

**IDEM Office of Land Quality**  
**Spatial Data Collection Standards**

Version 1.0

**Indiana Department of Environmental Management**  
**Office of Land Quality**  
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## Introduction

The Indiana Department of Environmental Management (IDEM), Office of Land Quality (OLQ) developed this document to support spatial data collection (data that describes the location and/or shape of a feature on the earth) by OLQ staff and external source data collectors and submitters. The standards will help facilitate the accuracy, validity, consistency, comprehensiveness, and relevancy of OLQ’s spatial data. This document provides both OLQ staff and the private sector, standards and guidelines for collecting spatial data. **The procedures and standards outlined in this document must be applied to spatial data collection work performed by or for OLQ.**

## Accuracy

OLQ’s horizontal and vertical accuracy standard for spatial data is dependent upon the type of data collected (Table 1). The accuracy standard will meet the requirements for most mapping applications such as point generation (wellheads, environmental sampling locations, point pollution sources), line generation (roads, streams, forest trails), and polygon generation (area boundaries).

*Table 1 – Required Accuracy*

| <b>Type of Data Collected</b>  | <b>Accuracy (less than or equal to)</b>                   |
|--|---|
| General Facility Point   | 5 meter RMSE @ 95% confidence level *                     |
| Regulatory Boundary Control Point<br>(e.g. engineering control area, area restricted due to contamination, institutional control area) | 1 meter RMSE @ 95% confidence level *                     |
| Monitoring Well  | 1 meter RMSE @ 95% confidence level *                     |
| Sampling Point   | 1 meter RMSE @ 95% confidence level *                     |
| Vertical Data**  | 0.01 ft RMSE @ 95% confidence level * (vertical data)     |
| Lines and Polygons   | 1 meter RMSE @ 95% confidence level * (vertex collection) |

\* - Root-mean-square error (RMSE) required by the National Standard for Spatial Data Accuracy (NSSDA) see FGDC Spatial Accuracy standard specification (Geospatial Positioning Accuracy Standards Part 3: National Standard for Spatial Data Accuracy, FGDC-STD-007.3-1998, <http://www.fgdc.gov/standards/projects/FGDC-standards-projects/accuracy/part3/chapter3>)

\*\* - vertical (elevation) spatial data is only required in cases where elevations will be derived from the location, such as the reference point for measuring ground water elevations or derivation of contour lines.

## Elevation Data

If elevation data is required by the project, it will be referenced to the North American Vertical Datum of 1988 (NAVD 88) vertical geodetic datum. Elevations must be generated as orthometric heights (relative to mean sea level) determined using the GEOID03 (CONUS) or later geoid conversion model and must be in feet or meters.

## **GPS Data Collection**

Many different types of GPS receivers are available (Table 2), (however not all GPS receivers are designed for collecting GIS data. OLQ has adopted GPS data collection standards to insure data quality and consistency.

## **GPS Receiver Types and Requirements**

Table 2 – GPS Receiver Types

| <b>Type of Receiver</b> | <b>Differential GPS Capable?</b> | <b>Real-Time Differential GPS Horizontal Accuracy</b> | <b>Post Processing Capable?</b> |
|-------------------------|----------------------------------|---|---------------------------------|
| Recreation              | Some                             | 5-10 meters   | N/A                             |
| Mapping                 | Yes                              | Centimeters – 5 meters                                | Centimeters – 5 meters          |
| Survey                  | Yes                              | Sub centimeter  | Sub centimeter                  |

To insure that the appropriate type of GPS receiver is matched to the mapping application, an understanding of receiver capabilities and limitations is required.

### **Recreational Grade Receivers**

The recreation grade receiver is **not** designed for mapping and GIS applications, but for basic navigation. Generally, these do not have data collection capabilities beyond waypoints and routes (points or routes you wish to navigate to or follow). Many newer GPS receivers in this category have WAAS (Wide Area Augmentation System) correction capabilities and though the WAAS correction can increase accuracy to within 5 meters, the WAAS correction signal is not always available. With this class of receiver, users can expect determined positions to be accurate to within 10 meters with a 95% confidence RMSE (no WAAS) under ideal conditions (GPS signals of sufficient strength, and favorable satellite geometry). Under more typical field conditions where a user has to contend with tree cover and other objects that block portions of the sky, with less than favorable GPS satellite geometry, users can expect the accuracy of determined positions to have much worse accuracy - perhaps as high as within 40 meters. **Data collected with recreation grade receivers is not acceptable for use in OLQ as it will not meet the 5 meter or better NSSDA accuracy standard.**

