VDOT GOVERNANCE DOCUMENT

Survey Manual

Location and Design Division

Issued 2009 **Rev. July 2016**

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.

The information provided in this electronic version of the Survey Manual is a product of, and copyrighted by, the Virginia Department of Transportation (VDOT) and is intended to be used for informational purposes only and is not to be sold or otherwise distributed for profit. Although this data has been tested by the Virginia Department of Transportation, no expressed or implied warranties are made by VDOT concerning, the accuracy, completeness, reliability and usability of this information. The Virginia Department of Transportation assumes no responsibility for any incorrect outcomes or damage resulting from the use of this information. All users shall expressly hold the Virginia Department of Transportation harmless from any liability or loss due to a virus or any other computer or software generated problem associated with these files.

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 a digital copy will be located on the official Virginia Department of Transportation website:
http://www.virginiadot.org/business/locdes/manual-survey-index.asp

This manual is **no longer** available for purchase.

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

The State Highway Commissioner is authorized by the Revised Code of Virginia **§33.2-1011. (Effective October 1, 2014)** **(see Figure 1-A)** 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 and Assignment of Surveys**

Sec. 1.02.1 Authorization

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 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 integrated Project Manager (iPM) provides a central management system for project development information. In addition to basic location and status information, iPM also includes division-specific comments, project contacts, project documents, meeting dates, project schedule, and action items. 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 IPM 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 IPM database. All VDOT District Survey Managers are responsible for the maintenance of starting and ending dates for the each of the survey-related IPM codes that relate to each project. Please refer to **Figure 1-B** 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 §33.2-236(see Figure 1-C) 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 Commissioner of Highways may prepare photogrammetric maps or plats of specific sites or areas at the request of the governing bodies of localities of the 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 Department of Mines, Minerals and Energy shall first review the request to determine whether suitable or alternate maps or plats are currently available, and the local governing body, agency, or chamber shall agree to reimburse the Department of Transportation for the cost of producing the maps or plats.

Sec. 1.02.2 **Survey Assignments**

Upon receipt of a survey authorization, the District Survey Manager will assign the project to a Survey Party Manager (Land Surveyor) in the district or Consultant staff. During the progress of the survey, the District Survey Manager will review the work for conformance with current instructions and ascertain that the survey data is complete and covers the proposed project.

Sec. 1.02.3 **Consultant Assignments***

VDOT has Survey and SUE primes consultants available for obtaining services in the surveying and subsurface utility engineering fields. These services are requested through task assignments. Each consultant is responsible for obtaining Falcon Access for each task assignment. The task assignment process is outlined below.
[Represents communication protocol to be used]

- Use the UPC first in the subject line of the email.

1. Assignments are initiated at the district or CO level by the Project Manager or other personnel and sent to the District Survey Manager or State Survey Program Manager (CO). **[LD forms and email]**

2. The District Survey Manager will contact the State Survey Program Manager with the project information so a prime can be assigned. Information includes: scope of work, UPC#, activity code, Agency One Use code, PM name and contact number, due date, and notice if any consultants have already been on the job. If aerial photography is necessary, the State Photogrammetrist will be contacted prior to assignment to a consultant**. [email]**

3. The State Survey Program Manager will assign a prime to the task based on the information provided by the district that best fits the Departments business needs. Consultants that have prior involvement on the job will be reassigned to the job when available. **[email]** {Time to return:} <=1 business day in general.

4. The District Survey Manager will contact the Prime assigned for an estimate based on the scope information. **[email]**

5. The Prime will complete an estimate based on the information provided. The following items should be included in the final estimate: {Time to return:} 5 days by contract

   a. Narrative letter – includes a detailed scope, VDOT responsibilities (if any), contract MOA date with term, schedule, and deliverables.
   b. Distribution of Man-hours in spreadsheet format –
   c. Fee Calculation work sheet – Limit to 1 page.
   d. Project limits provided by the Department –Sketches, maps, written documentation
   e. Attachments – Should be used for sub consultant's services.
   f. Any additional documentation if relevant to the task.

6. Prime submits copy of estimate to the District Survey Manager. The State Survey Program Manager will be cc'd with all correspondence. **[email]** Do not send color files unless Department requests.

7. District Survey Manager is responsible for reviewing and obtaining the Project Managers notice to proceed (NTP). NTP will be forwarded to the State Survey Program Manager. Project Managers will provide an open activity for the task assignment and must keep it open for the duration of the work. **[email]**

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8. State Survey Program Manager is responsible for reviewing and giving final NTP to the Consultant.

   a. NTP will be given by email first. **[email]**
   b. A formal letter will be provided by US mail service to the Consultant. **[letter]**

9. Consultant will track each task request and provide reports to the Department as requested. **[email]**

10. If NTP is not received by the Consultant within 2 weeks of submittal, the Consultant will email CO and the District requesting the status of the assignment. **[email]**

11. District Survey Managers will review the work for conformance with task request and meets the requirements outlined in the Survey Manual. District Survey Manager will notify the consultant and CC the State Survey Program Manager that the task has been completed ,reviewed, and submitted per Sec. 1.08 so the task assignment can be closed.**[email]** *

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 Party Manager (Land Surveyor) 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.

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Sec. 1.04 **Daily Diary**

A complete diary, which shall be kept by the Survey Party Manager (Land Surveyor), 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 Manager 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 Party Manager (Land Surveyor) 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 C**. Control and Right of Way surveying is to comply with all applicable requirements of the latest edition of the Virginia Board for Architects, Professional Engineers, Land Surveyors, Certified Interior Designers and Landscape Architects regulations**.**

Sec. 1.08 **Submission of Completed of Surveys**

All GPS control "subject data" for VDOT 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 immediately after completion of the primary control (deliverables are in Section 10.06). *

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After all field work has been completed as outlined in Chapter 4.00 and the processing and final quality control checking have been completed, a copy of all survey, utility, DTM, contour, and all updated files are to be stored on the appropriate Falcon Document Management server.

The District Survey Manager shall update activity 31S in the IPM system for all projects surveyed by VDOT staff.

A transmittal letter or an e-mail shall be sent to the individuals listed below and CC'd to State Survey Program Manager and Assistant State Location and Design Engineer's offices notifying them of the completion of the survey and location of the files:
Projects designed in District: Stored on district server. Transmittal or email to designer and project manager.

Projects designed in Central Office or by Consultants: Stored on central office server. Transmittal or email to project manager and designer.

Bridge projects designed in Central Office or by Consultants: Stored on central office server. Transmittal or email to State Bridge Engineer's office.

Bridge projects designed in District: Stored on district server. Transmittal or email to the bridge engineer in charge of the project, and if applicable, the L&D designer. *

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.

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.

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Sec. 1.10 **Outside Requests for Information**

As time permits, the District or Central Office staff may provide approved roadway or right of way plans for land surveying professionals outside VDOT when requested by phone, mail, or email at their discretion. If the information is on an approved plan sheet(s), it will be satisfactory to sell him a print of the plan sheet. This will apply to horizontal control, vertical control and other survey information. If a person would like to come to the appropriate office and copy the data himself, this would be satisfactory.

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/ .

Please refer to **Figure 1-C** in this chapter for requests from government agencies.

Figure 1-A

§ 33.2-1011. (Effective October 1, 2014) Right to enter on land to ascertain its suitability for highway and other transportation purposes; damage resulting from such entry.

A. The Commissioner of Highways, through his duly authorized officers, agents, or employees, may enter upon any land in the Commonwealth for the purposes of making examination and survey thereof, including photographing; testing, including soil borings or testing for contamination; making appraisals; and taking such actions as may be necessary or desirable to determine its suitability for highway and other transportation 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.

B. Notice shall be sent to the owner by mail, at the address recorded in the tax records, not less than 15 days prior to the first date of the proposed entry. Notice of intent to enter shall be deemed made on the date of mailing.

C. The notice shall include the anticipated date such entry is proposed to be made and the purpose of such entry. Any entry authorized by this section shall be for the purposes of making examination and survey thereof, including photographing; testing, including soil borings or testing for contamination; making appraisals; and taking such other actions as may be necessary or desirable to determine the suitability of such property for highway and transportation purposes, and shall not be deemed a trespass.

D. Notwithstanding the provisions in subsections A and B, nothing shall preclude entry prior to the anticipated date of entry specified in the notice if the property owner or his designated representative agrees to or requests a date of entry prior to the date of entry specified in the notice.

E. The Commissioner of Highways, through his duly authorized officers, agents, or servants, shall make reimbursement for any actual damages to real or personal property resulting from entry upon the property. In any action filed under this section, the court may award the owner his reasonable attorney fees, court costs, and fees for no more than three expert witnesses testifying at trial if (i) the court finds that the Commissioner of Highways maliciously, willfully, or recklessly damaged the owner's property and (ii) the court awards the owner actual damages in an amount 30 percent or more greater than the final written offer of the Commissioner of Highways made no later than 30 days after the filing of an answer in circuit court or the return date in general district court. A proceeding under this subsection shall not preclude the owner from pursuing any additional remedies available to the landowner.

(Code 1950, § 33-57.2; 1960, c. 491; 1970, c. 322, § 33.1-94; 2007, c. 755; 2011, c. 60; 2014, c. 805.)

Figure 1-B

Program/Project Management System (IPM) 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 the 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-C

§ 33.2-236. (Effective October 1, 2014) 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 Commissioner of Highways may prepare photogrammetric maps or plats of specific sites or areas at the request of the governing bodies of localities of the 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 Department of Mines, Minerals and Energy shall first review the request to determine whether suitable or alternate maps or plats are currently available, and the local governing body, agency, or chamber shall agree to reimburse the Department of Transportation for the cost of producing the maps or plats. (Code 1950, § 33-136.2; 1962, c. 96; 1970, c. 322, § 33.1-222; 1982, c. 184; 1984, c. 590; 2014, c. 805.)

CHAPTER 2

REPORTS

Chapter Contents

Sec. 2.01	**The Location Survey Report**
Sec. 2.02	**Surveying Equipment**
Sec. 2.03	**Human Resources Planning System**

Sec. 2.01 **Location Survey Report**

Unless specified otherwise by the State Survey Program Manager, a Location Survey Report shall be submitted at the initial completion of all location survey projects performed internally or by consultant staff. The Location Survey Report shall be submitted to the District Survey Manager, the appropriate quality control person and cc'd to the State Survey Program Manager. The report shall accompany all necessary digital files that contain all requested survey data.

The Location Survey Report shall be in a separate WORD document (*.doc) file format and shall consist of two parts, a heading (or informational block) and a body.

The heading shall contain the following:

- - Route number, -911 name -Project number -UPC #County/City - District -Project Length -Work Begin/End Date
- Horizontal & Vertical Datum Basis -Survey Personnel Involved.

The body of the narrative will be a <u>brief</u> 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 Program Manager's office
- general observations or recommendations regarding the field survey and completed survey files

The Location Survey Report shall 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 **Surveying Party Equipment Inventory and Major Equipment database**

An Equipment List shall be kept on each survey party of all equipment with a purchase cost of $ 2,000 or more. In addition all equipment that is furnished by the central office is to be kept on the Equipment List. The list is to be kept up to date and readily available upon request.

All major equipment with a purchase cost of $ 2,000 or more shall be added to the Major Inventory data base via the procurement section and a VDOT property tag is to be attached to the equipment upon receiving said equipment. The Major Equipment database is to be kept up to date with the transfer and disposal of major equipment. Central Office is responsible for the major equipment database.

Example of Equipment List:

_____ PARTY EQUIPMENT LIST

ITEM	MFG. AND MODEL	SERIAL NO.	VDOT TAG NO.	CURRENT LOCATION	ASSIGNED TO:	COMMENTS. CONDITION, ETC...	DATE LAST CHECKED	LAST CHECKED BY
TOTAL STATIONS								
DATA COLLECTORS								
TRANSITS, THEODOLITES AND LEVELS								
RADIOS								
PIN LOCATORS								
MISC.								

EXAMPLE

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 Party Manager (Land Surveyor) 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 Manager shall have the responsibility of submitting budgets for projects and revising the budgets when necessary. [VDOT] Budgets compiled by the District Survey Manager will be submitted to the Project Manager for inclusion into the “Project Cost Estimating System” (PCES) and the “Integrated Project Manager” (IPM) system. The [VDOT] activities listed in the current edition of the “Project Tasks and Scheduling Guide” should be used when making a budget for 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 “Project Cost Estimating System” (PCES) and the “Integrated Project Manager” (IPM) system after changes are approved[VDOT] by the Project Manager. The District Survey Manager 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 Manager.*

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CHAPTER 3

INSTRUMENTS AND SUPPLIES

Chapter Contents

Sec. 3.01	**Responsibility**
Sec. 3.02	**Care And Adjustment Of Instruments**
Sec. 3.03	**Calculators And Computers**
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. 3.07	**GPS**

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 Manager. This should be reported quarterly to the State Location and Design Engineer.

In the event a survey party is disbanded, all instruments and equipment should be returned to 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 (survey) 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 Party Manager (Land Surveyor) 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, all instruments should be placed in its carrying case, or protective cover, 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 could bounce around.

Levels

Many levels are assigned to other VDOT Divisions and Departments. These instruments also are delicate, very sensitive to vibration and subject to serious damage by careless handling. The District Survey Manager should facilitate minor adjustments and cleaning when necessary. They should never be disassembled except as authorized by the District Survey Manager. 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 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 and Computers**

Since programmable calculators and computers 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 Program Manager or by contacting the VITA representative.

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 reflector 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. Survey instruments should be serviced and calibrated by a qualified service technician licensed by the equipment manufacturer. The NOAA Technical Memorandum NOS NGS 8, "Establishment of Calibration Base Lines" should be used as a guideline when establishing your baselines.

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 Program Manager. An example is shown in **Figure 3-A**. Any major deficiencies should be reported immediately in order that corrective steps may be taken. Before adjusting the instrument, a check of the tribrachs must be made.

Sec. 3.07 **GPS**

The GPS equipment must be maintained with the utmost care possible. All components of the receiver must be inventoried and returned to the case after each use. Damage to any of the components must be reported immediately to the supervisor and arrangements made to have the damaged parts repaired or replaced.

Repair work shall only be performed by a qualified service technician licensed by the equipment manufacturer. Under no circumstance shall the instrument case be opened or field adjustments made. Updates to the onboard firmware shall be coordinated with the manufacturer and installed according to their guidelines.

Figure 3-A

SURVEYING EQUIPMENT – EDM and SURVEY INSTRUMENT EVALUATION												
YEAR 2004												
				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
99	TOPCON	601AF	F 30988	3-2		6-8		8-24		10-17		No Adj.
		Accessories	3 Tribrach	3-2		6-8		8-24		10-17		Needed
			2 RangePole	3-2		6.8		8-24		10-17		
99	TOPCON	501	P 70236	3-2		6-8		8-24		10-17		Dist. OK
		Accessories	1 Tribrach	3-2		6-8		8-24		10-17		Adj. Vert.
			0 RangePole									Cross Hair
99	TOPCON	GTS 2	B 40525	3-2		6-8		8-24		10-17		
		Accessories	1 Tribrach	3-2		6-8		8-24		10-17		
			RangePole									
		Accessories										
		Accessories										

CHAPTER 4

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 and Right-of-Way**
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. 4.18	**Digital Sealing Of Microstation And Adobe Files**

Sec. 4.01 **General Remarks**

In using these instructions, it must be realized that to write a set of rules as 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 Consultants, District Survey Managers and staff to resolve, or have these situations resolved. State Survey Personnel or Consultants 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 policies and procedures concurrent with a location survey.

Sec. 4.02 **Survey Assignment**

Upon receipt of a survey authorization, the District Survey Manager will assign the project to a Survey Party Manager (Land Surveyor) in the district or Consultant staff (see Sec. 1.02.2). During the progress of the survey, the District Survey Manager 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 Party Manager (Land Surveyor), staff, or consultants 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 Manager, and the standard memorandum shown on **Figure 4-A** of this manual prepared for each owner. As of July 1, 2011, a letter will be sent to all affected landowners on a project. The surveyor cannot enter the property until fifteen (15) days after the letter is received. This memorandum will be used statewide to insure uniformity because this is a law Section 33.2-1011. *The memorandum must state the survey task and the duration of the assignment if it exceeds 90 days. **Note: The duration must have specific dates and cannot cover the life of the project.**

* Rev. 1/13

*If the survey task is going to exceed the duration indicated on the initial letter, another memorandum will need to be sent 15 days prior to the end of the initial letters date. Survey updates cannot be included in initial memorandum duration. Update surveys will trigger another memorandum letter to each landowner. The brochure "Let's Take a Look" must be sent with this memorandum.

The Survey Party Manager (Land Surveyor) or consultant should deliver personally or by mail a copy of this memorandum, a list of parcels affected(list each parcel by address or tax id number) and brochure to each property owner affected.° In either case, a copy should be furnished to the Resident Engineer and/or Project Manager with a list of all property owners for which a memorandum and brochure was prepared. This will enable the Resident Engineer and/or Project Manager to be better prepared to handle inquiries that may be made as the survey progresses.

The Survey Party Manager or Consultants 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 Program Manager with the authorization memorandum. The District Survey Manager will assure that the Survey Party Manager (Land Surveyor) has sufficient data for control and/or will coordinate with the State Geodetic Survey Engineer the scheduling for setting GPS datum and will provide sufficient personnel to assist the State Geodetic Survey Engineer when securing GPS datum.

Standard VDOT 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**). 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 State 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.

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* Rev. 7/15

Form LD-200 (Horizontal Control Reference Card) **(Figure 10-F)** shall be completed for all permanent monuments set for horizontal control, for referencing purposes. When the cards have been completed by VDOT personnel or consultants, a copy will be sent to the State Geodetic Survey Engineer and the appropriate District immediately upon completion of the control.

Sec. 4.05 **Traverse alignments or baselines and Datum**

The traverse alignments (legacy) or baselines 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) 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 Program Manager, 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 Program Manager or State Geodetic Survey 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 is not acceptable.

In the establishment of the survey traverse alignments, 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 traverse line 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 traverse line should be located so that readings may be obtained and full coverage of both lanes recorded.

Traverse baselines or traverse alignments will be included in a VDOT Survey file and will be entered according to the VDOT CADD Standards. All traverse closures will be reported. The CADD Standards are included in **Chapter** 2 of the CADD manual. All text, levels, weights and line styles entered into a survey file will adhere to these standards. The file standards presently being used by VDOT are shown in the CADD manual.*

Legacy survey alignment stationing 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**.

* Rev. 3/14

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 Manager. 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 traverse line, depending upon the nature of the possible changes, to ensure the securing of all needed information. Complete survey information - topography, property lines, property owners, DTM's, etc. - should be secured for the full length of the connection. When a large skew angle is encountered, consideration should be given to relocate to 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")**.

Alignments for construction centerlines shall be shown on all plan sheets, bridge situations, and/or site plans, closed survey plats or any other surveys. All plus and offsets will be referenced from the construction centerline.

Generally, long easy curves that do not materially lengthen the route are preferred to a 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 GPS RTK, Mobile scanning, Robotic total station, or 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.

Sec. 4.07 **Topography**

Topography will be secured by the use of Total Survey Station, mobile scanning, and/ or Photogrammetric methods and procedures. The procedures and standards for creating Survey CADD files are explained in **Chapter 2** of the CADD manual. The Survey CADD Section has made a conscious effort in creating unique cells, levels, and linestyles for topography and utilities that may be encountered by a survey party or consultant staff. Examples of these cells and linestyles are also included in **Appendix A** of the CADD manual. It is required that these levels, cells and linestyles be used in all VDOT 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.

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The outside limits of all automobile graveyards will be shown.

All 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 "swlUPC#.dgn". **This data will not be merged in the survey master file**. The data shall be shown in the wetland file on appropriate level and the scale shall be the job scale. This information is listed in Ch**apter 2 of the CADD Manual.***

Unusual circumstances such as standing water, sinkholes, caves, outcrops, or any other condition which might need special attention from materials investigation should be noted by the District Survey Manager or Survey Party Manager (Land Surveyor) 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, etc.), the height (one story, two story, etc.) 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, etc. 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 flow lines). The location of the next structure (manhole, etc.) outside of survey limits shall be included with elevations. Also, the open ends of

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pipes shall have their locations with invert elevations secured by the field parties. All municipal sanitary sewer will be placed in the utility file(suUPC#).

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

Pipe Culverts

1. Diameter of culverts shall be shown to the nearest .1'.
2. Invert elevations shall be shown to the nearest 0.01 ft.

Storm Sewer

1. Diameter of culverts shall be shown to the nearest .1'.
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.
2. If a stream is three (3) or more feet wide, four breakline should be used for a more accurate depiction of the stream.

Pipe Cover

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

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 knowledge of the area and local research

* Rev. 3/14

on the part of the Survey Party Manager (Land Surveyor). 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

- Prior to Field Inspection the Project Manager will request that the District Environmental Manager provide any known areas of significant contamination. The Office of Safety and Health will be requested to provide recommendations for safety precautions to protect the surveyors.*

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. Location and Design Division staff should assist in the identification of any known or potentially contaminated sites early in the project development stage. The Survey Party Manager (Land Surveyor) 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.

The survey party will note features such as:

- Storage tanks (above-ground and underground)
- Environmental monitoring wells (marked "Monitoring Well" and stick up well casings)
- Oil/water separators
- Dumping areas
- Drums
- Waste lagoons
- Obvious surface contamination (e.g. staining and odors)
- Obvious surface water contamination (e.g. oil sheen)

- The route survey will include notes of any potential sites or conditions identified by the survey party.
- Areas of contamination, as provided by the District Environmental Manager, are to be shown on the plan sheet (hatching, crosshatching, etc.).
- The Project Manager, with the assistance of the Survey Manager, should communicate the findings of the route survey where potential contamination sites were identified, to the District Environmental Manager for further review.
- Based on the evaluation and recommendations of the District Environmental Section, avoidance of potential hazardous materials sites should be the first alternative design consideration.
- When the selection of other location/design alternatives is not feasible, project designs that minimize the impact of any hazardous materials site are to be evaluated.

* Rev. 4/14

- If stormwater basins or conveyances are proposed for locations within known or potential areas of contamination, coordinate with the District Environmental Manager to determine ways to avoid impacts and prevent the contamination of groundwater and surface water through such stormwater systems. Avoidance measures such as relocations, redesign to reduce cut, etc. are to be considered. If avoidance is not feasible, methods for preventing the spread of contamination are to be considered.

- The Project Manager will communicate to District Environmental Manager any substantial changes in grades, alignment, stormwater management features and subsurface utilities, especially those changes made late in project development.

Listed below are some sources which have potential for hazardous material waste from underground tanks or associated sources. This is a partial list and should not be taken as all inclusive. The surveyor should use common sense as well as research information as well as their working knowledge of the areas to be surveyed in order to determine sites with potential underground tanks.*

Possible Underground Tank Locations:

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

* Rev.4/14

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 etc., 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, etc., must be located. If anticipated construction will disturb or destroy these control markers, the disk number should be recorded and sent to the State Geodetic Engineer. The State Geodetic Engineer will request a new disk from the appropriate agency. The State Geodetic Engineer will coordinate the replacement of the mark with the District Survey Manager using VDOT or consultant staff.* The removed original disk and the new description and values of the reset mark are to be sent back to the federal agency concerned.

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, etc., 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.

City/County Boundaries & Road Names

The names of all cities, towns, villages (whether incorporated or unincorporated) must be shown. Accurate tie-ins must be made for all corporate limits, county or state lines, etc., showing stations and angular ties. When a project encompasses two or more cities or counties the city/county lines must be shown depicting the border. The appropriate names should be on each side of the boundary line. If a project is only located in one county or city, the Title Block description will suffice.

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* Rev. 3/14

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. The names and/or route numbers are required on every plan sheet once per sheet. 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 name.

Surveys Near Airports

When the proposed location is within three (3) miles of an airport, the Central Office Aerial Coordinator will be notified and helps with securing the necessary information listed below. 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, trunk line, express, continental, inter-continental, or Department of Defense Air Base shall be noted in the file.
6) During the late 1980's all public access airports were surveyed. It may be beneficial to acquire these surveys from the Virginia Department of Aviation.
7) The following information may be needed for a survey to be completed adjacent to airport property. This information is usually available on the plans. One is the Airport Approach Slope. This design element shows contours in and around the airport. It also assists designers in verifying that their road design does not hinder takeoffs or landings. The other is the Runway Protection Zone. This is the area surrounding the airport in which no modifications to the ground structures are allowed.

Sec. 4.08 **Property Data and Right-of-Way**

Existing fee right-of-way, property line data, existing easements[*] and prescriptive easements will be shown on all roadway and bridge plans.

[*] Rev. 7/16

Sec. 4.08.1 **Property Data**

All property data shall be secured by use of survey total station or GPS methods and procedures or enter the property information directly into the CADD software.

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.

All property corners (monuments, stones, iron pins, trees, fence corners, etc.) shall be located from the traverse alignment or baseline and will be referenced to the final construction centerline/baseline by station and right angle offset. Calculated plus and offsets will not be shown. Both station and distance shall be shown to the nearest one-hundredth foot **(0.01 ft)**.

Property lines shall have a calculated bearing based on the VDOT project datum. 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, plat book & page number, tax map or GPIN #, and acreage(x.xxx) or square footage(x,xxx). ***Where acreage or square footage is not recorded none is to be calculated, and a note, in parenthesis, will so state.*** Sufficient data shall be given so that the right-of-way take can be shown by a metes and bounds description on all total take parcels and only if requested by the Right of Way division on partial takes. The property data (owner, deed and map book reference & area) will be added to the property owner file using the VDOT CADD Standards shown in Section 2 of the CADD Manual.*

When subdivided land is encountered, prints of the subdivision, as well as the names and addresses of the effected 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.

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* Rev. 3/14

Prescriptive or statutory easements are to be shown on the plans but will not to be shown or labeled as existing fee 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 baseline and will reference to the final construction centerline/baseline by station and right angle offset. 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 acquisition of land owned by U.S. Government, State Agencies, National Forest Service, Railroad Companies[*] and Power Companies (Dominion VA Power). Metes and bounds descriptions will be provided to the Right of Way Division with plats on these parcels. Any legal description written will commence at the nearest offset point with the lowest stationing off the construction centerline thence clockwise around the parcel.

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.

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[*] Rev. 7/15

Sec. 4.08.2 **Right-of-Way & Easements**

Courthouse and old project file research are critical to establishing the fee right of way and easements. Plans are available on microfilm in district offices and at Central Office. If old plans show existing right-of-way, the old data sheet can be checked as the research is performed. The local planning offices will be checked to determine if any right-of-way proffers exist or dedications to local governing bodies. If a project will be acquiring right of way or easements, title reports should be requested on each parcel that will be affected. Title reports will be ordered through the Survey On-Call contracts or through Right of Way based on availability of internal Right of Way staff. Title reports should include a minimum of a 60 year title search. Title reports should include all items listed in the Right of Way Manual Section 3.3.3 in PDF format. PDF shall contain copies of all deeds for property and easements, and all plats referenced in the deeds. Parcel data will be submitted in PDF format using the UPC# + Tax ID number/GPIN number for each parcel. Once obtained internal or consultant staff will review and plot all easements that are applicable to the project limits. All easements should be labeled with the type and reference the pertinent deed book and page. The PDF files will be sent to CO Survey for storage and will be made accessible by other disciplines.*

All existing fee right of way will be shown on plans as established by all available research and field evidence. Label and show the existing right-of-way and easements. Right-of-way labels will include a reference to the old project.

Sec. 4.09 **Procedures for Locating Existing Underground Utilities**

Interstate, Primary and Urban projects, requiring surveys, will have subsurface utilities designated by a SUE Consultant. See Chapter 13 as well. A determination will be made and indicated on Form SR-1 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 (size and type) such as water meters, cutoff valves, poles, etc. All underground utilities and municipal utility services will be placed in the SU file for each project.

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 standard survey methods and procedures. VDOT Utility CADD File Standards are located in **Section 2**, of the CADD 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.

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* Rev 7/16

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 will 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 *VDOT 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 xM)**, 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. When a location survey parallels an existing road, the two 3d surfaces will be combined to ensure proper drainage calculations.

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**

DTMs (Digital Terrain Models) are to be secured by the use of Total Survey Station, Photogrammetry, or LIDAR methods in the required file formats. DTMs shall be taken at normal intervals **(50 ft. intervals along tangents, 25 ft. along curves)**, and everywhere 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. VDOT CADD DTM File Standards, and GEOPAK .tin file standards are included in this manual in **Chapter 2** of the CADD Manual.

DTM readings 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 flow line 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. If a stream is three (3) or more feet wide, four break lines should be used for a more accurate depiction of the stream.

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

Bridge Site Plans at streams shall be taken in accordance with **Chapter 7** 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.

Existing fee right-of-way, property line data, existing easements* and prescriptive easements will be shown on all bridge plans.

Topo and DTM will be taken fifty feet **(50 ft)** each side of the existing roadway center-line. 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, profiles are to be taken at twenty-five feet **(25 ft)** intervals, seventy-five feet **(75 ft)**, left or right of centerline, etc.

* Rev. 7/16

These profiles are to be drawn in a new .dgn file called sUPC#b(bridge #).dgn plotted 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.

Where the site plan is at a railroad crossing, instructions in **Sec. 4-5** and **Sec. 4-7** 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.

Elevation ticks shall be taken at twenty-five feet **(25 ft)** intervals from the centerline or baseline of the road or railroad being crossed 100' left and right of the crossing.

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** 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 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 will need to be determined on a per project basis. The following are the minimum guidelines:

1. Establish survey alignment 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 Resident Engineer or District L & D Engineer.

1. Obtain centerline profiles but DTMs or cross-sections are not to be taken unless specifically designated or requested 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.****

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. Updated memorandum letters will need to be sent to all affected parcels 15 days prior to entry per Section 4.03.

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 is available by this method, the request for this additional data should be forwarded to the Central Office, attention to the State Photogrammetry Manager. *

* Rev. 3/14

The additional data is to be requested by Form LD-261, See **Figure 4-B** this request is to be reviewed by the District Survey Manager in the Districts or the State Survey Program Manager or State Photogrammetry Manager 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 Design Units should be sent to the appropriate individuals per section 1.08.

Sec. 4.17 **Submission of Survey Report and Data**

Before submitting the survey data, all information should be checked by the Survey Party Manager. 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 Party Manager will then write the Survey Report (a copy of which shall be titled "**sUPC#.doc**" and shall be included on the server). This document will be placed in Falcon. 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 Manager to check each survey for correctness, completeness and notifying the Project Manager and State Survey Program Manager that the survey is complete. The District Survey Manager 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.

Sec. 4.18 **Digital Sealing of Microstation and Adobe Files**

Beginning July 1st, 2009, all newly submitted survey, utility, and update digital files will contain a digital signature certifying the Microstation file meets an accepted professional standard and quality. **(IIM-LD-243).** This IIM is very specific on what will and will not be sealed by a licensed professional. All plans submitted for Right of Way approval shall be Sealed and Signed by a Licensed Land Surveyor. The Microstation digital signature has been provided to VDOT's Licensed Surveyors (L.S.)**. It is the consultant's responsibility to acquire Falcon access and digital signatures for submission of files to VDOT upon Notice to Proceed.*** Survey digital files whose submission was prior to July 1st, 2009, will not require a digital signature.

* Rev. 3/14

Figure 4-A

May 22, 2013

Mr. Property Owner	Re: *Street Improvements*
Ms. Property Owner	From: *14th Street NE. To: 0.5 Mi. E. 9th Blvd*
222 Broad Street	City: *Richmond*
Richmond, VA 23219	UPC: *# 80561*

Dear Property Owner:

This letter of intent to enter your property is being sent to you pursuant to Section 33.2-1011 of the Code of Virginia. The Virginia Department of Transportation (VDOT) is in the early stages of developing the captioned project and will soon be working in your neighborhood.

Please be advised that VDOT employees or consultants may need to enter your property to perform some or all of the following investigative tasks: locate property lines and utilities; locate and review physical features and existing conditions; take photographs; talk to property owners; verify property tax information, perform environmental resource surveys; investigate potential environmental impacts; and conduct soil testing and sampling, including, but not limited to shovel tests, soil samples and borings.

Should soil borings or shovel tests be required, every effort will be made to minimize the disturbance to your property and reduce the time spent on your property. All holes will be backfilled and every effort will be made to return the surface to the same condition it was before our work began. If borings are required, approximately 30 days after completion of the borings, the borehole locations will be inspected for settlement and necessary repairs will be made, if required.

This investigative work does not indicate that improvements across your property are imminent or that a decision on an improvement has been made. This work is simply for the purpose of gathering data for the decision making process. Please watch for notices of public meetings or willingness to hold a meeting about this project. In the event that the transportation improvement does affect your property, a VDOT representative will personally contact you.

