Location & Design Manual Volume 4

Survey, Mapping, and Subsurface Utility Location Services Specifications

Department of Transportation

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OHIO DEPARTMENT OF TRANSPORTATION
Office of CADD & Mapping Services

Preface

Purpose

This manual is designed to provide a standardized framework to assists engineers, surveyors, and project managers in addressing the diverse challenges of data acquisition, spatial analysis, and subsurface utility location. It goes beyond conventional surveying and mapping practices by incorporating modern technologies such as LiDAR and photogrammetry, ensuring a more comprehensive and accurate approach to infrastructure planning and design. The development of this manual reflects a commitment to continuous improvement and technological advancement in transportation design.

Application

These standards and specifications have been developed for all surveying, mapping, and utility location work for the Ohio Department of Transportation. This document is neither a textbook nor a substitute for knowledge, experience, or judgement. It is intended to provide uniform procedures and to assure quality and continuity in the design and construction of the transportation infrastructure within Ohio and assure compliance with State and Federal rules and regulations.

Preparation

This manual has been developed by the Office of CADD and Mapping Services. Errors or omissions should be reported to the Administrator, Office of CADD and Mapping Services. A list of contacts can be found on the CADD and Mapping Services | Ohio Department of Transportation website.

Format and Revisions

Manuals and revisions may be downloaded from the Publications Gateway web page. Users are encouraged to sign up on this page for electronic (email) notification of revisions.

ODOT's Website can be accessed at https://www.transportation.ohio.gov/

Reference Documents

ODOT Real Estate Manual, Real Estate Manual | Ohio Department of Transportation

ODOT Location and Design, Volume 3, Location & Design Manual, Volume 3 - Highway Plans | Ohio Department of Transportation

Ohio Manual of Traffic Control Devices, Ohio Manual of Uniform Traffic Control Devices (state.oh.us)

Ohio Revised Codes 153.64, 3781.25 to 3781.38, 4733 and Ohio Administrative Code 4733.

ASCE C-1 38-22 - Standard Guidelines for Investigating and Documenting Existing Utilities - https://www.fhwa.dot.gov/programadmin/asce.cfm. (Limited to the sections of the Guidelines that address location and mapping of subsurface utilities. In cases of conflict with ODOT documents, ODOT documents will govern)

National Geodetic Survey (NGS), Online Positioning Service (OPUS) - https://www.ngs.noaa.gov/OPUS/

ASPRS (2014). ASPRS Positional Accuracy Standards for Digital Geospatial Data. American Society for Photogrammetry and Remote Sensing (ASPRS).

ASPRS (2019). American Society for Photogrammetry and Remote Sensing LAS Specification 1.4 – R13, July 2019.

Federal Geographic Data Committee (1998). FGDC-STD-007.3-1988, Geospatial Positioning Accuracy Standards, Part 3. National Standard for Spatial Data Accuracy (fgdc.gov)

Glossary of Terms

Azimuth Mark: A Type 'A' or Type 'B' project control monument set at the end points of the project for use as a 'backsight' point.

Approximate Location: The immediate area within the perimeter of a proposed excavation site where the underground utility facilities are located.

Benchmark: A relatively permanent object, natural or artificial, bearing a marked point whose elevation is above or below a referenced datum with a known published elevation.

Check points: 3-dimensional positions obtained independently of survey points by traditional ground surveying, Real Time Kinematic GNSS surveying or Static GNSS. Check points are used to verify the accuracy of the TIN.

Combined Scale Factor: A conversion factor that uses the combination of the Grid Scale factor and the Elevation Scale Factor of a point to reduce horizontal ground distances to grid distances.

Conventional Mapping Survey: A Conventional mapping survey is the collection of points to define the features (natural, manufactured, or both) of a physical surface that is collected directly from ground control, using conventional survey equipment, and is physically measured using a total station, Terrestrial Scanner, GNSS equipment or Hydrographic equipment.

Coordinates – A group of numbers used to indicate the position of a point, line, or plane.

Department: The Department of Transportation, State of Ohio.

Digital Terrain Model (DTM): A bare earth model of the earth that can be used in CADD programs. (Vegetation and other objects/artifacts are removed digitally from the surface)

DTM Accuracy Class: A specific area within the mapping limits with an assigned maximum allowable Dz and RMSE. The number of areas and the DTM accuracy class for each area is set by the District Survey Operations Manager.

Dz: Mathematical difference between elevations of check points and elevations produced from the TIN (created from the Survey Points) at the exact horizontal location.

Differential Leveling: Determining the difference in elevation between two points by the sum of incremental vertical displacements of a graduated rod.

Elevation Scale Factor: A multiplier used to change horizontal ground distances to geodetic (ellipsoid) distances.

Excavation: The use of hand tools, powered equipment, or explosives to move earth, rock, or other materials in order to penetrate or bore or drill into the earth, or to demolish any structure whether or not it is intended that the demolition will disturb the earth. "Excavation" includes such agricultural operations as the installation of drain tile but excludes agricultural operations such as tilling that do not penetrate the earth to a depth of more than twelve inches. "Excavation" excludes any activity by a governmental entity which does not penetrate the earth to a depth of more than twelve inches. "Excavation" excludes coal mining and reclamation operations regulated under Chapter 1513 of the Revised Code and rules adopted under it.

Excavator: The person or persons responsible for making the actual excavation.

Geodetic Datum:

1. "A set of constants specifying the coordinate system used for geodetic control, i.e., for calculating the coordinates of points on the Earth."
2. "The datum, as defined in (1), together with the coordinate system and the set of all points and lines whose coordinates, lengths, and directions have been determined by measurement or calculation."

Global Navigation Satellite System (GNSS): Any satellite system which can be used to determine a precise location on the surface of the Earth. The US system is known as NAVSTAR Global Positioning System (GPS). The Russian system is known as the **GLO**bal'naya **NA**vigatsionnaya **S**putnikovaya **S**istema or GLONASS. The European Space Agency system is known as GALILEO. The China National Space Administration system is known as BeiDou.

Grid Scale Factor: A measure of the distortion at a given point on a projected map. Typically, the difference between the ellipsoid distance between two points and the distance on a projected surface.

Hydrographic Survey: A survey having for its principal purpose the determination of data relating to bodies of water, and which may consist of the determination of one or several of the following classes of data; depth of water and configuration of bottom; directions and force of current; heights, times and water stages; and location of fixed objects for survey and navigation purposes.

Internal Navigation System (INS): A collection of sensors (typically a GNSS receiver and Internal Measurement Unit (IMU) or some combination thereof) that provide the positional information of a data collecting device (position and attitude) without direct observation of project control. These systems are often paired with cameras and LiDAR (Light Detection and Ranging) for mapping surveys.

Improvement: Any construction, reconstruction, improvement, enlargement, alteration, or repair of a building, highway, drainage system, water system, road, street, alley, sewer, ditch, sewage disposal plant, water works, and all other structures or works of any nature.

INS-Based Mapping Surveys: The collection of points to define the features (natural, manufactured, or both) of a physical surface that is carried out *without* the direct observation of geodetic/primary control points. The INS-based mapping survey collection equipment relies on positioning based on INS solutions and/or mapping control points. Examples may include Aerial Mapping Surveys, Mobile Mapping Surveys, UAS-based photogrammetry, etc.

Lambert Conformal Conic – A conic map projection used for aeronautical charts, portions of the State Plane Coordinate System, and many national and regional mapping systems, best suited for conformal mapping of land masses extending in and east-to-west orientation.

LiDAR (Light Detection and Ranging): A remote sensing method that uses light as a pulsed laser to measure variable distances to the Earth's surface.

Multipath (Multipath Error): The error that results when a reflected GNSS signal is received. When the signal reaches the receiver by two or more different paths, the reflected paths are longer and cause incorrect pseudoranges or carrier phase measurements and subsequent positioning errors. Multipath is mitigated with various preventive antenna designs and filtering algorithms.

NAD83 (2011) – The North American Datum of 1983 (NAD 83) is a geodetic reference system used for defining latitude and longitude in North America. It was refined in 2011 to improve accuracy by incorporating data from GPS receivers at Continuously Operating Reference Stations (CORS).

Nondestructive Manner: Using low-impact, low risk technologies such as hand tools, or hydro or air vacuum excavation equipment.

Ohio County Coordinate System (OCCS): The Ohio County Coordinate System (OCCS) is a set of conformal map projections designed by ODOT's Office of CADD and Mapping Services to provide a series of low distortion projections for the use of Ohio stakeholders. The OCCS can be used for surveying, engineering, GIS, precision agriculture, Emergency Management, and other applications where accurate maps are required. The OCCS is a set of conformal map projections that use county boundaries as their zone widths. The goal of the OCCS is to limit linear distortion between grid and ground to a point where it is negligible, eliminating the need to scale grid coordinates to obtain accurate ground distances.

OPUS Static: The National Geodetic Survey's On-Line Positioning User Service (OPUS). OPUS accepts a user's GPS tracking data. It uses corresponding data from the National CORS Network (NCN) to compute 3-dimensional positional coordinates of the user's submitted data. OPUS processes a 3-dimensional coordinate with an accuracy of a few centimeters for data sets spanning 2 hours or more.

OPUS-RS: A rapid static form of the National Geodetic Survey's On-Line Positioning User Service (OPUS). OPUS-RS accepts a user's GPS tracking data and uses corresponding data from the National CORS Network (NCN) to compute 3-dimensional positional coordinates of the user's submitted data. OPUS-RS can process a 3-dimensional coordinate with an accuracy of a few centimeters for data sets spanning as little as 15 minutes.

Planimetric Features: Existing 2-dimensional features collected with traditional ground surveying, Real Time Kinematic GNSS surveying, or Photogrammetry for use in engineering projects (example: existing pavement edge line).

Planimetric Check points: 2-dimensional positions obtained independently of the planimetric feature data collection. Use traditional ground surveying or Real Time Kinematic GNSS surveying.

Planimetric Accuracy Detail Class: The required number of detailed features to be collected. The District Survey Operations Manager assigns the mapping an accuracy detail class based on the final use of the mapping product.

Project Benchmark: A vertical position transferred from a primary project control monument for use on a specific project.

Project Development Process (PDP): The process used by The Ohio Department of Transportation to develop and manage construction projects. 5 Paths categorize ODOT projects Path 1 being the most straightforward ODOT project to Path 4 and Path 5 being ODOT's most complex projects.

Project Adjustment (scale) Factor: The inverse of the Combined Scale factor (1/Combined Scale Factor) used to convert grid distances and coordinates to ground distances and coordinates.

Position Dilution of Precision (PDOP): A numerical representation of the predicted accuracy of a geodetic position determined from GNSS satellites. The term represents the quality of the satellite geometry with respect to the receiver's location. A PDOP of 3 or less will generally ensure the highest survey quality accuracy.

Real-Time Kinematic (RTK) GNSS Survey: A method of determining relative positions between known control and unknown positions using carrier phase measurements. A base station at the known point transmits corrections to the roving receiver offering high-accuracy positions in real-time.

Right of Way Survey: A survey performed to lay out an acceptable route for an easement or right of way for a road, pipeline, utility, or transmission line. This survey would include establishing of all boundary lines and road crossings along the route.

Root Mean Square Error (RMSE): Mathematical calculation that describes horizontal and vertical mapping accuracy encompassing both random and systematic errors.

RTN GNSS Survey: A real-time geodetic survey that uses multiple survey-grade satellite receivers at surrounding CORS to determine an accurate "rover" position. The CORS data and the rover location are sent to a remote server where specialized software generates correctors. The correctors are then streamed via various communications technologies to the rover to yield enhanced three-dimensional positions. RTN-derived positions can be categorized as a "network" solution.

Static GNSS Survey: A geodetic survey that uses survey-grade satellite receivers to collect satellite data on a fixed-point requiring post-processing to determine position.

Temporary Benchmark: A vertical position transferred from a primary project control monument for use on a specific project.

Tolerance Zone: The site of the underground utility facility including the width of the underground utility facility plus eighteen inches on each side of the facility.

Transverse Mercator – A cylindrical map projection that minimizes distortion for north-south oriented areas, making it ideal for detailed mapping and surveying.

Underground Utility Facility: Includes any item buried or placed below ground or submerged under water for use in connection with the storage or conveyance of water or sewage; electronic, telephonic, or telegraphic communications; television signals; electricity; crude oil; petroleum products; artificial or liquefied petroleum; manufactured, mixed, or natural gas; synthetic or liquefied natural gas; propane gas; coal; steam; hot water; or other substances. "Underground utility facility" includes all operational underground pipes, sewers, tubing, conduits, cables, valves, lines, wires, worker access holes, and attachments, owned by any person, firm, or company.
"Underground utility facility" does not include a private septic system in a one-family or multi-family dwelling utilized only for that dwelling and not connected to any other system.

Utility: Any owner or operator, or an agent of an owner or operator, of an underground utility facility, including any public authority that owns or operates an underground utility facility. "Utility" does not include the owners of the following types of real property with respect to any underground utility facility located on that property:

1. The owner of a single-family or two-, three-, or four-unit residential dwelling.
2. The owner of an apartment complex.
3. The owner of a commercial or industrial building or complex of buildings, including but not limited to factories and shopping centers.
4. The owner of a farm.
5. The owner of an exempt domestic well as defined in section 1509.01 of the Revised Code.

U.S. Survey Foot - The U.S. Survey foot is defined as 1 meter = 39.37 inches. Use the following conversion factor: 1 meter = 3937/1200 U.S. Survey feet.

2000 Survey and Mapping Specifications

2001 Introduction

These requirements and specifications have been developed for all surveying and mapping work for The Ohio Department of Transportation and is intended to provide uniform procedures for surveying and mapping to ensure quality and continuity in the design and construction of the transportation infrastructure within Ohio. Ensure all work is performed in conformance with O.A.C. 4733 & O.R.C. 4733.

2002 Scope of Work

Ensure the District Survey Operations Manager is consulted during the scoping of projects that involve surveying and mapping. The Department will provide a scope of work document outlining the surveying and mapping work to be performed.

2003 Safety

2003.1 General

Ensure safe practices are utilized while performing all surveying and mapping work for ODOT. Follow safe practices according to 220-006(SP) Ohio Department of Transportation Employee Health and Safety Standard Operating Procedure.

2003.2 Public Utilities

In accordance with the Ohio Revised Code 3781.25 to 3781.32, everyone must contact OHIO811 (the Ohio Utilities Protection Service) (OUPS), at least 48 hours but no more than ten working days (excluding weekends and legal holidays) before beginning any excavation work, construction of Control Monuments, or driving of pins. For more information, http://www.ohio811.org/.

2003.3 Traffic Control

2003.3.1 Traffic Control: Conventional Survey

Ensure safety standards are followed according to the Ohio Manual of Uniform Traffic Control Devices (OMUTCD), Part 6. Temporary Traffic Control.

2003.3.2 Traffic Control: UAS Surveys

All flight operations planned near, or over (where permissible), highways that have not been closed to traffic shall have temporary signage giving the traveling public advanced notice of UAS operations in the area. The most current and applicable rules per FAA Part 107 rules governing UAS flights over traffic or non-participants shall be followed. Proper survey signage must be displayed per the Ohio Manual of Uniform Traffic Control Devices (OMUTCD), Part 6, Temporary Traffic Control.

2003.4 Property Owner Notifications

Survey crews performing work for the Department are granted access to private land per O.R.C. 163.03 & O.R.C. 5517.01. Property owner notification is required for all survey work on private property, including aerial survey operations where UAS flights and operations will require flights over private property. Property owners must be provided with a 48-hour advance notice of entry to private property, including aerial survey operations with a UAS. A standard property owner notification template can be found on ODOT's website in an editable word document format. Both ODOT and consultant surveyors may be responsible for any damage to the property of others incurred during the process of their work. Should any damage occur, the survey crew chief will document the damage and deliver a report to the district. Additionally, any accident involving UAS must follow applicable FAA and Ohio Unmanned Aircraft Systems Center (Ohio UASC) procedures.

2003.5 Construction Site Safety

Ensure safe practices are followed according to Federal Occupational Safety & Health Standards 29 CFR 1926, et seq.

2003.6 Confined Space Entry

Ensure safe practices are followed for confined space entry according to Federal Occupational Safety & Health Standards 29 CFR 1910.146 Permit-required confined spaces and the Ohio Department of Transportation Culvert Management Manual.

2004 Datums, Coordinate Systems, and Positioning Parameters

As of the publication date of this specification all project control and mapping will be surveyed and mapped on NAD 83 (2011 ADJ (2010.0 Epoch)) & NAVD 88 (Geoid 18) datums. The Ohio County Coordinate System will be the preferred map projection for all ODOT projects. The Ohio State Plane Coordinate System may still be used in special circumstances and only at the discretion of the ODOT District Survey Operations Manager.

Ensure all project control and mapping performed for ODOT meets the following positioning parameters unless otherwise directed by the District Survey Operations Manager. These values will also be used within the G105 Note when applicable. Please see Appendix G for examples.

2004.1 Horizontal Positioning

Furnish horizontal positions using the following:

- POSITIONAL DATA – OHIO COUNTY COORDINATE SYSTEM
    - Reference Frame: NAD 83 (2011 ADJ (2010.0 Epoch))
    - Ellipsoid: GRS 80
    - Coordinate System Name: XXXX County (OCCS)
    - Map Projection: Lambert Conformal Conic 1 Standard Parallel or Transverse Mercator
    - Central Latitude
    - Central Longitude
    - False Northing/False Easting
    - Projection Scale Factor

Information on the Ohio County Coordinate System can be found in Section 2100, Ohio County Coordinate System (OCCS) and on the ODOT CADD & Mapping website - Ohio County Coordinate System.

