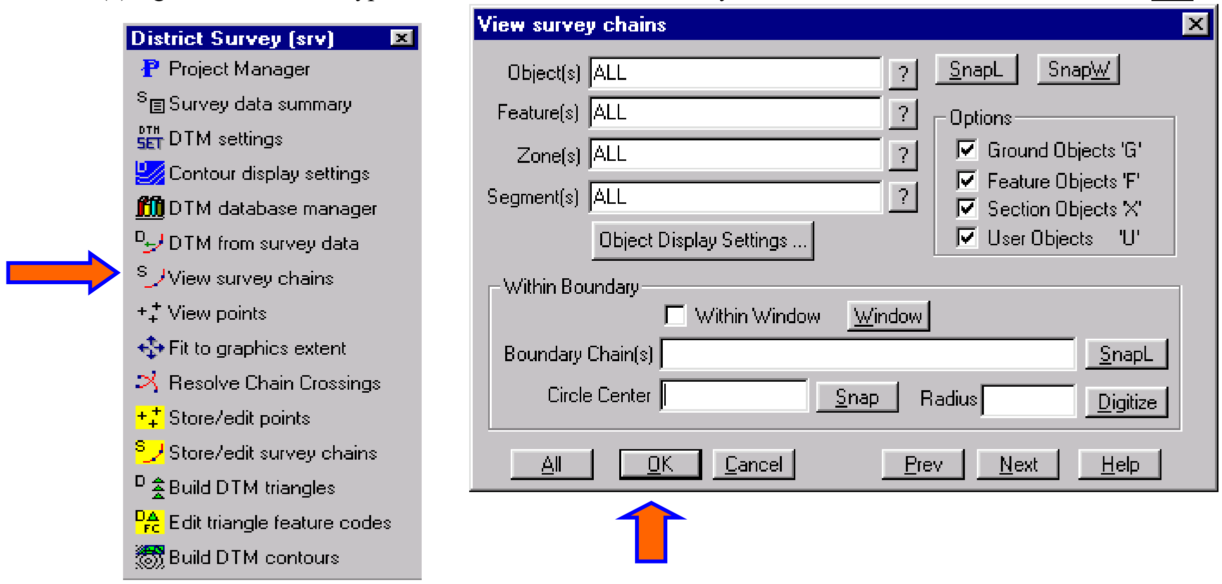
After creating your database you will need to import your **srv** information to it by selecting **DTM from survey data** from your Toolbar. The **DTM Data Load** box will appear. This box normally looks like the one below, but if your Survey party uses fence & wood lines as breaklines you will need to check the Feature Objects box under the **Load From Survey Chains** section. One thing to remember is that if you use this option you will need to plot and break those topo items; especially when they cross other items you are getting DTM information. Click **OK**.



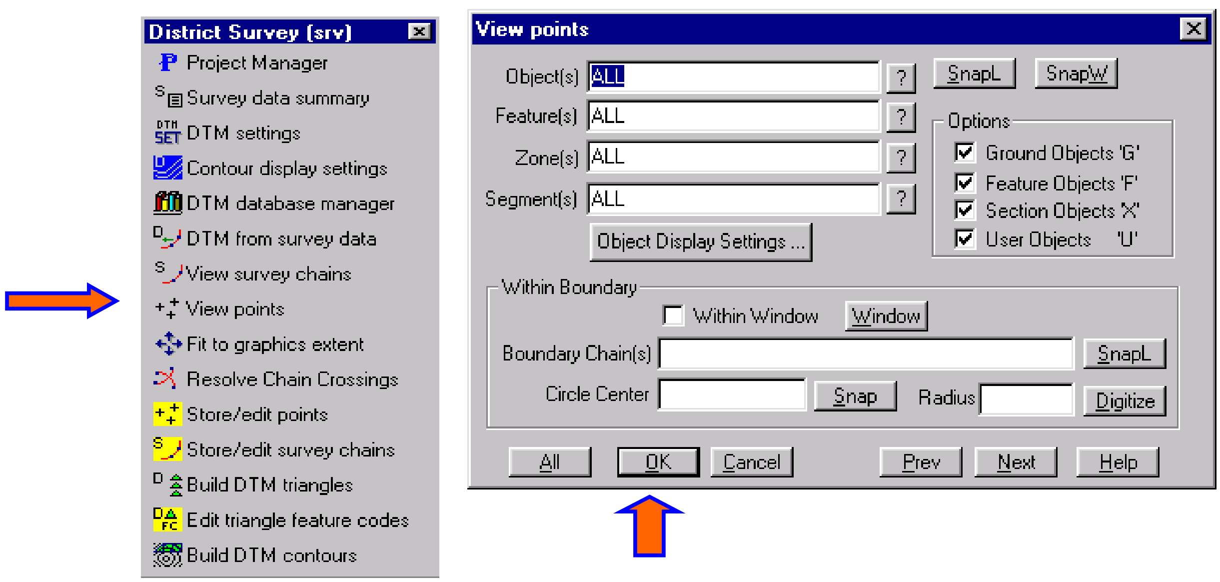


View Survey Chains & Points

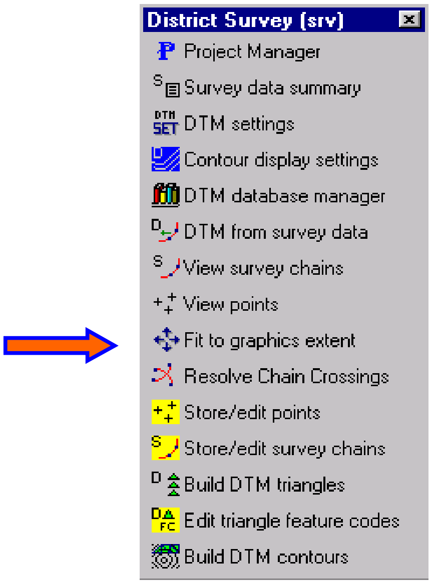
Selecting **View survey chains** from your Toolbar will display the box shown below. Most of the time all you will need to do is click on the **OK** button. Other times you may want to filter some items out, this is done by clicking on the question mark **(?)** right of the Feature type in field. You then select what you would like to view then click on the **OK** button.



Viewing your survey points is very similar to above. First select **View points** from your Toolbar, then click on the **OK** button. Filtering points is done as same as above. To fit your points and survey chains on the screen see the next section.

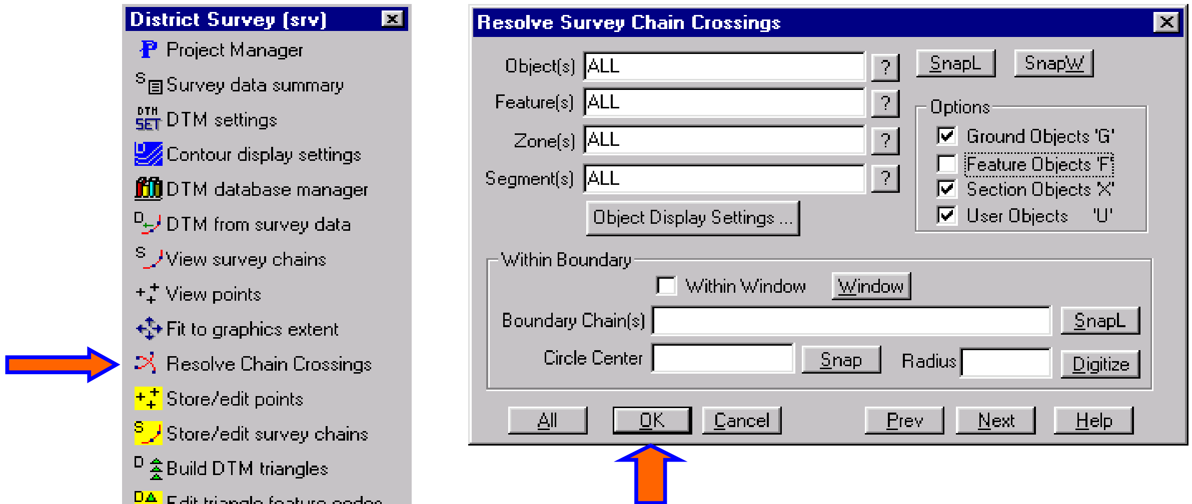


Select **Fit to graphic extent** from your Toolbar. This will take your min & max (x,y) from your database and fit it to your screen.

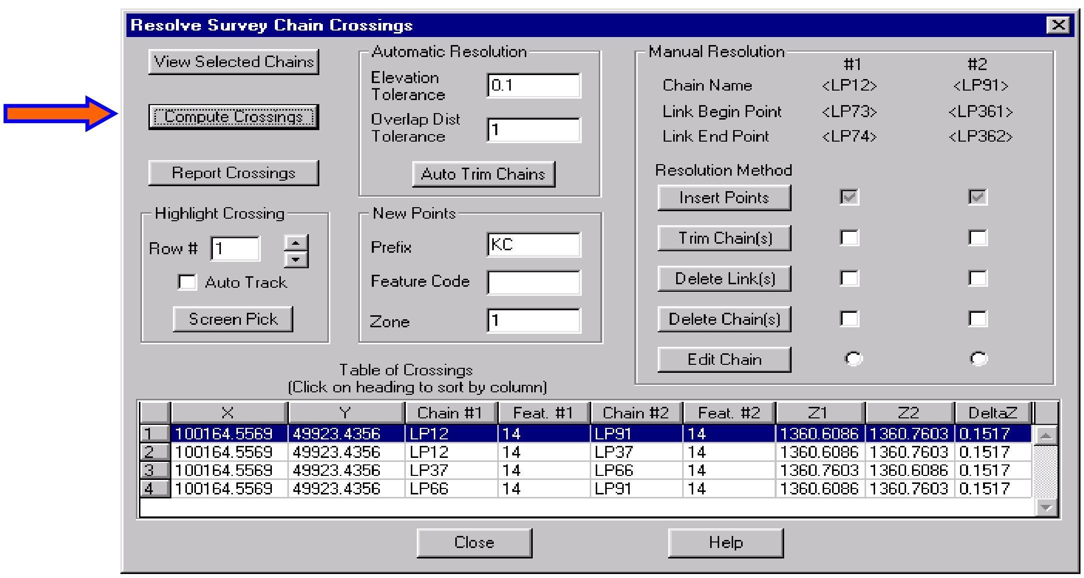


Resolve Survey Chain Crossings

Select **Resolve Survey Chain Crossings** from the Toolbar. The Resolve Survey Chain Crossings box to the right will appear, this gives you the ability to filter items you do not wish to calculate. Most of the time you will just click the **OK** button.



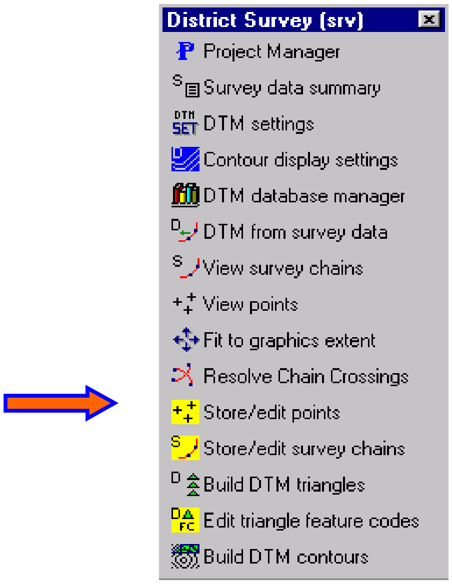
When the Resolve **Survey Chain Crossings** box appears click on the **Compute Crossings** button. If the field at the bottom populates this means you have crossing break lines. If none are present, click on the **Close** button.

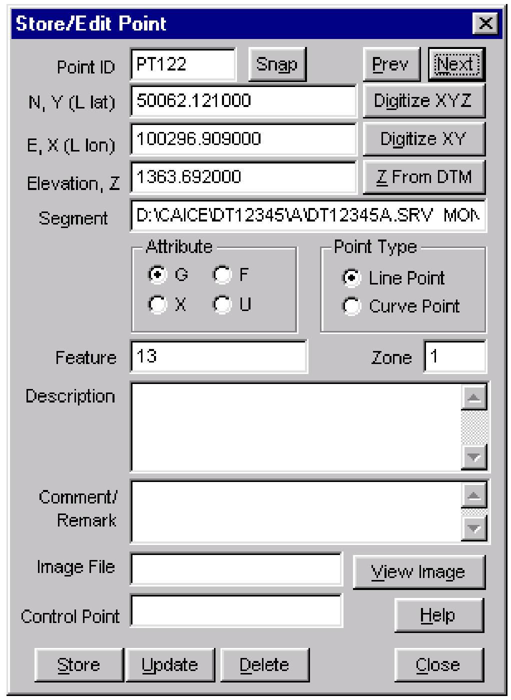


This program should be tested on a file that has never been corrected so can become familiar with it. The ***Automatic Resolution*** selection fields can be modified to your specification. You should review the breaklines before using the **Auto Trim Chains** option. The ***Highlight Crossing*** selection field will let you scroll through the breaklines and the **Auto Track** will center the crossing for you.

Edit Survey Points

Select **Store/edit points** from the Toolbar. Next hold down your left mouse button and drag a rectangle around the point you want to edit. If this brings up a dialog box click the **Accept** button. The **Store/Edit Point** dialog box to the right will appear.

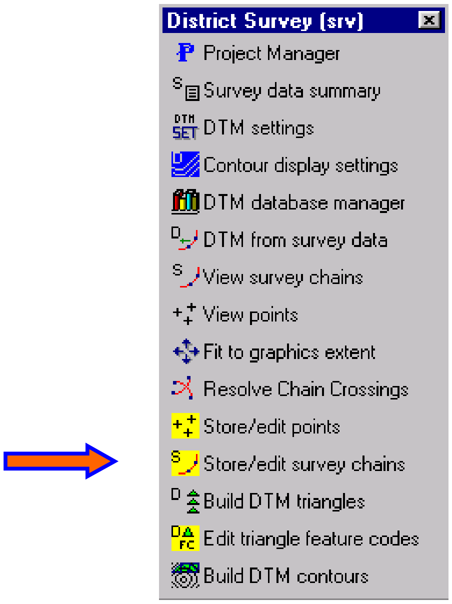


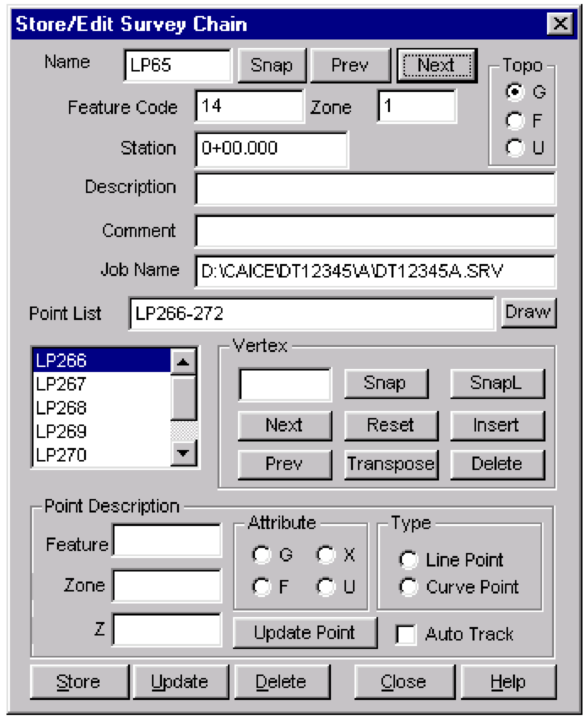


There are a few things to remember when you start changing a points' location or elevation. First, is that you need to look at what the points ***Feature*** is. This information tells you whether the point is in a chain or not. Second, after any changes are made you will need to hit the **Update** button in order for them to take affect. The **Snap** button lets you pick another point without leaving the program. **Prev**. & **Next** allow you to scroll through and highlight all of the points you may have selected. The X, Y, and Z can all be input by hand or you can use the **Digitize X,Y,Z** button. This option will ask you to point to a spot on the screen and click your left mouse button. You will notice that the X,Y,Z has changed, but remember to hit the Update button. This will actually move the point on the screen to its new location. When you are done with your changes click on the **Close** button.

Edit Survey Chains

Select **Store/edit survey chains** from the Toolbar. Next you will need to hold down the left mouse button and drag a fence across the chain you want to edit. If this brings up a dialog box click the **Accept** button. The **Store/Edit Survey Chain** dialog box to the right will appear. Here again the ***Feature Code*** number will tell you what type of chain this is.