VDOT anticipates that surveyors and engineers will be performing this work intermittently between approximately *September xx, xxxx* and *December xx, xxxx*. Should there be any need to further access your property after this time, you will be contacted either in person or by mail.

If you have any knowledge of cemeteries, easements, or homeowner installed utilities that are not recorded in your Locality's public records or items of interest that may affect the improvements in your area or have any questions, please contact the undersigned at 804-__-___ or by mail at VDOT _____District, PO Box ___, _____, VA 23219 or by electronic mail at _____.

John Smith, P.E.
Project Manager

LD-261 **Figure 4-B**

http://vdotforms.vdot.virginia.gov/SearchResults.aspx?strFormNumber=LD-261

LD – 261
(3-20-07)

DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN
REQUEST FOR ADDITIONAL SURVEY INFORMATION

TO: District Survey Manager

PROJECT DESCRIPTION Date: _____

From: _____ Route: _____
_____ Project: _____
To: _____ _____
_____ City/County: _____
UPC: _____

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

_____
_____
_____
_____

The following data is being handed you:

_____
_____
_____
_____

- Survey control information, Microstation files, design files, etc., on Falcon? (Yes or No) ____
- Marked up plan sheets, tax map, or ADC map depicting coverage area. (Yes or No) ____
- Drainage information/DTM's, required? (Yes or No) ____
- Benchmarks or vertical datum information. (Yes or No) ____
- Subsurface Utility Designation has been outlined on the prints, required? (Yes or No) ____

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

Requested by _____ Phone No. _____
Project Manager

Request has been reviewed by _____ (Project Designer.)

Remarks
_____
_____
_____

PLEASE DO NOT WRITE BELOW THIS LINE

Survey authorized by _____ Date _____

CHAPTER 5

PHOTOGRAMMETRIC SURVEYS

Chapter Contents

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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 collected rapidly and safely, at modest expense.

Sec. 5.02 **Pre-Photography Control**

On surveys where Photogrammetry is to be used, a map or aerial image will be marked by the Photogrammetry Section suggesting the general location for the placement of aerial targets. This marked map or aerial image, along with other pertinent data needed for securing the survey, should generally be sent at approximately the same time as the survey authorization. However, it is not uncommon for the map or image to be sent in advance of the official authorization to insure the photography is obtained during leaf-off conditions.

On projects where no centerline or traverse will be established, permanent 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 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** 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 one thousand foot **(1000 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 leg extensions 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 fifty to one hundred feet **(50-100 ft.)*** along the centerline or traverse to a station that is in an open or minimally obscured area.

If a connection exceeds one thousand feet **(1000 ft)** in length, targets should be placed at intervals of approximately seven hundred fifty to one thousand feet **(750-1000 ft)** along the connection, depending on the scale of the photography and the configuration of the connection on 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 Program Manager and the State Photogrammetrist or their representatives, in accordance with Section 4.17 of this manual.

* Rev. 4/14

Sec. 5.03 **Targets**

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

Prior to the placement of any aerial targets or Photogrammetry control, the District Survey Manager or their representative should notify the respective Resident Engineer responsible for the region where the project is located. The District Survey Manager or their representative should inform the Resident Engineer of the aerial targeting/control activity that will occur. When contacting the Resident Engineer, the following information should be provided: Name and number of the project; a brief description of what action is taking place; the expected duration that the aerial targets will be in place; the expected date when the aerial targets will be removed by VDOT personnel; and the importance of non-disturbance of the aerial targets until removed by VDOT personnel. This information will assist the Resident Engineer when responding to citizen inquiries regarding the targets and the presence of VDOT Survey personnel.

The most effective targets are made in the shape of a cross with the control 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 consistent 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** 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. Using white paint on new asphalt and black paint on new concrete make 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

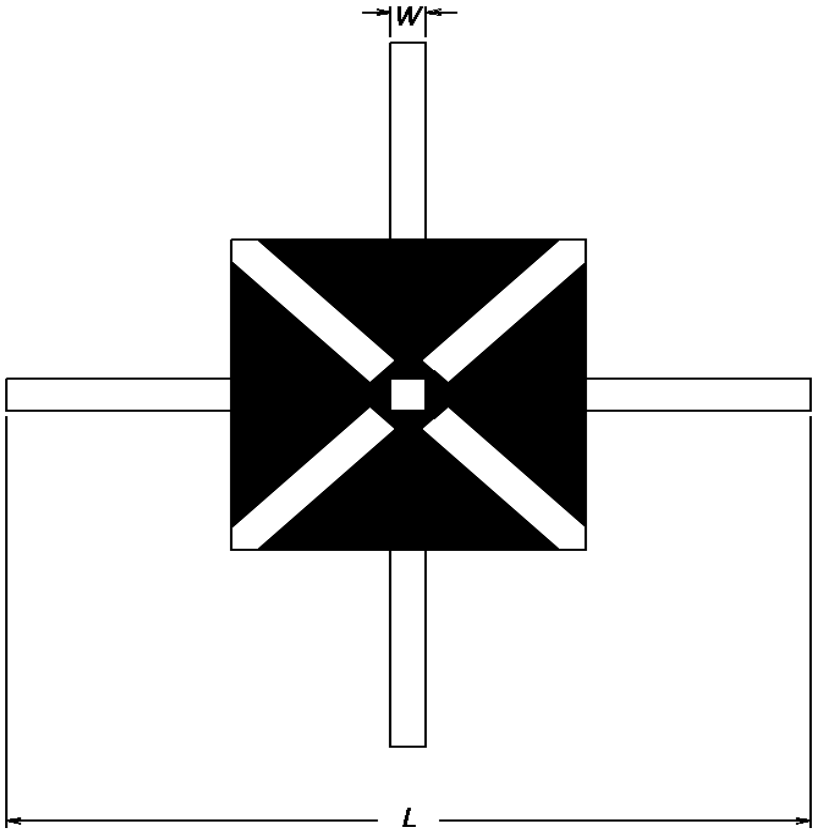


Figure 5-B

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.

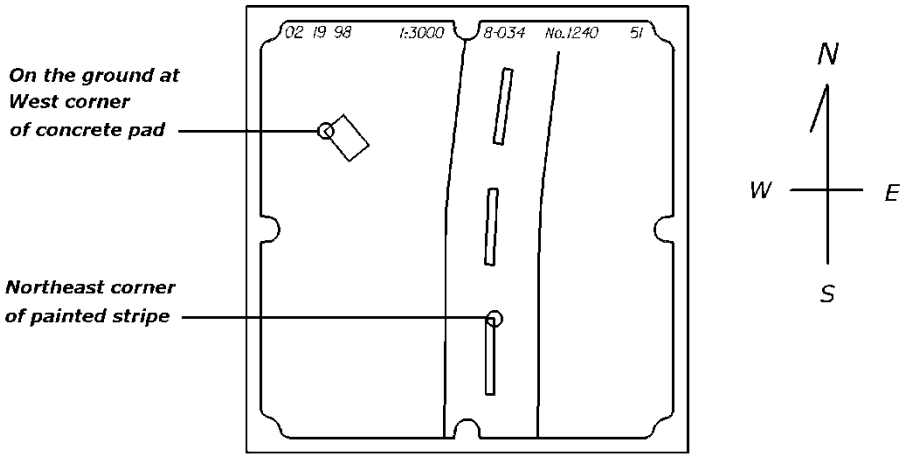
Good natural image points for **vertical** control only include, but are not limited to, the center of manhole covers, intersections of roads and/or trails, on pavement at the end of islands, bases of utility poles, fence corners, and fence intersections. These all work well for **vertical** control 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 survey crew will receive a set of photography, .dgn design files, .pdf files, and/or .kmz Google Earth files* 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 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 Photogrammetrist's 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 a film-derived photograph corresponds to the same side that contains the date, photo scale, and exposure number.) See **Figure 5-C**.



Note: Features enlarged to show detail.

* Rev. 4/14

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 replaces all existing methods. VDOT Photogrammetry Unit will make every effort to pre-select control point desired positions on all aerial projects.

If pre-marked targets are used, the points will be numbered sequentially, beginning with (UPC#)_101 and increasing one at a time, until all control points are numbered [(UPC#)_101, (UPC#)_102, (UPC#)_103, etc.]

When natural images or picture points are used, the points will be numbered sequentially, beginning with (UPC#)_501 and increasing one at a time, until all control points are numbered [(UPC#)_501, (UPC#)_502, (UPC#)_503, 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, the 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.

[*] Rev. 4/14

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 to the VDOT Photogrammetry Unit:*

- The complete set of annotated contact prints (if applicable), Microstation .dgn design files, Adobe .pdf files, and/or Google Earth .kmz files.
- Photogrammetric control values in ASCII text format or spreadsheet format (ID-X-Y-Z separated with at least one blank space.)
- Hardcopy of ASCII, text formatted control coordinate file.

		ID	X	Y	Z
Example of	**:**	123321_101	3660547.009	434232.333	81.789
ASCII File	**:**	123321_102	3659553.271	434596.146	86.184
Format	**:**	123321_103	3660667.354	432287.107	76.176
		123321_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 907
Richmond, VA 23219

For projects having the Photogrammetry performed by consultant forces, send the control information to the prime survey firm, and copy the transmittal letter to the central office survey coordinator and the Photogrammetry manager. The following Photogrammetric Targeting Standards document will be included with all new control requests:

* Rev. 4/14

Photogrammetric Control: Instructions to Surveyors

Date of Request:		UPC:	
Route:		Activity:	
City/County/Town:			

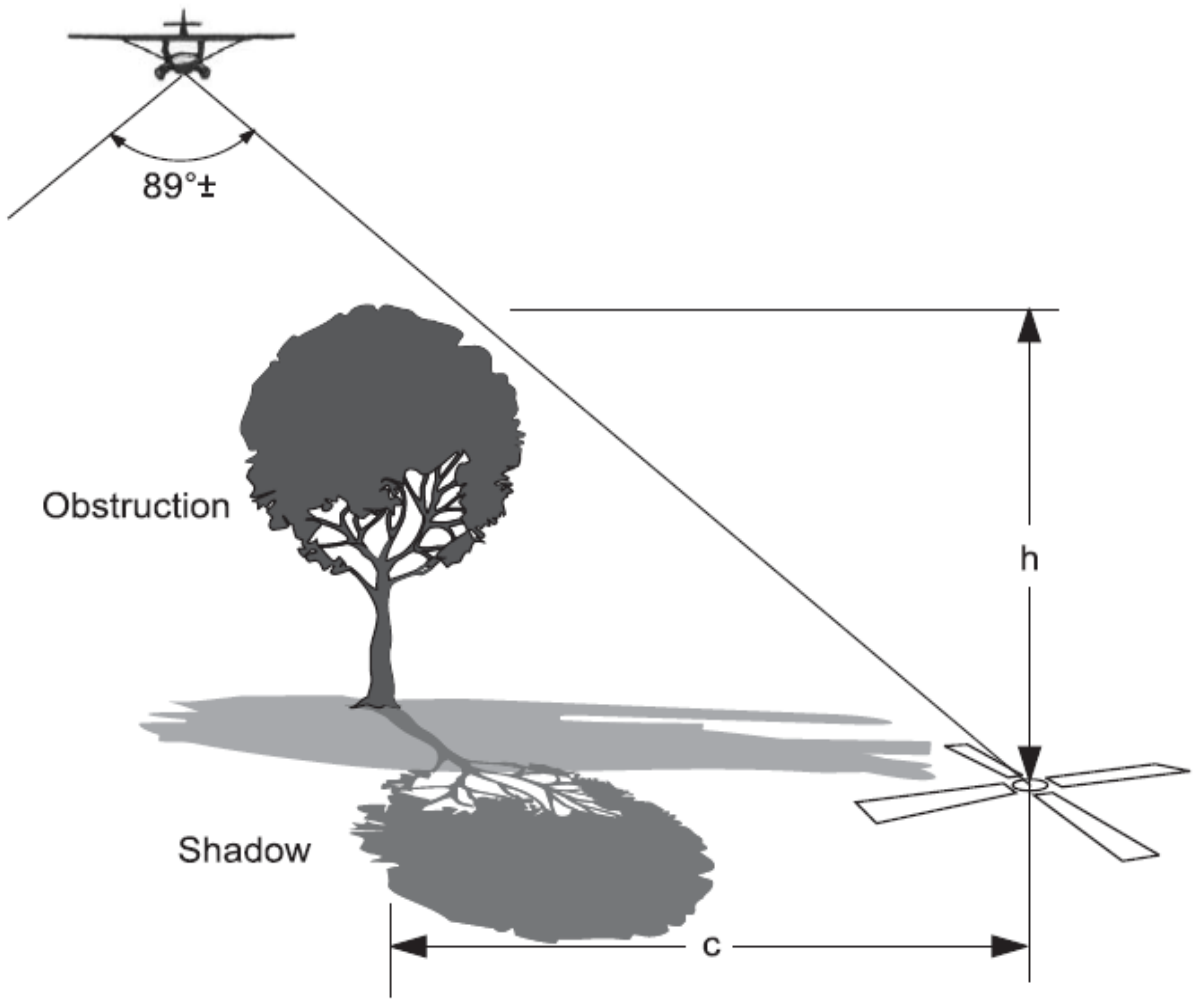
Photogrammetric Targeting Standards

ALL TARGET PANELS MUST BE CLEARLY SKY VISIBLE.
From each control point location, the sky must be clearly visible and free of obstructions such as trees, buildings, bridges, power lines, embankments, poles, signs, etc. (See figure on next page.)

"X" or "Cross" Photogrammetric ground control is the only acceptable pre-marked targeting for VDOT aerial mapping projects. Acceptable target materials are painted, cloth or vinyl varieties. **Always be cognizant of the flight path and each photo footprint.**

- "X" targets must be located on a flat, bare ground, and level surface. Flat, grassed areas must be cut very short before placement of targets.
- Mainline & wing target relocation maximum is 100 feet. Once again, be cognizant of the flight path and each photo footprint.
- Mainline targets limited to 50-100 feet target relocation laterally. Lateral movement is along a line perpendicular to the flight line.
- Wing targets limited to 50-100 feet relocation laterally, on a line perpendicular to the flight line, and **relocated towards flight path or center of photograph.**
- Use paved shoulders (clearly sky visible) on major highways.
- Use centerline on rural roads (sky visible.)
- **DO NOT place targets on slanted or sloping ground!**[*]

[*] Rev. 4/14



h = height of object above the target
c = clearance (1.0h minimum)

All targets should be placed in a relatively flat area either on pavement or short grass, free from shadows or obstructions.

Photogrammetric Control Deliverables

Pre-marked "X" or "Cross" Targets

A. Google Earth – .kmz 2D file containing field-surveyed control correctly located, and marked with provided point ID numbers. Pre-marked Photogrammetric point ID numbers will begin with **(*UPC #)_101***.

B. Control list with format: point #, Easting, Northing, Elevation. Include Excel spreadsheet file or formatted text (space delimited) file, in VDOT Project and Virginia State Plane coordinate values. Both control files must contain date, units, coordinate type and county & scale factor used for conversion.

C. Provide GPS Control Deliverables as referenced in VDOT Survey Manual, Chapter 10: GPS Deliverables (Sec 10.06)

Picture Points

A. Unless otherwise arranged, VDOT Surveys & Photogrammetry Section provides picture point locations and ID's. Ground feature / picture identifiable Photogrammetric picture points will be annotated with ID numbers beginning with **(*UPC #)_501***.

B. Provide detailed sketch of each **surveyed picture point location**, along with**,** a Microstation .dgn design file, Adobe .pdf file, and/or Google Earth .kmz file with each point located and labeled.

C. Provide digital pictures of each control location at the point of measurement.

Note: A copy of the document "Photogrammetric Control Standards" will be sent with each control survey request to District or Consultant surveyors. This document supplements the guidelines for ground control surveys found in the VDOT Survey Manual, Chapter 5: Photogrammetric Surveys.*

Sec. 5.07 **Digital Terrain Models, Cross-Sections, Profiles and Bridge Situations**

When digital terrain models (DTMs), or cross sections are being secured by Photogrammetric methods, 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. VDOT symbology for DTM collection is included in the table at the end of this section.

* Rev. 4/14

Note to survey parties: For best terrain definition when collecting break lines on curved features (such as curb and gutter around entrances), 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 from the existing structure.

In addition to streambeds, there will typically be other areas obscured to Photogrammetry 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, annotated Microstation file, or paper 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** 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 cross sections. In lieu of 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.

LEGACY VDOT SYMBOLOGY STANDARDS FOR DTM DATA FILES *Rev. 11/1/08*			
LEVEL	**DTM Data Source**	**Weight**	**Line Style**
3	Helicopter Photography (Low Level): Spot Shots	5	0
4	Helicopter Photography (Low Level): Break lines	1	0
12	Obscure Areas	5	OBSC
13	Field Survey: Spot Shots	5	0
14	Field Survey: Break lines	1	0
23	Standard Aerial Photography: Spot Shots	5	0
24	Standard Aerial Photography: Break lines	1	0
33	LIDAR spots	5	0
34	LIDAR Created Break lines	1	0
40	Bridge Decks: Spot Shots	5	0
41	Bridge Decks: Break lines	1	0
43	USGS Digital Elevation Model: Spot Shots	5	0
53	Low Accuracy Aerial Photography: Spot Shots (Orthophoto, Sound wall, etc.)	5	0
54	Low Accuracy Aerial Photography: Break lines (Orthophoto, Sound wall, etc.)	1	0

2014 VDOT SYMBOLOGY STANDARDS FOR DTM DATA FILES *Rev. 3/1/14* **(For weights and line styles, refer to LEGACY VDOT Symbology Standards For DTM Data Files above)**	
LEVEL	**DTM Data Source**
PHOTO_DTM_HCOPTER_SPOT_SYM	Helicopter Photography (Low Level): Spot Shots
PHOTO_DTM_HCOPTER_BREAKLINE	Helicopter Photography (Low Level): Break lines
PHOTO_DTM_OBSCURE	Obscure Areas
SURVEY_DTM_SPOT_SYM	Field Survey: Spot Shots
SURVEY_DTM_BREAKLINE	Field Survey: Break lines
PHOTO_DTM_SPOT_SYM	Standard Aerial Photography: Spot Shots
PHOTO_DTM_BREAKLINE	Standard Aerial Photography: Break lines
LIDAR_DTM_SPOT_SYM	LIDAR spots
LIDAR_DTM_BREAKLINE	LIDAR Created Break lines
PHOTO_DTM_BRIDGE_SPOT_SYM	Bridge Decks: Spot Shots
PHOTO_DTM_BRIDGE_BREAKLINE	Bridge Decks: Break lines
NOT IN USE	USGS Digital Elevation Model: Spot Shots
PHOTO_DTM_LOWACC_SPOT_SYM	Low Accuracy Aerial Photography: Spot Shots (Orthophoto, Sound wall, etc.)
PHOTO_DTM_LOWACC_BREAKLINE	Low Accuracy Aerial Photography: Break lines (Orthophoto, Sound wall, etc.)*

* Rev. 4/14

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 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 has a hovering capability which 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 survey party, but it will provide a high-accuracy supplement for the survey data produced by traditional Survey and Photogrammetry methods.

Helicopter Photography Aerial Targets

"X" or "Cross"* 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. See **Figure 5-D,** below for helicopter-photography target illustrations. See **Figure 5-E,** 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**. The surveyor must read the center of the top of the PK nail as the control point location.

* Rev. 4/14

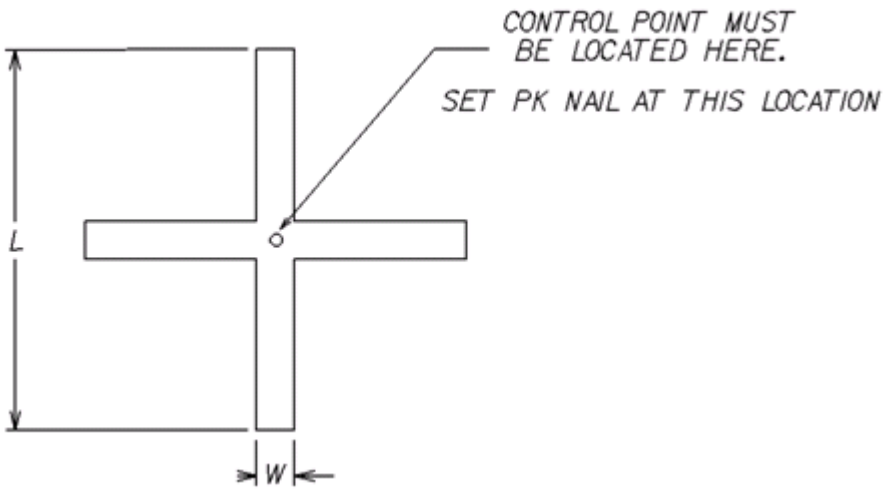


Figure 5-D

"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

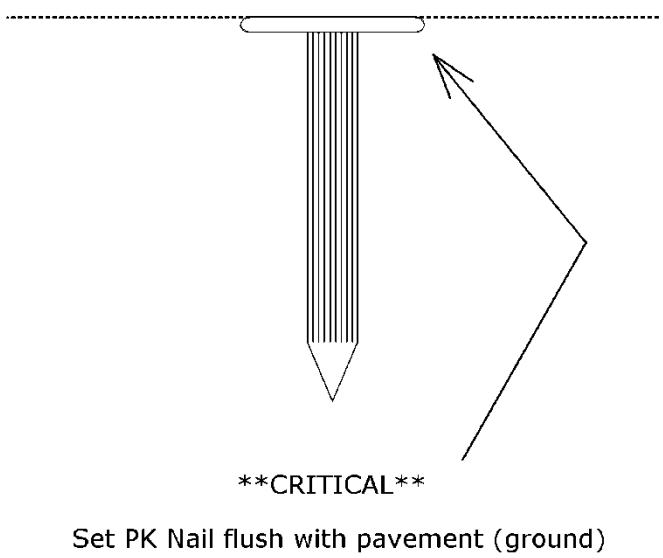


Figure 5-F

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 stereo model. 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**.

B: Set a single target on approximately every other stereo model 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 stereo model, 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**.

- 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.

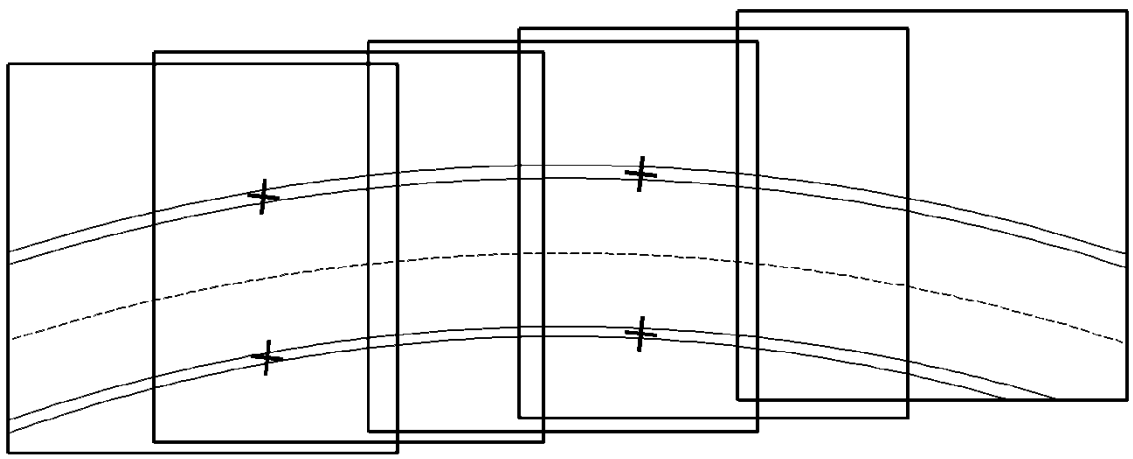


Figure 5-G

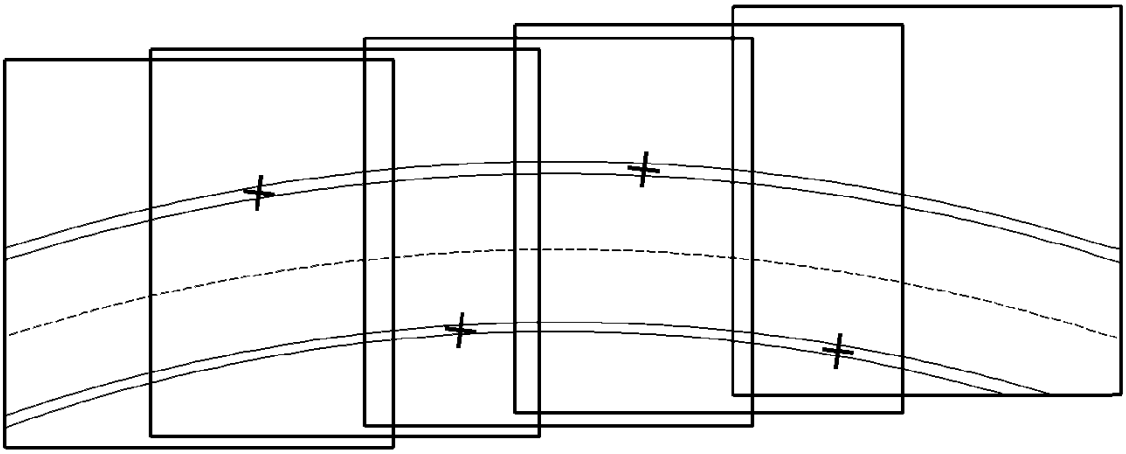


Figure 5-H

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 design 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 "Forms". The form number is **LD-392.**

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

Link: **http://vdotforms.vdot.virginia.gov/SearchResults.aspx?strFormNumber=LD-392**

LD-392
(11-14-13)

VIRGINIA DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN DIVISION
WORK REQUEST FOR AERIAL PHOTOGRAPHY AND MOSAICS

Date of Request: _____ UPC: _____
Route: _____ Activity: _____
State Project: _____ Agency Use 1: _____
UPC Lineage: _____
City/County/Town: _____
From: _____
To: _____
Requested By: _____ Phone/Email: _____

Check intended use of photography: ☐ Design ☐ Study ☐ Other

Contact Person if different than above: _____

Due Date: _____

Note: 1. Provide a Google Earth .kmz and/or Adobe .pdf file, depicting aerial photography coverage desired.

2. All aerial photography will be flown for engineering design scale (1"=25') specifications unless requested otherwise.

3. Provide survey project limits for design grade mapping. Limits should be delivered in a Google Earth .kmz and/or Adobe .pdf file.

Check items desired:

☐ Aerial Photography:
Photo Scale Desired: _____

☐ Mosaic:
Mosaic Scale Desired: _____

☐ Obliques

Remarks: _____
_____
_____

Cc: District Location & Design Engineer
Project Designer
Project Manager

Aerial Photography Coordinator
Photogrammetry Manager

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, located on the ninth floor at 1401 East Broad Street, Richmond, Virginia (*Telephone No. (804) 225-4201 or Telefax No. (804) 786-1788).* Examples of products that can be provided include: contact prints, diapositives, and paper 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 assigned to them 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 and imagery.

For image processing services, and information regarding the Virginia Base Mapping Program (VBMP) orthophotos, please see **Section 5.17**

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 (Aerotriangulation reports and files,* planimetric, utilities, 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 and utility files 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.

* Rev. 4/14

Sec. 5.13 **Aerial Photography Quality Control Procedures**

This section is to be used by all Virginia Department of Transportation (VDOT) personnel and consultants performing and providing aerial photography services for 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 coordinator* will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be reflown.

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 coordinator will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be reflown.

* Rev. 4/14

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 coordinator will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be reflown.

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 coordinator will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be reflown.

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 coordinator will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be reflown.

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 coordinator will be notified, and a determination will be made to accept or reject the photography. If the photography is rejected, the location will be reflown.

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

Sec. 5.14 **Photogrammetry Quality Control Procedures**

This section is to be used by Virginia Department of Transportation (VDOT) personnel and consultants performing and providing Photogrammetric services for 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 and delivery of all Photogrammetric products and services.

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 by the manager or the supervisor as correct.

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 on an analytic or softcopy Photogrammetric instrument. Interior orientation values at each fiducial must be 20 microns or less. 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 (Softcopy Photogrammetry)

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. These values and qualities must be verified by a senior technician or shift supervisor.

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 .1' vertical and .2' horizontal or less for imperial-unit, 1:3000 scale photography. Any point measurement exceeding .1' vertical or .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 Photogrammetrist at VDOT prior to mapping, or as soon as feasible after the start of stereo-compilation work.[*]

[*] Rev. 4/14

Planimetric/Utility Compilation and Editing

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

1. Before starting planimetric and utility compilation, the Photogrammetry technician will verify the following project-specific items and set up their work procedures accordingly:
   - Mapping Limits – delineate in separate Microstation 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.
   - Obscure Areas – if obscure areas have not been collected, delineate them in a separate Microstation file, or annotate on contact prints and submit to shift supervisor for submittal to the appropriate survey personnel. When obscure areas have been collected and delivered from survey, the file must be referenced, tied and merged as appropriate to the Photogrammetry data.
2. During planimetric/utility compilation, the Photogrammetry technician will perform continuous self-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 stereo models, field data, and other Photogrammetry data), and clean appearance of the data (fully edited)
4. Upon completion of the planimetric/utility compilation for each stereo model, all compiled data will be reviewed by the technician that collected the 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 stereo model, and that they require a quality review of the data contained within that stereo model.
6. The senior-level technician or shift supervisor will review and check the planimetric and utilities in the stereo model 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. These revisions will be reviewed by the senior technician or shift-supervisor before final sign-off on the stereo model. 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 stereo model. Steps 2 – 7 must be repeated for each stereo model within the project.

8. After the planimetry and utilities for the entire project have been compiled, edited, and checked as outlined above, the individual stereo model files will be merged (if necessary), and the utility data will be separated (if necessary) into a unique "utility" file. Each file (planimetric 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 supervisor 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.
    - Obscure Areas – if obscure areas have not been collected, delineate them in a separate Microstation file, or annotate on contact prints and submit to shift supervisor for submittal to the appropriate survey personnel. When obscure areas have been collected and delivered from survey, the file must be referenced, tied and merged as appropriate to the Photogrammetry data.
2. During DTM compilation, the Photogrammetry technician will perform continuous self-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 break lines and spot readings
    - Appropriate point spacing and DTM collection technique
    - Thoroughness of collected features
    - Adequate coverage of project area
    - Compatible (appropriately-tied) data (between stereo models, field data, and other Photogrammetry data), and clean appearance of the data (fully edited)
4. Upon completion of the DTM compilation for each stereo model, all compiled data will be reviewed by the technician that collected the 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 stereo model, and that they require a quality review of the data contained within that stereo model.
6. The senior-level technician or shift supervisor will review and check the DTM in the stereo model 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. These revisions will be reviewed by the senior technician or shift-supervisor before final sign-off on the stereo model. 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 stereo model. Steps 2 – 7 must be repeated for each stereo model within the project.
8. After the DTM for the entire project has been compiled, edited, and checked as outlined above, the individual stereo model 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 supervisor 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. Final acceptance of the result will be approved by a shift supervisor, or senior technician.
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, making the mosaic 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. Lastly, the digital ortho mosaic 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 (planimetric 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.

Important note: As referenced in the VDOT Survey Manual (Chapter 12), VDOT requires that engineering design grade Photogrammetric Surveys be performed under direct supervision of a Land Surveyor or Surveyor Photogrammetrist, licensed in the Commonwealth of Virginia. VDOT also requires that the Photogrammetric master survey file be digitally sealed and signed by a Land Surveyor or Surveyor Photogrammetrist licensed in the Commonwealth of Virginia.[*]

[*] Rev. 4/14

Sec. 5.15 **Photogrammetry and Aerial Photography 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 or Digital Camera Imagery*, Flight Map, Current Aerial Camera Calibration Report

Send To: Aerial Photography Coordinator
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, un-annotated, and uncut negatives to VDOT for inspection and annotation. Any contact prints and scanned imagery necessary for completing the Photogrammetry work will be sent to the Photogrammetry consultant upon request, by the VDOT Photogrammetry Unit.

When project circumstances and schedules do not allow sufficient time for the consultant to send the film to VDOT prior to Photogrammetry project startup, the 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 print; dispositive, scan, 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 all Contact Prints with annotated control points (good-quality copies are acceptable). Contact Prints or digital target location map file should have the mapping limits annotated.

Send To: State Photogrammetry Engineer
VDOT
1401 East Broad Street, Room 907
Richmond, VA 23219

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

Notes: Photogrammetry consultants will be expected to submit the aerotriangulation report and electronic data files by VDOT FTP server, regular mail, fax, or email. Contact prints or digital imagery are to be sent by regular mail.

Aerotriangulation reports and electronic files are to include the following information:

1) VDOT Project and UPC 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)
9) Complete set of as-flown photo center coordinates in text format.*
10) For digital camera, additional deliverables include camera system project files, exterior orientation data, ground sampling distance/resolution, flight strips/images index, and target location map.