### **Mapping Grade Receivers**

The most commonly used GPS receivers for spatial data collection are mapping or resource grade, code based receivers. These are specifically designed for storing mapped features (coordinates and attributes), achieving higher accuracy, operating in real-time differential correction mode, providing significant data storage capacity, and using processing software to improve the quality of the data. Positions determined by these receivers can be sub-meter accurate when using a Virtual Reference Station (VRS) network or up to 5 meter accuracy range after differential correction. These receivers generally perform better in less than

favorable environments. The GPS processing software includes utilities to enable GPS field data file transfer to a PC, perform post-process differential corrections, allow analysis/editing of data, and enable the export of collected data to standard GIS file format(s). Mapping grade GPS receivers are recommended for OLQ spatial data collection projects that do not require vertical coordinates.

*Mapping grade receivers used to collect data for OLQ must routinely achieve (at a minimum) 5 meter or better horizontal accuracy, using either real-time or post-processed differential correction.*

Mapping and survey grade receivers used for OLQ spatial data collection must meet the following requirements.

- Receiver must operate in a 3D mode, where the receiver requires signals from a minimum of four satellites to determine a 3D (latitude, longitude, and elevation) location (a fix). Fixes determined by calculations based on fewer than 4 satellites (2D or 2D/3D) are not permitted.
- Receiver must allow the storage of position fixes for features that are being mapped. When mapping point features, the receiver must be able to store a sample of position fixes (the minimum number depending on the quality of the receiver) for the feature.
- Receiver must have five or more channels for tracking satellites.

#### Survey Grade Receivers

The third class of GPS receiver, survey grade, is designed for applications that require extremely high accuracy. Positions determined by these receivers can be accurate to within less than a centimeter. These receivers are more sensitive to surrounding environmental conditions that cause signal blockage than mapping grade receivers. Data collected with this accuracy is only required for vertical spatial data such as potentiometric surface elevations, topographic elevations, and monitoring well water level measurement reference points.

Survey grade GPS receivers used for OLQ spatial data collection must adhere to the following additional requirements:

- Receiver must routinely achieve 2 cm or better horizontal accuracy, using either real-time or post-processed differential correction.
- Receiver must routinely achieve 2 cm or better vertical accuracy, using either real-time or post-processed differential correction.

### **GPS Field Data Collection**

GPS field work should be performed by staff that has had training in GPS and GIS or has a surveying or mapping background. Field staff should have a thorough understanding of GPS basic concepts, and receiver operation including how a receiver's critical parameter settings affect data collection. The staff should also have familiarity with the types of features that are to be located, and must be able to recognize/interpret features in the field. To achieve OLQ's target accuracy, all collected GPS data must be differentially corrected, either in real time or in a post processing step

## GPS Collection Parameter Settings

To be consistent with OLQ's spatial data collection guidelines, the following critical receiver parameters should be set accordingly:

*Table 3 - Standard GPS Collection Parameter Settings*

|                                      |   |
|--------------------------------------|---|
| Position Mode                        | All position fixes must be determined with 4 or more satellites. Manual 3D or over-determined 3D (5 satellites minimum) modes are acceptable. 2D fixes (using only 3 satellites) are <b>not</b> acceptable. 3D positions generated from 2D fixes supplemented with user entered elevations are also <b>not</b> acceptable.  |
| Elevation Mask                       | 10 degrees above horizon.   |
| PDOP Mask                            | Less than or equal to 6   |
| Signal to Noise Ratio Mask (SNR)     | If this parameter setting exists, set it to the manufacturer's recommendation. The more noise in a signal, the less reliable the signal will be for accurate position determination.  |
| Minimum Positions for Point Features | Use the manufacturer's recommended minimum number that will enable the collector to achieve the better than 5 meter, 95% confidence level. For some older receivers this will mean logging 100-200 fixes per point feature. For receivers capable of sub-meter accuracy, a minimum of 5 total fixes, at a 1 second log rate will be collected. Solutions based on a single fix are not acceptable unless the data is corrected in the field using real time correction (RTK) based on an established reference station. |
| Logging Intervals                    | Intervals for point features will be 1 or 5 second. Intervals for line and area features depend on the velocity at which the receiver will be traveling and the nature of the feature and the operating environment. Under normal circumstances (i.e., when the user is walking with the receiver) the interval for line and area features will be set to 1 second.   |
| Logging of DOP                       | The receiver must be set to allow the logging of DOP data along with position fixes.  |
| Datum                                | NAD 83  |
| Units                                | Meters, Feet, or Decimal Degrees (see Table 5)  |

|                   |   |
|-------------------|---|
| Coordinate System | Universal Transverse Mercator Zone 16 North<br>Indiana State Plane (East or West)<br>Latitude/Longitude (see Table 5) |
| Elevation Mode    | Height above ellipsoid (HAE)  |