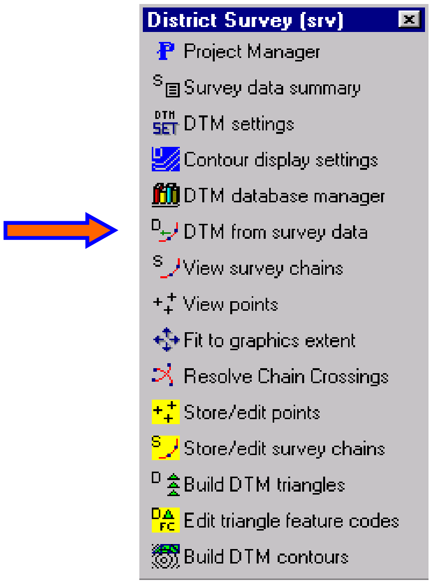


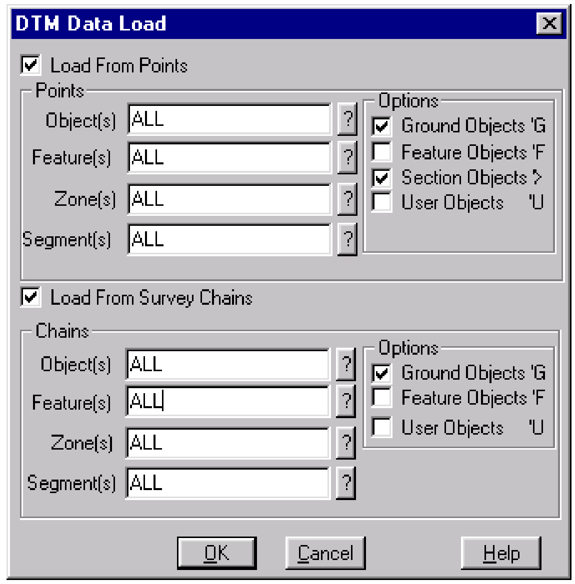


The ***Point List*** lets you know the name of the points and the number of points in the chain. Select a point in the drop down, this will place that point under the ***Vertex*** heading. Use the **Next** & **Prev**. buttons to scroll through the points. For example, say you located a driveway with a code that draws a chain that is point to point. If you wanted to make it a curve, you would need to change the point from a **Line point** to a **Curve Point**. When you make a change to a point, make sure you click on the **Update Point** button. Then click on the **Update** button on the bottom row, this will update the chain with the new information.

Reload Edited Database

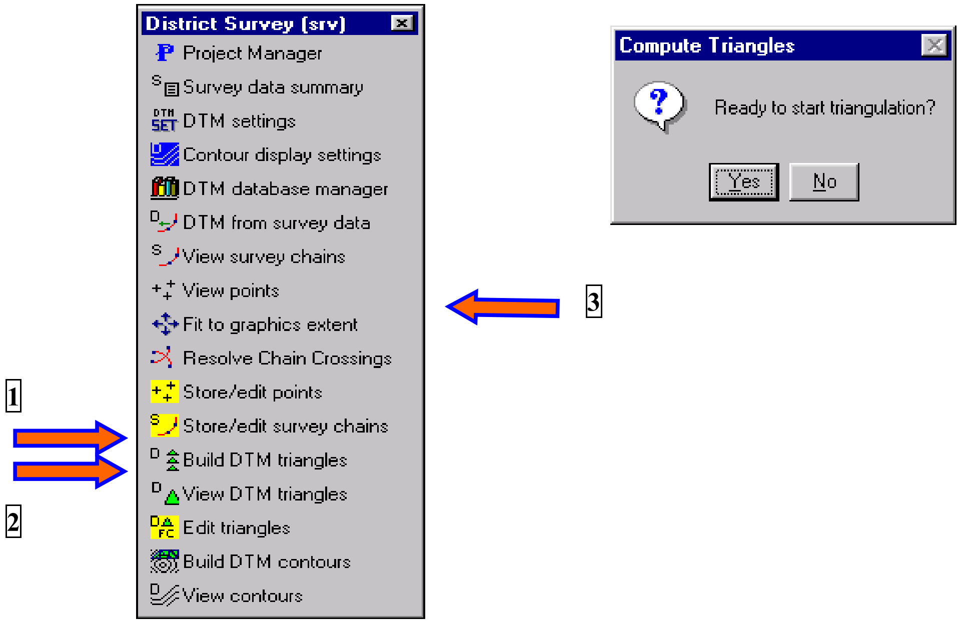
Select **DTM from survey data** from your Toolbar. When the ***DTM Data Load*** box appears select the options you had when you did this originally then click on **OK**. The box at the bottom of this page will show up, answer ***NO***. This will take the new changes you made and load it into your project.





Building & Viewing DTM Triangles

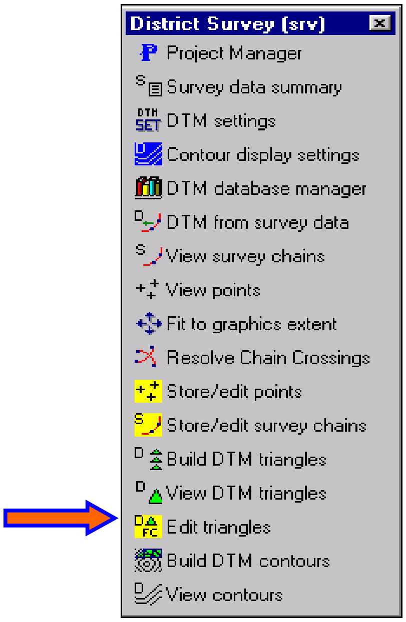
Select **Build DTM triangles** from your Toolbar. The ***Compute Triangles*** box will appear asking you are you ready to start triangulation. Click on the ***Yes*** Button. You will see a white shape form around your project. This is just CAiCE creating the limits for your project. Clear your view and look below.

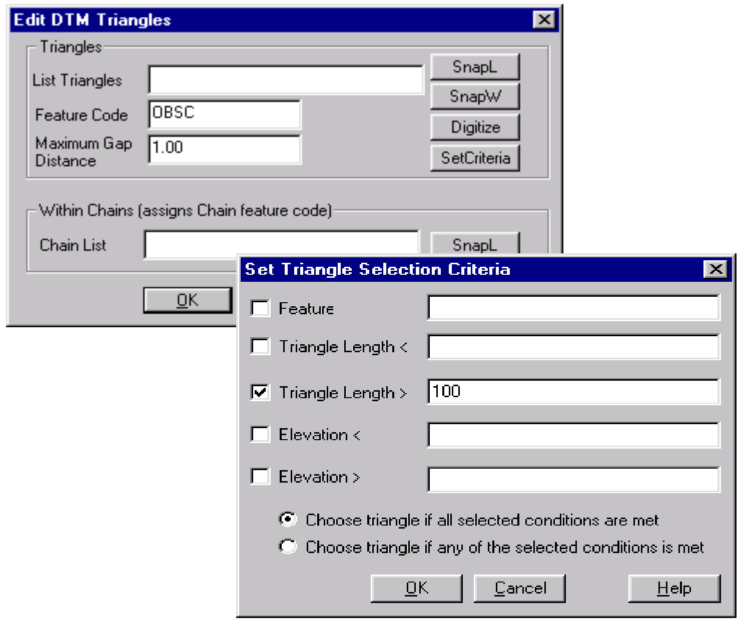


Select **View DTM triangles** from your Toolbar. At this point you should see your triangles on the screen, if not select **Fit to graphics extent** this should display your triangles

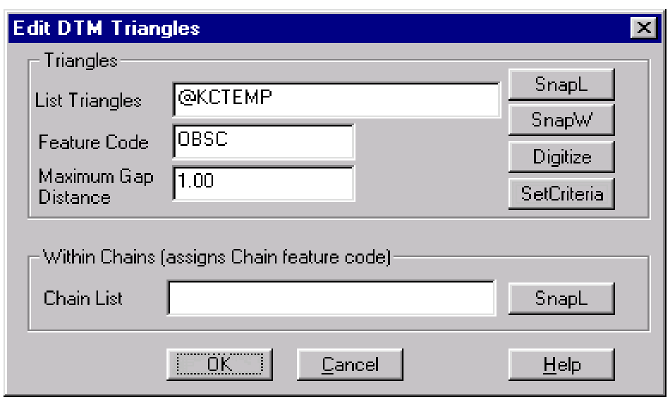
Editing Triangles

Select **Edit triangles** from your Toolbar. The ***Edit DTM Triangles*** box will appear. The first thing to do is type "OBSC" in the ***Feature Code*** text field. Second click on the ***Set Criteria*** button. Now the ***Set Triangle Selection Criteria*** box appears. Then click in the box next to *Triangle Length* > (greater than) and place a check mark. Enter 100 in the text field next to it (100 stands for 100 feet if metric use 30) then click on the ***OK*** button.



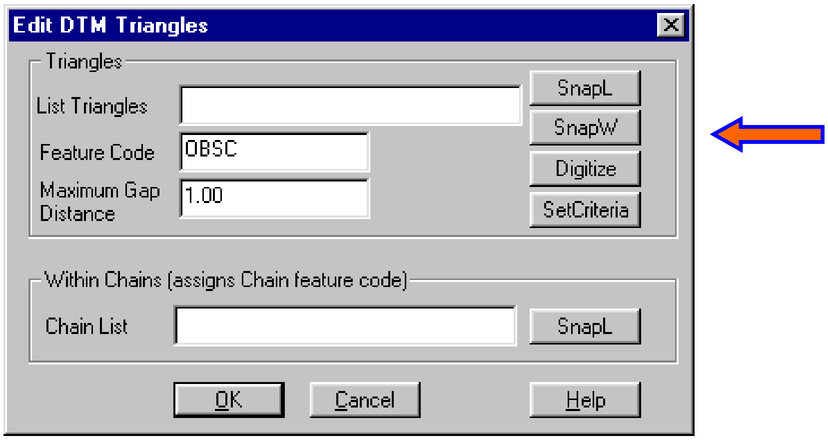


The ***Edit DTM Triangles*** box should appear with a KCTEMP file in the List Triangles text field. Now click on the ***OK*** button to delete the unwanted triangles.



(Continued on next page)

You can also edit triangles by selecting the ***SnapW*** (W=window) button from the ***Edit DTM Triangles*** box. This allows you to pick one or more triangles from a certain area.

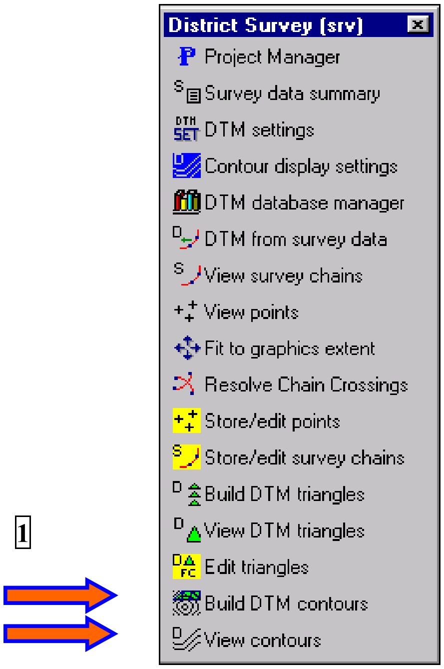


NOTE: It's a good idea to view your breaklines and points when editing your triangles. Doing this will show you where potentially bad triangles may be located. Remember to click the ***OK*** button after you select unwanted triangles. View your triangles in a color other than yellow because that is the color that CAiCE uses to identify triangles to be deleted. To see the changes you made to the triangles clear your view then review your triangles.

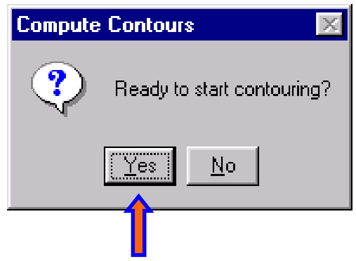
Building & Viewing DTM Contours

Select **Build DTM contours** from your Toolbar. The ***Compute Contours*** box will appear. Click on the ***YES*** button and CAiCE will compute your contours. If they do not show up on your screen select **View contours** from your Toolbar. If they don't appear you will have to select **Fit to graphics extent** from your Toolbar in order to see them all.

1

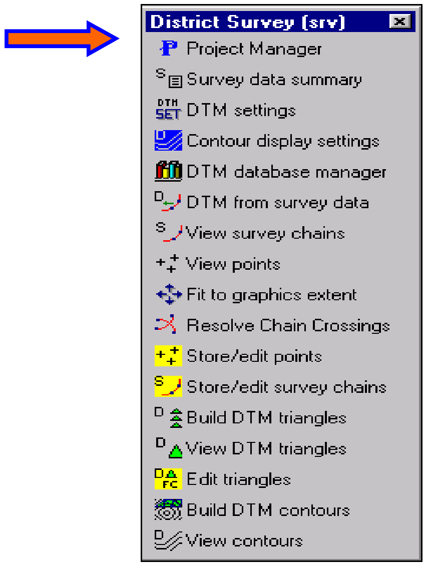


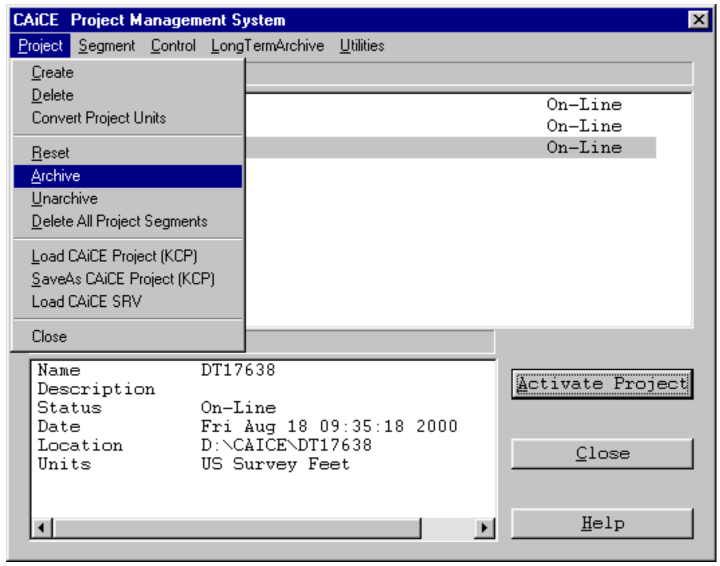
2



Turning in Your Project

Select **Project Manager** from your Toolbar. The ***CAiCE Project Management System*** box will appear. Click on Project then *Archive.*

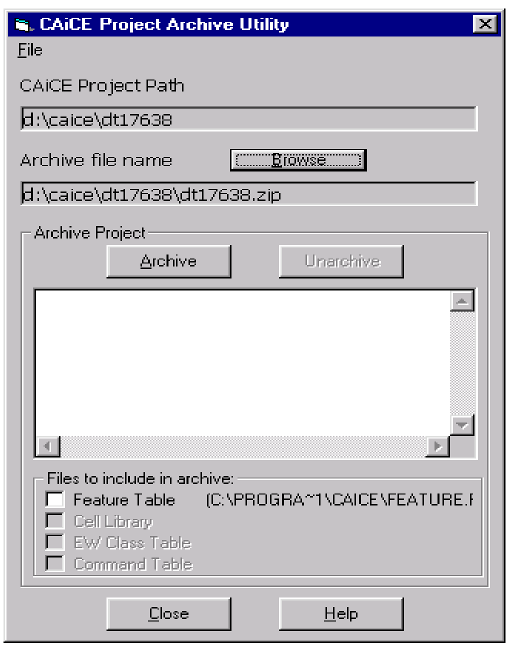


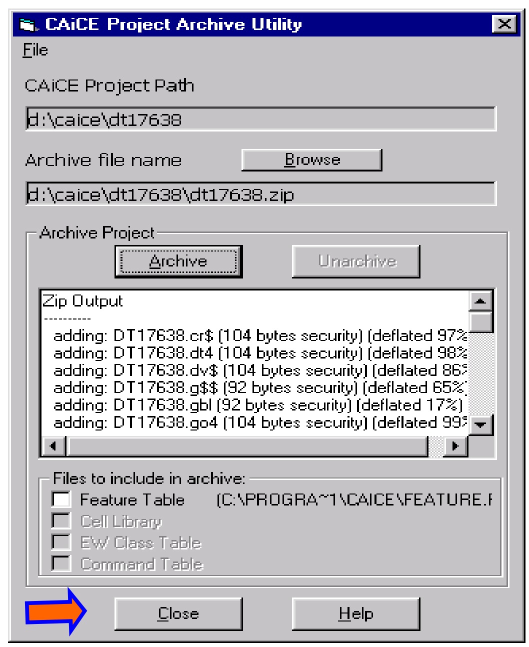


When the ***CAiCE Project Archive Utility*** box appears you will need to note a few things. First make sure the CAiCE Project Path displays the dt folder you wish to Archive. Secondly under Archive file name you should see the folder name with the **ZIP** file you are going to create. ***NOTE:*** *CAiCE now uses PKZIP and LHA (DOS based) for archiving projects*. PKZIP is the default and will be used by the Department. Now click on the ***Archive*** button, when CAiCE has finished the ***CAiCE Zip*** box appears click on ***OK***. The ***CAiCE Project Archive Utility*** box reappears showing you the files that are in the zip file. Click on the ***Close*** button shown on the picture to the right. (Continued on next page)