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.

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The following Photogrammetric Aerial Deliverables document will be included with all new aerial project requests:*

Post-Aerial Flight Deliverables Check List

Date of Request: _____ UPC: _____
Route: _____ Activity: _____
City/County/Town: _____

Consultant Responsibilities

A. Prime consultants will perform full QA/QC on all aerial photographic deliverables before providing to VDOT

B. Prime consultant will perform field and Photogrammetric Aerotriangulation QA/QC on survey control deliverables (if included as a task), before providing to VDOT. Include GPS Control Deliverables as referenced in VDOT Survey Manual and in the document ***VDOTProjectDeliverables.docx.*** Also include Photogrammetric Aerotriangulation QA/QC residual reports as referenced in **Section 5.15** of the VDOT Survey Manual.

C. Un-annotated, processed, aerial negative film or *digital sensor imagery* files delivered.

D. Flight folder and maps returned.

E. 1. Post-Flight Reports (Logs) including:

- Flying height, altitude, scale and *ground sampling distance (GSD)*
- Direction of flight for each flight line.
- Numbering order of photography frames.
- Current USGS Calibration Report for film cameras
- Applicable calibration report for *digital sensor* including internal camera parameters.
- "Actual" photo center X, Y coordinates for all frames/strips (Virginia State Plane).

F. Also required for *digital sensor imagery*:

- Number of bands in imagery.
- Bit-depth of deliverable imagery.
- Exterior orientation data.
- ISPM/ISAT project electronic files for DMC digital cameras

G. QA/QC performed ASAP. Check that the produced photos are what was ordered. Also include, but limited to: forward overlap (62% desired), crab, drift, side stepping, film or imagery contrast, brightness, sharpness, debris, etc.

H. VDOT will provide consultant with letter of acceptance/rejection of aerial photography, survey control, and Photogrammetric Aerotriangulation.

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Deliverable: Orthophotos and File Index
Send To: State Photogrammetry Engineer
VDOT
1401 East Broad Street, Room 907
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 or placed on VDOT FTP server. 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 airborne LIDAR capabilities and relies on the consultant community for all airborne LIDAR services.

VDOT does have limited terrestrial (ground-based) LIDAR capabilities for projects less than one mile in length. Terrestrial LIDAR can be used for location studies and any other preliminary engineering projects.*

* Rev. 4/14

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 break lines 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. Break lines are to be added by Photogrammetry along all pavement, ditches, ridges, valleys, streams, edges of water and any other significant surface feature that would require a break line for proper definition.

Note: LIDAR data is ***not*** to be used for any location survey unless written approval is given by the State Survey Program Manager or the State Photogrammetry Manager.*

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 Program Manager or the State Photogrammetry Manager.

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 break line compilation, quality control of LIDAR data, orthophoto generation, and planimetric compilation.
5. Filtering/data-editing of LIDAR mass points.
6. Photogrammetric quality control of LIDAR data and addition of break lines.
7. Orthophoto generation.
8. Quality review and assurance of all products.
9. Delivery of final products to VDOT.

* Rev. 4/14

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 (Break lines and points)	50MB*
Contours	2D Microstation - Contour interval as required. - Provide edge-to-edge match between "cut" contour files, **No Overlap**	100MB
Planimetrics *(When required)*	2D Microstation - Provide edge-to-edge match between "cut" planimetric files, **No Overlap**	50MB
Orthophotos *(When requested)*	Un-tiled GeoTiff (.tif and .tfw) <OR> Descartes (.hmr) - Provide edge-to-edge match between "cut" orthophoto files. **No Overlap** - File format will be determined by the project manager.	500MB
Index	2D Microstation - File indicating the area of coverage and filenames for all files/sheets in each deliverable category.	50MB

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

* Rev. 4/14

Sec. 5.17 **Image Processing**

Image Processing can be defined as the editing, manipulation, and modification of imagery in order to prepare the imagery for subsequent use. For VDOT use, imagery can be processed for numerous applications within Location and Design as well as many other divisions. Such applications include many of the same as for traditional aerial photography, but are not limited to: project scoping, public hearings, right-of-way claims, and project delineation, aerial photography mission planning, survey control diagrams. Imagery can be formatted for use on the primary VDOT graphics applications, in most any coordinate system and file format.

In response to increased demands for imagery (orthophotos, mosaics, etc.), the Photogrammetry Section has increased its image processing services and capabilities. VDOT has a large archive of color, and black and white aerial photography that can be converted into digital format. Rectified or non-rectified photos and mosaics can be generated from the aerial photography, and with the incorporation of a digital terrain model during processing, orthophotos can also be generated.

The Virginia Geographic Information Network (VGIN) developed the Virginia Base Mapping Program (VBMP) in 2002, which produced digital, color orthophotos at varying resolutions covering the entire state of Virginia. VDOT has procured a license to utilize the VBMP imagery. These images are updated every 2 to 4 years and are available for VDOT use on VDOT projects. The license agreement contains restrictions on the use of the imagery and users must understand and follow these restrictions.

To order VBMP imagery, complete a "Virginia Base Mapping Program Imagery Request Form" (LD-393, located at the end of this section). Also provide a location map (topographic map, Adobe .pdf, Google Earth .kmz, or other detailed project map)* indicating the area of desired coverage. Submit the form and map to the Photogrammetry Unit at Central Office (email submittals are acceptable and encouraged). If the imagery will be used by a consultant performing work on any VDOT project, the VDOT project manager and the consultant must complete a VGIN contractor's agreement and submit the completed agreement along with the imagery request form and annotated map.

All users of the VBMP imagery must read, understand, and abide by the license agreement, and the restrictions associated with imagery usage. For more information regarding the VBMP imagery, the contractor's agreement, or to request non-VBMP image processing services, contact the State Photogrammetry Manager or the Photogrammetry Unit's Image Analyst.

Additional VGIN/VBMP information available at the link:
http://www.vita.virginia.gov/isp/default.aspx?id=8412

Note: Copyright laws are in effect for current VBMP imagery.

* Rev. 4/14

Link: http://vdotforms.vdot.virginia.gov/SearchResults.aspx?strFormNumber=LD-393

LD-393
(11-20-12)

DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN DIVISION
IMAGERY REQUEST FORM

FOR VGIN COLOR ORTHOPHOTOGRAPHY

Date of Request: _____
UPC: _____ Project Number: _____
Activity Number: _____ Project Location (City/County, etc.): _____
Requested By: _____
Telephone Number: _____
Intended use of Imagery: _____
VDOT Personnel using the Imagery: _____

Has the person making this request read the L&D user instructions and the VBMP license agreement? If NO, this must be completed before requesting imagery. YES ____ NO___

Will this imagery be distributed to consultants or other non – VDOT person/entity? If YES a contractor's agreement must be received before imagery is released. YES___ NO___

Date Needed: _____

Image Format:
___ MrSid
___ GeoTiff (.tif)
___ Descartes/Micorstation (.hmr)

Coordinate System:
___ VDOT Project Coordinates County Scale Factor: _____
___ Virginia State Plane-North Zone
___ Virginia State Plane-South Zone

ALL DATA IS PROVIDED "AS IS". THE COMMONWEALTH OF VIRGINIA, THE VIRGINIA GEOGRAPHIC INFORMATION NETWORK AND THEIR RESPECTIVE OFFICERS, AGENTS AND EMPLOYEES JOINTLY AND SEVERALLY DISCLAIM ANY AND ALL REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED, WRITTEN OR ORAL, IN FACT OR ARISING BY OPERATION OF LAW, INCLUDING ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY, CURRENCY, COMMERCIAL VALUE, OR FREEDOM OF DATA FROM INFRINGEMENT OF ANY THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

CC: District Location & Design Engineer
Project Manager
Project Designer

CHAPTER 6

*Metes and Bounds SURVEYS

Chapter Contents

Sec. 6.01	***Metes and Bounds Surveys**

* Rev. 7/15

Sec. 6.01 [*]**Metes and Bounds Surveys**

A metes and bounds 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 *property owned by U.S. Government, State Agencies, National Forest Services, Railroad Companies, and Power Companies (Dominion VA Power), a metes and bounds survey is required. **See Section 4.08 and the Right of Way Manual of Instructions Sections 5.6.6-5.6.9**. These surveys will be prepared by computer-aided drafting techniques (CADD). 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 Party Manager or Consultant, 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 construction centerline or baseline of adjoining or nearby projects and the existing right-of-way, whether owned in fee or as an easement or dedication, *shall be 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.

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)**. When a part of the boundary line is a curve, the central angle, length of chord, chord bearing, delta, length of curve and radius of the curve must be shown in the CADD file. Areas greater than or equal to 1 acre will be shown in acres to 3 decimal places (x.xxx). Areas less than 1 acre will be shown to square feet (x,xxx).

A closed-loop traverse shall be *completed in the field 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 CADD file 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 (State Survey Program Manager), along with the CADD files and a legal description. Any legal description written will commence at the nearest offset point with the lowest stationing off the construction centerline thence clockwise around the parcel. If the construction centerline is not available, an easily identified, unique point will be chosen as a point of beginning and the courses will run in a clockwise direction.

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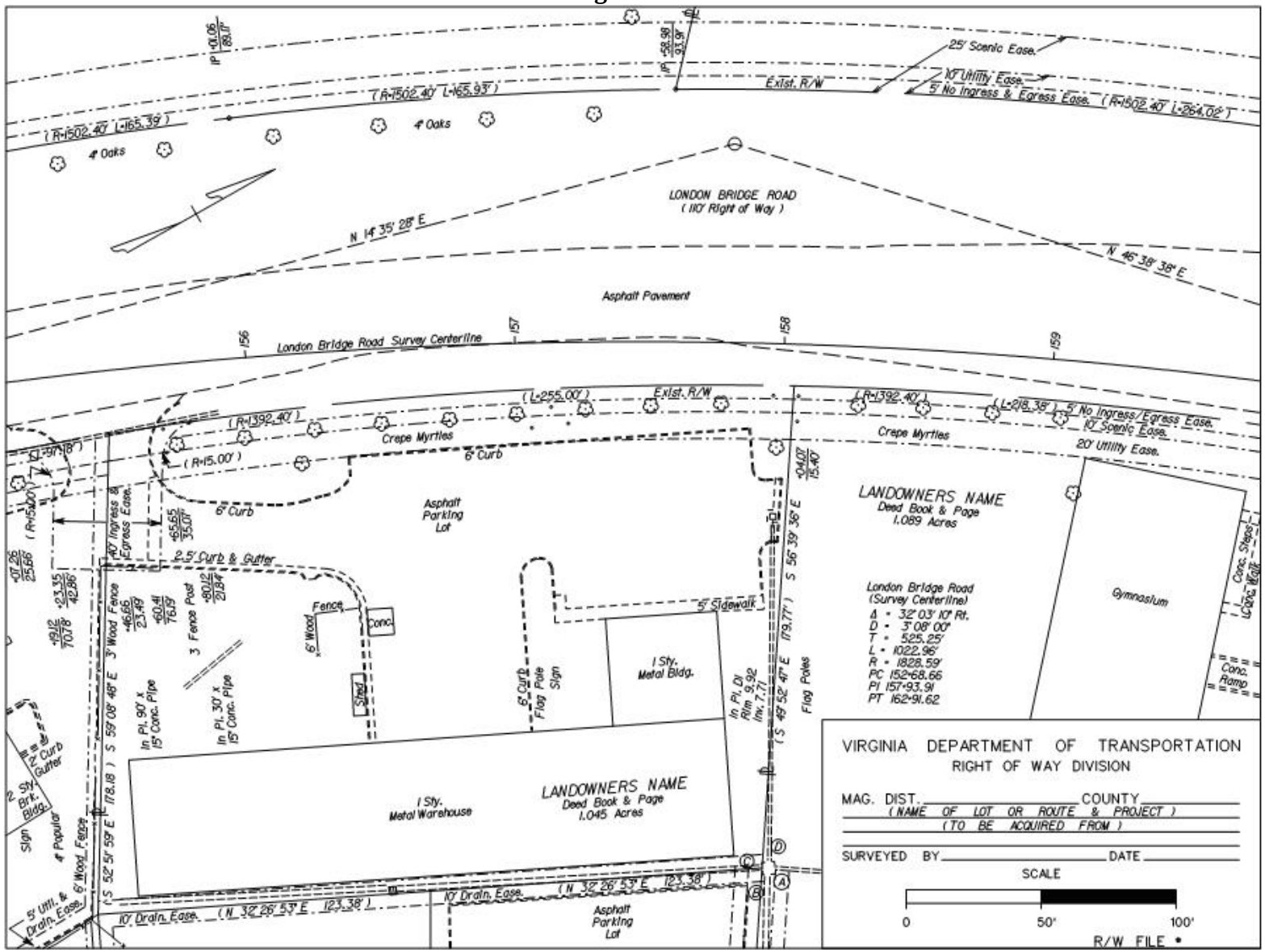
[*] Rev. 7/15

Figure 6-A


25' Scenic Ease.
10' Utility Ease.
5' No Ingress & Egress Ease.
Exist. R/W
4" Oaks
LONDON BRIDGE ROAD
(110' Right of Way)
N 14° 35' 28" E
N 46° 38' 38" E
Asphalt Pavement
London Bridge Road Survey Centerline
Crepe Myrtles
6" Curb
Asphalt Parking Lot
2.5' Curb & Gutter
5' Sidewalk
LANDOWNERS NAME
Deed Book & Page
1.089 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
20' Utility Ease.
10' Scenic Ease.
1 Sty. Metal Bldg.
1 Sty. Metal Warehouse
LANDOWNERS NAME
Deed Book & Page
1.045 Acres
10' Drain. Ease.
Flag Poles
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

CHAPTER 7

HYDRAULIC SURVEYS

Chapter Contents

Sec. 7.01	Introduction
Sec. 7.02	General
Sec. 7.03	Topographic Features
Sec. 7.04	Channel Characteristics
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Sec. 7.09	Major Structures Over Waterways
Sec. 7.10	Environmental Data
Sec. 7.11	Bridge Data Sheets (Form LD-23)
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 Manager 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 Structure & 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. Existing fee right-of-way, property line data and prescriptive easements will be shown on all hydraulic and drainage structures, or bridges surveys.*

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 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.

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* Rev. 3/14

In the case of a location paralleling a railroad, secure all information required above for a location paralleling an existing road. Right of entry must be secured to survey on railroad property.

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 may extend a considerable distance upstream in streams with relatively flat slopes. Structures, features, and buildings that may be affected by backwater should be located and elevations collected on the finished floors of buildings.

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, wash lines 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 500 feet ± upstream and downstream of the anticipated right-of-way line. The DTM should be taken at intervals not to exceed 50 feet **(50 ft)** and should extend each way from the existing 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. 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 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 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**

The survey manager or supervisor shall meet with the hydraulic design unit, the bridge design unit, and roadway designer to determine the topographic, DTM, contour, and profile needs. The bridge site survey will use a combination of the sUPC, suUPC, scrUPC, sbUPC, and as necessary the spoUPC file, which the bridge designer can plot as he or she desires. The survey section will not provide a 1" =10' bridge situation file on grid. The topography, contours, and profiles files will be provided so they can be appropriately referenced together in Microstation. LD-23 document will be in a separate document file. 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 District 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 District 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 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. **Consultation between the District Hydraulic Unit and the District Survey Manager is required and will be documented 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 Data**

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

1. Title Block - Route, Project, Date, Legend, Utility Owners, etc.
2. The profiles of the site area will be plotted under the site plan unless modified, if modified the profiles will be plotted to the right of the location survey.
3. 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.
4. Flood plain cross-sections, when necessary, will be plotted to the right of the stream centerline and grade separation profiles.
5. Sketches, when needed, will be plotted to the right of the flood plain cross-sections and/or stream traverse profiles.
6. Sketches or photos will be placed in a separate file.

Contours (Option 1) - the contours or DTM's should be extended along the existing roadway 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 or DTM's 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 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 (— — · · · — —)(custom line style WA). 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 existing roadway 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 be plotted to a scale of one inch equals ten feet (1”=10’) both vertically and horizontally.

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 Party Manager 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 DTM 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.

Stream Traverse sbUPC#.dgn- 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 site, 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. 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.

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 and saved in Falcon. 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 in the sUPCb#.dgn 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 in the sUPCb#.dgn file. 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)**

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 7-A.**

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 Party Manager 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.

LD-23 Figure7-A

Link: http://vdotforms.vdot.virginia.gov/SearchResults.aspx?strFormNumber=LD-023

LD-23
(3-20-07)

DEPARTMENT OF TRANSPORTATION
LOCATION AND DESIGN
STRUCTURE AND BRIDGE DATA SHEET

Project: _____ City/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

CONSTRUCTION SURVEYS

Chapter Contents

Sec. 8.01	General
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Sec. 8.01 **General**

Construction surveys shall be made in accordance with the **General Provision in Section 105.13 & 517** of the Road and Bridge Specifications and the **Construction Manual** with its corresponding sections.

The Contract Surveyor or District Survey Manager (whichever is performing the stakeout) should become familiar with the plans, Road and Bridge Specifications, and contract prior to the Pre-Construction Conference so any concerns can be addressed at that meeting.

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

Sec. 8.02 **Alignment**

The construction centerline shall be established using the alignment data sheet and the established coordinate values that are included in the plan set. All control points used during construction stakeout should be referenced and recorded for future use. Any discrepancies in the construction alignment should be brought to the immediate attention of the project inspector.

All notes relative to the retracing of the plan alignment shall be recorded in the digital, ASCII file, 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)**. For marking centerline and reference stakes, please see **Figure 8-I**.

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

Project benchmarks are shown on the alignment data sheet in the plan set. These benchmarks should be checked prior to their use in stakeout. Differential leveling should be run between benchmarks and recorded in field notes. Any appreciable differences in benchmark elevation should be recorded in field notes and check levels should be run to verify the difference. The project inspector should be notified of the discrepancies so he can notify the District Survey Manager. If additional benchmarks are set on the project, a list of these benchmarks with a description and elevation should be given to the project inspector and contractor. For examples of level notes see **Figures 8F, 8G, and 8H**.

Sec. 8.04 **DTM's**

DTM's will not be required on plan quantity projects. Of the majority of projects currently designed, regular excavation is plan quantity. For those projects that are designed as non-plan quantity, then original ground DTM's will need to be secured during the slope stake process. These will be done so accurate excavation quantities can be computed for the project. In these rare instances, the District Survey Manager can be contacted for proper procedures in securing DTM's.

The Department 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 accurately and more cost-effectively using a DTM than by the traditional field cross-section methods. DTMs are acceptable to VDOT for determining volumetric information.

There have been occasions when ground elevations have changed in certain areas on construction projects. In preparation for slope staking, sufficient checks should be made throughout the project to verify original ground elevations. If any areas are found that have appreciable variations in ground elevations within the project limits then the project inspector should be notified and DTM's should be secured in those areas to provide for computations of accurate quantities. If DTM's are to be used then the District Survey Manager should be contacted by the project inspector to make sure that the electronic format that the surveyor uses in securing this information is compatible with the Department software. DTM's will be based on plan elevations and coordinate values or electronic DTM file shall be given to the project inspector so he can give this information to the Design Section so new quantities can be computed.

Cross Sections are no longer used in construction surveys. **In lieu of securing cross-section information, a DTM surface is the accepted VDOT format for determining volumetric and grading information. I case of emergency or a special situation, cross sections can be requested. (Figures 8-A & 8-E)**.

After centerline elevations have been secured and checked where necessary, DTM's shall be secured at all stations, intermediate intervals and at all appreciable breaks in the ground. In all cases, the DTM's shall be based on the plan construction centerline.

DTM surfaces have made cross sections on multiple alignments obsolete. An adequate DTM surface with points and break lines will suffice.

Sec. 8.05 **Borrow Pits**

Borrow pits will be surveyed by VDOT survey crews, but the Survey Party Manager (Land Surveyor) should encourage the contractor to have his personnel or hire a survey crew to check behind the Department. Discrepancy in borrow quantities will not be considered unless supporting survey data was obtained by contractor to substantiate the claim.

If borrow material is shown on the plans, the Project Inspector should contact the District Survey Manager when the borrow pit location has been approved and properly prepared. All borrow pits shall have DTM's collected using the elevation of a benchmark shown on the plans if possible, if not, then a minimum of two benchmarks should be set and assumed elevations may be used. A diagram of all borrow pits shall be shown in the borrow pit notebooks or digital file 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. 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 DTM's.

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.

Borrow Pits will be surveyed by creating a digital DTM surface. DTM's are used to secure elevations, then an appropriate number of control stations should be used to insure the integrity of the pit and readings should be secured at appropriate intervals in insure accurate coverage for computations of volume.

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, ascii file or digital file whether borrow pit data was 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. (This paragraph should be added to second paragraph.)

According to the Road and Bridge Specifications Section 303.04 (b) the borrow excavation areas shall be bladed and left in a shape to permit accurate measurements for finals.

Sec. 8.06 **Culvert Stakeout**

All box culverts are to be staked, according to furnished alignment and grades. The Contract Surveyor 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 Contract Surveyor is to immediately notify the District Survey Manager 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** illustrates a procedure for checking the stake out of a box culvert. **All culverts will be staked in accordance with Section 105.13 and 517 and Figure 1 .**

All pipe culverts, 48"and larger, and all culverts with design grades, are to be staked in accordance with Section 105.13 & 517 Road and Bridge Specifications. All pipe culverts less than 48" will be staked by contract personnel.

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

Sec. 8.07 **Bridge Stakeout**

The Contract Surveyor should check the consistency between the stations and the dimensions given on the bridge plans. If any difference is found, the Contract Surveyor should immediately notify the District Survey Manager and the District Structure & 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 Contract Surveyor is to set stakes at the intersection of the baseline of the bridge and the centerline of each pier. Also, stakes shall be set 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 105.13 and 517, Figure 8J, and Figures 2 & 3 .**

All measurements of distances and angles are to be checked thoroughly by the Contract Surveyor using a different method than that used initially.

After completing the stakeout and thoroughly checking the same, the Contract Surveyor shall locate in red pencil on the layout sheet of the bridge plans used by the Project Inspector, and Contractor's Superintendent 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 Contract Surveyor 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 Contract Surveyor 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 in accordance with the latest standards. The correct method of marking and setting slope stakes is shown in **Figure 8-K**. 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 Manager 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 or GEOPAK is secured as considerable time and effort can be saved with its use.

If slope staking is performed by data collection stakeout software, then electronic files may be submitted in place of notebooks. However any electronic file submitted would need to contain the same information that the slope stake notebooks contain. Such as the catch point information (distance, elevation, cut/fill) and the offset point information (distance, elevation, cut/fill). Anything less than this will be unacceptable, and in this case the slope stake information would need to be transferred into a notebook in the same format as discussed above.

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 with 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 VDOT Surveyor as shown in Section 105.13 and 517 of the Road and Bridge Standards. Standard RM-2 monuments will be set by the VDOT Survey Personnel or Consultant 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 VDOT or Contract Surveyor 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 105.13 and 517 and Figure 4 .**

Sec. 8.11 **Federal and Non-Federal Aid State Force Account Projects**

Construction surveys for these type projects shall be made in accordance with the **General Provision in Section 105.13 and 517** of the Road and Bridge Specifications and the **Construction Manual** with its corresponding sections.

Sec. 8.12 **No-Plan Projects**

No-plan projects typically require very limited survey effort and this is addressed in the contract by copied note "c105a0b-0702".

Sec. 8.13 **Minimum Plan Projects**

Minimum Plan projects are either covered by Section 105.13 and 517 of the Road and Bridge Specifications or in the contract by Special Provision c105a0b-0702.

Sec. 8.14 **Condemnation Staking**

Condemnation stakeouts will be performed by the Department and are not to be performed by the Contract Surveyor for the project.

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

Sec. 8.15 **As-built Plan of Right-of-way Monumentation**

On projects where right of way monumentation is a plan quantity, an "As-Built" plan needs to be submitted.

Once construction has been completed and all R/W monumentation has been set, the VDOT Surveyor is responsible for an "As-built" survey of the right of way as required in Section 105.13 and 517 of the Road and Bridge Specifications. An example of what survey information is expected in the completed "As-Built" drawing is shown in Chapter 8, **Figure 4.**

Sec. 8.16 **Submitting Survey Data**

As soon as the project is complete the Contract Survey should submit all survey notes, electronic files, and required "sealed" drawings to the Project Inspector. This information will be reviewed by the District Survey Manager, and upon his approval that the survey information submitted meets all requirements, he will recommend to the Resident Engineer whether final payment should be made or if additional information should be required.

Figure 8-A

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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				

■ RRPC I.P. 241.16

■ RRPC I.P 190. 10

■ R.M. 2 Set 6-4-86

WBL

■ R.M. – 2 Set 6-4-86

■ RRPC I.P. 156. 43

■ RRPC I.P. 180. 05

EBL

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

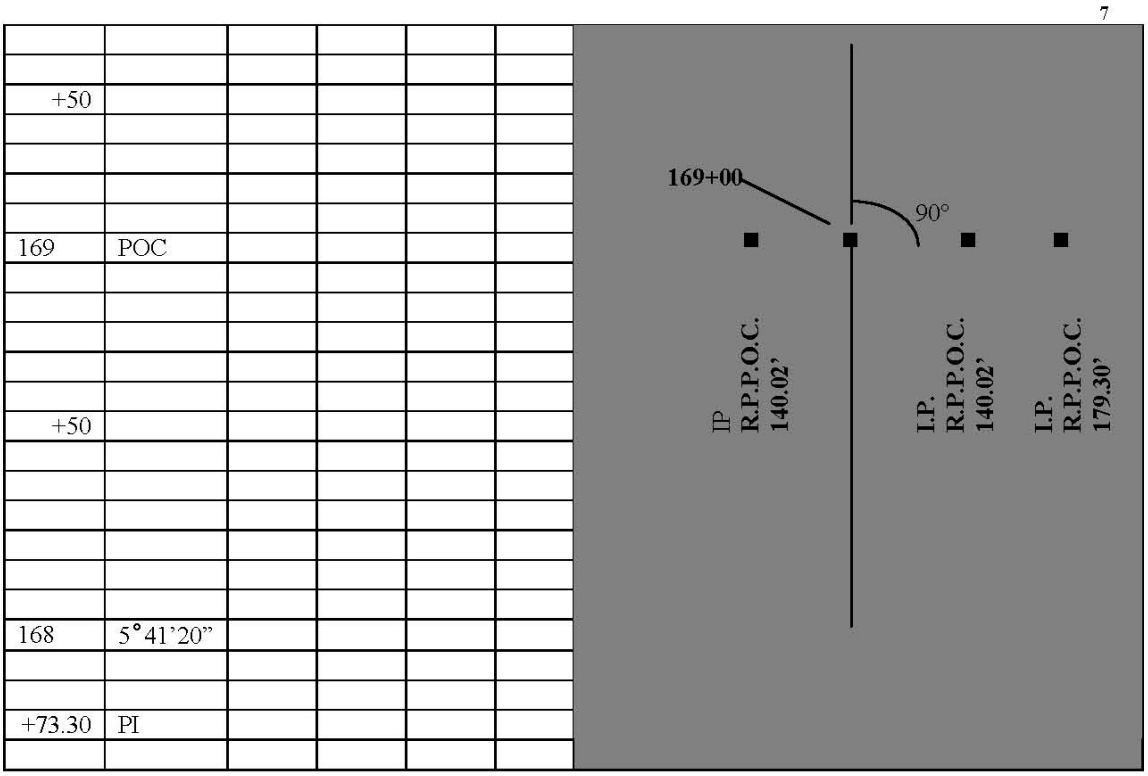

7
+50
169
POC
+50
168
5°41'20"
+73.30
PI
169+00
90°
IP
R.P.P.O.C.
140.02'
I.P.
R.P.P.O.C.
140.02'
I.P.
R.P.P.O.C.
179.30'

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

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		
	SOF = +0.4						C32.3	C30.6	11.9		98.9	C14.1		C13.4	
164	SOC = +0.4			6. 5	2498.1	2477.88	C32.7	08.9	+13.8		98.1	90. 1		C12.36	
	SIF = -1. 3						10.6	3.0	98.1		0.8	8. 0		90. 2	
	SIC = 1. 1						86.2	76.2	-0.8			59. 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		
	SOF = 0.0						C29.9	15.2	09.2		99.2	C15.0		C13.6	
	SOC = +0. 1						08.2	07.2	+10.8		98.4	92.2		C12.6 CL	
+50	SIC = -1. 0			4. 8	2498.4	2478.17	7.0	08.0	98.4		+0.8	7.0		90.8	
	Sh = 0. 5						75.2	-1.2	-0.8			61.0		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	3		
	Sh = 0. 1						C 30. 0		10. 5		00. 5				
							C 29. 8 CL	C28. 6	+ 10. 6			C 14. 8		C 13. 6	
	SOF = -0.04						08. 3	06. 9	99. 9		99. 9	92 . 5		C 12. 8 CL	
163	SOC = -0. 2			3.3	2499.9	2478.47	2. 2	3. 6	- 0. 6		0. 6	8. 0		91 . 3	
	SIF = 1. 0						83 . 2	73. 2				60. 6		70. 6	
	SIC = - 0. 8														
	Sh = 0.0														
								STD	05. 8		98. 8				
+50	SOF = -0.6			5.6	2497.6	2478.82	C 23. 9	C 23. 3	+ 8. 2			C 12. 6		C 11. 1	
	SOC = -0.4						02. 7	02. 7	97. 6		97. 6	89. 9		89. 9	
	SIF = -1.0						3. 1	3. 7	1. 2		1. 2	7. 4		8. 9	
	SIC = - 0. 8						78. 0	68. 0				57. 7		67. 7	
+31.23	T.S.														
T. P.	8. 41	2503. 15	0. 72		2494.74										
		2495. 46													

Figure 8-G

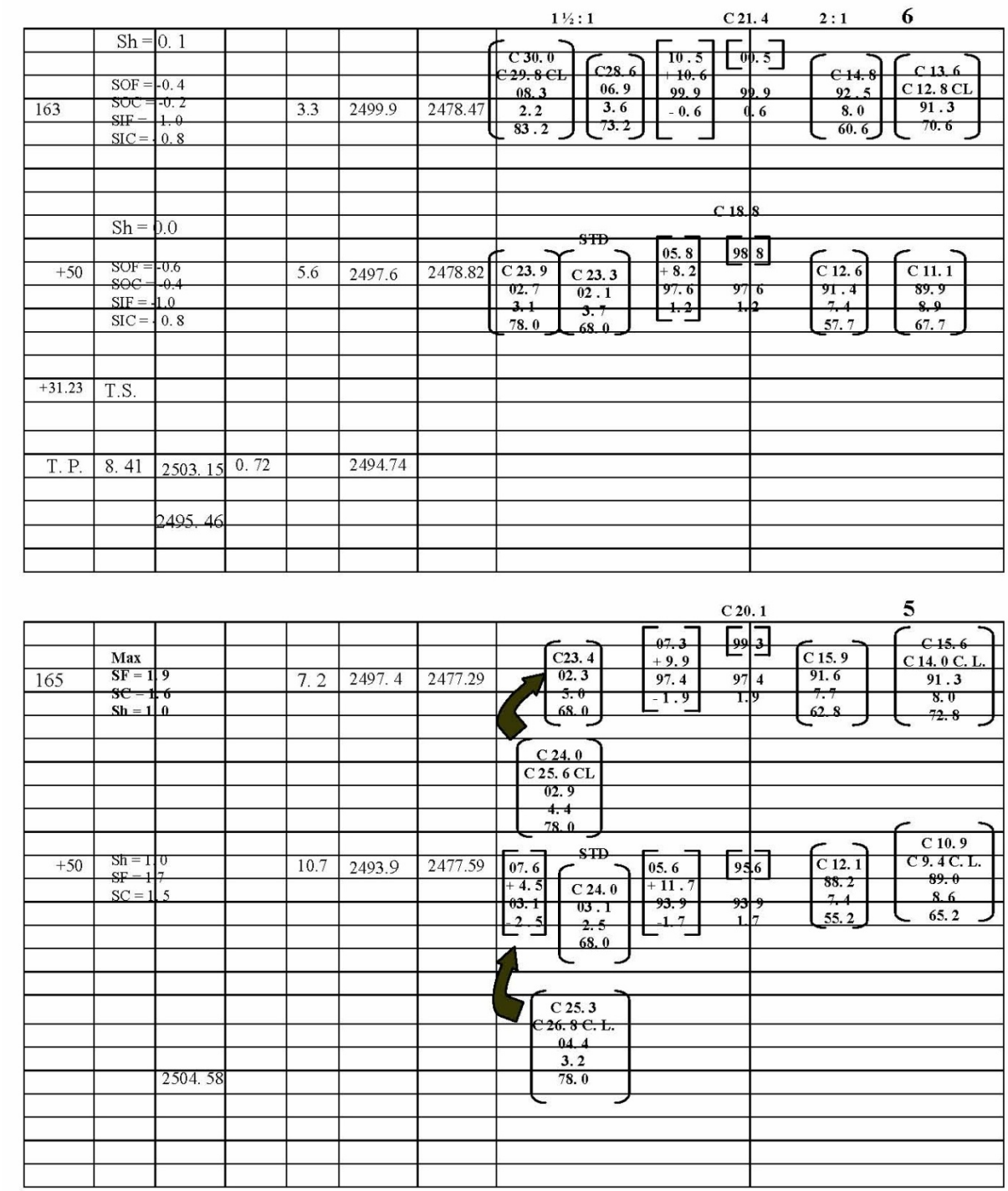

1 ½ : 1
C 21. 4
2 : 1
6
Sh = 0. 1
SOF = -0. 4
SOC = -0. 2
SIF = -1. 0
SIC = -0. 8
163
3.3
2499.9
2478.47
C 30. 0
C 29. 8 CL
08. 3
2. 2
83. 2
C28. 6
06. 9
3. 6
73. 2
10. 5
+ 10. 6
99. 9
- 0. 6
09. 5
99. 9
0. 6
C 14. 8
92. 5
8. 0
60. 6
C 13. 6
C 12. 8 CL
91. 3
70. 6
C 18. 8
Sh = 0.0
STD
05. 8
+ 8. 2
97. 6
1. 2
98. 8
97. 6
1. 2
+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. 1
3. 7
68. 0
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
5
Max
SF = 1. 9
SC = 1. 6
Sh = 1. 0
165
7. 2
2497. 4
2477.29
C23. 4
02. 3
5. 0
68. 0
07. 3
+ 9. 9
97. 4
- 1. 9
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 24. 0
C 25. 6 CL
02. 9
4. 4
78. 0
STD
+50
Sh = 1. 0
SF = 1. 7
SC = 1. 5
10.7
2493.9
2477.59
07. 6
+ 4. 5
03. 1
- 2. 5
C 24. 0
03. 1
2. 5
68. 0
05. 6
+ 11. 7
93. 9
-1. 7
95.6
93. 9
1. 7
C 12. 1
88. 2
7. 4
55. 2
C 10. 9
C 9. 4 C. L.
89. 0
8. 6
65. 2
C 25. 3
C 26. 8 C. L.
04. 4
3. 2
78. 0
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	St.
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