- POSITIONAL DATA – OHIO STATE PLANE COORDINATION SYSTEM
  - Reference Frame: NAD 83 (2011 ADJ (2010.0 Epoch))
  - Ellipsoid: GRS80
  - Coordinate System Name: Ohio State Plane, North Zone or Ohio State Plane, South Zone
  - Map Projection: Lambert Conformal Conic 2 Standard Parallel
  - Project Adjustment Factor (PAF): (1/Combined Scale Factor) from grid to ground as appropriate
    - (Refer to Section 2006.2.2.12 for further information)
  - Origin of the PAF: Use 0,0
    - (Refer to Section 2006.2.2.12 for further information)
    - North Zone: Latitude/Longitude of 0,0 origin point:
      - **N 39° 27' 01.76097"/W 89° 28' 32.98476"**
    - South Zone: Latitude/Longitude of 0,0 origin point:
      - **N 37° 47' 45.30621"/W 89° 19' 00.02517"**

2004.2 Vertical Positioning

Furnish vertical positions using the following:

- Orthometric Height Datum – NAVD88
- Geoid Model – Geoid 18

Note: For purposes of this document, the term "elevation" refers to the orthometric height.

2005 Units of Measurements

2005.1 U.S. Survey Foot Definition

The U.S. Survey foot is defined as 1 meter = 39.37 inches. Use the following conversion factor: 1 meter = 3937/1200 U.S. Survey feet.

Note: The U.S. Survey Foot definition shall be used in conjunction with the NAD 83 datum.

2005.2 Distance

Furnish units in U.S. Survey Feet. Provide distances to the nearest hundredth (e.g., 0.01) of a foot.

2005.3 Angles

Furnish angles in degrees-minutes-seconds to the nearest second (e.g., 01°01'01").

2005.4 Direction

Furnish directions as bearings in degrees-minutes-seconds to the nearest second (e.g., N 01°01'01" E).

2005.5 Area

Furnish units in square feet to the nearest square foot, in acres to the nearest thousandth (e.g. 0.001) of an acre.

2005.6 Volume

Furnish volumes to the nearest cubic yard unless otherwise stated.

2005.7 Horizontal/Vertical Positions

Furnish Ohio State Plane or OCCS coordinates for all survey control points, Right-of-Way, Centerline, and Boundary monuments that will be shown on any recorded documents and scaled using a project adjustment factor or in an ODOT-approved alternate projection in both metric and U.S. survey feet. Meters shall be shown to the nearest thousandth (e.g., 0.001) of a meter. U.S. survey feet shall be delivered to the nearest thousandth (e.g., 0.001) of a foot. The format for reporting all Horizontal and Vertical positions in OCCS, State Plane or scaled shall be:

Point Number/Northing coordinate/Easting coordinate/Elevation/Code/Attribute Pairs (if applicable) (P,N,E,Z,D,A1,A2,etc.).

2006 Types of Surveys

2006.1 General

The following survey types are those most commonly performed by ODOT. There are specialty surveys that may fall outside of these categories. The requirements for these specialty surveys will be determined on a project-by-project basis and implemented through the scope of services.

2006.2 Control Surveys

As the National Geodetic Survey (NGS) moves closer to the modernization of the National Spatial Reference System (NSRS), i.e., transitioning from NAD 83 and NAVD 88 to NATRF 2022 and NAPGD 2022, the establishing of control that will last the duration of the project will become critical.

2006.2.1 General

Control Surveys establish coordinate positions (e.g., northings, eastings, and elevations) on strategically located monuments throughout a project. Control Surveys govern all survey work that follows, including mapping, and construction layout.

2006.2.2 Project Control

The purpose of a geodetic/primary control survey is to establish a network of physically monumented coordinate points in and along a highway corridor that provide a common horizontal and vertical datum for the entire project. The geodetic control survey offers the means for tying all the geographic features and design elements of a project to one common horizontal and vertical reference system. The geodetic/primary control survey is performed at a higher level of accuracy and monumentation than the INS-based mapping control; the INS-based mapping control survey shall be considered secondary control.

2006.2.2.1 General

For projects where no ODOT geodetic/primary control survey has been completed, the District Survey Operations Manager shall be contacted, and a determination made if a geodetic/primary control survey is to be completed prior to the aerial control survey. ODOT discourages performing any INS-based mapping survey without a previously established geodetic/primary control survey network. This causes accuracy and coordinate conversion problems later in the project's progression.

Position all monuments following this specification. Previously established monuments may be used if those monuments were constructed, positioned, and verified according to this specification. Ensure existing monuments are in good condition and stable.

2006.2.2.2 Geodetic Project Control

Geodetic Control is required for, and will govern, the positioning of all ODOT Path 4 or 5 projects greater than 1 mile in length, and should also be used for any projects, regardless of the path, that are planned to span more than one year. All ODOT projects will be positioned based on the most current horizontal and vertical datums established by the National Geodetic Survey (NGS), and as set forth in Section 2004, Datums, Coordinate Systems, and Positioning Parameters of this document. For stability of the control network, monuments should be set outside of the active construction area to maintain and preserve the integrity of the monument location.

Path 4 & 5 projects greater than 1 mile in length but less than 5 miles in length shall have a minimum of 5 Geodetic Control monuments separate from the Primary Project Control. Projects greater than 5 miles in length will require additional pairs of Geodetic Control Monuments every 2.5 miles. Path 4 and 5 projects less than 1 mile in length shall have a minimum of three type A monuments set in locations that will protect them from being destroyed during construction activities.

Geodetic Control monuments should be set outside of the project limits to encompass the entire project within the control network (see Figure 1 below). Ease of accessibility and the ability to preserve the monuments' integrity should be taken into consideration when setting Geodetic Control to ensure the project has a stable control network available through the construction phase of the project. One Geodetic Control monument shall be set near the center of the project in an area where the monument can be protected from construction activities. This monument will serve as the primary source of vertical control for the project. Care should be taken to ensure this monument remains intact throughout the project's life cycle.

Geodetic Control monuments should have sufficient design, material, and construction to maintain their horizontal and vertical position throughout the project's life span. The project surveyor may use existing monuments (i.e., NGS horizontal control or benchmarks, County Geodetic Control monuments or PLSS monuments) or set type A monuments if no other options are available.

PATH 4 AND 5 PROJECTS
CONTROL REQUIREMENTS FOR PROJECTS REQUIRING MAPPING GREATER THAN 1 MILE IN LENGTH

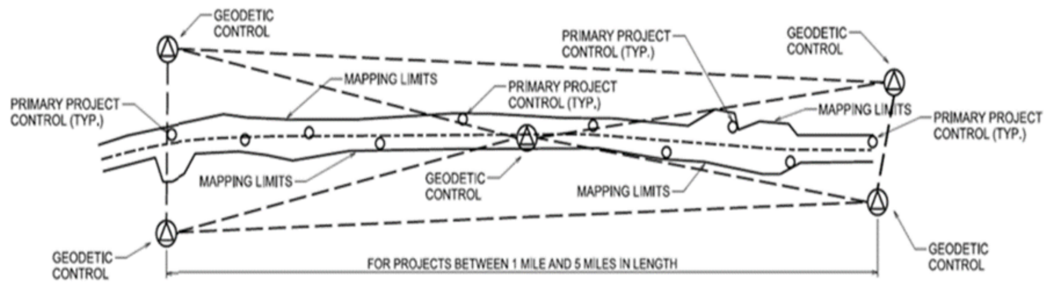


Figure 1 Path 4 & 5 Control Requirements

2006.2.2.3 Primary Project Control

Primary Project Control Monuments are monuments set along the project corridor used exclusively to collect topographic, boundary, and utility data and control construction activities. Primary Project Control should be established with a minimum of three monuments set outside the construction limits of the project. Primary project control shall be constructed to remain stable and last the duration of the project. Primary Project Control shall be set and positioned based on the Geodetic Control if used, or by methods outlined in Section 2006.2.2.5 Observation Methods to Establish Control on Path 1 through 3 Projects. Ensure all topographic, boundary, and utility data is collected and adjusted relative to the established Primary Control Monuments. Construct Primary Project Control Monuments flush to the ground according to details shown in Appendix F.

Primary Project Control Monuments should be positioned so that they:

- Are intervisible.
- Are able to be used with conventional survey equipment.
- Have a clear view of the sky to reduce the potential for GNSS multipath signals.

The placement of Primary Project Control Monuments is dependent upon the project length and should be set at a maximum of ½ mile intervals. Furnish Geodetic/Primary Project Control Monuments per the following table:

****Project Category**	**Type of Control**	***Monument Type**	**Monument Controls**	*****Horizontal Positioning Methods**	**Vertical Positioning Methods**
• Required: Path 4 &5 ≥ 1 mile • Optional: Path 1-3 Projects ≥ 1 year construction++	Geodetic and Primary	A	Horizontal & Vertical	Static GNSS, PPK, Conventional Traverse	+Differential Leveling
• Path 1-3++ • Path 4-5 <1 mile	Primary Only	A or B	**Type A:** Horz. & Vert. **Type B:** Horizontal only	Static GNSS, PPK, ODOT RTN, RTK, Conventional Traverse	+Differential Leveling

			Separate Vert. (BM) req. to be set		

Project Length	Begin & End of Project Limits (Excluding MOT)	Approx. Interval Distance Along Alignment	At Locations Specified by District	Minimum # of Monuments Required
< 1 mile	X	0.5 Mile * Intervisible to at least one other monument.	X	3
≥ 1 mile	X	0.5 Mile * Intervisible to at least one other monument.	X	4

Table 1 Geodetic/Primary Project Control Monument Placement Criteria

*If site geology or site conditions do not permit placement of the monument, contact the District Survey Operations Manager.
**Project Category is defined in the Project Development Process Manual.
***Contact the District Survey Operations Manager if GNSS positioning is not feasible. See 2006.2.2.4 for positioning methods.
+See Section 2006.3 – Differential Leveling
++Consider using Type A monuments for Path 1-3 projects that may expect to be delayed in project development or are expected to span more than one construction year.

2006.2.2.4 Observation Methods to Establish Geodetic Control on Path 4 and 5 Projects

- Static GNSS Surveys [Required on Path 4 and 5 projects, Recommended on Path 3 projects]. All control points need a minimum of 3 GNSS sessions observed on three separate days within a 4-week period. Use survey-grade GNSS receivers and antennas following Section 2009, Survey and Mapping Equipment. Use one of the following methods:
    - OPUS Solution for all Control Points
        - Collect a minimum of 3 sessions of static GNSS data following NGS requirements for an OPUS static session for each Geodetic Control Monument. Ensure the survey equipment is removed and reinstalled over the monument between sessions. Ensure proper GNSS survey planning to achieve the required data quality as outlined in this specification. Consider the following when planning the GNSS survey: positional dilution of precision (PDOP), number of satellites, mask angle, collection rate, multipath, solar activity, etc.
    - Base Receiver Setup/CORS with Rover unit collecting PPK data
        - Establish a base receiver by collecting the Geodetic Control Monument near the center of the project using a minimum of 3 static GNSS sessions as described above or a nearby CORS as a base. Simultaneously collect the remaining Geodetic Control and/or Primary Control points using a GNSS rover collecting fast-static data. Collect three individual sessions on each Geodetic Control and/or Primary Control point using fast-static data for a minimum of 20 minutes plus 1 minute per kilometer over 15 kilometers of baseline between the occupied control points.

- Traversing
  - Conduct a conventional survey traverse using an Electronic Total Station defined in Section 2009.2.2, Total Stations. A minimum of 2 direct/2 reverse angles and five distance measurements shall be observed and averaged for the final observation of each control point.
  - Closed loop traverses or ties to known control points at the beginning and end of each project should be used to adjust the traverse for errors.

Note: At least two monuments need to be tied to the NSRS, and the traverse transformed and adjusted to their positions.

2006.2.2.5 Observation Methods to Establish Control on Path 1 through 3 Projects

- ODOT RTN Surveys [For use on Path 1-3 projects only, not to be used on Path 4 or 5 projects]
  - For use on Path 1-3 projects only collect the Northing, Easting, and Elevation coordinates using 5-second observations at a 1-second epoch rate. Collect a minimum of 12 observations for each project control monument. Note: If more than 20 observations are needed to meet the minimum RMSE requirements, consider changing the control location and contact the district Survey Operations Manager. Collect four observations rotating the rod 90 degrees between each observation, remove the rod and break initialization, repeat this observation procedure until 12 positions have been recorded. Consider the following when planning and performing RTN surveys: positional dilution of precision (PDOP), number of satellites, mask angle, multipath, solar activity, etc. A minimum of 9 observations must be included in the RMSE calculations that meet the required accuracy.

- RTK Surveys [For use on Path 1-3 projects only, not to be used on Path 4 or 5 projects]
  - Establish a base receiver by collecting 3 GNSS static sessions that meet NGS requirements for an OPUS static session, on one control point. While the receiver is collecting static data perform an RTK survey on the remaining control points. Repeat with each static data collection session so that every control point has a minimum of 3 RTK/static positions.
  - Establish a base receiver by collecting using 5-second observations at a 1-second epoch rate. Collect a minimum of 12 observations on one control point as in the ODOT RTN Survey method above.

- Traversing
  - Conduct a conventional survey traverse using an Electronic Total Station defined in Section 2009.2.2 Total Stations. A minimum of 2 direct/2 reverse angles and five distance measurements shall be observed and averaged for the final observation of each control point.
  - Closed loop traverses or ties to known control points at the beginning and end of each project should be used to adjust the traverse for errors.

Note: At least two monuments need to be tied to the NSRS, and the traverse transformed and adjusted to their positions.

2006.2.2.6 Static GNSS Data Processing

- OPUS Solution for all Control Points
  - Process the collected data to determine the Northing, Easting, and Elevation (Orthometric Height) for each session using National Geodetic Survey's OPUS (Online Positioning User Service). Use the rapid or precise ephemeris only. Ensure the correct antenna height, make, and model is utilized. Use the same three nearest CORS base stations and standard logging rates when processing a primary project control point in OPUS. The user must manually select the CORS used in the OPUS processing.

- Base Receiver Setup with Rover unit collecting PPK data

  - Establish the base station coordinates to post-process GNSS baselines by submitting the GNSS data RINEX files to OPUS as described for OPUS Static solutions. Process the collected GNSS data by importing the data into GNSS post-processing software such as Trimble Business Center, Leica Infinity, or MAGNET, and post-process the GNSS baselines through the appropriate post-processing software. Calculate the positions of three observations per point and calculate the RMSE value to ensure the control point meets the ODOT Survey and Mapping Specifications for a type A monument.

- CORS with Rover unit collecting PPK data

  - Use the published coordinate values of the nearest CORS to post-process GNSS baselines. Process the collected GNSS data by importing the data into post-processing software such as Trimble Business Center, Leica Infinity, or MAGNET. Post-process the GNSS baselines through the appropriate post-processing software. Calculate the positions of three observations per point and calculate the RMSE value to ensure the control point meets the ODOT Survey and Mapping Specifications for a type A monument.

2006.2.2.7 Coordinate Statistical Analysis

Calculate the Root Mean Square Error (RMSE) for each coordinate component (Northing, Easting, and Elevation) at each Primary Project Control Monument as shown in Appendix E – Example GNSS Coordinate Statistical Analysis:

Ensure the RMSE for the Northing, Easting, and Elevation components do not exceed the maximum allowable RMSE for all project control monuments according to the following:

Coordinate Component	Maximum Allowable RMSE
Northing	0.029 feet [0.0088 meters]
Easting	0.029 feet [0.0088 meters]
Elevation	0.039 feet [0.0119 meters]

Table 2 See Appendix B for RMSE Calculation

2006.2.2.8 Geodetic/Primary Project Control Monument Horizontal Coordinates

The Northing and Easting of the Geodetic/Primary Project Control Monument coordinates are determined by taking the average of each coordinate component from the solutions that meet the RMSE requirements as specified in 2006.2.2.7 Coordinate Statistical Analysis.

2006.2.2.9 Geodetic/Primary Project Control Monument Vertical Coordinates

Establish the elevations of Geodetic/Primary Project Control Monuments or their associated project benchmarks by differential leveling. Refer to 2006.3 Differential Leveling for leveling procedures. Differential leveling for Geodetic/Primary Project Control Monuments and project benchmarks will originate from, and close on, the Geodetic Control Monument at the center of the project on Path 4 or 5 projects or the Primary Project Control Monument with the lowest Elevation RMSE value nearest to the center of the project on Path 1-3 projects. Level through all Geodetic and/or Primary Project Control Monuments and project benchmarks. Hold the elevation values established by differential leveling for all Geodetic and Primary Project Control Monuments. As a check, compare the leveled elevations to the GNSS determined elevations from 2006.2.2.7 Coordinate Statistical Analysis. Highlight any differences that exceed 0.10 U.S. Survey Foot.

2006.2.2.10 INS-based Mapping Control (Aerial photo and Mobile Mapping targets)

Aerial photo and Mobile Mapping targets are used to georeferenced images and point cloud data and correctly align and orient individual photos and mobile LiDAR individual scans to other photos and scans. Photo and LiDAR targets are considered secondary control and shall be positioned from and have a direct tie to the primary and/or geodetic control.

2006.2.2.10.1 Photo Targets

Place aerial targets at locations easily identified in aerial photographs. When possible, place all targets within the public right-of-way. Obtain permission prior to placing targets on private property.

The preferred target for ODOT internally acquired aerial photography is a 3 foot by 3 foot cross, 4 inches in width. Use white thermoplastic material thoroughly adhered to the pavement. Other target sizes, shapes, or material may be utilized provided they are clearly visible in aerial photographs. Furnish a PK nail driven flush to the ground at the center of the target.

Use a temporary cloth aerial target for non-pavement applications. Ensure the surface is relatively level. Pull the cloth target tight and securely stake the target to the ground.

2006.2.2.10.2 Picture Points in lieu of targets

Furnish picture point positions if aerial targets are not utilized. Select picture points that can easily be identified on the aerial photographs. Ensure the selected position is not obscured by shadows or directly adjacent to an object extending above the ground by more than 6 inches. Acceptable picture points include, but are not limited to the following:

1. Sidewalk corners
2. Stop bar pavement markings
3. Tip of pavement marking arrows
4. Concrete pad corners
5. Parking lot pavement markings
6. Top of grate corner for catch basins

Furnish a sketch of each picture point feature. Indicate the location of the surveyed point on the sketch. In lieu of a sketch, provide a photo of the Aerial Picture Point showing the point used in the photo.

