CONNECTICUT DEPARTMENT OF TRANSPORTATION

LOCATION SURVEY MANUAL

REVISED MAY 2026

PREFACE

The purpose of the Location Survey Manual is to maintain uniformity and conformance with Connecticut Department of Transportation (CTDOT) practices and procedures for all surveys being prepared by and for the State.

This manual has been revised to facilitate technical advances made in the surveying profession as well as changes in policy and procedure related to those changes.

As directed by the Commissioner, all assignments are to be performed utilizing the Microstation/ORD design file format as implemented by CTDOT as the standard for all of its CADD related functions.

Section 1, *Specifications for Location Surveys,* addresses the requirements necessary for Location Surveys.

Section 2, *Specifications for Digital Mapping*, addresses the preparation of survey mapping utilizing CADD.

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CONNECTICUT DEPARTMENT OF TRANSPORTATION
STANDARDS FOR LOCATION SURVEYS AND DIGITAL MAPPING

Section 1

Specifications for Location Surveys

Section 2

Specifications for Digital Mapping

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CONNECTICUT DEPARTMENT OF TRANSPORTATION

STANDARDS FOR LOCATION SURVEYS

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SECTION 1

CONNECTICUT DEPARTMENT OF TRANSPORTATION

SPECIFICATIONS FOR LOCATION SURVEYS

1.0 DEFINITION OF TERMS

Whenever in these Specifications the following terms, or pronouns in place of them, are used, the intent and meaning shall be interpreted as follows:

1.1 AGREEMENT – The signed covenant between the State and the Consultant Engineer covering the limits and scope of work to be performed by the Consultant Engineer. The Agreement, when at variance with these Specifications, shall take precedence.

1.2 COMMISSIONER – The Connecticut Department of Transportation Commissioner, acting directly or through his duly authorized representative.

1.3 CONSULTANT – The individual, firm, association, or partnership named in the agreement to perform the survey and/or mapping project (Consulting Engineer)

1.4 DESIGNER – The individual(s), District, Unit, Consulting Engineer, or Sub-Consultant authorized by Connecticut Department of Transportation and acting to prepare plans, specifications, and related design documents for the construction, reconstruction, or improvement of Department highways and associated assets.

1.5 ENGINEER OR REPRESENTITIVE – An employee of the Department of Transportation duly authorized by the Commissioner to act as his representative in dealing with the Consulting Engineer, and who may make any and all inspections of the work, and who shall issue such special instructions to the Consulting Engineer as are necessary, from time to time, for the completion of the designated project.

1.6 STATE – The Connecticut Department of Transportation (CTDOT).

1.7 SUB-CONSULTANT – The individual, firm, association, or partnership to whom the Consulting Engineer sublets or assigns any part or parts of the project covered by the agreement.

1.8 SURVEYOR – The person or persons, the District, Unit, Consulting Engineer, or Sub-Consultant actually engaged in the performance of the survey and/or mapping operations for the Connecticut Department of Transportation.

1.9 DISTRICT – The four (4) units of the Department of Transportation (Bureau of Engineering and Construction) responsible for all survey work performed inside their respective district areas (See Exhibits 1 and 2)

1.10CENTRAL SURVEYS – The centralized unit responsible for overseeing, tracking, and managing survey assignments and activities. This office is also responsible for property maps, geodetics, and survey Geographic Information Systems (GIS), as well as disseminating survey data.

2.0 DESCRIPTION

2.1 Individual Project Scope

The location and limits of the project are described in the contract agreement between the Consulting Engineer and the State or in an official Survey Request Memorandum.

The Surveyor will be required to furnish the qualified personnel, equipment, office space and supplies, except as described hereinafter, to perform the field and office work for completion of the survey and mapping, to the extent covered in the agreement or survey request memorandum in accordance with the provisions of this manual.

The State will designate the project number(s) to be assigned to the project and such number(s) shall be used on all pertinent documents and correspondence.

The State reserves the right to inspect, review, or check each field or office phase of the Surveyor's work to assure compliance with the standards and policies established by the State. Surveys performed by Consulting Engineers may be inspected by the State.

For all surveys, whether by State forces or Consultants, permission to enter private property should be obtained by the Surveyor before entering such property to perform survey activities, regardless of Chapter 925, Sec. 52-557o – Liability of Land Surveyors, Connecticut State Statutes.

A. Use of Previous Survey

The State recommends new location surveys to be conducted to supersede any existing mapping for all new projects. The practice of using previous survey has uncovered costly discrepancies due to paving, drainage, and other updates that may not be readily noticeable without current survey.

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2.2 Commissioner's Policy Statement and Engineering Directive

Commissioner Emil H. Frankel's Policy Statement – Policy No. ADMIN-24, dated March 16, 1993, states:

Subject: Computer Aided Design and Drafting Standardization

It is the policy of this Department to adopt the "Microstation file format as implemented by the Connecticut Department of Transportation" as the standard for all its CADD related functions. It should be emphasized that this standardization applies for the Department's entire business needs, whether performed by in-house staff or by consultants retained by the Department. (See Exhibit 3 for copy of this policy statement)

Further clarifying the use of its predecessor, Engineering Administrator Theodore H. Nezames' Engineering Directive – ED-2020-5, dated July 20, 2020 – states that all new projects beginning after August 1, 2020 shall use Bently CONNECT suite of products. (See Exhibit 3 for copy of this policy directive)

To comply with the Commissioner's Policy Statement as well as the Engineering Administrator's Directive, all survey location work – whether performed by in-house staff or by consultants – shall be provided in *ORD (OpenRoads Designer) Design File Format*, using the latest *Connect Digital Design Environment* CTDOT - CONNECT DDE.

The Consultant must deliver a Bentley OpenRoads Designer (ORD) file compiled according to Volume 4 OpenRoads Designer Survey of the CTDOT DDE Guide.

The Surveyor shall use a total station instrument, survey-grade GNSS receiver with data collector, or other survey-grade equipment to gather the field information. The

gathered information is to be stored in the data collector and later downloaded into the ORD Design File Format, utilizing the standard CTDOT seed file, symbology, features, levels, Bentley Fieldbook, etc. as indicated in the current Digital Design Environment and this manual.

The standards specified in this manual were selected to assure consistent precision and accuracy in all the coordinates, elevations and terrain models upon which design engineering is based.

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2.3 Materials and Information to be Furnished by the State

1. Location Plans showing area to be covered by the survey and sites of special surveys required.

2. Project datum.

3. Description of the location and elevation of existing benchmarks to be used as the base for vertical control. Metadata and details of methodology used to establish vertical control.

4. Control monuments and/or discs (when required), and right of entry forms.

5. The CTDOT CONNECT DDE (Digital Design Environment) CTDOT - CONNECT DDE, which contains resources, standards and the tools necessary for accomplishing survey projects in accordance with CTDOT CAD standards. It also contains a CTDOT standard WorkSet (Project) and CTDOT's Configuration Files (Workspace). All the necessary configurations and resource files (Cells, Level Names, Symbology, etc.) are contained within these files.

6. The CTDOT Survey Location manual: Location Manual.

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2.4 Supplies, Equipment, Engineering Services and Data to be Furnished and Completed by the Surveyor

1. All personnel working under direction of a Connecticut Licensed Land Surveyor.

2. GNSS (Global Navigation Satellite System) survey grade antennas/receivers, total stations, digital levels, automatic levels, scanners, LiDAR, SONAR, UAS, prisms, targets, rods, barometers, thermometers, vehicles, data collectors, software, stakes, pins, flagging, field books and any other supplies or equipment necessary to complete the survey.

3. Drawing media, mylar, and plotting/printing equipment.

4. Raw survey data – all unedited data from survey controller/data collector.

5. Location survey files in Bentley ORD design file format (or current CTDOT file format standard) with digital field books and ORD Terrain model(s). See Section 2 (1.5) for file requirements and CTDOT - CONNECT DDE.

6. Any registered point cloud files (LAS or e57), imagery, aerotriangulation reports, and validation points, as necessary, for projects utilizing remote sensing (see Specifications for Photogrammetry and LiDAR manual).

7. Completed topographic and planimetric maps, field books, original computations, control reports, and all data described hereinafter.

8. All safety equipment, training, and supplies as required by State and Occupational Safety and Health Administration (OSHA) regulations. Railroad training as required by owners and operators for access. Mine Safety and Health Administration (MSHA) training if required for access to quarries or mines per Part 46.

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3.0 PROJECT CONTROL

3.1 Description

When the term *project control* is used in this manual, it refers to the control traverses, base lines, GNSS networks, and level lines occurring within the area of a project. The purpose is to control the engineering and construction work required for a project. Points established under these standards and procedures are generally

within the work limits of the project and are assumed to be recoverable and stable, although potentially expendable.

The establishment in the field of a control traverse and/or network shall be the basis for all future surveying activities, such as: topography, sub-loops, base lines, and construction staking. The office computations required to adjust the field angles, distances, and coordinates shall be within the limits prescribed in Section 1 (3.2 and 3.4).

All survey information shall be collected or scanned electronically.

Generally, the surveyor shall *not* run control lines concurrently with that of topographic survey data collection. However, exceptions can be made where it is only possible to occupy a control point one time (due to access or traffic control issues, for example).

All raw survey data, including written field notes with control descriptions, sketches, ties, etc., collected must be preserved and provided electronically to the Department. An unadjusted (raw) control submission must be made so that any end-user can be assured that all accuracy and procedural parameters set forth in this manual have been met.

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3.2 Horizontal Project Control

Control surveys may be established using GNSS observations, traditional terrestrial traverse (angles and distances), or a combination of both. To ensure consistency across all State projects, **Weighted Least Squares adjustment is now the required method** for control adjustment and final coordinate determination.

The State has transitioned from legacy "Closure Ratios" (e.g., 1:10,000) to **Positional Uncertainty** standards. Least Squares is preferred because it:

- Integrates disparate data types (GNSS vectors and total station observations) into a single rigorous model.
- Provides a statistically sound "95% Confidence" report for every point.
- Identifies localized errors that traditional loop closures often mask.

Also see Section 4.5 regarding A-2 and legacy standards.

Horizontal project control will be established by GNSS and/or conventional methods. When possible, GNSS will be utilized, however horizontal control traverses may begin and end on control of at least second order, Class II (*Standards & Specifications for Geodetic Control Networks*, FGCC, 1984), or other Primary project control, with approval by the State's Central Surveys Unit.

A. Horizontal Project Control By GNSS

Utilizing GNSS methods for establishing primary project control is preferred to utilizing existing State primary control (CGS). When Connecticut Plane Coordinate System (CPCS) of 2022 is adopted by the State, GNSS methods will be required to establish primary project control. With the advent of more sophisticated GNSS receivers, software, and additional satellites, GNSS should typically be used to establish primary project control.

See CTDOT GNSS SURVEY STANDARDS MANUAL.

B. Horizontal Project Control by Conventional Traverse

Unless otherwise specified by the Department, all horizontal coordinates shall be on the Connecticut Coordinate System based on the most current realization of the National Spatial Reference System (NSRS). At present publication, that coordinate system is based on the 2011 realization of North American Datum of 1983 (NAD 83/2011), however, it is expected that the Connecticut Coordinate System will transition to the Connecticut Plane Coordinate System in the year 2027, at which point all new project coordinates shall be on said datum (Connecticut General Statutes, Chapter 241, Sec. 13a-255) upon approval by the State.

The control survey traverse shall be established and measured by current State methods such that they meet the accuracies at 95% in Exhibit 25.

Conventional Instrument requirements:

1. Accuracy or standard deviation must be capable of measuring horizontal and vertical angles to three (3) seconds of arc or less. Instruments shall be of the dual axis compensating type.

2. EDM's must have standard mean error of no more than ± (5mm+5PPM).

3. The total station, tribrachs, prism targets, prism poles, tripods, etc. used for control surveys must be adjusted properly and maintained in good condition. The records of maintenance and calibration are considered survey data and may be requested.
4. Angular sets (2D/2R) shall be observed at each angle point of the control line, preferably closing the horizon.
5. All horizontal control survey field measurements shall be employed using tripod mounted (fixed) targets and/or prisms.

General requirements and procedures:

- When turning angle sets, the rejection limit for any angle from each mean (direct and reverse) is 5".
- The sum closure of the two forward and two reverse sets shall be not more than 5".
- The mean of the foresight and backsight measurement differentials of a line shall meet a minimum precision ratio of one (1) part in 20,000.
- Total stations shall be tested on a calibrated base line, using procedure noted in Exhibit 4, or calibrated by the manufacturer.
- Measured lines are to be corrected for slope, PPM (temperature and barometric pressure), sea level factor (ellipsoid) and grid factor.
- Traverses should be tied to GNSS-established primary control at both ends or formed into closed loops to provide necessary redundancy for the Weighted Least Squares adjustment.
- Raw observations (angles, slopes, distances, and instrument heights) shall be imported into the adjustment software

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3.3 Vertical Project Control

This work includes the field survey and office computations necessary for establishing bench marks which will be used as the vertical control for all leveling operations connected with location and construction surveys.

The applicable vertical datum is established by the CTDOT Plane Coordinate System Manual. Prior to CPCS adoption, elevations shall be based on NAVD 88. Upon adoption, NAPGD2022 will be used.

The datum must be clearly noted on the title sheet and/or each plan sheet to avoid any confusion with other datums.

Level runs shall begin and end on bench marks classified as Second Order, Class II or higher order, on validated Level I GNSS benchmarks per the CTDOT Plane Coordinate System Manual, or as directed by either the State's Central Surveys or District Surveys Units.

For GNSS-derived vertical control procedures, primary benchmark spacing requirements, and the bench-closing workflow, see the CTDOT Plane Coordinate System Manual, Section C.

Recommended Procedure for Level Run

Three wire leveling, digital leveling, or trigonometric leveling shall be used. Differential GNSS techniques may also be utilized in certain circumstances. Digital or three-wire leveling are the preferred methods of the State.

A. Three Wire Leveling or Electronic Precision Digital Leveling

The Surveyor shall use the three-wire or digital level method, being careful to balance backsights and foresights, for level runs. Digital leveling is the preferred leveling method at the State.

The standard of vertical accuracy that shall be met for State control surveys is Class II, Second Order leveling (FGDC), which will also meet Connecticut V-2 per Sec. 20-300b-11 of Regulations of Connecticut State Agencies, as follows:

1. One piece invar scale rod or invar bar code staff.

2. Sight length of no more than approximately 150 feet.

3. Maximum closure for each run between previously established bench marks is $0.035\sqrt{M}$ where M is length of the level loop in miles or $0.010\sqrt{N}$ where N is the number of instrument setups in the level loop if run is less than a mile.

B. Trigonometric Leveling

Trigonometric leveling may be permitted under certain conditions using a total station whose specifications will produce Second Order, Class II accuracy. (Minimum vertical angle accuracy 3 seconds). The Surveyor shall obtain guidance from the State's Central Survey Unit or District Survey Units prior to utilizing Trigonometric Leveling.

Generally, the following field procedures are to be used:

1. One observation shall consist of four (4) pointings in each face (4 direct and 4 reverse). When recording the zenith angles, the average of the four pointings in face 1 (direct) shall not differ from the average of the four pointings in face 2 (reverse) by more than four seconds. Any deviation greater than four (4) seconds shall be rejected and the pointings repeated.

2. When recording the vertical distances (differences in elevation), the average of the four distances in face 1 shall not differ from the average distance in face 2 by more than the following:

   $0.0006\sqrt{F}$ where F is length of sight in feet

   The rejection of one set of observations can be determined from a comparison of either the average of zenith angles or vertical distances, **not necessarily both**. Repeat rejected observations.

3. Adjust instrument for collimation error prior to level run

4. Backsights and foresights are to be kept approximately equal where practical.

5. Slope distances shall not exceed 500 ft.

6. Vertical angles shall not exceed six (6) degrees from level.
7. The target bubbles on the plumbing poles are to be checked periodically.

8. If more than one plumbing pole is used, care shall be taken to ensure that both prisms are set at exactly the same height. Should it be required to alter either prism heigh for individual sightings, great care must be used in recording these changes through data collection or conventional means.

9. The following data is to be recorded for trigonometric leveling to verify the accuracy of the field work:

   Temperature and barometric pressure (°F and PPM)
   All zenith angles (optional)
   All vertical distances
   Two slope distances (See Exhibit 8)

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3.4 Horizontal and Vertical Control Adjustments

A. Horizontal Adjustment

Current Department of Transportation methods of traverse closure adjustment shall be as follows:

1. In-house, utilize Trimble Business Center, STARNET, or OpenRoads Designer

2. Any simultaneous weighted least squares adjustment program which meets the following minimum standards:

   a. Simultaneously adjusts all field measurements observed during the current scope of the control survey. For new projects, this includes all observations from a simple line to a multi-connected network. For supplemental control added to existing networks, the software must be capable of a constrained adjustment that holds previously established, high-order control values as fixed (see b.).

   b. Capable of holding point(s) as fixed reference control for a project.

   c. Allows for variable weighting strategies. As such, capable of varying control weights based upon instrument standard deviations, topographical site conditions, and differences in reference control orders/classes.

d. Provides a report which indicates residuals (corrections to observed quantities) of all angles and distances observed for the adjusted traverse.

e. Can also adjust GNSS data (preferred)

f. Can also adjust level data (preferred)

3. Weighted Least Squares

   a. Network Adjustments: When resolving coordinates at junction points, ensure that the software configuration utilizes a Weighted Least Squares Adjustment to produce a statistically rigorous Weighted Mean of all intersecting observations.

No other method of control adjustment will be acceptable.

All adjusted control shall meet the Positional Uncertainty levels specified in Exhibit 25. It is the responsibility of the surveyor to ensure that network geometry and redundancy are sufficient to achieve these standards.

It may be necessary for the control network to intersect with control established on other projects to ensure compatibility. This may involve computing multi-way junctions or, when GNSS methods are utilized, performing redundant occupations of existing base points to verify consistency across the project limits.

B. Default Standard Errors and Procedures for Weighted Least Squares Adjustment in Trimble Business Center

The following error allowances should be input into Trimble Business Center (or their equivalents in other least squares adjustment software). A network adjustment using these error estimates should provide a resultant Reference Factor of no more than two (2) before any additional scalars are applied to the adjustment. In the event of a resultant Reference Factor of more than 2, error estimates may only be revised upward if project particulars allow for it. Otherwise, outliers must be removed or reobserved for a compliant adjustment. See Exhibit 24.

Total station

Horizontal angle: 0°00’03”
Vertical angle: 0°00’03”
Slope distance: 0.010 ft + 2.0 ppm
Instrument centering error: 0.007’
Backsight centering error: 0.007’
Error in height of instrument: 0.007’
Error in height of target: 0.007’

Leveling

Default standard error on 1 km of double leveling: 0.028 in
Default standard error for each setup: 0.000 in

GNSS

Horizontal error: 0.016 ft + 1.0 ppm
Vertical error: 0.033 ft + 2.0 ppm
Error in height of antenna: 0.007 ft
Instrument centering error: 0.007 ft

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C. Vertical Adjustment

The Surveyor shall use such equipment and methods as noted hereinafter for all level runs to conform to Second Order, Class II leveling, as prescribed by the *Standards & Specifications for Geodetic Control Networks*, FGCC, 1984.

The error of closure in each line, between State approved bench marks previously established, shall not exceed $0.035\sqrt{M}$ where M is length of level loop in miles or $0.010\sqrt{N}$ where N is number of instrument setups in level loop (if run is less than a mile) (V-2 per Sec. 20-300b-11 of Regulations of Connecticut State Agencies). Where level runs terminate on GNSS benchmarks at both endpoints rather than by return loop, the Combined Allowable Misclosure defined in the CTDOT Plane Coordinate System Manual, Section C applies.

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3.5 Type and Location of Permanent Horizontal and Vertical Control Points to be Set

A. Horizontal Control

For major projects, the Surveyor shall set pairs of permanent intervisible monuments at two-mile intervals. The pairs should be separated by a minimum distance of approximately 750 feet. The location selected should be outside construction limits. These monuments shall be angle points in the control traverse line, typically measured with GNSS methods, from which points on the proposed base line or lines may be conveniently and accurately established on the ground.

All other control points shall be iron pins driven flush with the ground. Where possible, the pins should be spaced about 750 feet apart. They shall be a minimum of 0.5 inch stock and 36 inches in length. In establishing control networks through city streets, control discs can be set in concrete walks, and existing permanent highway boundary markers may be incorporated into the network. However, good engineering judgment should be used where short distances between street markers are encountered.

There may be certain instances where auxiliary loops will be run well outside the limits of a project. In these instances, the use of less permanent control points may be used (P.K. nails, mag nails, etc.) if prior approval from the State's Central Surveys Unit or District Survey Units.

All control points shall have three semi-permanent Reference Marks (RM). The RM distances should be less than 100 feet, if possible. Examples of RMs may include markers in trees, building corners, or other substantial cultural features, so that they may be readily found at any future time. Ninety degree in-line ties shall be used if other tie points are not available.

The control traverse line shall be established with definite angle points. In no case shall any attempt be made to establish long tangent control lines by plunging, double centering, or turning 180 degrees. No attempt shall be made to have the control line coincide with the proposed base line.

B. Vertical Control (Bench Marks)

The Surveyor shall establish, near the proposed highway, bench marks to be used as check points during the leveling operations. These semi-permanent

bench marks shall be easily identified and shall be definite points upon well-marked, substantial objects that can be readily found at a later date.

The following are procedures to be followed for setting bench marks:

1. A complete description and location of each bench mark shall be recorded in the field notes

2. Each bench mark shall be used as a turning point in the level line

3. Bench marks shall be located at intervals not exceeding 750 ft. along the entire line, or a maximum difference in elevation of 50 feet between benches, and at the location of bridge or grade separation structures. Each project shall have two bench marks, at a minimum

4. Bench marks shall be located outside of the area which is likely to be disturbed by construction, and on projects where separated roadways are proposed, the bench marks shall be set approximately midway between the proposed roadways or in location as appropriate to not be disturbed

5. At the beginning and end of the project, bench mark discs on permanent objects or bench mark monuments will be set outside of the area, which is likely to be disturbed by construction, so that permanent vertical control will be available during and after construction

6. If suitable objects, which may be used as bench marks, do not exist on the project site, the Surveyor will be required to set monuments or other rigid and permanent points to be used as bench marks

7. Bench marks may also be established on:

    a. Concrete bases or foundations
    b. Discs or other well-defined marks set in outcropping ledge
    c. Drainage structures, e.g. headwalls (excepting catch basins)
    d. Railroad spikes in non-ornamental trees with a diameter in excess of 1.0 ft.
    e. Other semi-permanent points as approved by the Engineer

8. Unacceptable bench marks:

    a. Objects driven into utility poles
    b. Small shade trees or ornamental trees

c. Houses
d. Iron pins, etc.
e. Hydrants (Top nut or other movable valve caps)
f. Catch basins and manhole rims
g. Points set in sidewalks or curbing
h. A series of elevations taken along the tops of steel pins used or the control line or base line, shall NOT be acceptable as bench marks, even if level line has been closed and adjusted to the required degree of accuracy. While it is understood that elevations will most likely be established on control points for DTM/Terrain surface locations, these elevations shall not be utilized as project bench marks.

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3.6 Check by the State of Survey Control Work

The State may inspect, at any time, during or after the control survey, any operation in the field or office.

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3.7 Horizontal and Vertical Control Data to be Furnished by the Surveyor

A. Horizontal Control

The Surveyor shall furnish a control sketch or drawing of the traverse/control network (if requested), a copy of the network adjustment computations, and the raw horizontal/angular field measurements and GNSS vector/collection statistics (if applicable).

B. Vertical Control

The Surveyor shall indicate the exact location of each bench mark in the mapping, including description and adjusted elevation.

The Surveyor shall submit to the State, prior to the completion of the location survey work, the following:

1. All original computations concerning the adjustment of bench levels

2. All original field books, Trigonometric Leveling Observation Sheets, or hard drive/electronic copies of raw field data from data collector or the bench run

3. Notation shall be put in the plan stating that the elevations are based on NAVD of 1988 or current vertical reference frame [See Section 1 (3.3)]

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3.8 Control Information and Reporting

A Control Index is required for all major survey projects to provide a comprehensive record of the horizontal and vertical control used. While traditionally delivered as a reproducible map, this index should be provided as a CAD drawing (ORD) and may also include a georeferenced data file (KMZ) with accompanying text files and reports. The index serves to show the spatial relationship of all control points and a limited amount of topography for orientation.

Control coordinates, which are derived from weighted least squares network adjustments, shall be reported to 0.001 ft (three decimal places) in all tie boxes. This level of reporting is a requirement intended to maintain mathematical consistency and diminish error propagation as control is utilized over time. While three decimal places is the standard, the Surveyor may choose to provide coordinates to 0.01 ft (two decimal places) if preferred, provided this rounding is not carried through the processing.

Positional Uncertainty thresholds are independent of this reporting and define the actual physical accuracy of the point. All control shall meet the applicable CTDOT positional uncertainty thresholds at the 95% confidence level, which are expressed to the nearest 0.01 ft (two decimal places).

Display of Horizontal Control (Tie Boxes) and Benchmarks on Survey Deliverable

The reporting of control data must include the following:

- All adjusted horizontal control points shall be numbered and labeled.
- Northings and eastings (horizontal coordinates) shall be displayed to the nearest thousandth of a foot (0.001') or to the nearest hundredth of a foot (0.01') provided the rounding is not carried through the processing.
- Each tie box shall show a sketch of the control point, a description of the point (e.g., ¾" iron pin), a north arrow, and descriptions of at least three ties (e.g., "X" cut on concrete headwall). Distances from the control point to each tie shall be denoted to the nearest hundredth of a foot (0.01').
- Adjusted bench mark elevations shall appear within benchmark description boxes, with the vertical datum, and be shown to the nearest thousandth of a foot (0.001') or to the nearest hundredth of a foot (0.01').

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3.8 GNSS Utilization for Horizontal and Vertical Control and Survey

See GNSS Survey Standards Manual dated December 2024.

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3.9 Control Survey for Photogrammetry, Aerial LiDAR, Terrestrial Static LiDAR, and Mobile LiDAR

See Specifications and Guidelines for Photogrammetry and LiDAR - July 2025.

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4.0 DATA COLLECTION

4.1 Description

All field locations of topographic and cultural features described herein shall be collected with total stations, data collectors, LiDAR sensors, photogrammetry, and other electronic surveying instruments. This information shall be edited for final map compilation in a Bentley Open Roads Designer (ORD) (Microstation) file format as

directed in a Commissioner Policy Statement dated March 16, 1993 and subsequent guidance documents (See Exhibit 3).

All location measurements are to be relative to control as described in Section 1 (3.0). The minimum area to be mapped shall be shown on an exhibit provided by the State, or as authorized, in writing, by the Engineer or Representative.