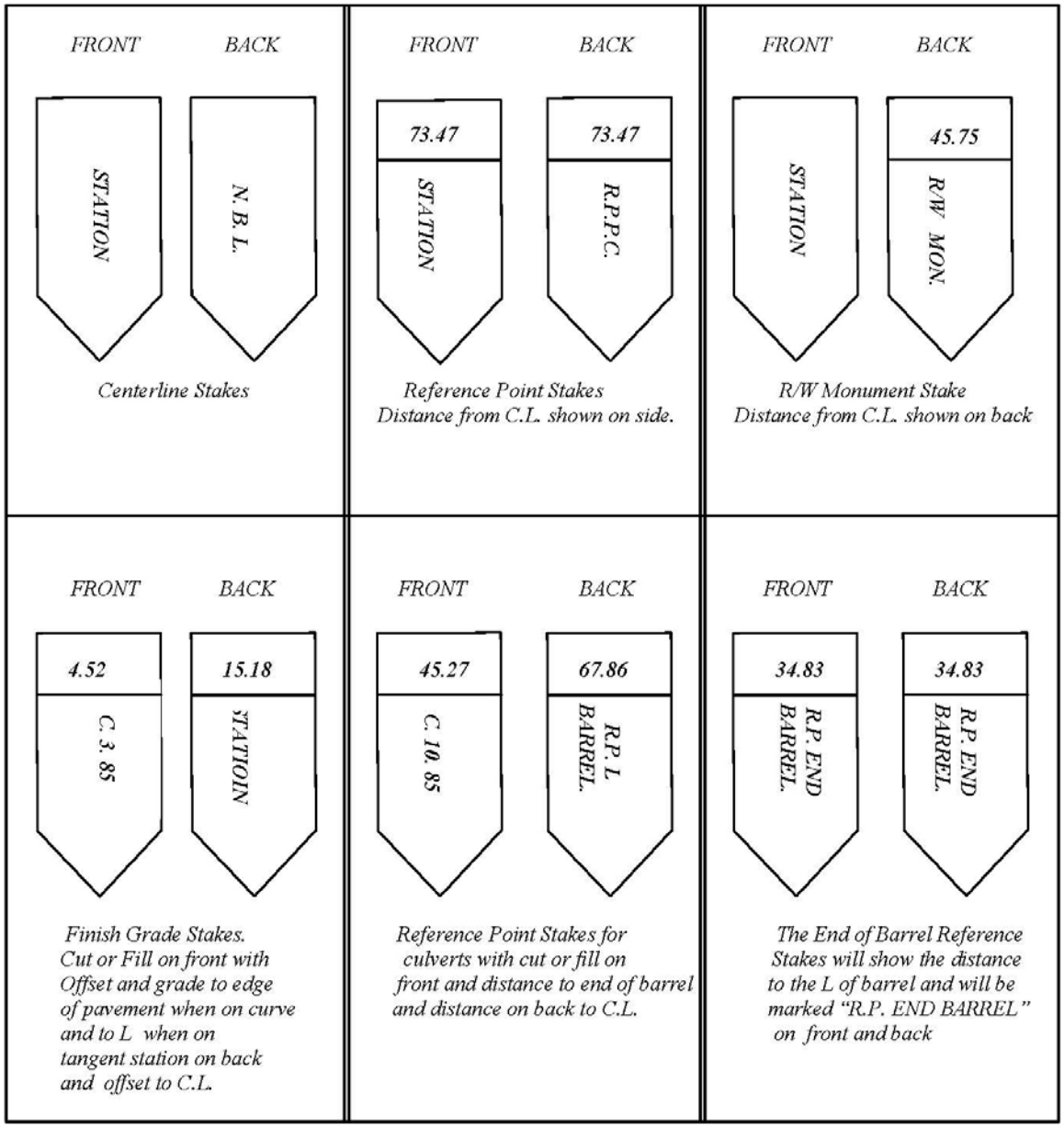

FRONT
BACK
STATION
N. B. L.
Centerline Stakes
FRONT
BACK
73.47
STATION
73.47
R.P.P.C.
Reference Point Stakes
Distance from C.L. shown on side.
FRONT
BACK
STATION
45.75
R/W MON.
R/W Monument Stake
Distance from C.L. shown on back
FRONT
BACK
4.52
C. 3. 85
15.18
STATIOIN
Finish Grade Stakes.
Cut or Fill 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.
FRONT
BACK
45.27
C. 10. 85
67.86
R.P. L
BARREL.
Reference Point Stakes for
culverts with cut or fill on
front and distance to end of barrel
and distance on back to C.L.
FRONT
BACK
34.83
R.P. END
BARREL.
34.83
R.P. END
BARREL.
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

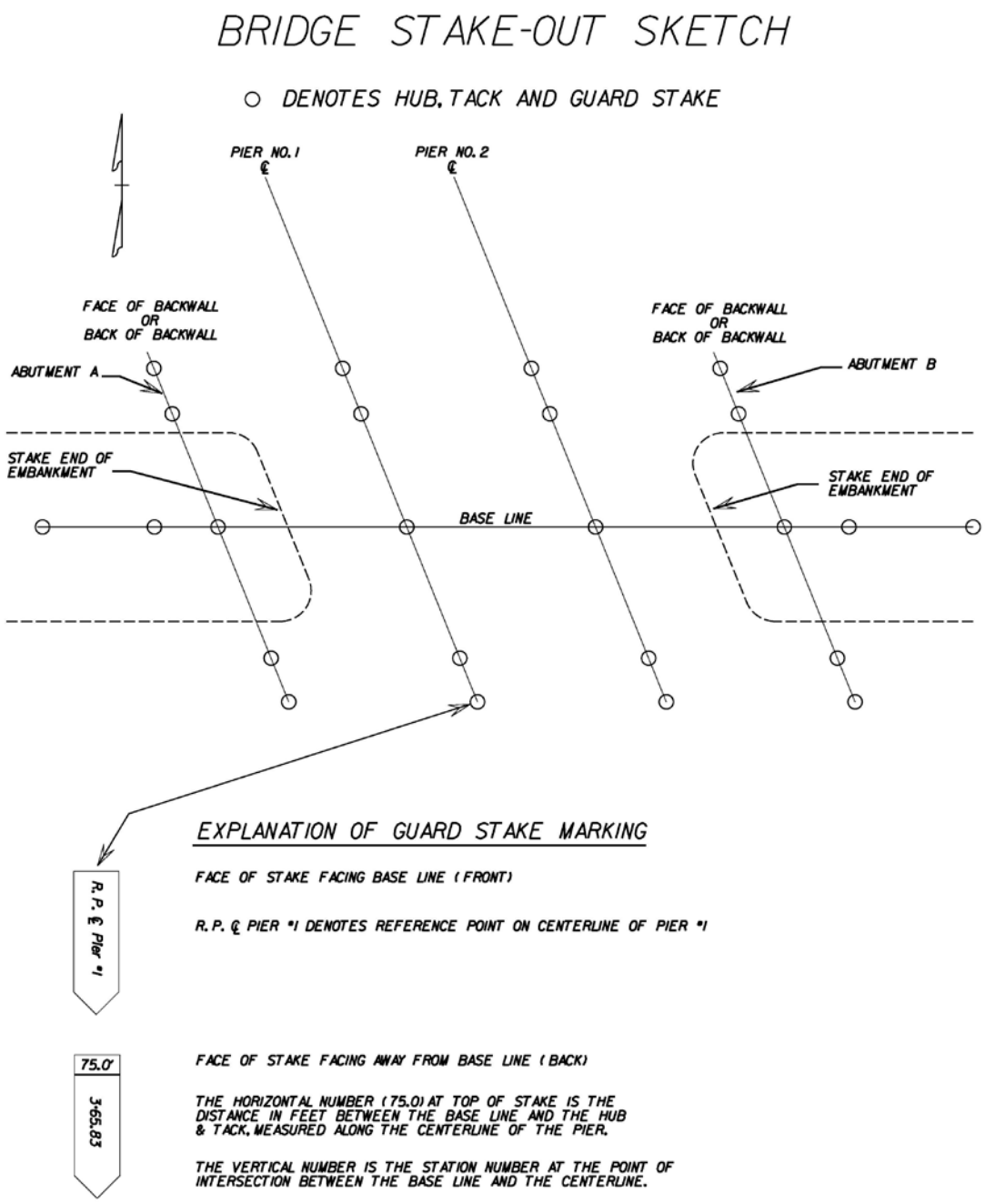

BRIDGE STAKE-OUT SKETCH
○ DENOTES HUB, TACK AND GUARD STAKE
PIER NO. 1 ℄
PIER NO. 2 ℄
FACE OF BACKWALL OR BACK OF BACKWALL
FACE OF BACKWALL OR BACK OF BACKWALL
ABUTMENT A
ABUTMENT B
STAKE END OF EMBANKMENT
STAKE END OF EMBANKMENT
BASE LINE
EXPLANATION OF GUARD STAKE MARKING
R. P. ℄ Pier #1
FACE OF STAKE FACING BASE LINE (FRONT)
R. P. ℄ PIER #1 DENOTES REFERENCE POINT ON CENTERLINE OF PIER #1
75.0'
3+65.83
FACE OF STAKE FACING AWAY FROM BASE LINE (BACK)
THE HORIZONTAL NUMBER (75.0) AT TOP OF STAKE IS THE DISTANCE IN FEET BETWEEN THE BASE LINE AND THE HUB & TACK, MEASURED ALONG THE CENTERLINE OF THE PIER.
THE VERTICAL NUMBER IS THE STATION NUMBER AT THE POINT OF INTERSECTION BETWEEN THE BASE LINE AND THE CENTERLINE.

Figure 8-K

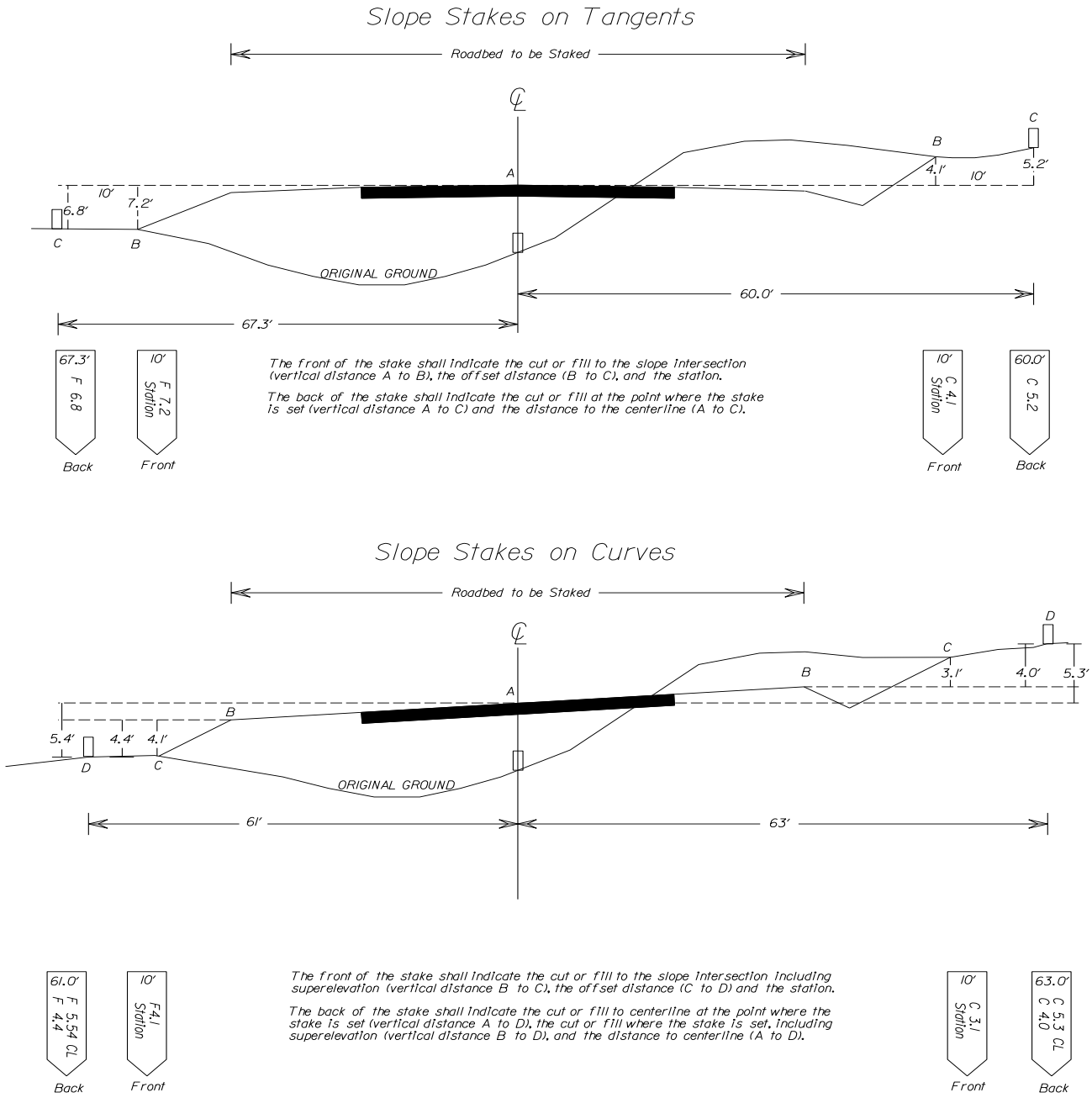
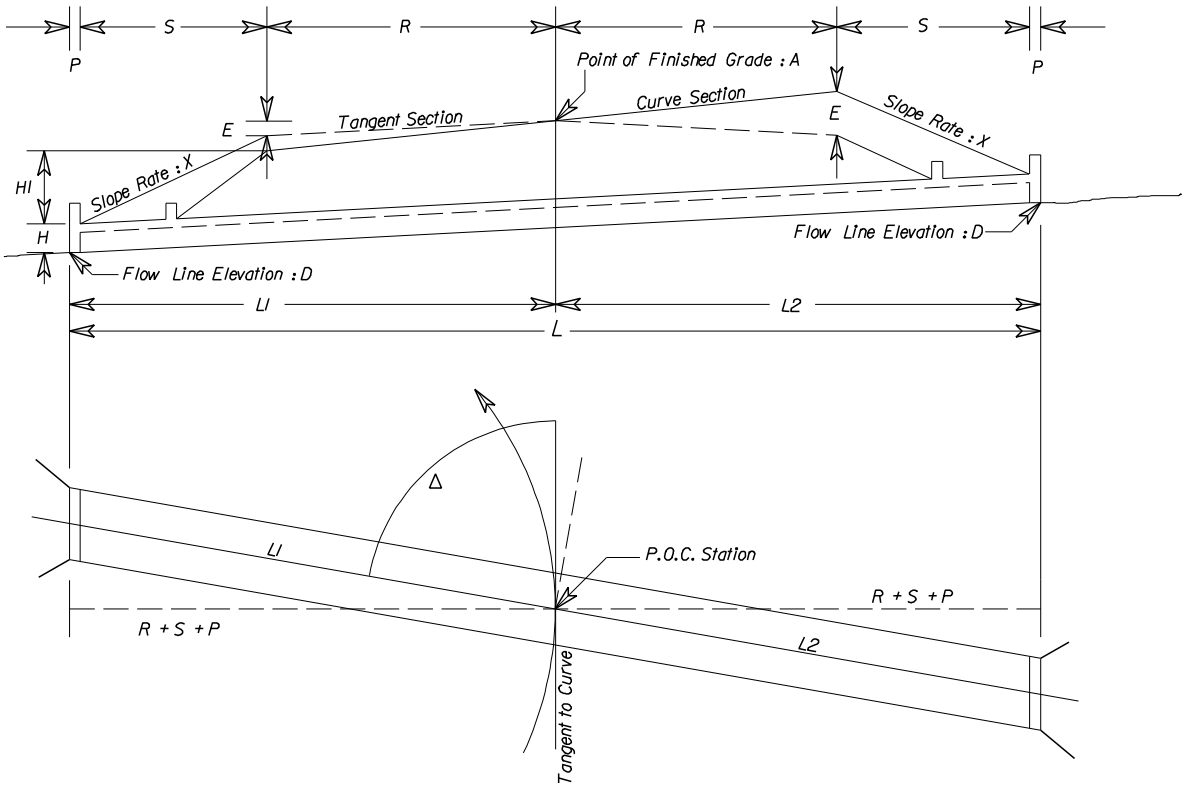

Slope Stakes on Tangents
Roadbed to be Staked
A
B
C
10'
6.8'
7.2'
4.1'
5.2'
ORIGINAL GROUND
60.0'
67.3'
67.3'
F 6.8
Back
10'
F 7.2
Station
Front
The front of the stake shall indicate the cut or fill to the slope intersection (vertical distance A to B), the offset distance (B to C), and the station.
The 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).
10'
C 4.1
Station
Front
60.0'
C 5.2
Back
Slope Stakes on Curves
Roadbed to be Staked
A
B
C
D
5.4'
4.4'
4.1'
3.1'
4.0'
5.3'
ORIGINAL GROUND
61'
63'
61.0'
F 5.54 CL
F 4.4
Back
10'
F4.1
Station
Front
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).
10'
C 3.1
Station
Front
63.0'
C 5.3 CL
C 4.0
Back

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	*(D)*

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 Skew Angles:

$$L1 \text{ or } L2 = \frac{\text{"R" + "S"}}{\text{Sin } D} + \text{"P"}$$

SECTION 105.13 CONSTRUCTION STAKES, LINES, AND GRADES

105.13—State Force Construction Surveying.

(a) **General Description:**

This work shall consist of the Department performing all surveying and providing surveying and stakeout sketches and information as detailed herein for the successful prosecution of work as indicated on the plans and as directed by the Engineer. Stakeout work will be in accordance with the details and requirements of the Department's Survey Manual and the provisions herein. Survey services will be provided to the extent detailed herein for Construction and for Minimum Plan projects.

(b) **Request for Survey Services:**

Once the Contractor requests survey services, the Department will begin the requested work within 3 working days. The Contractor shall not expect the Department survey party to work in the field during adverse weather conditions that could be detrimental to the survey equipment or paperwork, therefore the Contractor shall plan the need for such services accordingly.

It shall be the Contractor's responsibility to preserve all Department furnished centerline or baseline controls, references and location benchmarks. After initial stakeout, an hourly charge equal to the current hourly rate for Department survey services per district will be billed to the Contractor for resetting stakes where the cause for the resetting of such stakes is due to the fault of the Contractor or his operations. This rate will also apply to travel time to and from the project.

If the Contractor requests stakes after the initial staking and he is not ready to accommodate such work, the Contractor will be billed the hourly rate for Department survey services per district measured in travel time to and from the project. Such fees will be billed to the Contractor on the next monthly estimate.

(c) **Contractor Responsibility for Examination of Data:**

It shall be the responsibility of the Contractor to examine all surveying work provided by the Department for accuracy. Should a disagreement involving the accuracy of stakeout or survey work arise during construction, the Contractor shall within 24 hours provide written notice to the Engineer, precisely describing and documenting the discrepancy. The Engineer will determine the validity of the Contractor's assertion in the notice, respond to the Contractor within 3 working days of receipt of the Contractor's notice and provide direction on how to proceed. The Engineer will give consideration to an extension of time in accordance with the requirements of Section 108.04 of the Specifications or provide additional compensation as deemed appropriate after documentation and evidence to the Engineer's satisfaction if the following occurs:

1. There are delays to the project as a result of inaccurate stakeout information provided by the Department where such delays adversely impact the critical path of the work or,

2. where extra expense is encountered by the Contractor to correct elements of defective survey work by the Department, and

3. where written notice is provided by the Contractor within the timeframe specified. Failure to furnish written notice of such a discrepancy within the timeframe specified will invalidate any later claim for time impact or costs by the Contractor unless specifically waived by the Engineer.

(d) **Survey Services Furnished:**

1. **Construction (C) Projects:**

a. **Survey Stakeout Descriptions:**

Unless otherwise stated the Department will provide required horizontal and vertical controls for the proper construction stakeout of the project. The Contractor shall preserve all horizontal and vertical controls furnished by the Department.

The following surveying work will be performed by the Department:

(1) **Digital Terrain Model (DTM) and Construction Cross-Sections:** Original location Digital Terrain Model (DTMs) will be provided by the Department and will serve as a basis of payment for earthwork. The Contractor shall be responsible for taking construction DTMs or cross-sections of areas that, in their determination, do not agree with the Department furnished original location DTMs. The Contractor shall submit the disputed DTM information to the Engineer for verification prior to any excavation by the Contractor in these alleged areas of change. The DTM information furnished by the Department and submitted by the Contractor shall be compatible to the Department's current DTM format.

(2) **Borrow Pits:** All borrow pit DTM's or cross-sections, originals and finals, will be secured by the Department. The Contractor is encouraged to also secure DTM's or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate his claim.

(3) **Horizontal and Vertical Control for Bridges:** Certified plats, field notes, coordinates and computations will be furnished to the Contractor by the

Department prior to the Contractor beginning work on these structures.

(4) **Horizontal and Vertical Controls for all Box Culverts, all Pipe Culvert Installations (including single and multiple line installations) with total hydraulic openings equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** The Department will stake all such installations. Certified Plats will be furnished to the Contractor prior to the Contractor beginning work on these culvert structures. The notes, coordinates, or computations used to support the platted information will be furnished to the Contractor with the certified plat. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(5) **Horizontal and Vertical Control for Pipe Culvert Installations (including single and multiple line installations) having total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Department will be responsible for staking horizontal and vertical control for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. Sketches will be furnished to the Contractor prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(6) **Horizontal and Vertical Control for additional centerlines or baselines for roadways, ramps, loops and connections:** Upon written request from the Contractor the Department will provide horizontal and vertical controls for additional centerlines or baselines for roadways, ramps, loops and connections.

(7) **Grading and paving construction:** The Department will provide fine grade or other grade stakes required for the construction of the project as the work progresses except as stated herein.

Fine grade stakes will be set on all projects on which the plans show a definite grade line. Fine grade hubs will be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Department will provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and

elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be provided to the Contractor. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes will be provided by the Department only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches will be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections will be staked only if requested by the Contractor.

The Department will set all slope stakes. Upon written request from the Contractor cut\fill sheets for slope stakes will be furnished by the Department to the Contractor within 3 working days of the survey party's arrival at the project site or a timeframe agreed upon by the Contractor and the Engineer after reviewing the length and complexity of the project.

(8) **Right of way and boundary stakeout affecting property ownership:** Right of Way will be staked by the Department prior to the start of the project. Right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department's survey party.

(9) **Setting right-of-way monuments:** Final right of way monumentation will be performed by the Department in accordance with the following:

a) RM-1: The Department will furnish and install RM-1 right-of-way monuments in accordance with the Road and Bridge Standards.

b) RM-2: The Department will furnish and install RM-2 right-of-way monuments and optional locator posts, including the required caps, in accordance with the Road and Bridge Standards.

c) Other monumentation: The Department will determine if an alternative form of permanent monumentation will be used if RM-1 or RM-2 monuments are unsuitable for marking the right-of-way at various locations. The Department will indicate this alternative monument usage on the final as-built plan in accordance with the Department's Survey Manual.

When available, electronic data files along with paper sketches and drawings will be furnished by the Department when requested in writing by the Contractor. All electronic data files furnished to the Contractor will be in the format of the Department's current computer hardware and software or a format fully compatible with such hardware and software.

Additional surveying work and supplemental layout work shall be performed by the Contractor as needed to successfully complete the work. The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed during construction operations shall be reestablished by the Contractor at no additional cost to the Department. All drawings, field notes, and computations from such survey work performed by the Contractor shall be submitted to the Engineer.

2. **Minimum Plan (M) Projects:**

Survey Stakeout Descriptions:

Unless otherwise stated, the Department will provide required horizontal and vertical control for the proper construction stakeout of the project. The Contractor shall preserve all horizontal and vertical controls furnished by the Department.

The following surveying work will be performed by the Department:

(1) **Digital Terrain Model (DTM) and Construction Cross-Sections:** "M" projects are based on plan quantities; therefore DTM and construction cross-sections are not required, except for borrow pits.

Should the Engineer determine at any time that an actual measurement is warranted, the Department will make the necessary measurement in the field.

(2) **Borrow Pits:** All borrow pit DTM's, originals and finals, will be secured by the Department. The Contractor is encouraged to also secure DTM's or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained by the Contractor to substantiate his claim.

(3) **Horizontal and vertical control for bridges:** Certified plats, field notes, coordinates and computations will be furnished to the Contractor prior to the Contractor beginning work on these structures.

(4) **Horizontal and Vertical Control for all Box Culverts, all Pipe Culvert Installations (including single and multiple line installations) with a total**

hydraulic openings equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size: The Department will stake all such installations. Certified Plats for these stakeouts will be furnished to the Contractor prior to the Contractor beginning work on these culvert structures. The notes, or computations used to support the platted information will be furnished to the Contractor with the certified plat. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic openings.

(5) **Horizontal and Verticals Control for Pipe Culvert installations (including single and multiple line installations) having total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Department will be responsible for staking horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. Sketches will be furnished to the Contractor prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(6) **Grading and paving construction:** The Department will provide fine grade or other grade stakes required for the construction of all projects except as stated herein as the work progresses. Slope stakes are not required on “M” projects.

Fine grade stakes will be set on all projects on which the plans show a definite grade line. Fine grade hubs will be set on at least one side with distances and grades referenced to the finished centerline grade. Typically, on curves, the Department will provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be provided by the Department.. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes will be provided by the Department only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches will be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections will be staked only if requested by the Contractor.

(7) Right of way and boundary stakeout affecting property ownership: Right of Way will be staked by the Department prior to the start of the job. The right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department survey party.

(8) **Setting right-of-way monuments:** Final right of way monumentation will be performed by the Department in accordance with the following:

a) RM-1: The Department will furnish and install RM-1 right-of-way monuments in accordance with the Road and Bridge Standards.

b) RM-2: The Department will furnish and install RM-2 right-of-way monuments and optional locator posts, including the required caps, in accordance with the Road and Bridge Standards.

c) Other monumentation: The Department will determine if an alternative form of permanent monumentation will be used if RM-1 or RM-2 monuments are unsuitable for marking the right-of-way at various locations. The Department will indicate this alternative monument usage on the final as-built plan in accordance with the Department's Survey Manual.

SECTION 517—CONTRACTOR CONSTRUCTION SURVEYING

517.01—Description

This work shall consist of the Contractor providing all surveying and stakeout as detailed herein 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 Survey Manual and this specification

517.02—General Requirements

The Contractor shall ensure the following surveying work shall be performed by or under the direct responsibility, control and personal supervision of a surveyor who is licensed in Virginia as a Land Surveyor and is experienced in highway construction stakeout work including the following:

(a) horizontal and vertical control for bridges,

(b) horizontal and vertical control for box culverts and single and multiple line pipe culverts as specified herein,

(c) horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections and

(d) fine grade or other grade stakes as necessary for construction.

All other surveying work shall 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 construction benchmarks and reference stakes he develops as detailed herein. 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 certified plats, 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 this specification and the sample figure drawings as shown in the Department's Survey Manual. 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.

517.03—Contractor Responsibility for Examination of Data

It shall be the responsibility of the Contractor to examine all surveying work provided by the Department for accuracy. Should a disagreement involving the accuracy of stakeout or survey work arise during construction, the Contractor shall within 24 hours provide written notice to the Engineer, precisely describing and documenting the discrepancy. The Engineer will determine the validity of the Contractor's assertion in the notice, respond to the Contractor within 3 working days of receipt of the Contractor's notice and provide direction on how to proceed. The Engineer will give consideration to

an extension of time in accordance with the requirements of Section 108.04 of the Specifications or provide additional compensation as deemed appropriate after documentation and evidence to the Engineer's satisfaction if the following occurs:

(a) There are delays to the project as a result of inaccurate stakeout information provided by the Department where such delays adversely impact the critical path of the work or,

(b) Where extra expense is encountered by the Contractor to correct elements of defective survey work by the Department, and

(c) Where written notice is provided by the Contractor within the timeframe specified. Failure to furnish written notice of such a discrepancy within the timeframe specified will invalidate any later claim for time impact or costs by the Contractor unless specifically waived by the Engineer.

517.04—Construction (C) projects

The following specific requirements shall apply:

(a) **Digital Terrain Model (DTM) and Construction Cross-sections:** Original location Digital Terrain Model (DTM) will be provided by the Department and will serve as a basis of payment for earthwork. The Contractor shall be responsible for taking construction DTMs or cross-sections of areas that, in their determination, do not agree with the Department furnished original location DTMs. The Contractor shall submit the disputed DTM information to the Engineer for verification prior to any excavation by the Contractor in these alleged areas of change. The DTM information furnished by the Department and submitted by the Contractor shall be compatible to the Department's current DTM format.

(b) **Borrow Pits:** All borrow pit DTMs or cross-sections, originals and finals, will be secured by the Engineer through the Department Survey party. The Contractor is encouraged to also secure DTMs or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate their claim.

(c) **Temporary Benchmarks:** The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed by the Contractor's activities during construction operations shall be reestablished by the Contractor at no additional cost to the Department.

(d) **Horizontal and vertical control for bridges:** The Contractor shall stake all bridges. These stakeouts shall require certified plats. Certified plats, field notes, coordinates and computations shall be furnished by the Contractor to the Engineer in accordance with the requirements of Sample Figures 2 and 3 as shown in the Department's Survey Manual prior to the Contractor beginning work on these structures.

(e) **Horizontal and vertical control for all box culverts, all pipe culvert installations (including single and multiple line installations) with a total hydraulic opening equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and**

sanitary sewers regardless of size: These stakeouts are deemed critical and require certified plats. The Contractor's surveyor shall stake all such installations. Certified Plats for these stakeouts shall be furnished in accordance with the requirements of Sample Figure 1 as shown in the Department's Survey Manual and shall be submitted to the Engineer prior to the Contractor beginning installation work on these culvert structures. The notes, coordinates, or computations used to support the platted information shall be provided to the Engineer with the certified plat. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(f) **Horizontal and vertical control for pipe culvert installations (including single and multiple line installations) having a total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Contractor shall be responsible for staking horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. These stakeouts require sketches, but not certified plats and shall be furnished to the Engineer prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes shall apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(g) **Horizontal and vertical control for additional centerlines or baselines for roadways, ramps, loops and connections:** The Contractor shall provide horizontal and vertical controls for additional centerlines or baselines for roadways, ramps, loops and connections.