### **Real Time Correction GPS Collection Parameter Settings**

When using real-time differential correction, the additional parameters will be set accordingly (Table 4):

*Table 4 - Additional Real-Time Differential GPS Collection Parameter Settings*

|                              |  |
|------------------------------|--|
| Logging of Post Process Data | If the receiver allows, this parameter will be set to enable the real-time differentially corrected data to be optionally differentially corrected in a post process step. |
| RTCM Station                 | If the receiver allows, set this parameter so that the receiver will use RTCM GPS correction signals from the closest beacon.  |

### **Processing of GPS Field Data**

All GPS data collected for OLQ must undergo some post processing steps using GPS processing software before the data can be used to generate a GIS data file or can be submitted to OLQ. The GPS processing software must be able to download GPS data files from the GPS receiver, and perform differential correction. Post-processing differential correction is not required or recommended if real-time differential correction was used and the real-time correction provided higher accuracy than would be achieved in post-processing. Higher accuracy real-time correction is possible in situations where the real-time reference station is closer to the field area than the reference station used to collect the post-processing data file.

### **Analysis and Editing**

The fact that GPS field data is differentially corrected does not necessarily mean that it is of high quality. It must be inspected for errors and analyzed for precision. For point features, at least 95% of the position fixes making up the feature should be within 5 meters horizontally of the feature's true position (or better depending upon the type of data collected). Outlier fixes that are obviously in error may be edited (deleted) from the sample of position fixes for a point feature. A description of data edits should be included in the report (see Deliverables – General). For line and area features, the standard is the same. At least 95% of the fixes making up a line feature or area boundary should be within 5 meters (perpendicular) of (truth). Fixes that show significant deviation from what should be a relatively straight or smooth line or curve may be deleted.

## GPS Processing Software Requirements

GPS data processing software must adhere to the following requirements:

- Must be capable of performing differential corrections.
- Provide quality control information about, or summary reports on, satellite residuals, standard deviations of point features, Dilution of Precision (DOP), files processed, critical receiver setting parameters (collection mode, elevation mask, PDOP mask, signal to noise ratio mask, etc.)
- Detect and remove bad satellite data or positions.
- Exporting data to a GIS or text file format. Final submission to OLQ must be consistent with the approved export formats, coordinate system, datum, and projection (Table 5).

*Table 5 - Projection, and Unit Requirements*

Data must meet one of the following projection and unit combinations.

| <b>Standard</b>    | <b>Projection</b>                  | <b>Units</b>     |
|--------------------|------------------------------------|------------------|
| State of Indiana   | UTM Zone 16 North                  | Meters           |
| Alternate          | Indiana State Plane (East or West) | U.S. Survey Feet |
| Latitude/Longitude | None                               | Decimal Degrees  |

*Table 6 - Reference Datum*

All data must be collected and submitted in one of the following datums:

| <b>Datum</b>   | <b>Datum Type</b> | <b>Datum Description</b>   |
|----------------|-------------------|--|
| NAD83 (CONUS)  | Horizontal        | North American Datum of 1983                                     |
| NAD83 (2007)   | Horizontal        | National Spatial Reference System Readjustment of NAD 83         |
| NAD83 (CORS96) | Horizontal        | Continuously Operating Reference Stations Readjustment of NAD 83 |
| NAD83 (HARN)   | Horizontal        | High Accuracy Reference Network Readjustment of NAD 83           |
| NAVD88         | Vertical          | North American Vertical Datum of 1988                            |

## Surveying

Spatial data coordinates may be collected using traditional land surveying techniques provided that the coordinate data meets or exceeds the accuracy standards listed in Table 1. The person responsible for the spatial data collection shall provide a text narrative describing the survey procedures used to collect the coordinates. The narrative must include the following information, at a minimum:

- Date(s) and times of survey
- Surveyor Name
- Surveyor License #
- Legal Description (line and area features)

- All data necessary to indicate the mathematical relationships between the surveyed locations and to indicate the horizontal and vertical accuracy of the surveyed locations.
- Standard, projection, and units (listed in Table 5)
- A data table and digital tab-delimited text data file with the following information for each feature collected:
  - Feature Name
  - X Coordinate (in one of the geographic projections specified in Table 5)
  - Y Coordinate (in one of the geographic projections specified in Table 5)
  - Z Coordinate (if required)(in one of the geographic projections specified in Table 5)
  - Note: For line and area features X and Y, Coordinates must be submitted for each vertex of the feature.
  - Feature Type (from Table 8)
  - Date/Time Collected

## **Address Matching and Map Interpolation**

Due to the accuracy limitations inherent in the address matching and map datasets available for interpolation, these methods are only allowed for collecting the following spatial data:

- Facility Entrance location
- Location of drinking water samples collected from a house tap or spigot where a 911 address is known (e.g. residences where drinking water samples were collected as part of a complaint investigation).
- Location of houses or other buildings that are not directly regulated, but whose location may be affected by the regulated facility or area (e.g. residences within a certain distance of a facility under consideration for a permit or remediation activity).