2006.2.2.10.3 Aerial Photo Alignment Point Surveys

Collect coordinates and elevations at the center of the cross (aerial target) or at the selected picture point using conventional or GNSS survey equipment. Ensure all photo alignment points are positioned relative to the primary and/or geodetic project control. Differential leveling of photo alignment targets is not necessary due to the fact that the aerial photos are only used to determine horizontal locations of mapping features. Document the survey procedures and methods used.

Use the following survey feature codes when collecting aerial photo alignment targets:

Description	Feature Code
Target	AERTAR
Picture Point	AERPP

2006.2.2.10.4 Mobile Mapping LiDAR target Alignment Point Surveys

For ODOT internally collected data, provide chevron targets with a minimum tail of 2 foot by 6 inches wide, for aligning mobile mapping scans by setting targets at 600-foot intervals along the outside edges of pavement along the alignment to be mapped. Targets should be placed in a manner that makes them visible in as many scans as possible. Acquire horizontal coordinates on targets through GNSS or conventional surveys. Elevations of targets should be acquired through differential leveling. Other target sizes, shapes, or material may be utilized provided they are clearly visible within the point cloud.

2006.2.2.11 Intermediate Project Control

Intermediate project control for surveying purposes is to be positioned relative to the Geodetic/Primary Project Control.

2006.2.2.12 Project Adjustment Factor (Grid to Ground Multiplier) (Does not Apply to OCCS Projects)

The Project Adjustment Factor shall be documented and used for all projects using State Plane Coordinates scaled to Ground. The Project Adjustment Factor shall be calculated by taking the inverse of the combined scale factor (1/ (coordinate scale factor x ellipsoid height scale factor)). Scale the project about an origin of (0.0). Provide Project Adjustment Factor to the 8th decimal place. If a Project Adjustment Factor is required, use one of the following methods for establishing the combined scale factor:

- The Latitude of the center Geodetic Control Monument or Primary Project Control Monument closest to the center of the project shall be used to calculate the Project Adjustment Factor for all projects regardless of the method used to locate the monument or method used to determine the Project Adjustment Factor. An ellipsoid height that is a good representation of the average height of the project site shall be used to calculate the ellipsoid height scale factor.
- Project Adjustment Factor may be derived by other means with approval of the District Survey Operations Manager (e.g., Data Collector solution, TBC, Infinity, Magnet tools) based on GNSS data collected for any individual point. The control point used should meet the RMSE requirements as reported by OPUS or OPUS-RS.
- 0,0 Origin of the PAF in Lat/Long:
  - North Zone: Latitude/Longitude of 0,0 origin point:
    - **N 39° 27’ 01.76097”/W 89° 28’ 32.98476”**
  - South Zone: Latitude/Longitude of 0,0 origin point:
    - **N 37° 47’ 45.30621”/W 89° 19’ 00.02517”**

Projects completed using Ohio County Coordinate System projections are not to be scaled using a Project Adjustment Factor.

2006.2.2.13 Site Calibration

Site Calibration: Observe a minimum of 4 control points to establish a horizontal site calibration and 5 control points to establish a vertical site calibration. The entire project should lie within the control point network. Hold the initial scale of the site calibration fixed at 1 to determine if the horizontal and vertical residuals of the control points are within the current RMSE tolerances. If one or more control points are out of the current RMSE tolerances they can be discarded, and another point can be added to the calibration. If you are performing a Site Calibration on the Grid Coordinates, the GNSS observed Site Calibration Coordinates and the Horizontal and Vertical Residual, shall be included in the final deliverables to the Survey Operations Manager. Consult the Survey Operations Manager regarding Site Calibrations that need to be performed on ODOT projects.

2006.2.2.14 Deliverables

Furnish the following deliverables as soon as possible before the Beginning of Design:

- Surveyor's Certification Statement (See Appendix D – Surveyor's Certification Statement).
- A table that includes geodetic/primary project control coordinates. Include the following in the table:
    - Point Number
    - Point Description
    - Monument Type
    - Positioning Method
    - Type A primary geodetic/project control orthometric heights (U.S. survey feet)
    - Project Benchmark number, description, and orthometric height listed with each Type B primary control monument
    - Coordinates*
        - Northing
        - Easting
        - Ortho Height
            - If applicable, Scaled Coordinates (Ground)**
                - Include the Project Adjustment Factor, associated monument, and average ellipsoidal height.

For OCCS based coordinates provide values in US survey feet. State Plane (Grid) coordinates are to be provided in meters and US survey feet (Ground coordinates, when applicable, are furnished in US survey feet only, in addition to grid)

- NGS OPUS data sheets if used in the solutions
- Statistical analysis for each Geodetic/Primary Project Control Monument (See example, Appendix E – Example Static GNSS Coordinate Statistical Analysis)
- Native survey data files in Trimble RAW or RINEX format
- A general map of the entire project with the control monuments identified in PDF, .dgn (version according to the Location and Design Manual, Volume 3, Section 1204), or any standard raster format.
- All field notes, sketches, and adjustment calculations
- All differential leveling deliverables as specified in Section 2006.3.6 Deliverables
- Documentation confirming the calibration of all survey equipment used
- Copies of Ohio Utility Protection Service (OUPS) Tickets

Ensure all deliverables are on the same datum and coordinate system as specified in Section 2004 Datums, Coordinate Systems, and Positioning Parameters. Furnish deliverables to the District Survey Operations Manager before performing any additional work indicated in this specification. Allow ten working days for review. Consultants may proceed at their discretion if comments are not received after ten working days. A licensed Professional Surveyor registered in the State of Ohio will sign, seal, and certify that all work performed meets or exceeds the requirements of this specification for geodetic and primary project control.

2006.3 Differential Leveling

2006.3.1 General

Perform differential leveling to determine the orthometric height of Geodetic and Primary Project Control Monuments, project benchmarks, and other benchmarks. Differential leveling may also be performed to establish elevations of secondary and temporary control points as needed.

2006.3.2 Project Benchmarks

Construct or identify project benchmarks in conjunction with Type B Primary Horizontal Project Control Monuments. Construct project benchmarks as required to complete project-related tasks or were dictated by the District Survey Operations Manager. Ensure project benchmarks are stable. Furnish project benchmarks that are easily accessible, located outside anticipated construction areas, clear of traffic, and within a public right of way or easement. Include a list of project benchmarks with the deliverables. Ensure station/offset and descriptions are included. Commence and close all leveling for project benchmarks from an established geodetic/primary control point monument as specified in Section 2006.2.2 Project Control.

When Type B control monuments are used, separate benchmarks are required in addition to the Type B Control Monuments. Any Type B monuments should be included with any differential leveling performed for the establishment of the project's benchmarks, however they are not the project's primary vertical control.

2006.3.3 Differential Leveling Surveys

Complete leveling surveys to the accuracy required in this specification. Higher accuracy leveling may be required for specific projects or when specified by the District Survey Operations Manager. Ensure proper leveling procedures are followed to obtain the required accuracy. To increase accuracy, consider balancing foresights and backsights, sight length limitations, and multiple rod readings. Use equipment meeting Section 2009 Survey and Mapping Equipment requirements.

2006.3.4 Closure Requirements

The following equation defines the maximum allowable misclosure for all level loops:

$$\textbf{0.04 feet x } (\sqrt{\textbf{E}})$$

E = Length of the loop in miles (loop is defined as a series of setups closing on the starting point).

Re-level all level loops whose misclosure exceeds this closure requirement.

Consult the district Survey Operations Manager if site conditions make meeting the published closure requirements challenging.

2006.3.5 Leveling Adjustments

Adjust level loop misclosures that fall within given closure requirements. Corrections for the closing error can be prorated equally or adjusted using a weighted average using survey software. Each turning point and benchmark between the controlling monument(s) shall be adjusted for the length of the level loop.

2006.3.6 Deliverables

- Surveyor's Certification Statement
- Report of all geodetic/primary project control, and Project benchmark elevations established. Include the following as a minimum: point name, elevation, description of the mark and a sketch defining its location.
- Field notes for all leveling work
- Listing of all field crew members/titles
- Details of misclosures, calculations and adjustments
- Make, model, serial numbers and firmware versions of all equipment used
- Post-processing software used with version number (where applicable)
- Show the difference between leveled and GNSS-derived elevations for all Type A Geodetic/Primary Project Control Monuments or Project benchmarks for Type B monuments.
- Documentation confirming the calibration of appropriate survey equipment used.

2007 Boundary Surveys

2007.1 General

ODOT surveying and mapping projects may require the location, retracement and establishment of boundaries including private and public properties, federal, state, county and municipal boundaries, public land subdivisions, highway alignments, easements, etcetera. Ensure all ODOT boundary surveys originate from monumentation constructed and/or positioned according to this specification. Ensure conformance to all county, municipal and jurisdictional survey requirements for the project location. Ensure all work is performed in conformance with O.A.C. 4733 & O.R.C. 4733 and the ODOT Right-of-Way Design Manual.

2007.2 Boundary Surveys

Boundary surveys are required for all parcels that may be legally affected, altered or transferred, either temporarily or permanently, as part of an ODOT project. Refer to the project scope of services or the District Survey Operations Manager for further project-specific information. All boundary surveys shall be tied to the Geodetic and/or Primary Project Control.

2007.3 Right of Way & Highway Centerline Surveys

Boundary surveys are required for all parcels that may be legally affected, altered or transferred, either temporarily or permanently, as part of an ODOT project. Refer to the project scope of services or the District Survey Operations Manager for further project-specific information. All boundary surveys shall be tied to the Geodetic and/or Primary Project Control.

2008 Mapping Surveys

2008.1 General

A mapping survey is the collection of points to define the features (natural, manufactured, or both) of a physical surface. This section is divided into different methodologies in which these features are collected:

- INS-Based Mapping Surveys: An INS-Based Mapping Survey is the collection of points to define the features (natural, manufactured, or both) of a physical surface that is carried out without the direct observation of geodetic/primary control points. The equipment used in INS-based mapping survey collection relies on positioning based on INS solutions and/or mapping control points. Examples may include Aerial Mapping Surveys, Mobile Mapping Surveys, UAS-based photogrammetry, etc.

- Conventional Mapping Survey: A Conventional mapping survey is the collection of points to define the features (natural, manufactured, or both) of a physical surface that is collected directly from ground control, using conventional survey equipment, and is physically measured using a total station, Terrestrial Scanner, or GNSS equipment. Conventional mapping surveys do not require separate, independent ground control for controlling and verifying mapping accuracies (due to the ability of the equipment to observe/occupy project control directly). Examples may include conventional topographic surveys and hydrographic surveys.

All ground control work associated with positioning INS-based mapping surveys shall be directly supervised and certified by a professional surveyor licensed in the State of Ohio.

2008.2 INS-Based Mapping Surveys

All INS-based mapping surveys must abide by the following absolute accuracy classes outlined in 2008.2.1 DTM Vertical Accuracy and 2008.2.2 Horizontal Planimetric Accuracy. The testing procedures necessary for all INS-Based Mapping Surveys and are outlined in Appendix B – Example RMSE Calculation for Vertical DTM & Horizontal Planimetric Features. Conventional Mapping Surveys must utilize established processes and internal checks to meet the accuracy classes outlined in the following sections.

2008.2.1 DTM Vertical Accuracy

DTM vertical accuracy shall be uniformly tested amongst all INS Based Mapping Surveys to meet the project's requirements.

Checkpoints used to verify INS Based Mapping Surveys should be dispersed throughout the project and collected by an independent source of higher accuracy.

- **Independent Source of Higher Accuracy**: The independent source of higher accuracy shall be acquired separately from data used in the aero-triangulation solution or other production procedures. The independent source of higher accuracy shall be of the highest accuracy feasible and practicable to evaluate the accuracy of the dataset. Unless otherwise specified, these points shall be located using techniques described in Section 2006.2 Control Surveys of this document. (FGDC, 1998, Appendix 3 Section 1)

- **Checkpoint Location:** Due to the diversity of project limits and requirements, it is unrealistic to outline the exact location of independent checkpoints. As a guideline, checkpoints should be distributed more densely in the vicinity of important features. They may be more sparsely distributed in areas that have limited influence on the project. Attempt to maintain equal dispersion through the corridor limits. For rectangular-based project limits (as opposed to corridor limits), check points may be distributed so that points are spaced at intervals of at least 10% of the diagonal distance across the dataset and at least 20% of the points are located in each quadrant of the dataset. Checkpoint quantities must follow the quantity calculations below. (ASPRS, 2014, Section C.4)

- **Vertical Checkpoints:** Vertical checkpoints shall be established at locations that minimize interpolation errors. Vertical checkpoints shall be surveyed on flat or uniformly sloped open terrain and with slopes of 25% or less and must avoid vertical artifacts or abrupt changes in elevation, as noted in ASPRS (2014, Section 7.9). In a single checkpoint location, points shall be spaced apart by five ft. with a maximum of four points per location.

Datasets shall be tested for both vegetated and non-vegetated vertical accuracy:

- Non-Vegetated Vertical Accuracy (NVA) – The vertical accuracy at the 95% confidence level in non-vegetated open terrain, where errors should approximate a normal distribution.
  - Non-Vegetated land cover is categorized as bare soil, sand, rock, asphalt, concrete surfaces, etc.
- Vegetated Vertical Accuracy (VVA) – An estimate of the vertical accuracy, based on the 95th percentile, in vegetated terrain where errors do not necessarily approximate a normal distribution.
  - Vegetated land cover is to include grass areas, tall weeds, crops, brush lands, etc.

To determine the minimum number of checkpoints, use the following formula:

Minimum Number of Non-Vegetated Points = 20+2*x

AND

Minimum Number of Vegetated Points = 20+2*x

Note: X is equal to the distance of the project in miles

Data Set	Vertical Accuracy Class	$RMSE_Z$, Non-Vegetated	NVA at 95% Confidence Level	VVA at 95% Confidence Level
	US ft.	US ft.	US ft.	US ft.
Design (High Accuracy)	0.03	≤0.03	≤0.06	≤0.09
Design (Standard Accuracy)	0.07	≤0.07	≤0.14	≤0.21
Planning Accuracy	0.25	≤0.25	≤0.49	≤0.75

Table 3 Based on ASPRS Positional Accuracy Standards for Absolute Vertical Accuracy

Required methods for absolute accuracy testing are located in Appendix B – Example RMSE Calculation for Vertical DTM & Horizontal Planimetric Features.

For all Mapping Surveys the Department may collect Vertical Checkpoints for independent verification of the DTM accuracies anywhere within the project. If the Department finds any vertical discrepancies that exceed the maximum allowable $RMSE_Z$, the Consultant will perform any corrective work necessary to meet this specification at no additional cost to the Department within a time frame agreed upon by the Department and the Consultant.

2008.2.1.1 DTM Vertical Accuracy Statement

Utilize this statement in any metadata/documentation/surveyor certification when referencing the accuracy of the dataset:

"This data set was tested to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for an Ohio Department of Transportation (**Insert Vertical Accuracy Class Label)** (US ft.) $RMSE_Z$ Vertical Accuracy Class. Actual NVA accuracy was found to be $RMSE_Z$ = ___ US ft., equating to +/- ___ US ft. at a 95% confidence level. Actual VVA accuracy was found to be +/- ___ US ft. at the 95th percentile."

Calculation examples are in Appendix B – Example RMSE Calculation for Vertical DTM & Horizontal Planimetric Features.

2008.2.2 Horizontal Planimetric Accuracy

This specification covers the collection of existing planimetric features and all known underground utilities. INS Based Mapping Survey products are included with this specification and may be required in the scope of services. Ensure positioning is performed relative to geodetic/primary project control.
Collect Planimetric Checkpoints along well-defined planimetric features shown in the delivered mapping. Checkpoints collected for the vertical DTM accuracy test may be utilized if they are on a planimetric feature (for example: painted edge line). Checkpoints should be dispersed throughout the project and not located within 200 ft. of mapping control points.

- Well-Defined Points: Represent a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself.

To determine the minimum number of checkpoints, use the following formula:

Number of Planimetric Checkpoints = 20+2*x, where x is equal to the distance of the project in miles

Planimetric Features	**Maximum Allowable Horizontal Accuracy Class**	**Maximum $RMSE_X$ and $RMSE_Y$**	**Maximum $RMSE_R$**	**Maximum Horizontal Accuracy at 95% Confidence Level**
	US ft.	US ft.	US ft.	US ft.
Planimetric features listed in Appendix A	0.21	0.21	0.30	0.51

Table 4 Based on ASPRS Positional Accuracy Standards for Absolute Horizonal Data

Required methods for absolute accuracy testing are located in Appendix B–Example RMSE Calculation for Vertical DTM & Horizontal Planimetric Features.

For all Mapping Surveys the Department may collect planimetric Checkpoints for independent verification of the planimetric feature accuracies anywhere within the project. If the Department finds any planimetric features that exceed the maximum allowable $RMSE_R$, the Consultant will perform any corrective work necessary to meet this specification at no additional cost to the Department within a time frame agreed upon by the Department and the Consultant.

2008.2.2.1 Horizontal Planimetric Accuracy Statement

Utilize this statement in any metadata/documentation/surveyor certification when referencing the horizontal accuracy of the dataset:
"This data set was tested to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for an Ohio Department of Transportation 0.21 (US ft.) $RMSE_X$ / $RMSE_Y$ Horizontal Accuracy Class. Actual positional accuracy was found to be $RMSE_X$ = ___ (US ft.) and $RMSE_Y$ = ___ (US ft.) which equates to Positional Horizontal Accuracy = +/- ___ US ft. at 95% confidence level."

See Appendix B –Example RMSE Calculation for Vertical DTM & Horizontal Planimetric Features for horizontal planimetric feature accuracy calculation procedure.