Mapping shall be produced by electronic methods, however, field books should be used for sketches, swing ties, test pits, or for any other information pertinent to data collection or clarification.

3D surveying requires that the survey information be collected using individual x, y, z point locations in conjunction with breaklines (i.e., along roadway edges, roadway crowns, curb lines, sidewalks, bottom and top of slopes, bridges, culvert heads, brooks, ditches, etc.). Breaklines control and/or restrict triangulation of the Terrain model. The Terrain can be used to generate cross sections, profiles, and contour mapping.

Areas defined by a 3-dimensional closed shape element, which controls project perimeter triangulation, are referred to as Boundary Areas. See Section 2 (1.5).

Areas where triangulation should not occur within the limits of the Surface Model are defined as Void Regions (e.g. buildings, lakes, ponds, dense vegetation, etc.). See Section 2 (1.5).

An understanding of breakline surveying and data collection must be demonstrated before collecting 3D survey data. The collected 3D survey must include enough survey data to generate an accurate Surface Model (Terrain) from which contours and cross sections at the required design intervals are developed. With the wider adoption of technologies such as LiDAR scanning, and advances in computing power and 3D modeling, there may be instances where breakline surveying and extraction is modified for design and mapping processes. Central Surveys shall be consulted in these instances.

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4.2 Features to be Located

The Surveyor shall make all topographic and cultural feature measurements with appropriate survey instruments. All locations must have an accurate elevation or z value. It is important to locate all breaklines in order that an accurate 3D Terrain Model can be generated in the design file.

The survey mapping should include but is not limited to the following features:

1. Waterways or swales, whether running or dry
2. Swampy and wooded areas
3. Streets and roads with their monumented or established highway lines
4. Railroads with their monumented center lines
5. Electric transmission/distribution, communications lines, public and private utilities
6. Bridges
7. Culverts
8. Manholes and handholes
9. Hydrants, gas and water gates, etc.
10. Individual ornamental and shade trees, including diameter and type
11. Houses, including house numbers, types and owner's name
12. All structures including schools, churches, and factory buildings
13. Wells
14. Sidewalks
15. Curbs
16. Joints in concrete pavement where required
17. Fences, walls and hedges
18. Town, city, state, National Geodetic Survey monuments
19. All found property monumentation whether merestones, iron pins or pipes and stakes. Effort shall be made to locate all monumentation within project limits
20. Inland wetlands and Ordinary High Water (OHW) shall be located as marked (flagged) in field by a soils scientist
21. Tidal wetlands shall be shown, with an appropriate note, specifying whether it is based on field delineation by a soil scientist or Federal, State or municipal record mapping
22. All other details necessary for the complete mapping of the area
23. All established project control points (horizontal and vertical)

Note: Reference should be made to the Check List in Section 1 (9.3) and the current configurations and resource files (Cells, Level Names, etc.) as part of the most current CTDOT Digital Design Environment (DDE). Also reference any drawing aids from the exhibits in the back of this manual.

4.3 Location of Boundary Monuments, CHDs, and Random Monuments

All highway line monumentation (CHD) and random monuments found in the field are to be located. A concerted effort is to be made to find and locate CHDs that are

not visible. Right of Way maps should be used to assist in finding and calculating search coordinates for CHD monumentation.

Every effort shall be made to resolve highway lines using best-practice techniques resulting in horizontal accuracy at or better than Connecticut Class A-2. In many circumstances—particularly on longer tangents—State Level III (or better) shall be utilized. State Level III (Exhibit 25) is functionally similar to Regulatory G-2 and, in many common field scenarios, mathematically exceeds the precision requirements of the A-2 Class (*Regulations of Connecticut State Agencies Section 20-300b-11*).

Field Execution:

- **Methodology:** Boundary monuments must be measured using conventional terrestrial methods and/or GNSS.
- **GNSS Standards:** All GNSS observations must adhere to the GNSS Survey Standards Manual (December 2024). The Surveyor shall determine the appropriate methods to meet or exceed the horizontal accuracy required by Sec. 20-300b-5.
- **Evidence Collection:** Property pins and street line monuments shall be located whenever physically possible.
- **Legacy Standards:** For guidance on reconciling A-2 requirements and legacy survey standards, refer to Section 4.5.

The practice of locating a minimum number of random monuments to tie into the random line, and then simply computing the highway line with Right of Way map information for final mapping is unacceptable and may lead to plotting highway lines erroneously. However, this practice is often a helpful first step to more accurately search for the highway monumentation in the field. Locating a minimum number of CHDs to compute the highway line for final mapping is also unacceptable.

The goal of ROW survey is to locate the CHDs as they exist in the field, and it is not an attempt to correct or make a new Right of Way map. Also, if the CHDs and property pins are field located prior to construction, they can be replaced in their original position after construction, if needed.

Many Right of Way maps are very old and may contain errors or discrepancies. Even more recent mapping may not be entirely free from error. The older maps have angles shown only to the nearest minute and extending these lines using those angles for just 1000 feet could lead to a difference of 0.3 ft.

CHD monuments, as positioned in the field, depict the true lines of occupation. These CHDs have been recognized over the years by property owners, town officials, land surveyors, and others and have been the basis for land transactions and surveys.

Although at times there may be slight discrepancies between the Right of Way mapping and the monuments, the position of the monument as located in the field prevails, provided the Surveyor does not uncover evidence of tampering, disturbance, or other material defects which may necessitate additional research or rejection.

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4.4 Degree of Accuracy Required of Field Measurements

The following requirements apply when using a total station, however, when using other survey instruments (GNSS, scanners, etc.) equivalent accuracies must be achieved.

Linear measurements to property, street, and highway monuments, or other definite points on these lines, shall be made to the nearest five-thousandth of a foot (0.005'), and angular measurements of two sets (D/R) with a closure of 5 seconds (5") or better. Linear measurements to the other sharply defined topographic and cultural details shall be made to the nearest 0.01', and angular measurements to the nearest 10 seconds. These measurements shall be made from either primary or auxiliary control lines, which conform to the requirements hereinbefore stated. Details such as wooded areas, meandering streams, wetland flagging and ledge outcroppings may be located the nearest three-tenths of a foot (0.3') from convenient traverse lines.

Ground Control Targets (GCTs) shall be carefully measured. Where possible, they should be located from more than one control point or traversed through when possible. GNSS may be used (see below). Linear and angular measurements to the GCTs shall conform to the requirements for the location of property and street line monumentation (above). Vertical measurements shall be read to the nearest thousandth of a foot (0.001'). Also see CTDOT LiDAR and Photogrammetry Specifications - July 2025.

Sub-loops shall be run when the cultural features are inconvenient to locate from the main control or exceed 500 feet away from existing control. These sub-loops or auxiliary traverses established to locate topographic and cultural details are to be carefully run, and the positional certainty shall be Level III or better (Exhibit 25).

For specific accuracy requirements and recommendations when utilizing GNSS, see GNSS Survey Standards Manual dated December 2024.

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4.5 Statement on A-2 and Positional Uncertainty – for Boundary and Right of Way Surveys

Statutory Requirement (RCSA § 20-300b-1 thru 20-300b-20)

All Surveys (e.g. Right of Way) conducted for the State must adhere to the standards for a Horizontal Accuracy Class A-2 or better. Per state regulations, a ROW survey must accurately define the limits of existing or proposed highways, easements, and parcels to be acquired, referenced to a baseline or project centerline.

Standard of Practice & Technical Equivalency

To ensure quality control, the State requires **Weighted Least Squares adjustment** as the primary method for coordinate value determination. While regulations utilize relative "Closure Ratios" (1:7,500 and 1:5,000 for A-2), the State's Positional Uncertainties are the modern technical equivalent.

Level III (0.07 ft at 95%) is the threshold for boundary work, any adjustment meeting Level I, II, or III (see Exhibit 25) standards is considered mathematically superior to the legacy A-2 closure ratio with the following considerations:

- **Statistical Integrity:** A 1:7,500 closure ratio is a relative check that can mask significant localized errors in long traverses. In contrast, the 95% Confidence Level provides statistically-derived confidence that any given point remains within its defined radius 95% of the time.

- **Redundancy:** Unlike traditional loop closure methods that distribute error proportionally, Least Squares identifies and isolates specific measurement outliers. By utilizing redundant observations, the system provides a mathematically verified level of precision for all control points and markers. Furthermore, it quantifies the statistical reliability of the entire network through the analysis of residuals and error ellipses.

- **Modern Statistical Approach vs. Legacy Linear Limits:** While RCSA § 20-300b-11 mandates a maximum error of **0.02 ft** for courses under 150 feet, achieving a **Level I (0.03 ft)** or **Level II (0.05 ft)** Positional Uncertainty at a 95% Confidence Level is considered the modern technical equivalent. Because the

0.02-ft legacy standard often approaches the physical "noise" floor of field equipment (e.g., equipment tolerances, systematic error, monument stability), the Surveyor must use professional discretion in prioritizing the statistical integrity of a redundant Weighted Least Squares adjustment over a traditional linear closure ratio, ensuring the survey remains mathematically equivalent or superior to the A-2 requirement.

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5.0 DIGITAL MAPPING

5.1 Description

This work shall consist of preparing a digital map in the OpenRoads Designer (ORD) format accurately depicting the planimetric (cultural) features and topographic (contour) features necessary for establishing the base line of the proposed highway design and for the preparation of the property acquisition maps, which will be produced by the Central Surveys Unit.

The four basic graphic elements of the ORD Surface Model (Terrain) contained in the delivered ORD file, many of which are to be processed as part of a digital Field Book, are:

1. Individual x, y, z field locations of all surveyed features and topography
2. Breaklines
3. Terrain Boundary
4. Void regions

Contours and triangles will be dynamically produced by the Terrain with these four graphic elements contained therein.

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5.2 Digital Delivery

The project shall be digitally submitted to Central Surveys with “_ORD” at end of the filename to indicate the current format.

5.3 Map Scale Required

The digital aerial and ground survey map, prepared for design and/or related construction activities, shall be 1:480 (1”=40’), or as directed by the Engineer.

However, the following scales are also used for other surveys depending on the type of project for which it is intended:

Mapping Scales	Contour Interval
1:240 (1”=20’)	0.5 ft.
1:480 (1”=40’)	1.0 ft.
1:960 (1”=80’)	2.0 ft.
1:1920 (1”=160’)	4.0 ft.

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5.4 Coordinate Grid Lines

The coordinate grid lines shall be drawn so as to represent even 400-foot values on the Connecticut Coordinate Grid. The grid lines shall be depicted on the final plots as grid “ticks”, which indicate their corresponding coordinate values. Special care in view rotation shall be taken to assure proper orientation of the map, so that each section of map will be as long as permitted by the alignment of the proposed highway and the map will cover all required locations.

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5.5 Matching Adjoining Digital Maps

Whenever it becomes necessary to end a section of a digital map due to length or file size, the drawing of details shall end at a match mark roughly perpendicular to the proposed highways. Match marks must coincide from one file break to the next. See Section 2 (2.2, D)

The drawing of detail on the adjoining digital map shall be commenced at the match line so that all details are completely shown without duplications or truncated text.

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5.6 Features to be Shown on the Mapping

The details below shall be included in the mapping:

1. All topographic cultural details located in the field
2. The values of coordinate grid “ticks”
3. All monumentation including geodetic, base line, boundary, and railroad
4. High water marks (and OHW) in addition to tidal lines per the latest publication of CALS Resources for Tidal & Navigable Waters in Connecticut or NOAA website as check or secondary method (HTL, MLW, etc.) (See 8.3 Portrayal of Tidal and Coastal Jurisdiction Lines)
5. FEMA flood plain limits (100-year and 500-year) (See 8.4 Portrayal of FEMA Floodway and Floodplain Lines)
6. Coastal Jurisdiction Lines
7. State and Federal wetland limits as field delineated
8. Tidal wetlands as field delineated
9. The type of pavement or road surface on streets, roads, and driveways
10. The type of surface on sidewalks
11. The type and material of curbs
12. Utility structures, Call-Before-You-Dig markings, and ownership
13. Field-located Advanced Traffic Management System (ATMS) infrastructure. Assistance or GIS-grade information can be provided by Highway Operations (See Exhibit 23)
14. Location and type of all signs, traffic signals with electrical and support wires, and overhead wires
15. Poles with utility name, pole numbers, and overhead wires
16. Buildings with construction material type, number of stories, and street numbers. Sill elevations upon request by the designer
17. Direction of flow and types of streams (with name if available), pipes, and ditches
18. Size and type of conduits, ducts, sanitary, and storm sewer systems including elevations on top, bottom or sump, pipe inverts, etc.
19. North arrow with reference frame and realization
20. State route numbers
21. Street names and street lines
22. Property owners’ names of record and property lines

Whenever a State Highway Line or Railroad Line is shown, it shall carry a notation of the map number (i.e. “R.O.W. Map No. 58-06, Sheet 2 of 3”, “See Construction Project 0116-0084”, or “R.R. Valuation Map No. 53-61/62-31”.

When a bridge of any type of located, whether it be over another highway, a stream, or railroad, a full description should be noted on the plan, such as:

Type of Structure

Width from face of curb to face of curb (traveled way)
Square span
Skew span
Clear height
  For railroads – highest rail to lowest member of bridge
  For Stream – bed of stream to lowest member
  For roads – from crown or highest point to lowest member
If bridge has overhead trusses, the distance from deck to highest member is required

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5.7 Manner of Depicting Detail and Explanatory Note on All Digital Mapping

All topographic and cultural details shall follow, maintain, and conform to the State'ss Existing Features Cell Library within the CTDOT Connect Digital Design Environment (DDE), which contains the State's configuration/workspace for Open Roads Designer (ORD):

1. Level
2. Color
3. Weight
4. Text size
5. Patterns
6. Cells

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5.8 Map Accuracy Required

Horizontal Accuracy

All well-defined features shall be plotted at their geographic positions. Topographic features shall be at a Level IV Horizontal accuracy (Exhibit 25).

Vertical Accuracy

Traditionally, the State relied on the T-1 Accuracy standard, which required that 90% of all contours extracted from a digital terrain model (DTM) be accurate within one-half of the basic contour interval. For a typical 1-foot contour interval, this would allow for an error of 0.50 ft.

To modernize the approach, the State has transitioned to Positional Uncertainty at the 95% Confidence Level. Current projects generally require a vertical accuracy meeting 0.15 ft at 95% Confidence (Level IV), which applies to most topography. This shift moves away from the "90% probability" of a contour line and toward a rigorous statistical "95% probability" for every discrete elevation point. To ensure an accurate terrain model, all plotted elevations shall be to at least two decimal places.

The change from T-1 to Level IV is a significant change, especially for 1-foot contour mapping:

- **Statistical Approach:** T-1 only requires a 90% success rate, leaving a 10% "blind spot" for errors. The new standard requires 95% Confidence Level, significantly reducing the margin for outliers and ensuring more reliable survey data.
- **Precision Increase:** Under the legacy T-1 standard for 1-foot contours, a point could be off by 0.50 ft and still pass. 0.15 ft at 95% is about four times more precise.
- **Absolute vs. Relative:** T-1 is a "looser" relative standard tied to visual map intervals. Level IV is an absolute statistical standard.

While 0.15’ at 95% is the baseline, vertical accuracy is not "one size fits all." Requirements are still:

- **Project/Design Dependent:** A bridge deck rehabilitation or high-speed rail corridor may require higher vertical accuracy (0.03’ to 0.05’).
- **Feature Dependent:** Hard surfaces (concrete, asphalt, curb lines) demand higher vertical precision than soft surfaces (wooded areas, wetlands, or grass slopes). Hard surfaces shall generally be twice the accuracy of Level IV (0.07’ at 95%, which would be between Level I and Level II vertically).
- **Survey Method Dependent:** The choice of technology—whether **Digital Leveling**, **GNSS, Total Station**, or **Aerial LiDAR/Photogrammetry**—must be matched to the required vertical tolerance of the specific project task.

The Surveyor must verify Project-specific survey instructions to determine if higher vertical accuracy is required for the specific project.

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5.9 Map Reference Notes

The title block of all digital mapping files shall contain the following information, at minimum:

1. Project horizontal and vertical reference frames
   a. Include basis of reference frames with measurement methods, NSRS reference stations utilized, dates/times of observations, and any other information pertinent to establishing control coordinates
2. Field book names and pages
3. ROW and any record mapping that was used
4. Any pertinent narrative to how utilities were located or placed in the mapping
5. Date and methods for survey data collection (ie, conventional, GNSS, mobile LiDAR, image digitization, static terrestrial LiDAR, photogrammetry, statewide LiDAR with tile number) (See Specifications and Guidelines for Photogrammetry and LiDAR dated July 2025)

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5.10 Submission of the Mapping Files

The following items are to be submitted to the State after each digital map or maps have been field-checked and the final map contains all the required information.

1. Digital transfers for completed project containing ORD files, terrain(s), and other required data. In the event of file sizes excessive for digital transfer, Consultants must verify the acceptability of other media type prior to project finalization

2. Digital plots of mapping sheets, signed and sealed by a licensed Connecticut Land Surveyor and ASPRS registered photogrammetrist (when applicable)

3. Raw Data files

   All unedited data from the electronic field book received from the data collector. Unedited raw data may be used in a legal dispute as may any conventional field book

4. The State must be supplied with all data used to produce the mapping. The five basic elements required for processing a 3D survey are:

   a. Individual x, y, z field locations with digital and conventional field books

b. Breaklines
c. Boundary areas
d. Void regions
e. Surface model (Terrain)

In addition, any registered point clouds (formatted as LAS version 1.2 or higher or e57) and photography shall be provided to the State.

5. All submitted mapping must follow and maintain the Existing Feature templates in the AEC DDE with respect to:

a. Level
b. Color
c. Weight
d. Text size
e. Line style
f. Cells
g. Scale

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6.0 ESTABLISHING BASE LINE

6.1 Description

Historically, the physical establishment of highway baselines in the field was a primary requirement for design and construction. With the advancement of modern GNSS (Global Navigation Satellite System) and high-precision digital modeling, the need to physically run baseline tangents is not always necessary. Most current projects involve existing alignments rather than new corridors, further reducing the frequency of physical baseline staking during the design phase.

The State or Consultant remains responsible for computing and placing the proposed highway baselines within the digital design file (CADD). While the physical establishment of the baseline on the ground typically does not occur until the construction phase, the Surveyor may be required to stake the roadway baseline under specific project constraints or at the request of the State.

Although digital workflows are now standard, the following instructions have been retained in this manual to serve as a technical guide for future practice and to provide a procedural framework that is not currently documented in other State manuals. These steps ensure that if a physical baseline is required, it is established

with consistency. The retention of these field procedures is critical as they provide the framework necessary for the accurate digital creation of the baseline.

Please also see the latest Form 819.

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6.2 Computing Base Line Coordinates

The base line points to be set, tied-in, and shown on the plan are as follows:

1. The beginning and ending points of the project
2. The PCs, POCs, and PTs of the horizontal curves
3. The PIs (optional) and POTs

The coordinates and bearings shall be shown as follows:

1. Control line, base line, center line, and curve data to the nearest 0.001'
2. Bearings to the nearest tenth (0.1) of a second
3. Distances (stations) to the nearest 0.001'
4. Ties to the base line PCs, POC, PTs, POTs, PIs, and beginning and ending points to the nearest 0.001'.

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6.3 Type and Locations of Base Line Control Points to be Set

The Surveyor shall establish semi-permanent control points on the ground along the proposed base line, including PIs, POTs, PCs, PTs, and POCs, as may be necessary so that each intermediate point will be visible from adjacent points. The distance between these points shall not exceed 750 feet. In the case of new expressway or "cross country" realignments, these control points will be either a sharply defined cross or drill hole in rock or concrete, or an iron pin firmly set in the ground and marked on the top with a drill hole. These iron pins shall be a minimum of 0.5 in. stock and 36 in. in length. All iron pins used for points on base lines shall be driven flush with the ground and location marked by guard stake or stakes. All sub-control and intermediate points shall be referred to nearby and easily identified trees, buildings, or other substantial cultural features so that the original point may be readily found or re-established at any future time. At least three reference ties shall be used for each control point.

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6.4 Running and Stationing the Base Line

Upon verification of the computations, the Surveyor shall stake out the base line as provided by the Engineer.

Offset base lines shall be staked and marked as needed.

The angle between the base line and the railroad, together with the base line station and the railroad monumented center line station, shall also be determined and shown on the plan.

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6.5 Base Line Data to be Furnished by the Surveyor

When requested, the Surveyor shall establish the base line in the field based on the following base line information from the design plan:

1. The coordinates of all base line control points
2. The delta angle
3. Radius
4. Length of curve
5. Tangent distance
6. External distance
7. Computed bearing on each tangent
8. Station of each PC, PT, POC, and POT
9. Base lines will be set-up/established at half (1/2) mile intervals with 50 foot sub-stations. Thus 1+50 would be exactly 50 feet beyond station1+00
10. Location and coordinates of PI (if it is located within the mapped area)

The Surveyor shall submit to the State the following:

1. All original computations concerning the base line and the ties between the control survey line and the base line
2. The original field books and/or computer printout containing the base line staking notes
3. All base line control ties which are to be shown on the submitted deliverable

The base line staking notes shall also show the following:

1. The base line station as determined by field measurements
2. The calculated station of each intermediate base line control point previously set

The comparison between the calculated and the field stationing shall have a minimum accuracy of 1:5000.

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7.0 UTILITIES

7.1 Utilities and Test Pits

In accordance with Section 1 (4.2) “Features to be Located” and Section 1 (5.6) “Features to be Shown on the Mapping,” the Surveyor is required to identify, field locate, and plot all visible utility structures on the base map.

In addition, the Surveyor must gather data from each utility company regarding their underground facilities and integrate this information into the mapping. This can be accomplished through the following method:

Direct Request: Send a project summary letter to each utility company that might have underground facilities in the project area. Include a depiction of the project area. The utility company should then provide the requested mapping data or indicate that no utilities exist within the area. Can utilize this utility company database to assist with determining utility companies active in the project’s town.

For each utility, the mapping should clearly display the location, owner’s name, size, and material.

When the vertical and horizontal positions of underground utilities are established through test pit excavations, the Surveyor shall record information about the crew on a Daily Labor and Work Record for Test Pits form and forward it to the Designer, retaining a copy for records (See Exhibit 13) (Fillable version). The data to be recorded on the Test Pit Form and the field book is as follows:

1. Name of utility and utility company
2. Horizontal location either by base line stationing (Station – Offset) or coordinates
3. Top of pipe, duct, conduit elevation
4. Ground elevation
5. Diagram
6. Vertical and horizontal location of other unknown utilities if uncovered
7. Utility contractor, date and time of excavation

The procedure (also see guide Exhibit 11) for obtaining test pit information is as follows:

1. **Test Pit Request:** The designer initiates the process by requesting test pits at locations shown on plan sheets—specifically at base line stations or coordinates where potential conflicts may exist between the proposed construction and existing utility facilities.
2. **Federal Participation:** The designer must clearly specify which test pits fall under federal participation, ensuring proper alignment with federal requirements.
3. **Change Notification:** Any modifications in the number or location of test pits should be promptly communicated to the District or Surveyor. This ensures that adjustments can be coordinated with the relevant utility companies and that any agreements are amended accordingly.
4. **Letter of Agreement:** If a test pit is not governed by the "Master Utility Agreement," the designer should prepare a formal letter of agreement with the respective utility company or municipality.
5. **Reimbursement Verification:** During the letter agreement process, verify with the Office of Engineering Utility Section the State's participation percentage in reimbursing the utility company for test pit costs. Additionally, confirm which State Statute applies (13a-126/13a-98f) (See Exhibit 14).
6. **Cost Estimation and Work Order:** Determine the estimated expenses for the test pits and then request a work order.
7. **Permit Acquisition:** Obtaining the necessary permits is the sole responsibility of the utility company or the municipality involved
8. **Excavation Coordination:** Coordinate the test pit excavation activities among the utility company, municipality, police, and contractor to ensure efficient and compliant execution.
9. **Data Recording:** Record all data using a standard field book or data collector, and prepare a CTDOT Form CON-40 on a daily basis.
10. **Billing Submission:** Ensure that billing is submitted by the utility company or municipality on a CTDOT Form CLA-3
11. **Document Verification:** Finally, review the CLA-3 form and its supporting documents for accuracy. Once verified, forward the package to the Accounts Payable Unit for processing.

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7.2 Utilities – Private

An investigation of local records shall be made to determine available underground utility information. This investigation may include discussions with the local building inspector, public works director, or other individuals knowledgeable about local utilities.

If town records lack detailed information, consult relevant property owners for their recollections regarding the locations of wells, septic tanks, leaching fields, private services, and similar features. Depict these on the plan and label them clearly as “approximate location.”

The Surveyor should focus on locating private utilities within the designated area defined by the Designer. The Designer will evaluate this data in relation to the overall design and determine where more precise utility locations are necessary. If further accuracy is required, the Designer should request additional survey information following the same procedure used for utility test pits.

To minimize the State’s exposure to liability, requests by the Designer for specific information about private utilities will be handled by the Surveyor according to the following procedures:

1. **Obtain Right of Entry:** Secure access if it has not already been established.
2. **Letter of Agreement:** Include a letter of agreement with the private utility regarding the test pits.
3. **Contractor Engagement:** Hire a contractor to expose the utility, using the annual bids obtained by the Office of Maintenance for equipment rental.
4. **Purchase Requisition:** Submit a budget-cleared purchase requisition to the Director of Purchasing for the work specified.
5. **Contractor Coordination:** Once a purchase order is issued, coordinate with the contractor to accurately locate the facilities in question.
6. **Site Restoration:** After the contractor’s work is completed and reviewed by the utility, arrange with the Office of Maintenance for any loaming and seeding needed to restore the site.
7. **Documentation Submission:** Compile a complete listing of both public and private utility companies, including the names of the officials in charge of each area, and submit it along with the completed survey to the State.

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8.0 CONSIDERATIONS FOR CERTAIN SURVEYS

8.1 Railroad

The scope of railroad surveys may range from a complete definition of every feature within the railroad right-of-way, bridges/high way crossings, and/or stations.

A. Railroad Monumented Center Line

The railroad monumented center line must be thoroughly researched, verified in the field, coordinated, and clearly depicted on the plan. Each monument should be shown with an equality station with Imperial values, consistent with the railroad “VALUATION” maps. Monuments may be required even outside the requested mapping area.

There may be instances where, despite thorough research and field investigations, no railroad monumentation is found. In such cases, it is crucial to examine the railroad “VALUATION” maps closely to identify areas where monumented stations appear—such as near culverts, bridges, or other significant features—that can be used to tie the railroad center line to the base line. Historical highway maps, property surveys, and other sources may also help to delineate the railroad monumented center line. This accurate depiction is essential for orienting the highway design with the railroad.

B. Location Survey and Mapping

The cultural features, railroad alignment, and track profiles shall be surveyed to extend at least 1500 feet beyond the anticipated project limit, or as directed by the Engineer.