## **Deliverables**

### ***General***

The final deliverables will include the following (plus any data the project manager or program requires):

- a) A report in .pdf format describing the methodology used to collect the spatial data, including:
  1. Site/Facility Name
  2. Site/Facility Regulatory ID
  3. OLQ regulatory program(s) for which the data was collected.
  4. Purpose of data collection.
  5. Names of personnel involved in collecting/processing the data and their role in the project.
  6. Method (Mapping Grade GPS, Survey Grade GPS, Surveying, Address Matching, Map Interpolation).
  7. Description of data sources (address match and map interpolated data only) including accuracy of the data source.
  8. Table of address data used for address matched locations.
  9. Field notes

10. Narrative describing post processing and other data preparation.

**Data Files**

- a) All corrected GPS field data files must be submitted. If edits are made to corrected files (i.e., fixes deleted or offset), copies of both edited and unedited are to be submitted.
- b) All GPS processing log files pertaining to post-processing differential correction and GIS export (if produced by the GPS processing software) in text file format.
- c) Data files of corrected data (see example in Appendix 1) (Table 7) in tab-delimited text or .xls format.
- d) The report in .pdf format and all data files must be submitted electronically as an email attachment sent to [OLQDATA@idem.in.gov](mailto:OLQDATA@idem.in.gov) with a CC: to the project manager for the site.

The following attributes must be included for all features in the data files:

*Table 7 – Data File Attributes*

|  |
|--|
| <b>All Features</b>                        |
| Feature Name (well name, point name, etc.) |
| Feature Type (from Table 8)                |
| Maximum PDOP                               |
| X Coordinate                               |
| Y Coordinate                               |
| Elevation (MSL in feet or meters) *        |
| Vertical Precision*                        |
| Standard deviation                         |
| Correction Method (from Table 9)           |
| Date of collection                         |
| Time of collection                         |
| Data file name                             |
| Total positions                            |
| Filtered positions                         |
| Receiver Brand                             |
| Receiver Model                             |
| Receiver type                              |

\* Only necessary if elevation data is required by project

*Table 8 – Feature Type*

|                       |                                   |                   |
|-----------------------|-----------------------------------|-------------------|
| Access Point          | Other                             | Surface Water     |
| Air Ambient Sample    | Outfall                           | Surveyed Location |
| Boundary (General)    | Pad                               | Tank              |
| Boundary (Property)   | Sampling Location - General       | Waste Storage     |
| Building              | Sampling Location – Ground Water  | Waste Disposal    |
| Control               | Sampling Location - Sediment      | Waste Process     |
| Ditch                 | Sampling Location – Surface Water | Well              |
| Drinking Water Supply | Sampling Location -               |                   |
| Effluent              | Soil Boring                       |                   |
| Influent              | Spill                             |                   |
| Landmark              | Stack                             |                   |

*Table 9 - Correction Method*

|                             |  |
|-----------------------------|--|
| Uncorrected                 | Uncorrected positions.   |
| P(Y) Code                   | Positions collected using P-code or Y-code. Only military receivers can compute or log positions using these codes.  |
| Real-time SBAS Corrected    | Positions that have been corrected using real-time SBAS.   |
| Real-time Code              | Positions collected using real-time differential GPS and computed using a code phase solution.   |
| Postprocessed Code          | Positions that have been differentially corrected using code processing.   |
| Real-time Carrier Float     | Positions collected using real-time differential GPS and computed using a carrier float solution.  |
| Postprocessed Carrier Float | Positions that have a carrier float position. These positions were corrected using either the H-Star processing (Trimble) option in the Differential Correction wizard, or using the Smart Code and Carrier Phase Processing option or the Carrier Phase Processing option in the Differential Correction utility. |
| RTK Fixed                   | Positions collected using real-time kinematic techniques and computed using a carrier fixed solution   |
| Postprocessed Carrier Fixed | Positions corrected in the Differential Correction utility using the Centimeter Processing option, and having a carrier fixed solution.  |