(h) **Grading and paving construction:** The Contractor shall provide fine grade or other grade stakes required for the construction of the project as the work progresses except as otherwise stated herein.

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. Typically, on curves, the Contractor shall provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be required by the Engineer. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes shall be provided by the Contractor only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches shall be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections shall be staked by the Contractor.

Generally, slope stakes shall be set by the Contractor as an initial part of the construction operations on the project.

(i) **Right of way and boundary stakeout affecting property ownership:** The right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department survey party.

(j) **Locating and setting right-of-way monuments:** All location and final right of way monumentation will be performed by the Department in accordance Section 105.13.

517.05—Minimum Plan (M) projects

The following specific requirements shall apply:

(a) **Digital Terrain Model (DTM) and construction cross-sections:** "M" projects are based on plan quantities; therefore DTM and construction cross-sections are not required.

Should the Engineer determine at any time that an actual measurement is warranted, the Department will make the necessary measurement in the field.

(b) **Borrow Pits:** All borrow pit DTM's, originals and finals, will be secured by the Department. The Contractor is encouraged to also secure DTMs or cross-sections of borrow areas. A claim of discrepancy in borrow volume will not be considered by the Engineer unless survey data was obtained and submitted by the Contractor to substantiate the claim.

(c) **Horizontal and vertical control for bridges:** These stakeouts require certified plats. Certified plats, field notes, coordinates and computations shall be furnished to the Engineer by the Contractor in accordance with the requirements of Sample Figures 2 and 3 as shown in the Department's Survey Manual prior to the Contractor beginning work on these structures.

(d) **Horizontal and vertical controls for all box culverts, all pipe culvert installations (including single and multiple line installations) with a total hydraulic opening equivalent to 12.6 square feet and larger, and for all closed systems such as storm sewers, and sanitary sewers regardless of size:** These stakeouts are deemed critical and require certified plats. Exceptions may be granted by the Engineer for simple closed systems by requiring stake out sketches. The Contractor shall stake all such installations. Certified Plats for these stakeouts shall be in accordance with the requirements of Sample Figure 1 as shown in the Department's Survey Manual and shall be submitted to the Engineer prior to the Contractor beginning work on these culvert structures. The notes, coordinates, or computations used to support the platted information shall be provided by the Contractor to the Engineer with the certified plat.

(e) **Horizontal and vertical control for pipe culvert installations (including single and multiple line installations) having a total hydraulic openings equivalent to 3.1 square feet and up to 12.5 square feet:** The Contractor shall be responsible for staking horizontal and vertical controls for pipe culvert installations having a total hydraulic opening equivalent to 3.1 square feet and up to 12.5 square feet. These stakeouts require sketches, but not certified

plats and shall be furnished to the Engineer prior to the Contractor beginning work on these culvert structures. For the purposes of identifying those pipe culvert installations please refer to the areas (hydraulic openings) shown in the PB-1 Standards for the respective sizes of pipes specified on the plans. Where multiple lines of pipes are shown, the areas of the pipe sizes will apply to the total areas of the number of lines specified in the plans. For box culverts refer to the sizes shown in the BC-1 Standards to determine areas of total hydraulic opening.

(f) **Temporary Benchmarks:** The Contractor shall provide and protect temporary construction benchmarks within the construction limits. Temporary construction benchmarks shall be located not farther than 500 feet apart for the total length of the project or as indicated on the plans. Temporary construction benchmarks that are disturbed by the Contractor's activities during construction operations shall be reestablished by the Contractor at no additional cost to the Department.

(g) **Grading and paving construction:** The Contractor shall provide fine grade or other grade stakes required for the construction of all projects except as stated herein as the work progresses. Slope stakes are not required on "M" projects.

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. Typically, on curves, the Contractor shall provide the distances and elevations to each edge of pavement and centerline through the transitions and the distances and elevations to the edge of pavement only (straight-line super) through full super portions of the curve.

On projects where grading and paving is performed under the same contract, only one set of fine grade stakes will be required by the Engineer. Fine grade stakes may be used for fine grade and paving grade.

On Secondary Road projects, fine grade stakes shall be provided by the Contractor only on those projects having curb and gutter or as directed by the Engineer.

Special design ditches shall be staked with an offset and cut to the centerline of the ditch. Radius points for pavement flares at connections shall be staked by the Contractor.

(h) **Right of way and boundary stakeout affecting property ownership:** The right of way stakes will be placed at a minimum of 100-foot intervals on each side of the roadway or as directed by the Engineer and the stakes will be marked with both the station and offset back to centerline. All final boundary stakeout will be performed by the Department survey party.

(i) **Setting right-of-way monuments:** Final right of way monumentation will be performed by the Department in accordance Section 105.13.

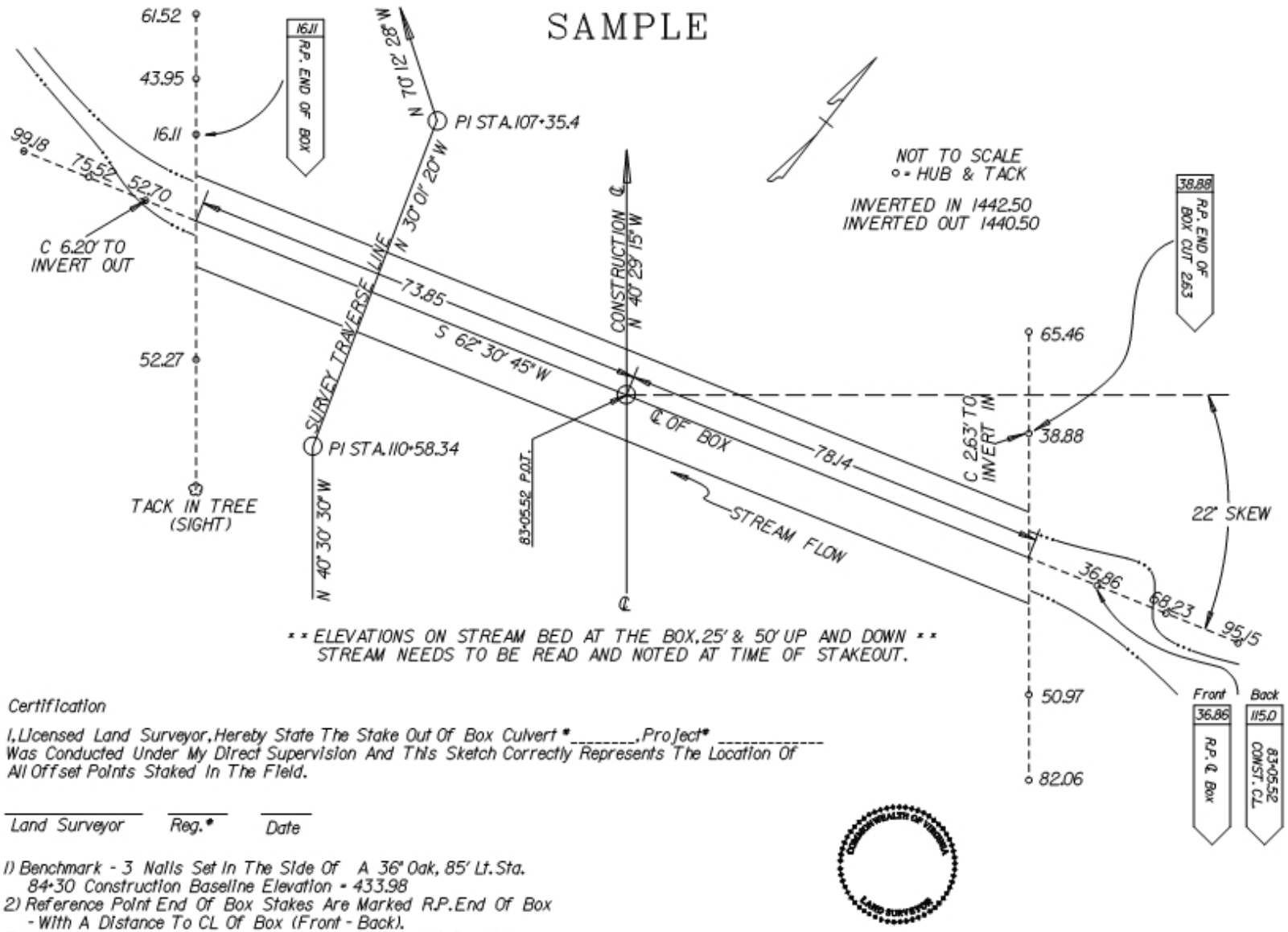
517.06—Measurement and payment

Construction surveying will be paid for at the contract lump sum price for the type of project specified, 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, certified plats, sketches and drawings in the format approved by the Engineer.

Payment will be made under:

Pay Item	Pay Unit
Construction surveying (Construction)	Lump sum
Construction surveying (Minimum Plan)	Lump sum



Certification

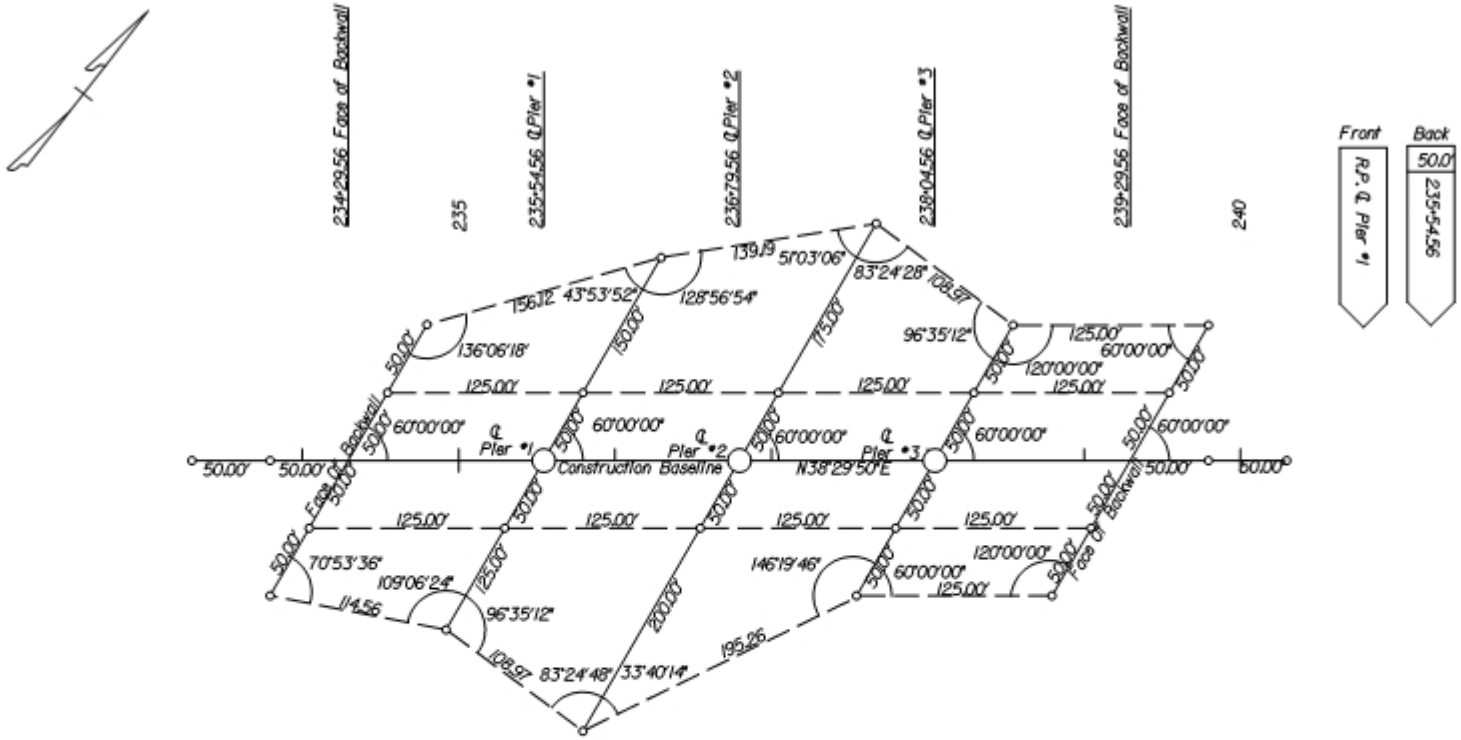
I, Licensed Land Surveyor, Hereby State The Stake Out Of Box Culvert *_____, Project* _____ Was Conducted Under My Direct Supervision And This Sketch Correctly Represents The Location Of All Offset Points Staked In The Field.

_____ _____ _____
Land Surveyor Reg.* Date

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



Certification

I, Licensed Land Surveyor, Hereby State The Stake Out Of Bridge #_____, Project# _____ Was Conducted Under My Direct Supervision And This Sketch Correctly Represents The Location Of All Offset Points Staked In The Field.

Land Surveyor Reg.# Date

Benchmark #1 - 3 Nails Set In The Side Of A 36" Oak, 85' Lt. Sta. 232+00 Construction Baseline
Elevation - 433.98

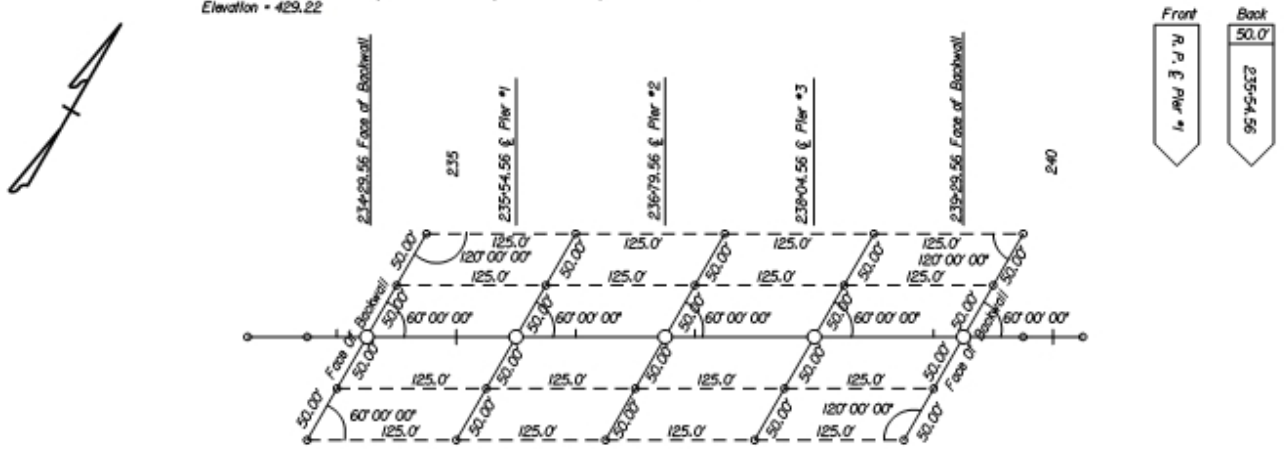
Benchmark #2 - Railroad Spike Set In The Top Of A 48" Stump, 105' Rt. Sta. 240+50 Construction Baseline
Elevation - 429.22

FIGURE 2

SAMPLE

Benchmark #1 - 3 Nails Set In The Base Of A 36" Oak, 85' Lt. Of Sta. 232+00 Constuction 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 Of 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 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 Reestablishing Of Fae Of Backwall And Centerlines Of Piers Will Be Intersection Only. Distances Are Provided For Checking Purposes Only

Certification

I, Licensed Land Surveyor, Hereby State The Stake Out Of Bridge # _____, Project # _____
Was Conducted Under My Direct Supervision And This Sketch Correctly Represents The Location Of All Offset Points Staked In The Field.

_____ _____
Land Surveyor Reg.# Date

FIGURE 3

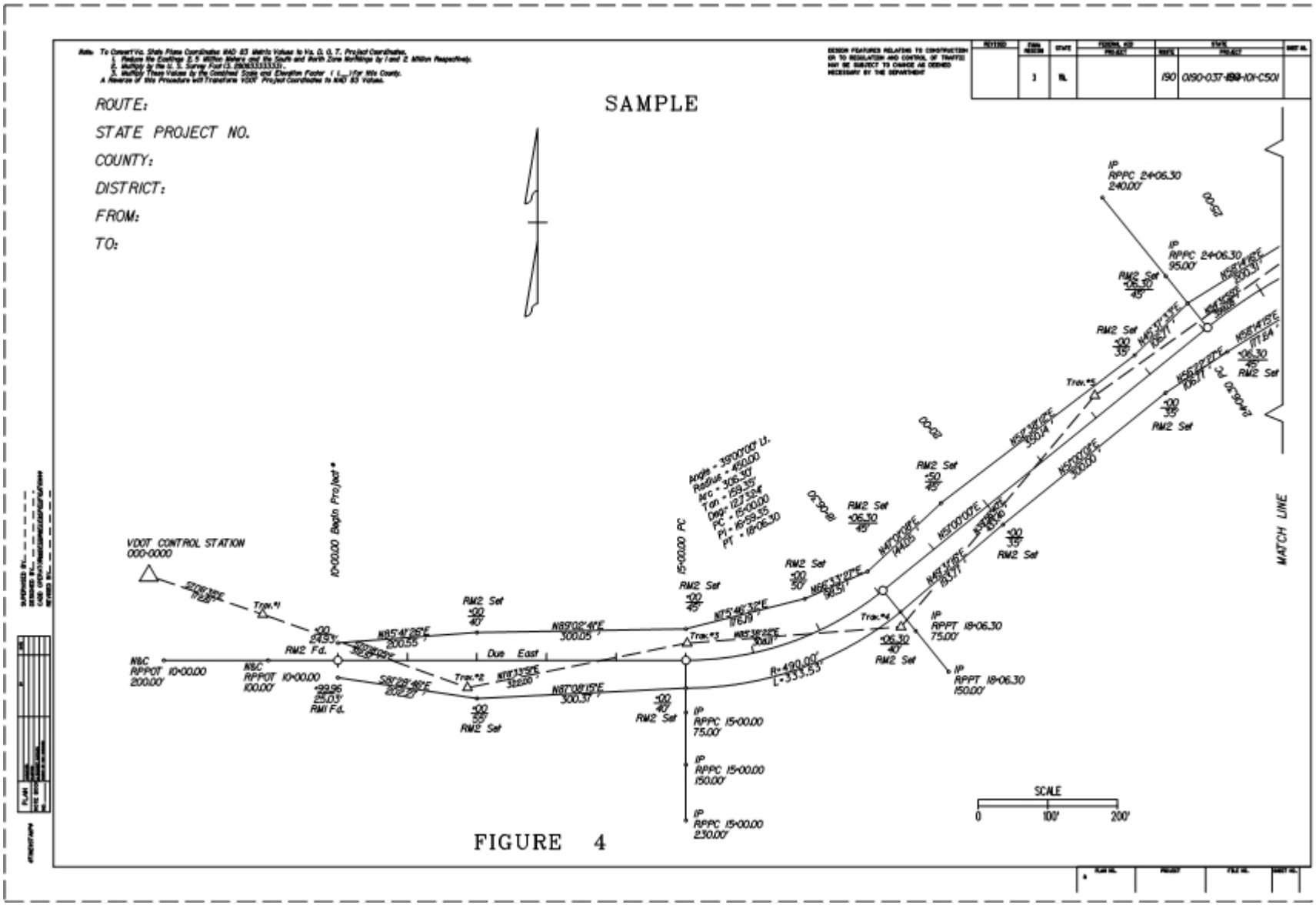

SAMPLE
ROUTE:
STATE PROJECT NO.
COUNTY:
DISTRICT:
FROM:
TO:
VDOT CONTROL STATION
000+0000
10+00.00 Begin Project
15+00.00 PC
Angle = 39°00'00" Lt.
Radius = 450.00
MC = 306.30'
Tan = 159.35'
Degr = 12°32'54"
PC = 15+00.00
PI = 16+59.35
PT = 18+06.30
N&C
RPPOT 10+00.00
200.00'
N&C
RPPOT 10+00.00
100.00'
RM1 Fd.
RM2 Fd.
Due East
RM2 Set
Trav.#1
Trav.#2
Trav.#3
Trav.#4
Trav.#5
IP
RPPC 15+00.00
75.00'
IP
RPPC 15+00.00
150.00'
IP
RPPC 15+00.00
230.00'
IP
RPPT 18+06.30
75.00'
IP
RPPT 18+06.30
150.00'
IP
RPPC 24+06.30
240.00'
IP
RPPC 24+06.30
95.00'
R=450.00'
L=353.53'
MATCH LINE
SCALE
0
100'
200'

FIGURE 4

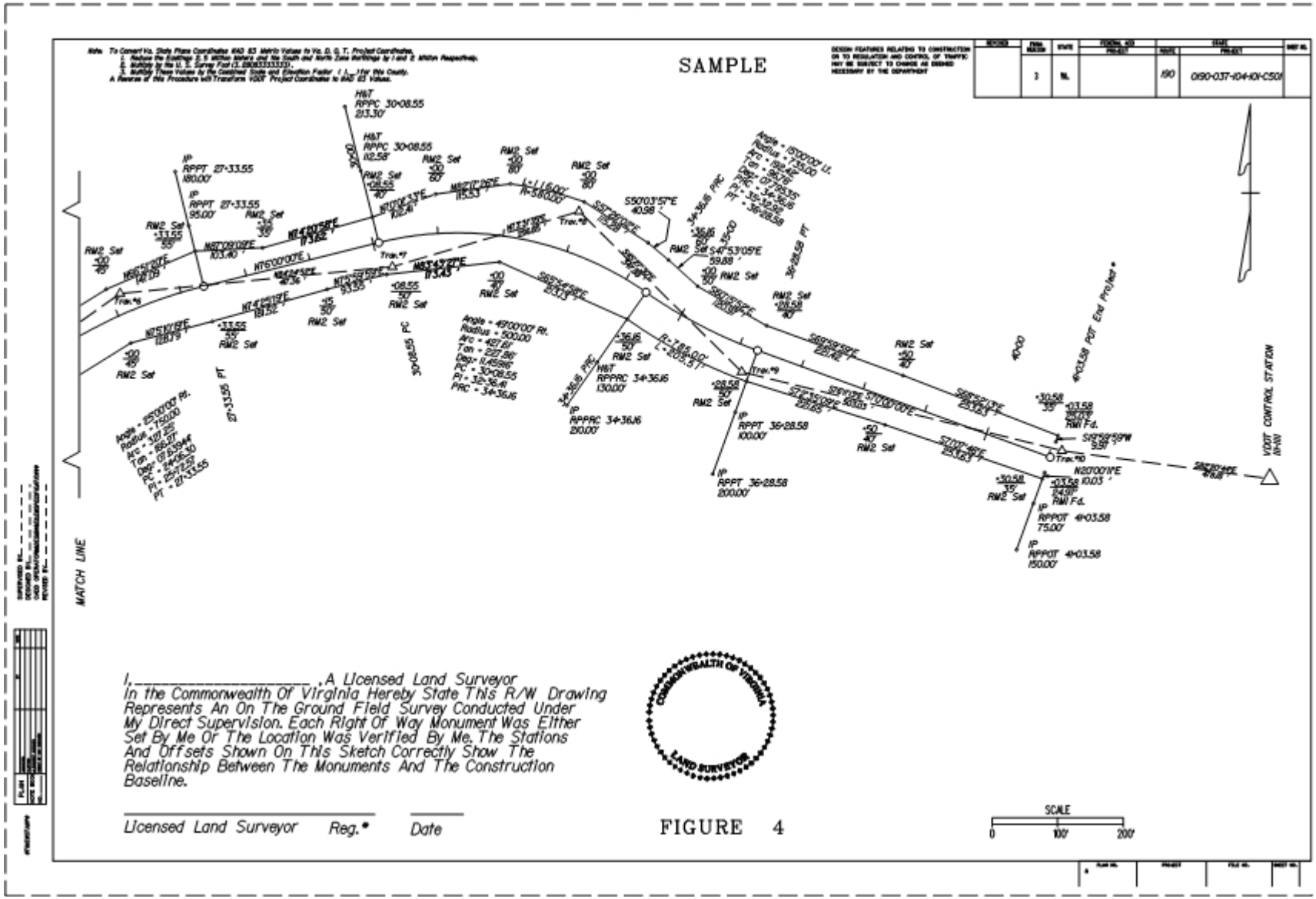

SAMPLE
MATCH LINE
VDOT CONTROL STATION
SCALE
0
100'
200'
I, _____ , A Licensed Land Surveyor
In the Commonwealth Of Virginia Hereby State This R/W Drawing
Represents An On The Ground Field Survey Conducted Under
My Direct Supervision. Each Right Of Way Monument Was Either
Set By Me Or The Location Was Verified By Me. The Stations
And Offsets Shown On This Sketch Correctly Show The
Relationship Between The Monuments And The Construction
Baseline.
Licensed Land Surveyor Reg.# Date
COMMONWEALTH OF VIRGINIA
LAND SURVEYOR

FIGURE 4

CHAPTER 9

FINAL SURVEYS

Chapter Contents

Sec. 9.01	**General**
Sec. 9.02	**Alignment**
Sec. 9.03	**Levels**
Sec. 9.04	**Cross-Sections**
Sec. 9.05	**Borrow Pits**
Sec. 9.06	**Plan Quantity Projects**
Sec. 9.07	**Federal Aid State Force Account Projects**
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 current **Post Construction Manual**, or as directed by the District Construction Engineer. If the District Construction Engineer requests finals, the following sections and the Post Construction Manual should be used as guidelines.

Sec. 9.02 **Alignment**

The centerline should be retraced accurately putting in all points where slope DTM's were taken. In case the centerline can be retraced accurately without running a traverse line over the project, a note conspicuously placed in the digital file, ascii file, or field book should state that a traverse 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 DTM's were taken. These levels shall be run in accordance with the procedure outlined in **Sec. 8.03.**

Sec. 9.04 **Cross-Sections**

Cross Sections are no longer used in final surveys. **In lieu of securing cross-section information, a DTM surface is the accepted VDOT format for determining final volumetric and final grading information. I case of emergency or a special situation, cross sections can be requested.**

Except in the case of Plan Quantity projects **Section 9.06**, DTMs shall be secured as outlined below.

Sec. 9.05 **Borrow Pits**

DTM readings 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 DTM's 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 surfaces. DTM readings 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 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 DTM readings were secured, a break line 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.

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 of the DTM's, these areas will again have DTM's collected to show the changes and a final DTM surface taken to coincide with these sections.

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 DTMs are **not** necessary.

Sec. 9.10 **Submitting Survey Data**

As soon as the final survey is completed, the Survey Party Manager (Land Surveyor) should send to the District Survey Manager all notebooks and Inspector's records which are in his possession. The District Survey Manager will then transmit these books to the District Design Unit.

. For the current **Post Construction manual** please click here:

http://www.virginiadot.org/business/resources/pc_manual.pdf

CHAPTER 10

GNSS* SURVEYS & THE STATE PLANE COORDINATE SYSTEM

Chapter Contents

Sec. 10.01	General
Sec. 10.02	GNSS Equipment
Sec. 10.03	GNSS Networks And Accuracy Standards
Sec. 10.04	General Specifications For GNSS* 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. 10.12	Airborne GNSS

* Rev. 7/15

Sec. 10.01 **General**

[*]The Global Positioning System (GPS) technology is the system created and maintained by the United States. GLONASS is the Russian counterpart to GPS. These two systems combined are now referred to as Global Navigational Satellite System (GNSS) and continues to advance and improve its capabilities which has become a common 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 terrestrial survey methods with a total station for example. GNSS has enabled surveyors the ability to establish control for a project from known existing control that may be miles away. VDOT utilizes GNSS for securing control values for primary control as well as photo control. VDOT allows other uses of GNSS specifically, the use of Real-Time Kinematic (RTK) GNSS surveying for photo control, right-of-way and corridor baseline stakeout, and also topographic collection when standard industry guidelines are followed. Other divisions within VDOT are also utilizing GNSS 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 GNSS 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. Additionally a number of memoranda from the National Geodetic Survey should be followed as a guide when establishing new survey control. Specifically NOAA Technical Memorandum NOS NGS 58, Guidelines for establishing Ellipsoid Heights, and NOAA Technical Memorandum NOS NGS 59, Guidelines for establishing GPS-Derived Orthometric Heights. This chapter was prepared heavily in parts, from these NGS publications. VDOT will continue its procedures to generate, via GNSS survey techniques, state plane coordinates and orthometric heights in U.S. Survey Feet for its Route Survey projects. These values shall be converted to the VDOT Project Coordinates, which are also given in the U.S. Survey foot. For more on Project coordinates, see **Section 10.07** regarding LD-200 cards in this chapter. It is important to remember however that legacy projects, projects started or completed before 2014, will reflect a variety of coordinate configurations and VDOT survey control from older projects should be used with this understanding.

Sec. 10.02 **GNSS Equipment**

The GNSS geodetic receivers used for static survey operations shall receive both carrier frequencies transmitted by the current constellation of GNSS satellites and shall have the capability of tracking a minimum of eight GNSS 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.

[*] Rev. 7/15

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,** is an example from the NGS illustrating the different antenna measurements required for different antenna types. ***Fixed Height Tripods are recommended for use during [*]GNSS missions to avoid measurement or transcription errors.*** These GNSS receivers should be programmable and have several I/O ports. The software should be able to convert the data to RINEX-3 format for use with other GNSS systems and software.

Sec. 10.03 **GNSS Networks and Accuracy Standards**

In general, the GNSS 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 GNSS 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 GNSS 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

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Sec. 10.04 **General Specifications for *GNSS Surveys**

In general, this section is intended to be a guide for any surveyor who is providing VDOT with GNSS data. These procedures are general minimum requirements that must be met by the surveyor in order for the GNSS survey data to be accepted by VDOT. These procedures are for static and rapid static GNSS 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. When experience and field conditions allow for alternative procedures, at the discretion of the surveyor in charge, then documentation will be provided demonstrating the accuracy obtained and the procedures followed.

1. **GNSS Survey Project Datum.** Unless otherwise instructed, **ALL VDOT GNSS 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 GNSS methods from reference stations included in the NSRS will be accepted by VDOT. The NSRS contains GNSS 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) GNSS surveys.

2. **GNSS Network Control Procedures.** All GNSS 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 GNSS 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-P**, for easy reference.

2a. A minimum of three (3) GNSS receivers shall be used simultaneously during all Static & Rapid Static GNSS 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.

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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 *GNSS 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 GNSS 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**.

2f. During 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. Each session's, 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**) 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 to be used shall be the **2012A 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 to be used for determining elevation of the ellipsoid, shall be the **WGS 1984** ellipsoid model.

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2l. VDOT requires that the final adjusted coordinates for the *GNSS 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 minute 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 may be used for all baselines shorter than 20 kilometers (km) in length. Observation sessions shall be at a minimum, 15 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. The determination of observation duration is the responsibility of the Surveyor of responsible charge, and 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 among other factors. Again, if control is farther than 20 kilometers from the project, static observation procedures will be used.

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 GNSS on VDOT Projects.** At the time of this revision to the Survey manual, VDOT is currently allowing the use of Real-Time Kinematic (RTK) GNSS surveying equipment and procedures capable of achieving a 2-cm positional accuracy. RTK GNSS surveying techniques utilizing a base station on established control such as a VDOT project control point, a HARN point, or dialing into a subscription RTK service for corrections for securing photo control and topography will be acceptable to VDOT when measures are taken to insure similar accuracy results as would be achieved by using Static or Rapid-Static procedures outlined in this manual*. 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.

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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. RTK techniques are relatively new and therefore are continually evolving as field practices and experience present improved methods of collection. *RTK surveying techniques are being improved almost daily and are too numerous to outline in this manual. Therefore it is incumbent on, and the responsibility of, the surveyor with responsible charge providing data to VDOT to secure results that would meet similar accuracy standards as other methods outlined herein. It is also required that documentation demonstrating the method of collection, status of base station control, ties to the CORS or HARN, if used, as well as the accuracy acquired, shall be provided along with the deliverable survey data. Any questions regarding field procedures may be directed to VDOT's Geodetic Surveys Engineer.

5. **Utilizing OPUS on VDOT Projects:**

*This ***Online Positioning User Service*** (**OPUS**) provides simple access to high-accuracy National Spatial Reference System (NSRS) coordinates. By uploading a data file collected with a survey-grade GPS receiver you can obtain an NSRS position via email.

OPUS requires minimal user input and uses software which computes coordinates for NGS' Continuously Operating Reference Station (CORS) network. The resulting positions are accurate and consistent with other NSRS users.

Your solution is sent privately via email, and, if you choose, can also be shared publicly via the NGS website. To use properly, please familiarize yourself with all the information provided on the National Geodetic Survey website http://www.ngs.noaa.gov/OPUS/.

As with RTK GNSS procedures outlined above it is permissible to use OPUS for establishing data for VDOT Projects as long as measures and care are taken to achieve similar accuracy results that meet or exceed the accuracy results that would otherwise be achieved by using Static or Rapid-Static procedures outlined in this manual.