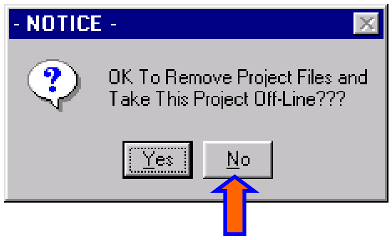
(1)

(2)

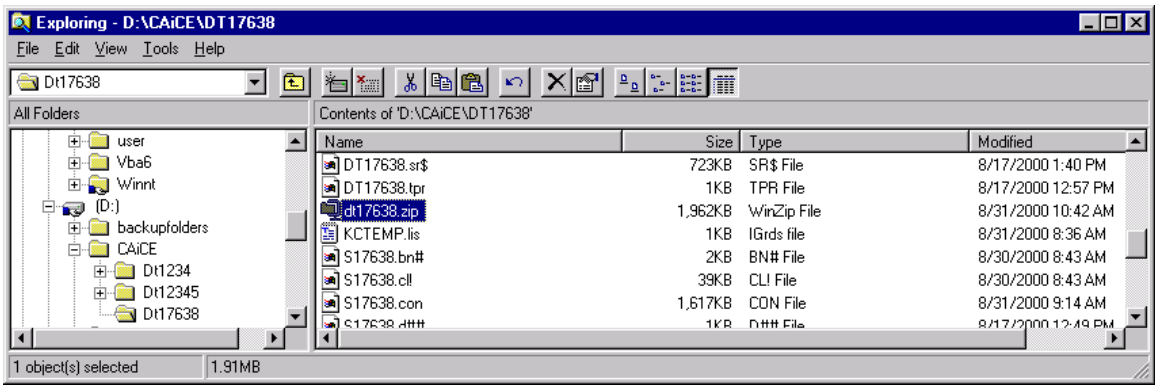




When the ***NOTICE*** box appears asking if you would like to remove the project files answer ***NO***. The reason for this is that the DT(PPMS#).zip file is still located in your DT(PPMS#) folder. You will also need to put this project in Falcon for the Designers.



Using your Windows Explorer, **CUT** the DT(PPMS#).zip file out of the DT(PPMS#) folder and paste it in the folder where you are storing your other master files for this project.



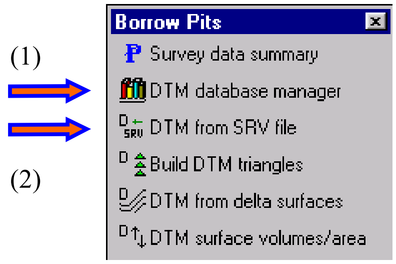
NOTE: For adding your files to Falcon please refer to the ***Falcon Survey Manaul*** located as shown below. You can also click on the Hyperlink below if you are viewing this in Microsoft Word.

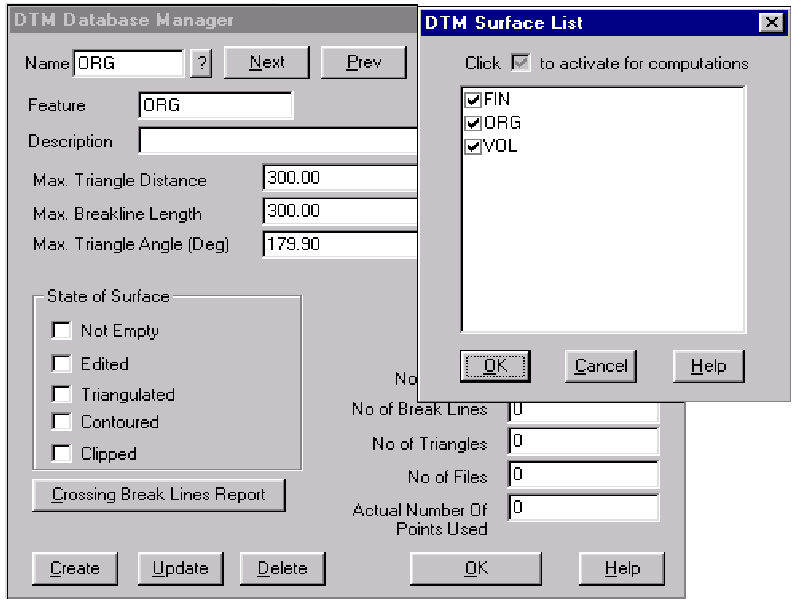
\\0501cosurvey\public\Survey Documentation\Falcon\falcon.doc

Computing Borrow Pits

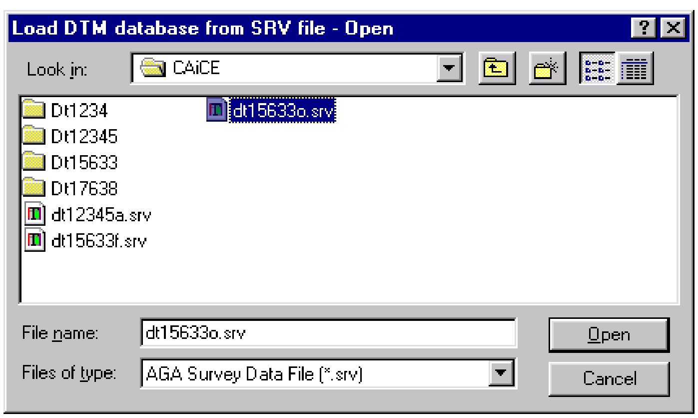
Before you can start calculating your borrow pit please refer to page 2 (Creating a New Project in CAiCE). Now select **DTM database manager** from your Toolbar. You will need to create the 3 Dtm Data Bases listed below.

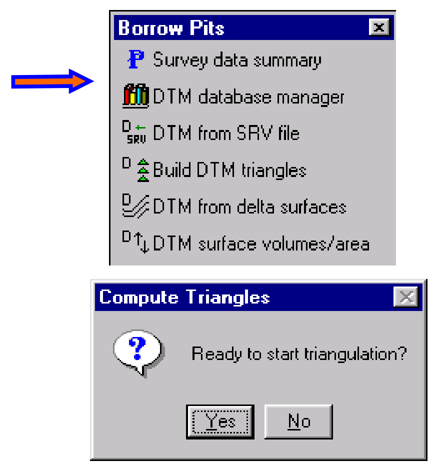
(1) ORG = Original ground surface of borrow pit.
(2) FIN = Final ground readings after pit is excavated.
(3) VOL = Quantities figured by CAiCE.





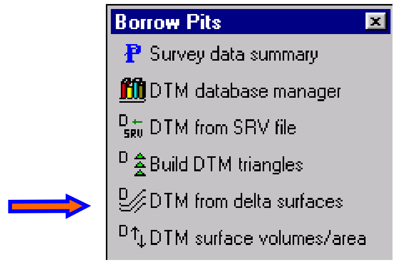
After you have created your Databases make sure you are in your "ORG" database then select **DTM from SRV file** from your Toolbar. It will now ask you for your SRV file, select it then click ***OPEN***. CAiCE then loads your SRV file into the database. Select **Build DTM triangles** from your Toolbar. Click ***Yes***. Follow the same steps for your "FIN" database.

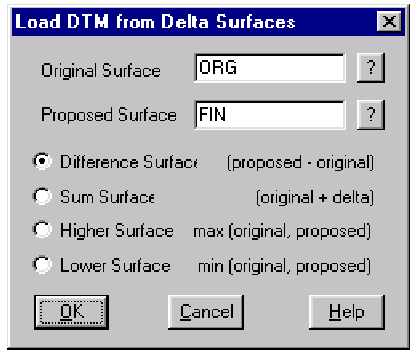




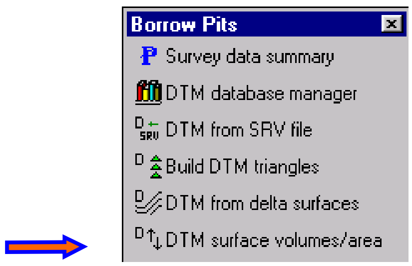
(Continued on next page)

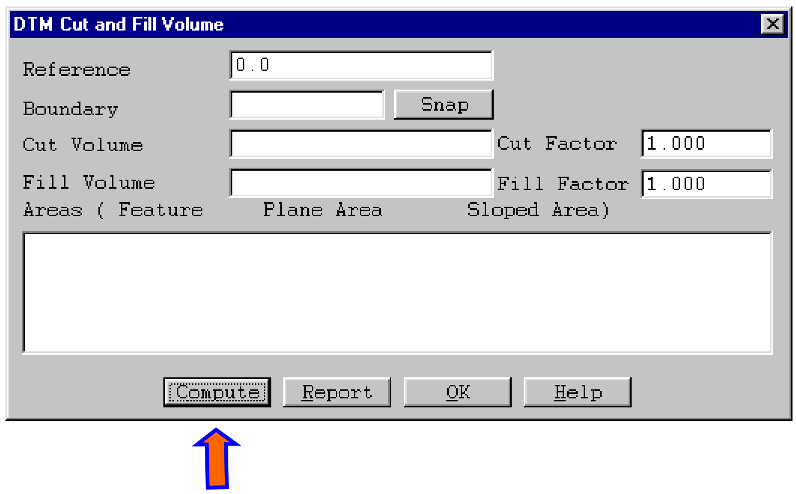
Now we are ready to load the two databases into the "VOL" database and do some calculations. First select **DTM from delta surfaces** from your Toolbar. Use the Question mark buttons to select first your ORG then your FIN database. Second click on the ***OK*** button. Third select **Build DTM triangles** from your Toolbar, this calculates triangles between the two surfaces.



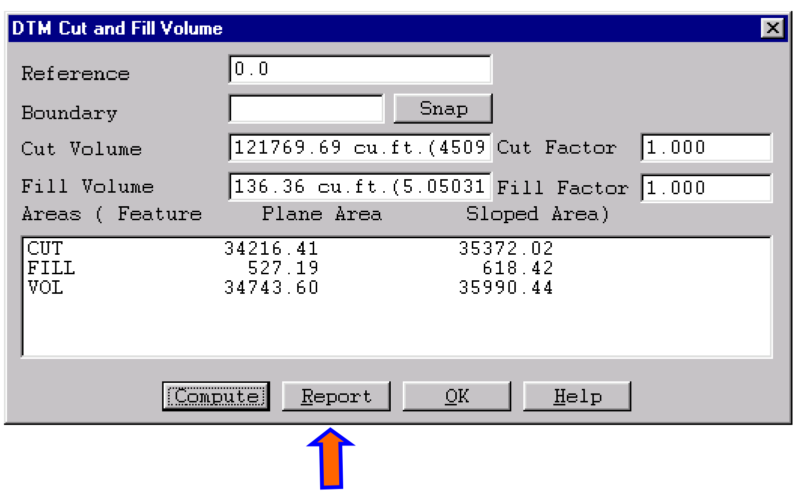


The last thing you do is select **DTM surface volumes/area** from your Toolbar. When the ***DTM Cut and Fill Volume*** box appears click the ***Compute*** button.



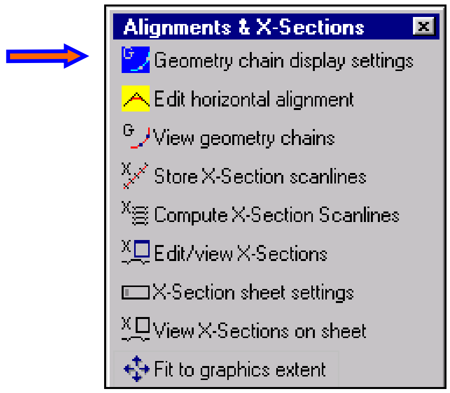


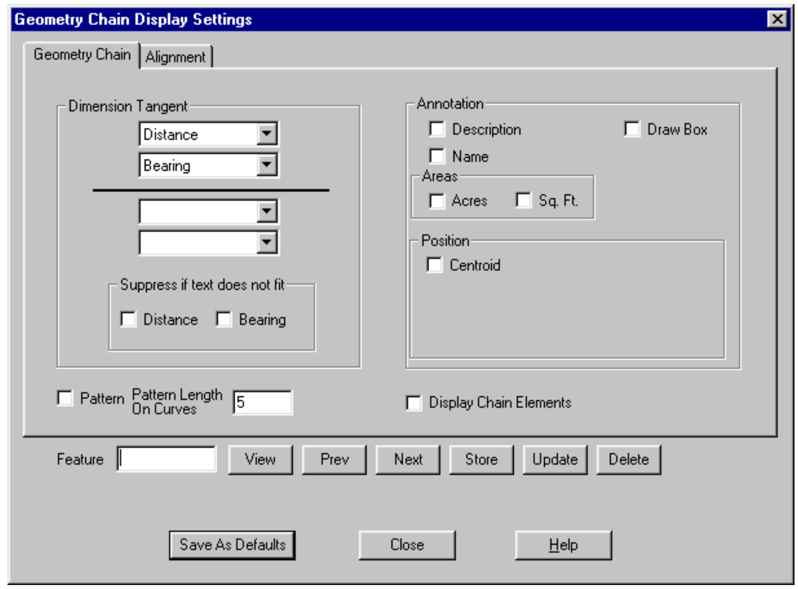
Once CAiCE has finished computing your borrow pit the ***DTM Cut and Fill Volume*** box will display the cut and fill volume. Now if you click on ***Report***, CAiCE will generate a RPT file. The file will be stored in your CAiCE project folder. You can print or save this file for later references.



Alignment And Geometry Chain Settings

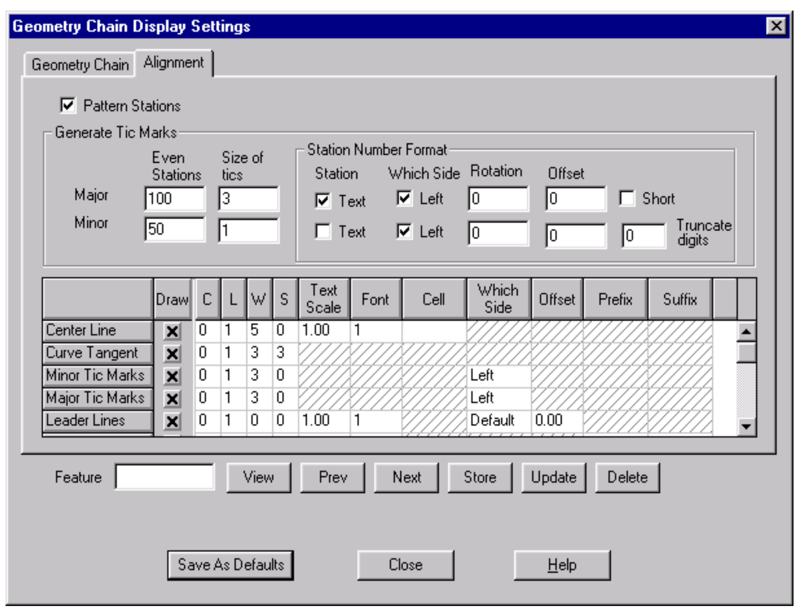
Select **Geometry chain display settings** from your Toolbar. The ***Geometry Chain Display Settings*** box will appear. The only thing needing to be set in the **Geometry Chain** table is under Dimension Tangent. Now click on the down arrow next to the top text field, choose **distance** form the drop down box. Do the same thing for the text box below it but pick **Bearing** this time.