The survey shall primarily capture breaklines that represent key physical features. For instance, the tops of the rails on all tracks should be measured with shots taken at the gauge edge of the rail (at a minimum). Additional breaklines to be measured include the edge of the ballast, the toe of the ballast slope, the edge of the sub-ballast, and the toe of the embankment slope. Measurements for these breaklines shall be taken at intervals of approximately 50 feet; however, on alignment curves, transitions, within the highway design area, or in other areas of special interest, measurements should be recorded at shorter intervals.

Switches and frogs, which are necessary for accurately defining the horizontal alignment, shall be located and referenced (See Exhibit 15).

Furthermore, the survey must locate all relevant cultural features within the right-of-way. This includes, but is not limited to, catenary towers, bridges, culverts, signals, signal boxes, whistle posts, remnants of old railroad right-of-way fencing, utility poles with identification numbers, and any other pertinent features.

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8.2 Requirements for Waterway Hydraulic Data

The design of highway culverts and bridges is a complex undertaking involving the application of hydrologic/hydraulic principles in order to achieve a design which is safe, efficient, and compatible with environmental concerns. The acquisition of hydraulic survey data is a key element in this process. The following are basic survey requirements for transportation facilities at stream crossing sites. More detailed requirements may be outlined by the Designer on a site-specific basis. These requirements shall apply to all culverts and bridges as noted:

1.) Topographic Plan - A topographic plan shall be prepared to indicate the relationship of the proposed or existing facility to the watercourse being crossed. In addition to the channel (top and bottom of bank, edge of water, thalweg) limits, islands, bars and significant localized obstructions should be identified. Cultural features must also be included, and ground and sill elevations must be provided for specific structures as requested by the Designer.

2.) Channel Profile – When requested by the Designer, a channel profile limits will be specified both upstream and downstream of the culvert or bridge crossing. For this purpose, all distances should be referenced to the inlet or outlet face of the culvert, and should increase in the upstream or downstream direction, as appropriate. This profile should define the channel thalweg (deepest portion of the channel) and should indicate all existing drainage crossings within the limits of survey. Invert grades of existing culverts shall be determined to the nearest 0.01’.

A formal base line is generally not necessary for this profile as horizontal distances are measured along the center line of the stream.

3.) When required by the Designer, hydraulic cross sections for detailed studies must be referenced to the requested vertical datum. The nature or character of the ground cover across the section shall be identified with the associated limits noted, and the vegetation line within the channel side slope, where clearly discernible, should be shown on each applicable section.

The location, orientation, and length of the required hydraulic cross sections shall be indicated on a topographic plan, where feasible. Each cross section shall be labeled by an appropriate identifier and shall further be labeled as "looking upstream" or "looking downstream".

Cross section locations are normally specified with reference to a fixed stream location (Ex. "500' downstream of the downstream bridge face"). If a survey base line is established for the purpose of obtaining hydraulic cross sections, it shall be indicated in the mapping.

Typical hydraulic cross section locations for structures within this category are indicated on Figure 1, Exhibit 16. Figure 2, Exhibit 17, depicts typical hydraulic section orientation with respect to the channel and flood plain.

For selected coastal structures or structures with tidal influence, supplemental cross sections or bathometric mapping may be required. Specific coastal survey requirements will be requested on a site-specific basis.

4.) Additional Information –

Culverts - the size. type and invert elevations of all culverts within the limits of the hydraulic survey shall be included. Culvert invert elevations shall be determined to the nearest 0.01’.

Bridges - The waterway opening dimensions shall be provided for both the inlet and outlet fasciae (bridge face). This information shall be provided as "elevation" views of the openings, drawn to a convenient scale with the underside (lowest deck member) elevations, top of footing elevations (if visible) and stream channel elevations indicated, as appropriate.

8.3 Portrayal of Tidal and Coastal Jurisdiction Lines

Tidal lines, including Mean High Water (MHW), Mean Low Water (MLW), and related lines should be shown for any projects whose limits fall within tidal areas. They shall generally be established from NAVD88 elevation values provided by the Connecticut Association of Land Surveyors (CALS) Resources for Tidal and Navigable Waters in Connecticut (first printing October 15, 2012), which may require proration between tidal stations depending on project location. That document should also be used to determine the Coastal Jurisdiction Line (CJL). Alternatively, CJL is also available from the Connecticut Department of Energy and Environmental Protection's (DEEP) Coastal Jurisdiction Line Fact Sheet.

The High Tide Line (HTL) shall be located in the field, when required, by identifying the wrack line or other physical evidence.

As a check on the CALS-derived values, NOAA Tides and Currents tidal station values for the appropriate tidal epoch may be utilized. NOAA Tides and Currents station(s) values relevant to project should be assessed according to the following procedure:

1. Transform the station's Mean Lower Low Water (MLLW) datum to NAVD88 (or the project's vertical reference) using NOAA's Vertical Datum Transformation Tool.
2. Apply the resulting conversion factor to any other NOAA Tides and Currents station values shown in the MLLW datum to derive other tidal lines required in NAVD88 (MHW, MLW, etc.).

The NOAA transformation approach may at times align better with modern GNSS-based workflows. Furthermore, the State will accept direct vertical control survey of tidal benchmarks to accurately transform tidal datums to project vertical datums. However, the State acknowledges that the general public and many jurisdictions accept the CALS-derived values, and the deviations these values have from State project-derived vertical NAVD88 elevations, regardless of survey method, are expected to be small. The State's preferred method is to directly use published values per the aforementioned CALS guidance document, unless differing values or methods are utilized to maintain consistency with previous projects, specific effort is made to survey tidal benchmarks (often not feasible), or the Surveyor deems it appropriate to use another method for adopting tidal data. As NOAA updates tidal epochs and transitions from NAVD88 to the NAPGD22 datum, the CALS guidance is expected to be revised. At that time, the State will reassess and potentially update its protocols for placing tidal lines.

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8.4 Portrayal of FEMA Floodway and Floodplain Lines

Many State designs require the portrayal and elevation of the FEMA 100-year and 500-year floodplain lines.

FEMA shapefiles or georeferenced FEMA FIRMETTE (or FIRM) maps can be utilized both as a reference or to horizontally place the lines absent other information.

However, the most accurate and preferred State method for placing the floodplain lines is as follows:

1. **Prepare the Profile Terrain** – Define the elevation profile of the 100-year or 500-year elevations required from a FIRM map's cross-section elevations upstream and downstream of the project (or other feature elevations on the FIRM). Generate a Terrain, which slopes according to the profile and encompasses the project area.
2. **Load the Survey Terrain** – Bring in your existing survey ground Terrain model (or, if flood lines fall outside project area, use statewide LiDAR dataset if deemed appropriate by the Surveyor). Ensure both terrains share the same vertical datum.
3. **Create the Delta Terrain Model** – In OpenRoads Designer, select the "Delta Terrain Model" tool. Run the tool to subtract the ground file Terrain from the FEMA elevation terrain, producing the Delta terrain.
4. **Extract the Zero-Contour Line** – From the resulting Delta terrain, generate contour lines at the 0' elevation. This contour, labeled "0", marks where the two surfaces intersect. This intersection is the FIRM-approximated profile in relation to the survey Terrain.
5. **Finalize the Floodplain Line** – Select this 0-contour polyline. Extract it and ensure it is styled as 100-year or 500-year floodplain boundary line. Drape it to the created FIRM elevation profile Terrain if 3D attributes are desired.

A FEMA regulatory floodway may be required to be shown on the survey as well, which is the channel of a river or stream and the adjacent land that must remain open to allow floodwaters to pass during a 100-year flood. Often, the term floodplain is mistaken for floodway.

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9.0 FIELD CHECK AND QUALITY CONTROL

9.1 Field Check

After the 3D map has been completed, the Surveyor shall thoroughly field check the map and make such corrections or additions as may be necessary before the final submittal as a completed project.

This field check should be made at a time sufficiently in advance of the scheduled completion date of the project, so that all errors or omissions may be corrected and the project can be submitted to the State on or before the official completion date. All prints of the maps used during the field check shall be included with the final submission to the State.

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9.2 Inspection

The State reserves the right to inspect, review, or check each field or office phase of the Surveyor's work to assure compliance with standards and policies established by the State.

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9.3 Check List for Survey Maps Before Final Submission

The following check list provides a guide for checking survey maps, which shall be forwarded to and conducted by the office of Central Surveys. It is a guide only and is not intended to supersede any instruction previously given or included in this manual. Depending on the nature and extent of the survey, these items may not appear on all projects. Also see Exhibit 26 for a sample checklist.

Check List for Survey File

1. Ensure project limits are met based on survey request document.

2. Refer to list Section 1 (5.6) to ensure all require features are included in the mapping.

3. North Arrow (use correct symbol for grid, geodetic, magnetic, or true north). Ensure correctly denoted project reference frame (i.e. NAD 83 [2011]) and

vertical datum.

4. Current title block as depicted in the State's Existing Feature Cell Library for current CTDOT DDE. All pertinent reference notes included per Section 1 (5.9).

5. Mapping is to be signed and sealed by a Connecticut Licensed Land Surveyor when survey is not performed by the State.

6. Bench marks shall be labeled with a leader to a text box that includes the elevation, reference frame, and description. Distance between benches should be 750 ft. or less, and not greater than 50 ft. difference in elevation. Ensure bench marks are located and depicted in mapping file. Each project should have at least two bench marks.

7. Tie boxes for control points should be included with coordinates and a depiction of at least three reference ties (not necessarily to scale).

8. Property owners' names and property lines shall be depicted on plans using N/F Convention (Now or Formerly). Properties owned by the State of Connecticut do not use this convention and shall be labeled with "State of Connecticut" with appropriate ROW file reference number (previously BRC number).

9. Direction and flow of brooks, streams, culverts, sanitary, and storm sewers should be designated with an arrow. Brooks, watercourses, sloughs, and ditches should be labeled, with name included if available. If a watercourse or brook is unnamed, label as "Unnamed".

10. Include size and type of culverts, storm and sanitary sewers, or other utilities (i.e. 18 in. R.C.P., 18 in. C.M.P., 18 in. C.I.P., concrete box 48 in. high x 72 in. wide). Compare sizes on plan with profile and cross sections along with all related elevations of these structures when applicable. Measure Box Culverts to nearest 0.01'.

11. Ensure pipe sizes shall conform to the International Standards Organization (ISO) usage of nominal pipe sizes for field identification purposes (See APPENDIX E)

12. Ditches — describe the type (earth, riprap, bituminous, etc.)

13. Bridge sizes -- type and span, railing skew width, square width, low chord, clear height,

and overhead clearance, if applicable.

14. Label houses, buildings, garages with address number; i.e. 1-story frame house, cinder block garage, stores, apartments, gas station, parking lot, etc.

15. All stand-alone trees should be shown (including size and type) and shrubs or hedges.

16. Type of drives and walks (gravel, bituminous concrete, trap rock, concrete, etc.).

17. Type of roads (concrete, gravel, surface treated gravel, bituminous macadam, surface treated macadam, bituminous concrete, armor-coated gravel, etc.).

18. At edges of roadway on map, show where to, back and ahead: to Hartford, to New Britain, etc.

19. Show all woods, cultivation, open fields, lawns, tent tobacco, etc.

20. Highway and street lines. When highway lines shown on plans are based upon Right of Way Maps, the file number of the Right of Way Map should be shown along the highway line; i.e. "Highway Line" above and "R.O.W. Map No. '76-24, Sheet 1 of 2" below. When highway lines are based upon construction plan for yet unbound roadways, the appropriate construction project shall be noted. When highway lines are based upon taking lines, they should be labeled as "Highway Line" with the ROW File No. map reference, including project and serial numbers.

21. All utilities are to be shown on the plan (water mains, gas mains, sanitary sewers, electrical and telephone conduits, private lines, septic systems, etc.). Show elevation of all intersecting pipes for sanitary and storm sewer systems and the low point of the lowest wire of high-tension lines. Show wire attachment point elevations at poles when requested.

22. Specify type of catch basins; i.e. Type "C", "CG", "CL", etc.

23. Note type of Wire Rope Railing and Guide Railing, whether wood or metal; and also metal beam railing and type.

24. The limit of the Inland Wetlands, Tidal Wetlands, and Ordinary High Water

(OHW) shall be shown with an appropriate note specifying whether they are based on field delineation by a soil scientist or mapping. Also include all regulatory lines, such as FEMA lines and CJL, per Section 1 (5.6).

25. Joints in concrete pavement shall be located and shown where evident or as required.

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9.4 Plan and Accuracy Checks for Photogrammetry, Aerial LiDAR, and Mobile LiDAR Mapping

See Specifications and Standards for Photogrammetric and LiDAR Surveys.

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9.5 Field Edit of Photogrammetry, Aerial LiDAR, and Mobile LiDAR Mapping

See Specifications and Standards for Photogrammetric and LiDAR Surveys.

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9.6 Considerations for Final Plan Review

The State's Central Surveys Unit and the District Survey Unit, shall confirm the survey information displayed on the final construction plans during the various stages of plan review.

Items to review include, but are not limited to:

1. First sheet notes, which should include who conducted the survey (i.e. District Survey Unit, Consultant) with pertinent details, horizontal and vertical reference frames, and date of survey.

2. Proper notes and callouts for CHD's and CGS (Connecticut Geodetic Survey) monuments to be protected or replaced if impacted. The Geodetics Section within the Central Surveys Unit should be contacted in regards to any CGS marks being impacted.

3. Correct labels for Highway Lines (from ROW maps and previous acquisitions), Taking Lines, and CHD's to be set from Property Maps.

4. Bearings of base lines, center lines, and control lines, if relevant. Stations on center line or base line, P.C.'s, P.T.'s, P.O.T.'s, P.O.C.'s, etc. No stations along control line to be shown.

5. At the points of curvature or tangency, include a small circle with a radial leader line indicating the stationing and coordinates. The P.I.'s of curves shall be indicated by a small delta with a short segment of tangent line on either side of the P.I. extending to both the P.C. and P.T. Curve data shall be noted and shall be placed on the inside of the curve. When a curve extends onto more than one sheet, the survey data shall be shown on each sheet.

6. Where separated roadways are not parallel, individual base lines shall be established for each roadway.

7. The stationing of the base lines shall be continuous for each line from the point of separation from a single base line. Where the two base lines again merge to a single base line, the stationing of the longer shall be carried forward and an equality placed in the shorter base line at this point.

8. On all plans, the stations must extend from west to east and south to north.

9. Check that there are tie boxes for control points showing three ties each.

10. Proper display of features, annotations, linework, and contours.

11. At 60% review, ensure any property impacts are depicted per the Property Maps.

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10.0 SURVEYING ACTIVITIES

10.1 Policy Regarding Private Property

It is important that surveys shall be performed observing the rights and concerns of the property owners. To this end, the following instructions are issued:

Surveyors shall not enter private property without first advising the landowners of their purpose and intended activities. It is the responsibility of the District Surveyor or Consultant to properly notify landowners of surveying activities. This shall be done whether or not the owner actually resides at the location of the work. The Surveyors shall explain the work requirements without committing the State in any respect to any fixed highway location or matters relating to right of way acquisition. Although the statutes of the State of Connecticut provide surveyors the necessary right of entry, this statutory right should only be used as a last resort.

GENERAL STATUTES OF CONNECTICUT
CONNECTICUT HIGHWAY LAWS
SECTION 13A-60

“Entry Upon Private Property in Altering Highways.

The commissioner or his agent may enter upon private property for the purpose of conducting surveys, inspections or geological investigations for the location, relocation, construction, or reconstruction of any proposed or existing highway. After giving reasonable notice to the property owner or owners affected, he or his agent may also enter private property for the purpose of performing borings, soundings or other tests required to accomplish any of the foregoing objectives with respect to such highways. He shall use care so that no unnecessary damage shall result, and the state shall pay damages to the owner of any property from appropriations made to the Department of Transportation for any damage or injury he causes such owner by such entrance and use. If entry to any property for the purpose of performing borings, soundings or other tests is refused to the commissioner or his agent after he has given reasonable notice to the owner or owners thereof, the commissioner shall assess damages in the manner provided by statute for the taking of land for highway purposes, and, at any time after such assessment has been made by said commissioner, may enter said property for the purpose of performing borings, soundings or other tests. If the owner accepts such assessment of damages, he shall notify the commissioner in writing, and said commissioner shall pay such sum to said owner within thirty days or, after the expiration of said thirty days, shall pay such sum with interest at six per cent. If the owner is aggrieved by such assessment, he shall notify the commissioner in writing and may appeal to any court within its jurisdiction for a reassessment of such damages within six months from the date said commissioner forwarded such assessment to such owner. This section shall not limit or modify rights of entry upon property otherwise provided for by law.”

Because of public hearings, newspaper items, letters, etc., all property owners should be fully aware of the purposes of the State surveys. In spite of this, it has become necessary that all those engaged in surveying activities make sure that one of their representatives personally visits each owner and/or tenant and

explains the reasons for survey and have the property owner sign a Right of Entry form. In the case of absentee owners, it may be necessary that the notification be made by mail, which will include a Right of Entry form and letter of explanation.

In cases where right of entry cannot be obtained by a surveyor, it is requested that the Office of Central Surveys be notified before final action is taken under the above statute.

If the property owner gives verbal permission, but will not sign the Right of Entry letter, the agent shall complete the Right of Entry letter with the notation that only verbal permission was granted. This notation shall also contain the name of the representative who actually interviewed the owner and the date of the interview. A confirming letter shall be mailed to the property owner within 24 hours.

If there is no response by the property owner to the right of entry requests, either by personal visits or by mail, the agent shall, by certified mail, request permission for entry onto the property and shall enclose a Right of Entry letter to be signed and returned if permission should be given for such entry.

If permission is again refused, the Commissioner will then request the Attorney General to apply for a Court Order for the condemnation of property. This request to the Attorney General will be processed by the Legislative and Administrative Advisor on the basis of a complete report with sufficient documentation submitted to him through established channels of communication.

The Right of Entry form letter, to be furnished by the Central Surveys Office, shall be signed by all property owners involved on a project (See Exhibit 18). The latest version may also be found on the State intranet. *On State projects being performed by Consulting Engineers, the return addressed envelope shall be that of the Consultant.*

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A.) Damage to Private Property

1. Damage to any part of any property shall be minimized, and brazen tree cutting and brush clearing shall not occur. Where brush cutting is necessary, the surveyors are not to leave stubble that can be dangerous to humans or animals. Particular care shall be exercised in the unsightly

trimming of trees for sight line purposes and the slashing or blazing of shade trees for tie or bench mark purposes.

2. Where surveyors must leave stakes in mowing lots, they shall be either flush with the ground or evidenced by higher stakes to preclude mowing machine damage.

3. Of particular importance is the regard for farm fences and walls. Extensive damages have resulted from livestock being freed to roam on properties beyond their confines through “survey or made” breaks in the fences and walls.

4. For the information of all, it should be noted that eating wilted wild cherry is fatal to cattle. If it is necessary to cut branches from wild cherry trees, they shall not be left at any location reachable to livestock. The State has knowledge of several instances where the eating of wilted wild cherry has taken the lives of cattle.

5. Of no small importance is the parking of Surveyors’ cars and trucks. Blocking of drives or passageways shall not be done. Neither shall traffic on a traveled highway be obstructed. Lunch wrappers, newspapers, and uneaten food are not to be scattered along the road or left as unsightly debris on property.

6. Control points shall be located away from private property where possible.

Claims for damage to private property by survey forces shall be referred to **The Connecticut Bureau of Finance and Administration, Office of Property and Facilities Services, Claims Division**, for processing.

Practices other than those cited hereinbefore, which could place the State in disfavor with landowners, shall be avoided.

All dealings with persons in the working area are to be handled in a diplomatic, friendly, and courteous manner. Explain the survey in general terms. Remember base lines can be, and sometimes are, revised at the last minute. Do not answer specific questions concerning private properties or potential acquisitions. Land owners may be referred to the State’s Office of Rights of Way.

It is to be remembered that, whether by our units or contracting engineers, the surveys are being performed on behalf of the State, and all persons working in the field must conduct themselves accordingly.

Consultants are reminded that the State has reserved the right to have any person removed from the work who is found to be unsatisfactory for any reason. The prerogative will be exercised by the State with respect to any person on any project found to be acting contrary to the established policies of the Department of Transportation in their dealings with the public.

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10.2 Railroad Requirements

A.) Railroad Procedures

Procedures for survey activities on railroad property in advance of proposed work are as follows:

1. Railroad Liability Insurance
    a) Obtained by Consultant for their personnel when working on State projects (see Form 819 2024)
2. PAL Funding Agreement
    a) Set up by Designer to fund access and flagging prior to rail survey work
3. Preliminary Engineering Agreement for survey work on AMTRAK railroad
    a) Obtained through the Utility Section, Division of Design Services, Bureau of Engineering and Highway Operations
4. Railroad Permit
    a) To be obtained by the Surveyor from railroad prior to entering their Right of Way
5. Railroad Flag Person
    a) To be obtained by the Surveyor from railroad prior to entering their Right of Way

The Consultant will be billed by the railroad for services of the flagger.

The name insured may include the following:

National Railroad Passenger Corporation (AMTRAK)
Consolidated Rail Corporation (CONRAIL)
Connecticut Southern Railroad
Central New England Railroad
Metro North Commuter Railroad Company
Central Vermont Railway, Inc.
Boston & Maine Corporation
Providence & Worcester Railroad Company
Connecticut Central Railroad, Inc.
Connecticut Valley Railroad Company
Springfield Terminal Railway Company
Branford Steam Train
Essex Steam Train
Genesee & Wyoming, Inc.
CSX Transportation
Pan Am Southern
Housatonic Railroad
Naugatuck Railroad
New England Central Railroad

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B.) Railroad Safety

All surveying personnel, whether State Forces or Consultant, are required to complete a **CONTRACTOR'S SAFETY ORIENTATION CLASS**, which is now available online, provided by AMTRAK and METRO-NORTH prior to entering their respective properties.

Railroads have strict rules concerning trespassers that allow their police to arrest violators.

The scheduling of railroad safety classes can be obtained by contacting the *Division of Safety, Office of Personnel, Bureau of Finance and Administration*, as outlined in a memorandum by John McGill, Director of Safety, dated May 3, 1994, regarding rail safety class (see Exhibit 19).

All railroads require that all personnel working on railroad property be accompanied by a qualified railroad flag person.

The Surveyor shall wear all protective clothing as outlined by *the Railroad's* and *the CTDOT Railroad Safety Awareness Booklet* from the Bureau of Public Transportation, Office of Rail, i.e. hard hats, approved safety vests, safety glasses, safety shoes while on railroad property.

See AMTRAK and METRO-NORTH Roadway Worker requirements for current safety PPE requirements for working in railway. Surveyor responsible for adherence to all current safety requirements.

Other railroads generally accept the protective clothing and safety requirements established by AMTRAK and METRO-NORTH. However, a check should be made of their safety requirements when scheduling the railroad flag person. Freight lines, such as Genesee & Wyoming and CSX, have their own training requirements.

All railroads require that all personnel working on railroad property be accompanied by a qualified railroad flag person (and Railroad Groundman if necessary).

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C.) Surveying Equipment

All Railroads:

Measuring tape must be non-metallic to avoid shunting the signal system electric circuits. This will occur when a metallic object is laid across the top of two rails of any track.

METRO-NORTH:

Electrically-rated fiber glass elevation rods are to be used to avoid injury in the event contact is made with energized catenary or signal/communication lines. Elevation of catenary wires must be obtained by, or under direct supervision of, a qualified Railroad Class "A" Groundman.

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10.3 Cooperation with Others

The Surveyor shall cooperate with other Contracting Engineers, State personnel, municipal agencies, public utility companies, and others who are engaged in survey and/or mapping within or adjacent to the project. They shall provide for a mutual exchange of coordinate points, bench mark points, or other data, and shall assist in a mutual adjustment of coordinate values or bench mark elevations as may be necessary at common terminal points.

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10.4 Historical Items

Every effort shall be made to locate all historical buildings, with appropriate dates, historical and landmark trees, isolated graves, small cemeteries with only fieldstone markers, and other items of historical or commemorative importance.

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SECTION 2

CONNECTICUT DEPARTMENT OF TRANSPORTATION

SPECIFICATIONS FOR DIGITAL MAPPING

1.0 GENERAL SPECIFICATIONS

1.1 Introduction

These SPECIFICATIONS set forth the standards to be met and general procedures to be followed in the production of digital ground mapping for the State. As used in this document, digital ground mapping refers to the preparation of small scale, electronically collected surveying maps to be used in the State's CADD system for highway and structures design. This mapping typically requires the generation of a surface model (Terrain), which may be derived from a combination of field survey technologies.

The Survey Request provides specific details for each digital ground mapping project and should be used in conjunction with this document. Specifications in the Survey Request have precedence when in conflict with this document.

All digital ground mapping provided to the State must be delivered in OpenRoads Designer (ORD) format. The Surveyor must utilize ORD in order to provide the State with an accurate final product. AutoCAD (.dwg), or any other CADD file type will not be accepted by the department.

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1.2 Surveyor's Responsibilities

It is the Surveyor's responsibility to be familiar with all specifications and guidelines provided by the State, and to follow them in performing work for the State.

It is the Surveyor's responsibility to consult with the State to resolve all discrepancies and ambiguities between these SPECIFICATIONS and the Survey Request prior to proceeding with work on the project.

It is the Consultant's responsibility to provide all labor, materials, equipment, and other incidentals necessary to perform the work. Each of these items are to be of uniformly high quality and compatible with the quality and accuracy standards specified for the project.

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1.3 Materials to be Provided to the Surveyor by the State

The Survey Request or scope for each project awarded to the Surveyor shall include the following:

a. A detailed list of products to be delivered
b. A written description of the project area
c. A mapping limits diagram including dimensions or clear survey boundaries
d. Special project requirements, such as hydraulic cross-sections and clearances
e. Desired delivery date
f. CTDOT Location Survey Manual
g. CTDOT Digital Design Environment (DDE)

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1.4 Materials to be Provided to the State by the Surveyor

Mapping Review - The Surveyor shall provide a digital copy of the ground survey. If a Terrain or other surface model is required, a PDF plot of the surface model generated contours, breaklines, and individual x,y,z point locations shall also be provided.

Upon receipt of the mapping file(s), the State will promptly and thoroughly review the files for specification compliance. Included in the mapping review will be an evaluation of working units, color usage, level placement, point codes, line weight assignment, text placement/portrayal, correct usage of cell library, ORD field book usage, portrayal of line junctures, line patterning, number of vertices, etc. as dictated by the CTDOT DDE Guide.

Included in the surface model review will be an evaluation of level placement, accurate portrayal of terrain surface, breaklines, data density, etc. See Section 2 (1.5).

