## Section 9-1 Introduction

### 9-1-1 General
- **9-1-1-1** Originator
- **9-1-1-2** General

### 9-1-5 Description of Surveys
- **5-1** Engineering Surveys
- **5-2** Control Surveys
- **5-3** Primary Control Surveys
- **5-4** Secondary Control Surveys
- **5-5** Alignment Surveys
- **5-6** Photogrammetric Surveys
- **5-7** Right-of-Way Surveys

### 9-1-10 Automation Links to Surveys

### 9-1-15 Need for Accuracy

## Section 9-5 Policies

### 9-5-1 Preservation of Survey Monuments
- **9-5-1-1** General
- **9-5-1-2** Definitions
- **9-5-1-3** Types of Monuments Typically Found along WisDOT Projects
- **9-5-1-4** Geodetic Survey Control Station Replacement Procedure
- **9-5-1-5** Procedure to Perpetuate USPLSS and/or Land Parcel Boundary Monuments

### 9-5-3 Monument Perpetuation Document
- **9-5-3-1** Monument Perpetuation Document Procedure
- **9-5-3-2** Monument Perpetuation Document Examples

#### Attachment 3.1
- Edited Transportation Project Plat Example

#### Attachment 3.2
- Table Option with Maps Example

#### Attachment 3.3
- Table Option without Maps Example

### 9-5-5 Right-of-Way Monumentation

### 9-5-10 Standard Geodetic References

### 9-5-15 Requests for Photogrammetric Products and Services
- **9-5-15-1** Procedure
- **9-5-15-2** Resources

#### Attachment 5.1
- Right-of-Way Monumentation Policy

## Section 9-10 Public Relations

### 9-10-1 Public Contacts
- **9-10-1-1** Informational Letter
- **9-10-1-2** Notification of Local Officials
- **9-10-1-3** Property Owner Contacts
- **9-10-1-4** Published Notices and Press Releases
- **9-10-1-5** Public Contacts

### 9-10-5 Entry and Operations on Private Land
- **9-10-5-1** Entry on Private Land
- **9-10-5-2** Right of Entry Process
- **9-10-5-3** Entry on Indian Land
- **9-10-5-4** Entry on Public Land
- **9-10-5-5** Entry on Utility Right-of-Way
- **9-10-5-6** Entry on Railroad Right-of-Way
- **9-10-5-7** Operations on Private Land
- **9-10-5-8** Operations on Public Land

### 9-10-6 Surveys or Inspections on Railroad Right-of-Way
- **9-10-6-1** Right of Entry
- **9-10-6-2** Entry Process
- **9-10-6-3** Working on Railroad Right-of-Way
Section 9-20 Spatial Reference Systems

9-20-1 General
9-20-5 The Public Land Survey System
9-20-10 The National Spatial Reference System (NSRS)
  10.1 Horizontal Network
  10.2 Vertical Network
  10.3 Monumentation
9-20-15 Horizontal Datums
  15.1 North American Datum of 1927
  15.6 North American Datum of 1983 (2011)
  15.7 Datums Compared
9-20-20 Vertical Datums
  20.1 Introduction
  20.2 National Geodetic Vertical Datum Of 1929 (NGVD 29)
  20.3 North American Vertical Datum Of 1988 (NAVD 88)
  20.4 International Great Lakes Datum (IGLD)
  20.5 Local Vertical Datums
9-20-25 Coordinate Systems
  25.1 Map Projections
  25.2 Geographic Coordinate System
  25.3 Rectangular Coordinate Systems
  25.4 Using More Than One Coordinate System
9-20-26 Wisconsin State Plane Coordinate System
9-20-27 Wisconsin County Coordinate System
9-20-28 Wisconsin Coordinate Reference System
9-20-30 Coordinate Transformation
  30.1 Definitions
  30.2 Methods
  30.3 Horizontal Transformation
  30.4 Vertical Transformation
  30.5 Software
  30.6 Interpolation
  30.7 Trimble Geometrics Office (TGO)
9-20-35 Combination Factor Selection
  35.1 Elevation or Sea Level Factor
  35.2 Scale Factor
  35.3 Combination Factor
  35.4 Computational Accuracy
9-20-40 Grid/Ground Coordinate Conversions
  40.1 SPC Coordinates
Section 9-25 Monumentation

9-25-1 Perpetuation of Landmarks
   1.1 Corners To Be Recovered And Perpetuated
   1.2 Landmark Perpetuation

9-25-5 Control Monumentation
   5.1 Horizontal Control
   5.2 Vertical Control
   5.3 Three-Dimensional Control
   5.4 Alignment Surveys