2008.2.3 Mapping Control

Collect coordinates and elevations at the center of the aerial target or selected picture point for photo control. All ground control (Targets and Picture Points) shall be furnished with a survey nail except on private property. Ensure all photo control is positioned relative to the Geodetic Control and/or Primary Project Control and meets the RMSE tolerances outlined in 2006.2.2.7 Coordinate Statistical Analysis. A professional surveyor licensed in the State of Ohio will document the accuracies, survey procedures and methods used. Vertical control for debiasing point cloud data does not require a physical monument but should still be positioned following Section 2006.2 Control Surveys and tied to Geodetic and/or Project Control.

If a geodetic/primary control survey will not be performed, all aerial control horizontal surveys shall be referenced to and tied into the National Spatial Reference System (NSRS) as defined by the National Geodetic Survey (NGS) or through the project scoping process.

2008.2.3.1 UAS Specific Mapping Control

The total number of Ground Control Points (GCPs) shall be determined by the following formula:

Total GCPs = Area (in acres) x 0.2

There will be a minimum number of 5 GCP's set for any project. GCPs shall be located to ensure an evenly distributed Triangular network exists throughout the entire project area. These points are used to control the products generated, not check the absolute accuracy of the deliverables.

2008.2.4 UAS Specific Data Collection (Flight Parameters)

For projects utilizing UAS, consult with the District Survey Operations Manager, or the Office of CADD and Mapping Services to determine equipment and collection that best meets project needs. It is generally recommended that UAS data collection for survey and mapping be limited to projects that are no larger than 50 acres or 1 mile in length.

Flights should be planned with FAA requirements, UAS Center's policies and procedures, as well as ground sampling distance (GSD) condition requirements.

2008.3 Conventional Mapping Surveys

2008.3.1 Accuracies

All data collected via conventional technologies shall be collected using means and methods that meet the mapping accuracy requirements set forth within this section. Deliverables should be generated by directly observing/occupying Geodetic/Project Control as defined in Section 2006.2 Control Surveys.

Conventional mapping surveys do not require separate, independent ground control for controlling and verifying mapping accuracies (due to the ability of the equipment to directly observe or occupy project control). Using established workflows and surveying judgement, proper equipment must be utilized to achieve these accuracy thresholds as scoped for the project:

Data Set	Vertical Accuracy Class	$RMSE_Z$, Non-Vegetated	NVA at 95% Confidence Level	VVA at 95% Confidence Level
	US ft.	US ft.	US ft.	US ft.
Design (High Accuracy)	0.03	≤0.03	≤0.06	≤0.09
Design (Standard Accuracy)	0.07	≤0.07	≤0.14	≤0.21
Planning Accuracy	0.25	≤0.25	≤0.49	≤0.75

Table 5 Based on ASPRS Positional Accuracy Standards for Vertical Data

Planimetric Features	**Maximum Allowable Horizontal Accuracy Class**	**Maximum $RMSE_X$ and $RMSE_Y$**	**Maximum $RMSE_R$**	**Maximum Horizontal Accuracy at 95% Confidence Level**
	US ft.	US ft.	US ft.	US ft.
Planimetric features listed in Appendix A	0.21	0.21	0.30	0.51

Table 6 Based on ASPRS Positional Accuracy Standards for Absolute Horizonal Data

For all Mapping Surveys, the Department may collect vertical and planimetric checkpoints for an independent verification of the planimetric feature and vertical accuracies anywhere within the project. If the Department finds any planimetric features that exceed the maximum allowable $RMSE_R$ or $RMSE_Z$, the Consultant will perform any corrective work necessary to meet this specification at no additional cost to the Department within a time frame agreed upon by the Department and the Consultant.

2008.3.1.1 Conventional Mapping Surveys Accuracy Statement

Utilize this statement in any metadata/documentation/surveyor certification when referencing the accuracy of the dataset collected using conventional means (as defined in 2008.1 General):
"This data set was produced to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for an Ohio Department of Transportation (**Insert Vertical Accuracy Class**) US ft. $RMSE_Z$ Vertical Accuracy Class equating to NVA = +/- (**Insert NVA Value to corresponding Vertical Accuracy Class**) US ft. at 95% confidence level and VVA = +/- (**Insert VVA Value to corresponding Vertical Accuracy Class**) US ft. at the 95th percentile and 0.21 US ft. $RMSE_X$ / $RMSE_Y$ Horizontal Accuracy Class which equates to Positional Horizontal Accuracy = +/- 0.51 US ft. at a 95% confidence level."

Utilize the report template located within the Appendix C – Example Mapping Quality Control Report (Downloadable Templates) for Conventional Based Mapping Surveys.

2008.4 Deliverables

Furnish deliverables to the District Survey Operations Manager prior to performing any engineering design work. If 2006.2.2.14 Deliverables have not been previously submitted, the below mapping deliverables shall include the 2006.2.2.14 Deliverables. Allow 10 working days for review. Consultant may proceed at their own discretion if comments are not received.

The following deliverables are required to be delivered to the Survey Operations Manager when applicable:

- Surveyors Certification Statement (See Appendix D)
- Quality Control Report
- Control Report (Survey Master Excel Sheet)
- Differential Leveling Data
- Calibration Report(s)
- Image Specific
    - Aero-Triangulation Solution for Imagery
    - Orthomosaic referenced in project coordinate system**
    - Processed images in digital format (Raw images need to be available on request without additional cost to the department) **
- UAS Collection Information
- Basemap(s)
- .xml files (alignments and terrains)
- Point Cloud(s) (when requested)**
- Survey Research, when applicable (i.e., plans, deeds, reference surveys, record Sub Plats, record easements, etc.).

Ensure all deliverables are on the proper datum and coordinate system as scoped for the project.
**All imagery and lidar point cloud files are considered the property of ODOT and must be available for delivery at no additional cost to the department (when utilized in a required deliverable).

2008.4.1 Surveyor's Certification Statement

Any control established and verification of a mapping survey must be done under the direct supervision of a professional surveyor licensed in the State of Ohio (e.g., Primary Control, Ground Control Points etc.).

Appendix I –See Appendix I – for a template of a Surveyor's Certification Statement.

2008.4.2 Quality Control Report

A Survey and Mapping Quality Control Report (Appendix C – Example Mapping Quality Control Report) must be submitted to the District Survey Operations Manager for review and comments before submission of Stage 1 engineering plans. All mapping to be used for ODOT projects must be reviewed and certified by a licensed Professional Surveyor as to accuracy (Planning level or Design level) of the mapping and control accuracy. The quality control report shall include all field notes, level notes, and any other pertinent information attesting to the accuracy of the mapping and control. This certification applies to all mapping as specified under Section 2006 Types of Surveys.

Calculations based within the report are explained in Appendix B – Example RMSE Calculation for Vertical DTM & Horizontal Planimetric Features. All data must meet the reporting language outlined in 2008.2 INS-Based Mapping Surveys (Accuracies) for the acquisition method.

2008.4.3 Control Report

Provide all documentation as a result of the completion of Section 2006.2 Control Surveys as scoped by project requirements. A statistical evaluation of the data shall be completed following the standards set forth in Section 2006.2.2.7 Coordinate Statistical Analysis.

2008.4.4 Equipment Calibration/Certifications

Any equipment used in the creation of project deliverables must meet the calibration requirements as specified in Section 2009 Survey and Mapping Equipment. Include the following as applicable:

- Boresight alignment calibration parameters for any airborne/mobile sensors utilized for mapping
- Camera calibration certificate
- GNSS/INS system lever arms for any airborne sensors
- Documentation confirming the calibration of all survey equipment used
- Any calibration/certificates for equipment required to adjust the data set
    - GNSS/INS system lever arms for any sensors

2008.4.5 Imagery Deliverables

- Raw and Processed images in digital format
- Aero Triangulation Solution
- Orthomosaic TIFF referenced in project coordinate system

    - Furnish an orthophoto that is rectified to the ground and bridge deck surfaces. "True orthophotos" of buildings, utilities, or other items (exclusive of bridge deck surfaces) that are 4 feet or more above the existing ground surface are not required.
    - Ensure the pixel size of the orthophoto is less than or equal to 6 inches and the file size is less than 1GB.
    - Ensure the orthophoto is color, free of visible image smear, noticeable seam lines, artifacts, has a uniform tone and brightness, and is free of misalignment errors.
        - Make all effort within project scope and reason, to minimize image distortion in deliverables or deliverables generated from imagery (terrain relief, lens, etc.).

2008.4.6 Basemap Design Files

Provide all basemap design files produced for mapping survey. See the Location and Design Manual Volume 3, Section 1204, for proper design file standards.

2008.4.7 LandXML

All existing surfaces and alignments (if applicable) shall be submitted in LandXML format or as otherwise scoped.

2008.4.8 Point Clouds

When required, provide the Survey Operations Manager with a point cloud delivered in a .las format. If the point cloud was utilized in the creation of a Digital Terrain Model (DTM) deliver the classified point cloud with the final deliverables using ASPRS (2019) classification schema (e.g., Ground Classification (Class 2), etc.).

2009 Survey and Mapping Equipment

2009.1 Equipment Care and Maintenance

Proper handling and servicing of all surveying equipment is essential to achieving the accuracy and precision required for ODOT projects. Careful handling of high accuracy instrumentation such as total stations, levels, GNSS receivers and other components is critical. Replace or repair broken, faulty, or inaccurate equipment prior to performing ODOT survey work.

2009.2 Equipment Types and Specifications

2009.2.1 Levels

Optical and digital levels are acceptable for leveling operations. Leveling rods are to be single section or multi-section fiberglass, wood, or metal. Leveling instruments are required to meet the following minimum manufacturer specifications:

- Internal compensator/auto-level
- Height accuracy of ± 1.5mm standard deviation for 1km double run leveling

2009.2.2 Total Stations

Total Stations are to be capable of measuring horizontal angles, vertical angles, and distances electronically in a single unit. Total stations are required to meet the following minimum manufacturer specifications:

- Compensated with a dual axis compensator
- Horizontal and vertical angular accuracy with a minimum of 5 seconds
- EDM accuracy of ± (3mm + 3ppm) to a reflective prism

2009.2.3 GNSS Receivers

GNSS receivers are to be survey grade units and are required to meet the following minimum specifications as provided by the manufacturer:

- Capable of tracking L1 and L2 frequency signals
- Static positioning accuracy of 5mm+1ppm horizontal/6mm+1ppm vertical (post processed)
- Kinematic positioning accuracy of 10mm+1ppm horizontal/20mm+1ppm vertical

2009.2.4 INS Based Mapping Systems

INS Based Mapping Systems are required to be survey grade and meet the accuracy standards set forth in 2007.3.1 Accuracies. INS Based Mapping Systems include but are not limited to LiDAR Systems, Digital Cameras, etc.

2009.2.4.1 Authorized use of UAS for Survey and Mapping

OAC 4733-31-01 requires all surveying and mapping applications, which encompasses photogrammetry based on code definition, to be conducted under the direct supervision of a Professional Surveyor licensed in the State of Ohio. In addition, OAC 4733-31-01 states:

(A) Surveying shall mean any professional service performed for the purpose of determining land areas, the monumenting of property boundaries, the platting and layout of lands and sub-divisions thereof, including the topography, the alignment and the preliminary grades of streets, the preparation of maps, record plats, field note records and property descriptions representing such surveys.

(B) The adequate performance of such work involves the application of special knowledge of the principles of mathematics, the related physical and applied sciences, and the relevant requirements of law for adequate evidence to the act of measuring, and locating lines, angles, elevations, natural and man-made features in the air, on the surface of the earth, within underground workings, and on the beds of bodies of water.

2009.3 Equipment Calibration and Maintenance

Ensure all surveying and mapping equipment is calibrated and adjusted in accordance with the manufacturer's recommendations. Documentation of all equipment adjustments and calibrations shall be kept and made available to ODOT upon request. Refer to the following criteria as a minimum for equipment maintenance.

2009.3.1 Levels

Ensure professional calibration and servicing is performed per the manufacturer's specifications.
A two-peg test should be performed each day or at minimum at the beginning of a new project.
In addition, perform maintenance and care according to the following schedule:

Every 3 Months:

- Clean and inspect optics, electrical contacts, instrument body, and instrument case.
- Check and adjust level vials.
- Peg test the level and adjust as needed.

2009.3.2 Total Stations

Ensure professional calibration and servicing is performed per the manufacturer's specifications.
Perform an instrument collimation at the beginning of each day or at a minimum at the beginning of a new project.
In addition, perform maintenance and care according to the following schedule:

Every 3 Months:

- Clean and inspect optics, electrical contacts, instrument body, and instrument case.
- Check and adjust level vials.
- Check and adjust vertical plummet.
- Check horizontal and vertical circle collimation and adjust as needed.

Every 6 Months:

- Check calibration of E.D.M. on a baseline and adjust as needed.

2009.3.2.1 Tripods, Tribrach's, Prism Rods, and RTK Rods

Perform maintenance and care according to the following schedule:

Every 3 Months:

- Clean and inspect.
- Adjust level vials.
- Adjust the optical plummet.
- Tighten all clamps, locks, feet, and screws to the proper specification.

2100 Ohio County Coordinate Systems (OCCS)

2101 Introduction

The Ohio County Coordinate System (OCCS) is a set of low-distortion projection coordinate systems tailored specifically for individual counties in Ohio. It was developed to meet the needs of modern surveying, mapping, and engineering by reducing the distortion that can occur when using broader, statewide coordinate systems like State Plane Coordinates.

The OCCS is a group of customized coordinate zones, each designed specifically for one of Ohio's 88 counties. These zones use transverse Mercator or lambert conformal conic projections that are optimized to:

- Align with each county's shape and orientation
- Minimize ground-to-grid distortion (often less than 1 part in 50,000)
- Provide more accurate real-world coordinates for construction, land surveying, and GIS work

The Ohio County Coordinate System is the preferred map projection for all ODOT projects. The Ohio State Plane Coordinate System may still be used in special circumstances and only at the discretion of the ODOT District Survey Operations Manager.

2102 Zone Parameters

The following table contains the projection parameters for each county zone. All county zones are based on NAD 83 (2011) using the GRS 80 ellipsoid. Each zone is either a Lambert Conformal Conic with 1 standard parallel or a Transverse Mercator projection. False northing/easting of 100,000m/50,000m for all Lambert projections and false northing/easting of 0/50,000m for all Mercator projections were used to meet NGS requirements. The ellipsoid was scaled in each zone to closely match the topographic surface, minimizing distortion. The U.S. Survey Foot definition should be used for all OCCS zones in NAD 83 (2011).

Low Distortion Map Projections

Reference Frame (Datum): NAD 83 (2001)
Foot Definition: U.S. Survey Foot

County Number	Name	Abbreviation	Projection	Origin Latitude	Origin Longitude	False Northing (m)	False Easting (m)	Scale Factor	Average PPM	Lowest PPM	Highest PPM	95% Confidence Level
1	Adams	ADA	LCC 1 Parallel	N 38° 45’ 00”	E 276° 30’ 00”	100000	50000	1.000028	-4.2	-26.7	13.3	15.1
2	Allen	ALL	LCC 1 Parallel	N 40° 54’ 00”	E 275° 54’ 00”	100000	50000	1.000032	-0.4	-7.9	6.6	5.3
3	Ashland	ASD	TM	N 39° 39’ 00”	E 277° 42’ 00”	0	50000	1.000052	4.1	-10.3	15.3	9.2
4	Ashtabula	ATB	LCC 1 Parallel	N 41° 51’ 00”	E 279° 15’ 00”	100000	50000	1.000032	-0.3	-17.3	17.6	12.5
5	Athens	ATH	LCC 1 Parallel	N 39° 21’ 00”	E 277° 54’ 00”	100000	50000	1.000033	1.0	-10.8	15.3	8.8
6	Auglaize	AUG	LCC 1 Parallel	N 40° 36’ 00”	E 275° 45’ 00”	100000	50000	1.000039	1.1	-7.6	8.2	7.0
7	Belmont	BEL	TM	N 38° 30’ 00”	E 279° 00’ 00”	0	50000	1.000041	-4.4	-20.4	23.9	16.4
8	Brown	BRO	TM	N 37° 33’ 00”	E 276° 00’ 00”	0	50000	1.000036	0.9	-7.5	22.9	11.8
9	Butler	BUT	TM	N 38° 03’ 00”	E 275° 30’ 00”	0	50000	1.000032	2.1	-10.8	15.5	10.3
10	Carroll	CAR	TM	N 39° 15’ 00”	E 278° 45’ 00”	0	50000	1.000043	-2.2	-11.8	13.9	8.4
11	Champaign	CHP	LCC 1 Parallel	N 40° 09’ 00”	E 276° 15’ 00”	100000	50000	1.000045	-2.7	-14.4	7.8	7.2
12	Clark	CLA	LCC 1 Parallel	N 39° 54’ 00”	E 276° 12’ 00”	100000	50000	1.000045	0.5	-10.2	11.6	8.4
13	Clermont	CLE	TM	N 37° 33’ 00”	E 275° 45’ 00”	0	50000	1.000030	-2.0	-8.8	16.0	10.0
14	Clinton	CLI	TM	N 38° 03’ 00”	E 276° 06’ 00”	0	50000	1.000043	1.6	-5.2	11.1	5.2
15	Columbiana	COL	TM	N 39° 24’ 00”	E 279° 21’ 00”	0	50000	1.000042	-3.5	-19.0	16.8	11.7
16	Coshocton	COS	LCC 1 Parallel	N 40° 15’ 00”	E 278° 06’ 00”	100000	50000	1.000036	-2.7	-17.0	9.7	10.5
17	Crawford	CRA	TM	N 39° 27’ 00”	E 277° 00’ 00”	0	50000	1.000040	-1.4	-10.5	8.3	5.2
18	Cuyahoga	CUY	TM	N 40° 09’ 00”	E 278° 15’ 00”	0	50000	1.000029	-3.5	-26.1	13.5	15.8
19	Darke	DAR	TM	N 38° 45’ 00”	E 275° 24’ 00”	0	50000	1.000041	-2.5	-10.4	7.2	4.5
20	Defiance	DEF	LCC 1 Parallel	N 41° 21’ 00”	E 275° 30’ 00”	100000	50000	1.000031	1.6	-5.4	8.0	5.6
21	Delaware	DEL	TM	N 38° 54’ 00”	E 276° 51’ 00”	0	50000	1.000041	4.0	-1.9	11.2	4.6
22	Erie	ERI	LCC 1 Parallel	N 41° 24’ 00”	E 277° 27’ 00”	100000	50000	1.000027	1.9	-8.4	13.1	7.9