Click the **Alignment** tab.

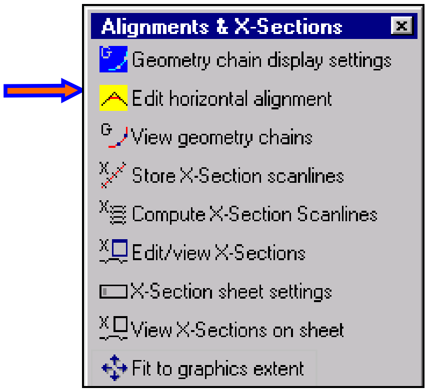
The following is set for a 1”=25’ Imperial project. Save this feature as **CLI25** by choosing the feature select ***Store***. You can also set up the rest of the alignment feature codes and save them. Just change the **Text Scale** according to the project scale. Save each feature as **CLM250** for 1:25 metric project, **CLM500** for 1:500 metric project, and **CLI50** for 1”=50’ imperial project. Now you can just select the feature that you want and select ***Close***.

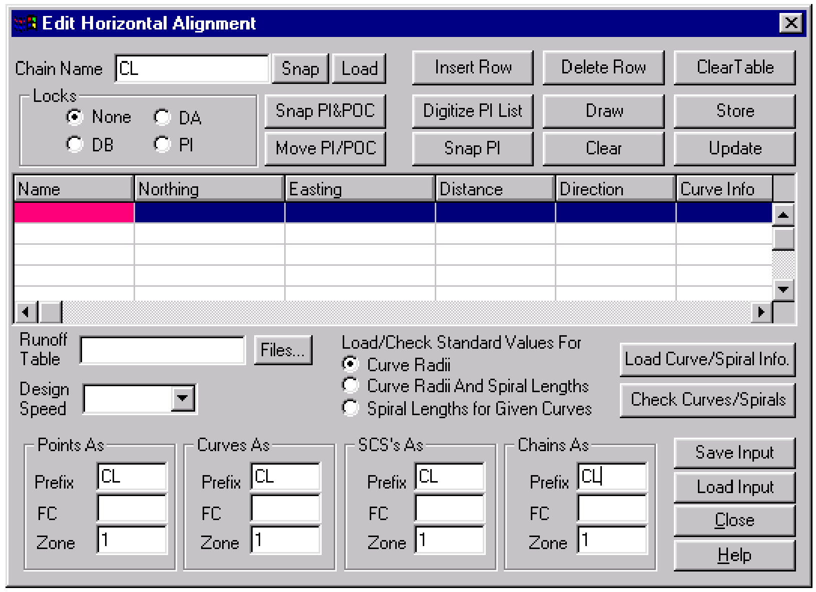


You may need to make some changes to fit your specific needs.

Entering Alignments Into CAiCE

Select **Edit horizontal alignment** from your Toolbar. The ***Edit horizontal alignment*** box will appear.





To enter the alignment, place a data point in the blank field and type in the alignment information. Then place a data point in the next blank field etc…. Make your **Chain Name** and all of your **Prefixes** at the bottom of the palette **CL**, as shown above. The first of two ways of entering alignment is shown below.

1. Enter your starting coordinates.
2. Starting station.
3. Distance to the next PI.
4. Bearing to the PI.
5. Enter the radius for the curve. (If there is one.)
6. Spiral length back. (If there is one.)
7. Spiral length ahead. (If there is one.)

Northing	Easting	Distance	Direction	Curve Info	SLB	SLA	Station
123786.8028	205092.6772						81250.02
123259.5163	205642.9322	762.11	S 46 13 16 E	1368.39	320.00	320.00	
123253.4738	206347.0663	704.16	S 89 30 30 E				

Continue on until you are finished. Select **Save Input** and give it a name. This is just in case you have to go back and edit the alignment information. Then select ***Draw*** and ***Store***.

The second way to enter your alignment is shown below.

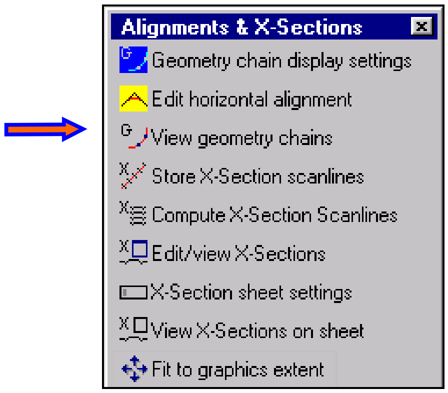
1. Enter your starting coordinates.
2. Starting station.
3. Enter the next PI coordinates.
4. Enter the radius for the curve. (If there is one.)
5. Spiral length back. (If there is one.)
6. Spiral length ahead. (If there is one.)

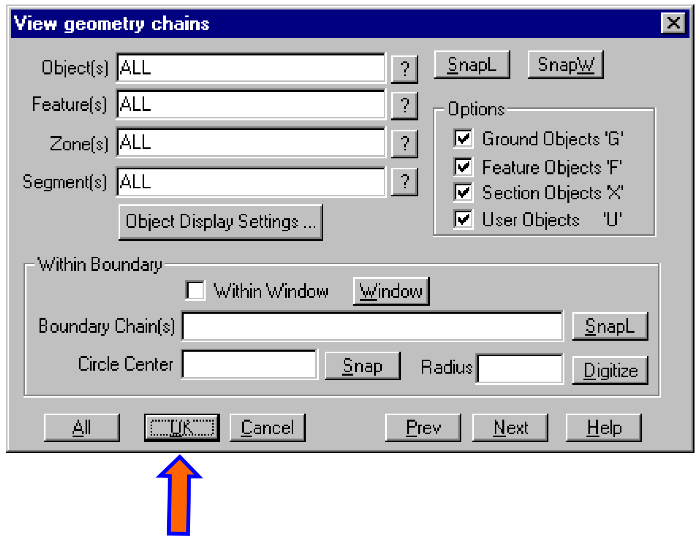
Northing	Easting	Distance	Direction	Curve Info	SLB	SLA	Station
123786.8028	2057092.6772						81250.02
123259.5163	2057642.9322			1368.39	320.00	320.00	
123253.4738	2058347.0663						

Continue on until you are finished. Select ***Save Input*** and give it a name. This is just in case you have to go back and edit the alignment information. Then select ***Draw*** and ***Store***. If you need to enter another alignment select ***Clear Table*** and start entering your next alignment.

Viewing Alignment And Geometry Chains

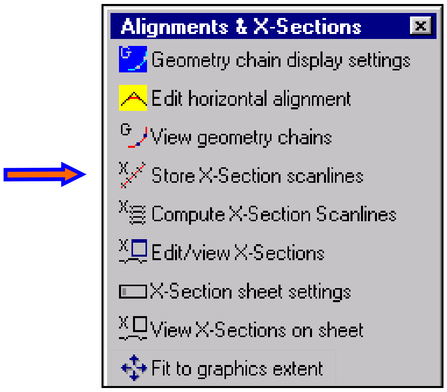
After you have entered your alignments and set up the parameters, select **View geometry chains** from your Toolbar. The ***View geometry chains*** box will appear. Click the ***OK*** button.

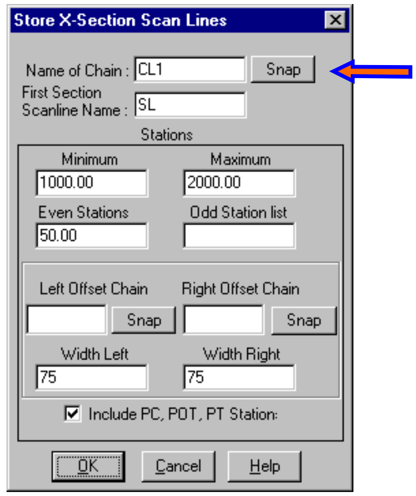




Processing Cross Sections

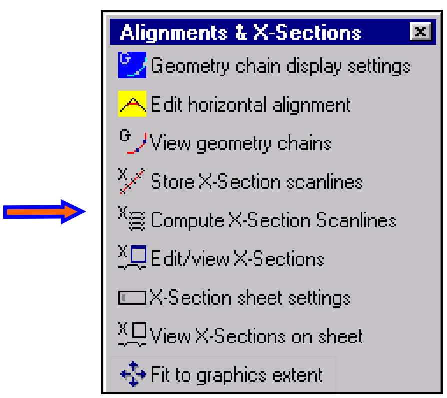
Occasionally you might need to create some cross sections for checking the DTM data that you have collected. Select **Store X-Section scanlines** from your Toolbar. The ***Store X-Section Scan Lines*** box will appear. Enter the name of your alignment chain or select ***Snap*** and snap to the chain that will be used. Enter the starting and ending stations and the station interval that you want to use. Imperial projects are usually set to **50** and metric projects are set to **20.** Also enter the width that you want the cross sections calculated from, for both the left and right sides. If you want cross sections for the PC and PT calculated, select the **Include PC, POT, PT Stations** box for this. Then select ***OK***.

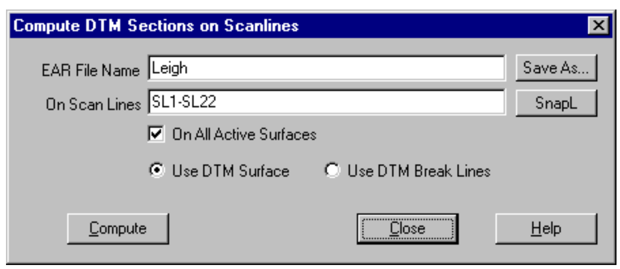




It is recommended to first do the section scan lines, then the cross section. That way you will not be confused with which section scan lines went with which alignment.

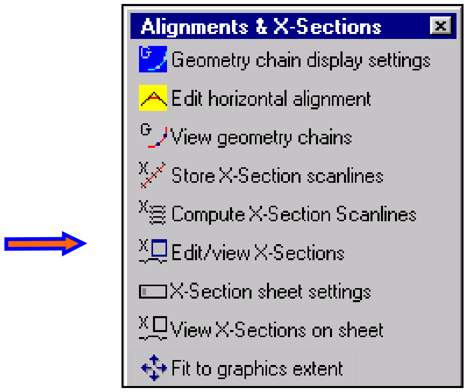
To compute the cross sections select **Store X-Section scanlines** from your Toolbar. This will take you to the ***Compute DTM Sections on Scanlines*** box. You need to enter the section scanlines numbers, **note** it will default to the last set that were computed. Also, enter the name of the alignment for this section. **Remember, enter up to eight characters, not including the extension.** For example: **Leigh**. Select ***Compute***. Once the cross sections are computed select ***Close***.

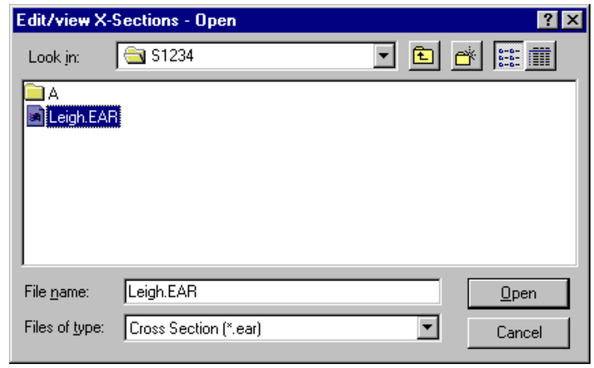




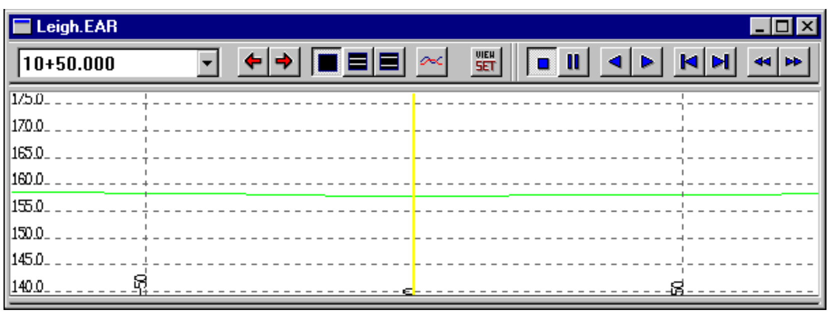
Viewing Cross Sections

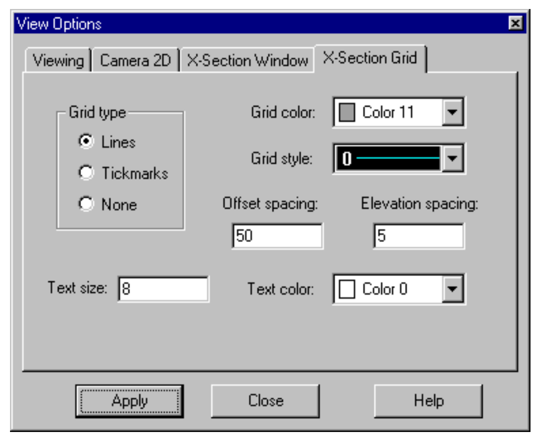
There are two ways of viewing cross sections. One way is through a window box. To do this, select **Edit/View X-Sections**, on the main menu. An ***Edit/view X-Sections – Open*** box will appear and prompt you to select the cross section file that you wish to view.



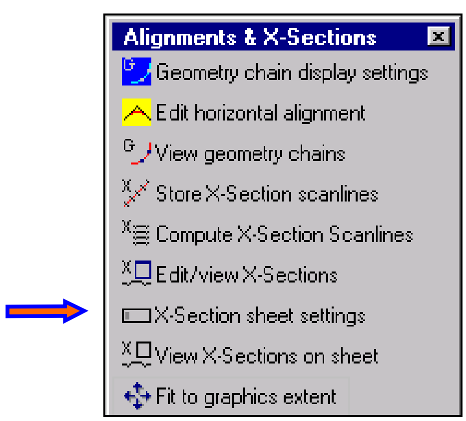


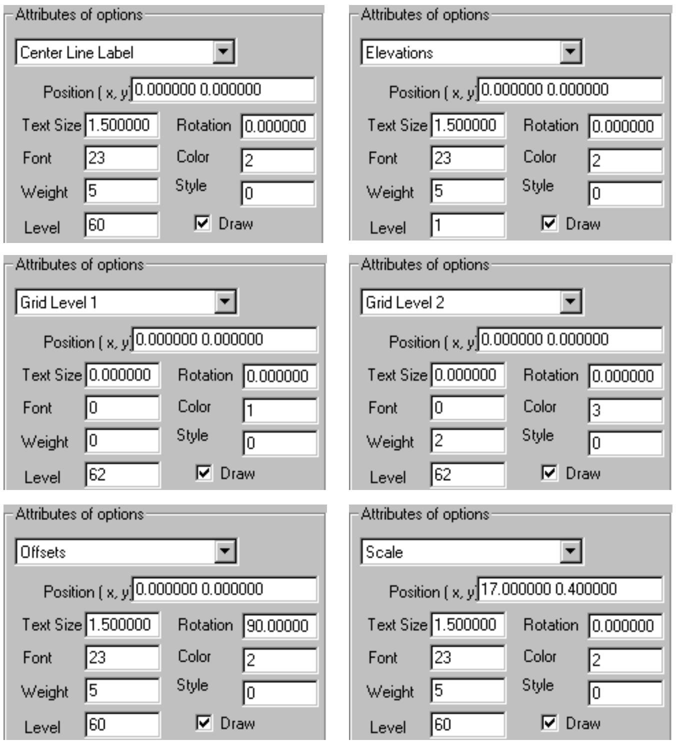
Once you have selected your cross section file, a box will appear showing your cross section data. Use the arrow buttons to select which section you would like to view. If you select the **VIEW SET** button, a ***View Options*** box will appear. With this box you can change how your cross section view will appear.