The Surveyor shall always inspect any three-dimensional file in the "front" and "isometric" views to see errors in 3D line placement before submission to the State. The main objective here is to check for line connections to and from unrelated elevations.

The State will notify the Surveyor of the results of the review. The Surveyor will be advised of any errors detected in the mapping and requested to make the necessary corrections. The State will review the revised file(s) and notify the Surveyor if required corrections were properly made.

Completed Project Review – Materials to be provided within the allotted production time for checking and review by Central Surveys:

1. All files to be digitally submitted, generally via State-provided upload link, including Open Roads Designer files and any supplemental survey and mapping data
2. A written summary of all the file names and contents of all submitted files

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1.5 File Requirements

A.) General Requirements of 3D Mapping Files

1. All files are to be digitally submitted, generally via State-provided upload link, or external hard drive if previously approved

2. All CAD files to be OpenRoads Designer 3D design file format, to current CTDOT DDE file structure standard

3. Files shall be compiled with coordinate values to the nearest thousandth (1/1000) of a foot. Coordinate values shall be based on the grid system indicated by the control data. The working units for the OpenRoads Designer design files shall be:

   Master Units = US Survey Feet
   Sub Unit = US Survey Feet
   Accuracy = 0.123 (three decimal places)

Note: Upon CPCS adoption, both Master and Sub Units will be required to be International Feet when using said system.

4. The global origin for the map files shall be in the center of the design plane, which will be accomplished automatically by using the most up-to-date CTDOT survey seed file. If the Surveyor chooses to work outside of the OpenRoads Designer CTDOT Digital Design Environment (DDE) to compile or map survey data, the Surveyor must still maintain the same standards set forth by CTDOT for the final deliverable format, which must be in an OpenRoads Designer file.

5. All files shall be delivered at the proper plot/view rotation angle, rounded to the nearest full degree, with those settings saved when submitted. Once rotation has been determined, the view must be saved for future retrieval. The plot rotation angle shall be recorded in the space provided below the title block.

6. The Surveyor shall keep a backup of all files for a minimum of 90 days after final acceptance by the State.

7. The file information shall be identified within the State's Title Block Cell. The Surveyor shall be responsible for the placement of the information in the title block data fields. A sample title block showing placement of the data will also be provided (See Exhibit 20).

8. The file name shall be in the appropriate data fields of the title block using logical file names generated by the Surveyor. The names will have unique number/letter designations with "_ORD.dgn" at the end. (Example: SV_D4_0123-0456_BR01234_ORD.dgn). The actual file name and the file name placed in the title block will be the same.

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B.) Terrain Model Elements (Point elements, Breaklines, Void regions, Boundary areas, and Terrains)

1.) **Point elements** represent the actual field locations depicted as three-dimensional OpenRoads Designer point elements. These point elements will be incorporated into the 3D ORD design file Field Book, which graphically depicts the x,y,z point locations and builds an ORD Terrain based on the CTDOT DDE. Point elements shall be placed in accordance with CTDOT Feature Definitions.

2.) **Breaklines** are the three-dimensional **Line Elements,** which control internal triangle construction within the Terrain model. Elements of this type shall be placed in accordance with the **CTDOT DDE.**

3.) **Void Regions** are three-dimensional **Closed Shape** Elements, within the 3D ORD Terran, which are comprised of **graphic** point-to-point connections defining all areas in which triangulation shall not occur within the limits of the surface model (e.g., Buildings, Lakes & Ponds, Dense Vegetation, etc.). Elements of this type shall be placed in accordance with the **CTDOT DDE.**

4.) **Boundary Areas** are three-dimensional **Closed Shape** Elements placed in the 3D ORD design file, which are constructed to restrict triangulation to within project limits. It is imperative that surfaces information is not generated in areas where actual survey data was not collected. The import of survey data into ORD Field Books automatically creates a Terrain. The boundary and edge settings of this Terrain may require editing accordingly. This is accomplished by placing a **graphic** point-to-point closed shape connection just outside the perimeter of the limits of the survey or editing the vertices of the automatically created boundary. This boundary area feature is used to restrict triangulation to areas within the closed shape. Elements of this type shall be placed in accordance with the **CTDOT DDE**.

5.) **Terrains** are the three-dimensional *software-generated* **surface elements**, created in the ORD design file by survey data compiled in ORD Field Books, which **dynamically and graphically** display the surface triangulated irregular network (TIN) and contours. The Terrain should be assigned the feature definition of “Existing Ground” as defined within the **CTDOT DDE**.

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2.0 FEATURE COMPILATION SPECIFICATIONS

2.1 Statement on Planimetric versus Topographic Mapping

In legacy State mapping, the categories of topographic, planimetric, or both, were used to classify which file or model a feature resided in. Although it is understood that certain features will only be mapped two-dimensionally (north arrow, scale bar, ROW lines, record utility information, etc.), most surveyed features are intended to be both displayed on two-dimensional maps and included with the topography (Terrain). Some features may reside in unique models within the ORD drawing file. For example, record utilities will reside in the Utilities Model, and ROW lines will reside in the Boundary Model. All field-surveyed features will reside in the Existing Ground model and be included or excluded from the Terrain based on ORD Feature Definitions attached to the field code feature library according to the CTDOT DDE.

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2.2 General Mapping Production Techniques

A.) Features shall be of the following ORD element types as appropriate: cell, line, line string, curve string, connected (complex) strings, linear patterns, simple shapes, complex shapes, ellipses (includes circles), and text string. See APPENDIX F. All surveyed features will reside in the **Existing Ground Survey model**.

B.) Features to be labeled and the labels to be used, shall be as described in the **CTDOT DDE and as defined in the CTDOT ORD Workspace**. Labels shall be oriented along linear features or parallel to the map border and view rotation angle. Mapping orientation shall conform to the **east to west** and/or **south to north** standard mapping conventions. Labels will reside in the **Annotation model** (or as advised in the most current version of the DDE Volume 4 – OpenRoads Designer Survey Guide**)** of the ORD design file.

C.) Road alignments shall be carefully compiled using ORD Horizontal Geometry elements and consist of curve and tangent line strings. Enough points should be located to assure smooth curves. All points must be connected using the line to point tool under the Geometry tab. In the case of digitized mapping, stream digitizing is not allowed.

D.) Match marks on adjacent map file edges shall coincide exactly. Mapping limits separating mapping sheets or Terrains shall be delineated. Project beginning and ending points shall also be delineated.

E.) Detail

1. All mapping shall show required features in accordance with the Existing Features Cell Library provided by the State.

2. Particular attention shall be given to include all transportation and transportation-related features such as roads, railroads, bridges, canals, streams, dams, utilities, drainage, etc. as well as other features along transportation corridors.

3. Features not readily identifiable or not included in the Existing Features Cell Library shall be shown and symbolized with the most equivalent symbol, level, and color along with its associated label.

F.) Coordinate grid ticks for design scale mapping shall be taken from the Existing Features Cell Library and placed at 400' intervals for 40 scale mapping. Grid ticks shall only be labeled outside of the mapping limits and omitted in congested areas. Show two rows of grid ticks above and two rows below the mapping limit if possible.

G.) Each design file shall include the supplied title block placed outside the mapping area, preferably located in the lower right corner.

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2.3 Three-dimensional Mapping Production Techniques

A.) Topographic elements consist of three dimensional data measured along surface specific features in the form of lines along with terrain changes; as well as individual x,y,z point locations elsewhere. The field collection of this data is similar in concept to taking profiles where features are collected longitudinally rather than cross-sectionally. Topographic mapping elements delineate both terrain and cultural features.

B.) All three-dimensional terrain and cultural features will be identified with the following ORD element types, as appropriate: cell, line, point, line string, and curve string and complex shapes. See APPENDIX F. Guidelines for feature portrayal and their corresponding levels are provided by the CTDOT DDE and CTDOT Workspace functions.

C.) A Mapping File Break is required between specified mapping files to divide a project or Terrain into manageable file sizes. Mapping File

Breaks must coincide with Mapping File Limits and be compiled as perfectly straight lines. See Section 2 (2.5, A).

D.) The Surveyor must collect a regular density of measurements to depict the ground surface accurately. A typical guideline for the number of shots is to not exceed an interval of 25-50 ft. intervals along the alignment. The Surveyor is still required to pick up any notable surface breaks between these intervals. When LiDAR or other methods are utilized that result in highly dense data, these guidelines can be used as a minimum for extraction intervals. See APPENDIX G.

E.) Terrain and cultural features will be compiled using breaklines. Breaklines define the slope and direction of the terrain changes. They delineate and portray the seams in the surface, the places where adjacent areas of constant slope change. Examples of breaklines are ridge tops, ditch bottoms, top and bottom of road cuts, curb lines, road crowns, etc. **Breaklines are not contour lines, as elevations usually vary along breaklines.**

F.) Breaklines will be compiled as linear elements with 3D data points located as often as needed to accurately portray the feature or terrain being defined. They must include sufficient data points to accurately portray the feature in 3D, based on State accuracy standards. All data points will be directly located. Additional software generated or interpolated points are not to be included.

G.) The greatest attention to detail should be within the requested limits of survey as follows:

1. Transportation Surfaces

   This category includes such features as paved and unpaved roads, shoulders, parking lots, and driveways, in addition to curbs, bridges, retaining walls, sidewalks, etc. These features should be portrayed using breaklines. Individual x,y,z point locations should rarely be used in defining these features except in areas, such as parking lots. Along straight segments, breakline vertices (point locations) should not exceed 25 to 50 ft. apart. Along tightly curved segments, intersections, and complex areas, additional breakline vertices (points) should be located at an interval appropriate to accurately model the surface. Additional points shall be located at road and driveway intersections to show crowns and dips. Superelevation along curves should also be delineated.
2. Engineered Surfaces / Drainage

This category includes such features as roadway embankments, drainage ditches, water body and well-defined water course edges, lawns, etc. Drainage ditches and water body edges should be defined using breaklines. Embankments, lawns, and other areas within the mapping limits shall be defined with breaklines at the slope changes and with individual x,y,z point locations elsewhere. Data points along breaklines, which parallel transportation surfaces, should be taken at the same 25-50 ft. interval. Data points along other breaklines should generally be between 50-75 ft. apart unless additional intermediate x,y,z point locations are required to correctly model the Terrain. Individual x,y,z point locations should also be taken between 50-75 ft. apart in a “grid like” fashion to densify the model. The regular pattern need not be an exact grid. The Surveyor must be sure to locate all minimum and maximum elevations of the specific ground features (high and low points).

3. Other surfaces

   This includes hillsides, fields, wooded areas, and brush areas where only the general contour of the ground is required. These areas should be compiled with breaklines at significant slope changes and with individual x,y,z point locations elsewhere. Individual x,y,z point locations should generally be between 25 and 75 ft. apart taken in a “grid like” fashion to densify the Terrain. The regular pattern need not be an exact grid. The Surveyor must be sure to locate all minimum and maximum elevations of the specific ground features (high and low points).

4. It is the responsibility of the Surveyor to ensure that the accuracy of the individual point measurements and the density of those measurements is appropriate for the type of surface and associated cultural features to achieve State accuracy standards.

H.) In the ORD survey drawing, the primary model, including the roadway, should be shown up to the bridge deck lines. Separate supplemental models within the CAD file should contain the bridge decks within the project area. These bridge deck model boundaries should coincide exactly with the primary Terrain boundary found in the **Existing Ground Survey** model. See Section 2 (2.5,C)

I.) Vertical features, such as curbs or walls, are to be compiled as though the vertical faces were slightly canted. ORD Terrains cannot handle perfectly vertical surfaces or multiple z values for an x,y location. See Section 2 (2.5,C)

J.) Areas where the Surveyor physically cannot obtain accurate ground information are designated as *Void Areas*. Void areas will be delineated with a closed shape polygon, labeled, and added to the Terrain as a void.

K.) The mapping files submitted shall contain the edited 3D breaklines and the individual x,y,z point location data, as well as a 3D graphic representation of the processed or triangulated surface files. The Surveyor will produce a surface model and generate 1 ft. contours unless otherwise specified. Void regions and Boundary regions shall be included in the mapping files. All mapping features should be free of gaps and overlap. Particular attention should be paid to the shape and interval of contours along road surfaces, drainage, and vertical features. All above features will be placed in accordance with the **CTDOT DDE**.

Review of the contours will be an important part of the Surveyor's edit. Final contours from the Terrain model, produced from ORD Field Books and edited by the Surveyor if necessary, will be submitted to CTDOT Central Surveys for review.

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2.4 Planimetric and Topographic Mapping Feature Compilation

The compilation of planimetric and topographic mapping features shall follow the instructions in Section 2 (2.5). These feature descriptions are listed by general category then alphabetically within each category. Refer to Existing Features Cell Library and CTDOT DDE Feature Definition Template descriptions for additional details.

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2.5 Selected Feature Descriptions and Mapping Procedures

A.) Mapping Features

The following features may be added without the aid of survey data collection.

Survey Mapping Limit

Usually, the survey mapping limit or topographic mapping limit is the Terrain boundary of an ORD Terrain. On occasion, boundary, utility, or other record information will extend beyond the three-dimensional mapping limit. See APPENDEX G.

Grid
The grid should be based on the control data provided and should be based on the Connecticut Coordinate System (or Connecticut Plane Coordinate System upon its adoption).

Use CTDOT DDE grid mark cell at 400 ft. (true scale) intervals when providing a 1" = 40' map within Title Block model. Scale accordingly if mapping at a different map scale. Label all ticks in non-congested areas with grid coordinates. The labels should be placed such that when the file is rotated to its final plotting position each label is above its corresponding cross tick member and the text is in the mostly upright position. Do not place ticks such that they will overlap ticks within, above, or below the mapping limits of an adjacent file.

Grid North Arrow
Place arrow indicating grid north, along with its label, in a non-congested area within the appropriate model.

Title Block
Place the title block horizontally with respect to the plan border, in the lower right corner whenever possible. Fill in the "enter data fields" with the appropriate information in the mapping file title block (See Exhibit 20). Additional Title Block templates available within the CTDOT workspace.

Scale Bar
Place appropriate scale bar**.**

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B.) Survey Control

Horizontal and vertical control points shall be shown as in Section 1 (3.0). All control points shall be shown both inside and outside the mapping limits.

Base line (Shown only when requested)
See Section 6.0

Base Line Points (Shown only when requested)
Surveyed points for establishment of project base line.

Horizontal Control Point
Surveyed point for horizontal ground control. Show point symbol and label with the point name. Show coordinates in tie boxes and align label and symbol with grid.

Vertical Control Point
Surveyed point for vertical ground control. This is a project bench mark. Show elevation, datum, and brief description in the template supplied in the Existing Features Cell Library from the DDE. Place a leader from the bench mark template to the actual point on the plan.

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C.) Transportation Features

Bridges

Mapping - Structure, including supports or piers, erected over a depression or an obstruction such as water, highway, or roadway.

In the primary mapping Terrain, the roadway shall be shown up to the bridge deck expansion joints or abutment. Then each bridge deck will be mapped as a separate ORD Terrain element.

Bridge Abutments - Locate abutments and parapet concrete or steel surface at edge of bridge deck. Locate piers when possible and bridge deck or clear span as indicated below. The abutments are typically shown in the Ground Survey model. Bridge abutments have vertical or near vertical faces and require a minimum of two breaklines to be defined properly. A breakline is required at both the top and bottom of the structure, and these breaklines must be slightly offset to triangulate in a Terrain. Breaklines are used to show the edge of the clear span and tops and bottoms of the wing walls. Show all structures that are part of the abutment. Locate the top of the wall lines first and then offset the bottom lines of the wingwalls, outward slightly using a terrain breakline at grade. See APPENDIX G.

Bridge Deck - It is usually indicated by change of pavement or expansion joint. Locate as bridge deck when a change of pavement or an expansion joint is evident. If the bridge deck joint is not visible, locate the clear span. The clear span is the distance between the inner faces of the abutments. Show using bridge deck symbology. Each bridge deck should be contained

in a separate **Bridge Deck Terrain element**, containing the unique bridge designation in the name. Each **Bridge Deck Terrain** should contain all transportation features (breaklines for each road centerline, travel lane, pavement edges, curbs, shoulders, sidewalks, etc.) between the first and last expansion joints. Each end of the deck Terrain model will consist of a breakline or boundary that is coincident with the breakline or boundary of the primary ground Terrain in the Existing Ground Survey model. The limits of the bridge deck will be along expansion joints or visible change of pavement at the outer edges of the bridge abutment. Locate all roadway features between the expansion joints, snapping to the two end breaklines. Each deck line must have a vertex at the intersection of all breaklines delineating other features, such as pavement edges, shoulders, road centerline etc. See APPENDIX G.

Bridge Piers – Bridge piers are clear span supports. Locate piers whenever possible. They should be placed in the primary Terrain model.

Map edge-of-pavement (EOP) and shoulder delineation to the bridge deck or clear span as appropriate. Continue all other symbology (e.g., railroad tracks, guide rails, curbs, paved gutters, etc.) across bridge when present.

Curb

A curb is raised edging along a paved road defining the edge of pavement or outlining traffic islands (i.e., raised median). Show curb at all paved driveways where the curb is seen to continue through the drive without any appreciable height. Use edge of pavement symbology where the curb stops at a drive and continues on the other side of the drive. Curb symbology takes precedence over sidewalk and paved or unpaved drive/parking lot symbology when the features coincide.

Curbs shall be located as two nearly parallel breaklines portraying the face of the curb. Locate the bottom line first then offset the top line away from the road slightly (See APPENDIX G). Points should be measured at least every 50 ft. in a regular pattern. Additional shots must be taken along curves and at intersections. The two breaklines must not overlap. Curbs at grade and ADA sidewalk ramps can be shown by flaring the top-of-curb breakline into the bottom-of-curb breakline. CAD-generated parallel lines are not to be used to generate tops or bottoms of curbs.

Paved Road

Paved road is defined by the edge of pavement or the area between gutter lines. Where the edge of pavement changes between the surface types, the line work should reflect these changes. If the road appears to be straight, the EOP should be compiled as lines or line strings. If the road does not appear to be straight, the edge of pavement should be compiled as curves or curve strings, having enough vertices to insure a smooth curve. Add road names to the Annotation model from available source material.

The edge of pavement should be located with the properly coded breakline. Breaklines should also be compiled along the road centerline and between each travel lane. Points should be measured at most every 50 ft. in a regular pattern, with additional intermediate locations when necessary (such as dips and high points). Additional shots must be taken along curves and at intersections.

Railroad

All rail lines should be shown, including all siding tracks for passing and storage. All rail yard tracks shall be shown as well. Add railroad names in the Annotation model from available source material.

Railroads will be shown by locating the railroad bed as well as the ties. A minimum of six breaklines is required unless otherwise requested. The first two are along the center each rail. The next two are along the top outside edges of the railroad ties, and the last two are along each side of the bottom outside edges of the railroad ties where they meet the ballast. Topographically, paved road features take precedence over railroad features, except for the rails themselves. Snap all railroad breaklines, except those defining the rails, to the paved road edge.

Retaining Wall

A retaining wall is defined as a fixed structure of concrete, brick, stone, etc. that retains earth. Retaining walls shall be located with breaklines in a similar technique to other vertical features. First locate the top front and back of the retaining wall in its true horizontal location. Then locate the bottom of the wall as a breakline slightly offset outward from the top front breakline.

Unpaved Road

Defined as a dirt or gravel road maintained as a thoroughfare, usually found in rural areas. Define by edge of graded surface when visible with breaklines. If not visible, or the surface is not graded, define by outside edges of travel way as indicated by tire wear. Use edge of grass where travel way is indistinguishable. At intersection with paved road, end

unpaved road symbology at paved shoulder. In addition, a breakline should be compiled at the crown of the road. Vertices should be measured at least every 50 ft. in a regular pattern, except where additional shots are needed along curves and at intersections.

Gas Island

Defined as raised and curbed concrete pad for gas pumps. Curb should be located with two nearly parallel breaklines. Locate the bottom breakline first, and offset the top breakline slightly to the interior of the island. Plot pumps, gas island, roof, and lightpoles. The roof and pumps should be excluded from the Terrain.

Paved Shoulder

A paved shoulder is pavement extending beyond the normal travel lanes. Locate the shoulder edge with breaklines when the shoulder extends beyond the normal travel lanes. Shots should be taken at least every 50 ft. in a regular pattern. Add supplemental points where necessary to portray the contour of the shoulder, taking shots along the feature at changes in elevation and at intersections with driveways, catch basins, and sidewalks. At the intersection of the shoulder and driveway, a Terrain breakline, not to typically be displayed in the mapping, should be added between the driveway flares.

Sidewalk

Show all walks, whether public and parallel to the road, or private and leading from road to house or adjacent to a building. Continue sidewalk delineation through a driveway only if it is a different pavement type. Sidewalk symbology takes precedence over unpaved drive symbology when they coincide. When the sidewalk parallels the road, measure points at least every 50 ft. in a regular pattern, taking additional shots along curves and corners. Other sidewalks, which are not parallel to the road, should be measured along the feature, locating all changes in direction to accurately portray the walkways' extent and contour.

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D.) Signs

Billboard

Plot centers of supporting posts with post symbols. Locate sign face with a single line tangent to the post symbols.

Overhead Sign

Traffic sign supported by one, two, or four poles over a highway. Plot centers of supporting poles with pole symbol. Locate horizontal support structure and identify location of sign faces. Manually draw sign faces if they exist on both sides of the support structure.

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E.) Drainage

Catch Basin or Field Inlet

Plot location of drainage grating. Catch basins along straight line curb segments should be parallel to the curb face and not be at odd angles to the curb. Corners of catch basins should be snapped to straight line segments of curb or edge of pavement. Annotation should be placed near the catch basin and off the road surface if possible. Catch basins represent a local depression in respect to the surrounding features. Rectangular or circular drain inlets should be located in parking lots, sides of roads, and intersections. Curbed catch basins should be located on the grate at the gutter line (throat), and all other basins at the center of the grate.

Culverts

Defined as a conduit for channeling water under a road, drive, or railroad embankment.

Locate the head walls, wing walls, pipe inverts and other visible structures. Concrete culverts and head walls should be located with two to four breaklines in a manner similar to bridge abutments. Locate the top edges (top back and top front) of the head wall. The bottom face of the concrete walls should be measured along the ground using the top face of the head wall as a horizontal guide, offsetting the bottom breakline outward slightly. Connect all ditch lines to the culvert.

When the outlet pipe is physically above the ground, the flow line elevation cannot be included in the surface model compilation, or it will alter the appearance of the existing ground. Although this information is important to designers, it must not be included in the Terrain model triangulation.

The information should be shown in the Annotation. Channel lines should end at the head or wing walls.

Ditch

A ditch is an unnatural channel for drainage. Each top edge of the ditch must be located using the ditch field code. The top edges act as a breakline in the topographic mapping. Locate length, depth, and breadth of the drainage channel (regardless of width) with multiple Terrain breaklines, as appropriate, to define the feature extent. Ditches with a “U” shape will have four or more breaklines, and ditches with a “V” shape will have three breaklines. If water is present, the edge of the water should be depicted with a “stream” breakline. Vertices should be located at least every 50 ft. in a regular pattern.

Trench Grate

A trench grate is a long grate in pavement for drainage (i.e., at bridges, driveway, or parking lot entrances). Compile a breakline that clearly defines the corners of the grate, taking measurements at each corner regardless of whether they appear lower than the surrounding terrain.

Bituminous and Earth Leak offs

Defined as a bituminous or earth channel for road water runoff. Locate outer edges of the leak off. They should be located at least every 50 ft. in a regular pattern. Additional points must be measured along curves and at corners. The trough of the leak off should be shown with one or more terrain breaklines running longitudinally.

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F.) Structures

Building

Buildings are defined as structures including dwellings, businesses, houses, garages, barns, etc. Locate the building, including covered porches and attached structures. Locate carports, decks, patios, stairs, etc. as part of the structure. Building symbology takes precedence over other symbology when features coincide. The building extent should be located with breaklines measured along the ground. Locate the ground surface at the base of the building including all attached structures (e.g., porches, decks, loading docks, etc.). The breakline must follow ground

contours and define the building outline. A single spot shot depicting the sill elevation may also be required.

Fence

Locate feature, joining cleanly to other structures if appropriate. Do not show temporary snow fences. Locate gates as found in field. It is important to follow ground breaks when collecting fence data as it will be used for compiling the Terrain.

Rip Rap

Rock piled along a stream, shoreline, or road to lesson erosion. Locate outline and grade changes on slope and add rip rap symbols.

Stone Wall

A stone wall is defined as a loose rock wall, not retaining earth, usually located in farm fields or residential areas. Locate the feature, joining cleanly to other structures if appropriate. The walls should be shown with four breaklines. A “stonewall” breakline will define the top front face along with a Terrain breakline to define the top back edge. Additionally, two terrain breaklines offset outwardly will be used to define the bottom where the wall meets the ground. Locate the general form of the wall, including any angle points, in a regular pattern.

G.) Terrain Features

Void Regions

A void region is a polygon inside of which precise and accurate vertical data cannot be measured within State specifications. The void region limit is located with a breakline accurately representing the feature and ground surface at the edge of the undefinable area. This breakline must be a single line string closing onto itself.