County Number	Name	Abbreviation	Projection	Origin Latitude	Origin Longitude	False Northing (m)	False Easting (m)	Scale Factor	Average PPM	Lowest PPM	Highest PPM	95% Confidence Level
23	Fairfield	FAI	LCC 1 Parallel	N 39° 45’ 00”	E 277° 21’ 00”	100000	50000	1.000037	-0.8	-13.7	9.7	8.2
24	Fayette	FAY	TM	N 38° 12’ 00”	E 276° 39’ 00”	0	50000	1.000040	0.2	-4.1	7.3	4.1
25	Franklin	FRA	TM	N 38° 24’ 00”	E 276° 54’ 00”	0	50000	1.000037	4.0	-5.0	17.0	8.8
26	Fulton	FUL	LCC 1 Parallel	N 41° 30’ 00”	E 275° 51’ 00”	100000	50000	1.000025	-2.8	-6.7	4.2	3.9
27	Gallia	GAL	TM	N 37° 30’ 00”	E 277° 45’ 00”	0	50000	1.000025	-3.1	-17.8	7.0	9.3
28	Geauga	GEA	LCC 1 Parallel	N 41° 36’ 00”	E 278° 48’ 00”	100000	50000	1.00042	-4.2	-16.8	14.4	11.7
29	Greene	GRE	TM	N 38° 15’ 00”	E 276° 06’ 00”	0	50000	1.000041	1.1	-5.0	12.9	8.0
30	Guernsey	GUE	LCC 1 Parallel	N 40° 09’ 00”	E 278° 27’ 00”	100000	50000	1.000041	3.2	-15.1	20.6	12.8
31	Hamilton	HAM	LCC 1 Parallel	N 39° 06’ 00“	E 275° 24’ 00“	100000	50000	1.000026	0.0	-13.1	13.0	12.6
32	Hancock	HAN	LCC 1 Parallel	N 41° 03‘ 00”	E 276° 21‘ 00”	100000	50000	1.000030	-1.3	-6.3	4.3	3.5
33	Hardin	HAR	LCC 1 Parallel	N 40° 45’ 00”	E 276° 24‘ 00”	100000	50000	1.000042	2.9	-2.5	8.9	3.6
34	Harrison	HAS	TM	N 38° 57‘ 00”	E 278° 54‘ 00”	0	50000	1.000043	-2.7	-13.1	12.3	10.2
35	Henry	HEN	TM	N 40° 03‘ 00”	E 275° 54‘ 00”	0	50000	1.000027	0.3	-3.2	6.0	3.3
36	Highland	HIG	LCC 1 Parallel	N 39° 09‘ 00”	E 276° 24‘ 00”	100000	50000	1.000042	1.2	-15.0	15.2	8.5
37	Hocking	HOC	LCC 1 Parallel	N 39° 33‘ 00”	E 277° 36‘ 00”	100000	50000	1.000034	-3.1	-18.2	12.6	10.0
38	Holmes	HOL	TM	N 39° 12‘ 00”	E 278° 06‘ 00”	0	50000	1.000044	-0.2	-13.4	14.4	10.5
39	Huron	HUR	LCC 1 Parallel	N 41° 18‘ 00”	E 277° 24‘ 00”	100000	50000	1.000037	4.7	-1.5	14.2	6.4
40	Jackson	JAC	LCC 1 Parallel	N 39° 03‘ 00”	E 277° 24‘ 00”	100000	50000	1.000027	-3.5	-16.7	8.8	8.4
41	Jefferson	JEF	TM	N 39° 00‘ 00”	E 279° 24‘ 00”	0	50000	1.000040	-3.0	-15.4	15.4	13.9
42	Knox	KNO	LCC 1 Parallel	N 40° 24‘ 00”	E 277° 33‘ 00”	100000	50000	1.000048	1.0	-14.0	16.1	9.4
43	Lake	LAK	LCC 1 Parallel	N 41° 48‘ 00”	E 278° 45‘ 00”	100000	50000	1.000031	3.5	-18.2	15.4	14.0
44	Lawrence	LAW	LCC 1 Parallel	N 38° 21‘ 00”	E 277° 27‘ 00”	100000	50000	1.000019	-1.8	-21.6	27.0	16.1
45	Licking	LIC	LCC 1 Parallel	N 40° 00‘ 00”	E 277° 30‘ 00”	100000	50000	1.000041	-0.1	-13.7	15.0	10.0
46	Logan	LOG	LCC 1 Parallel	N 40° 24’ 00”	E 276° 15‘ 00”	100000	50000	1.000046	-0.9	-20.6	7.5	10.8
47	Lorain	LOR	LCC 1 Parallel	N 41° 24‘ 00”	E 277° 54‘ 00”	100000	50000	1.000033	4.9	-2.9	13.0	6.0
48	Lucas	LUC	LCC 1 Parallel	N 41° 36’ 00”	E 276° 21‘ 00”	100000	50000	1.000025	1.6	-3.1	9.3	4.2
49	Madison	MAD	TM	N 38° 33‘ 00”	E 276° 39‘ 00”	0	50000	1.000041	-0.5	-7.1	6.8	4.3

County Number	Name	Abbreviation	Projection	Origin Latitude	Origin Longitude	False Northing (m)	False Easting (m)	Scale Factor	Average PPM	Lowest PPM	Highest PPM	95% Confidence Level
50	Mahoning	MAH	LCC 1 Parallel	N 41° 09‘ 00”	E 279° 15‘ 00”	100000	50000	1.000041	-1.3	-9.5	9.7	6.8
51	Marion	MAR	LCC 1 Parallel	N 40° 36‘ 00”	E 276° 51‘ 00”	100000	50000	1.000040	0.8	-5.5	5.7	4.0
52	Medina	MED	LCC 1 Parallel	N 41° 09‘ 00”	E 278° 09‘ 00”	100000	50000	1.000046	3.0	-8.6	16.0	10.1
53	Meigs	MEG	LCC 1 Parallel	N 39° 06‘ 00”	E 278° 00‘ 00”	100000	50000	1.000028	-0.4	-11.3	13.1	9.8
54	Mercer	MER	LCC 1 Parallel	N 40° 36‘ 00”	E 275° 24‘ 00”	100000	50000	1.000036	1.8	-3.2	6.5	3.0
55	Miami	MIA	TM	N 38° 39‘ 00”	E 275° 45‘ 00”	0	50000	1.000042	3.0	-3.6	11.5	6.1
56	Monroe	MOE	LCC 1 Parallel	N 39° 36‘ 00”	E 278° 54‘ 00”	100000	50000	1.000034	-6.0	-23.2	20.3	13.6
57	Montgomery	MOT	TM	N 38° 18‘ 00”	E 275° 39‘ 00”	0	50000	1.000038	1.6	-6.4	12.0	8.9
58	Morgan	MRG	LCC 1 Parallel	N 39° 30‘ 00”	E 278° 09‘ 00”	100000	50000	1.000032	-0.3	-12.9	17.0	10.6
59	Morrow	MRW	TM	N 39° 09‘ 00”	E 277° 09‘ 00”	0	50000	1.000050	1.0	-11.3	14.5	12.1
60	Muskingum	MUS	LCC 1 Parallel	N 39° 57‘ 00”	E 278° 00‘ 00”	100000	50000	1.000036	0.5	-13.4	15.8	9.9
61	Noble	NOB	LCC 1 Parallel	N 39° 45‘ 00”	E 278° 30‘ 00”	100000	50000	1.000034	-4.8	-19.9	11.8	10.7
62	Ottawa	OTT	LCC 1 Parallel	N 41° 30‘ 00”	E 276° 54‘ 00”	100000	50000	1.000023	1.4	-3.0	9.7	3.3
63	Paulding	PAU	LCC 1 Parallel	N 41° 06‘ 00”	E 275° 27‘ 00”	100000	50000	1.000029	0.7	-1.9	5.5	2.7
64	Perry	PER	LCC 1 Parallel	N 39° 45‘ 00”	E 277° 45‘ 00”	100000	50000	1.000038	0.2	-11.3	15.3	8.9
65	Pickaway	PIC	LCC 1 Parallel	N 39° 39‘ 00”	E 277° 00‘ 00”	100000	50000	1.000033	2.1	-14.7	13.6	8.6
66	Pike	PIK	TM	N 37° 42‘ 00”	E 277° 00‘ 00”	0	50000	1.000030	-2.2	-20.7	12.1	14.7
67	Portage	POR	TM	N 39° 48‘ 00”	E 278° 54‘ 00”	0	50000	1.000043	-1.5	-13.4	9.7	8.1
68	Preble	PRE	TM	N 38° 15‘ 00”	E 275° 21‘ 00”	0	50000	1.000042	-1.2	-10.4	13.3	8.9
69	Putnam	PUT	TM	N 39° 39‘ 00”	E 275° 54‘ 00”	0	50000	1.000030	1.8	-1.9	9.9	4.4
70	Richland	RIC	TM	N 39° 30‘ 00”	E 277° 24‘ 00”	0	50000	1.000050	-0.8	-16.2	14.1	11.1
71	Ross	ROS	LCC 1 Parallel	N 39° 21‘ 00”	E 277° 00‘ 00”	100000	50000	1.000033	-0.4	-22.2	15.6	14.1
72	Sandusky	SAN	LCC 1 Parallel	N 41° 24‘ 00”	E 276° 54‘ 00”	100000	50000	1.000026	1.5	-4.2	10.2	3.4
73	Scioto	SCI	LCC 1 Parallel	N 38° 45‘ 00”	E 277° 00‘ 00”	100000	50000	1.000025	-5.6	-29.7	11.3	16.6
74	Seneca	SEN	LCC 1 Parallel	N 41° 12‘ 00”	E 276° 51‘ 00”	100000	50000	1.000033	1.7	-6.0	9.4	5.9
75	Shelby	SHE	TM	N 38° 54‘ 00”	E 275° 45‘ 00”	0	50000	1.000042	0.8	-3.3	6.6	3.7
76	Stark	STA	TM	N 39° 24‘ 00”	E 278° 39‘ 00”	0	50000	1.000045	0.0	-11.0	12.6	8.8

County Number	Name	Abbreviation	Projection	Origin Latitude	Origin Longitude	False Northing (m)	False Easting (m)	Scale Factor	Average PPM	Lowest PPM	Highest PPM	95% Confidence Level
77	Summit	SUM	TM	N 39° 48‘ 00”	E 278° 24‘ 00”	0	50000	1.000042	-1.2	-13.8	18.1	9.4
78	Trumbull	TRU	TM	N 39° 54‘ 00”	E 279° 09‘ 00”	0	50000	1.000040	1.0	-9.8	13.3	7.4
79	Tuscarawas	TUS	TM	N 39° 03‘ 00”	E 278° 36‘ 00”	0	50000	1.000041	-0.9	-13.8	14.6	9.8
80	Union	UNI	TM	N 39° 00‘ 00”	E 276° 39‘ 00”	0	50000	1.000040	-1.2	-5.8	5.3	3.5
81	Van Wert	VAN	LCC 1 Parallel	N 40° 54‘ 00”	E 275° 24‘ 00”	100000	50000	1.000032	1.4	-2.3	5.4	2.8
82	Vinton	VIN	LCC 1 Parallel	N 39° 15‘ 00”	E 277° 30‘ 00”	100000	50000	1.000034	0.5	-13.5	17.7	10.2
83	Warren	WAR	LCC 1 Parallel	N 39° 24‘ 00”	E 275° 51‘ 00”	100000	50000	1.000035	1.3	-8.4	16.6	9.0
84	Washington	WAS	LCC 1 Parallel	N 39° 24‘ 00”	E 278° 36‘ 00”	100000	50000	1.000031	-0.9	-17.0	14.9	11.6
85	Wayne	WAY	TM	N 39° 27‘ 00”	E 278° 06‘ 00”	0	50000	1.000045	0.6	-11.4	11.0	8.7
86	Williams	WIL	LCC 1 Parallel	N 41° 30‘ 00”	E 275° 27’ 00”	100000	50000	1.000035	1.6	-5.9	8.7	5.8
87	Wood	WOO	TM	N 40° 09‘ 00”	E 276° 21‘ 00”	0	50000	1.000025	0.5	-4.7	8.0	5.0
88	Wyandot	WYA	LCC 1 Parallel	N 40° 51‘ 00”	E 276° 42‘ 00”	100000	50000	1.000036	1.3	-5.0	11.9	4.4

2103 Test Points

The following test points are used to ensure the zone parameters are entered correctly into your software. Simply enter the latitude/longitude of the test point into your software and check the coordinate values for that point. Small variations may occur in the results due to rounding and the way each software projects the geodetic coordinate into a planar coordinate.

County Number	Name	Abbreviation	Test Point Latitude	Test Point Longitude	Height	Northing	Easting	PPM
1	Adams	ADA	N 38.818144069	E 276.450250281	214	107566.1539	45679.2268	-4.866
2	Allen	ALL	N 40.787334908	E 275.823570986	211	87490.8504	43548.7888	0.768
3	Ashland	ASD	N 40.846106458	E 277.703218600	315	132821.8672	50271.4405	2.649
4	Ashtabula	ATB	N 41.675899042	E 279.219112236	258	80662.6502	47427.8867	-3.880
5	Athens	ATH	N 39.413903486	E 277.812449797	170	107098.6310	42459.9732	6.881
6	Auglaize	AUG	N 40.628950747	E 275.861435058	242	103220.9704	59428.3561	1.131
7	Belmont	BEL	N 40.077837578	E 279.052685803	335	175181.6416	54494.1157	-11.379
8	Brown	BRO	N 39.218450011	E 276.088621839	263	185214.6654	57653.6052	-4.611
9	Butler	BUT	N 39.415335978	E 275.449719536	147	151572.5458	45669.8245	9.200
10	Carroll	CAR	N 40.590520414	E 278.907910283	321	148860.5370	63368.2704	-5.149
11	Champaign	CHP	N 40.128332339	E 276.251229492	288	97593.9738	50104.7990	-0.099
12	Clark	CLA	N 39.892166403	E 276.183613378	278	99130.3046	48598.4214	1.379
13	Clermont	CLE	N 39.088893129	E 275.774212894	214	170826.4595	52094.9118	-3.485
14	Clinton	CLI	N 39.444858150	E 276.130226825	278	154851.2444	52602.0777	-0.480
15	Columbiana	COL	N 40.793380828	E 279.220727929	328	154730.6716	39089.3171	-8.497
16	Coshocton	COS	N 40.287244572	E 278.136545053	196	104136.4194	53107.7199	5.416
17	Crawford	CRA	N 40.837567139	E 277.069439472	281	154080.3404	55856.8565	-3.596
18	Cuyahoga	CUY	N 41.524743400	E 278.337084936	143	152674.4080	57268.7013	7.183
19	Darke	DAR	N 40.090334092	E 275.392569247	283	148814.7388	49366.2703	-3.467
20	Defiance	DEF	N 41.307790458	E 275.640130925	180	95321.5321	61735.2867	3.036
21	Delaware	DEL	N 40.281234547	E 277.006750399	254	153372.1109	63330.9950	3.366

County Number	Name	Abbreviation	Test Point Latitude	Test Point Longitude	Height	Northing	Easting	PPM
22	Erie	ERI	N 41.396844703	E 277.280297302	156	99663.4577	35807.6388	2.467
23	Fairfield	FAI	N 39.702302633	E 277.331451507	241	94704.1594	48409.1564	-0.422
24	Fayette	FAY	N 39.551060457	E 276.603147753	263	149992.4826	45972.8671	-1.075
25	Franklin	FRA	N 39.922738087	E 276.987921486	180	169062.1703	57516.6884	9.429
26	Fulton	FUL	N 41.573299359	E 275.892442057	195	108142.0162	53539.8416	-4.848
27	Gallia	GAL	N 38.985524458	E 277.423541242	185	164949.6556	21713.5510	1.607
28	Geauga	GEA	N 41.470890130	E 278.826606377	329	85660.2347	52222.6240	-7.108
29	Greene	GRE	N 39.745908237	E 276.114042449	259	166075.8380	51203.6210	0.359
30	Guernsey	GUE	N 39.999326833	E 278.421217659	210	83269.5371	47542.0316	11.471
31	Hamilton	HAM	N 39.217023512	E 275.495056727	207	112996.4174	58209.4373	-4.449
32	Hancock	HAN	N 40.988278136	E 276.27714164	210	93147.8762	43868.7758	-2.329
33	Hardin	HAR	N 40.716552163	E 276.308234874	270	96289.5565	42246.0183	-0.262
34	Harrison	HAS	N 40.289326269	E 278.958832029	263	148709.8917	55002.8415	2.090
35	Henry	HEN	N 41.332004131	E 275.962062094	173	142369.6296	55195.4569	0.170
36	Highland	HIG	N 39.204083234	E 276.360765065	284	106005.2449	46610.8602	-2.126
37	Hocking	HOC	N 39.523096942	E 277.621831449	186	97013.1942	51877.2399	4.961
38	Holmes	HOL	N 40.564318582	E 278.045358979	233	151491.6378	45372.4256	7.672
39	Huron	HUR	N 41.139926143	E 277.416775243	249	82221.9470	51408.4567	1.819
40	Jackson	JAC	N 39.040212689	E 277.377994718	170	98913.6498	48094.7896	0.315
41	Jefferson	JEF	N 40.359676378	E 279.298522328	327	150973.8061	41379.7217	-10.382
42	Knox	KNO	N 40.338444679	E 277.528825757	285	93164.6765	48200.7208	3.815
43	Lake	LAK	N 41.654457413	E 278.780956885	274	83834.8234	52578.7184	-8.708
44	Lawrence	LAW	N 38.433865277	E 277.418694703	137	109310.0170	47266.6024	-1.500
45	Licking	LIC	N 40.058444239	E 277.50025938	246	106489.6347	50022.1315	2.872
46	Logan	LOG	N 40.423218394	E 276.259224806	357	102578.3894	50782.8931	-9.915
47	Lorain	LOR	N 41.313575233	E 277.837759689	209	90403.1471	44788.1192	1.350
48	Lucas	LUC	N 41.691094889	E 276.334007235	158	110117.9626	48668.5633	1.546