The responsible charge surveyor shall verify that the positional accuracy meets or exceeds the required survey specifications. OPUS techniques are relatively new and therefore are continually evolving as field practices and experience present improved methods of collection. OPUS surveying techniques are being improved almost daily and are too numerous to outline in this manual. Therefore it is incumbent on, and the responsibility of, the surveyor with responsible charge providing data to VDOT to secure results that would meet similar accuracy standards as other methods outlined herein. It is also required that documentation demonstrating the method of collection, status of base station control used, ties to the CORS or HARN, as well as the accuracy acquired, shall be provided along with the deliverable survey data. OPUS provides an

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adjustment report and this report shall be include in the documentation provided to VDOT. Any questions regarding field procedures may be directed to VDOT's Geodetic Surveys Engineer.*

Data File of dual-frequency GPS (L1/L2) full-wavelength carrier observables:

- Static data only; the antenna must remain unmoved throughout the observing session.
- 15-minutes of data or more, up to 48-hours, but not crossing UTC midnight more than once.
- Files under 2 hours, processed as rapid-static, must include the P2 and either P1 or C1 observables.
- GLONASS or Galileo observables may be included; though only the GPS are used.
- Any elevation cut-off or mask angle; though only satellites more than 10° above the horizon are used.
- Recording (epoch) rates of 1, 2, 3, 5, 10, 15, or 30 seconds; though all are decimated to 30 seconds.
- RINEX 2.x data format, or many raw data formats
- Compressed UNIX, gzip, pkzip, or Hatanaka formats are allowed, including multiple file archives (all must share the same antenna type & height).

Antenna

Selecting your antenna will engage the appropriate antenna calibration model, to counter the unique measurement biases inherent in each antenna's design. Take care! Choosing an incorrect antenna may result in a height error as large as 80 cm vertical, 1 cm horizontal. Tip: Use antenna calibration to find an exact match.

Antenna Height

Enter the vertical height in meters of your Antenna Reference Point (ARP) above the mark you are positioning, as shown in the image at right. The ARP for your antenna, usually the center of the base or tripod mount, is illustrated in antenna calibration images. If you enter a 0.0 antenna height, your ARP position will be returned.*

Sec. 10.05 **Quality Control Procedures**

This section of the Survey Manual will assist the surveyor with the minimum field practices to ensure quality GNSS survey data for VDOT. As with any high-tech measuring device, certain standards of care should be followed 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.

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b. Care should be taken when setting a control monument or station, (see **Figure 10-D**) 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**) 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. *Site log forms should be filled out in the field during the session.** Please refer to **Figure 10-A**, 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 GNSS receiver. Vehicles will be parked a minimum of 50 feet away from the GNSS receiver.

g. Every member of the GNSS survey mission should know his or her responsibilities, session starting and ending times, station locations and basic operation of the GNSS equipment.

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Sec. 10.06 **Deliverables**

All *GNSS "subject data" for VDOT contracted surveys (either primary control or photogrammetric control) *whether they are performed by VDOT staff or Consultants, shall be delivered to, or at least copied to VDOT's Geodetic Surveys Engineer for a quality control check and evaluation. This information will be delivered to the Geodetic Surveys Engineer **before** 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 *the final adjusted state plane coordinates with orthometric heights *in U.S. Survey feet, 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**), 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.

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i. A one-page summary of the *GNSS 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**).

k. One *digital copy of original GNSS raw data in Leica, Trimble, Topcon, or RINEX-3 format. This data can be delivered on a CD or via FTP server if the client has an existing FTP account with VDOT.

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. GNSS 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**) 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.** A point is positioned using GNSS 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**).

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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**. Similarly, the longitude can be defined as the angular difference from Greenwich, England, as shown in **Figure 10-J**. This point would be defined as 38° North latitude and 78° 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 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 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° 46' to Point A would be shorter than the distance along the arc from 36° 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° 46' and 37° 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° 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° 30' West longitude for both the North and South Zones. This means that throughout both zones grid north is exactly parallel to the 78° 30' West longitude, central meridian. The angular difference between the true north and grid north is called the θ (theta) angle. **Figure 10-L)** shows this graphically.

Sec. 10.11 **The VDOT Project Coordinate System**

[*]Beginning June 1, 2014 all new VDOT Projects will be based on the new VDOT Project Coordinate System outlined below (Now known as "VDOT Project Coordinates-2014"). To convert Virginia State Plane Coordinates (based on the US Survey Foot) to VDOT Project Coordinates-2014, the coordinates will need to be multiplied by the combined Scale & Elevation Factor for each specific project. One method of obtaining the scale factor for each project will be to submit GNSS data to OPUS (NGS utility) for each primary control point on the project. Submitting "Static" data to OPUS (minimum 2- hour occupations per point) will be required. Once the OPUS results are obtained, take the average of the combined factors under the State Plane Coordinates for the primary control points. Once this step is done, the inverse function (1/x) should be applied, resulting in the Combined Scale Factor for the project (9 decimal places- Example= 1.000000009).

This is only one method of obtaining the scale factor for a project. Regardless of the method used, the procedure shall be described in detail in the project notes as well in the Project Deliverables (Sec. 10.06).[◊]

Special Note on Projects that predate June 1, 2014:[◊]

Projects completed or started prior to January 1, 2014 should continue to use the former language below.

The VDOT Coordinate System is based on **NAD83 METRIC values** as defined in **The Code of Virginia §55-292** (see **Figure 10-H**). 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**). Last, multiply the Northing and Easting values by the Combined County Scale & Elevation Factor. **Figure 10-N** 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 10-F,** showing the use of the above procedures as depicted on a LD-200 Horizontal Control Station Reference Card.

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Sec. 10.12 [*]**Airborne GNSS**

1. Airborne GNSS techniques can be used to acquire supplemental control for use on photogrammetric projects.
2. It is important to maintain Reference Base Stations over known control points during the duration of the flight.
3. These Reference Stations should be spaced 10 to 25 kilometers from the project. The entire project should be reachable within this range.
4. The range of 10 to 25 kilometers should be scrutinized keeping in mind the accuracy needs of the project. A general rule of thumb, under optimal conditions, would be about 1 cm of residual per 10 kilometers of baseline distance. Bear in mind, there usually are other factors involved that could result in an increase in your residual values. i.e. a poor GDOP value
5. If multiple Reference Stations are required, then no part of the project should be farther than 10 to 25 kilometers from at least one of the Reference Stations.
6. Reference Stations as well as Rovers should be set to collect one second epoch data.

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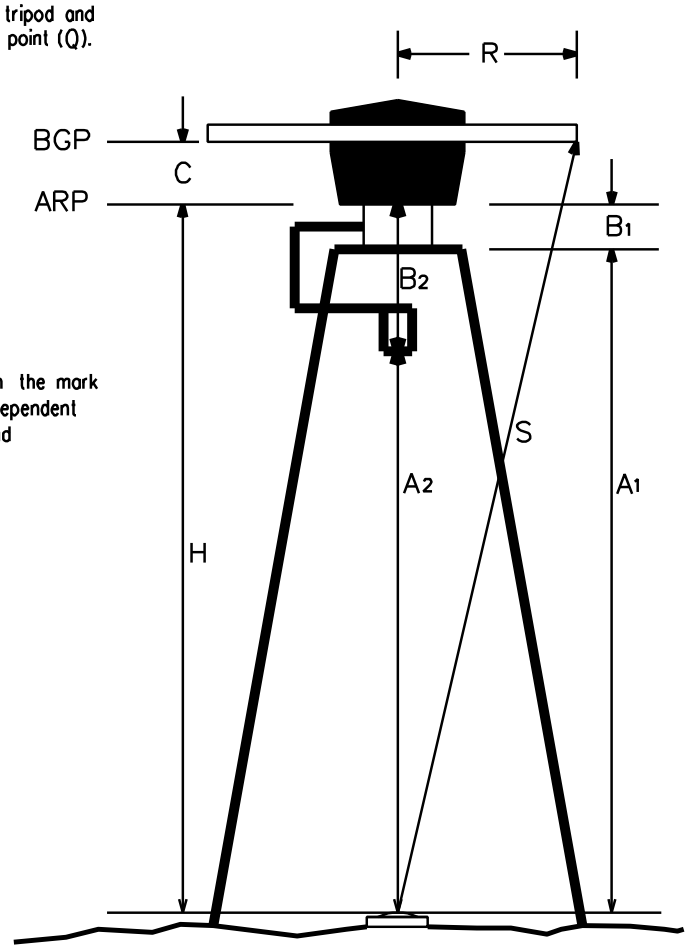
Figure 10-A

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 = Inch 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:

Antenna Height $H = ((\sqrt{S^2 - R^2}) - C) - Q$

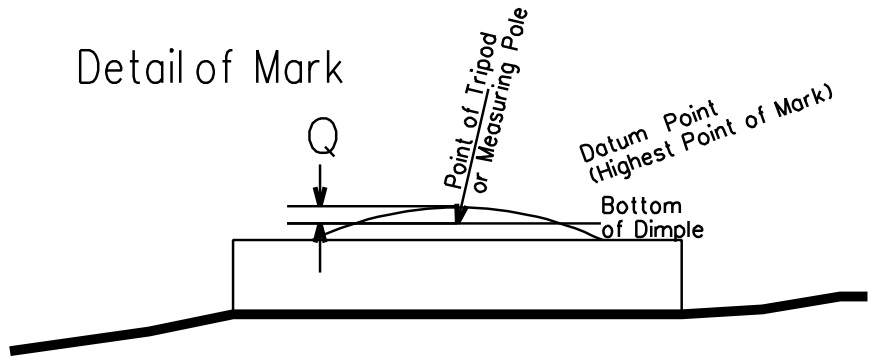
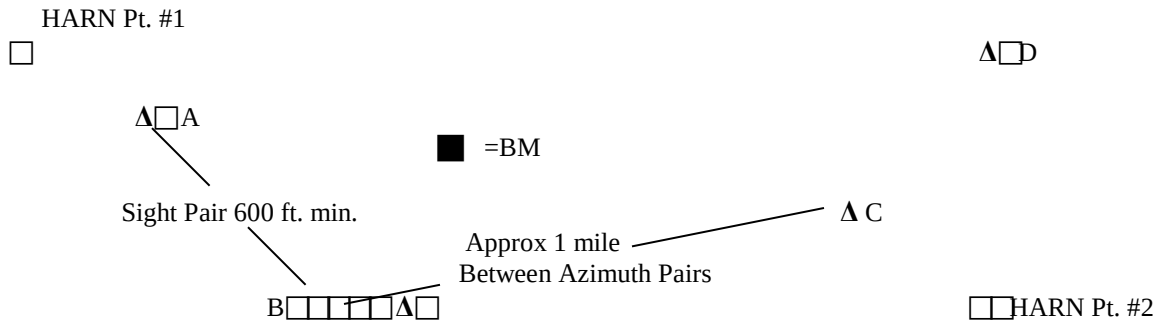


Figure 10-B



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.

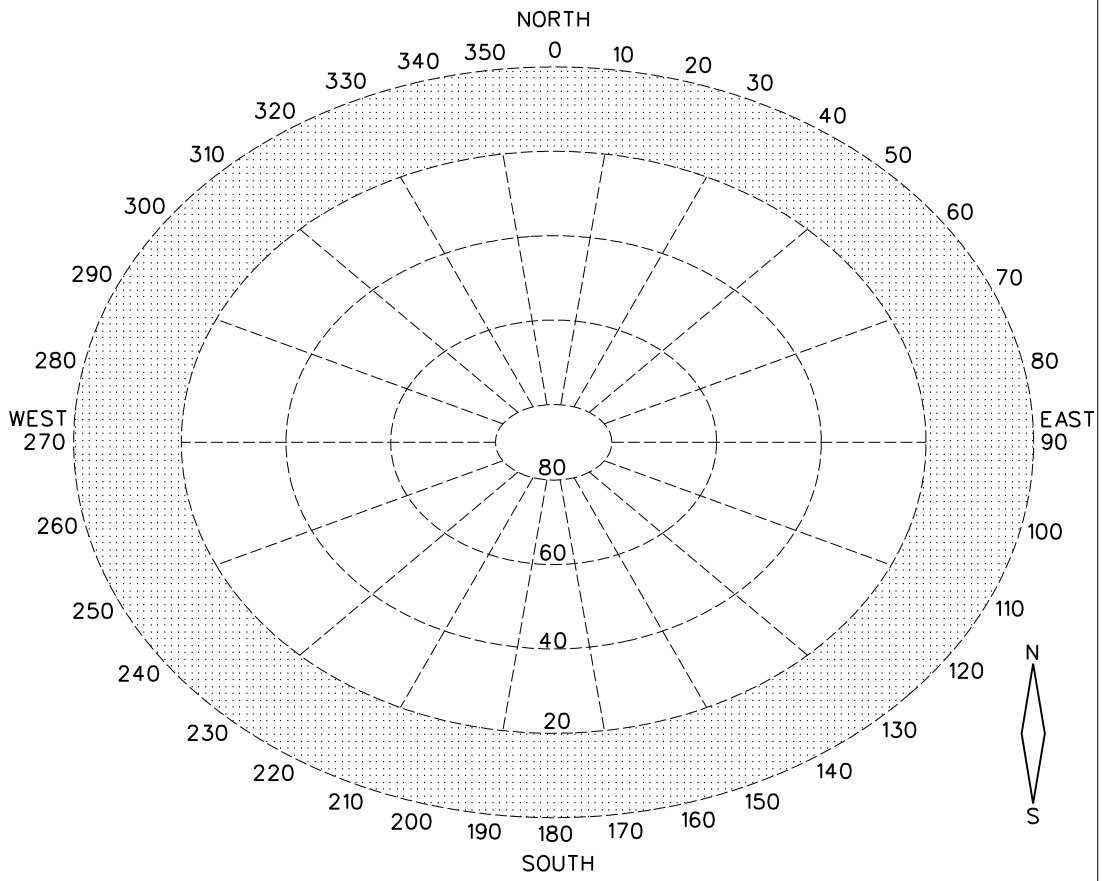
Observation Session #5, 4 Receivers, Duration 15 Minutes Minimum, Use Rapid Static Procedures, Occupy A, B, C & D.

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 GNSS 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

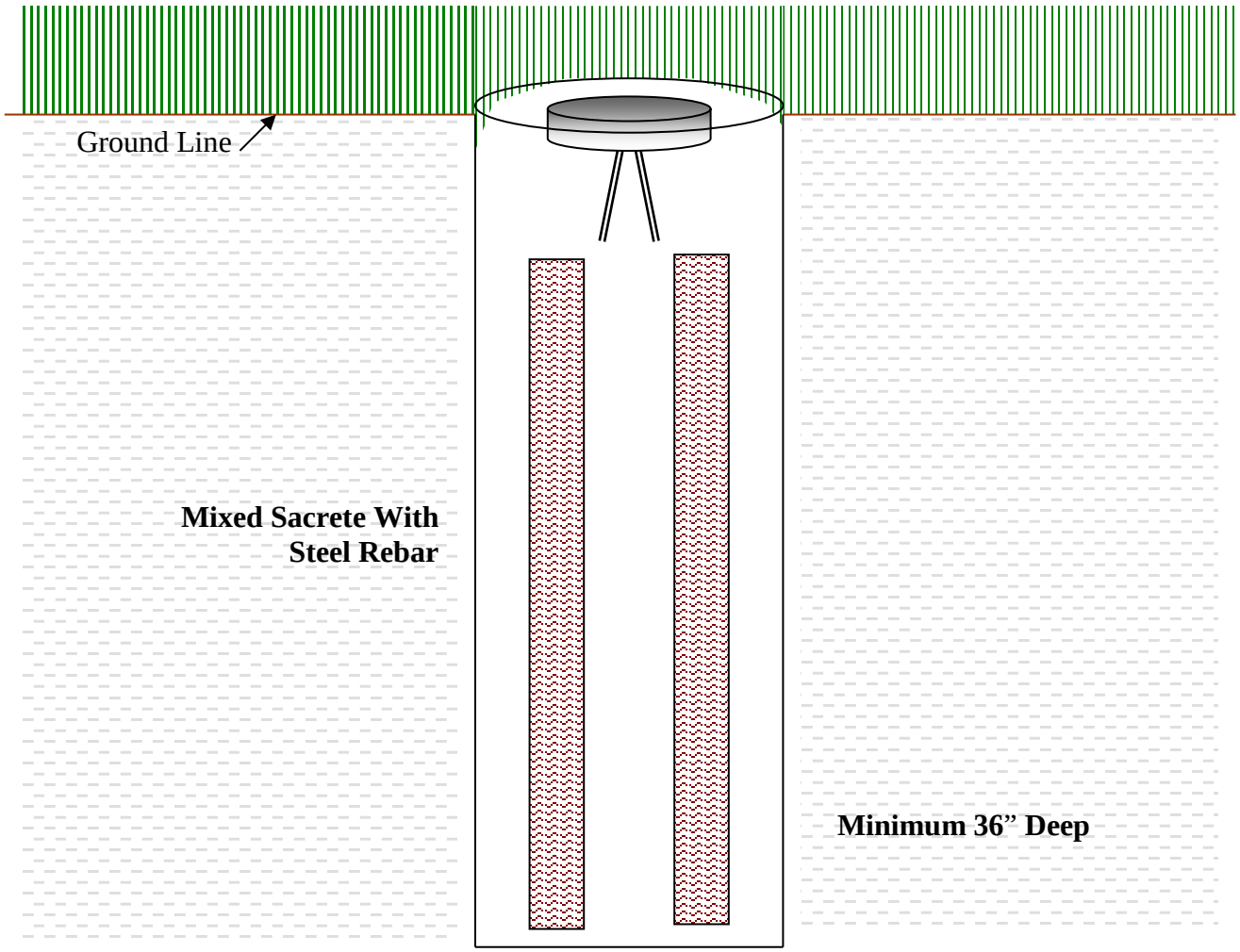


Figure 10-E

VDOT *GNSS OBSERVATION SITE LOG

DATE: _____ **OBSERVER: _____**

RECEIVER NUMBER: BASE _____ R1 _____ R2 _____ (_____)

SERIAL NUMBER (LAST 4 DIGITS): _____

STATION NUMBER (NAME): _____ **SESSION NUMBER: _____**

BEGIN ANTENNA HEIGHT: _____ m CHECK: _____ ft.

MEASUREMENT TAKEN TO: ___ BOTTOM OF MOUNT
(Check One) ___ ANTENNA PHASE CENTER
___ BUMPER ___ HEIGHT HOOK

ANTENNA OFFSET: _____ m (Leica: 0.441m)

START SESSION TIME: _____

START MINIMUN Q.I. READING: _____ SAT NUMBER: _____

INTERMEDIATE MINIMUM Q.I. READING: _____ SAT NUMBER: _____

END MINIMUN Q.I. READING: _____ SAT NUMBER: _____

END SESSION TIME: _____

ENDING ANTENNA HEIGHT: _____ m CHECK: _____ ft.

COMMENTS AND SPECIAL NOTES

* Rev. 7/15

Figure 10-F

LD-200 (REV. 10/2014)

Virginia Department of Transportation Horizontal Control

Control Station I.D. : _-___ Date : _-_-_

VDOT Project Coordinates (2014) East (X) : _____ ft. North (Y) : _____ ft. Elevation : ___ ft.	VA State Plane Coordinates : NAD 83- U.S. Survey Feet East (X) : _____ ft. North (Y) : _____ ft. Ortho. Elevation (H) : ____ ft. Zone : North_ South_ (place an 'X' beside one)
Project Specific Combined Scale Factor: 1.,,,,,,, (8 Decimal Places)	Project Information Project Number : _____ Route : __ City/County : _____ Established By : _____
Latitude : _° _' ___" N (5 Decimal Places) Longitude : _° _' ___" W (5 Decimal Places) Geoid Separation (N) : _____ Ellipsoid Height (h) : _____ Horizontal Datum : _____ Year : ___ Vertical Datum : _____ Geoid : ___ Azimuth to Station : ___ is ___° _' _" Control Based On: Station (Name/PID) _____ or Project (Monument No.) : _____	To convert Virginia State Plane Coordinates to VDOT Project Coordinates, use the following formula : * Multiply the Easting And Northing Values (For Both Zones) by the Project Specific Combined Scale Factor. (Located above left) * Reverse this Procedure to convert VDOT Project Coordinates (2014) to NAD 83 - U.S. Survey Feet

DETAILED SKETCH (Not to Scale)

LD-200 (REV. 10/2014)

[*]Sample Horizontal Control Card "LD-200"

[*] Rev. 7/15

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, HR, 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

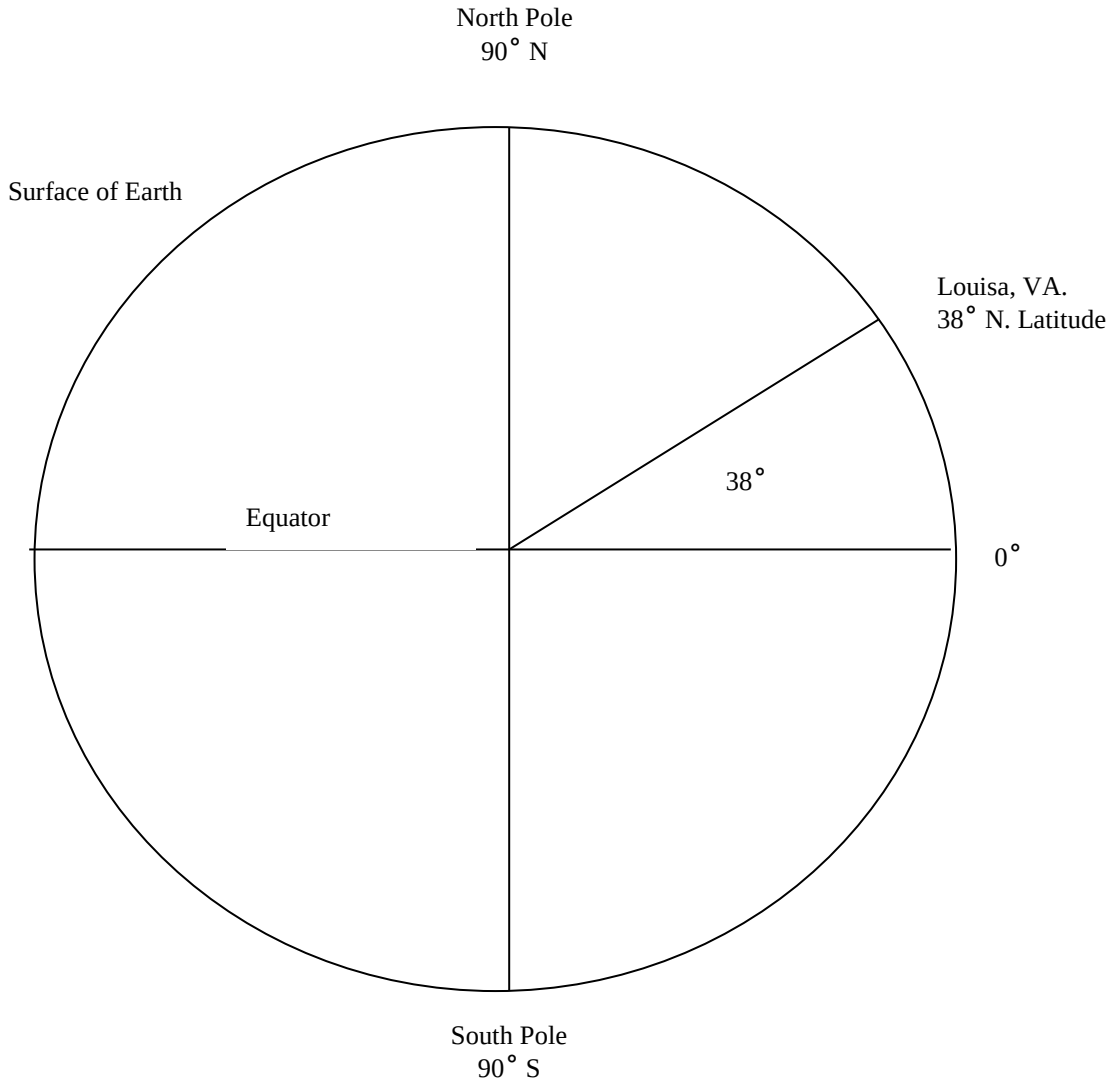


Figure 10-J

HORIZONTAL PLANE THROUGH THE CENTER OF THE EARTH
LONGITUDE

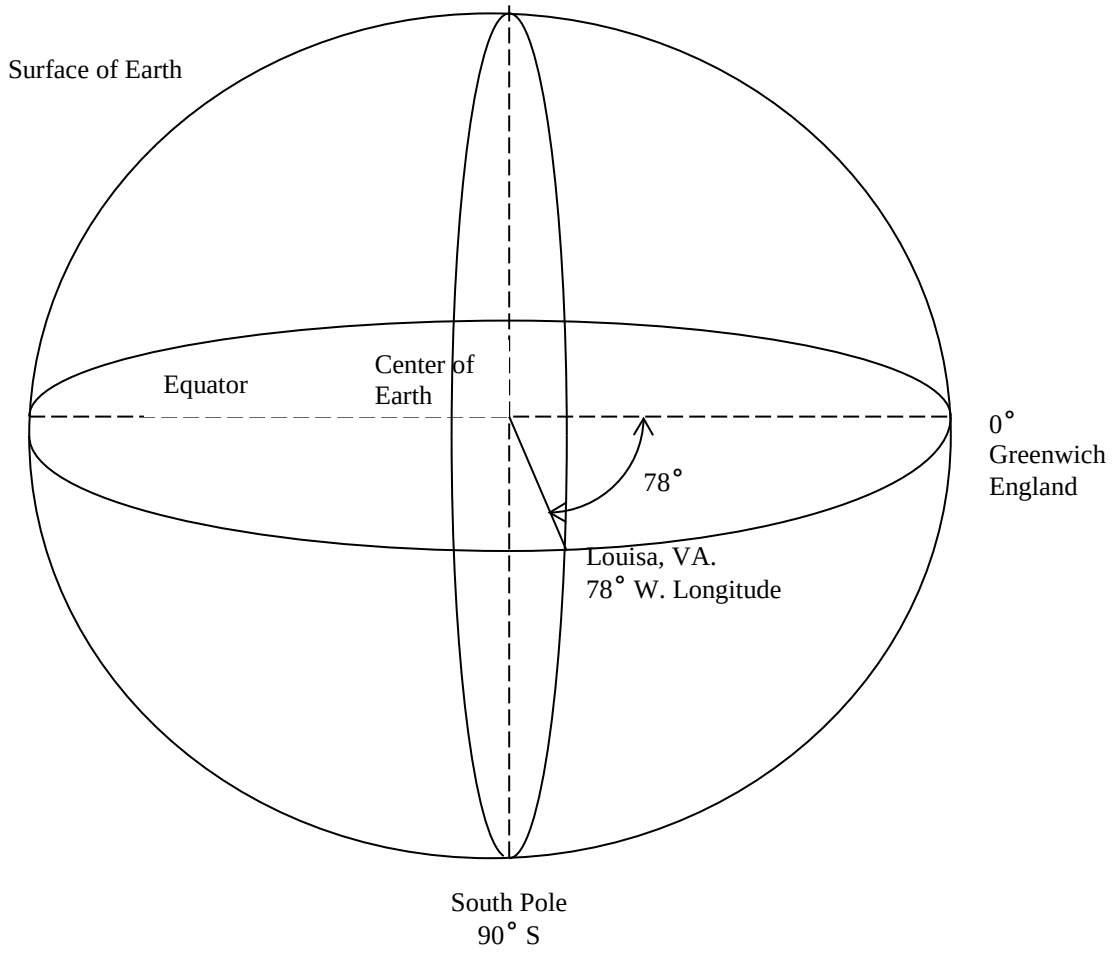


Figure 10-K

PROFILE VIEW
VIRGINIA STATE PLANE COORDINATE SYSTEM

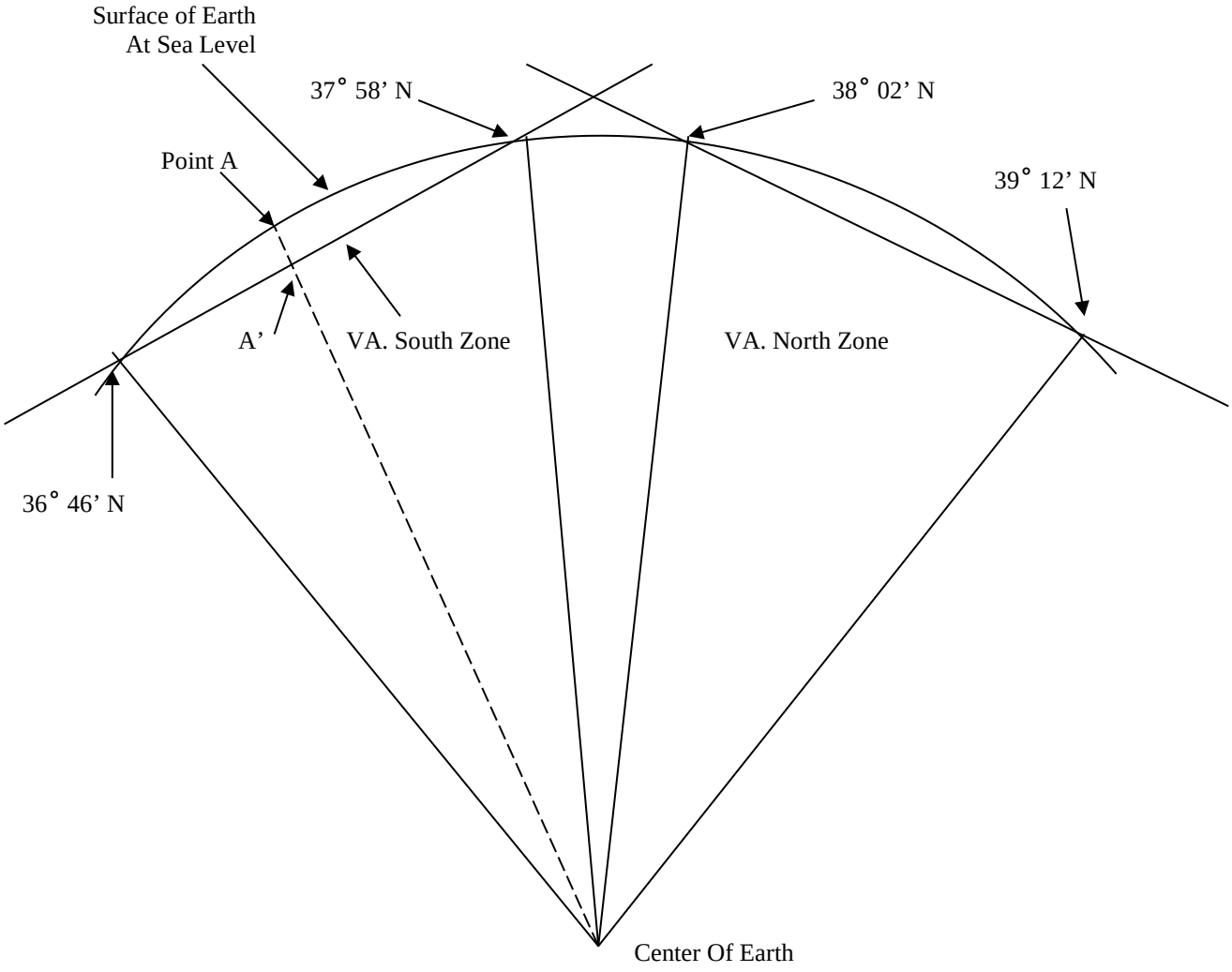


Figure 10-L

RELATIONSHIP BETWEEN TRUE NORTH &
GRID NORTH

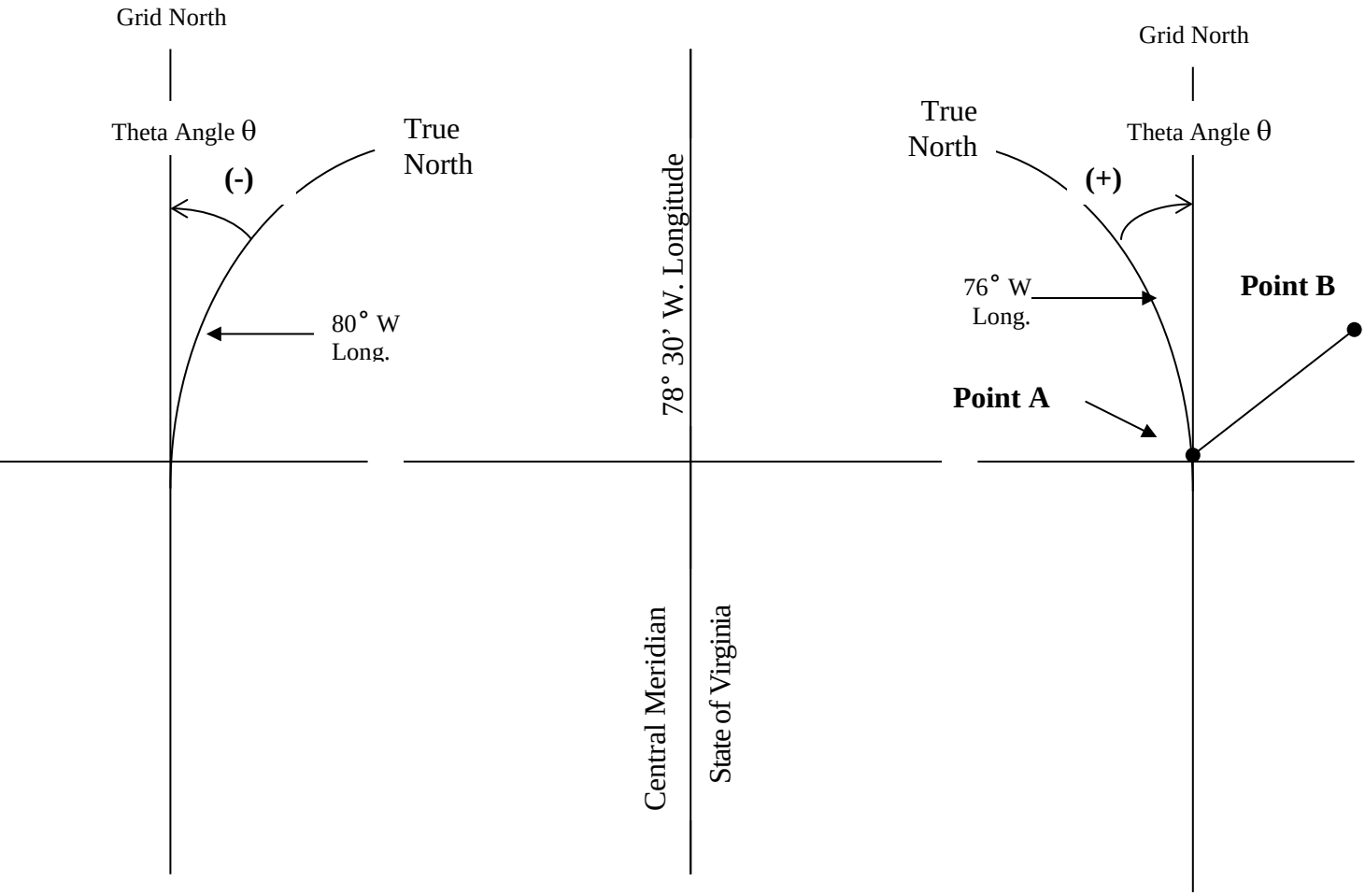


Figure 10-M

§ 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 HR
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