Terrain Breakline

Terrain breaklines may be isolated segments, closed figures, or polygons used to locate any visual change in slope or aspect of a feature. They can be used to show feature forms and changes, general ground surface, and other three-dimensional mapping features. Terrain breaklines are needed at the tops and bottoms of cliffs, at the top and toe of slopes, and in any area where breakline information is required. The ends of breaklines should be snapped (x,y,z) to vertices on other breaklines, where appropriate, and may change direction as often as needed. Terrain

breaklines can never cross one another. A node, with one common elevation, must be generated at the junction of the two breaklines where they can be joined together at a single point. Stream digitizing is not allowed. Breaklines should be compiled with sufficient 3-D data points to meet accuracy standards. Measurements along breaklines (vertices) should never exceed 50 ft. apart. Tight curves, such as curb corners, will require additional measurements. (See APPENDIX G)

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APPENDIX A

LIST OF ACRONYMS

ASCII ..... **AMERICAN STANDARD CODE FOR INFO. INTERCHANGE**
CADD (OR CAD) ..... **COMPUTER AIDED DRAFTING AND DESIGN**
CGS ..... **CONNECTICUT GEODETIC SURVEYS**
CPCS ..... **CONNECTICUT PLANE COORDINATE SYSTEM**
DDE ..... **DIGITAL DESIGN ENVIRONMENT**
DGN ..... **MICROSTATION DESIGN FILE DEFAULT EXTENSION**
DTM ..... **DIGITAL TERRAIN MODEL**
DXF ..... **DATA TRANSFER FILE**
EDM ..... **ELECTRONIC DISTANCE METER**
FGCC ..... **FEDERAL GEODETIC CONTROL COMMITEE**
GPS ..... **GLOBAL POSITIONING SYSTEM**
GNSS ..... **GLOBAL NAVIGATION SATELLITE SYSTEM**
HARN ..... **HIGH ACCURACY REFERENCE NETWORK**
HI ..... **HEIGHT OF INSTRUMENT**
HT ..... **HEIGHT OF TARGET**
IPS ..... **INDIVIDUAL PROJECT SCOPE**
NAD27 ..... **NORTH AMERICAN DATUM OF 1927**
NAD83 ..... **NORTH AMERICAN DATUM OF 1983**
NAPGD2022 ..... **NORTH AMERICAN-PACIFIC GEOPOTENTIAL DATUM OF 2022**
NATRF2022 ..... **NORTH AMERICAN TERRESTRIAL REFERENCE FRAME OF 2022**
NGS ..... **NATIONAL GEODETIC SURVEY**
NGVD29 ..... **NATIONAL GEODETIC VERTICAL DATUM 1929**
NAVD88 ..... **NORTH AMERICAN VERTICAL DATUM 1988**
ROW ..... **RIGHT OF WAY**
TIN ..... **TRIANGULATION IRREGULAR NETWORK**
USE ..... **UNITED STATES CORP. OF ENGINEERS**
VLBI ..... **VERY LINE BASE LINE INTERFEROMETRY**

APPENDIX B

LIST OF FILE EXTENSIONS

CROSS SECTIONS (LEGACY) ..... **.XSC**

LASER (POINT CLOUD) ..... **.LAS**

POINT CLOUD AND IMAGERY ..... **.E57**

SURFACE MODELING BRIDGE DECK FILES (LEGACY) ..... **.BDX**

TOPOGRAPHIC/PLANIMETRIC MAPPING FILE (LEGACY) ..... **.GRN**

APPENDIX C

GLOSSARY OF TERMS

Azimuth:

The horizontal angle reckoned clockwise from the meridian – from grid north in highway surveying.

Backsight:

The reference point from which horizontal angles are measured.

Benchmark:

The specific case of a vertical control point.

Boundary Area Element:

A three-dimensional ORD closed shape element which defines the field location limits. This feature is acts as the Terrain boundary and restricts triangulation to the area within the shape and prevents association between points that have no relation.

Breaklines:

The three-dimensional graphic line elements that control and/or restrict triangulation during the processing of the surface model Terrain.

Channel Limits:

Top and bottom of bank as well as the edge of water.

Contour Line:

An imaginary line connecting the points on a land surface that have the same elevation; also, the line representing this feature on a map.

CPCS:

Connecticut Plane Coordinate System. The latest system of plane coordinates established by the NGS for defining geographic positions in the state of Connecticut based on the North American Terrestrial Reference Frame of 2022. Anticipated to be adopted by the State in 2026.

Cultural Features:

Man-made structures, such as roads, buildings, culverts, etc.

Data Collector:

Portable computer or tablet, usually sized to fit in one hand, that records observations made with a total station, GNSS receiver, or other surveying measurement instrument.

DDE:

Digital Design Environment. CTDOT's DDE is configured by CTDOT AEC, and it defines feature definitions, codes, drafting tools, annotation styles, models/seed files, and backend software rules that automate Terrain generation.

Direct (Face 1):

Refers to the total station with its telescope in the normal orientation relative to the supporting instruments trunnions.

Discrete Points:

Additional individual x,y,z field locations used to densify the surface model.

Design File:

Refers to CADD File Format produced by the Bentley (Microstation, Open Roads Designer) software products.

Electronic Distance Meter (EDM):

A device that measures reflected electromagnetic waves to accurately calculate distances.

Elevation:

Orthometric height. The height of a station above the geoid measured along the plumb line.

Ellipsoid:

A simple mathematical surface that approximates the shape of the earth. It is the surface generated by an ellipse revolving about its minor axis, which can be considered to be the polar axis of the earth.

Ellipsoid Height:

The height of the station above the ellipsoid surface defining the reference datum.

Electronic Field Book:

The term referring to the raw survey data received by the data collector.

Face 1:

(See Direct)

Face 2:

(See Reverse)

Fascia:

Refers to the bridge face.

Floodway:

FEMA-designated channel of a river or stream and the adjacent land that must remain open to allow floodwaters to pass during a base flood (1% annual chance flood) without causing a significant increase in water surface elevation.

Floodplain:

FEMA-designated boundary lines of predicted 100-year and 500-year probability flood events.

Foresight:

The station or location to which a horizontal angle (relative to the backsight), zenith angle, and distance are measured.

GNSS:

Global Navigation Satellite System. Includes constellations of Earth-orbiting satellites that broadcast locations in space in time that can be used by ground-based receivers to calculate position.

GPS:

Global Positioning System. A satellite-based radio navigation system owned by the U.S. Military that is one constellation utilized as part of GNSS.

HARN:

High Accuracy Reference Network. This was a single horizontal network of GPS and VLBI stations based on a continental network established by NGS. (See NSRS)

HI:

Height of Instrument. The vertical distance from the station mark to the center of the trunnion axis of the total station or level.

HT:

Height of Target. The vertical distance from the station mark, or the ground, to the center of the object being sighted with the total station.

Individual Point Locations:

Any number of separate x,y,z point locations used to densify the surface model.

NAD 27:

North American Datum of 1927. Horizontal reference datum.

NAD 83:

North American Datum of 1983. Horizontal reference datum that superseded NAD 27.

NAPGD 2022:

North American-Pacific Geopotential Datum of 2022. Vertical reference datum to supersede NAVD 88. Anticipated to be adopted by the State in 2026.

NATRF2022:

North American Terrestrial Reference Frame of 2022. Realization of International Terrestrial Reference Frame of 2020. Reference frame for CPCS.

NGVD 29:

National Geodetic Vertical Datum of 1929. Vertical reference datum.

NAVD 88:

North American Vertical Datum of 1988. Vertical reference datum that superseded NGVD 1929.

NSRS:

National Spatial Reference System. A consistent coordinate system that defines latitude, longitude, height, scale, gravity, and orientation throughout the United States, which includes a network of Continuously Operating Reference Stations (CORS) which supports three-dimensional positioning activities.

Void Region Format:

The three-dimensional ORD Closed Shape Element that defines areas in which triangulation should not occur within the limits of the surface model (e.g. buildings, lakes & ponds, dense vegetation, etc.). Elements of this type shall be placed in accordance with the Existing Features Cell Manual.

Photogrammetry:

A procedure by which accurate maps and three-dimensional surface models are made from photographs (usually captured aerially).

Position:

The coordinates, in a horizontal reference system, of station mark or feature. Latitude and longitude, and northing and easting, are examples of position coordinates in systems used in surveying.

Point Element:

The three-dimensional graphical representation of an x,y,z field location.

Project Control:

A localized network of survey reference points—including traverses, GNSS networks, and level lines—established within a project's limits. It serves as the primary spatial framework to ensure the accuracy of engineering and construction work. While these points are designed to be stable and recoverable for the duration of the project, they may sometimes be considered expendable upon project completion.

Reverse (Face 2):

The telescope of the total station is “upside down” from its normal position relative to the supporting instruments trunnions.

ROW:

Right-of-Way. The strip of land around a state highway granted as an easement or fee to the State and managed by CTDOT.

Surface Model:

A three-dimensional mathematical and/or graphic representation that attempts to depict the existing ground through a series of triangular connections. (Also known as: DTM – Digital Terrain Model, TIN – Triangulation Irregular Network, Terrain, ORD Terrain)

Thalweg:

The line following the lowest part of a channel or river, whether under water or not.

Total Station:

An electronic surveying instrument that combines angle and distance measuring capabilities in a single instrument.

VLBI:

Very Long Base line Interferometry. The fundamental techniques and stations upon which intercontinental horizonal and HARN networks are based. (See NSRS)

Zenith Angle:

The angle, measured in a vertical plane, between straight up (zero) and the target of observation. Horizontal is, therefore, 90°.

APPENDIX D

EXHIBITS

Exhibit 1 – CTDOT Maintenance and Construction Districts

Exhibit 2 – CTDOT Construction Districts by Town and Town Number

Exhibit 3 – Memos and Directives Regarding CTDOT Digital CAD Adoption

Exhibit 4 – Angular Baseline Information and Calibration Instructions

Exhibit 5 – Distance Calibration Log Sheet

Exhibit 6 – Angular Calibration Log Sheet

Exhibit 7 – Connecticut Geodetic Survey GNSS Observation Skyplot

Exhibit 8 – Trigonometric Leveling Observations Log

Exhibit 9 – Circular and Railroad Curve Data Computations

Exhibit 10 – Vertical Curve Data Computations

Exhibit 11 – Test Pit Process Quality Assurance Checklist

Exhibit 12 – Sample Test Pit Coordinate Sheet

Exhibit 13 – Sample Daily Labor and Work Record for Test Pits

Exhibit 14 – Percentage of Participation in Highway Relocation Projects (Utilities)

Exhibit 15 – Railroad Turnout

Exhibit 16 – Typical Hydraulic Cross-Section Locations

Exhibit 17 – Typical Hydraulic Cross-Section Orientation and Profile

Exhibit 18 – Sample Private Property Access Letter

Exhibit 19 – Railroad Safety Memorandum

Exhibit 20 – Sample Title Block

Exhibit 21 – Sample Field Edit Delineation (typically for aerial photogrammetry)

Exhibit 22 – Sample Notation for Sanitary and Storm Systems

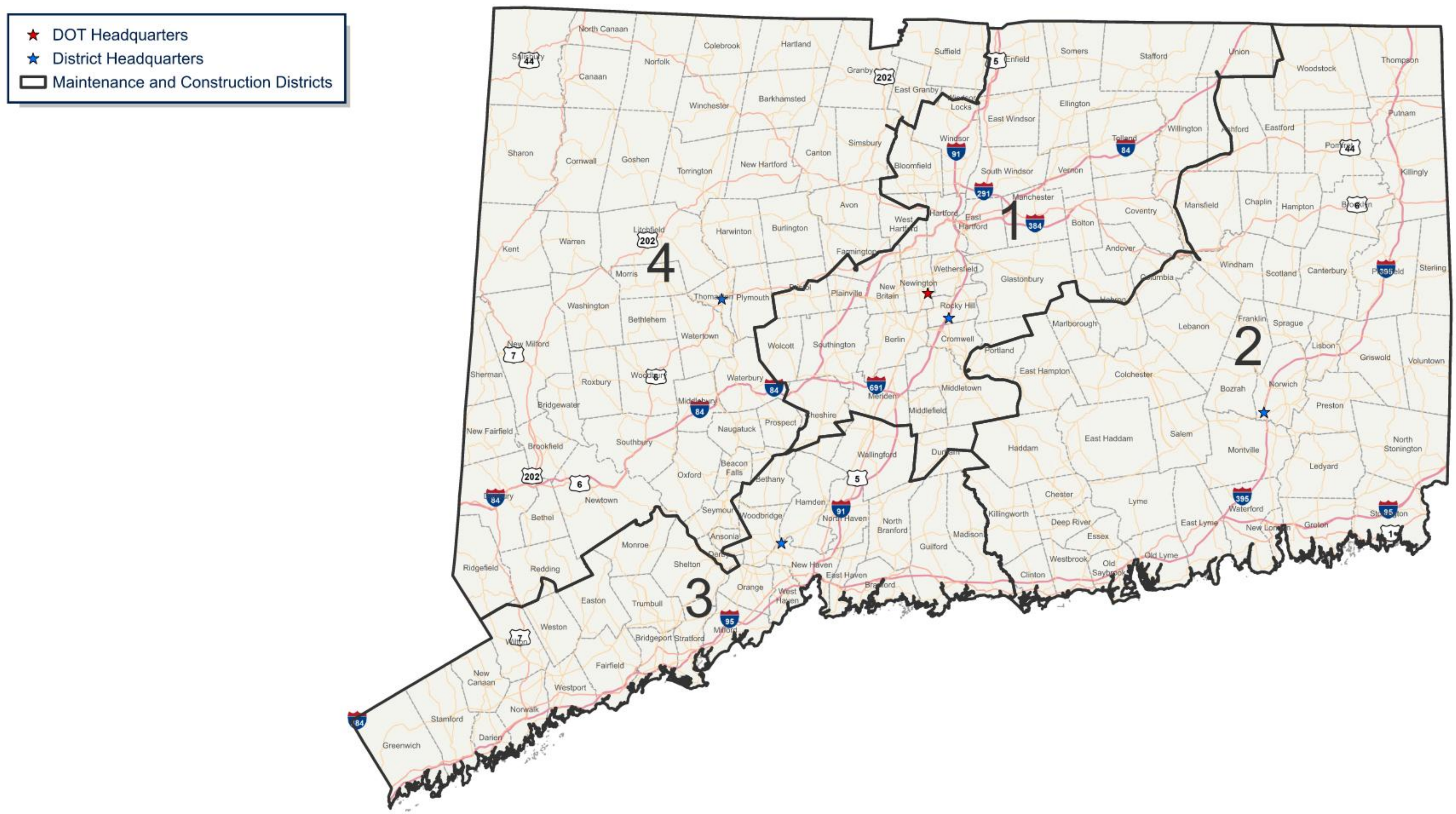
Exhibit 23 – Examples of Advanced Traffic Management Systems (ATMS)

Exhibit 24 – Default Standard Errors for Trimble Business Center

Exhibit 25 – State Positional Accuracy Classes

Exhibit 26 – Sample Project Completion Checklist

EXHIBIT 1



MAINTENANCE AND CONSTRUCTION DISTRICTS

The data presented here is for informational purposes only. The data is not to be used in legal documents or proceedings.
The Connecticut Department of Transportation makes every effort to ensure the data is current and accurate. Data is not updated in real time;
please refer to the metadata to learn more about the update schedule for each individual data asset. Neither the State of Connecticut, nor the
Connecticut Department of Transportation, nor any of its employees, makes any warranty, expressed or implied, including the warranties of merchantability and fitness for a particular purpose
or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of the data. Reliance on the data is at the user's own risk. Additionally, please refer to the overall
State of Connecticut policies webpage for statewide disclaimer information, specifically related to data distribution and a statement of liability, located at https://portal.ct.gov/Policies/Disclaimer
Basemap:

	DISTRICT 1 ROCKY HILL UNIT 601
1	ANDOVER
7	BERLIN
11	BLOOMFIELD
17	BRISTOL
25	CHESHIRE
32	COVENTRY
33	CROMWELL
37	DURHAM
42	EAST HARTFORD
46	EAST WINDSOR
47	ELLINGTON
53	GLASTONBURY
63	HARTFORD
76	MANCHESTER
79	MERIDEN
81	MIDDLEFIELD
82	MIDDLETOWN
88	NEW BRITAIN
93	NEWINGTON
109	PLAINVILLE
118	ROCKY HILL
129	SOMERS
131	SOUTHINGTON
132	SOUTH WINDSOR
134	STAFFORD
142	TOLLAND
145	UNION
146	VERNON
155	WEST HARTFORD
159	WETHERSFIELD
160	WILLINGTON
164	WINDSOR
165	WINDSOR LOCKS
166	WOLCOTT

	DISTRICT 2 NORWICH UNIT 701
3	ASHFORD
12	BOLTON
13	BOZRAH
19	BROOKLYN
22	CANTERBURY
24	CHAPLIN
26	CHESTER
27	CLINTON
28	COLCHESTER
30	COLUMBIA
38	EASTFORD
40	EAST HADDAM
41	EAST HAMPTON
44	EAST LYME
49	ESSEX
52	FRANKLIN
57	GRISWOLD
58	GROTON
60	HADDAM
62	HAMPTON
66	HEBRON
68	KILLINGLY
69	KILLINGWORTH
70	LEBANON
71	LEDYARD
72	LISBON
74	LYME
77	MANSFIELD
78	MARLBOROUGH
85	MONTVILLE
94	NEW LONDON
101	NORTH STONINGTON
103	NORWICH
104	OLD LYME
105	OLD SAYBROOK
108	PLAINFIELD
111	POMFRET
112	PORTLAND
113	PRESTON
115	PUTNAM
120	SALEM
122	DEEP RIVER (SAYBROOK)
123	SCOTLAND
133	SPRAGUE
136	STERLING
137	STONINGTON
141	THOMPSON
147	VOLUNTOWN
152	WATERFORD
154	WESTBROOK
163	WINDHAM
169	WOODSTOCK

	DISTRICT 3 NEW HAVEN UNIT 801
8	BETHANY
14	BRANFORD
15	BRIDGEPORT
35	DARIEN
43	EAST HAVEN
45	EASTON
50	FAIRFIELD
56	GREENWICH
59	GUILFORD
61	HAMDEN
75	MADISON
83	MILFORD
84	MONROE
89	NEW CANAAN
92	NEW HAVEN
98	NORTH BRANFORD
100	NORTH HAVEN
102	NORWALK
106	ORANGE
126	SHELTON
135	STAMFORD
138	STRATFORD
144	TRUMBULL
148	WALLINGFORD
156	WEST HAVEN
157	WESTON
158	WESTPORT
161	WILTON
167	WOODBRIDGE

	DISTRICT 4 THOMASTON UNIT 901
2	ANSONIA
4	AVON
5	BARKHAMSTED
6	BEACON FALLS
9	BETHEL
10	BETHLEHEM
16	BRIDGEWATER
18	BROOKFIELD
20	BURLINGTON
21	CANAAN
23	CANTON
29	COLEBROOK
31	CORNWALL
34	DANBURY
36	DERBY
39	EAST GRANBY
51	FARMINGTON
54	GOSHEN
55	GRANBY
64	HARTLAND
65	HARWINGTON
67	KENT
73	LITCHFIELD
80	MIDDLEBURY
86	MORRIS
87	NAUGATUCK
90	NEW FAIRFIELD
91	NEW HARTFORD
95	NEW MILFORD
96	NEWTOWN
97	NORFOLK
99	NORTH CANAAN
107	OXFORD
110	PLYMOUTH
114	PROSPECT
116	REDDING
117	RIDGEFIELD
119	ROXBURY
121	SALISBURY
124	SEYMOUR
125	SHARON
127	SHERMAN
128	SIMSBURY
130	SOUTHBURY
139	SUFFIELD
140	THOMASTON
143	TORRINGTON
149	WARREN
150	WASHINGTON
151	WATERBURY
153	WATERTOWN
162	WINCHESTER
168	WOODBURY

CONNECTICUT DEPARTMENT OF TRANSPORTATION

POLICY STATEMENT

POLICY NO. ADMIN-24

March 16, 1993

SUBJECT: Computer Aided Design and Drafting Standardization

It is the policy of this Department to adopt the "Intergraph file format as implemented by the Connecticut Department of Transportation" as the standard for all of its CADD/Graphic related functions. All future assignments are to be performed utilizing this technology. Exceptions to this directive will only be given at the discretion of the Deputy Commissioner, Bureau of Finance and Administration. This will assure that the Department achieves a total quality effort in its development of a Department-wide Geographic Information System. It should be emphasized that this standardization applies for the Department's entire business needs, whether performed by in-house staff or by consultants retained by the Department.

Emil H. Frankel
Commissioner

Connecticut DOT

Office of Engineering

Number: ED-2020-5

Date: July 20, 2020

ENGINEERING DIRECTIVE

Theodore H. Nezames, P.E.
2020.07.16 15:02:45-04'00'

Engineering Administrator

CONNECT Digital Design Environment (CAD Standards) for Capital Projects

This directive establishes the requirements to use Bentley's CONNECT Suite of products with CTDOT's CONNECT Digital Design Environment (CAD Standards) to prepare CAD models and contract plans for capital projects starting July 1st in accordance with the following:

- All new projects starting after August 1, 2020.
- Projects that have not reached design approval by August 1, 2020 should be moved to CONNECT, but at the discretion of the Project Manager (PM). AEC Applications is available to support the conversion of a project from V8i to CONNECT.
- Projects that have reached design approval by August 1, 2020 should remain in V8i, but can be moved at the discretion of the PM. AEC Applications is available to support the conversion of a project from V8i to CONNECT.

Training for the CONNECT suite of products will continue and be available to in-house designers as required.

AEC Applications will also continue to provide support for the existing V8i design environment.

ED-2020-5
July 20, 2020

Background

CTDOT is currently migrating its CAD software from Bentley Systems V8i Select Series platform to the CONNECT Edition platform due to Bentley Systems discontinuing support for its V8i products as of December 31st, 2020. This means that although V8i versions will still function in its current configuration, Bentley will not continue to certify it on future versions of the Windows Operating System.

In addition, CTDOT sees the advantage and the need to move into a 3D model-centric environment. This will allow CTDOT to increase productivity, reduce design errors, and adhere to industry trends of AMG (Automated Machine Guidance), eConstruction, GPS Inspection, and Asset Management.

As the transportation industry worldwide adapts to new technology, Transportation Agencies must ascertain their readiness to adapt to these industry trends. FHWA has elevated 3D modeling through its Every Day Counts initiative and has encouraged Transportation Agencies to adopt policy for delivering a digital product in lieu of a set of plans (paper, Mylar or PDF).

When a project is designed using current civil design software (InRoads SS2), it is created within a 3D model. Then,, as the design progresses, projects are often flattened to convey design intent in a 2D medium such as a PDF or paper plan set. During this conversion, data is lost and cannot be reused and precision is reduced.

With the CONNECT Edition products, designers are able to produce a product that retains the civil data and design intent through construction. This data, also known as Electronic Engineering Data (EED), can be consumed further in construction and then further downstream in Asset Management and Maintenance. However, for now, CTDOT recognizes that the contract document shall remain as PDF set of plans.

Reference Material

The following web page contains a link to the ***CTDOT DDE Guide – Bentley CONNECT Edition,*** which provides documentation to be followed by both in-house and consultant designers. Also on this webpage is a link to download the CONNECT Digital Design Environment.

https://portal.ct.gov/DOT/Engineering-Applications/CTDOT---CONNECT-DDE

This web page also has a link to Frequently Asked Questions:

https://portal.ct.gov/DOT/Engineering-Applications/CTDOT---CONNECT-DDE-FAQs

ED-2020-5
July 20, 2020

New Requirement

CONNECT Project Request – All projects that use the CONNECT Suite of products require the creation of a CONNECT Project on Bentley's CONNECT Center. The project manager shall request a CONNECT project by emailing a request to DOT.AECApplications@ct.gov.

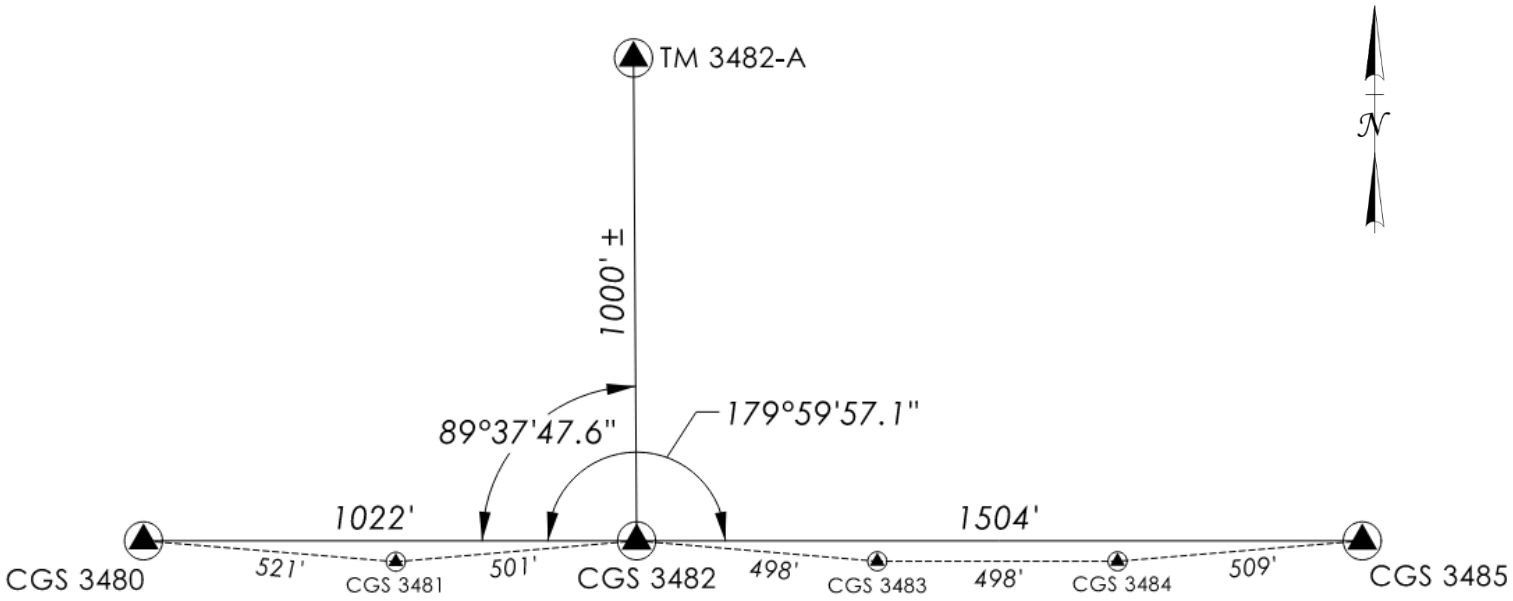
Workset (Project Container) - CTDOT Employees Only

All projects that use the CONNECT Suite of products will work within their respective discipline folders under the project folder in COMPASS.

For questions, please contact Mathew Calkins @ 860-594-2988 or at Mathew.calkins@ct.gov

Angular Baseline Range

(West Hartford Range)



1. Measure one 3485 – 3480 (2526’). Record in Section 1.

2. Set instrument @ 3482. Measure lines 3482 – 3480 (1022’) and 3482 – 3485 (1504’). Record in Section 2.

3. With instrument still @3482, observe 4 angular positions to check angles 3480 – 3482 – TM 3482-A and 3480 – 3482 – 3485.

4. Use forms provided by the State and record a minimum of 4 readings for each line measured. Fill out each form completely.