County Number	Name	Abbreviation	Test Point Latitude	Test Point Longitude	Height	Northing	Easting	PPM
49	Madison	MAD	N 39.939058135	E 276.622497158	272	154220.1454	47649.2433	-1.639
50	Mahoning	MAH	N 41.024591628	E 279.157043538	267	86076.2899	42181.6607	1.461
51	Marion	MAR	N 40.616443558	E 276.934270425	266	101829.4877	57131.2979	-1.873
52	Medina	MED	N 41.138014092	E 278.116340569	295	98669.3698	47173.8430	-0.229
53	Meigs	MEG	N 39.062339945	E 277.981836043	175	95819.1324	48427.8590	0.821
54	Mercer	MER	N 40.574347277	E 275.428730866	226	97151.6638	52432.8483	0.621
55	Miami	MIA	N 40.019432502	E 275.822864797	216	152045.9098	56220.7034	8.634
56	Monroe	MOE	N 39.754003274	E 278.963935445	336	117101.2928	55479.4410	-15.055
57	Montgomery	MOT	N 39.745999241	E 275.665627363	235	160535.1715	51339.4630	1.086
58	Morgan	MRG	N 39.656414515	E 278.190651224	269	117367.5267	53488.8250	-12.894
59	Morrow	MRW	N 40.559180195	E 277.213288524	333	156473.6324	55360.3776	-1.920
60	Muskingum	MUS	N 39.948606770	E 278.025515024	229	99845.6109	52180.5373	0.036
61	Noble	NOB	N 39.730338935	E 278.475513822	190	97817.2516	47900.7575	4.297
62	Ottawa	OTT	N 41.519988653	E 276.850598931	143	102221.2445	45876.3737	0.575
63	Paulding	PAU	N 41.106234807	E 275.426409197	188	100692.7005	48018.3163	-0.482
64	Perry	PER	N 39.693222939	E 277.809412914	285	93697.5325	55096.3247	-6.226
65	Pickaway	PIC	N 39.562892525	E 277.059567483	182	90330.0867	55119.1566	5.597
66	Pike	PIK	N 39.051449911	E 277.083428814	159	150023.6330	57222.1184	5.676
67	Portage	POR	N 41.129145927	E 278.769327962	303	147607.7014	39026.8982	-3.091
68	Preble	PRE	N 39.726178435	E 275.341385608	294	163885.2619	49261.4230	-4.126
69	Putnam	PUT	N 41.028270238	E 275.849500298	187	153050.5543	45752.8867	0.864
70	Richland	RIC	N 40.747877646	E 277.515680798	323	138573.9852	59770.3075	0.514
71	Ross	ROS	N 39.386265502	E 276.915341066	202	104029.8372	42706.1011	1.456
72	Sandusky	SAN	N 41.334386814	E 276.832970183	163	92714.9128	44388.8830	1.086
73	Scioto	SCI	N 38.839858467	E 277.148684344	167	109986.0674	62909.3060	0.023
74	Seneca	SEN	N 41.096888217	E 276.791122364	203	88550.0277	45053.4094	2.770
75	Shelby	SHE	N 40.380402138	E 275.839248975	284	164376.4292	57579.1735	-1.919

County Number	Name	Abbreviation	Test Point Latitude	Test Point Longitude	Height	Northing	Easting	PPM
76	Stark	STA	N 40.782644097	E 278.534589962	313	153537.1376	40257.6876	-2.943
77	Summit	SUM	N 41.017867794	E 278.500007659	299	135245.5929	58412.2441	-4.024
78	Trumbull	TRU	N 41.301900461	E 279.247364636	247	155686.5357	58154.6260	2.075
79	Tuscarawas	TUS	N 40.476535818	E 278.511204979	236	158398.6929	42470.1136	4.664
80	Union	UNI	N 40.282782209	E 276.649862679	279	142430.1301	49988.3217	-3.781
81	Van Wert	VAN	N 40.851846568	E 275.442825566	206	94653.2007	53611.3096	0.079
82	Vinton	VIN	N 39.327045132	E 277.552337248	257	108555.2247	54512.9994	-5.379
83	Warren	WAR	N 39.422958783	E 275.906504512	249	102550.5731	54865.6778	-4.063
84	Washington	WAS	N 39.505651683	E 278.530514992	163	111732.5574	44023.6462	7.121
85	Wayne	WAY	N 40.799407774	E 278.015181348	242	149844.4485	42841.8534	7.717
86	Williams	WIL	N 41.596816881	E 275.444007235	235	110753.3196	49500.3548	-5.989
87	Wood	WOO	N 41.421627167	E 276.362744488	170	141217.5224	51065.4245	-1.689
88	Wyandot	WYA	N 40.898457510	E 276.724310194	216	105381.7568	52048.5529	2.539

For more information on the Ohio County Coordinate System visit the CADD and Mapping Website - OCCS.

2200 Subsurface Utility Locations Specifications

2201 Introduction

These specifications have been developed for all subsurface utility location series performed for the Ohio Department of Transportation, or Local Public Agencies (LPA) responsible for developing projects. This section is a supplement to the Real Estate Manual, Section 8200 - Procedures for Coordination Associated with Utility Relocations and Adjustments, which sets out the Department's policies for treatment of utilities during project development. The Department's Location and Design Manual, Volume 3, Highway Plans, addresses the requirements for inclusion of the locations of underground utilities on highway plans. This section is intended to provide uniform procedures for subsurface utility location services to ensure accurate subsurface utility information for inclusion in highway plans. In the event there is a conflict between the information proposed by the Consultant and these specifications, this Specification shall govern. This specification does not pertain to sanitary and storm sewers. For sanitary and storm utilities, pipe sizes, types, locations, and invert elevations at structures shall be measured and located to the best ability possible. A SULS quality level will not be given on these utilities unless specifically contracted to do so by the project scope.

2202 Scope of Work

The Department will provide a scope of work document outlining the subsurface utility location services to be performed. Utility facilities which are above the surface of the ground are traditionally acquired by survey and mapping operations and are not included in these specifications.

2203 Permits

Various entities (including ODOT) may require a permit to access properties, excavate to expose a utility, establish traffic control for a work zone, etc. The cost for each permit required shall be listed separately on the Subsurface Utility Location Services Proposal form as non-salary direct costs. Administrative costs that may be associated with the processing of permits are to be included in the utility facility identification and positioning methods work.

2204 Traffic Control

Traffic control shall be maintained in accordance with the Ohio Manual of Uniform Traffic Control Devices (OMUTCD) and local ordinances as applicable. Costs for traffic control provided by the subsurface utility location services vendor's own forces shall be included in the utility facility identification and positioning method portion of the fee proposal. Costs for traffic control provided by other consultants shall be listed separately (per traffic control application) on the Fee Proposal Form as non-salary direct costs.

2205 Utility Facility Identification/Positioning Method

Utility Quality Level D shall be required for all ODOT projects where utilities are known to be located within the project limits and are required to be shown on the plans to aid in the design of said project. Typical methods of location marking provided by Utility Companies, visible evidence of utility structures and other evidence shall be used. Utility Quality Levels A-C may be required on a case-by-case basis and/or in certain areas of a project as needed and authorized in the project scoping documentation. This quality level does not apply to storm and sanitary sewer utilities as stated 2201. Structure locations, pipe sizes, types, and invert elevations shall be obtained as part of the topographic survey.

2205.1 Utility Quality Level A

Utility Quality Level A shall be reserved for areas of projects where a utility conflict is eminent and the exact location of said utility is critical for the design of the project.

2205.1.1 ASCE 38-22 Definition:

A value assigned to that position (x-, y-, and z-geometry) of a Utility Segment or subsurface Utility Feature that is directly exposed and measured and whose location and dimensions are tied to the Project Survey Datum. The Utility Segment or subsurface Utility Feature shall be tied to the Project Survey Datum with an accuracy of 0.1 ft (30 mm) vertical and to 0.2 ft (60 mm) horizontal for the measurements of the outside limits of the Utility Feature or Utility Segment that is exposed.

2205.2 Utility Quality Level B

Utility Quality Level B shall be an in-depth research of the utility location based on records, Utility Company markings, and physical evidence of utility structures to locate utilities within the project limits. Quality Level B requires spending more time researching the existence and location of utilities than a typical 811 call.

2205.2.1 ASCE 38-22 Definition:

A value assigned to a Utility Segment or subsurface Utility Feature whose existence and horizontal position is based on Geophysical Methods combined with professional judgement and whose location is tied to the Project Survey Datum.

2205.3 Utility Quality Level C

Utility Quality Level C shall be required for all ODOT projects where utilities are known to be located within the project limits and are required to be shown on the plans to aid in the design of said project. Typical methods of locating markings provided by Utility Companies, visible evidence of utility structures and other evidence shall be used.

2205.3.1 ASCE 38-22 Definition:

A value assigned to a Utility Segment not visible at the ground surface whose estimated position is judged through correlating Utility records or similar evidence to Utility Features, visible above ground and/or underground. The Utility Anchor Point on the Utility Features shall be tied to the Project Survey Datum with an accuracy of 0.2 ft (60 MM) horizontal.

Quality Level C data is determined by correlating underground Utility segments from existing second party information to observable and measurable visible Utility Features.

2205.4 Utility Quality Level D

2205.4.1 ASCE 38-22 Definition:

A value assigned to a Utility segment or Utility Feature not visible at the ground surface whose estimated position is judged through Utility records, information from others, or from visual clues such as pavement cuts, obvious trenches, or existence of service.

2206 Surveying

It is the responsibility of the consultant to ensure that the equipment and approach utilized to survey/position and show/identify the underground utility facility meets the requirements of these specifications. The consultant is required to obtain permission in writing from ODOT in advance if the utility facility positioning is not based on Primary Project Control established in accordance with Section 2000 - Survey & Mapping Specifications.

2207 Subsurface Utility Location Services Proposal

Cost proposals for subsurface utility location services to be performed for ODOT are to be submitted using the Subsurface Utility Location Services Proposal form. As part of the SULS proposal, the consultant may also submit pertinent site-specific narrative (information/details) as appropriate.

2208 Deliverables

2208.1 Approved SULS Limits

A graphic that shows the subsurface utility location services limits approved by ODOT's managing office for the contract. The graphic or SULS coverage plan shall be provided prior to fee development.

2208.2 Hard Copy Plan Sheets

Hard copy plan sheets (1/4 size) which display the subsurface utility facilities within the approved SULS limits are to be provided in accordance with ODOT's Location & Design Manual, Volume 3.

2208.3 Electronic Files

Electronic files of all work (including scanned information such as survey field notes) in accordance with ODOT's Location & Design Manual, Volume 3, are to be provided.

2208.4 Subsurface Utility Facility Matrix

A subsurface utility facility matrix shall be provided by the consultant. This matrix is to include the utility facility owner, utility facility type, positioning method, source of utility facility depth information, approximate distances per segment and applicable comments. All utility data provided by the consultant shall be associated with one of the four identification/positioning methods. The Matrix should be generated after preliminary design and updated at final plan deliverable. An example matrix is provided in Appendix H.

2208.5 Surveyors Certification Statement

A Professional Surveyor registered in the State of Ohio shall provide a signed and sealed statement indicating that the utility data provided met the requirements of these specifications for the Quality Level requested by ODOT and as noted in the utility facility matrix. See Appendix I – Surveyor's Certification Statement (Template).

2209 Compensation

Compensation shall be made in accordance with the applicable contract documents and the Subsurface Utility Location Services Proposal form on a cost plus a fixed fee basis. The cost of permits, utility access charges, travel expenses and any other non-salary direct costs shall be compensated at actual cost.

Appendix A - Planimetric Collections

Standard Mapping Collection Features (within Project Limits affected by Design)

1. Edge of pavement (e.g. paint line)
2. Edge of treated shoulder
3. Curb (for more than 2D locations, field collection is required)
4. Curb Ramps (for more than 2D locations field, collection is required)
5. Sidewalks
6. ADA Ramps (for more than 2D locations field, collection is required)
7. Driveways
8. Bikeways
9. Parking Lots
10. Bridges (for more than 2D locations field, collection is required)
11. Culverts (for more than 2D locations field, collection is required)
12. Streams, Rivers, Ponds, Lakes, Wetlands (for more than 2D locations field, collection is required)
13. Highway barriers
14. Walls (retaining, headwalls, etc.) (for more than 2D locations field, collection is required)
15. Fences
16. Buildings (for more than 2D locations field, collection is required)
17. Mailbox (specify number of mailboxes in survey notes)
18. Signs (public and private, note which is in survey notes)
19. Septic Systems
20. Wells/Cisterns
21. Sprinkler Systems
22. Utilities (for more than 2D locations field, collection is required)
    a. Power Poles
    b. Manholes
    c. Light Pole
    d. Telecommunication poles
    e. Unknown poles
    f. Fire Hydrants
    g. Catch Basins
    h. Underground utilities (must be field collected)
    i. Pull Boxes
23. Above Ground Tanks (oil/gas)
24. Cemeteries
    a. Roads
    b. Buildings
    c. Estimated Cemetery boundary
    d. Any headstones within Road Right-of-Way
25. Swimming pools

26. Towers
    a. Cell phone
    b. Etc.
27. Field Tiles
28. Railroads
29. Survey Control Points for AT solution
30. Landscaping
31. Trees (with size)
32. Shrubs
33. Any other item(s) that will be significant to the cost of a planning project or that have been identified by the District Survey Operations Manager that are not listed above.

Additional Aerial Mapping Collection Features (Outside Project Limits affected by design)

1. Edge of pavement (e.g. paint line)
2. Edge of treated shoulder
3. Edge of graded shoulder
4. Driveways
5. Bikeways
6. Parking Lots
7. Bridge Deck (for more than 2D locations, field collection is required)
8. Streams, Rivers, Ponds, Lakes, Wetlands (for more than 2D locations, field collection is required)
9. Sidewalks
10. Highway barriers
11. Walls (retaining, headwalls, etc.) (for more than 2D locations, field collection is required)
12. Buildings (for more than 2D locations, field collection is required)
13. Utilities (for more than 2D locations, field collection is required)
    a. Power Poles
    b. Manholes
    c. Light Pole
    d. Telecommunication poles
    e. Unknown poles
    f. Fire Hydrants
    g. Catch Basins
    h. Underground utilities (must be field collected)
14. Traffic Signs (specify number of posts, sign size, and sign message in survey notes)
15. Above Ground Tanks (oil/gas)
16. Large piles (junk yard, stockpiles of material, etc.)
17. Above Ground Pumps
18. Mailbox (specify number of mailboxes in survey notes)
19. Cemeteries
    a. Roads
    b. Buildings
    c. Estimated Cemetery boundary
20. Yard Lights
21. Airport Lights

22. Airport Windsock
23. Basketball Hoops
24. Flag Poles
25. Landscaping
    a. Bushes (individual and lines)
    b. Rocks (Boulders)
    c. Flower Beds
    d. Trees (individual sizes according CMS Item 201)
        i Evergreen
        ii Deciduous
        iii Stumps
    e. Shrubs (individual)
26. Golf Course greens
27. School Playgrounds (Equipment not itemized)
28. Swimming pools
29. Ground based/mounted satellite dishes
30. Towers
    a. Cell phone
    b. Etc.
31. Fences
32. Guardrail
33. Bird houses (unknown post)
34. Traffic Mast arms
35. Culverts (for more than 2D locations, field collection is required)
36. Trails (dirt roads)
37. Railroads
38. Billboards
39. Utility boxes
40. Survey Control Points for AT solution
41. Any other item(s) that will be significant to the cost of an engineering project or that have been identified by the District Survey Operations Manager that are not listed above. These items may require a higher order of accuracy as specified by the District Survey Operations Manager.

Appendix B - Example RMSE Calculation for Vertical DTM & Horizontal Planimetric Features

Vertical Accuracy Test

Example Survey Check Shot Data Compared to Map-Derived Values
(Units in U.S. Survey Feet)

The methodology behind vertical accuracy testing is derived from the National Standard for Spatial Data Accuracy (NSSDA) and endorsed by ASPRS (ASPRS, 2014, Annex D). The following will outline the overall procedure utilizing a small sample set for visualization purposes only. Follow the requirements for the minimum number of checkpoints derived from Section 2008.2 INS-Based Mapping Surveys.

Sample Data Vertical

Number	Easting	Northing	Survey Z	Map-derived Z	ΔZ (Elevation)
SV104	1916324.0000	784556.2000	1147.6880	1147.6700	0.0180
SV105	1916317.0000	784565.3000	1147.4630	1147.4300	0.0330
SV106	1916311.0000	784574.1000	1147.2360	1147.2300	0.0060
SV107	1916304.0000	784583.3000	1147.1090	1147.0800	0.0290
SV108	1916296.0000	784594.2000	1146.8490	1146.9300	-0.0810
Number of Checkpoints					5
Mean Error					0.0010
Standard Deviation					0.0420
RMSE					0.0420
Vertical Accuracy, at 95% Confidence Level					0.08232

Table 7 Vertical Accuracy Example Data

Computation of Mean Errors in the Z (Vertical)

$$\bar{z} = \frac{1}{n}\sum_{i=1}^{n} z_i$$

Where:

z_i *is the* i^{th} *error in the z direction*

$$n \text{ is the number of checkpoints tested}$$
$$i \text{ is an integer ranging from } 1 \text{ to } n$$

$$\frac{0.0180 + 0.0330 + 0.0060 + 0.0290 + (-0.0810)}{5} = 0.0010\ US\ ft.$$

Computation of Standard Deviation (Vertical)

$$S_z = \sqrt{\frac{1}{(n-1)}\sum_{i=1}^{n}(z_i - \bar{z})^2}$$

Where:

$$z_i \text{ is the } i^{th} \text{ error in the z direction}$$
$$\bar{z} \text{ is the mean error in the z direction}$$
$$n \text{ is the number of checkpoints tested}$$
$$i \text{ is an integer ranging from } 1 \text{ to } n$$

$$S_z = \sqrt{\frac{(0.0180-0.0010)^2 + (0.0330-0.0010)^2 + (0.0060-0.0010)^2 + (0.0290-0.0010)^2 + (-0.0810-0.0010)^2}{(5-1)}}$$

$S_z =$ 0.0420 US ft.