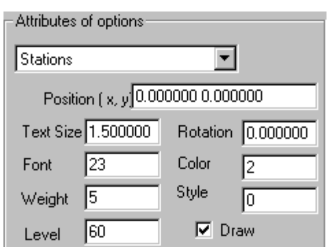




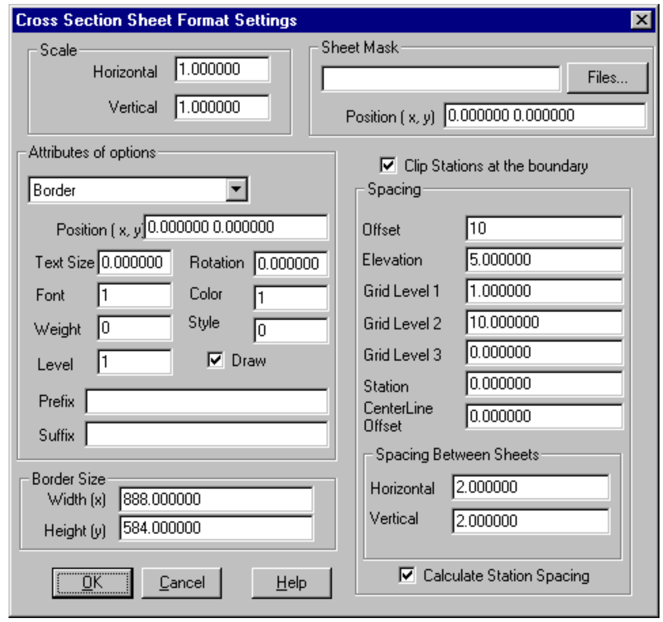
Before you can view your cross section data the other way, you must first set up some parameters. To do this, select **X-Section sheet Settings** from the toolbar. A **Cross Section Sheet Format Settings** box will appear (**Fig 21B**). Please note that the format is set to imperial. Under **Border**, you will still need to set, **Center Line Label**, **Elevation**, **Grid Level 1**, **Grid Level 2**, **Offset**, **Scale,** and **Stations**. You will just also need to set the text scale, weight, line style, level and color.



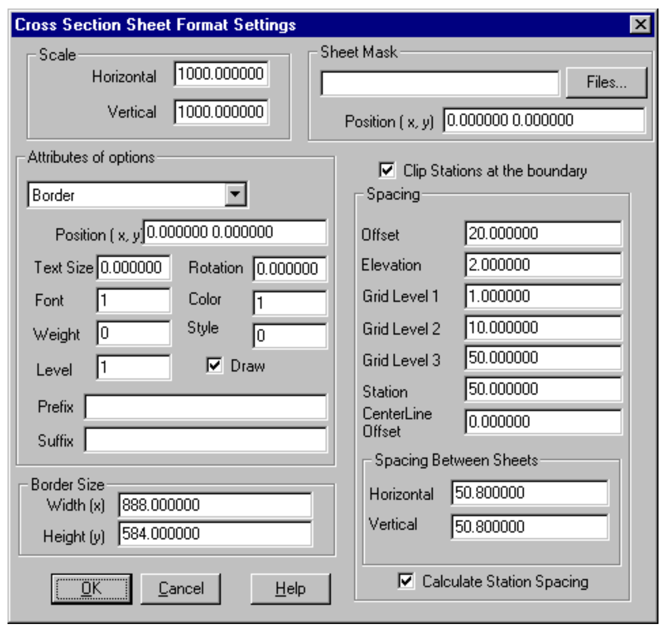




The only difference in imperial to metric is the **Attributes of options** section is the **Text Size**, .375 not 1.5.



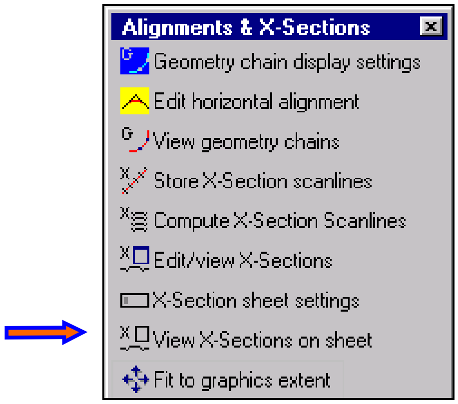
↑ **English** **Metric** ↓

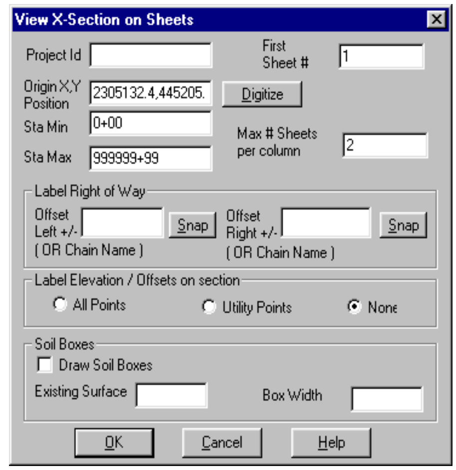


Once your settings are set, select ***OK***. Now you are ready to view your cross sections

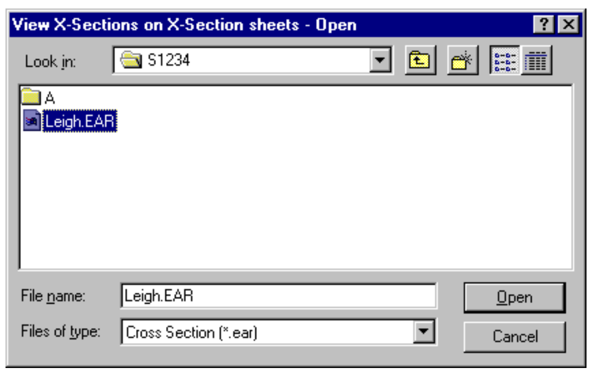
(Continued on next page)

Then select **View X-Sections On Sheets** from the toolbar. A ***View X-Section on Sheets*** box will appear. You can select **Digitize** and pick a point where you want to start. You can also select the minimum and maximum that you want to view. After you have set everything that you want, select ***OK***.



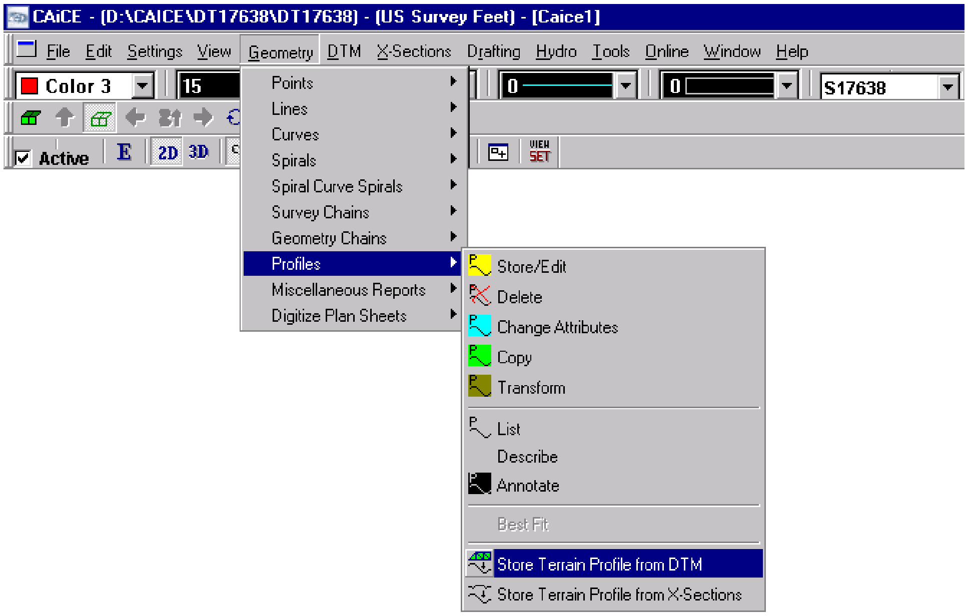


A ***View X-Section on X-Section sheets – Open*** box will appear. Select your file then ***Open***. Remember that if your drawing doesn't appear use your window fit command.

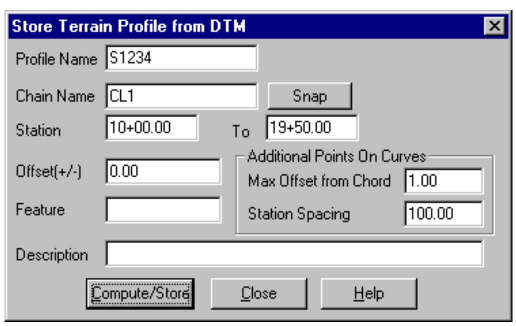


Processing Profiles

To process profiles, go to ***Geometry***, ***Profiles***, and then ***Store Terrain Profile from DTM*** on the main menu. A ***Store Terrain Profile from DTM*** box will appear. (shown at bottom of page)

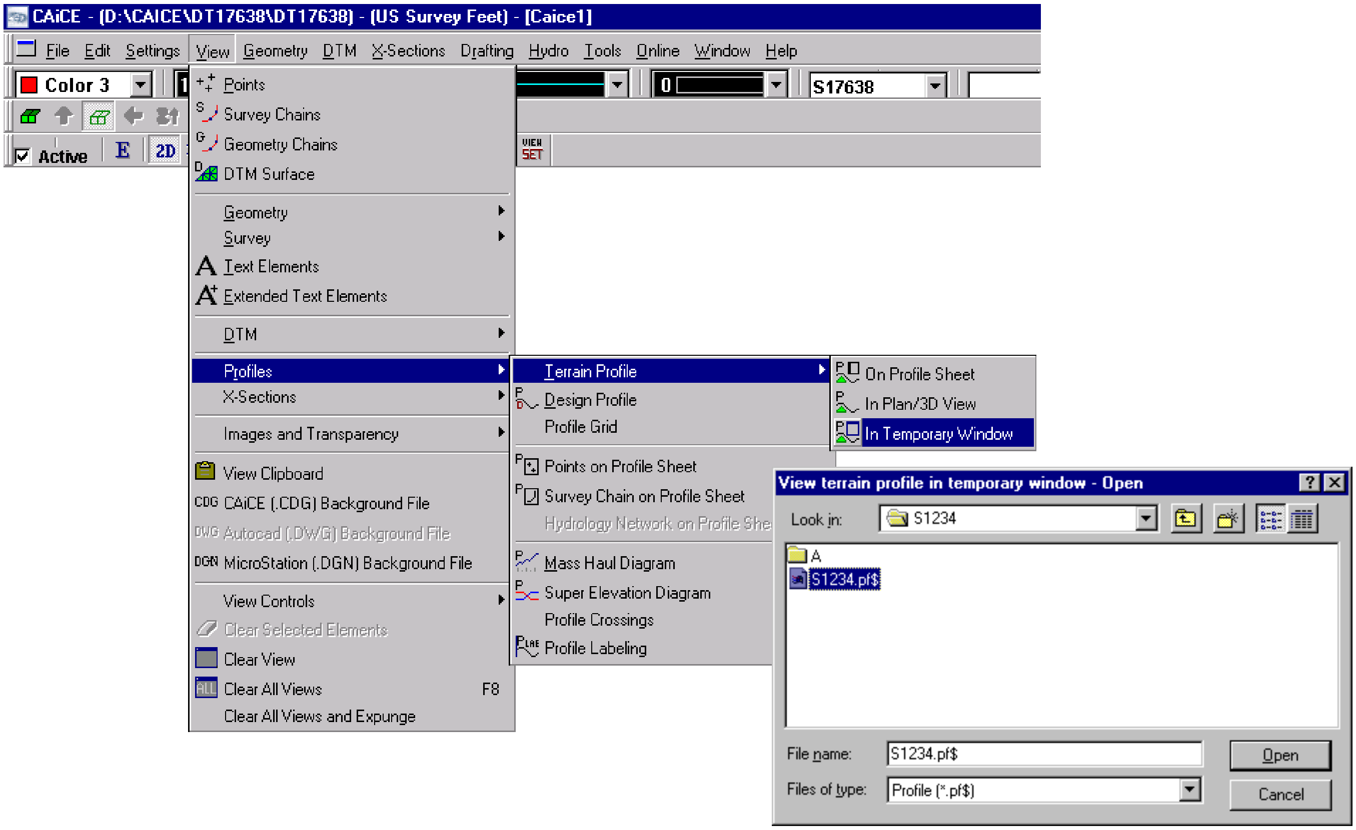


Enter the name you want to call the profile (maximum of eight characters) in the **<u>Profile Name</u>**. It is recommended to call this the same as your alignment name. Either enter the **<u>Chain Name</u>** if you know it or ***<u>Snap</u>*** to select the alignment. For the station, you can use the default or enter the station that you want it to calculate. You can leave the rest of the selections as is. Now select ***<u>Compute/Store</u>***. After it has finished calculating the profile then select ***<u>Close</u>***.

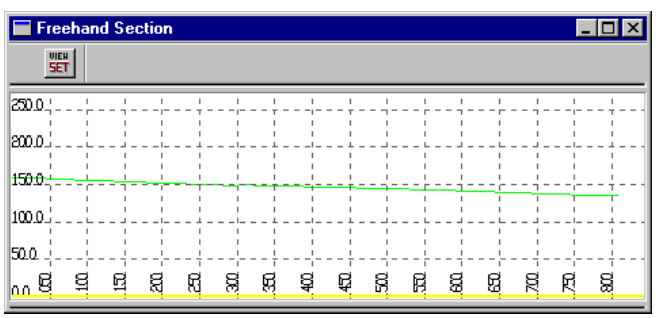


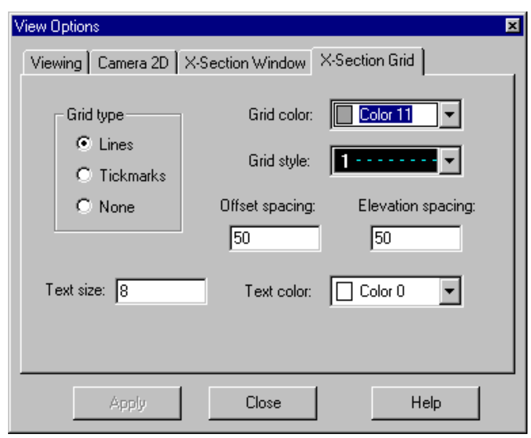
Viewing Profiles

After processing your profiles, there are two ways of viewing them. One way is on your screen through a window. To do this select ***View, Profiles, Terrain Profile,*** then ***In Temporary Window***. A ***View terrain profile in temporary window – Open*** box will appear. Select the profile that you want to view and select ***Open***.

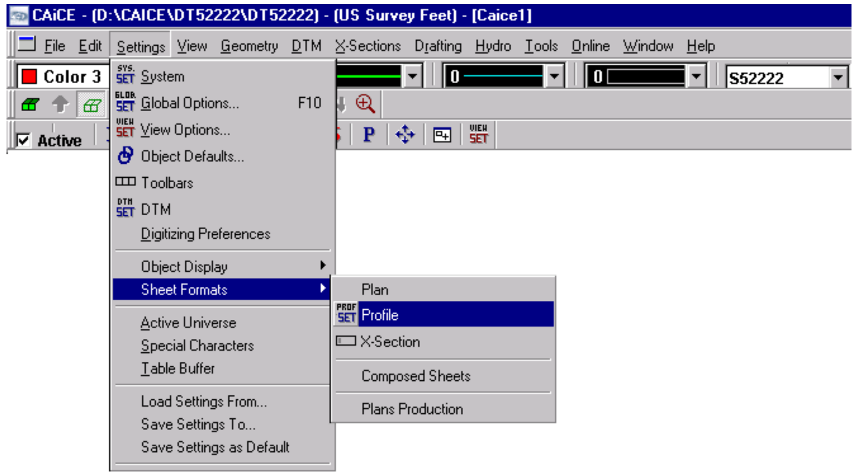


A ***Freehand Section*** window will appear, showing how the profile looks. If you select the ***VIEW SET*** button, a ***View Options*** box will appear. With this box you can change how your profile view will appear.