5. Be sure to keep the instrument and prism heights the same if slope distances are to be shown on forms.

6. Compute mean angles, distances, and discrepancies. Retain a copy for your records and if requested by State Surveys.

ELECTRONIC DISTANCE MEASUREMENTS ON CALIBRATED BASE LINES

INSTRUMENT _____ MODEL _____ INSTRUMENT NO. _____

OBSERVER _____ LOCALITY _____ DATE _____

_____ AIR CONDITION: STILL____ WINDY_____

VISIBILITY: GOOD____FAIR____ POOR____

HUMIDITY: DRY ____DAMP___ WET_____

SECTION 1

MEASUREMENT TO FORESIGHT STATION

TEMP. _____ PRESSURE _____ IN/FT. 1 _____

F.S. TEMP. _____ F.S PRESSURE _____ IN/FT. 2 _____

MEAN TEMP. _____ MEAN PRESSURE _____ IN/FT. 3 _____

4 _____

PPM SET _____

MEAN DISTANCE. _____

BASE LINE DISTANCE _____

DISCREPANCY _____

SECTION 2

STATION OCCUPIED _____ AIR CONDITION: STILL____ WINDY_____

VISIBILITY: GOOD____FAIR____ POOR____

HUMIDITY: DRY ____DAMP___ WET_____

MEASUREMENT TO BACKSIGHT STATION _____

TEMP. _____ PRESSURE _____ IN/FT. 1 _____

B.S. TEMP. _____ B.S. PRESSURE _____ IN/FT. 2 _____

MEAN TEMP. _____ MEAN PRESSURE _____ IN/FT. 3 _____

4 _____

PPM SET _____

MEAN DISTANCE _____

BASE LINE DISTANCE _____

DISCREPANCY _____

MEASUREMENT TO BACKSIGHT STATION _____ STATION OCCUPIED

TEMP. _____ PRESSURE _____ IN/FT. 1 _____

B.S. TEMP. _____ B.S. PRESSURE _____ IN/FT. 2 _____

MEAN TEMP. _____ MEAN PRESSURE _____ IN/FT. 3 _____

4 _____

PPM SET _____

MEAN DISTANCE _____

BASE LINE DISTANCE _____

DISCREPANCY _____

ANGLE MEASUREMENTS ON CALIBRATED BASE LINES

INSTRUMENT _____
OBSERVER _____ MODEL _____ INSTRUMENT NO. _____
RECORDER _____ LOCALITY _____ DATE. _____

STATION OCCUPIED _____ AIR CONDTITIONS: Still __ Windy __
VISIBILITY: Good __ Fair __ Poor __
HUMIDITY: Dry __ Damp __ Wet __

HORIZONTAL ANGLE TO STA _____
ZERO SET ON STATION _____

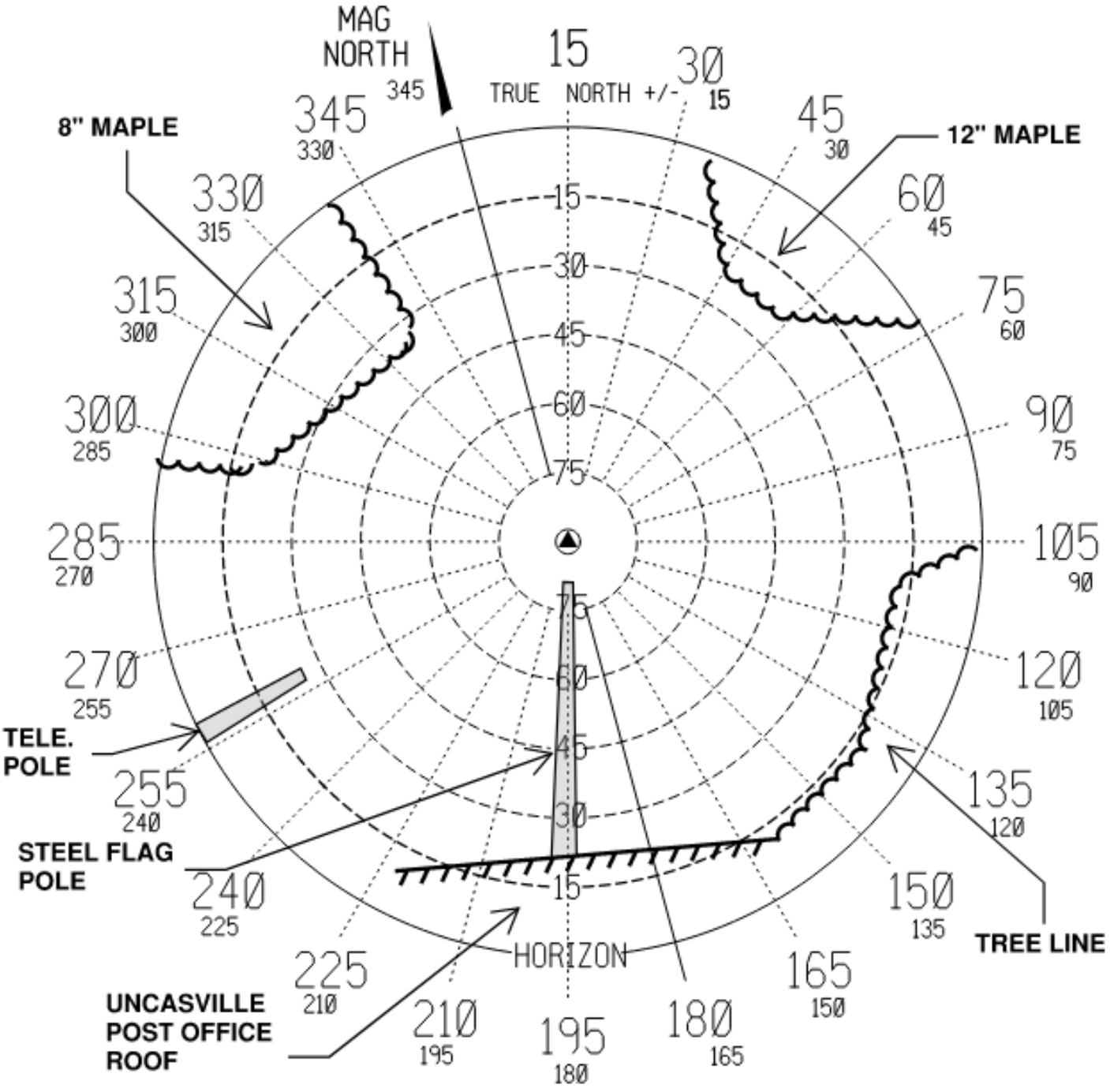
	DIRECT	REVERSE	
1	_____	_____	MEAN ANGLE _____
2	_____	_____	BASE LINE ANGLE _____
3	_____	_____	DISCREPANCY _____
4	_____	_____	
	_____ MEANS	_____	

HORIZONTAL ANGLE TO STA _____
ZERO SET ON STATION _____

	DIRECT	REVERSE	
1	_____	_____	MEAN ANGLE _____
2	_____	_____	BASE LINE ANGLE _____
3	_____	_____	DISCREPANCY _____
4	_____	_____	
	_____ MEANS	_____	

CONNECTICUT GEODETIC SURVEY

GPS OBSTRUCTION SHEET



STATION CTGS BM 2897 MATES DNA (VERT. REF. CONTROL ONLY)
STATION DESCRIPTION BRASS DISK STAMPED "R 97 1986"
TOWN MONTVILLE
LOCALITY
DATE 11/20/1994 OBSERVER R.B. & D.M.
LATITUDE 41° 28 ' 05 . " N +/- NAD 27 / (83)
LONGITUDE 72° 06 ' 11 . " W +/-
GPS ☐OPEN ☐GOOD ☒FAIR ☐POOR ☐NO ☐TOTAL OBSTRUCTION
COMMENTS: GEO. POSITION IS APPROX. REFERENCE TO NGS DATABASE. PROVIDED FOR ORIENTATION PURPOSES ONLY

Sheet __ of __

TRIGONOMETRIC LEVELING OBSERVATIONS

BACKSIGHT		AIR CONDITIONS:		STILL __	WINDY__
FORESIGHT		VISIBILITY:		GOOD__	FAIR __ POOR __
		HUMIDITY:		DRY __	DAMP __ WET __
INSTRUMENT	MODEL		INSTRUMENT NO.		
PROJECT NO.		TOWN (S)			
DATE	OBSERVER		RECORDER		
TEMP.	PRESURE		PPM SET		

BACKSIGHT STATION

DIRECT (FACE I)	DIRECT (FACE 2)	DIRECT (FACE I)	DIRECT (FACE 2)
MEAN		MEAN	
DIFF. =		DIFF.=	
ALLOWABE DIFF. 4"		ALLOWABLE DIFF. ___	

MEAN OF FACE I & FACE II

MEAN OF FACE I & FACE II

SLOPE DISTANCE (FT.)

FORESIGHT STATION

ZENITH ANGLES		VERTICAL DISTANCES	
DIRECT (FACE I)	DIRECT (FACE 2)	DIRECT (FACE I)	DIRECT (FACE 2)
MEAN		MEAN	
DIFF. =		DIFF.=	
ALLOWABE DIFF. 4"		ALLOWABLE DIFF. ___	

MEAN OF FACE I & FACE II

MEAN OF FACE I & FACE II

SLOPE DISTANCE (FT.)

ELEV. BM ___

ALLOWABLE DIFFERENCE OF VERTICAL DISTANCES

BACKSIGHT VD

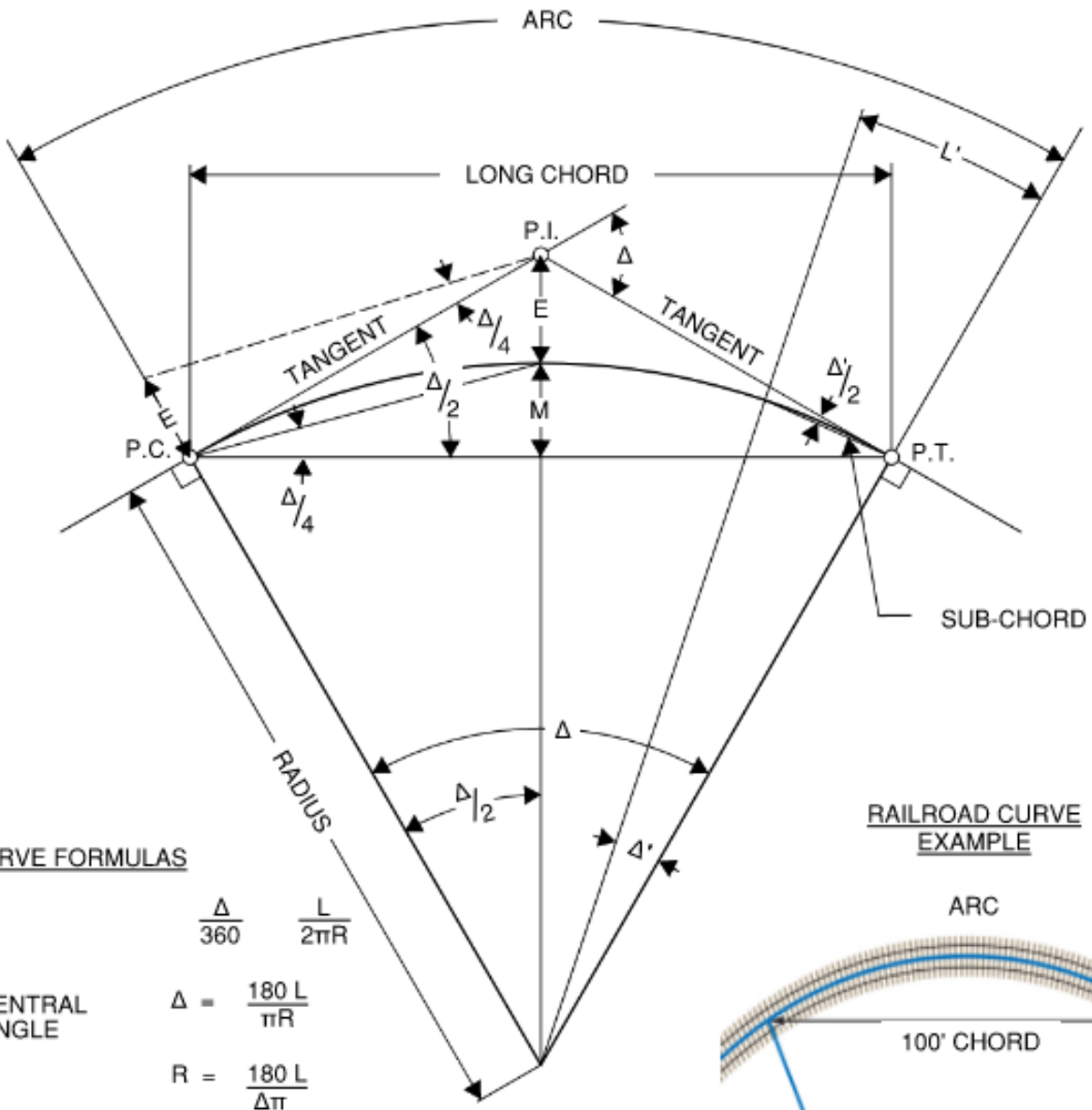
0.0006√F

FORESIGHT VD

ELEV. TP ___

F = DISTANCE OF SLOPE IN FEET

CIRCULAR CURVE DATA



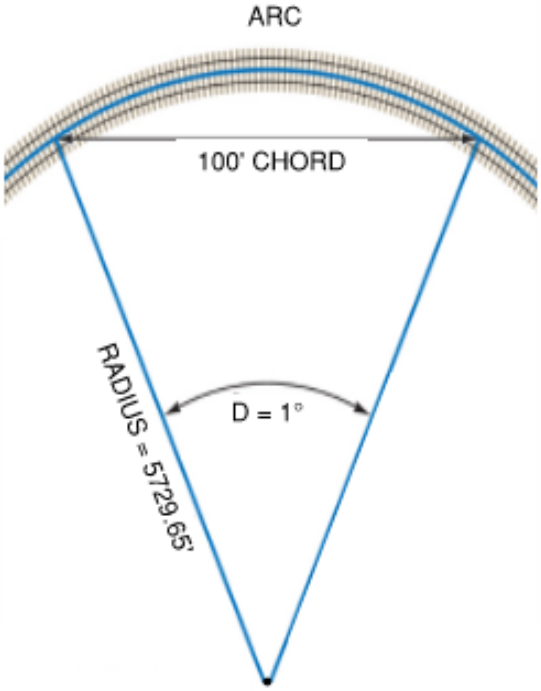
CURVE FORMULAS

CIRCLE	$\frac{\Delta}{360} \quad \frac{L}{2\pi R}$
DELTA, CENTRAL ANGLE	$\Delta = \frac{180\ L}{\pi R}$
RADIUS	$R = \frac{180\ L}{\Delta \pi}$
TANGENT	$T = R \tan (\Delta/2)$
LENGTH OR ARC	$L = \frac{\Delta \pi R}{180}$ or $\frac{\Delta R}{57.29578}$
LONG CHORD	$Ch = 2\ R \sin (\Delta/2)$
EXTERNAL	$E = T \tan (\Delta/4)$
MIDDLE ORDINATE	$M = R\ (1 - \cos (\Delta/2))$ or $T \sin (\Delta/2) - E$

CURVE SEGMENTS FOR STATIONING

DEFLECTION ANGLE	$\angle = \Delta'/2$ for Curve Segment
DEFLECTION ANGLE	$\angle = \Delta'/2 = \frac{180\ L'}{2\pi R}$
SUB-CHORD	SUB-CH. $= 2\ R \sin (\Delta'/2)$

RAILROAD CURVE EXAMPLE

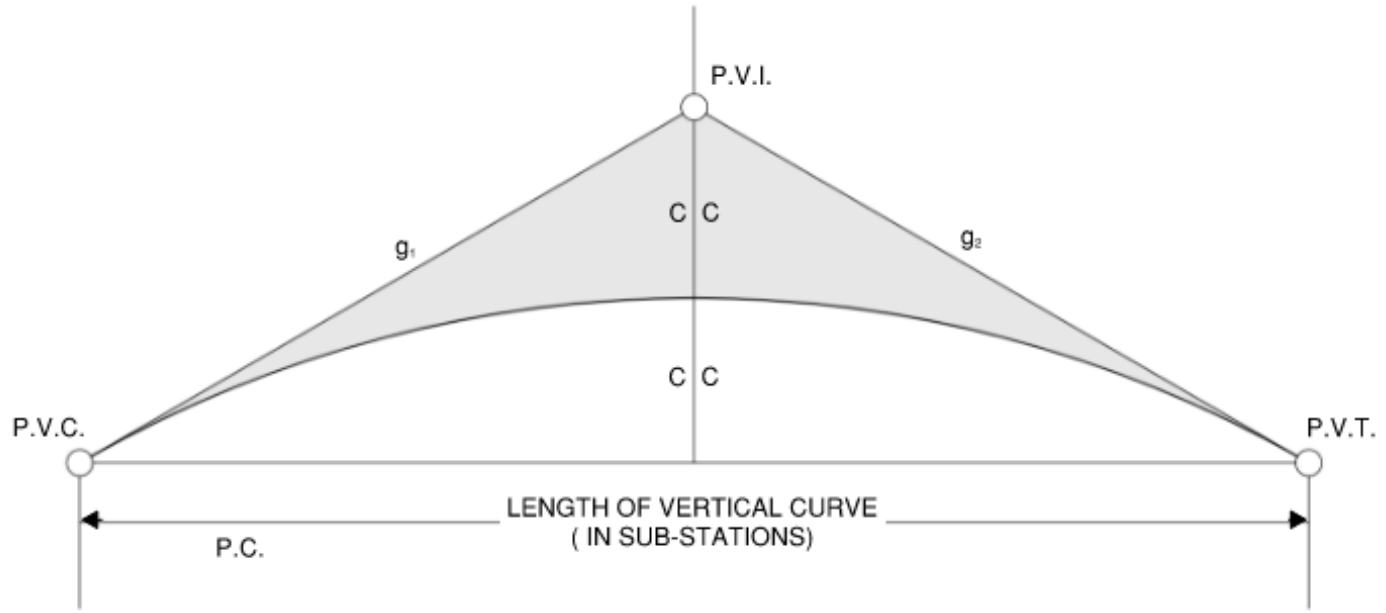


CHORD DEFINITION: 100' OF CHORD SUSTENDS A CENTRAL ANGLE OF 1°

$\sin (D/2) = \frac{50}{R}$

$R = \frac{50}{\sin (D/2)}$

VERTICAL CURVE DATA



CURVE FORMULAS

$$C\,C = \frac{\text{ALG. DIFF (IN GRADES)} \times L}{8}$$

$$K = \frac{C\,C}{(1/2\ L)^2} \quad \text{or} \quad K = \frac{\text{ALG. DIFF.}}{2\,L}$$

K x (DISTANCE FROM PVC AHEAD TO PVI OR FROM PVT BACK TO PVI) ^{2} = +/- CORRECTION FROM TANGENT ELEV.

LOW (OR HIGH) POINT STATION = PVC STATION + D

WHERE $D = \frac{g_1 \times L}{\text{ALG. DIFF.}}$

ALG. DIFF. = ALGEBRAIC DIFFERENCE IN GRADES
D = DISTANCE FROM PVS TO LOW (OR HIGH) POINT (IN SUB-STATIONS)
g_1 = BACK TANGENT GRADE
L = LENGTH OF VERTICAL CURVE (IN SUB-STATIONS)

EXAMPLE

GIVEN:
g_1 = + 2%
g_2 = - 2%
L = 400 FT (4 SUB-STATIONS)
PVC STA. = 1+00
PVC ELEVATION = 50.00 FT
PVI STA. = 1+200
PVT STA. 1+400

$$C\,C = \frac{\text{ALG. DIFF (IN GRADES)} \times L}{8}$$

$$C\,C = \frac{[+2 - (-2)] \times 4}{8}$$

$$C\,C = 2.0 \text{ FT}$$

$$K = \frac{C\,C}{(1/2\ L)^2} \quad \text{or} \quad \frac{\text{ALG. DIFF.}}{2\,L}$$

$$K = \frac{2}{(2)^2} \quad \text{or} \quad \frac{4}{8}$$

$$K = 0.5$$

CALCULATION OF HIGH POINT

$$D = \frac{g_1 \times L}{\text{ALG. DIFF.}}$$

$$D = \frac{2 \times 4}{4}$$

D = 2 (SUB-STATIONS)

STA. PVC = 1 + 000
D = + 200
STA. HIGH PT. = 1 + 200

TEST PIT PROCESS- QUALITY ASSURANCE CHECKLIST

Design - Central Surveys – District Survey - Contractor:

Design:

- Issues request to Central Surveys

Request contains:

- Design ensures funding is in place
- Plan/schematic depicting test pit locations
- .txt coordinate file of test pits

Central Surveys:

- Location Survey Unit:
    - Review Design Request package
    - Forward package to Test Pit Coordinator
- Test Pit Coordinator:
    - Review funding
    - Prepare Cost Estimate based on number of test pits and locations Assemble project package (design submitted package and cost estimates)
    - Generate & Submit requisition through CORE for approval by Central Surveys
        - Cc Requisition budget approver (Office of Finance)
        - Cc Requisition purchase approver
        - Track purchase requisition

    Upon Requisition Approval

    - Test Pit Coordinator assigns Contractor (from approved list)
        - Send contact letter to District Surveys and Contractor
        - Forwards Test Pit information to Contractor
        - Forward's Contractor response and information to appropriate District Survey office

Contractor

- Provides to District Surveys office
    - Work Plan
        - Personnel performing work
        - Traffic Control measures
        - Coordination Plan
        - Equipment
        - Test Pit restoration materials
        - Daily Job Briefing (on site)
- Contact Call Before You Dig (CBYD) to request site mark-up and forward ticket to Central Surveys, Test Pit Coordinator, and District Office

On Site

Contractor

- Conduct on site job briefing with all participating personnel
- Implement traffic control plan (if necessary)
- Excavate test pit for utility location by Survey Crew
- Restore site to original condition

District Survey Field Crew (Party Chief)

- Participate in on site job briefing
- Ensure traffic control sufficient for Field Crew safety
- **Immediately notify Rob Ceballos of any contractor related concerns**
- Photograph test pit
    - Prior to excavation
    - Upon exposure of utility
    - During restoration of test pit
    - Upon completion of restoration
- Daily test pit labor and work record
    - Utility size, type, and xyz location

- Contractor personnel
- Equipment on site
- Equipment used
- Restoration materials and quantities

Office

District Survey Office

- Review field data (field measurements, restoration photos)
- Submit field data to Central Surveys Location Survey Unit
- Forward any Contractor Incident reports to Central Surveys (Evaluation)

Central Surveys

- Review District survey field data
- Submit field data to Design (original requestor)
- Test Pit Coordinator – Review test pit field data and Daily test pit labor and work record
- Contractor Submits request for (payment)
- Receiver is created for payment, sent to Accounts Payable

Note reminding us to get new approval when a new Bureau Chief is appointed. In order to
provide Purchasing Justification for Req's & P.O's.

Bureau Chief Scott A. Hill: The purchase of project specific Test Pits is hereby approved. (5-26-2021)

Bureau Chief James A. Fallon: The purchase of project specific Test Pits is hereby approved. (2-05-2025)

Test Pit Coordinate Data Sheet

- **PROJECT: 0171-0471** Replacement of traffic control signals in the towns of Glastonbury, Rocky Hill, & South Windsor

CNG (GAS) TEST PITS: G-1, G-2

FRONTIER (COMMUNICATIONS) TEST PITS: T-1, T-2

DUG: 12/4/2023

OBSERVED by: G. N. Scott-Stephens, B. Level, FB: Glastonbury 53, Rocky Hill 118 p.72

S. Windsor 132 p.29

COMPUTATIONS by: Gemma Noelle Scott-Stephens

Gas T.P. #G-1

6" Plastic Pipe: GND = 73.1'±, N=810274.12, E=1040754.49, Top of 6" Plastic Pipe Elev. =69.38', (Located 3.0'± southwest of staked location using coordinates provided by consultant / utility).

TOWN	STATE OF CONNECTICUT	
FEDERAL PROJECT NO.	DEPARTMENT OF TRANSPORTATION	REQ #
STATE PROJECT NO.	DAILY LABOR AND WORK RECORD	P.O. # / CONTRACTOR
DATES	FOR TEST PITS	CBYD#

LABOR EMPLOYED				EQUIPMENT USED			MATERIALS AND SUPPLIES USED			REMARKS
DATES	CLASSIFICATION	NO.	Total Hours	KIND (SIZE OF CAPACITY)	NO.	Total Hours	ITEM	QTY	UNIT	DESCRIPTION AND LOCATION

I CERTIFY TO THE BEST OF MY KNOWLEDGE AND BELIEF, THAT THE ACCOUNT HEREIN SHOWN IS AN ACCURATE STATEMENT OF THE LABOR AND EQUIPMENT EMPLOYED AND THE MATERIALS USED IN THE CONSTRUCTION WORK IDENTIFIED BY THE HEADING ON THIS SHEET.