Computation of Root Mean Squares Error (RMSE) (Vertical)

$$RMSE_Z = \sqrt{\frac{1}{n}\sum_{i-1}^{n}(z_{i(map)} - z_{i(surveyed)})^2}$$

Where:

$$z_{i(map)} \text{ is the } i^{th} \text{ coordinate in the z direction}$$

$$z_{i(surveyed)} \text{ is the } i^{th} \text{ coordinate in the } z \text{ direction of the independent source}$$
$$n \text{ is the number of checkpoints tested}$$
$$i \text{ is an integer ranging from } 1 \text{ to } n$$

$$RMSE_Z = \sqrt{\frac{(0.0180)^2 + (0.0330)^2 + (0.0060)^2 + (0.0290)^2 + (-0.0810)^2}{5}}$$

$$RMSE_Z = 0.0420 \text{ US ft.}$$

Computation of Root Mean Squares Error (RMSE) (Vertical)

$$Vertical\ Accuracy\ at\ 95\%\ Confidence\ Level = 1.9600(RMSE_Z)$$
$$Vertical\ Accuracy\ at\ 95\%\ Confidence\ Level = 1.9600(0.0420)$$
$$Vertical\ Accuracy\ at\ 95\%\ Confidence\ Level = 0.08232 \text{ US ft.}$$

Horizontal Planimetric Feature Accuracy Test

The methodology behind horizontal accuracy testing is derived from the National Standard for Spatial Data Accuracy (NSSDA) and endorsed by ASPRS (ASPRS, 2014, Annex D). The following will outline the overall procedure utilizing a small sample set for visualization purposes only. Follow the minimum number of checkpoints derived from [Section 2008.2 INS-Based Mapping Surveys](#).

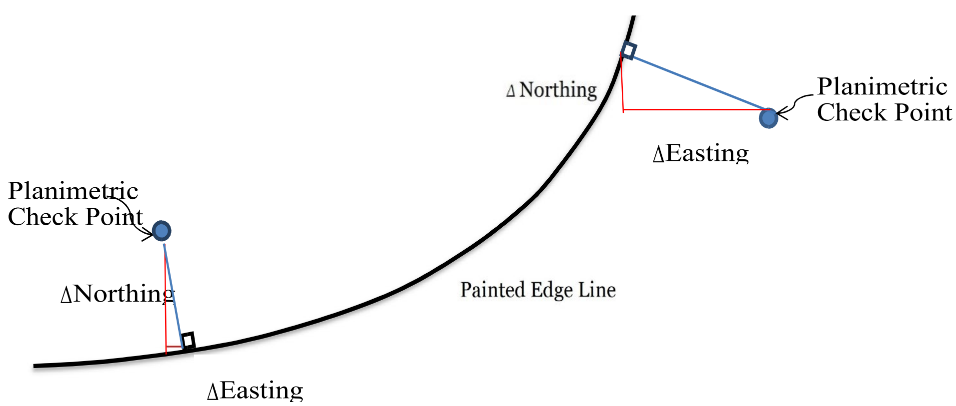


Figure 2 Graphic of Horizontal Planimetric Feature Test on Painted Edge Line

Measurements are taken perpendicular to the center of the feature (e.g. painted edge line). Determine the ΔX (Easting) and ΔY (Northing) for accuracy determination.

Sample Data Horizonal

Point Number	Map-Derived		Survey Check Points		Residuals (Errors)	
	Easting	Northing	Easting	Northing	ΔX (Easting)	ΔY (Northing)
SV104	1916324.0000	784556.2000	1916324.1400	784556.2700	-0.1400	-0.0700
SV105	1916317.0000	784565.3000	1916317.1000	784565.4000	-0.1000	-0.1000
SV106	1916311.0000	784574.1000	1916310.9830	784574.1700	0.0170	-0.0700
SV107	1916304.0000	784583.3000	1916304.0700	784583.1500	-0.0700	0.1500
SV108	1916296.0000	784594.2000	1916295.8700	784594.0800	0.1300	0.1200
Number of Checkpoints					5	5
Mean Error					-0.0326	0.0060
Standard Deviation					0.0963	0.1063
RMSE					0.10167	0.10648
$RMSE_R$					0.1472	
Horizontal Accuracy, at 95% Confidence Level					0.2548	

Table 8 Horizontal Accuracy Example Data

Computation of Mean Errors in the Horizonal X Direction (Easting)

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

x_i *is the* i^{th} *error in the x direction*
n is the number of checkpoints tested
i is an integer ranging from 1 to n

$$\bar{x} = \frac{(-0.140) + (-0.100) + 0.017 + (-0.070) + 0.130}{5}$$

$$= -0.0326\ US\ ft.$$

Computation of Mean Errors in the Horizonal Y Direction (Northing)

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$$

$$y_i \text{ is the } i^{th} \text{ error in the } y \text{ direction}$$
$$n \text{ is the number of checkpoints tested}$$
$$i \text{ is an integer ranging from } 1 \text{ to } n$$

$$\bar{y} = \frac{(-0.070) + (-0.100) + (-0.070) + 0.150 + 0.120}{5}$$
$$= 0.006\ US\ ft.$$

Computation of Standard Deviation Horizonal X Direction (Easting)

$$\boldsymbol{S_x} = \sqrt{\frac{\mathbf{1}}{(\boldsymbol{n}-\mathbf{1})}\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{n}}(\boldsymbol{x_i}-\overline{\boldsymbol{x}})^{\mathbf{2}}}$$

Where:

$$x_i \text{ is the } i^{th} \text{ error in the } x \text{ direction}$$
$$\bar{x} \text{ is the mean error in the } x \text{ direction}$$
$$n \text{ is the number of checkpoints tested}$$
$$i \text{ is an integer ranging from } 1 \text{ to } n$$

$$S_x = \sqrt{\frac{(-0.140-0.006)^2 + (-0.100-0.006)^2 + (0.017-0.006)^2 + (0.0290-0.006)^2 + (-0.0810-0.006)^2}{(5-1)}}$$

$S_x =$ 0.0963 US ft.

Computation of Standard Deviation Horizonal Y Direction (Northing)

$$\boldsymbol{S_y} = \sqrt{\frac{\mathbf{1}}{(\boldsymbol{n}-\mathbf{1})}\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{n}}(\boldsymbol{y_i}-\overline{\boldsymbol{y}})^{\mathbf{2}}}$$

Where:

y_i *is the* i^{th} *error in the y direction*
$\bar{y}$ *is the mean error in the y direction*
n *is the number of checkpoints tested*
i *is an integer ranging from* 1 *to* n

$$S_y = \sqrt{\frac{(-0.07-0.006)^2+(-0.100-0.006)^2+(0.07-0.006)^2+(0.150-0.006)^2+(0.12-0.006)^2}{(5-1)}}$$

$S_y =$ 0.1063 US ft.

Computation of Root Mean Squares Error (RMSE) (Horizontal Easting (X))

$$RMSE_x = \sqrt{\frac{1}{n}\sum_{i-1}^{n}(x_{i(map)}-x_{i(surveyed)})^2}$$

Where:

$x_{i(map)}$ *is the* i^{th} *coordinate in the x direction*
$x_{i(surveyed)}$ *is the* i^{th} *coordinate in the x direction of the independent source*
n *is the number of checkpoints tested*
i *is an integer ranging from* 1 *to* n

$$RMSE_x = \sqrt{\frac{(-0.140)^2+(-0.100)^2+(0.017)^2+(-0.070)^2+(0.130)^2}{5}}$$

$$RMSE_x = 0.10167 \text{ US ft.}$$

Computation of Root Mean Squares Error (RMSE) (Horizontal Northing (Y))

$$RMSE_y = \sqrt{\frac{1}{n}\sum_{i-1}^{n}(y_{i(map)} - y_{i(surveyed)})^2}$$

Where:

$y_{i(map)}$ *is the* i^{th} *coordinate in the y direction*

$y_{i(surveyed)}$ *is the* i^{th} *coordinate in the y direction of the independent source*

n *is the number of checkpoints tested*

i *is an integer ranging from* 1 *to* n

$$RMSE_y = \sqrt{\frac{(-0.070)^2 + (-0.100)^2 + (0.070)^2 + (0.150)^2 + (0.120)^2}{5}}$$

$$RMSE_y = 0.10648 \text{ US ft.}$$

Computation of Root Mean Squares Error (RMSE) (Radial)

$$RMSE_R = \sqrt{RMSE_x{}^2 + RMSE_y{}^2}$$

$$RMSE_R = \sqrt{(0.10167)^2 + (0.10648)^2}$$

$$RMSE_R = 0.14722 \text{ US ft.}$$

Computation of Horizontal Accuracy at 95% Confidence Level (Radial)

$$Horizontal\ Accuracy\ at\ 95\%\ Confidence\ Level = 1.7308(RMSE_R)$$

$$Horizontal\ Accuracy\ at\ 95\%\ Confidence\ Level = 1.7308(0.14722)$$

$$Horizontal\ Accuracy\ at\ 95\%\ Confidence\ Level = 0.2548 \text{ US ft.}$$

Appendix C - Example Mapping Quality Control Report

Downloadable Templates

The mapping Survey Quality Control Report templates can be downloaded in a word format here:

Conventional Based Mapping Survey Quality Control Report Template and/or

INS Based Mapping Survey Quality Control Report Template

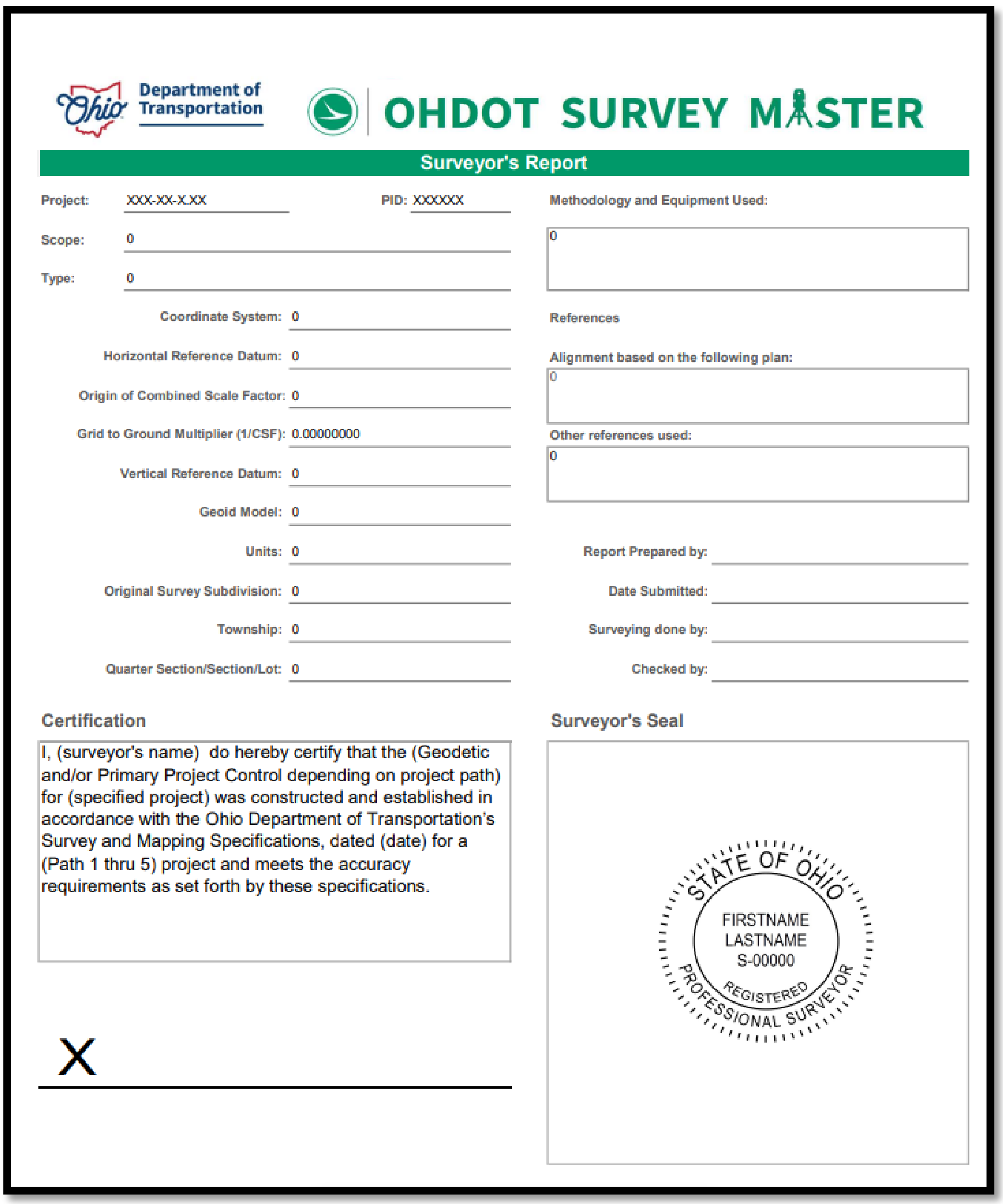
The Vertical Accuracy Statistic Worksheet and the Horizontal Accuracy Statistic Worksheet can be downloaded for assistance in calculating INS Based Mapping Survey statistics here:

Vertical Accuracy Statistic Worksheet

Horizontal Accuracy Statistic Worksheet

Appendix D - Surveyor's Certification Statement

An editable copy of the Surveyor's Certification Statement is available within the SurveyMaster excel sheet. The excel sheet can be found within the OHDOT standards (\\...\Standards\Survey Files\XXXXXX_SurveyMaster.xlsm) or on CADD and Mapping Services website.



Ohio Department of Transportation

OHDOT SURVEY MASTER

Surveyor's Report

Project: XXX-XX-X.XX PID: XXXXXX

Scope: 0

Type: 0

Coordinate System: 0

Horizontal Reference Datum: 0

Origin of Combined Scale Factor: 0

Grid to Ground Multiplier (1/CSF): 0.00000000

Vertical Reference Datum: 0

Geoid Model: 0

Units: 0

Original Survey Subdivision: 0

Township: 0

Quarter Section/Section/Lot: 0

Methodology and Equipment Used:

0

References

Alignment based on the following plan:

0

Other references used:

0

Report Prepared by:

Date Submitted:

Surveying done by:

Checked by:

Certification

I, (surveyor's name) do hereby certify that the (Geodetic and/or Primary Project Control depending on project path) for (specified project) was constructed and established in accordance with the Ohio Department of Transportation's Survey and Mapping Specifications, dated (date) for a (Path 1 thru 5) project and meets the accuracy requirements as set forth by these specifications.

X

Surveyor's Seal

STATE OF OHIO
FIRSTNAME
LASTNAME
S-00000
REGISTERED
PROFESSIONAL SURVEYOR

Appendix E – Example GNSS Coordinate Statistical Analysis

An editable copy of the SurveyMaster excel is available within the OHDOT standards (\\...\Standards\Survey Files\XXXXXX_SurveyMaster.xlsm) or on CADD and Mapping Services website.

RTN GNSS Project Control Monument Coordinate Analysis

Project: XXX-XX-X.XX	GPS Antenna: 0	Report Date: 1/0/1900
PID: XXXXXX	VRS Network: Ohio RTN	Prepared By: 0
Point ID: CP129	No. of Sessions: 12	Checked By: 1/0/1900

0

SESSION #	Point	Observation Date	Start Time	Northing(sft)	Easting(sft)	Height(sft)	Δ Northing(sft)	Δ Easting(sft)	Δ Height(sft)	Include in Solution?
1	CP129	4.20.2022	12:22:55 AM	612770.95490	270034.60500	1181.29601	-0.00062	0.00845	0.01348	☑
2	CP129	4.20.2022	12:23:04 AM	612770.95100	270034.61020	1181.30262	0.00328	0.00325	0.00687	☑
3	CP129	4.20.2022	12:23:13 AM	612770.95000	270034.61140	1181.30197	0.00428	0.00205	0.00752	☑
~~4~~	~~CP129~~	~~4.20.2022~~	~~12:23:33 AM~~	~~612770.95290~~	~~270034.61370~~	~~1181.31656~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
5	CP129	4.20.2022	12:23:39 AM	612770.94850	270034.62040	1181.31781	0.00578	-0.00695	-0.00832	☑
6	CP129	4.20.2022	12:23:48 AM	612770.96000	270034.61280	1181.32386	-0.00572	0.00065	-0.01437	☑
7	CP129	4.20.2022	12:23:57 AM	612770.96130	270034.62090	1181.31466	-0.00702	-0.00745	-0.00517	☑
~~8~~	~~CP129~~	~~4.20.2022~~	~~12:24:06 AM~~	~~612770.96690~~	~~270034.62400~~	~~1181.31345~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
9	CP129	4.20.2022	12:24:53 AM	612770.97790	270034.61570	1181.33034	-0.02362	-0.00225	-0.02085	☑
10	CP129	4.20.2022	12:25:02 AM	612770.98280	270034.61560	1181.33282	-0.02852	-0.00215	-0.02333	☑
11	CP129	4.20.2022	12:25:11 AM	612770.98050	270034.61540	1181.32719	-0.02622	-0.00195	-0.01770	☑
12	CP129	4.20.2022	12:25:20 AM	612770.97980	270034.61930	1181.31579	-0.02552	-0.00585	-0.00630	☑
~~13~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
~~14~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
~~15~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
~~16~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
~~17~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
~~18~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
~~19~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
~~20~~	~~0~~	~~0.00.00~~	~~12:00:00 AM~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	☐
			AVERAGE	612770.95428	270034.61345	1181.30949	RMSE:	RMSE:	RMSE:	
					RMSE IN U.S. Survey Feet:		0.01689	0.00488	0.01386	
					Tolerance:		0.02900		0.03900	
							PASS	PASS	PASS	

AVERAGED GPS-DERIVED POSITION

U.S. Survey Feet ()	612770.9543	270034.6135	1181.309

LEVELED ELEVATION

U.S. Survey FT	2.000	(Fill out Level Run Sheet or N/A if no leveled elevation is available)
MONUMENT HELD	CP129	(Type the monument name from which leveling originated)
LEVELED ELEVATION - GPS DERIVED ELEVATION =	-1179.309	U.S. Survey FT

FINAL MONUMENT COORDINATES

MONUMENT COORDINATES	NORTHING	EASTING	ELEVATION	FEATURE CODE
U.S. Survey Feet (GRID)	612770.9543	270034.6135	2.000	CMON
U.S. Survey Feet (GROUND)	612770.9543	270034.6135	2.000	CMON

Notes:

Δ North, Δ East, and Δ Ht. are the difference between the average northing, easting, and height for each observation.