9-25-6 Right of Way Monumentation
   6.1 Monument Location and Type
   6.2 Right-of-Way Marker Post
   6.3 Coordinates
   6.4 Positioning Requirements
   6.5 Documentation
   6.6 Minor Acquisition

9-25-10 Engineering Survey Monuments
   10.1 Type 1 Monument
   10.2 Type 2 Monument
   10.3 Type 3 Monument
   10.4 Type 4 Monument

Section 9-30 Real Time Kinematic (RTK) Surveys

9-30-1 Introduction
   1.1 Overview

9-30-5 RTK Application Categories and Their Uses

9-30-10 General Scheme of RTK Survey Data Collection

9-30-15 RTK Surveying Guidelines
   15.1 Table of RTK Surveying Guidelines
   15.2 Discussion of Items in Table

9-30-25 Definitions

Section 9-35 Horizontal Control - Traverse

9-35-1 When Used

9-35-5 Classification, Standards and Specifications
   5.1 Reasons for Classification, Standards and Specifications
   5.2 Classification
   5.3 Standards and Specifications

9-35-10 Horizontal Control Data Base
   10.1 The National Geodetic Reference System: NAD 27

9-35-15 Field Reconnaissance
   15.1 Recovery of Horizontal Control Stations
15.2 Horizontal Control Survey Configuration
15.3 Field Sketches

9-35-20 Field Procedures - Distance Measurement
20.1 Electronic Distance Measurements
20.2 Principle of Measurement
20.3 Sources of Error
20.4 Prisms
20.5 EDM Operation
20.6 Data Collection
20.7 Taping

9-35-25 Field Procedures - Angle Measurement
25.1 Total Stations
25.2 Horizontal Angles
25.3 Vertical/Zenith Angles
25.4 Instrument Orientation
25.5 Horizontal Orientation
25.6 Vertical Orientation
25.7 Data Collection

9-35-30 Computations
30.1 Horizontal and Vertical Angle Reduction
30.2 Horizontal and Vertical Distance Reduction
30.3 Curvature and Refraction
30.4 Methods for Traverse Adjustment
30.5 Accuracy Evaluations

9-35-35 Monumentation Required
Attachment 5.1 Recommended Minimum Classification Requirements
Attachment 5.2 Standards and Specifications for Horizontal Control
Attachment 10.1 Sample Data Sheet for Typical Horizontal Control Station

Section 9-40 Vertical Control

9-40-1 When Used
9-40-5 Classification, Standards and Specifications
5.1 Reasons for Classification, Standards and Specifications
5.2 Classification
5.3 Standards and Specifications

9-40-10 Vertical Control Data Base
10.1 First-Order (Primary Network)
10.2 Second-Order (Secondary Network)
10.3 Third-Order (Local Vertical Control)
10.4 Project Order (Project Specific Vertical Control)

9-40-15 Field Reconnaissance
9-40-20 Field Procedures
20.1 Single Run Double Simultaneous Leveling
20.2 Double Run Leveling
20.3 Three Wire Leveling
20.4 Single Wire Leveling
20.5 Reciprocal Leveling
20.6 Trigonometric Leveling
20.7 Digital Leveling
20.8 Curvature and Refraction
20.9 Peg Test
20.10 Data Collection

9-40-25 Computations
25.1 Single-Wire Adjustment
25.2 Three-Wire Adjustment
25.3 Least Squares Adjustments
25.4 Accuracy Evaluations
Table of Contents

9-40-35 Monumentation
  Attachment 5.1 Recommended Minimum Classification Requirements
  Attachment 5.2 Standards and Specifications for Vertical Control

Section 9-43 Planning and Scheduling

9-43-1 Minimum Data Requirements
  1.1 Reconstruction, Reconditioning, or Expansion Project
  1.2 Pavement Replacement Project
  1.3 Resurfacing Project
  1.4 Bridge Replacement or Bridge Rehabilitation Project
  1.5 References

9-43-5 Survey Time Frame
  Attachment 1.1 Surveying Operations to Meet Minimum Data Requirements

Section 9-45 Geospatial Projects

9-45-1 General

9-45-5 Aerial Imagery Products
  5.1 Vertical Aerial Imagery
  5.2 Digital Aerial Mosaic
  5.3 Digital Geo-Referenced Imagery
  5.4 Oblique Aerial Imagery

9-45-10 Aerial Photogrammetry Products
  10.1 Digital Terrain Model (DTM)
  10.2 Planimetric Map
  10.3 Expedient Planimetric Map
  10.4 Extensions to DTM and Mapping Products
  10.5 Digital Ortho Imagery