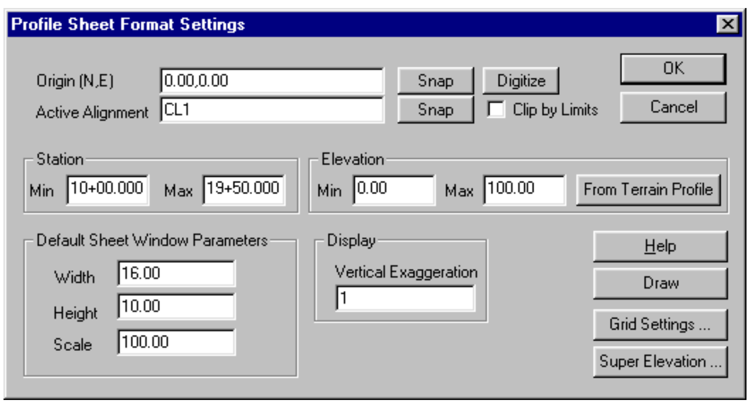


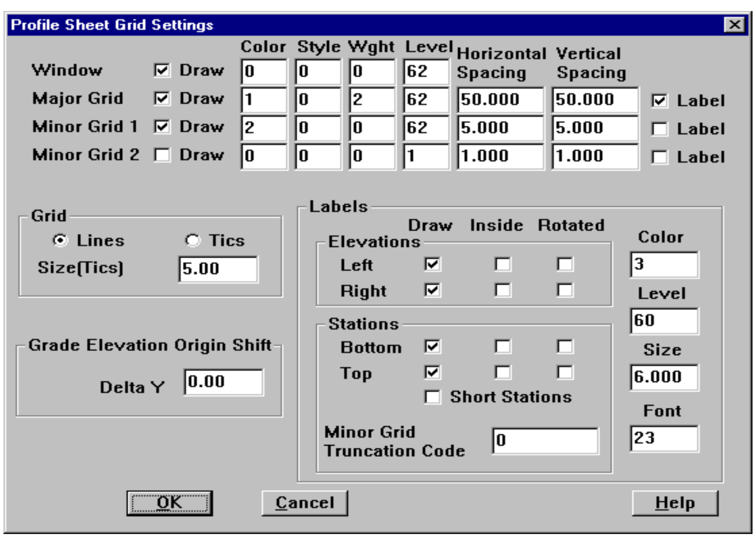


Before we use the other method to view the profile, we must first set up some parameters. To set up the profile sheet, select ***Settings***, ***Sheet Formats***, and then ***Profile***.

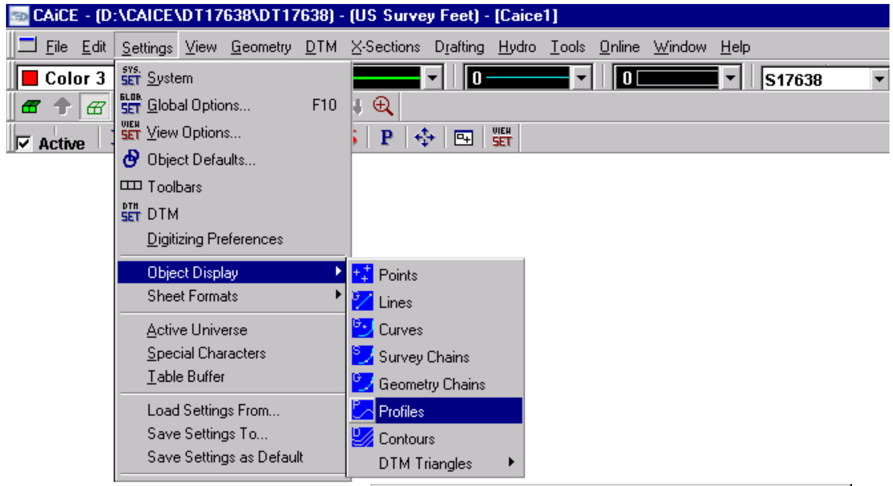


A ***Profile Sheet Format Settings*** box will appear. First select the **Active Alignment** that you want to use by either keying in the name or using the **<u>Snap</u>** button. Once the alignment is selected the station minimum and maximum will change and display the beginning and ending station. If this is all correct leave it, if not then enter a different starting station for the minimum and a different ending station for the maximum. The scale should stay at the default setting, which is set to **1000** for metric and **100** for imperial. The **Vertical Exaggeration Display** should be set to **1**. Select **<u>Digitize</u>** and select a point in your drawing where you want the profile to start. Now select **<u>Grid Setting</u>** and a ***Profile Sheet Grid Settings*** box will appear. With this box you can set up your **Color**, **Style**, **Weight**, **Level**, and **Horizontal** and **Vertical Spacing**. Once everything is set, then select **<u>OK</u>**. This will take you back to the ***Profile Sheet Format Settings*** box, now select **<u>Draw</u>**, and then **<u>OK</u>**. **Draw** will then place the grids in graphics and **OK** will save the current settings for the profile sheet grid.

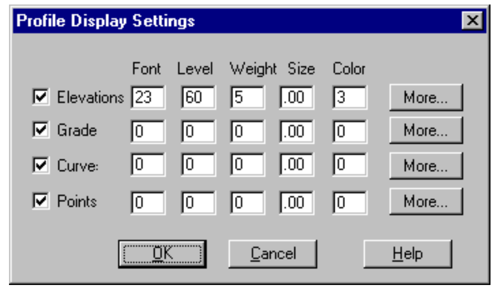




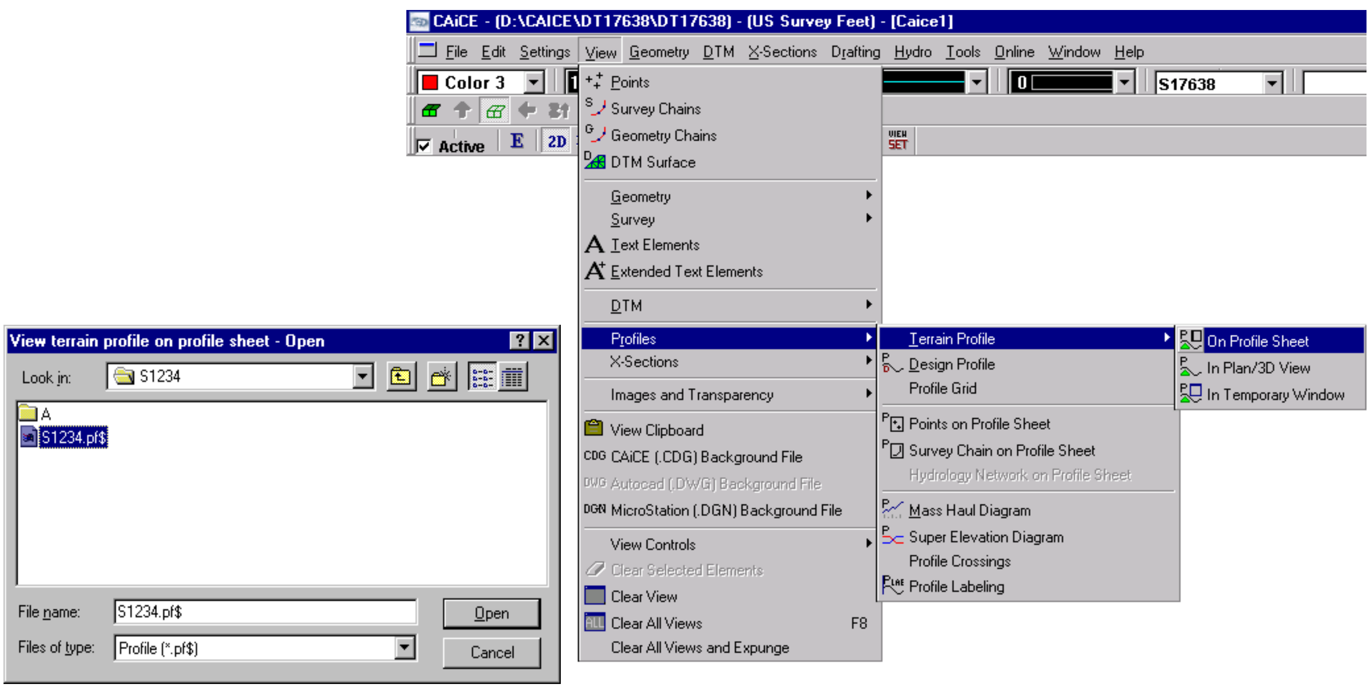
Before we draw the actual profile, we must set up some parameters. To set up the profile select **Settings**, **Object Display**, and then **Profile**.



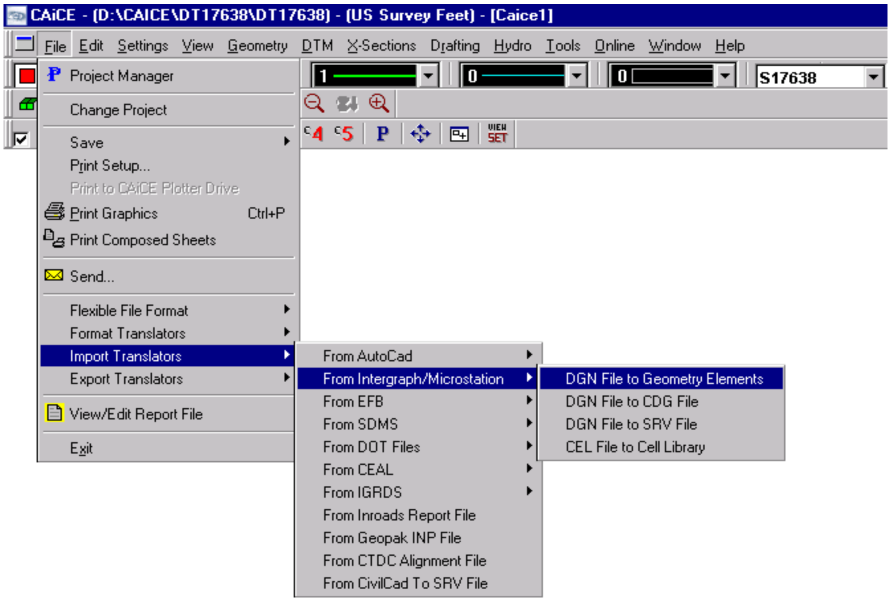
A ***Profile Display Settings*** box will appear. Set the **Elevations Font**, **Level**, **Weight**, **Size**, and **Color**.



Now to view the actual profile, go to the main menu and select **View Profiles, Terrain Profile**, then **On Profile Sheet**. A ***View terrain profile on profile sheet – Open*** box will appear Select the profile that you want to view and select ***Open***. The profile will appear with the profile grids that you have drawn previously.

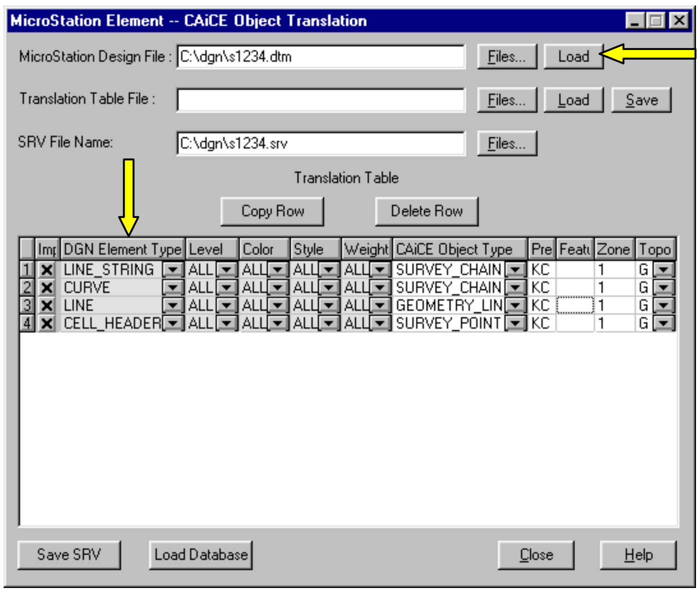


Converting a 3D MicroStation Design File To an SRV File



From the main drop-down menu select **FILE, IMPORT TRANSLATORS, FROM INTERGRAPH/MICROSTATION**, then **DGN FILE TO GEOMETRY ELEMENTS** .

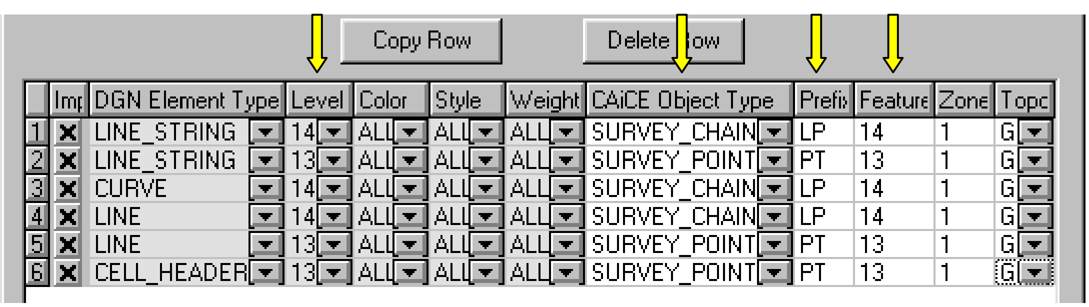
A ***CAiCE Object Translation*** box will appear. Enter the file path and name of the **DTM** file to be converted to an **SRV** in the **Microstation Design File** box. Next, enter the file path and name of the **SRV** file to be created in the **SRV File Name box.**



Now, load the DTM file by selecting the **LOAD** button next to **Microstation Design File** box. The DTM file will load and the information will be displayed in rows 1-4. If you have problems with any other types of "DGN Elements" you must go into the DTM file and correct the elements and reload the corrected DTM.

Once the DTM is loaded and the DGN Elements are acceptable you must copy **row 1: LINE_STRING** and **row 3: LINE**. To copy a row, ***select the corresponding row number*** to the far left and the row will be highlighted. Now select ***Copy Row***.

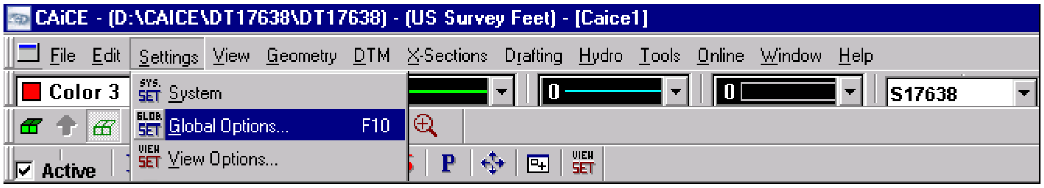
Now the following columns must be filled in **Level**, **CAiCE Object Type**, **Prefix**, and **Feature** as shown in.



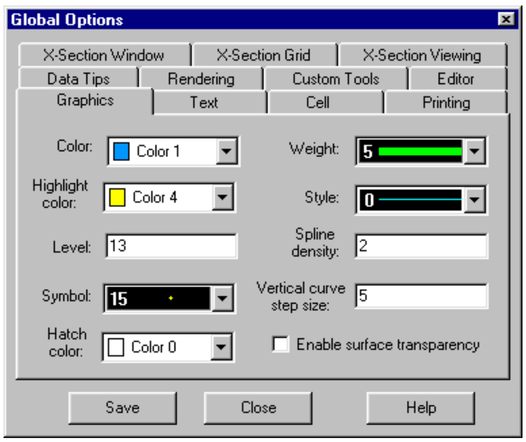
Use as a template to complete your **CAiCE Object Translation**. After the columns have been filled in properly you can "click" on the **Load Database** button at the bottom of the **CAiCE Objects Translation** box to load the survey data. Then "click" the **Save SRV** button at the bottom left of the **CAiCE Objects Translation.**

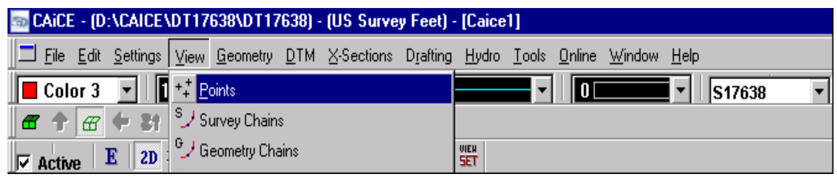
Creating A MicroStation DTM 3D Graphics File From CAiCE

Now it is time to set the display settings for the points and breaklines by selecting **Settings**, then **Global Options**. This will bring up the ***Global Options*** dialog box. Below are the settings for Points.