Mask Angle: 10°

Appendix F – Geodetic/Project Control Monuments

The following standard drawings are for ODOT project control only and should not be associated with Right of Way or Centerline monumentation. For Right of Way or Centerline monumentation details, please refer to ODOT standard drawing RM-1.1.

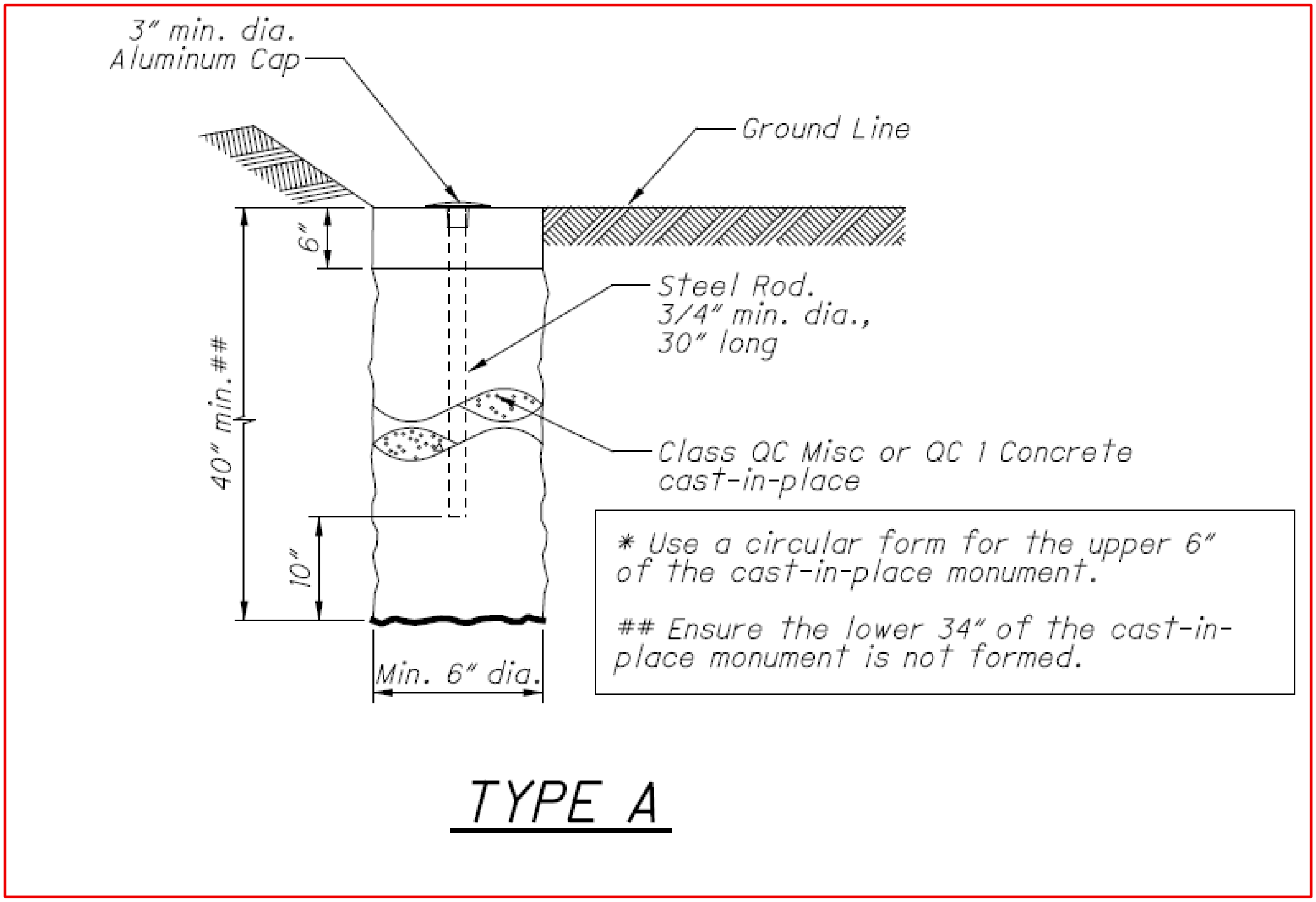


Figure 3 Geodetic and Primary Project Control Monument, Type A

Notes:

Use Cap Design 1 for Primary Project Control Monuments

Use Cap Design 2 for Primary Project Control Monuments to be used as Azimuth Marks

See Figure 5 Cap Designs Plan View and Figure 6 Cap Designs Side View for Cap Designs

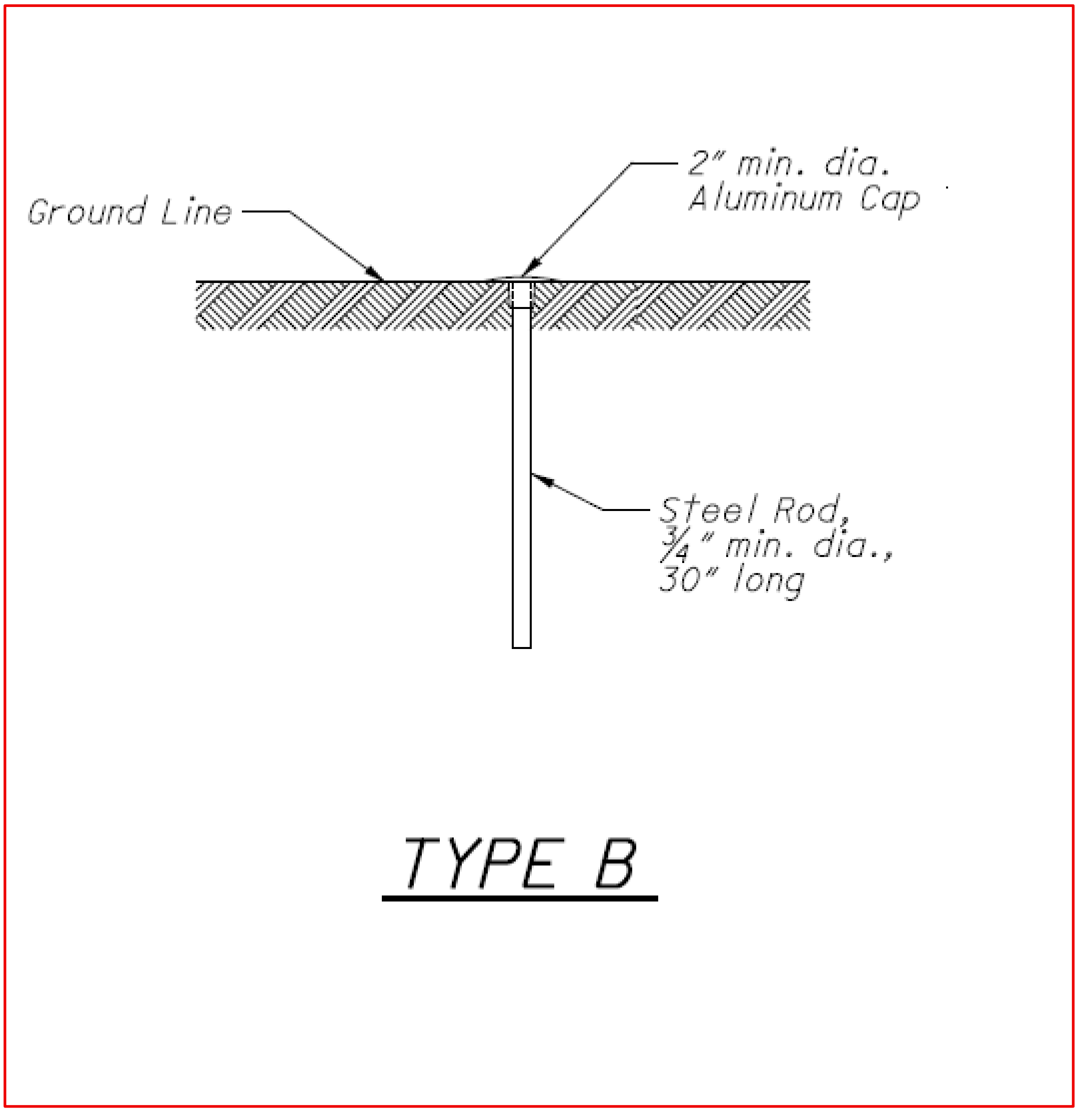


Figure 4 Primary Project Control Monument, Type B

<u>Notes:</u>

Use Cap Design 1 for Primary Project Control Monuments

Use Cap Design 2 for Primary Project Control Monuments to be used as Azimuth Marks

See Figure 5 Cap Designs Plan View and Figure 6 Cap Designs Side View for Cap Designs

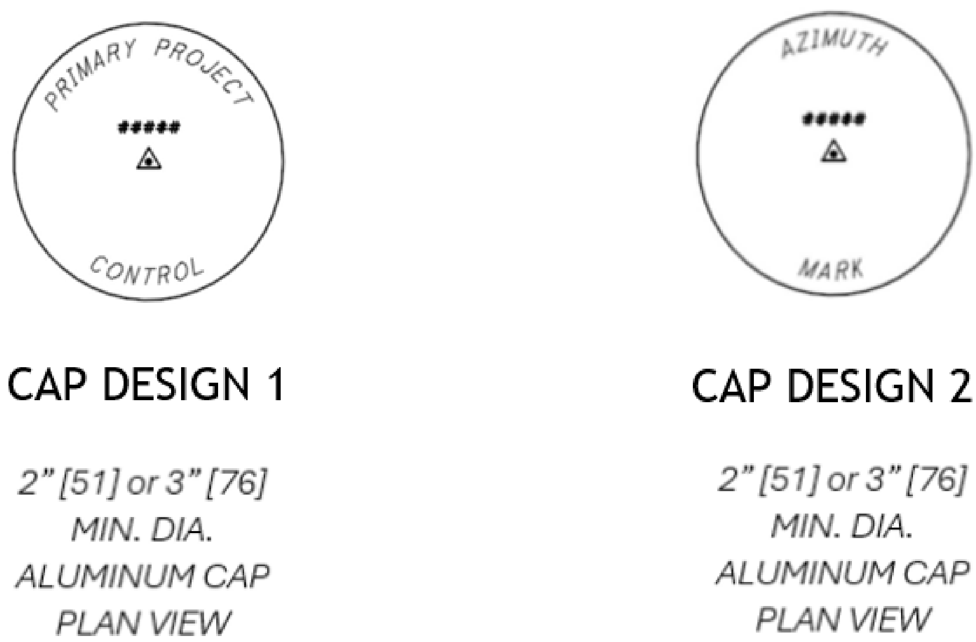


Figure 5 Cap Designs Plan View

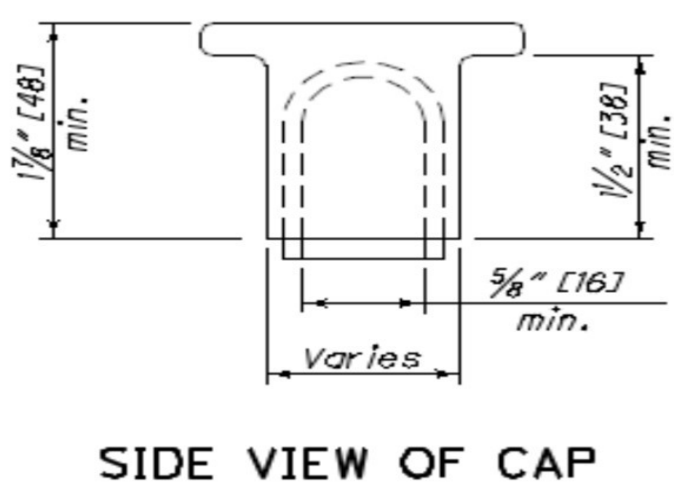


Figure 6 Cap Designs Side View

Appendix G – G105 Survey Parameters

G105 – Surveying Parameters

The following pages provide examples for both the Ohio County Coordinate Systems and Ohio State Plane (North/South) notes. For template notes please see Location and Design Manual, Volume 3, Appendix B for a complete list of plan and designer notes.

G105 B (Ohio County Coordinate System (OCCS)) Example

SURVEYING PARAMETERS – OHIO COUNTY COORDINATE SYSTEM (OCCS)

PRIMARY PROJECT CONTROL MONUMENTS GOVERN ALL POSITIONING ON ODOT PROJECTS. SEE SHEET ___ OF THE PLANS FOR A TABLE CONTAINING PROJECT CONTROL INFORMATION.

USE THE FOLLOWING PROJECT CONTROL, VERTICAL POSITIONING, AND HORIZONTAL POSITIONING PARAMETERS FOR ALL SURVEYING:

PROJECT CONTROL
POSITIONING METHOD: STATIC GNSS NETWORK WITH DIGITAL LEVELING
MONUMENT TYPE: TYPE A

VERTICAL POSITIONING
ORTHOMETRIC HEIGHT DATUM: NAVD 88
GEOID: 18

HORIZONTAL POSITIONING
REFERENCE FRAME: NAD 83 (2011 ADJ (2010.0 Epoch))
ELLIPSOID: GRS 80
COORDINATE SYSTEM: FRANKLIN COUNTY (OCCS)
MAP PROJECTION: TRANSVERSE MERCATOR (TM)
CENTRAL LATITUDE: N 38° 24' 00"
CENTRAL LONGITUDE: W 83° 06' 00"
FALSE NORTHING: 0 (METERS)
FALSE EASTING: 50,000 (METERS)
PROJECTION SCALE FACTOR: 1.000037

USE THE POSITIONING METHODS AND MONUMENT TYPE USED IN THE ORIGINAL SURVEY TO RESTORE ALL MONUMENTS RELATED TO PRIMARY PROJECT CONTROL THAT ARE DAMAGED OR DESTROYED BY CONSTRUCTION ACTIVITIES. RESTORE THE DAMAGED OR DESTROYED MONUMENTS IN ACCORDANCE WITH CMS 623.

UNITS ARE IN U.S. SURVEY FEET.

G105 A (Ohio State Plane (North/South) Example

SURVEYING PARAMETERS – OHIO STATE PLANE (NORTH/SOUTH)

PRIMARY PROJECT CONTROL MONUMENTS GOVERN ALL POSITIONING ON ODOT PROJECTS. SEE SHEET ___ OF THE PLANS FOR A TABLE CONTAINING PROJECT CONTROL INFORMATION.

USE THE FOLLOWING PROJECT CONTROL, VERTICAL POSITIONING, AND HORIZONTAL POSITIONING PARAMETERS FOR ALL SURVEYING:

PROJECT CONTROL
POSITIONING METHOD: STATIC GNSS NETWORK WITH DIGITAL LEVELING
MONUMENT TYPE: TYPE A

VERTICAL POSITIONING
ORTHOMETRIC HEIGHT DATUM: NAVD 88
GEOID: 18

HORIZONTAL POSITIONING
REFERENCE FRAME: NAD83 (2011 ADJ (2010 EPOCH))
ELLIPSOID: GRS80
COORDINATE SYSTEM: OHIO STATE PLANE (SOUTH)
MAP PROJECTION: LAMBERT CONFORMAL CONIC 2 STANDARD PARALLEL
PROJECT ADJUSTMENT FACTOR: 1.00003954
ORIGIN OF COORDINATE SYSTEM: (0,0)

USE THE POSITIONING METHODS AND MONUMENT TYPE USED IN THE ORIGINAL SURVEY TO RESTORE ALL MONUMENTS RELATED TO PRIMARY PROJECT CONTROL THAT ARE DAMAGED OR DESTROYED BY CONSTRUCTION ACTIVITIES. RESTORE THE DAMAGED OR DESTROYED MONUMENTS IN ACCORDANCE WITH CMS 623.

UNITS ARE IN U.S. SURVEY FEET.

Appendix H - Subsurface Utility Facility Matrix

PID: 12345
Agreement Number: 14256
Co/Rt/Sect: FRA-70-0.00

Utility Owner	Utility Facility	Quality Level	Depth/Elevation Source	Depth/Elevation	Location From:	Location To:	Approx. Distance	Comments
AT&T	Telephone	B	Records	30"	Sta 1+50	4+00	250'	Rt.
AT&T	Telephone	A	Surveyed	924.25'	Sta 4+00	N/A	N/A	Rt., At new light pole
AT&T	Telephone	B	Records	30"	Sta 4+00	12+55	855'	Rt.
AEP	Electric	B	Records	36"	Sta 5+25	7+80	255'	Lt.
AEP	Electric	A	Surveyed	923.74'	Sta 7+80	N/A	N/A	Lt., At new abutment
AEP	Electric	B	Records	36"	Sta 7+80	11+45	365'	Lt.

Appendix I – Surveyor's Certification Statement (Template)

Surveyor's Certification Statement

I, (Surveyor's Name) do hereby certify that the positioning of the utility facilities provided utilizing (Quality Level A, Quality Level B, Quality Level C, or Quality Level D as applicable) was performed in accordance with ODOT's Location and Design Volume 4 Manual.

______________________________ ____________

Signature Date Surveyor's Seal

Surveyor Printed Name
and Registration Number