SIGNED: ____ (FOR UTILITY) ____ (TITLE) ____ (DATE) ____ (FOR DEPT. OF TRANSPORTATION) ____ (TITLE) ____ (DATE)

COPY 1 - FINANCIAL SERVICES | COPY 2 - UTILITY COMPANY | COPY 3 - DISTRICT OFFICE | COPY 4 - INSPECTOR | COPY 5 - UTILITY REPRESENTATIVE

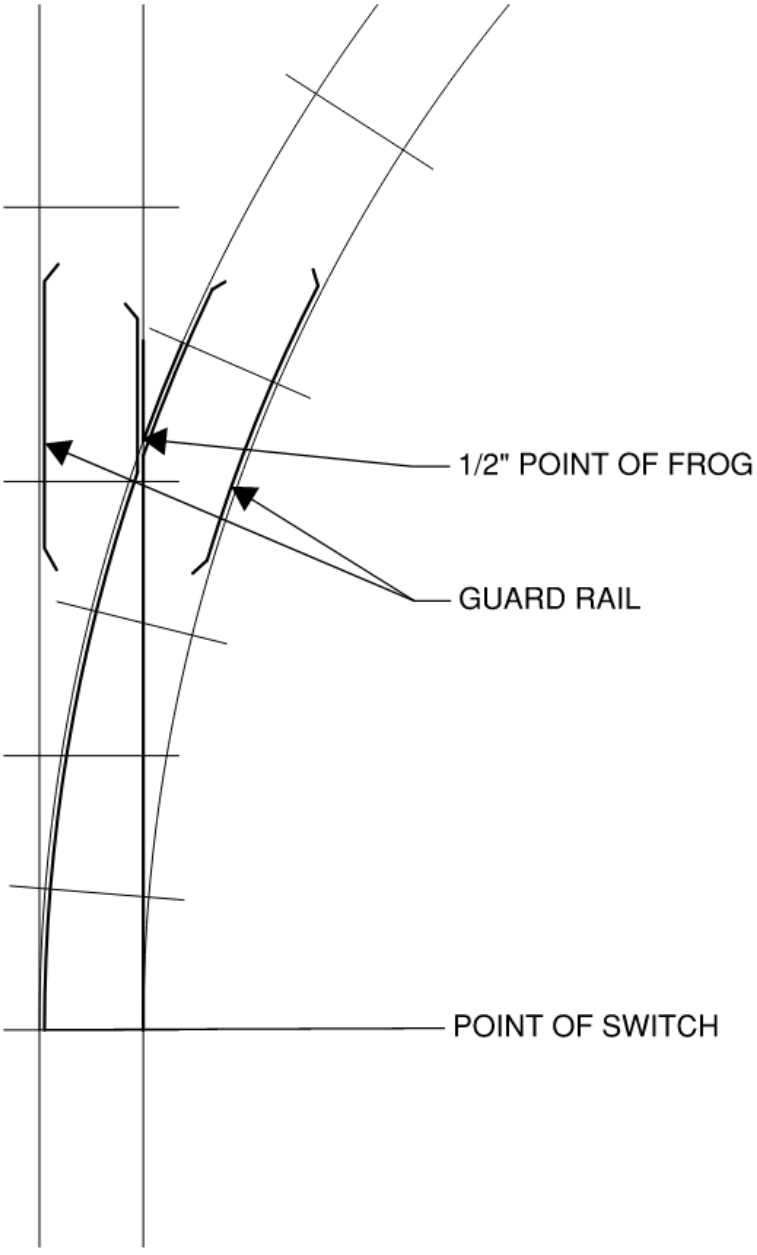
EXHIBIT 13

PERCENTAGE OF PARTICIPATION IN HIGHWAY RELOCATION PROJECTS

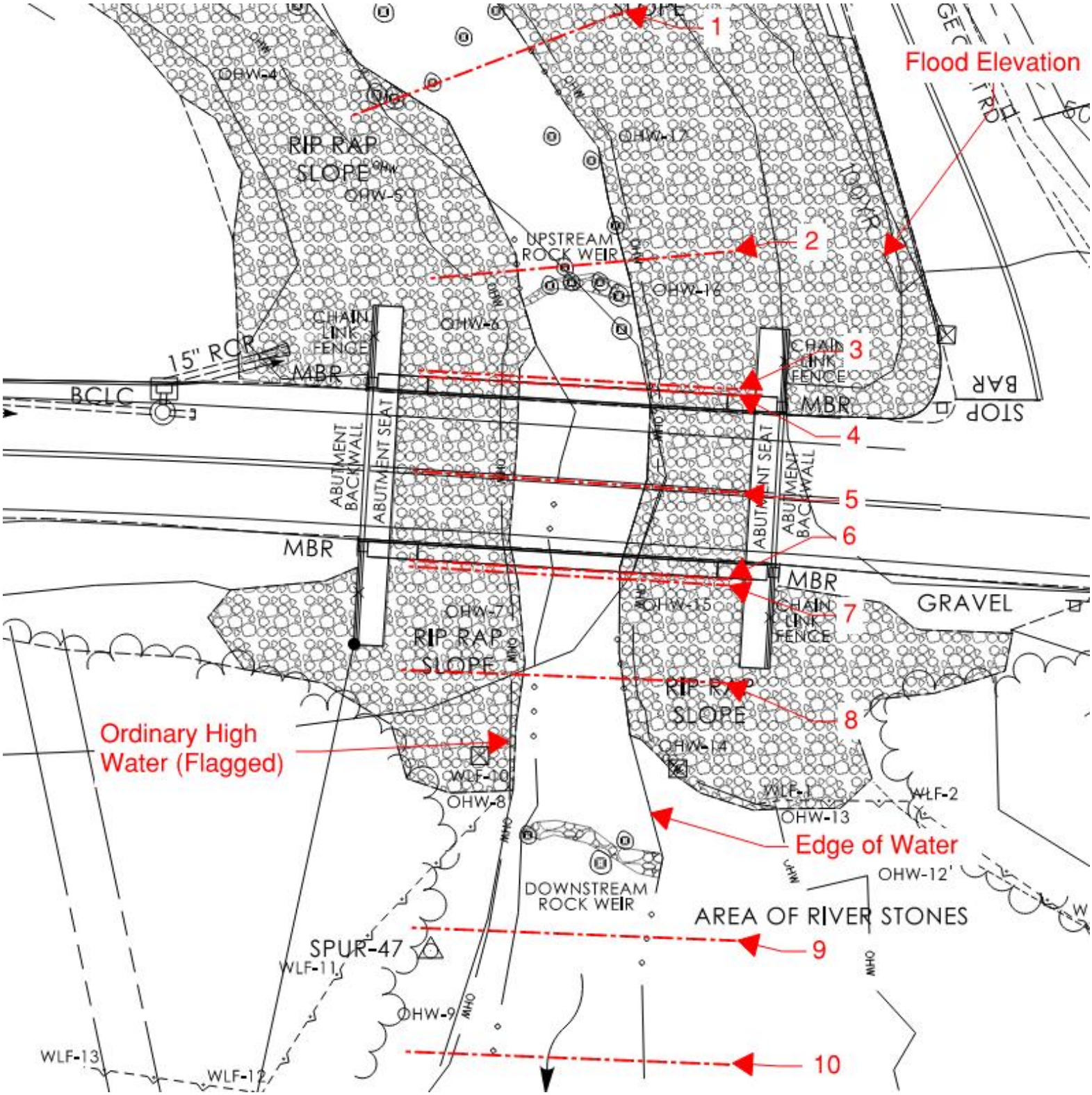
SECTION 13a-126 OF C.G.S.	STATE ROADS Unlimited Access Highway	STATE ROADS Limited Access Highway
Private Utility Company	50%	100%
Municipal Utility (all classifications)	50% on non-federally funded projects	100%

SECTION 13a-98f OF C.G.S.	STATE ROADS	LOCAL ROADS
Private Utility Company	see Section 13a-126 of C.G.S.	0%
Municipal Utility (City or Town)	cost of apportionment	cost of apportionment
Other Municipalities (MDC, RWA, etc.)	100%	100%

RAILROAD TURNOUT



TYPICAL HYDRAULIC CROSS-SECTION LOCATIONS

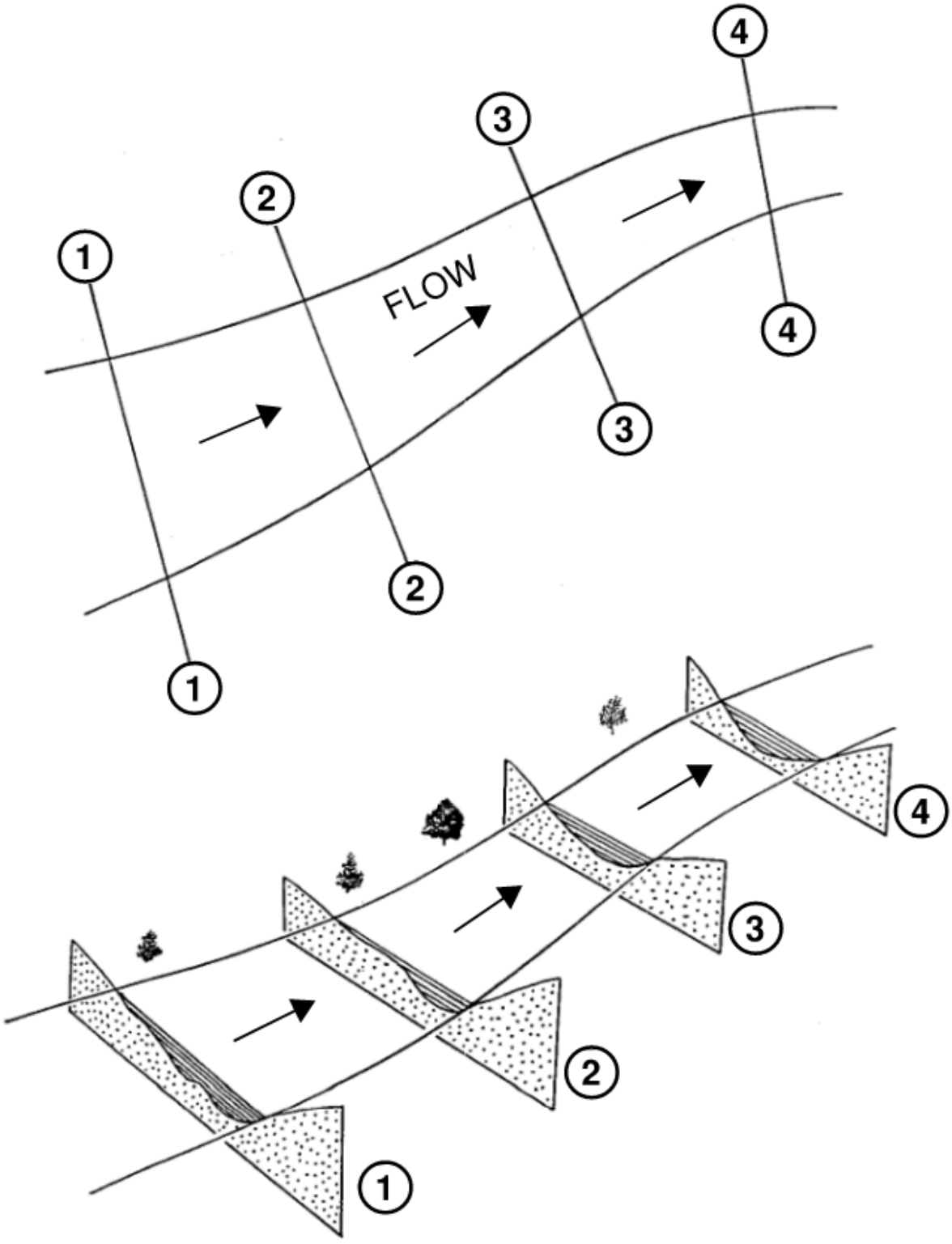


TYPICAL HYDRAULIC CROSS-SECTION LOCATIONS LEGEND

1. Upstream sections as required
2. Section one bridge opening width upstream of bridge
3. Section one foot upstream of bridge fascia
4. Section at upstream bridge fascia
5. Section at centerline of roadway (roadway profile)
6. Section of downstream bridge fascia
7. Section one foot downstream of bridge fascia
8. Section one bridge opening width downstream of bridge
9. Section four bridge opening widths downstream of bridge
10. Downstream sections as required

Note: the bridge opening width is the width as measured “along the roadway” perpendicular to the direction of flow

TYPICAL HYDRAULIC CROSS-SECTION ORIENTATION WITH RESPECT TO STREAM CHANNEL / FLOODPLAIN



CONNECTICUT

CTDOT
CONNECTICUT TRANSPORTATION

[DATE]

Name_____
Address_____
_____

Town_____
Project_____

Dear Property Owner:

Section 13a-60 of the General Statutes of Connecticut, as revised, provides that the Department of Transportation's Commissioner or his agent may enter upon private property for the purpose of conducting surveys, inspections or geological investigations for the location, relocation, construction or reconstruction of any proposed or existing highway or transportation facility.

In the course of performing a survey, inspection or geological investigation, it may be necessary to set markers of various types adjacent to or on your property. The placement of these markers does not necessarily indicate the location of a proposed highway or other facility to be constructed or reconstructed by the Department of Transportation.

Section 13a-60 provides that the Department of Transportation's Commissioner or his agent shall use care that no unnecessary damage shall result and that the State shall pay damage to the owner for any damage or injury he causes such owner by such entrance or use.

Your consent to the Department of Transportation's Commissioner or his agent to enter upon your property for the purpose of carrying out the provisions of this statute is requested.

A signature to authorize entrance upon your property does not indicate your approval or disapproval of the above-noted project.

Please sign in the space provided below and return to the attention of _____, Transportation Principal Engineer, in the enclosed self-addressed stamped envelope.

Thank you for your cooperation.

2800 Berlin Turnpike
P.O. Box 317546
Newington, CT 06131-7546
860-594-2000

Very truly yours,

James A. Fallon, P.E.
Chief Engineer
Bureau of Engineering and Construction

I hereby give my consent to the Department of Transportation Commissioner or his agent to enter upon my property in order to carry out the provisions of Sec. 13a-60 of the 1969 Supplement to the General Statutes and for the purposes as checked.

__Survey Owner_____
Date_____
__Borings,
Soundings
Interviewer_____Date_____
Or Other Tests

EXHIBIT 19

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

memorandum

COM-09A REV. 2/91 Printed on Recycled or Recovered Paper

subject Rail Safety Class

date May 3, 1994

to TO ALL CONCERNED

from John P. McGill
Director of Safety

ext.

It has come to my attention that Department of Transportation personnel are visiting construction or proposed construction sites where active railroad lines are involved without regard to proper railroad safety.

The Department's Guidelines for Safe Practices states, in part, that "Department of Transportation employees must be protected whenever it is necessary for personnel or equipment to work alongside railroad tracks." Also, DOT employees must wear proper protective equipment; for example, hard hats, approved safety vests, glasses and shoes while on railroad property.

Furthermore, railroads have strict rules concerning trespassers that allow their police to arrest violators. They also require that no person may enter upon their property until he/she has attended a respective Railroad's Safety Orientation Class or be accompanied by a qualified railroad flag person.

To insure the safety of Department personnel, employees who intend to visit active rail lines and have not attended a rail safety class should have their supervisor contact this Office so that information can be obtained from the Bureau of Public Transportation, Office of Rails, on how to receive training.

All employees that have attended a rail safety class should review their materials to update their awareness of safety procedures. Your compliance with these safety procedures is essential.

EXHIBIT 20

NOTES:

1.) SURVEY BY DISTRICT 3.

2.) FIELD BOOK: BRIDGE "W" PAGES 72-92 & 108-113.

3.) 400 FOOT GRID BASED ON CONNECTICUT COORDINATE SYSTEM N.A.D. 1983 (2011) GEOID 18. COORDINATES OBTAINED FROM A STATIC GPS SURVEY ON 09/05/24 USING CORS STATIONS CTBK, CTDA & CTGU.

4.) VERTICAL DATUM BASED ON N.A.V.D. 1988. ELEVATIONS OBTAINED FROM HOLDING C.G.S. B.M. #660 STAMPED U34 1965.

5.) PROPERTY LINES ARE TAKEN FROM CITY OF NEW HAVEN'S TAX ASSESSOR MAPS. NOT ALL HAVE BEEN FIELD VERIFIED AND SHOULD BE CONSIDERED APPROXIMATE.

6.) MAPPING WAS COMPILED FROM A MOBILE LIDAR DATA SET COLLECTED BY GPI ON 09/24/2024. IT HAS BEEN TESTED ACCORDING TO ASPRS POSITIONAL ACCURACY STANDARDS FOR DIGITAL GEOSPATIAL DATA, EDITION 2, VERSION 2 (2024). THE STANDARDS CALL FOR A MINIMUM OF THIRTY (30) VALIDATION POINTS, THIS TEST WAS PERFORMED USING 16 VALIDATION POINTS. THIS DATA SET WAS PRODUCED TO MEET 0.05 FT VERTICAL ERROR AT 95% CONFIDENCE. THE TESTED VERTICAL POSITIONAL ACCURACY WAS FOUND TO BE 0.012 FT AT 95% CONFIDENCE USING THE NUMBER OF CHECKPOINTS IN THE NVA (NON VEGETATED ACCURACY) TESTED AREA. PLANIMETRIC MAPPING FEATURES WERE COMPILED BY GPI AND MERGED WITH ADDITIONAL SURVEY PROVIDED BY DISTRICT 3 SURVEYS.

7.) THE FOLLOWING UTILITIES ARE APPROXIMATE AND ARE BASED ON UTILITY COMPANY RECORDS AND LIMITED FIELD INVESTIGATIONS:

- UNITED ILLUMINATION COMPANY
- SOUTHERN CONNECTICUT GAS COMPANY
- FRONTIER COMMUNICATIONS OF CONNECTICUT
- GREATER NEW HAVEN WATER POLLUTION CONTROL AUTHORITY
- SOUTH CENTRAL CONNECTICUT REGIONAL WATER AUTHORITY

STATE OF CONNECTICUT
DEPARTMENT OF TRANSPORTATION

BRIDGE REHABILITATION
ROUTE 34 OVER U.S. ROUTE 1 & M.N.R.R.
@ BRIDGE #00333

IN THE CITY OF

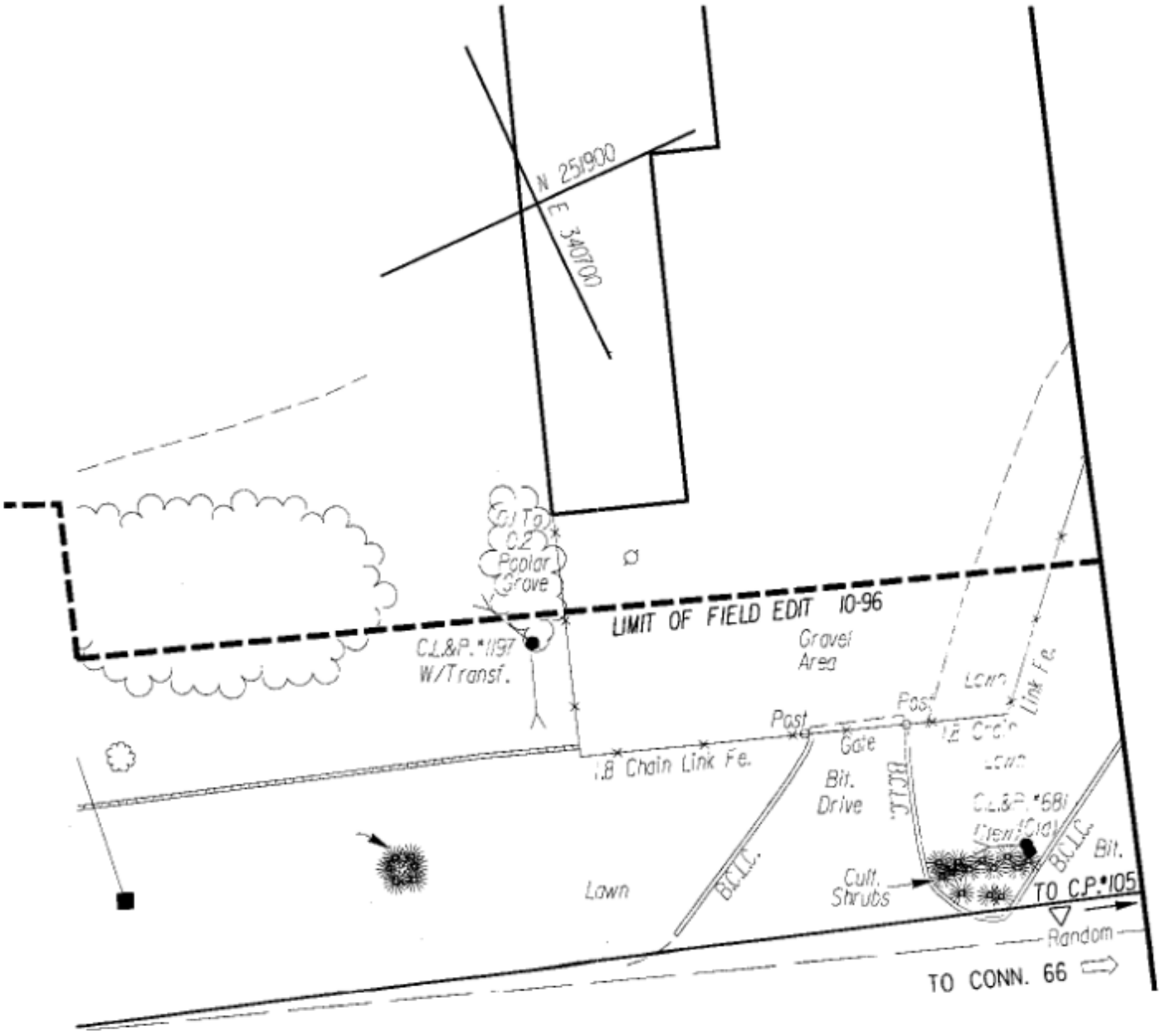
NEW HAVEN

PROJECT NO. 0092-0696

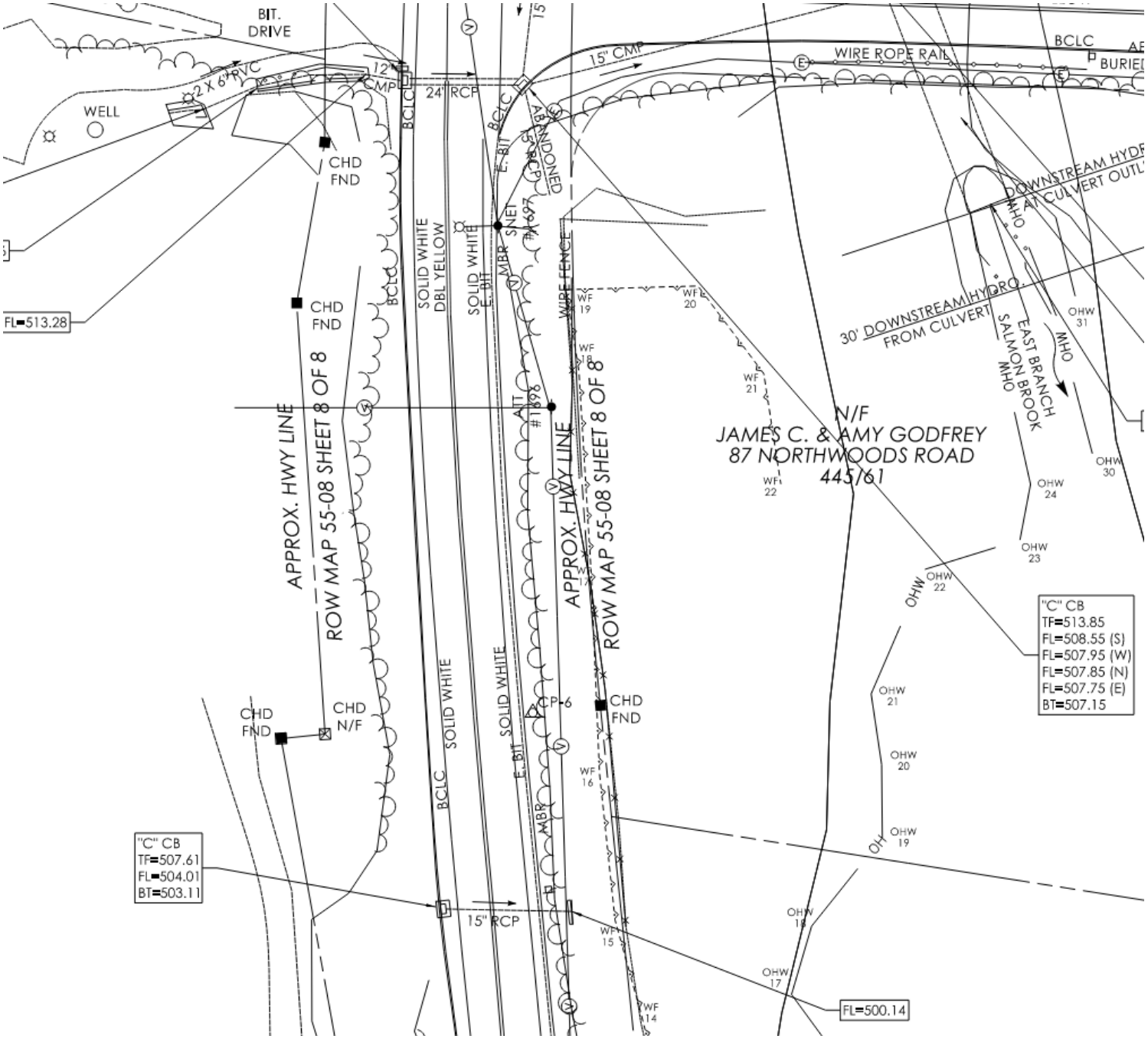
SURVEYED BY: G. WASHINGTON
PLOTTED BY: A. LINCOLN
CHECKED BY: T. BRADY
FILE:SV_D3_0092_0696_NEW_HAVEN_CT_ROUTE_34_OVER_USROUTE_1_&_MNRR_ORD.dgn

MAY 2025

FIELD EDIT DELINEATION



STANDARD NOTATIONS FOR LABELING STORM AND SANITARY SYSTEMS



Examples of ATMS

CCTV Cameras

(left – 70 ft pole)

(right – 45 ft pole)

Variable Message Signs

Bridge mounted

Cantilever

Pedestal Mounted

Truss Mounted

2-Post Mounted

Examples of ATMS

Roadway Weather Information System (RWIS)

RWIS Tower

RWIS Sensor

(note these may be on wood poles sometimes)

Traffic Flow Monitor

(note these are no longer supported or being installed but still remain in the field)

DEFAULT STANDARD ERRORS FOR TRIMBLE BUSINESS CENTER

Total Station:

Default Standard Errors	
Horizontal angle:	0°00'03"
Vertical angle:	0°00'03"
Slope distance:	0.010 ft + 2.0 ppm
Default Centering Errors	
Instrument centering error:	0.007 ft
Backsight centering error:	0.007 ft
Default Height Errors	
Error in height of instrument:	0.007 ft
Error in height of target:	0.007 ft

GNSS:

Default Standard Errors	
Default standard error on 1 km of double leveling:	0.028 in
Default standard error for each station setup:	0.000 in

Digital:

Default Standard Errors	
Error horizontal:	0.016 ft + 1.0 ppm
Error vertical:	0.033 ft + 2.0 ppm
Default Setup Errors	
Instrument centering error:	0.007 ft
Error in height of antenna:	0.007 ft

State Positional Accuracy Classes*

SPATIAL ACCURACY	**Level** I	**Level** I I	**Level** I I I	**Level** IV
Application	Geodetic Control Primary Project Control Densification	Primary Project Control Aerial and LiDAR Control	Secondary Project Control Aerial and LiDAR Control ROW Bounds Property Corners	Topography Non-critical stakeout
Maximum allowable horizontal error at 95% confidence interval	0.03’	0.05’	0.07’	0.10’
Maximum allowable vertical error at 95% confidence interval (when applicable)	0.06’	0.10’	0.10’	0.15’
Legacy and Regulatory Guidance Equivalence (approximate, situation-dependent)	1:10,000 or better (A-1)	1:7,500 or better (A-2)	1:5,000 or better (A-2)	90% within ½ contour interval (T-1) (vertical, exceeds considerably)

*Positional uncertainty thresholds (Level I-IV) are intended for standard project distances. For baselines exceeding 2 miles, a distance-dependent error allowance of 2 ppm may be applied to the 95% confidence interval to account for GNSS scale and atmospheric effects, provided level-specific thresholds are not substantially exceeded. All accuracy standards refer to the positional uncertainty of individual points.