**Appendix – Example Text Data File**

| Point Feature Data Example                    |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
|---|---------------------|-----------------|--------------------|---------------------|---------------------------|--------------------------|---------------------------|---------------------------|-----------------------|------------------------|---------------------------|
| <u>Feature Name</u>                           | <u>Feature Type</u> | <u>Max PDOP</u> | <u>Easting (X)</u> | <u>Northing (Y)</u> | <u>Standard Deviation</u> | <u>Correction Method</u> | <u>Date of Collection</u> | <u>Time of Collection</u> | <u>Data File Name</u> | <u>Total Positions</u> | <u>Filtered Positions</u> |
| Sampling Point 1                              | Sampling Point      | 1.2             | 571260.4699        | 4402644.447         | 0.8612                    | Postprocessed Code       | 6/5/2008                  | 5:15 PM                   | R060520A.ssf          | 42                     | 0                         |
| <i>Collector: Shane Moore</i>                 |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Projection: UTM Zone 16 N</i>              |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Datum: NAD 83</i>                          |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Units: Meters</i>                          |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>GPS Receiver Brand/model Trimble GeoXT</i> |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Receiver Type Mapping Grade</i>            |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| Line Feature Data Example                     |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <u>Feature Name</u>                           | <u>Feature Type</u> | <u>Max PDOP</u> | <u>Easting (X)</u> | <u>Northing (Y)</u> | <u>Standard Deviation</u> | <u>Correction Method</u> | <u>Date of Collection</u> | <u>Time of Collection</u> | <u>Data File Name</u> | <u>Total Positions</u> | <u>Filtered Positions</u> |
| Slurry wall - Vertex 1                        | Control             | 1               | 571303.4334        | 4402644.53          | 1.813                     | Postprocessed Code       | 7/1/2008                  | 10:21:00 AM               | R070115A.ssf          | 51                     | 8                         |
| Slurry wall - Vertex 2                        | Control             | 0               | 571503.3507        | 4402599.336         | 2.345                     | Postprocessed Code       | 7/1/2008                  | 10:25:43 AM               | R070115B.ssf          | 40                     | 0                         |
| Slurry wall - Vertex 3                        | Control             | 1.1             | 571660.4699        | 4402599.336         | 0.0312                    | Postprocessed Code       | 7/1/2008                  | 10:47:21 AM               | R070115C.ssf          | 45                     | 10                        |
| Slurry wall - Vertex 4                        | Control             | 0               | 571868.5669        | 4402623.627         | 5.983                     | Postprocessed Code       | 7/1/2008                  | 11:06:25 AM               | R070116A.ssf          | 38                     | 0                         |
| <i>Collector: Shane Moore</i>                 |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Projection: UTM Zone 16 N</i>              |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Datum: NAD 83</i>                          |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Units: Meters</i>                          |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>GPS Receiver Brand/model Trimble GeoXH</i> |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Receiver Type Mapping Grade</i>            |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| Area Feature Data Example                     |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <u>Feature Name</u>                           | <u>Feature Type</u> | <u>Max PDOP</u> | <u>Easting (X)</u> | <u>Northing (Y)</u> | <u>Standard Deviation</u> | <u>Correction Method</u> | <u>Date of Collection</u> | <u>Time of Collection</u> | <u>Data File Name</u> | <u>Total Positions</u> | <u>Filtered Positions</u> |
| Affected Area - Vertex 1                      | Control             | 0               | 571268.5669        | 4402623.627         | 0.8571                    | Postprocessed Code       | 5/23/2008                 | 1:22:47 PM                | R052318A.ssf          | 8                      | 0                         |
| Affected Area - Vertex 2                      | Control             | 0               | 571268.5669        | 4402639.573         | 0.3204                    | Postprocessed Code       | 5/23/2008                 | 1:36:34 PM                | R052318B.ssf          | 5                      | 0                         |
| Affected Area - Vertex 3                      | Control             | 0               | 571287.4873        | 4402639.49          | 0.5423                    | Postprocessed Code       | 5/23/2008                 | 1:53:52 PM                | R052318C.ssf          | 7                      | 0                         |
| Affected Area - Vertex 4                      | Control             | 1               | 571287.4873        | 4402623.544         | 1.012                     | Postprocessed Code       | 5/23/2008                 | 2:17:36 PM                | R052319A.ssf          | 7                      | 0                         |
| <i>Collector: Shane Moore</i>                 |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Projection: UTM Zone 16 N</i>              |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Datum: NAD 83</i>                          |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Units: Meters</i>                          |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>GPS Receiver Brand/model Trimble ProXR</i> |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |
| <i>Receiver Type Mapping Grade</i>            |                     |                 |                    |                     |                           |                          |                           |                           |                       |                        |                           |