Winnebago County, Wisconsin
LiDAR Project Report

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1. Summary / Scope

1.1. Summary

This report contains a summary of the Winnebago County, WI QL2 LiDAR acquisition task order, issued by Winnebago County under their contract on July 1, 2016. The task order yielded a project area covering approximately 432 square miles over Winnebago County. The intent of this document is only to provide specific validation information for the data acquisition/collection work completed as specified in the task order.

1.2. Scope

Aerial topographic LiDAR was acquired using state of the art technology along with the necessary surveyed ground control points (GCPs) and airborne GPS and inertial navigation systems. The aerial data collection was designed with the following specifications listed in Table 1 below.

Table 1. Originally Planned LiDAR Specifications

Average Point Density	Flight Altitude (AGL)	Field of View	Minimum Side Overlap	RMSEz
≥ 2 pts / m^2	2,000 m	40°	30%	≤ 10 cm

1.3. Coverage

The LiDAR project boundary covers approximately 432 square miles and includes partial coverage of Winnebago County in eastern Wisconsin. A buffer of 100 meters was created to meet task order specifications. LiDAR extents are shown in Figure 1.

1.4. Duration

LiDAR data was acquired from April 21, 2014 to May 21, 2014 in seven total lifts. Data from five lifts were used. See “Section: 2.4. Time Period” for more details.

1.5. Issues

There were no issues to report with this project.

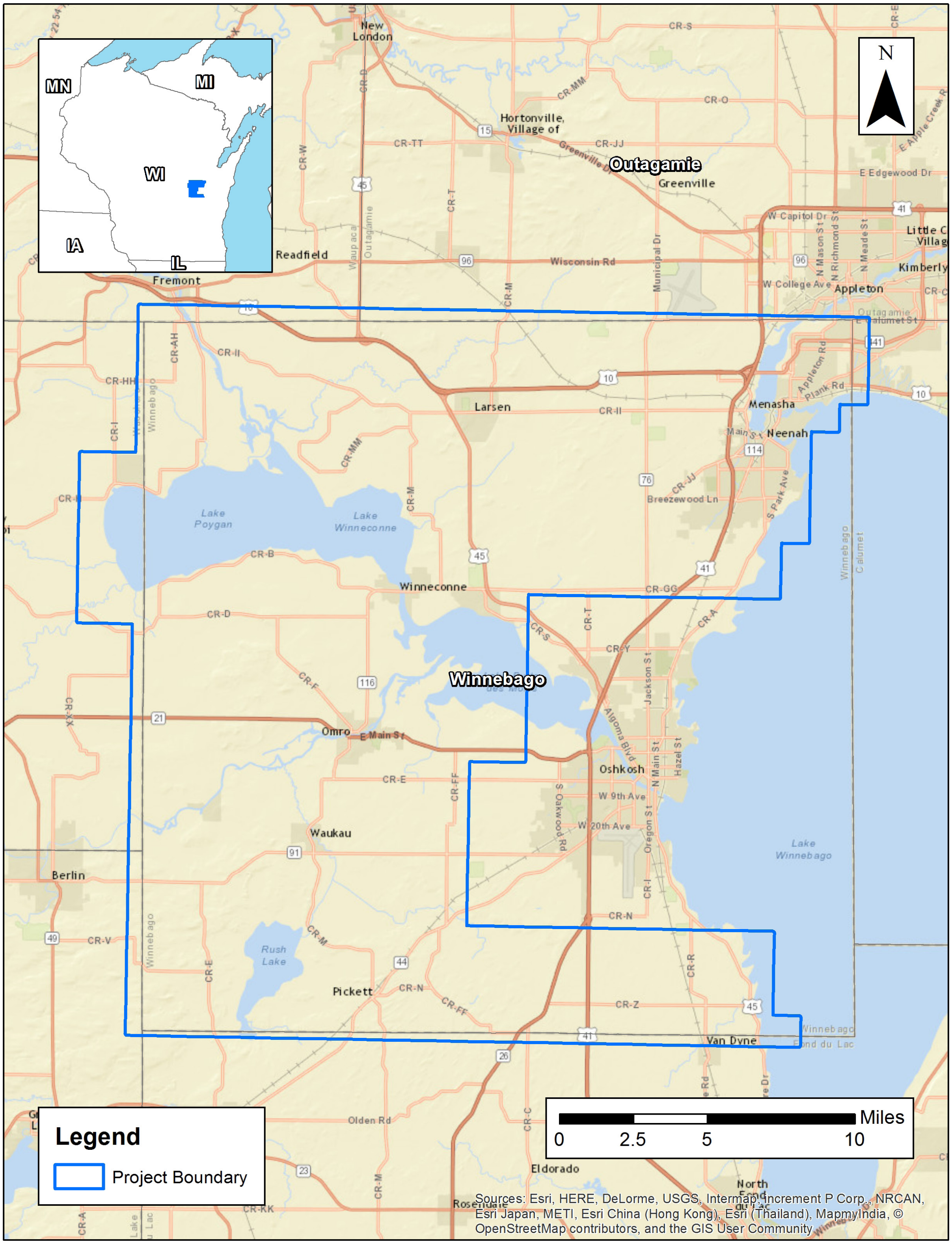
1.6. Deliverables

The following products were produced and delivered:

- Raw LiDAR point cloud data swaths in LAS 1.4 format
- Classified LiDAR point cloud data, tiled, in LAS 1.4 format
- Hydro-flattened breaklines in Esri shapefile format
- 5-foot hydro-flattened bare earth raster DEMs, tiled, in ERDAS .IMG format
- 5-foot intensity images, tiled, in GeoTIFF format
- 2-foot contours, tiled, in Esri file geodatabase format

All geospatial deliverables were produced in NAD83 (2011) Wisconsin Coordinate Reference System (WISCRS) Calumet, Fond du Lac, Outagamie and Winnebago Counties, US survey feet; NAVD88 (GEOID12B), US survey feet. All tiled deliverables have a tile size of 5,000 feet x 5,000 feet.

Figure 1. Project Boundary



2. Planning / Equipment

2.1. Flight Planning

Flight planning was based on the unique project requirements and characteristics of the project site. The basis of planning included: required accuracies, type of development, amount / type of vegetation within project area, required data posting, and potential altitude restrictions for flights in project vicinity.

Detailed project flight planning calculations were performed for the project using Leica MissionPro planning software. The entire target area was comprised of 57 planned flight lines measuring approximately 1,189 flight line miles (Figure 2).

2.2. LiDAR Sensor

Quantum Spatial utilized a Leica LiDAR sensor (Figure 3), serial number 7178, during the project. The Leica ALS 70 system is capable of collecting data at a maximum frequency of 500 kHz, which affords elevation data collection of up to 500,000 points per second. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor is also equipped with the ability to measure up to 4 returns per outgoing pulse from the laser and these come in the form of 1st, 2nd, 3rd and last returns. The intensity of the returns is also captured during aerial acquisition.

A brief summary of the aerial acquisition parameters for the project are shown in the LiDAR System Specifications in Table 2.