EXHIBIT 26

Project Completion Checklist

Project: _____
Town: _____
Location: _____

Drafted By: _____
Date: _____
Reviewed By: _____
Date: _____

Draft	Review	
☐	☐	Create DGN file (SV_D2_0172-0495_TOWN_DESC_ORD), "CT Survey English" Workspace, Proj # Workset, "CT Survey Design" Seed
☐	☐	Verify Models as needed (Existing Ground, Annotations, Bridge Deck, Boundary, Hydraulics)
☐	☐	Download needed Raster Images and Place in Raster Reference File Folder CT Aerial Imagery and Lidar Elevation Download App
☐	☐	Check FB notes for edits, verify all notes are scanned
☐	☐	Create Fieldbook w/ "Project # Ground" or "Bridge Deck", Import all needed TXT files
☐	☐	Modify Fieldbook, Uncross all crossing break lines/join line segments/transpose line directions as needed
☐	☐	Check Memo Request - Verify completeness of topo area, hydraulics, bridge locations, ect.
☐	☐	Terrain set to rule bound, assign appropriate feature definition w/ "Existing Boundary" Template in Ground and Bridge Deck
☐	☐	Place Border& Fill in Title Block including: Town, Description of Project, Route, Project No., Unit, Scale, Date, File Name, Surveyed By:, Drafted By:, Checked By;
☐	☐	Place Survey Notes and update accordingly: Basis of Datums (GPS/CGS - Previous Project Reference)
☐	☐	Place Coordinate Grid (400' X 400')
☐	☐	Place appropriate CT Coordinate Grid North Arrow- EX) NAD83 (2011)
☐	☐	Connect all Control Points with Random Line and Label
☐	☐	Merge in Rotated ROW, including: Highway Line, Street Line, Property Line & Names, Drainage R.O.W.'s and Easements and Label only Found Mon's (CHD, I.P., CONC. MON., BRASS BOLT, RANDOM, etc..).
☐	☐	Reference to a R.O.W. Map Number.
☐	☐	Label all features including: Buildings(Type & Address #), Driveways, Fences(Heights for Chain Link), UPs, MHs, etc.
☐	☐	Label Roads, Rivers, Brooks and watercourses w/direction of flow(Reference in Nad 83 TRU for named watercourses)
☐	☐	Label Wetlands "Field Located Wetlands", Label WF Flags, OHW Elevations
☐	☐	Tie Boxes for ALL CONTROL POINTS in Annotation Model
☐	☐	Bench Marks with N.A.V.D. 1988(Spaced 800' Max. Horizontal, 50' Vertical)
☐	☐	Direction of Road to be noted at each end of plan. Only use State Routes.(Reference in Nad 83 TRU for a guide)
☐	☐	Plot all drainage 3D including: Size, Type, Flow and provide all info to each structure
☐	☐	Plot all Utilities from mapping received in Survey Data Model and labels in Annotations Model
☐	☐	Plot and connect Hydraulic Sections in separate model, label point descriptions, use hydro points in ground model if in limits. Check for surface discrepancies
☐	☐	Verify hydro section point accuracy/sequence elevation check - update TXT file if needed
☐	☐	Create Separate TXT file with Hydraulic Section Points, separated by section and in order by location (not point number)
☐	☐	Remove all attachments (rasters + references that are not project models)
☐	☐	Update Field Book including : Updating Index, Final Coordinates & Elevations Boxed Out in Red
☐	☐	Create Final PDF Plot of Project, Final Control File with all coordinated control with Date in file name (0123-4567_Control_Date)

APPENDIX E

UNIT CONVERSIONS AND MEASUREMENT STANDARDS

METRIC CONVERSIONS

* 1 meter (m) = 39.37 inches (U.S. Survey Foot)

1 meter (m) = 3.2808333(3) feet (U.S. Survey Foot)

1 kilometer (km) = 0.62137 miles

1 hectare (ha) = 2.471 acres

* 1 meter (m) = 1000 millimeters (mm)

* 1 kilometer (km) = 1000 meters (m)

* 1 hectare (ha) = 10,000 square meters (m^2)

ADDITIONAL CONVERSIONS

* 1 foot (international) = 0.3048 meter

* 1 rod, pole, perch = 16.5 feet

* 1 chain (Gunter's) = 66 feet

* 1 link = 7.92 inches (0.66 foot)

* 1 mile = 5280 feet

* 1 acre = 43,560 $feet^2$

* 1 station = 100 feet (imperial) or 1000 meters

* 1 staking interval = 50 feet

* Denotes exact conversion values. All others correct to significant figures shown.

INDIVIDUAL MEASUREMENTS

Horizontal Measurements nearest 0.001' with EDM/Total Station/GNSS receiver

nearest 0.01' with steel chain

nearest 0.01' with cloth/fiberglass tape

Vertical Measurements nearest 0.001' on benchmarks

nearest 0.01' on sanitary and storm structures

nearest 0.01' on bridge structures/super structures

nearest 0.01' on concrete pavement

nearest 0.1' on bridge clearances

nearest 0.1' on bituminous pavement, sill, pond/lake, dam elevations, etc.

Leveling nearest 0.001' for H.I. and target height

NOTE: All surveying measurements will be made in feet and decimals of feet.

PIPE SIZES

Pipe sizes and their metric equivalents shall conform to the International Standards Organization (ISO) usage of nominal pipe sizes for field identification purposes. Also, for pipes under 4”, professional rounding shall be utilized to describe nominal sizes to the nearest 25mm (i.e.: 1” = 25mm, 2” = 50mm).

The following guidelines should be used for classification of existing features.

English	Metric
4”	100mm
6”	150mm
8”	200mm
10”	250mm
12”	300mm
15”	375mm
18”	450mm
24”	600mm
30”	750mm
36”	900mm
42”	1050mm
48”	1200mm
54”	1350mm
60”	1500mm
66”	1650mm
72”	1800mm
78”	1950mm
84”	2100mm
90”	2250mm
96”	2400mm

CTDOT SURVEY STANDARDS AND RECOMMENDATIONS

The following standards are currently being recommended for use by the Department in preparation of Location Survey plans.

These standards were prepared and revised by the CTDOT Central Survey Office and supersedes the previous version titled “STATEWIDE METRIFICATION SURVEY STANDARDS (Revised – September 7, 1994)”. It is intended as an overview of general standards as specified in this Manual and no longer serves as a unit conversion guide. Should the information conflict with guidelines previously outlined in this Manual, please contact the Office of Central Surveys. In addition, any other comments, questions, or suggestions should also be directed to the Office of Central Surveys.

A. Map scales shall be 1”=40’ (1:480) or 1”=20’ (1:240) (if requested).

B. Roadway features will be surveyed at a maximum of 50-foot intervals. Tighter intervals may be requested or provided as data collection method allows.

C. A 400-foot (400’) coordinate mapping grid shall be used on all plans (200-foot for 1” = 20’ mapping).

D. Unless otherwise requested for 1:480 (1”=40’) mapping, a one-foot (1’) contour interval shall be used with index contours identified/accentuated at five-foot (5’) intervals. Mapping at 1:240 scale (1”=20’) shall have a half-foot (1/2’) with index contours accentuated at two-foot (2’) intervals.

E. Spot elevations shall be depicted to the nearest hundredth of a foot on hard surfaces (0.01’) and to the nearest tenth of a foot on soft surfaces (0.1’).

F. Tree sizes shall be shown to the nearest inch. Ornamental trees under 4” in diameter will be shown to the nearest half an inch (1/2”).

G. Pipe sizes, given in inches, shall conform to the International Standards Organization (ISO) usage of nominal pipe sizes for field identification purposes.

H. Elevations typically critical to design shall be depicted as indicated:

    1. Sanitary and storm sewer structures – nearest hundredth of a foot (0.01’)
    2. Bridge structure/super structure – nearest hundredth of a foot (0.01’)
    3. Concrete pavement – nearest hundredth of a foot (0.01’)
    4. Bituminous pavement, sill, dam, etc. elevations will be depicted on plans to the hundredth of a foot (0.01’).
    5. Bridge clearance – nearest hundredth of a foot (0.01’)
    6. Pond/lake – nearest tenth of a foot (0.1’)

I. Bench marks shall be adjusted and depicted to the nearest thousandth of a foot (0.001'). That shall be located at intervals of no more than 750 feet with a minimum of two depicted/established per project. The error of closure in each line shall not exceed $0.035\sqrt{M}$, where M is the length of run in miles, or $0.010\sqrt{N}$, where N is the length of run in feet (if line is less than a mile). Achieving this accuracy will typically require digital leveling for typical-sized projects. Items used for benchmarks should be permanent and stable (such as discs or bolts in ledge, geodetic monuments, etc.)

J. Primary horizontal control points should as intervisible pairs spaced at a minimum of 750 feet shall be placed at one-mile intervals. Primary points shall have error of no more than 0.05' positional uncertainty at 95% confidence (Level II). All horizontal control shall undergo weighted least squares network adjustment.

    a. Coordinates in tie boxes should be shown to the nearest thousandth of a foot (0.001')
    b. Swing ties in tie boxes should be shown to the nearest hundredth of a foot (0.01')
    c. Major control points should be concrete monuments and other primary points should be iron pins. Nails may be used at Surveyor's discretion for secondary control points.

K. All angular measurements and published relationships should be depicted in Degrees, Minutes, and Seconds.

L. Survey collection methods (GNSS, LiDAR, photogrammetry, conventional, etc.) should be identified in map reference notes as deemed necessary by the Surveyor.

APPENDIX F

GRAPHIC ELEMENT DEFINTIONS

Line:

A linear graphic element containing two vertices.

Point:

A special case of Line where the location of both vertices are identical.

Line string:

A single linear graphic element containing more than two vertices.

Curve string:

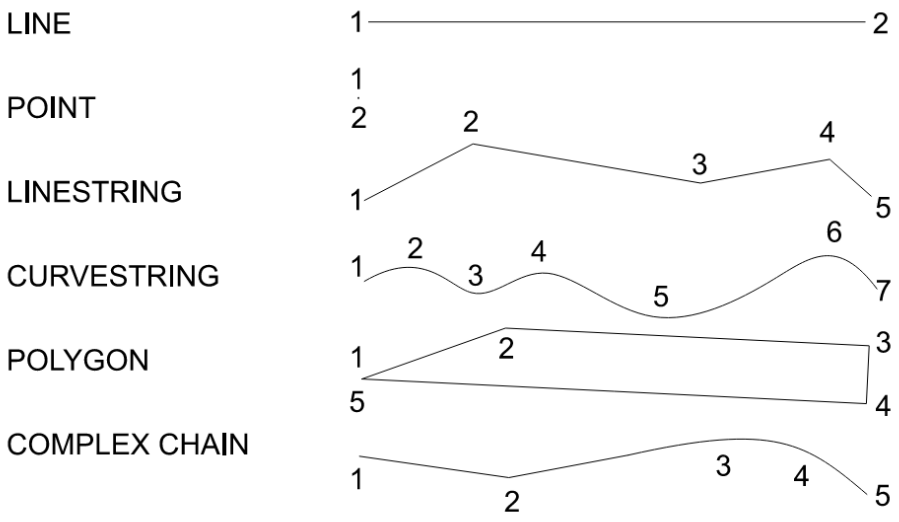
A single linear graphic element containing at least three vertices that display as a smoothly interpolated representation between vertices.

Polygon:

As used by CTDOT in this document, a line string or curve string, which closed upon itself (the last vertex is identical to the first vertex).

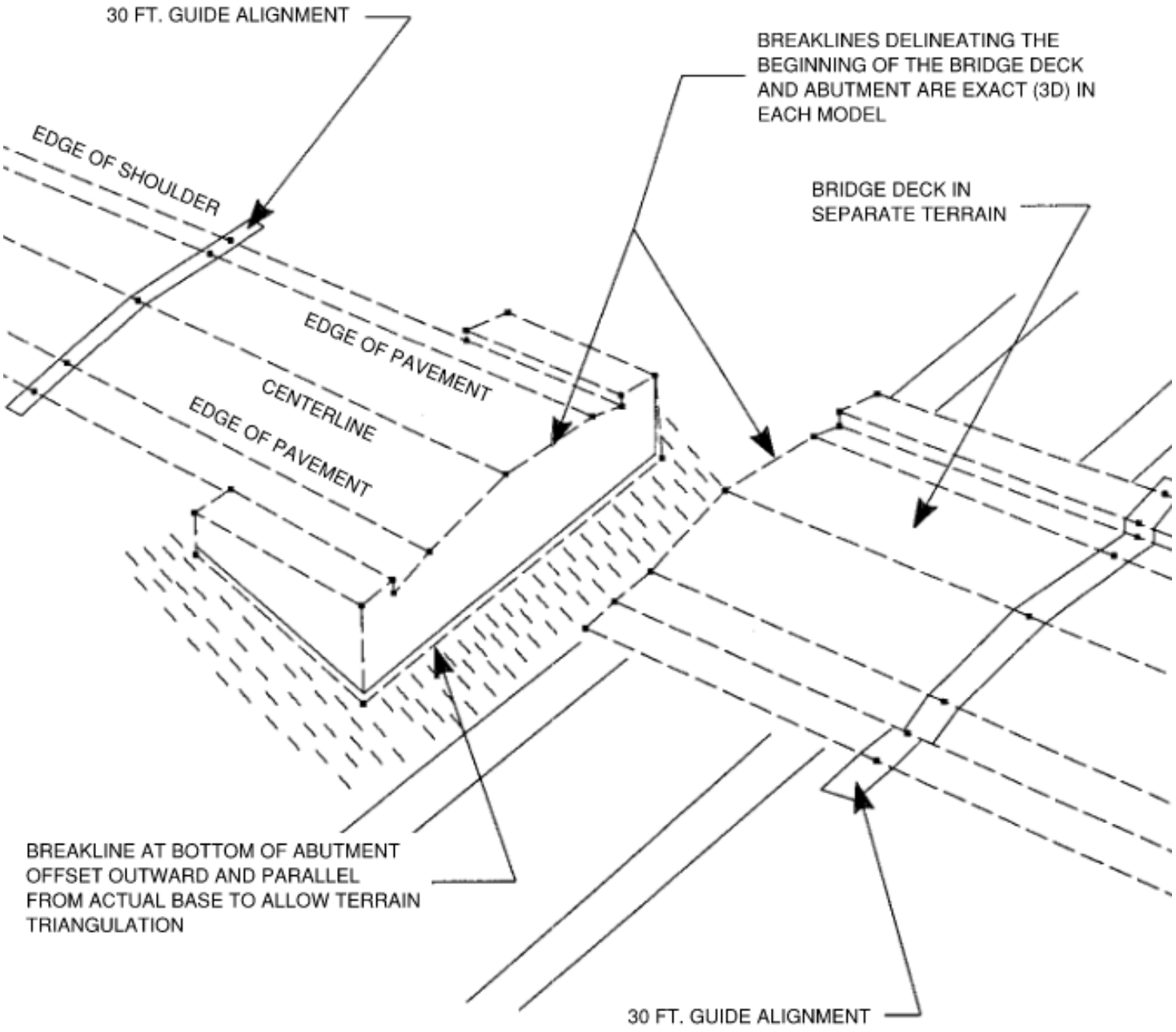
Complex chain:

A series of connected open elements, such as lines, linestrings, and curve strings, that are grouped for manipulation as a single element. Example would be the tangent of a roadway combined with a curve.



APPENDIX G

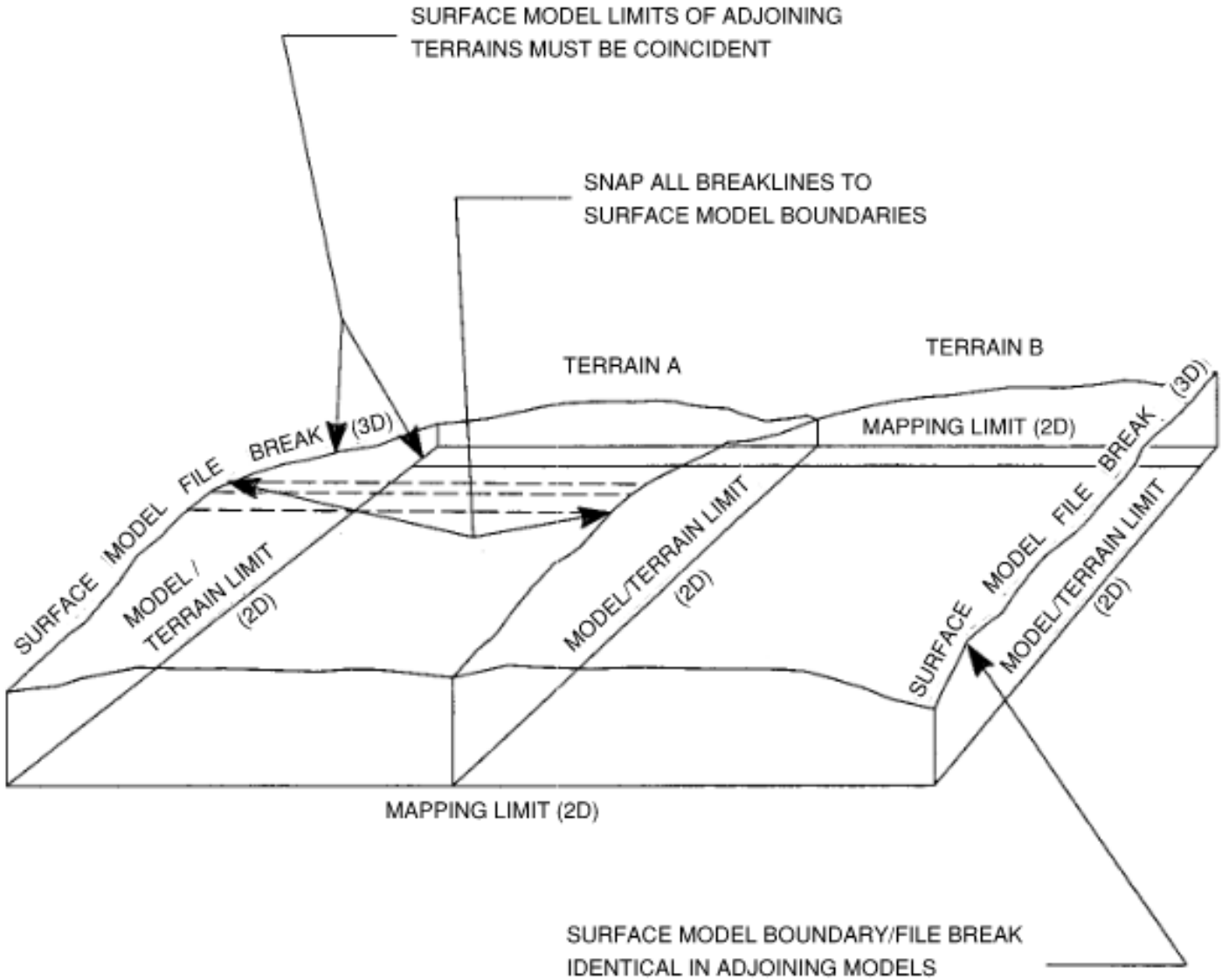
SURFACE MODEL (TERRAIN) COMPILATION AND GUIDE ALIGNMENT DIAGRAMS



- BREAKLINE DATA POINT (MEASUREMENT)

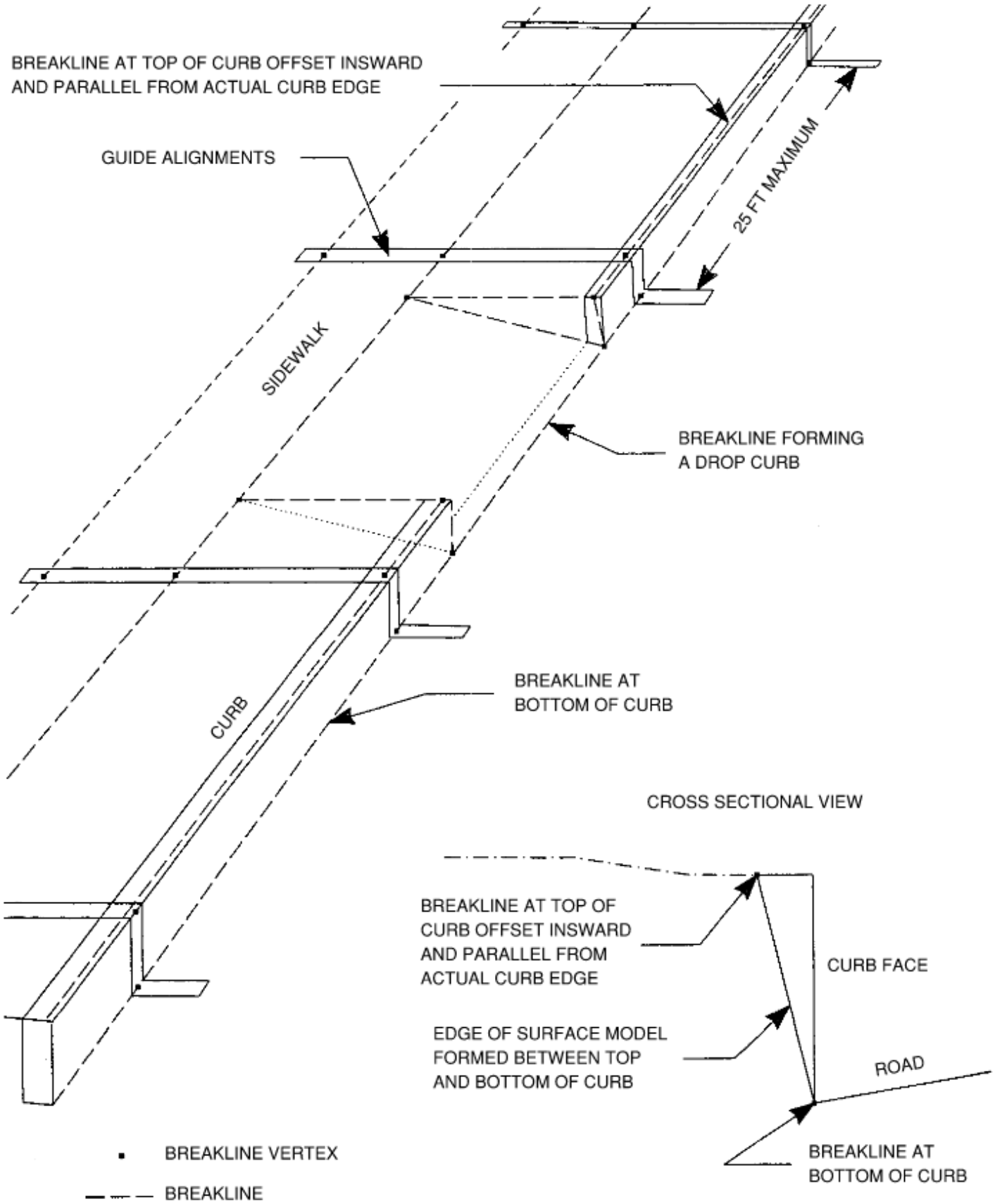
— — — BREAKLINE

SURFACE MODEL BREAKS BTEWEEN ADJOINING TERRAINS SHOULD GENERALLY BE PLACED IN PERFECTLY STRAIGHT LINES PLANIMETRICALLY (2D)



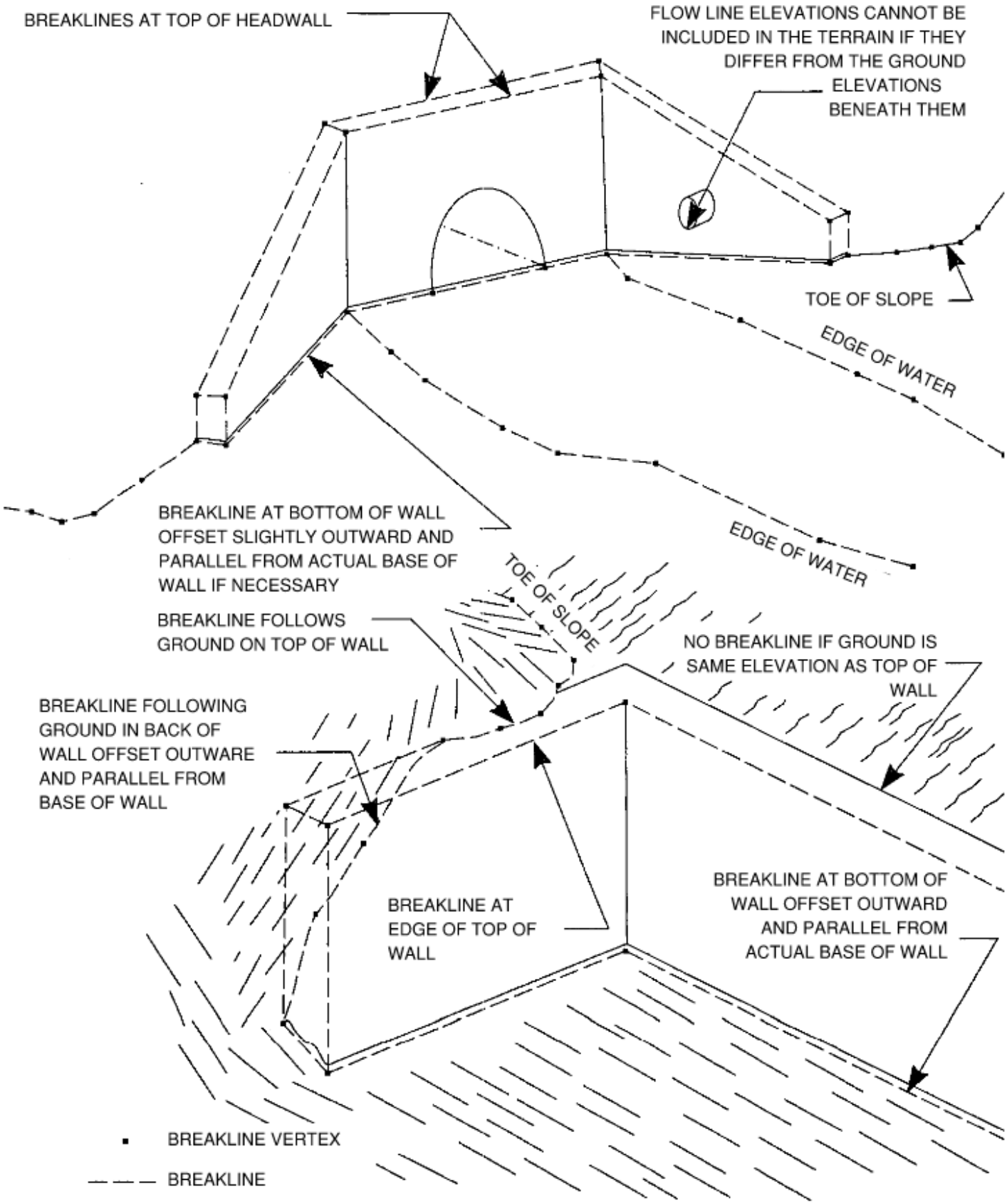
SURFACE MODEL (TERRAIN) COMPILATION DIAGRAM
FOR BITUMINOUS CONCRETE LIP CURBING
GRANITE CURBING CONCRETE CURBING

5 /97
REV. 10/2025



SURFACE MODEL (TERRAIN) COMPILATION
DIAGRAM FOR MAJOR CULVERT AND
RETAINING WALL

5 /97
REV. 10/2025



CONNECTICUT DEPARTMENT OF TRANSPORTATION

Location Survey Manual

May 2026 Edition

Change Log

6/22/2026 **–** Added Reference to CTDOT Plane Coordinate System Manual procedures and standards to section 3.3 and 3.4. Allowed Control Tie boxes to show coordinates to two decimal places.