COUNTY CODE NUMBER REFERENCE FOR CITIES AND TOWNS

City or Town Code			County Location		District
100	Alexandria	C	000	Arlington	Nova
101	Big Stone Gap	T	097	Wise	Bristol
102	Bristol	C	095	Washington	Bristol
103	Buena Vista	C	081	Rockbridge	Staunton
104	Charlottesville	C	002	Albemarle	Culpeper
105	Clifton Forge	C	003	Alleghany	Staunton
106	Colonial Heights	C	020	Chesterfield	Richmond
107	Covington	C	003	Alleghany	Staunton
108	Danville	C	071	Pittsylvania	Lynchburg
109	Emporia	C	040	Greensville	HR
110	Falls Church	C	029	Fairfax	NOVA
111	Fredericksburg	C	088	Spotsylvania	Fredericksburg
112	Front Royal	T	093	Warren	Staunton
113	Galax	C	017	Carroll	Salem
114	Hampton	C	027	City of Hampton	HR
115	Harrisonburg	C	082	Rockingham	Staunton
116	Hopewell	C	074	Prince George	Richmond
117	Lexington	C	081	Rockbridge	Staunton
118	Lynchburg	C	015	Campbell	Lynchburg
119	Marion	T	086	Smyth	Bristol
120	Martinsville	C	044	Henry	Salem
121	Newport News	C	094	City of Newport News	HR
122	Norfolk	C	064	City of Norfolk	HR
123	Petersburg	C	026	Dinwiddie	Richmond
124	Portsmouth	C	064	City of Portsmouth	HR
125	Pulaski	T	077	Pulaski	Salem
126	Radford	C	060	Montgomery	Salem
127	Richmond	C	020	Chesterfield	Richmond
128	Roanoke	C	080	Roanoke	Salem
129	Salem	C	080	Roanoke	Salem
130	South Boston	C (T)	041	Halifax	Lynchburg
131	Chesapeake	C	064	City of Chesapeake	HR
132	Staunton	C	007	Augusta	Staunton
133	HR	C	061	Nansemond	HR
134	Virginia Beach	C	075	City of Virginia Beach	HR
135					
136	Waynesboro	C	007	Augusta	Staunton
137	Williamsburg	C	047	James City	HR
138	Winchester	C	034	Frederick	Staunton
139	Wytheville	T	098	Wythe	Bristol
140	Abingdon	T	095	Washington	Bristol
141	Bedford	C	009	Bedford	Salem
142	Blackstone	T	067	Nottoway	Richmond
143	Bluefield	T	092	Tazewell	Bristol
144	Farmville	T	073	Prince Edward	Lynchburg
145	Franklin	C	087	Southampton	HR
146	Norton	C	097	Wise	Bristol
147	Poquoson	C	099	York	HR

148	Richlands	T	092	Tazewell	Bristol
149	Vinton	T	080	Roanoke	Salem
150	Blacksburg	T	060	Montgomery	Salem
151	Fairfax	C	029	Fairfax	NOVA
152	Manassas Park	C	076	Prince William	NOVA
153	Vienna	T	029	Fairfax	NOVA
154	Christiansburg	T	060	Montgomery	Salem
155	Manassas	C	076	Prince William	NOVA
156	Warrenton	T	030	Fauquier	Culpeper
157	Rocky Mount	T	033	Franklin	Salem
158	Tazewell	T	092	Tazewell	Bristol
159	Luray	T	069	Page	Staunton
160	Accomack	T	001	Accomack	HR
161	Alberta	T	012	Brunswick	Richmond
162	Altavista	T	015	Campbell	Lynchburg
163	Amherst	T	005	Amherst	Lynchburg
164	Appalachia	T	097	Wise	Bristol
165	Appomattox	T	006	Appomattox	Lynchburg
166	Ashland	T	042	Hanover	Richmond
167	Belle Haven	T	001	Accomack	HR
168	Berryville	T	021	Clarke	Staunton
169	Bloxom	T	001	Accomack	HR
170	Boones Mill	T	033	Franklin	Salem
171	Bowling Green	T	016	Caroline	Fredericksburg
172	Boyce	T	021	Clarke	Staunton
173	Boydton	T	058	Mecklenburg	Richmond
174	Boykins	T	087	Southampton	HR
175	Branchville	T	087	Southampton	HR
176	Bridgewater	T	082	Rockingham	Staunton
177	Broadway	T	082	Rockingham	Staunton
178	Brodnax	T	012	Brunswick	Richmond
178	Brodnax	T	058	Mecklenburg	Richmond
179	Brookneal	T	015	Campbell	Lynchburg
180	Buchanan	T	011	Botetourt	Salem
181	Burkeville	T	067	Nottoway	Richmond
182	Cape Charles	T	065	Northampton	HR
183	Capron	T	087	Southampton	HR
184	Cedar Bluff	T	092	Tazewell	Bristol
185	Charlotte C. H.	T	019	Charlotte	Lynchburg
186	Chase City	T	058	Mecklenburg	Richmond
187	Chatham	T	071	Pittsylvania	Lynchburg
188	Cheriton	T	065	Northampton	HR
189	Chilhowie	T	086	Smyth	Bristol
190	Chincoteague	T	001	Accomack	HR
191	Claremont	T	090	Surry	HR
192	Clarksville	T	058	Mecklenburg	Richmond
193	Cleveland	T	083	Russell	Bristol
194	Clifton	T	029	Fairfax	NOVA
195	Clinchport	T	084	Scott	Bristol
196	Clintwood	T	025	Dickenson	Bristol
197	Clover	T	041	Halifax	Lynchburg
198	Coeburn	T	097	Wise	Bristol
199	Colonial Beach	T	096	Westmoreland	Fredericksburg
200	Columbia	T	032	Fluvanna	Culpeper

201	Courtland	T	087	Southampton	HR
202	Craigsville	T	007	Augusta	Staunton
203	Crewe	T	067	Nottoway	Richmond
204	Culpeper	T	023	Culpeper	Culpeper
205	Damascus	T	095	Washington	Bristol
206	Dayton	T	082	Rockingham	Staunton
207	Dendron	T	090	Surry	HR
208	Dillwyn	T	014	Buckingham	Lynchburg
209	Drakes Branch	T	019	Charlotte	Lynchburg
210	Dublin	T	077	Pulaski	Salem
211	Duffield	T	084	Scott	Bristol
212	Dumfries	T	076	Prince William	NOVA
213	Dungannon	T	084	Scott	Bristol
214	Eastville	T	065	Northampton	HR
215	Edinburg	T	085	Shenandoah	Staunton
216	Elkton	T	082	Rockingham	Staunton
217	Exmore	T	065	Northampton	HR
218	Fincastle	T	011	Botetourt	Salem
219	Floyd	T	031	Floyd	Salem
220	Fries	T	038	Grayson	Bristol
221	Gate City	T	084	Scott	Bristol
222	Glade Spring	T	095	Washington	Bristol
223	Glasgow	T	081	Rockbridge	Staunton
224	Glen Lyn	T	035	Giles	Salem
225	Gordonsville	T	068	Orange	Culpeper
226	Goshen	T	081	Rockbridge	Staunton
227	Gretna	T	071	Pittsylvania	Lynchburg
228	Grottoes	T	082	Rockingham	Staunton
228	Grottoes	T	007	Augusta	Staunton
229	Grundy	T	013	Buchanan	Bristol
230	Halifax	T	041	Halifax	Lynchburg
231	Hallwood	T	001	Accomack	HR
232	Hamilton	T	053	Loudoun	NOVA
233	Haymarket	T	076	Prince William	NOVA
234	Haysi	T	025	Dickenson	Bristol
235	Herndon	T	029	Fairfax	NOVA
236	Hillsboro	T	053	Loudoun	NOVA
237	Hillsville	T	017	Carroll	Salem
238	Holland	T	061	Nansemond	HR
239	Honaker	T	083	Russell	Bristol
240	Independence	T	038	Grayson	Bristol
241	Iron Gate	T	003	Alleghany	Staunton
242	Irvington	T	051	Lancaster	Fredericksburg
243	Ivor	T	087	Southampton	HR
244	Jarratt	T	091	Sussex	HR
244	Jarratt	T	040	Greensville	HR
245	Jonesville	T	052	Lee	Bristol
246	Keller	T	001	Accomack	HR
247	Kenbridge	T	055	Lunenburg	Richmond
248	Keysville	T	019	Charlotte	Lynchburg
249	Kilmarnock	T	051	Lancaster	Fredericksburg
249	Kilmarnock	T	066	Northumberland	Fredericksburg
250	LaCrosse	T	058	Mecklenburg	Richmond
251	Lawrenceville	T	012	Brunswick	Richmond

252	Lebanon	T	083	Russell	Bristol
253	Leesburg	T	053	Loudoun	NOVA
254	Louisa	T	054	Louisa	Culpeper
255	Lovettsville	T	053	Loudoun	NOVA
256	Madison	T	056	Madison	Culpeper
257	McKenney	T	026	Dinwiddie	Richmond
258	Melfa	T	001	Accomack	HR
259	Middleburg	T	053	Loudoun	NOVA
260	Middletown	T	034	Frederick	Staunton
261	Mineral	T	054	Louisa	Culpeper
262	Monterey	T	045	Highland	Staunton
263	Montross	T	096	Westmoreland	Fredericksburg
264	Mt. Crawford	T	082	Rockingham	Staunton
265	Mt. Jackson	T	085	Shenandoah	Staunton
266	Narrows	T	035	Giles	Salem
267	Nassawadow	T	065	Northampton	HR
268	New Castle	T	022	Craig	Salem
269	New Market	T	085	Shenandoah	Staunton
270	Newsoms	T	087	Southampton	HR
271	Nicklesville	T	084	Scott	Bristol
272	Occoquan	T	076	Prince William	NOVA
273	Onancock	T	001	Accomack	HR
274	Onley	T	001	Accomack	HR
275	Orange	T	068	Orange	Culpeper
276	Painter	T	001	Accomack	HR
277	Pamplin City	T	006	Appomattox	Lynchburg
277	Pamplin City	T	073	Prince Edward	Lynchburg
278	Parksley	T	001	Accomack	HR
279	Pearisburg	T	035	Giles	Salem
280	Pembroke	T	035	Giles	Salem
281	Pennington Gap	T	052	Lee	Bristol
282	Phenix	T	019	Charlotte	Lynchburg
283	Pocahontas	T	092	Tazewell	Bristol
284	Port Royal	T	016	Caroline	Fredericksburg
285	Pound	T	097	Wise	Bristol
286	Purcellville	T	053	Loudoun	NOVA
287	Quantico	T	076	Prince William	NOVA
288	Remington	T	030	Fauquier	Culpeper
289	Rich Creek	T	035	Giles	Salem
290	Ridgeway	T	044	Henry	Salem
291	Round Hill	T	053	Loudoun	NOVA
292	Rural Retreat	T	098	Wythe	Bristol
293	Saint Charles	T	052	Lee	Bristol
294	Saint Paul	T	097	Wise	Bristol
295	Saltville	T	086	Smyth	Bristol
296	Saxis	T	001	Accomack	HR
297	Scottsburg	T	041	Halifax	Lynchburg
298	Scottsville	T	002	Albemarle	Culpeper
298	Scottsville	T	032	Fluvanna	Culpeper
299	Shenandoah	T	069	Page	Staunton
300	Smithfield	T	046	Isle of Wight	HR
301	South Hill	T	058	Mecklenburg	Richmond
302	Stanardsville	T	039	Greene	Culpeper
303	Stanley	T	069	Page	Staunton

304	Stephens City	T	034	Frederick	Staunton
305	Stony Creek	T	091	Sussex	HR
306	Strasburg	T	085	Shenandoah	Staunton
307	Stuart	T	070	Patrick	Salem
308	Surry	T	090	Surry	HR
309	Tangier	T	001	Accomack	HR
310	Tappahannock	T	028	Essex	Fredericksburg
311	The Plains	T	030	Fauquier	Culpeper
312	Timberville	T	082	Rockingham	Staunton
313	Toms Brook	T	085	Shenandoah	Staunton
314	Troutdale	T	038	Grayson	Bristol
315	Troutville	T	011	Botetourt	Salem
316	Urbanna	T	059	Middlesex	Fredericksburg
317	Victoria	T	055	Lunenburg	Richmond
318	Virgilina	T	041	Halifax	Lynchburg
319	Wachapreague	T	001	Accomack	HR
320	Wakefield	T	091	Sussex	HR
321	Warsaw	T	079	Richmond	Fredericksburg
322	Washington	T	078	Rappahannock	Culpeper
323	Waverly	T	091	Sussex	HR
324	Weber City	T	084	Scott	Bristol
325	West Point	T	050	King William	Fredericksburg
326	Whaleyville	T	061	Nansemond	HR
327	White Stone	T	051	Lancaster	Fredericksburg
328	Windsor	T	046	Isle of Wight	HR
329	Wise	T	097	Wise	Bristol
330	Woodstock	T	085	Shenandoah	Staunton
331	Hurt	T	071	Pittsylvania	Lynchburg
			044	Henry	Salem
333	Collinsville	UUP	076	Prince William	NOVA
			076	Prince William	NOVA
335	Quantico Station	UUP	025	Dickenson	Bristol
			004	Amelia	Richmond
			010	Bland	Bristol
338	West Gate	UUP	018	Charles City	Richmond
339	Clinchco	T	024	Cumberland	Lynchburg
			036	GloucesterFredericksburg	
			037	Goochland	Richmond
			048	KingGeorge	Fredericksburg
UUP	Uninc. Urb. Place		049	King and Queen	Fredericksburg
			057	Mathews	Fredericksburg
			062	Nelson	Lynchburg
			063	New Kent	Richmond
			072	Powhatan	Richmond
			089	Stafford	Fredericksburg

Figure 10-P
***GNSS 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 GNSS 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	15 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

* Rev. 7/15

CHAPTER 11

SURVEY
CADD

Please refer to Chapter 2
Of the VDOT CADD Manual

CHAPTER 12

Revised April 4, 2016

SIGNING AND SEALING OF PROFESSIONAL SURVEY DELIVERABLES

Chapter Contents

Sec. 12.01	**Introduction**
Sec. 12.02	**Business & Legal Purpose For Signing And Sealing Survey Products**
Sec. 12.03	**Engineering/Topographic Surveys**
Sec. 12.04	**Right-of-Way, Boundary And Easement Surveys**
Sec. 12.05	**Construction Surveys**
Sec. 12.06	**Survey Information Not Requiring A Seal Or Signature**

Sec. 12.01 **Introduction**

The purpose of the VDOT Survey Program Area is to provide accurate and complete survey information, which meets legally required minimum standards and can be utilized for design, right-of-way and construction efforts. The creation of survey plan base, the platting of rights-of-way and easements, and the monumentation of right-of-way limits falls under the responsibility and purview of professional land surveyors. This chapter establishes new processes, streamlines existing processes and addresses issues that will bring VDOT into compliance with the Code of Virginia with respect to the professional practice of land surveying. This chapter is a general plan to focus attention on these areas of practice within the Department, to aid management in scheduling and budgeting resources for successful implementation and to assure compliance with both the Code of Virginia and Department policies and procedures.

Sec. 12.02 **Business and Legal Purpose for Signing and Sealing Survey Products**

In accordance with the Chief Engineer's directives, beginning July 1, 2009, all new VDOT surveys, deliverables and services listed and described in this chapter and the current VDOT L&D IIM-243 "Sealing and Signing of Plans and Documents", shall be sealed and signed by a surveyor, licensed in the Commonwealth of Virginia. The work shall be performed by, or under the direct supervision of, a land surveyor in good standing, licensed in the Commonwealth of Virginia. The survey products and services shall meet applicable APELSCIDLA minimum standards and regulations and shall follow procedures and practices established in the Department's Survey Manual.

VDOT requires that all plans and documents are to be signed with ACES (Access Certificates for Electronic Services) Business Representatives Digital Certificates. These certificates are purchased from IdenTrust, LLC, and supplied to VDOT staff. For information regarding the application of these products refer to VDOT's CADD Manual [*]Appendix F.

Sec. 12.02.1 **Description of Work and Guidance**

These services consist of performing records research, field work and office computations that ultimately provide certified professionally surveyed information to the Department for its use in evaluating and ascertaining an area for its suitability for transportation purposes, construction or for any other purpose incidental thereto. Safety in the field is paramount therefore; all work zones shall conform to the VDOT Work Zone Safety Protection Manual.

Sec. 12.02.2 **Materials Necessary to Provide Services**

Survey work shall be performed using calibrated, modern surveying equipment, combined with practices and procedures that ensure applicable accuracy requirements are met. All work shall be authorized by the respective District Survey Manager (VDOT employees) or State Survey Program Manager (limited services consultants) with a written notice to proceed and anticipated delivery date. The limits of the area and/or identified facilities requiring survey information shall be identified as the result of a scoping meeting or field site review.

[*] Rev. 7/15

Sec. 12.02.3 **Application of Survey Seal**

These survey products will follow the guidelines outlined in the electronic submission guides and contain* the surveyor's electronic seal, digital signature and certification statement(s) when necessary. These products may contain notes and statements, by the professional, that define what the product represents and what it does not. The **Survey Cell Library** contains sample notes for modification and insertion into the CADD file product. These survey products are deliverables contained within the MicroStation CADD environment. The surveyor shall affix his seal in the proximity of the Title Block portion of the survey file as depicted **Figure 12-A**. Additionally, the surveyor shall include general notes pertaining to the representation of the survey in the same proximity of his seal. In the case of specific notes, the surveyor shall place these in proximity to the areas of concern that require attention. Digital signatures are to be placed with ACES (Access Certificates for Electronic Services) Business Representatives Digital Certificates.

Sec. 12.03 **Engineering/Topographic Surveys**

The majority of this work occurs after project scoping, once funding is authorized, and is delivered at various periods prior to the Plan Coordination Review stage as depicted in the VDOT Project Development Process.

Sec. 12.03.1 **Professional Surveying Services & Responsibilities**

The application of the professional's seal, electronic signature, and date shall be evidence that the survey meets the minimum requirements of DPOR's APELSCIDLA regulations, is an accurate representation of the existing site and ownership conditions on that date for the area of concern, and correct to the best of the professional's knowledge, information, and belief on that date for:

a. Location Surveys

These types of surveys shall conform to **Chapter 4** of the VDOT Survey Manual, titled, "Location Surveys". These surveys include and encompass ownership of record, compiled title evidence, topography, planimetry, drainage information, subsurface utilities and base survey control. These surveys are requested to obtain information pertaining to wetland identification and mitigation and bridge site surveys. Survey updates will be evaluated during the Detailed Design phase of the VDOT project plan process. Updates are critical to the successful completion of the plan, all survey and sue information will be evaluated to see if it warrants updating the survey or sue information. If consultants or VDOT personnel are being used on the project, the same party should be used to complete the project through setting monumentation at the completion of construction if available by contract. If the original consultant is not available, it is imperative that the Project Manager and District Survey Manager determine who will be responsible for signing and sealing the plans.

* Rev. 4/16

b. Photogrammetric Surveys

These types of surveys shall conform to **Chapter 5** of the VDOT Survey Manual, titled, "Photogrammetric Surveys".

c. Hydraulic Surveys

These types of surveys shall conform to **Chapter 7** of the VDOT Survey Manual, titled, "Hydraulic Surveys". These surveys are requested for the specific purpose of hydrologic and hydraulic opening evaluation and engineering. The VDOT Survey Manual establishes the methods and criteria to achieve the desired result. This section of the Manual contains guidance for the performance of Bridge Situation surveys and deliverables.

Sec. 12.04 **Right-of-Way, Boundary and Easement Surveys**

The majority of this work occurs after the Design Approval phase as depicted in the VDOT Project Development Process but before the Project Advertisement phase. This work requires good communication and coordination between Survey and Design team members during the project.

Sec. 12.04.1 **Description of Work and Guidance**

On October 28, 2009, the Department presented the DPOR with a letter entitled "Virginia Department of Transportation – Documents Required to be Signed and Sealed" outlining the documents to be signed and sealed.
On July 17, 2012, the Department sent an updated document to clarify the use of the right of way plan sheet, monumentation be set and the timing for setting final monumentation. The LS/PE board met on August 16, 2012 and accepted the clarification. On September 25, 2012, the full APELSCIDLA met and accepted the clarification letter.

L & D Survey and Right of Way have agreed upon the following work products and documentation includes:

- The Right-of-Way Section will record each acquisition recordation instrument with a right of way plan sheet for partial takes and a plat for total take parcels per the Right-of-Way Manual. Additional plats may be necessary and will be provided on an as needed basis.
- The right-of-way plan sheet or plat will be referenced in the conveyance documents.
- The Survey Section will provide acreage for fee take, permanent and temporary easements at the appraisal stage.
- The Right-of-Way Section will pay landowners for the replacement of lot corners. VDOT or a consultant will be responsible for setting the right of way corners once construction is complete.

Right of Way Plan Sheets -

Right-of-Way Division and the Location and Design have agreed to utilize a right of way plan sheet to acquire properties.

This will be a collaborative effort by the design teams and the survey teams. *Communication is the key to the success of this process.*

Design Team responsibilities:

a. The design team will create the master right of way design file.
   The master Right of Way design file will only have the line work for proposed right of way and easements that is referenced into the master roadway design files.
b. After UFI is reached and comments are addressed the Design team will create a RW file for each plan sheet in the R folder. At the discretion of the Project Manager and District Survey Manager, these may be created at FI so Survey can proceed with checking and sheet setup.
   Permissions will be restricted to Survey staff only for the R and O folders after UFI. The Design teams will provide the GEOPAK GPK files that have the alignment data so GEOPAK can be used to annotate the stations and offsets.
c. The handoff from Design to Survey shall be documented so each team understands their responsibilities.
d. The Design team will coordinate any changes to the SPO and Right of way design files through Survey after the handoff*. Major revisions to the Right of way design files will be completed by the design teams and resubmitted to Survey.

Survey Team responsibilities:

a. The Survey team is responsible for master right of way design file, right of way data sheet and SPO file from the handoff until Ad. Any changes to this line work through the checking or annotation process should be communicated back to the PM and the design team so all reference files can be updated. RW sheets will be provided to Survey by the Design team per Chapter 5 in the CADD manual and should match the plan sheets. Survey will turn off all design information from the RW sheet except for proposed right of way and easements for clarity.
b. All existing monumentation, owners information, and boundary data should be shown and referenced to the construction centerline. Prescriptive easements will be shown graphically only. The typical notes should be added to the sheet and all references to sheet numbers should be corrected to RW this includes match line references.
c. VDOT Monuments should be shown on the applicable RW sheets and labeled.

* Rev. 4/16

d. All angle breaks should be annotated using plus and offsets for the proposed right of way and proposed easements. A plus and offset legend will be shown on the sheet. The perimeter of the new proposed right of way will be shown with metes and bounds sufficient to close the right of way, tie lines may be necessary.
e. All proposed right of way will be labeled on the sheet. All easements will be labeled for their respective uses.
f. All Right of way takes, existing prescriptive easement and proposed easement areas shall be shown the RW sheet in table format per parcel. The table will specify the areas for each different easement use. Areas less than 1 acre will be shown in square feet (x,xxx) and areas greater than 1 acre will be shown in acres(X.XXX acres) to three decimal places.
g. On each sheet, two points on the construction centerline will be labeled with the project coordinate values. The construction centerline will show all tangent and curve data shown on the plan sheet. Roads will be labeled with Route numbers and names.
h. The Surveyor of Record will be responsible for setting right-of-way break points along the perimeter of the proposed right of way after construction is complete.

Example sheets have been provided. **See Figure 12-C and Figure 12-D.**

Please reference Chapter 5 of the CADD manual for more specific details.

All submissions will follow the* Electronic Plan Submission Process Reference and Right of Way Submission Guides shown below.

Electronic Plan Flow Chart
http://www.extranet.vdot.state.va.us/locdes/reference-guides/ElectronicPlan_Submission.pdf

Right of Way Submission Tier 1 & Tier 2
http://www.virginiadot.org/business/locdes/Right_of_way_partial_take.asp

Metes and Bounds Surveys

These types of surveys shall conform to **Chapter 6** of the VDOT Survey Manual, titled, "Metes and Bounds Surveys and Section 5.6.6-5.6.9 in the Right of Way Manual of Instructions. These surveys, also referred to as Boundary Surveys or Metes and Bounds Surveys, represent an extensive effort beyond a typical location survey, to identify and delineate record title lines of a parcel of interest to VDOT.

Sec. 12.04.3 **Plat Process prior to January 1, 2013.**

Right-of-Way Acquisition Plats

***Note: This process is only available for projects prior to January 1, 2013 that have been started using individual plats. All projects after January 1, 2013 will use the RW plan sheet. Plats will be needed for total takes and special properties.**

* Rev. 4/16

Right-of-Way Division and Location and Design agreed in 2010 to a pilot program to utilize the Survey Section to develop right-of-way acquisition plats for use in acquiring fee property and/or interest in property for transportation purposes. The plat shall contain a note that it is produced from compiled data, and will contain the fee take, all easements and applicable minimum requirements as required by DPOR's APELSCIDLA regulations. The plat shall meet the State Library standards for recordation. Preliminary plat preparation shall begin after all Utility* Field Inspection comments have been incorporated into the project plans.

By sealing and signing the product, the land surveyor is testifying that the information shown and depicted in the Right-of-Way Acquisition Plat is a representation of the existing field and ownership conditions on that date for the area of concern, it is produced from compiled sources of data **and** that the survey meets the minimum requirements of DPOR's APELSCIDLA regulations pertaining to boundary or compilation surveys and plats of record. Please refer to **Figure 12-B** for a sample Right-of-Way Acquisition Plat.

Bearings and Distances are the controlling elements for acquisition plats. Stations and offsets are shown on the plat to tie the plat to the project baseline controls (Provide a minimum of 2 points). Plats shall reference the VDOT project number, UPC number parcel number and the corresponding plan sheet associated with these project controls and plusses and offsets. Plats shall clearly show calculated areas of right-of-way and/or each easement type required to construct the project.

As part of plat development, recordation and prior to the commencement of construction, **The Surveyor of Record will be responsible for setting right-of-way break points and points of intersection between the new right-of-way and existing property lines.** Such break points will be shown on the acquisition plats. VDOT will no longer pay the affected property owners for the placement of these points when right of way plats are used.

Sec. 12.05 **Construction Surveys**

The majority of this work occurs after the Project Advertisement phase as depicted in the VDOT Project Development.

Sec. 12.05.1 **Professional Surveying Services & Responsibilities**

All survey work shall adhere to the minimum specifications and guidance as referenced in the current Road and Bridge Specifications (Sections 105.13 and 517) and **Chapters 8** and **9** of the VDOT Survey Manual and Sec. 12.02

* Rev. 4/16

Sec. 12.06 **Survey Information Not Requiring a Seal or Signature**

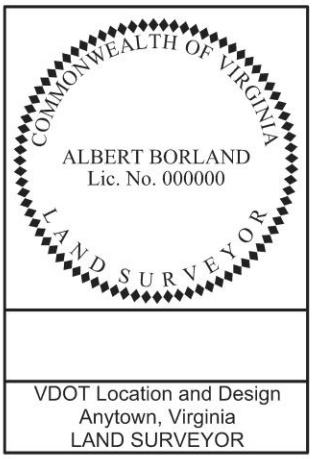
Asset management surveys, or those surveys that are for purely quantitative purposes (i.e. measuring linear feet of guardrail, number of signs, etc.) will not require a seal or signature unless deemed necessary by the requestor. Information secured by surveyors that does not depict critical elevations or planimetric locations, modeled existing conditions or boundary evidence are not required to be sealed and signed.

Information not listed above that is contained within the **Chapter Contents** section of Chapter 8 of the VDOT Survey Manual will not require sealing and signing unless specifically requested.

IIM-LD-243 Signing and Sealing

http://www.virginiadot.org/business/locdes/rd-ii-memoranda-index.asp

Figure 12-A



Route : I
Project : 0001-026-107-P101,C501
District : Richmond
County : Dinwiddie
From : 0J6 Mi.N.Of Int.Rte.I & Rte.226
To : 0J5 Mi.S.Of Int.Rte.I & Rte.226
Horizontal Datum Based On NAD 83 (93)
Vertical Datum Based On NAVD 88
Survey By : Albert Borland L.S.
Operator : P.W. Herman
Date : 7 - 13 - 09
Scale : 1" = 25'
UPC# : 73268

Sample

NOTES:

I HEREBY CERTIFY THAT THIS ROUTE SURVEY TO THE BEST OF MY KNOWLEDGE AND BELIEF IS CORRECT AND COMPLIES WITH THE STANDARDS AND PROCEDURES AS ESTABLISHED BY THE VIRGINIA DEPARTMENT OF TRANSPORTATION LOCATION AND DESIGN DIVISION. SURVEY MANUAL 2009.

PROPERTY INFORMATION IS BASED ON DEEDS AND PLATS OF RECORD. PHYSICAL EVIDENCE FOUND WAS PLACED ON DRAWING.