9-45-15 Aerial Photogrammetry Work Flow

9-45-20 LiDAR Products
  20.1 Scanner Types
  20.2 Ground Control and Targeting
  20.3 Accuracy Requirements
  20.4 How to Request a LiDAR Project
  20.5 Deliverables
  20.6 Limitations
  20.7 Factors to Consider when Selecting LiDAR for a Project
  20.8 Conclusion

9-45-25 LiDAR Work Flow

9-45-30 Unmanned Aircraft Systems (a.k.a. UAS, UA, UAV, Drones)

9-45-35 Ground Control
  35.1 Target Document
  35.2 Surveying Photogrammetry and LiDAR Targets

9-45-40 Computation, Documentation and Distribution
  40.1 Computation
  40.2 Naming Standards
  40.3 Documentation and Distribution of Ground Control

Attachment 1.1 Geospatial Products
Attachment 5.1 Aerial Imagery Product Examples
Attachment 10.1 Geospatial Product Examples
Attachment 15.1 Aerial Photogrammetry Work Flow Diagram
Attachment 35.1 Geospatial Targeting Guidelines
Attachment 40.1 Naming Standards for WSI Files
Attachment 40.2 Naming Standards for Folders and Files on the LiDAR Server
Attachment 40.3 Wisconsin County Coordinate System Numbers and Abbreviations
Attachment 40.4 Sample WSI Files for Ground Control and Map Check Data

Section 9-50 Alignments - Reference Line with Stationing

9-50-1 When Used
9-50-5 Standards and Specifications
Section 9-50 Alignment Surveys

5.1 Alignment Surveys
5.2 Reference Line With Stationing

9-50-10 Field and Office Reconnaissance
10.1 Establishing Existing Alignments
10.2 References

9-50-15 Field Procedures
15.1 Establishing Existing Alignments
15.2 New Alignments

9-50-20 Alignment Computation
20.1 Field-Surveyed Alignments
20.2 Alignments Established by Design Computation
20.3 Elements Common to All Alignments
20.4 Data Storage

9-50-25 Monumentation Required
Attachment 20.1 Adjustment of Intermediate POT

Section 9-55 Drainage Structure Surveys

9-55-1 Introduction
1.1 When Used
1.2 Data Collected
1.3 Standards and Specifications
1.4 Coordination

9-55-5 Field Procedures
5.1 Horizontal Alignment
5.2 Topography
5.3 Profile
5.4 Cross Sections/DTMs
5.5 Existing Structure Information

9-55-10 Computations
9-55-15 Monumentation Required
Attachment 5.1 Horizontal Alignment at Drainage Structure
Attachment 5.2 Flood Plain Section at Drainage Structure
Attachment 5.3 Waterway Opening at Drainage Structure

Section 9-60 Structure Surveys

9-60-1 Introduction
1.1 When Used
1.2 Standards and Specifications
1.3 References

9-60-5 Field Procedures
5.1 Separation Structure Survey
5.2 Rehabilitation Structure Survey

9-60-10 Monumentation Required
10.1 Separation Structure Survey
10.2 Rehabilitation Structure Survey
Attachment 5.1 Survey Data for Structure Rehabilitation Project
Attachment 5.2 Structure Terminology Diagram

Section 9-65 Cross Sections/Digital Terrain Models (DTMs)

9-65-1 Introduction
1.1 When Used
1.2 Standards and Specifications

9-65-5 Field Procedures
5.1 Cross Sections
5.2 Digital Terrain Models (DTMs)
5.3 Computations

9-65-10 Monumentation Required

Section 9-70 Topography
Section 9-70 Field Procedures

- 9-70-1 Introduction
  - 1.1 When Used
  - 1.2 Standards and Specifications
  - 1.3 Other References

- 9-70-5 Field Procedures
  - 5.1 Computations
  - 5.2 Field Notes

Section 9-70-10 Data Destination, Formats, etc.

Section 9-75 Right-of-Way

- 9-75-1 Introduction
  - 1.1 When Used
  - 1.2 Standards and Specifications

- 9-75-5 Field Procedures
  - 5.1 Methods
  - 5.2 Monumentation
  - 5.3 Computations

Section 9-80 Survey Mathematics

- 9-80-5 Survey Mathematics
  - Attachment 5.1 Curve Formulas
  - Attachment 5.2 Trigonometric Formulas
  - Attachment 5.3 Cosine Law - Oblique Triangle
  - Attachment 5.4 Coordinate Geometry