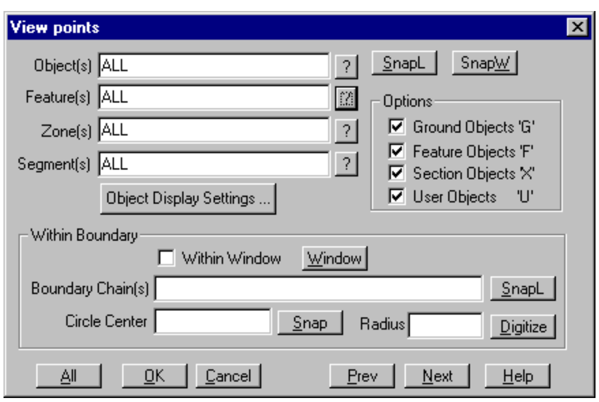


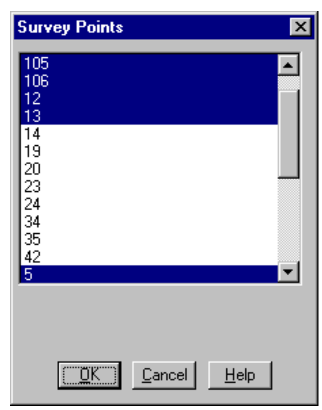
DTM Points



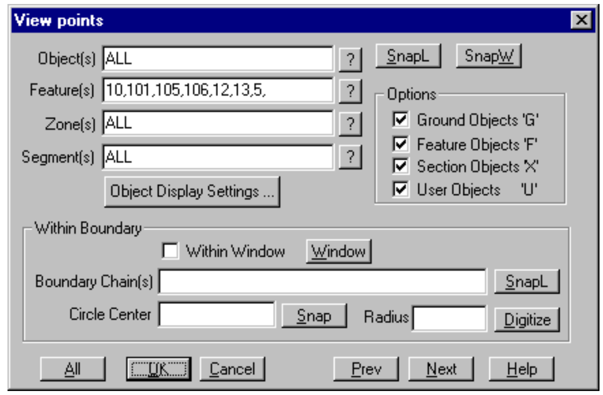


First set the settings for Points then select **Save**. Next you have to pick what you want to display; you do this by selecting **View**, then **Points**. Then the ***View points*** dialog box will appear. To select which points you wish to display select the question mark (**?**) to the right of **Feature(s)**. This will bring up the **Survey Points** dialog box . Holding down your control key select the numbers that you want to display as points. These numbers are the same as the topo codes. After selecting the appropriate items select ***OK***.

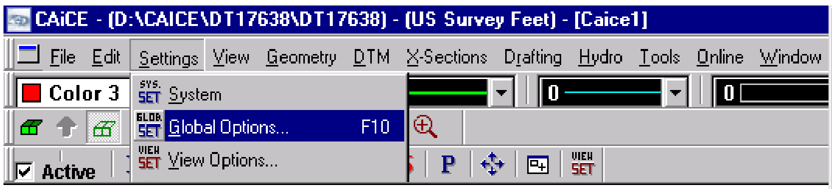


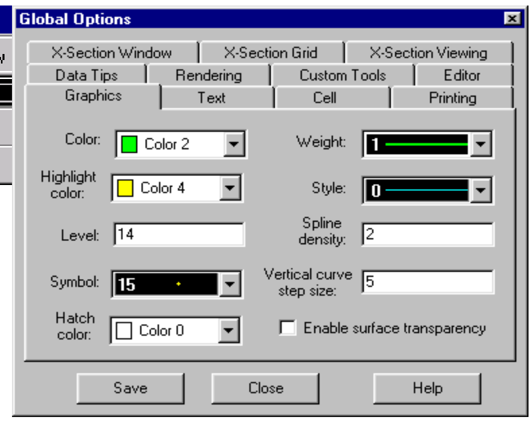


This will bring back the ***View points*** dialog box with the items selected. Now click on the ***OK*** button and this will display the items you selected. You may have to press **F6** to see all the points on the screen.

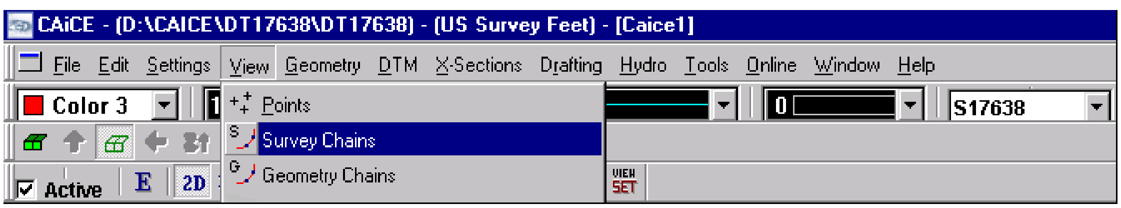


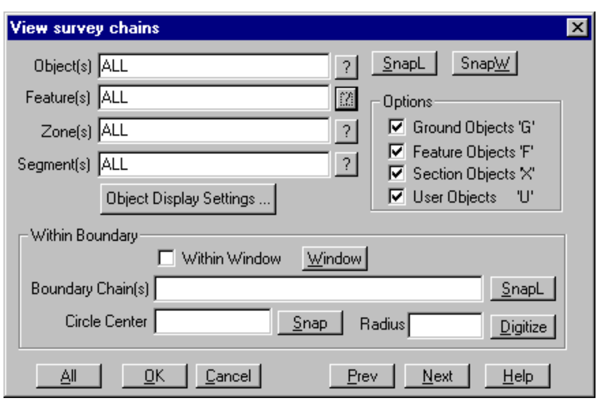
Now you are ready to set the **Global Options** for the DTM breaklines.

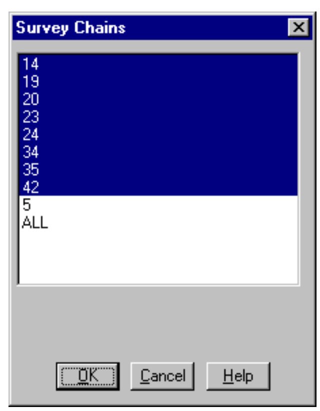




After saving the settings for the breaklines select **View**, then **Survey Chains**. This will bring up the ***View survey chains*** dialog box.

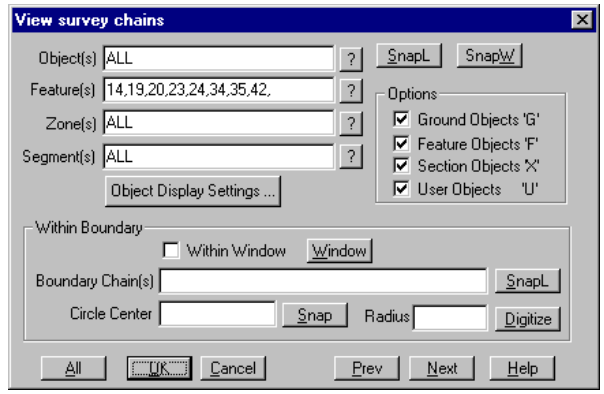




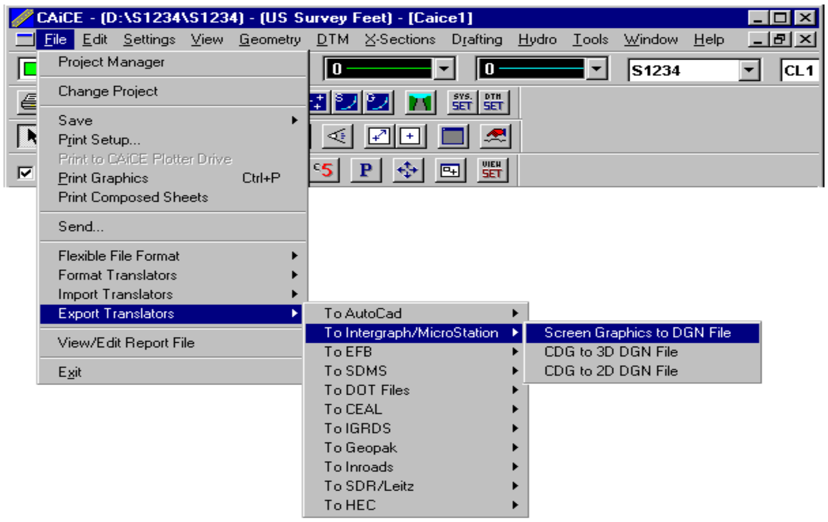


To select which breaklines to display, select the question mark **(?)** to the right of the **Feature(s)** text box. This will bring up the ***View survey chains*** dialog box. Holding down your control key select the numbers that you want to display as breaklines. These numbers are the same as the topo codes. After selecting the appropriate items click ***OK***.

This will bring back the ***View survey chains*** dialog box with the items selected. Now select ***OK***, this will now display the items selected. Now you are ready to convert CAiCE graphics to MicroStation graphics.

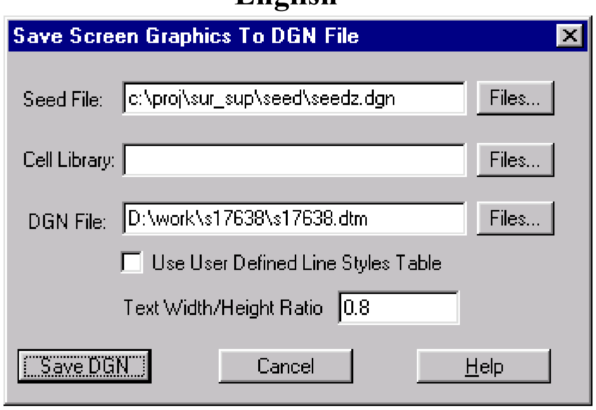


To convert CAiCE graphics to MicroStation graphics first select **File**, **Export Translators**, **To Intergraph/MicroStation**, then **Screen Graphics to DGN File**. The ***Save Screen Graphics To DGN File*** box will appear.

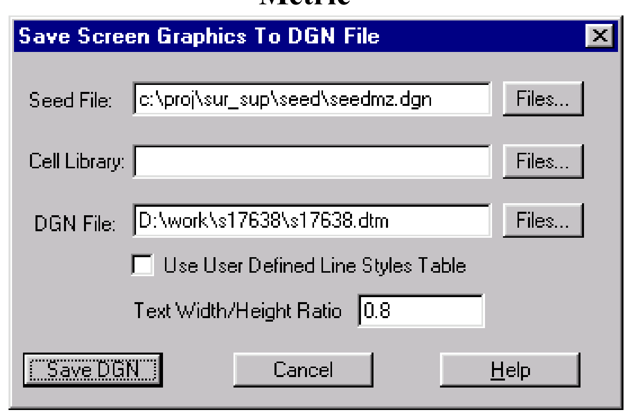


Now click on the **Files** button right of the Seed File text box. A ***MicroStation Design Files*** box will open asking you for the seed file you would like to use. Look at the two pictures below and they show the location of these files. In the text box next to DGN file tell it the location where you want the DTM file to be created. Select **Save DGN**. You can now exit CAiCE and view your DGN file in MicroStation.

English



Metric



Note: If you are making a 2D file use the seed files without the (z) in them. Also if you cannot find the files on your machine you can look on the central office server in the following location. \\0501cocadd\proj\sur_sup\seed\

APPENDIX D

Model Virginia Map Accuracy Standards
National Map Accuracy Standards

Commonwealth of Virginia

Information Technology
Resource Management
Guideline

Model Virginia Map Accuracy Standards

Council on Information Management

Preface

PUBLICATION DESIGNATION
COV ITRM Guideline 92-1

SUBJECT
Map Accuracy Standards.

EFFECTIVE DATE
March 20, 1992.

AUTHORITY
Code of Virginia, § 2.1-563.31 (Powers and Duties of the Council on Information Management).

SCOPE
This Guideline is applicable to all state agencies and institutions of higher education (hereinafter collectively referred to as "state agencies") that are engaged in such functions as planning, managing, developing, purchasing and using information technology resources in the Commonwealth.

PURPOSE
To provide a model approach for defining spatial accuracy as it pertains to maps of all scales greater than or equal to 1:100,000 prepared for special purposed or engineering applications in state agencies.

OBJECTIVES
The Commonwealth's Model Standard for Map Accuracy will:

- Define horizontal and vertical accuracy requirements;
- Define map accuracy classes; and
- Define map accuracy testing requirements.

GENERAL RESPONSIBILITIES
In accordance with the Code of Virginia, the following provisions apply:

The Council on Information Management (CIM)

Responsible for:

Directing the development and promulgation of policies, standards, and guidelines for managing information technology resources in the Commonwealth.

Advisory Committees
Responsible for:

Meeting, conferring with, and advising the Council in the development of the Commonwealth's policies, standards, and guidelines for managing information technology resources.

The Department of Information Technology (DIT)
Responsible for:

Providing administrative support to the Council and performing such other services as the Council may direct in the performance of its powers and duties. Support may include advising the Council in the development, interpretation, and dissemination of its policies, standards, and guidelines, and maintaining records thereon for the Council

All State Agencies
Responsible for:

Cooperating with the Council in the performance of its powers and duties; and
Complying with the Council's policies, standards and guidelines for managing information technology resources in the Commonwealth

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SECTION 1

INTRODUCTION

BACKGROUND

The only universally recognized map accuracy standard is the National Map Accuracy Standard. It was adopted in 1941 to aid in the procurement of hardcopy map products by federal agencies. The National Map Accuracy Standard (NMAS) is generally recognized as not being specific enough to meet the accuracy needs for large scale or local government not being specific enough to meet the accuracy needs for large scale or local government mapping products. The NMAS may continue to be used for generalized small scale mapping at scales of less than 1:100,000, but a new standard is needed within Virginia to provide detailed accuracy requirements and verification procedures to state, regional, and local governing bodies for preparing map specifications for larger scale maps.

The use of digital mapping data throughout the Commonwealth is increasing and the requirement for local, regional, and state groups to share such data is especially important as government activities are streamlined and coordinated. This model standard will provide the information needed to guide the collection and labeling of hardcopy and digital map products and will facilitate the exchange of map data by ensuring that maps of the same scale and class developed by different groups are indeed compatible. This model standard will provide:

- a common recognized standard to guide the collection of data for all map scales;

- a common method for verifying and interpreting the data collected and map products produced; and

- a common method of labeling data and map products.

PURPOSE

This model standard is based on the American Society of Photogrammetry and Remote Sensing (ASPRS) Accuracy Standards for Large-Scale Maps. It was developed to serve as a common standard that can be used by state, regional, and local governing bodies in Virginia to meet their needs for a map accuracy standard.

SECTION 2

MAP ACCURACY STANDARDS

When using the National Map of Accuracy Standard, a map either meets the standard or it does not; no specific levels of compliance are specified. This model standard for map accuracy defines the positional accuracy of a hardcopy or digital map product much more fully by incorporating classes of maps. The Class One (1) map designation is used to set the standard and is not easily attained. For map Classes Two (2) and beyond, the average positional error allowed is a multiple of the allowable Class One (1) error and the map class designation number. This use of numerical levels for map accuracy provides several advantages.

- the use of map accuracy class designations will assist map users in determing how appropriate the data is for their particular purposes by giving them more precise positional information; and
- the use of numerical levels of map accuracy provides the capability to request and have map producers deliver higher class maps, thus improving the level of mapping services provided with the Commonwealth.

This model standard defines spatial accuracy as it pertains to maps of all scales greater than or equal to 1:100,000 prepared for special purposes or engineering applications. Emphasis is on the final spatial accuracies that can be derived from the map in terms most generally understood by the users. It should be noted that the accuracy statement pertains to the map at the date of its creation.

The vertical part of the proposed accuracy standard is important in that it allows for the specification of vertical accuracies for maps without contour lines. Digital elevation models and digital terrain models are frequently being used and no mechanism exists for reporting their level of accuracy.

A major feature of this model standard is that it indicates accuracy on the surface of the earth. Thus, digital spatial data of known accuracy can be related to the appropriate map scale for graphic presentation at a recognized standard.

This model standard addresses horizontal and vertical accuracy and defines the test requirements needed to meet various map accuracy classes.

HORIZONTAL ACCURACY

Horizontal map accuracy is defined as the root mean square (rms) error (see Appendix A, Section A1) in terms of the project's planimetric survey coordinates (X,Y) for checked points as determined at full (ground) scale of the map. The rms error is the cumulative result of all errors including those introduced by the processes of ground control surveys, map compilation and final extraction of ground dimensions from the map. The limiting rrms errors established by this standard are the maximum permissible rms errors for 90% of the check points on a map. These limiting rms errors for various classes of maps are tabulated in Tables 1 and 2 along with the map scales typically associated with the limiting errors. These limits of accuracy apply to tests made on well-defined points only (see Appendix A, Section A2).