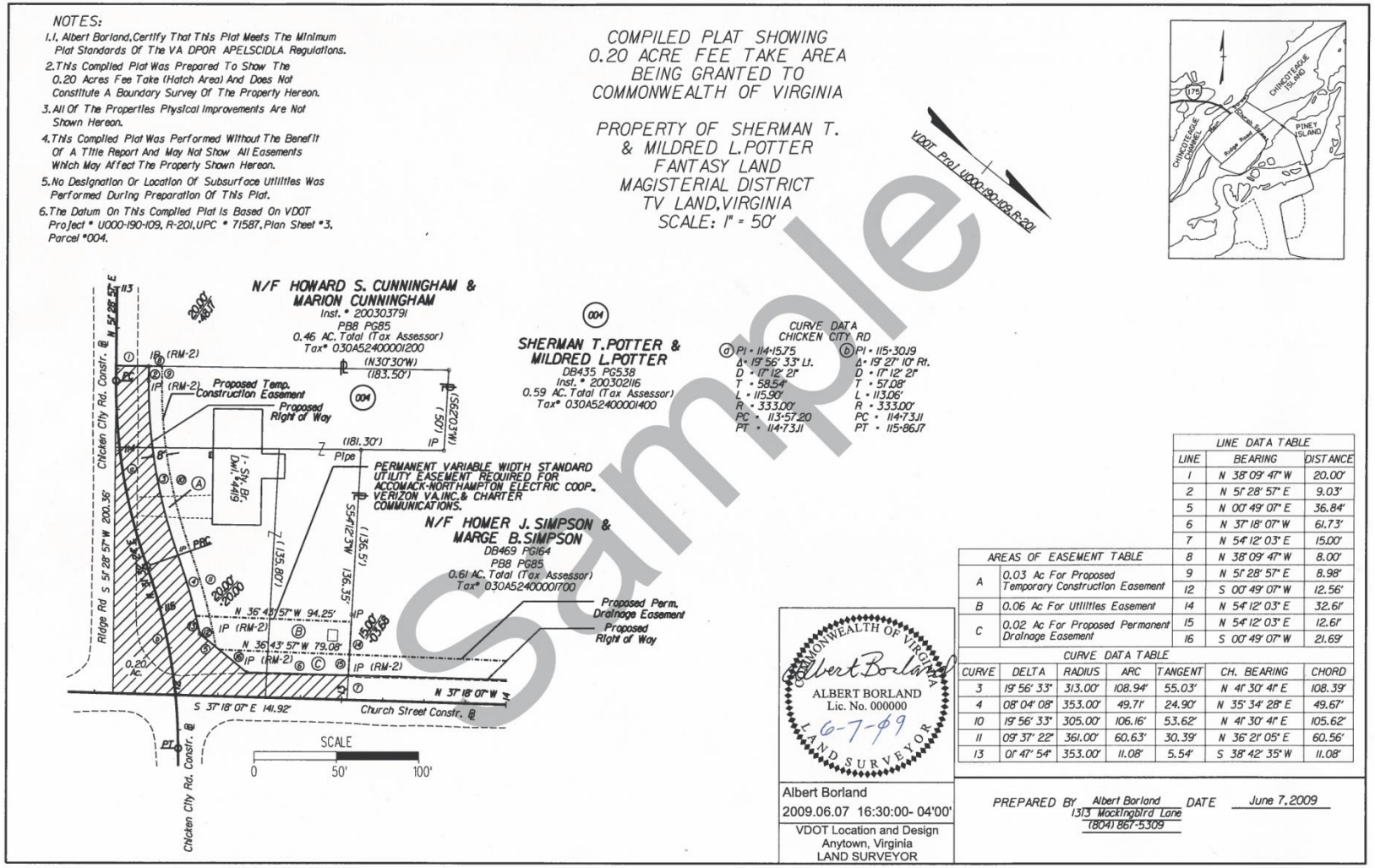
THE INFORMATION SHOWN ON THIS DRAWING WAS COMPILED FROM EXISTING LAND RECORDS AND DOES NOT REPRESENT A BOUNDARY SURVEY.

BEARINGS AND DISTANCES IN PARENTHESES ARE FROM RECORDED PLATS OR DEED DATA

Sample Location of Seal and Signature in MicroStation File

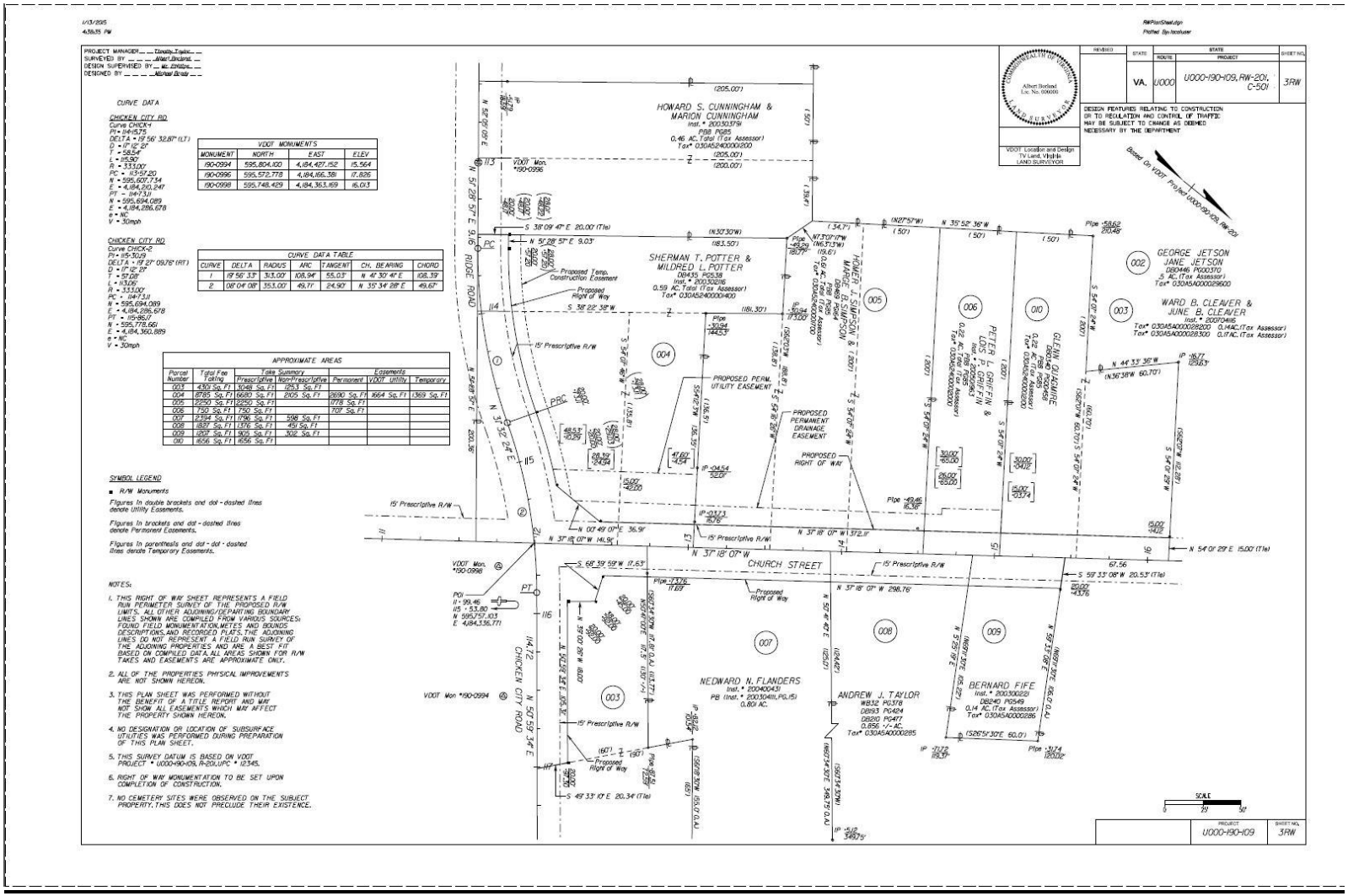
(Note: Digital Signature is embedded in the MicroStation Cell

Figure 12-B



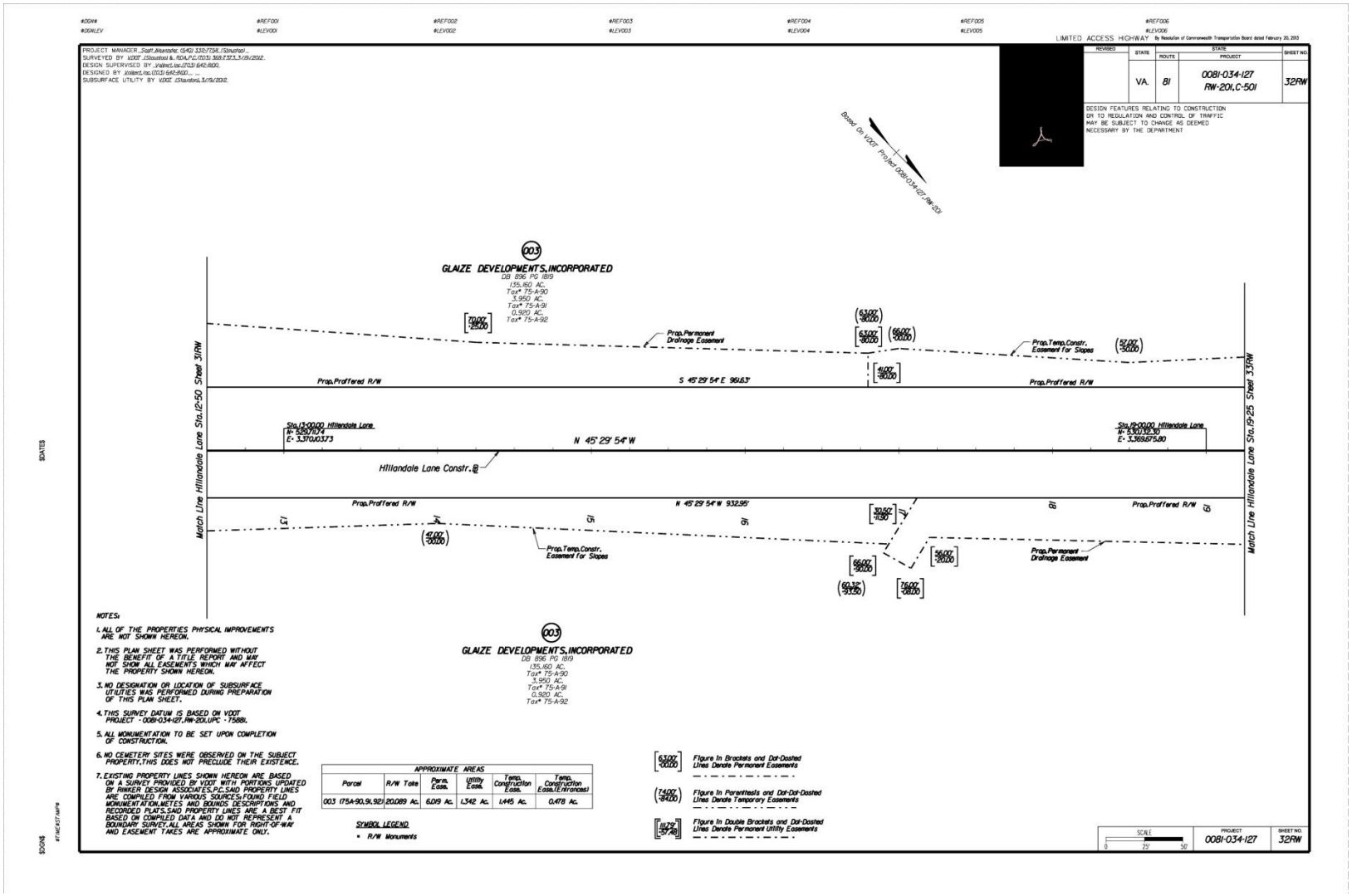
Sample Right-of-Way Acquisition Plat

Figure 12-C Sample Right-of-Way Plan



Line Weights have been turned off for clarity.

Figure 12-D



Sample Right-of-Way Plan

CHAPTER 13

New January 1, 2013

SUE

Subsurface Utility Engineering

Designation and Location

Chapter Contents

Sec. 13.01	Introduction
Sec. 13.02	Standards and Policy
Sec. 13.03	Work Flow Process
Sec. 13.04	Data Distribution
Sec. 13.05	Evaluation of Location(Test-hole) Data
Sec. 13.06	Roadway and Utility Field Inspections

Sec. 13.01 Introduction

Subsurface Utility Engineering (SUE) involves managing risks associated with utility mapping at appropriate quality levels, utility coordination, and utility relocation design and coordination. These utility risks are managed by using designation and locating. Designation is defined as the process of using surface geophysical method or methods to interpret the presence of a subsurface utility and to mark its ***approximate*** horizontal location (designation) on the ground surface. Utility locating is defined as the process of exposing and recording the ***precise*** vertical and horizontal location of utilities (test-holes).

Sec. 13.02 Standards and Policy

Standards:

The Department will follow the most current version of CI/ASCE 38-02 standard entitled "Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data" with the following requirements:

1. All submissions (designation or location) to the department shall contain the names and contact numbers for any utility shown thereon. Test-hole data sheets should contain the name and contact information for the each utility exposed.
2. All fiber optic (FO) lines shall be identified with the company name.
3. VDOT cell symbols and line styles will be used in lieu of the information shown in the ASCE guideline legend (see Figure 11-J in the Survey Manual, page 11-15).
4. Test-holes should not be returned to the Department as unknown. If the utility cannot be identified the department should be contacted immediately while mobilized on the project.
5. Designation and locations shall meet applicable APELSCIDLA minimum standards and regulations, procedures and practices outlined in the Department's Survey Manual, and any other state codified regulations pertaining to land surveying in the Commonwealth.
6. Duct Banks shall be dimensioned in width and depth and located. Elevations shall be determined on all corners top and bottom.

In using this standard, it must be realized that this is not an all-inclusive set of rules and if situations are encountered, the department depends on the skill and initiative of all employees and consultants to resolve, or have these situations resolved efficiently and practically.

Policy:

All projects with buried utilities including water, gas, electric, telephone, television cables, or sanitary sewer force mains should be designated at quality level B unless a waiver is requested from the State Utility Manager or the State Survey Program Manager.
All projects shall be designated by a prequalified Consultant with SUE capabilities. The Department has contracts statewide with Subsurface Utility Engineering (SUE) consultants to designate and locate utilities on projects selected by the Department. These contracts also have GPR (ground penetrating radar) and CCTV available for use.

Designation:

The horizontal location of existing subsurface utilities will be by the consultant and the information will be returned to the department in the format requested on the task request. This includes showing 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 the survey limits will be shown with elevations and inverts. Annotation, property data and any other information will be secured and plotted simultaneously with the designating of the subsurface utilities.
The Consultant/VDOT unit preparing the plan base shall submit MicroStation DGN files electronically via the FTP Server of the entire_project (including title sheet and/or location map) for the designation of the horizontal location of subsurface utilities. If this is an extension of an existing project, the files should clearly show the survey line and control that was established in the field along with sufficient references to locate and retrace.

Location (test-holes):

Test-holes should be secured on all underground facilities, i.e., water and gas lines larger than 3" (75 mm), telecommunications (copper/fiber optics) and electric lines in conduit systems and sanitary sewer force mains when there are potential conflicts. Direct buried telephone or electric cables typically should not require test-holes. Service lines to properties should not be secured unless they are 6" (150 mm) or greater in size. ***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 18" (0.5 m) or less. (Test-holes should not be requested in cuts where the excavation would be expected to uncover the utility.)

Sec. 13.03 **Workflow Process**

Designation:

Survey:

1. PM-100 is used to establish the limits of mapping and authorize the topographical survey and the SUE designation. This also establishes begin and end dates for activity 31S. Additional requests are submitted on LD-261 if necessary.
2. Completed work is stored on the Falcon Document Management system.

Preliminary Road Plan Development

1. Upon receipt of the underground utility designation (horizontal) data, preliminary road plans, including hydraulic design, will be developed. The Project Manager will request that the Structure and Bridge and Central Office Location and Design Traffic Engineering Design Program Area submit preliminary bridge, sign, signal and lighting plans, including estimates, for detailed plan development prior to the public hearing.
2. A review is to be made with these divisions by the Project Manager to determine if there are utility conflicts with bridges, signs, signals, etc. based on the horizontal location of the utilities.
3. The design of the project drainage facilities, walls and other features are to avoid horizontal utility conflicts where feasible.
4. An email outlining any changes made is to be resubmitted to Structure and Bridge and/or Central Office Location and Design Traffic Engineering Program Area and any other preliminary engineering sections, including the Regional Utility Coordinator if the design is altered during plan development affecting their preliminary plans.

Utility Location (Test-holes)

Scheduling

1. The Project Manager 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.
2. The Project Manager should minimize the request for test-holes to one order, or one mobilization by the SUE consultant.

Determination

1. It is expected that the request for test-holes will be based upon several factors one of which is hydraulic design. Additional test-holes may be required when the hydraulic design is finalized.
2. Potential vertical utility conflicts shall be determined after all feasible horizontal design adjustments have been incorporated into the design.
3. When other Divisions need test-holes, they are to submit their requests directly to the Project Manager for inclusion in his submission. Test-hole locations should be based on station and offset to the proposed construction centerline or by project coordinates.
4. The Project Designer with input from the project team shall clearly identify the location of test-holes to be secured on the plan sheets. Test-hole locations should be based on station and offset to the proposed construction centerline or by project coordinates.
5. The Project Manager shall request that the - Regional Utility Coordinator review the marked plans to assure that all necessary data will be secured with the initial request.
6. The Regional Utility Coordinator should advise the Project Manager of any known utility relocations that are proposed which will negate the need for any test-holes.
7. Determination is complete when the Project Manager and Regional Utility Coordinator are in concurrence with the requested test-holes.

Requesting Locating (Test-holes) Information (Project related)

1. The Project Manager shall submit the test-hole scoping data in PDF format to the District Survey Manager. Scoping data will include:

    a. The LD-261 form must be signed by the Regional Utility Coordinator and the Project Manager.
    b. An appropriate and open activity charge code to be used at invoicing.
    c. A list of each test-hole with station and offset or project coordinates.
    d. If the project was designated previously, the names of the Prime and SUE consultant and the dates of the last designation must be provided.
    e. Email address for submission of the test-hole data: submit directly to the Project Manager and cc the District Survey Manager and the State Survey Program Manager.
    f. Due dates for the test-hole data.

2. The District Survey Manager will:
    a. Contact and provide the scoping data to the State Survey Program Manager for a consultant. If a consultant has been on a project, the SOP should be to continue to use the same firm if available.
    b. Provide the scoping data to the selected consultant for the task with the survey control data for the project.
    c. Will Review the task request with the Project Manager and send NTP to the State Survey Program Manager.

3. The State Survey Program Manager will review the task request and give final NTP to the selected consultant.

4. District Survey Manager will track the consultant progress by email or phone communication protocols.

Requesting Locating (Test-holes) Information (Non-Project related)

1. The Requestor shall submit the test-hole scoping data in PDF format to the District Survey Manager. Scoping data will include:
    a. A request by memorandum made to the District Survey Manager stating the need.
    b. A sketch showing the location with horizontal and vertical control.
    c. An appropriate charge number
    d. Email address for submission of the test-hole data: submit directly to the Requestor and cc the District Survey Manager and the State Survey Program Manager.
    e. Due dates for the test-hole data.

2. The District Survey Manager will:
    a. Contact and provide the scoping data to the State Survey Program Manager for a consultant. If a consultant has been on a project, the SOP should be to continue to use the same firm if available.
    b. Provide the scoping data to the selected consultant for the task.
    c. Will Review the task request with the Project Manager and send NTP to the State Survey Program Manager.
3. The State Survey Program Manager will review the task request and give final NTP to the selected consultant.
4. District Survey Manager will track the consultant progress by email or phone communication protocols.

Sec. 13.04 **Data Distribution**

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

The data should include:

a. The test-hole data sheets.
b. The Utility Test-hole Information Sheet in electronic format.
c. An original copy of the underground utilities test-hole information sheet
d. A plan sheet showing the location of the test-holes.
e. The test-hole certification sheet should be provided to the Regional Utilities Coordinator.

Sec. 13.05 **Evaluation of Location (Test-hole) Data**

The Regional Utility Coordinator in conjunction with the Project Manager 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 Project Manager shall determine if changes can be made to eliminate the utility conflict.

If the design is changed, new test-hole data may be required. Should such changes significantly increase the cost of the construction items, the Project Manager shall advise the Right of Way Division Utilities Program Manager, the State Utilities Engineer and the Local Project Program Manager, if applicable, of the estimated cost for proper disposition.

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

Sec. 13.06 **Roadway and Utility Field Inspections**

Distribution of Prints

After Roadway P.F.I. and F.I. evaluation is complete and approval received, the appropriate changes must be incorporated into the plans.

The Project Manager shall distribute notification of where the plans are located in Falcon for the Utility F.I. in accordance with the Utility Field Inspection Form LD-428.

The computer plotted cross sections are located in Falcon along with the CADD plans.

The Project Manager/Consultant is to be notified of the Utility Field Inspection on all projects. Check the appropriate data on the Utility Field Inspection Form.

The Location and Design Division maintains the LD Forms and they are available for applicable projects at: http://vdotforms.vdot.virginia.gov/

Construction Plans

Required utility adjustments will be determined by the Regional Utility Coordinator.

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., 17” (430 mm) 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.

APPENDIX A

This section has been moved to the CADD Manual as Appendix B

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					

Minutes & Seconds to Decimals of a Degree

	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:

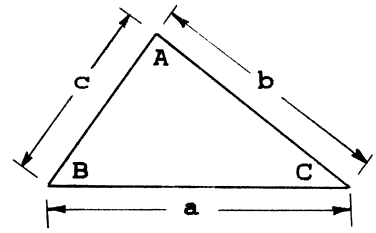
8° = 8.000000
49’ = 0.816667
27” = 0.007500

Add the three numbers to get the result…..8.824167°

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: 8° 49’ 27”

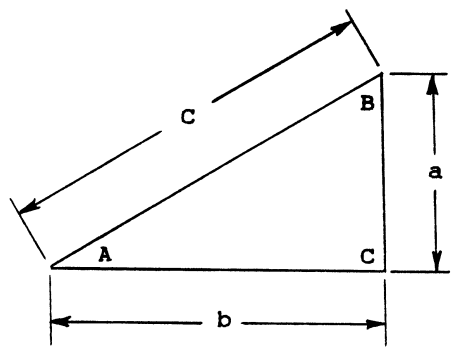
Law of sines	$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$
Law of cosines	$a^2 = b^2 + c^2 - 2bc \cos A$ $b^2 = a^2 + c^2 - 2ac \cos B$ $c^2 = a^2 + b^2 - 2ab \cos C$
Law of tangents	$\frac{a - b}{a + b} = \frac{\tan 1/2\ (A-B)}{\tan 1/2\ (A+B)}$



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	$\sqrt{a^2 + b^2 - (2ab \times \cos C)}$

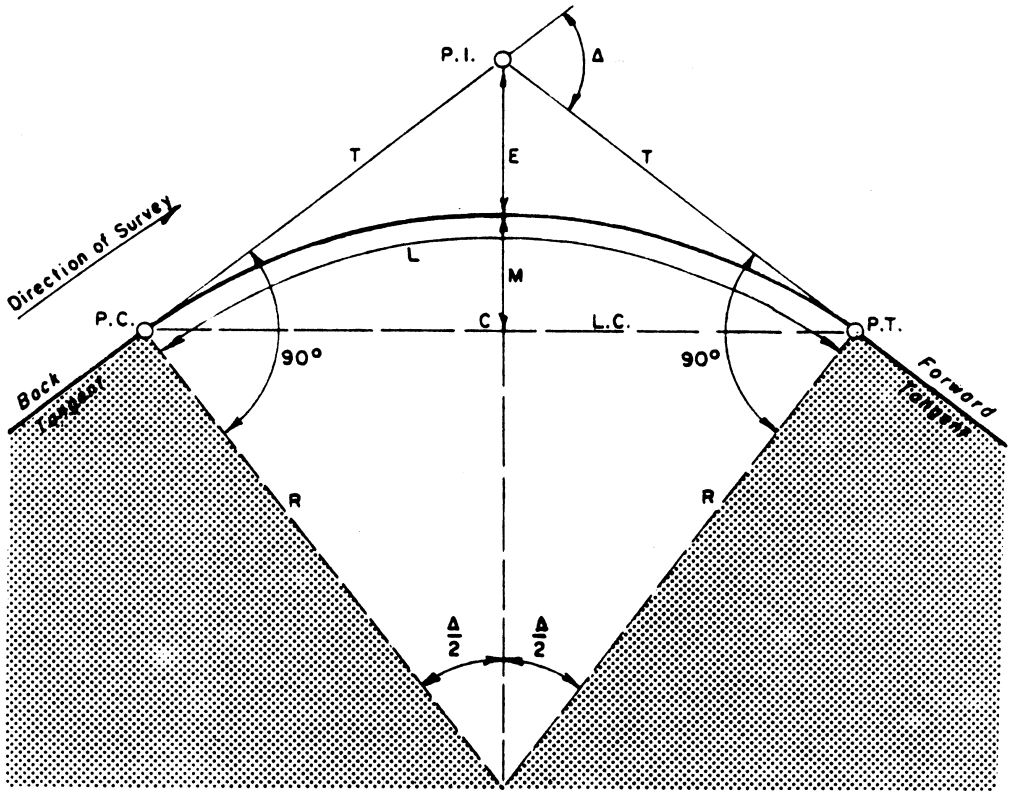
SIN = $\frac{\text{Opposite Side}}{\text{Hypotenuse}}$	TAN = $\frac{\text{Opposite Side}}{\text{Adjacent Side}}$	SEC = $\frac{\text{Hypotenuse}}{\text{Adjacent Side}}$
COS = $\frac{\text{Adjacent Side}}{\text{Hypotenuse}}$	COT = $\frac{\text{Adjacent Side}}{\text{Opposite Side}}$	CSC = $\frac{\text{Hypotenuse}}{\text{Opposite Side}}$



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	$\sqrt{1 - \text{Cos}^2 A}$
COS A	Sides b, c	$\frac{b}{c}$
COS A	Sin A, Tan A	$\frac{\text{Sin A}}{\text{Tan A}}$
COS A	Sin A	$\sqrt{1 - \text{Sin}^2 A}$
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

Find	Given	Formula
SIDE b	Side a, Tan A	$\frac{a}{\text{Tan A}}$
SIDE c	Sides a, b	$\sqrt{a^2 + b^2}$
SIDE c	Side a, Sin A	$\frac{a}{\text{Sin A}}$
SIDE c	Side b, Cos A	$\frac{b}{\text{Cos A}}$
TAN A	Sin A, Cos A	$\frac{\text{Sin A}}{\text{Cos A}}$
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

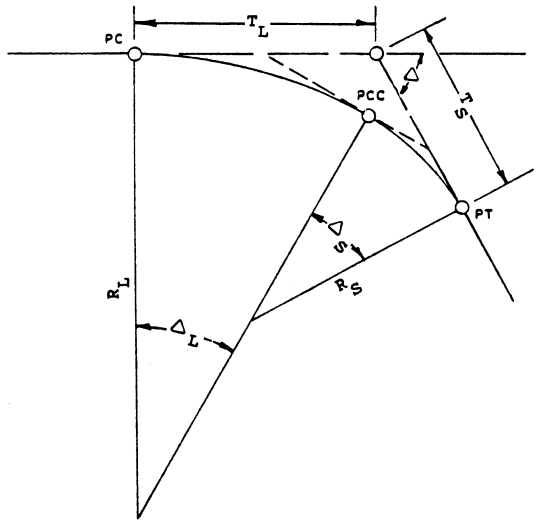
M – Middle Ordinate

L.C. – Long Chord (Distance Between P.C. and P.T.)

C – Midpoint of Long Chord

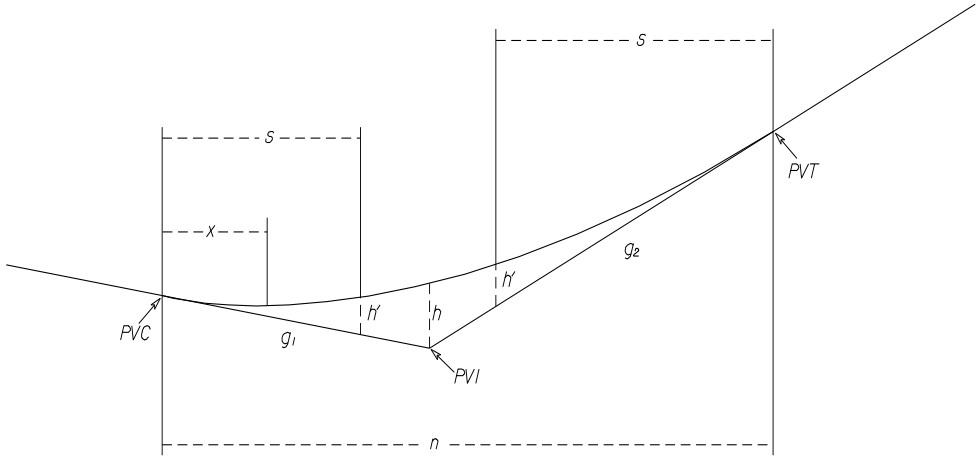
D – Degree of Curvature

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.

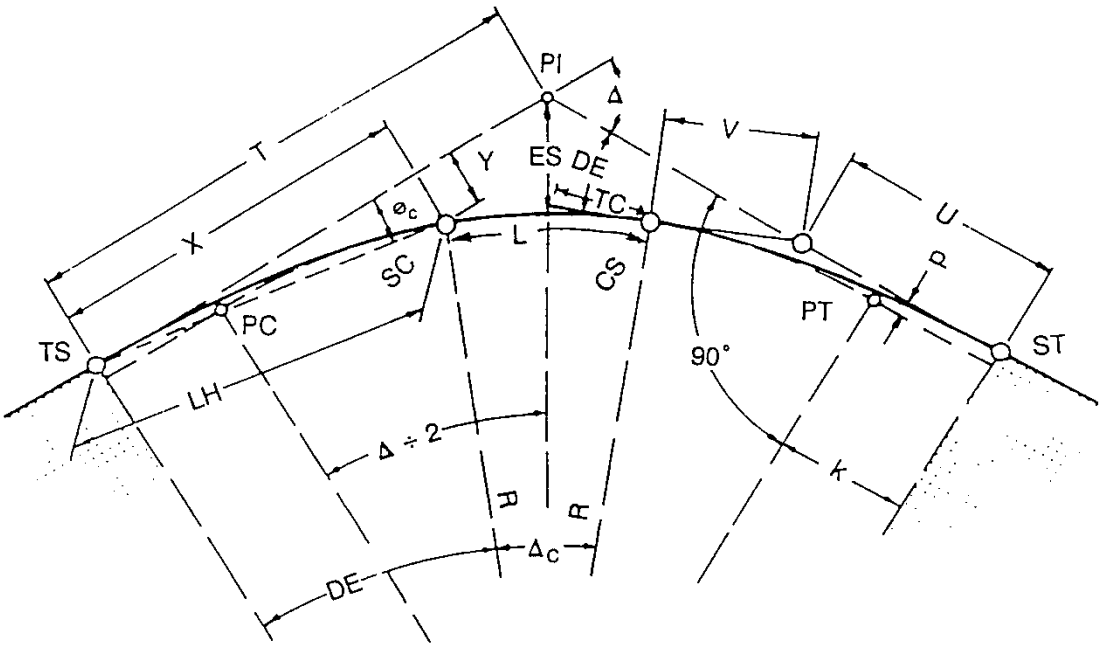
   Δ_L central angle for spiral for a length

   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	V =	Short Tangent
L =	Length of Circular Curve	X =	Tangent Distance for SC
R =	Radius of Circular Curve	Y =	Tangent Offset of the SC
TC =	Tangent of Circular Curve	k =	Simple Curve Coordinate (Abscissa)
T =	Tangent Distance	p =	Simple Curve Coordinate (Ordinate)
Δ =	Deflection Angle Between the Tangents	$\varnothing_C$ =	Deflection Angle of Spiral Curve
DE =	Spiral Angle	TS =	Tangent to Spiral
Δ_C =	Central Angle Between the SC and CS	SC =	Spiral to Circular Curve
ES =	External Distance	CS =	Circular Curve to Spiral
LH =	Long Chord	ST =	Spiral to Tangent
U =	Long Tangent		

SPIRAL CURVE FORMULAS

DE =	$(28.6479 \times LS) \div R$	TC =	$R \times [\text{Tan}\ (\Delta_C \div 2)]$
Z =	$0.01745 \times DE$	Δ_C =	$\Delta - (2 \times DE)$
X =	$LS \times [1 - (Z^2 \div 10) + (Z^4 \div 216)]$	p =	$Y - [R \times (1 - \cos (DE)]$
Y =	$LS \times [(Z \div 3) - (Z^3 \div 42) + (Z^5 \div 1320)]$	k =	$X - [R \times (\sin (DE)]$
L =	$(R \times \Delta_C) \div 57.2958$		

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} $[(R + p)_1 \div \sin \Delta] - [(R + p)_2 \times \cot \Delta] + k$

APPENDIX C

Model Virginia Map Accuracy Standards
National Map Accuracy Standards

Commonwealth of Virginia

Information Technology Resource Management Guideline

Model Virginia Map Accuracy Standards

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:

$$D^2 = d_1^2 + d_2^2 + \text{----------} + d_n^2$$

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]:

$$CMAS = 2.146\sigma_x \qquad \text{or:} \qquad CMAS = 2.146\sigma_y$$

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:

b = S/√(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 = **S/√d = 28.1 mm/√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.

U.S. BUREAU OF THE BUDGET

Issued June 10, 1941
Revised April 26, 1943
Revised June 17, 1947