VERTICAL ACCURACY

Vertical map accuracy is defined as the rms error in elevation in terms of the project's elevation datum for well-defined points only. For Class 1 maps the limiting rms error in elevation is set by the standard at one-third the indicated contour interval for well-defined points only. Spot heights shall be shown on the map within a limited rms error of one-sixth of the contour interval. The limiting rms error in elevation for spot height data not associated with contours can be determined by consulting Tables 1 and 2. Tables 1 and 2 can also be used as a reporting standard for determining appropriate map scales for various spot height data.

MAP ACCURACY CLASSES

Map accuracies can also be defined at lower spatial accuracy standards. Maps compiled within limiting rms errors of twice or three times those allowed for a Class 1 map shall be designated as Class 2 or Class 3 maps respectively. A map may be compiled that complies with the one class for vertical accuracy and another class for horizontal accuracy.

Table 1
Planimetric and Vertical Coordinate Accuracy Requirements in Feet Ground X or Y or Z for Well-defined Points[1]

Planimetric Classes (Limiting rms error, feet)			Typical Map Scale	Possible Contour Interval in Feet	Vertical Classes (Limiting rms error, feet)		
CLASS 1	CLASS 2	CLASS 3			CLASS 1	CLASS 2	CLASS 3
0.0500	0.1000	0.1500	1:60	0.05	0.0083	0.0167	0.0249
0.1000	0.2000	0.3000	1:120	0.10	0.0167	0.0333	0.0501
0.2000	0.4000	0.6000	1:240	0.20	0.0333	0.0667	0.0999
********	********	********	********	********	********	********	********
0.2500	0.5000	0.7500	1:300	0.25	0.0417	0.0833	0.1251
0.3000	0.6000	0.9000	1:360	0.30	0.0500	0.1000	0.1500
0.4000	0.8000	1.1200	1:480	0.40	0.0667	0.1333	0.2001
0.5000	1.0000	1.5000	1:600	0.50	0.0833	0.1667	0.2499
1.0000	2.0000	3.0000	1:1,200	1.00	0.1667	0.3333	0.5001
2.0000	4.0000	6.0000	1:2,400	2.00	0.3333	0.6667	0.9999
4.0000	8.0000	12.0000	1:4,800	4.00	0.6667	1.3333	2.0001
5.0000	10.0000	15.0000	1:6,000	5.00	0.8333	1.6667	2.4999
8.0000	16.0000	24.0000	1:9,600	8.00	1.3333	2.6667	3.9999
10.0000	20.0000	30.0000	1:12,000	10.00	1.6667	3.3333	5.0001
20.0000	40.0000	60.0000	1:24,000	20.00	3.3333	6.6667	9.9999
30.0000	60.0000	90.0000	1:36,000	30.00	5.0000	10.0000	15.0000
40.0000	80.0000	120.0000	1:48,000	40.00	6.6667	13.3333	20.0001
52.8000	105.6000	158.4000	1:63,360	50.00	8.8000	17.6000	26.4000

* indicates the practical limit for aerial methods - for scales above this line, ground methods are normally used.

1 see Appendix A, Section A2.

MAP ACCURACY TEST (see Appendix A, Section A4)

Testing for horizontal accuracy compliance is done by comparing the planimetric (X and Y) coordinates of well-defined ground points to the coordinates of the same points as determined by a horizontal check survey of higher accuracy. The check survey shall be designed according to the Federal Geodetic Control Committee (FGCC) [FGCC, 1984] standards and specifications to achieve standard deviations equal to or less than one-third of the “limiting rms error” selected for the map. The distance between control points (d) used in the FGCC standard for the design of the survey shall be the horizontal ground distance across the diagonal dimension of the map sheet.

Testing for vertical accuracy compliance shall be accomplished by comparing the elevations of well-defined points as determined from the map to corresponding elevations determined by a survey of higher accuracy. For purposes of checking elevations, the map position of the ground point may be shifted in any direction. The vertical check survey should be designed to produce rms errors in elevation differences at check point locations no larger than $1/20^{th}$ of the contour interval. The distance (d) between benchmarks used in the FGCC standard for the design of the vertical check survey shall be the horizontal ground distance across the diagonal of the map sheet. Generally, vertical control networks based on surveys conducted according to the FGCC standard for the design of the vertical check survey shall be the horizontal ground distance across the diagonal of the map sheet. Generally, vertical control networks based on surveys conducted according to the FGCC standards for Third Order provide adequate accuracy for conducting the vertical check survey.

Table 2
Planimetric and Vertical Coordinate Accuracy Requirements in meters Ground X or Y or Z for Well-defined Points[1]

Planimetric Classes (Limiting rms error, meters)			Typical Map Scale	Possible Contour Interval in Meters	Vertical Classes (Limiting rms error, meters)		
CLASS 1	CLASS 2	CLASS 3			CLASS 1	CLASS 2	CLASS 3
0.0125	0.0250	0.0375	1:50	0.0125	0.0021	0.0042	0.0063
0.0250	0.0500	0.0750	1:100	0.0250	0.0042	0.0083	0.0125
0.0500	0.1000	0.1500	1:200	0.0500	0.0083	0.0167	0.0250
******	******	******	******	******	******	******	******
0.1000	0.2000	0.3000	1:400	0.1000	0.0167	0.0333	0.0500
0.1250	0.2500	0.3750	1:500	0.1250	0.0208	0.0417	0.0625
0.2000	0.4000	0.6000	1:800	0.2000	0.0333	0.0667	0.1000
0.2500	0.5000	0.7500	1:1,000	0.2500	0.0417	0.0833	0.1250
0.5000	1.0000	1.5000	1:2,000	0.5000	0.0833	0.1667	0.2500
1.0000	2.0000	3.0000	1:4,000	1.0000	0.1667	0.3333	0.5000
1.2500	2.5000	3.7500	1:5,000	1.2500	0.2083	0.4167	0.6250
1.8750	3.7500	5.6250	1:7,500	1.8750	0.3125	0.6250	0.9375
2.0000	4.0000	6.0000	1:8,000	2.0000	0.3333	0.6667	1.0000
2.5000	5.0000	7.5000	1:10,000	2.5000	0.4167	0.8333	1.2500
5.0000	10.0000	15.0000	1:20,000	5.0000	0.8333	1.6667	2.5000
10.0000	20.0000	30.0000	1:40,000	10.0000	1.6667	3.3333	5.0000
12.5000	25.0000	37.5000	1:50,000	12.5000	2.0833	4.1667	6.2500
25.0000	50.0000	75.0000	1:100,000	25.0000	4.1667	8.3333	12.5000

* indicates the practical limit for aerial methods - for scales above this line, ground methods are normally used.

1 see Appendix A, Section A2.

The same survey datums, both horizontal and vertical, must be used for both the project and the check control surveys. Although a national survey datum is highly recommended, a local datum is acceptable.

A minimum of 20 check points shall be established through the area covered by the map and shall be distributed in a manner agreed upon by the contracting parties (see Appendix A, Section A5).

Maps produced according to this spatial accuracy standard shall include the following statement in the title block:

THIS MAP WAS COMPILED TO MEET THE COMMONWEALTH OF VIRGINIA
STANDARD FOR CLASS 1 MAP ACCURACY AS OF <date of map compilations>

Tests for compliance of a map sheet are optional. If the map was checked and found to conform to this spatial accuracy standard, the following statement shall appear in the title block:

THIS MAP WAS CHECKED AND FOUND TO CONFORM
TO THE COMMONWEALTH OF VIRGINIA
STANDARD FOR CLASS 1 MAP ACCURACY AS OF <date of map compilations>

APPENDIX A

EXPLANATORY COMMENTS

A1. Root Mean Square Error

The "root mean square" rms error is defined to be the square root of the average of the squared discrepancies. In this case, the discrepancies are the differences in coordinated or elevation values as derived from the map and as determined by an independent survey of higher accuracy (check survey). For example, the rms error in the X coordinate direction can be computed as:

$$rms = \sqrt{(D^2/n)}$$

where:
$D^2 = d_1^2 + d_2^2 +$ ------------------ $+ d_n^2$

d = discrepancy in the X coordinate direction = $X_{map} - X_{check}$

n = total number of points checked on the map in the X coordinate direction

A2. Well-defined Points

The term "well-defined points" pertains to features that can be sharply identified as discrete points. Points which are not well-defined (that is poorly-defined) are excluded from the map accuracy test. In the case of poorly-defined image points, these may be of features that do not have a well-defined center such as roads that intersect at shallow angles. [U.S. National Map Accuracy Standards, 1941]. In the case of poorly defined ground points, these may be such features as soil boundaries or timber boundaries. The selection of well-defined points is made through agreement by the contracting parties.

A3. Relationship to U. S. National Map Accuracy Standards

Planimetric accuracy in terms of the "limiting rms error" can be related to the United States National map Accuracy Standards (NMAS) provided the following assumptions are made:

- the discrepancies are normally distributed about a zero mean
- the standard deviations in the X and Y coordinate directions are equal
- sufficient check points are used to accurately estimate the variances

To compute the "circular map accuracy standard" (CMAS) which corresponds to the 90% circular map error defined in the NMAS [ACIC, 1962, p.26, p. 41]:

$CMAS = 2.146\sigma_x$ or: $CMAS = 2.146\sigma_y$

Given these relationships and assumptions, the limiting rms errors correspond approximately to the CMAS of 1/47th of an inch for all errors and related scales indicated in Table 1. For the metric cases indicated in Table 2, the CMAS is 0.54 mm for rms errors and corresponding scales. It is emphasized that for the Commonwealth of Virginia Standard, spatial accuracies are stated and evaluated at full or ground scale. The measures in terms of equivalent CMAS are only approximate and are offered only to provide a comparison to the national Map Accuracy Standard of SMAS of 1/30th inch at map scale.

A4. Check Survey

Both the vertical and horizontal (planimetric) check surveys are designed based on the National standards of accuracy and field specifications for control surveys established by the Federal Geodetic Control Committee (FGCC). These standards and specifications [FGCC, 1984] are intended to establish procedures which produce accuracies in terms of relative errors. For horizontal surveys, the proportional accuracies for the various orders and classes of survey are stated in Table 2.1 of the FGCC document and for elevation accuracy in Table 2.2. These tables along with their explanations are reproduced below. From FGCC [1984]:

2.1 HORIZONTAL CONTROL NETWORK STANDARDS

When a horizontal control is classified with a particular order and class, NGS certifies that the geodetic latitude and longitude of that control point bear a relation of specific accuracy to the coordinates of all other points in the horizontal control network. This relationship is expresses as a distance accuracy, 1:a. A distance accuracy is the ratio of relative positional error of a pair of control points to the horizontal separation of those points.

Table 2.1
Distance Accuracy Standards

Classification	Minimum distance accuracy
First-order	1: 100.000
Second-order, class I	1: 50,000
Second-order, class II	1: 20,000
Third-order, class I	1: 10,000
Third-order, class II	1: 5,000

A distance accuracy, 1:a, is computed from a minimally constrained, correctly weighted, least square adjustment by:

a = d/s

where
a = distance accuracy denominator

s = propagated standard deviation of distance between survey points obtained from the least squares adjustment

d = distance between survey points

correctly weighted means that prior knowledge of the accuracy of points is applied in their weighting

VERTICAL CONTROL NETWORK STANDARDS

When a vertical control point is classified with a particular order and class, NGS certifies that the orthometric elevation at that point bears a relation of specific accuracy to the elevations of all other points in the vertical control network. That relationship is expressed as an elevation accuracy, b. An elevation difference accuracy is the relative elevation error between a pair of control points that is scaled by the square root of their horizontal separation traced along existing level routes.

Table 2.2
Elevation Accuracy Standards

Classification	Maximum elevation difference accuracy
First-order	0.5
Second-order, class I	0.7
Second-order, class II	1.0
Third-order, class 1	1.3
Third-order, class II	2.0

An elevation difference accuracy, b, is computed from a minimally constrained, correctly weighted, least square adjustment by:

$$\mathbf{b = S/\sqrt{(d)}}$$

where

d = approximate horizontal distance in kilometers between control point positions traced along existing level routes.

S = propagated standard deviation of elevation difference in millimeters between survey points obtained from a least squares adjustment. Note that the units of b are **(mm)/ √ (km).**

Correctly weighted means that prior knowledge of the accuracy of points is applied in their weighting.

For an example of designing a check survey (selecting an order and class), assume that a survey is to be designed to check a map which is intended to posses a planimetric (horizontal) "limiting rms error" (see Table 1 of the map standard) of one foot and a contour interval of two feet. In contrast to survey accuracies, which are stated in terms of relative horizontal distances to adjacent points, map features are intended to posses accuracies relative to all other points, map features are intended to possess accuracies relative to all other points appearing on the map. Therefore, for purposes of the check survey, the distance between survey points (d) is taken as the diagonal distance on the ground across the area covered by the map. According to the "FGCC survey standards this is the distance across which the "minimum distance accuracy" and "maximum elevation difference accuracy" are required (see Table 2.1 and 2.2 of the [FGCC, 1984] document.

For the planimetric check survey, assume that the diagonal distance on the ground covered by the map is 6,000 feet. The propagated standard deviation (s) required for the check survey is one-third of the limiting rms error of one foot or 0.33 foot in this example. Returning to the equation from the FGCC [1984] document relating distance between survey points (d), standard deviation (s) and distance accuracy denominator (a):

a = d/s = (6000 feet)/0/33 feet) = 18,182

By referring to Table 2.1 of the FGCC document, it is clear that a control survey designed according to the standards and specifications for second–order, class II is required to produce the horizontal check survey for this example. If the project control survey is conducted at a standard of accuracy equal to or better than second-order, class II, the check survey can tie to the project control network in accordance with FGCC standards.

For the vertical check survey, the distance (d) is also taken as a diagonal ground distance across the map to account for the fact that elevation accuracy pertains to all mapped features. The propagated standard deviation in elevation (S) is required by this standard to be equal or less than $1/20^{th}$ of the contour interval (CI) of two feet:

S = (1/20) CI = 1.10 feet

Returning to Table 2.2 of the FGCC document, relating distance between bench marks (d in km), the standard deviation in elevation (S in mm), and the elevation difference accuracy (b);

where;

$S = 0.10$ feet $= 30.5$ mm

$D = 6000$ feet $= 1.181$ km

then;

$b = \mathbf{S/\sqrt{d} = 28.1\ mm/\sqrt{km}}$

It is clear that a third-order survey for elevation differences is more than adequate for purposes of conducting the check survey for this map example. Other methods for conducting the check survey for elevation are acceptable provided they have demonstrated accuracy capability equal to that required by this map standard. Such departures, however, must be agreed upon by the contracting parties prior to conducting the survey.

A5. Check Point Location

Due to the diversity of requirements anticipated for any special purpose or engineering map, it is not realistic to include statements that specify the spatial distribution of check points designed to assess the spatial accuracy of the map. For instance, it may be preferred to distribute the check points more densely in the vicinity of important structures or drainage features and more sparsely in areas that are of little or no interest.

For a map sheet, however, of conventional rectangular dimensions, intended to portray a uniform spatial accuracy over the entire map sheet. It may be reasonable to specify the distribution. For instance, given the minimum of twenty check points, it could be specified that at least 20% of the points be located in each quadrant of the map sheet and these points be spaced at intervals equal to at least 10% of the map sheet diagonal.

APPENDIX B

UNITED STATES NATIONAL MAP ACCURACY STANDARDS

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standards or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. **Horizontal accuracy.** For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as benchmarks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general, what is well defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two roads or property lines meeting at right angles would come with a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within the limits quoted, even though their positions may be scaled closely upon the map. In this calss would come timber lines, soil boundaries, etc.

2. **Vertical accuracy,** as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

3. **The accuracy of any map may be tested** by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.

4. **Published maps meeting these accuracy requirements** shall note this fact on their legends, as follows: “This map complies with National Map Accuracy Standards.”

5. **Published maps whose errors exceed those aforestated** shall omit from their legends all mention of standard accuracy.

6. **When a published map is a considerable enlargement** of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."

7. **To facilitate ready interchange and use of basic information for map construction** along all Federal mapmaking agencies, manuscript maps and published maps, whenever economically feasible and consistent with the uses to which the map is to be put, shall conform to latitude and longitude boundaries being 15 minutes of latitude and longitude, or 7.5 minutes, or 3-3/4 minutes in size.

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