Figure 2. Planned Flight Lines

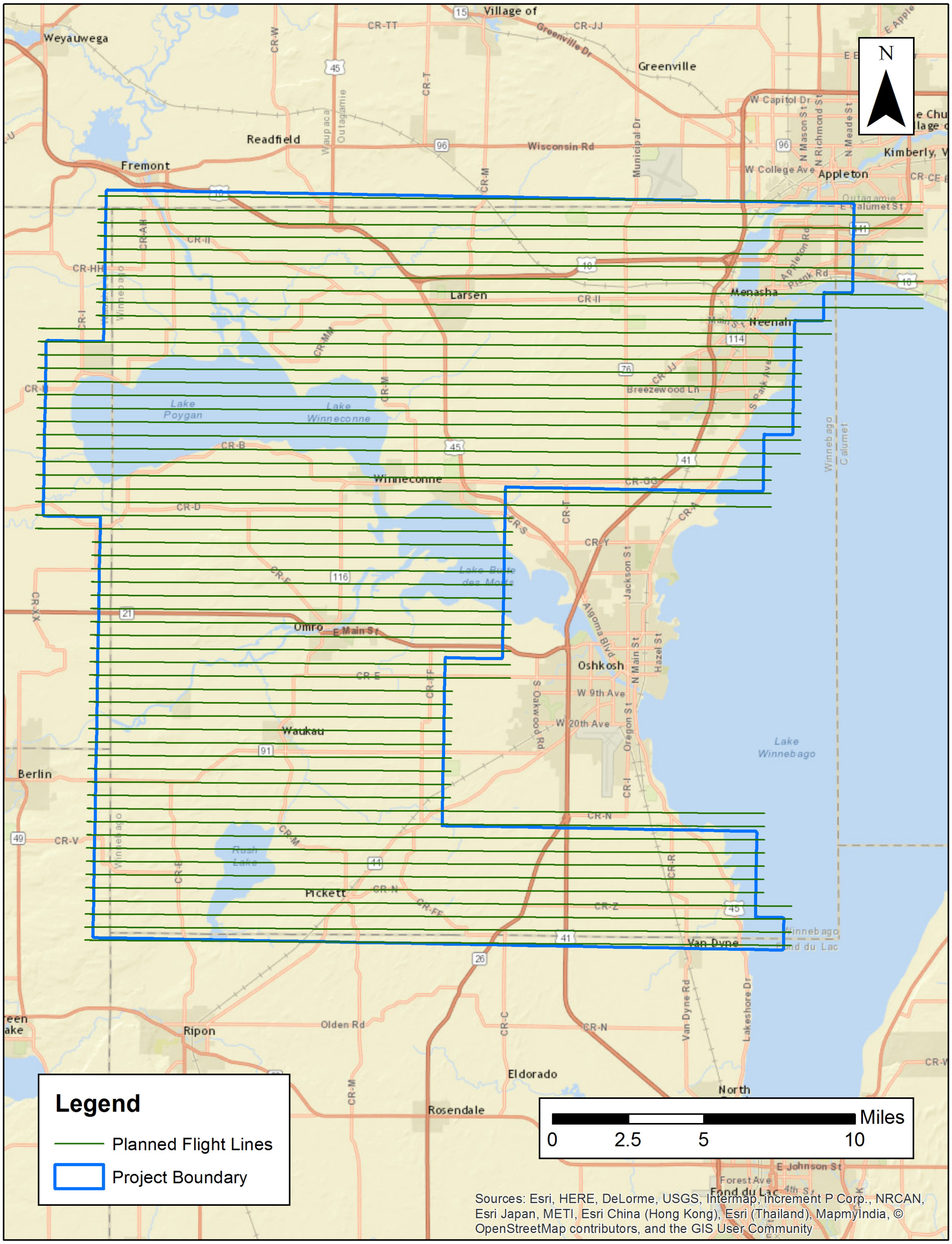


Table 2. Lidar System Specifications

		SN7161
Terrain and Aircraft Scanner	Flying Height	2,000 m
	Recommended Ground Speed	150 kts
Scanner	Field of Vie	40.0°
	Scan Rate Setting Used	53.4 Hz
Laser	Laser Pulse Rate Used	273.6 kHz
	Multi Pulse in Air Mode	Enabled
Coverage	Full Swath Width	1,455.88 m
	Line Spacing	1,243.98 m
Point Spacing and Density	Maximum Point Spacing Along Track	0.94 m
	Maximum Point Spacing Across Track	0.94 m
	Average Point Density	2.44 pts / m^2

Figure 3. Leica ALS70 LiDAR Sensor

2.3. Aircraft

All flights for the project were accomplished through the use of customized Piper Navajo (twin-piston), Tail Number N812TB. This aircraft provided an ideal, stable aerial base for LiDAR and orthoimagery acquisition. This aerial platforms has relatively fast cruise speeds which are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which proved ideal for collection of high-density, consistent data posting using a state-of-the-art Leica LiDAR systems. Some of Quantum Spatial's operating aircraft can be seen in Figure 4 below.

Figure 4. Some of Quantum Spatial's Planes

2.4. Time Period

Project specific flights were conducted over two months. Seven sorties, or aircraft lifts were completed. Accomplished sorties are listed below.

- Apr 22, 2014-A (N812TB, SN7161)*
- Apr 23, 2014-A (N812TB, SN7161)
- Apr 23, 2014-B (N812TB, SN7161)
- Apr 26, 2014-A (N812TB, SN7161)*
- May 3, 2014-A (N812TB, SN7161)
- May 14, 2014-A (N812TB, SN7161)
- May 21, 2014-A (N812TB, SN7161)

* Data from these missions were not used due to cloud interference.

3. Processing Summary

3.1. Flight Logs

Flight logs were completed by LIDAR sensor technicians for each mission during acquisition. These logs depict a variety of information, including:

- Job / Project #
- Flight Date / Lift Number
- FOV (Field of View)
- Scan Rate (HZ)
- Pulse Rate Frequency (Hz)
- Ground Speed
- Altitude
- Base Station
- PDOP avoidance times
- Flight Line #
- Flight Line Start and Stop Times
- Flight Line Altitude (AMSL)
- Heading
- Speed
- Returns
- Crab

Notes: (Visibility, winds, ride, weather, temperature, dew point, pressure, etc). Project specific flight logs for each sortie are available in Appendix A.

3.2. LiDAR Processing

Inertial Explorer software was used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the LiDAR sensor during all flights. Inertial Explorer combines aircraft raw trajectory data with stationary GPS base station data yielding a "Smoothed Best Estimate Trajectory (SBET) necessary for additional post processing software to develop the resulting geo-referenced point cloud from the LiDAR missions.

During the sensor trajectory processing (combining GPS & IMU datasets) certain statistical graphs and tables are generated within the Inertial Explorer processing environment which are commonly used as indicators of processing stability and accuracy. This data for analysis include: Max horizontal / vertical GPS variance, separation plot, altitude plot, PDOP plot, base station baseline length, processing mode, number of satellite vehicles, and mission trajectory.

The generated point cloud is the mathematical three dimensional composite of all returns from all laser pulses as determined from the aerial mission. Laser point data are imported into TerraScan and a manual calibration is performed to assess the system offsets for pitch, roll, heading and scale. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above-ground features are removed from the data set. Point clouds were created using the Leica CloudPro software. GeoCue distributive processing software was used in the creation of some files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. TerraScan and TerraModeler software packages were then used for the automated data classification, manual cleanup, and bare earth generation. Project specific macros were developed to classify the ground and remove side overlap between parallel flight lines.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper was used as a final check of the bare earth dataset. GeoCue was used to create the deliverable industry-standard LAS files for both the All Point Cloud Data and the Bare Earth. In-house software was then used to perform final statistical analysis of the classes in the LAS files.

3.3. LAS Classification Scheme

The classification classes are determined by the USGS Version 1.2 specifications and are an industry standard for the classification of LIDAR point clouds. All data starts the process as Class 1 (Unclassified), and then through automated classification routines, the classifications are determined using TerraScan macro processing.

The classes used in the dataset are as follows and have the following descriptions:

- Class 1 – Processed, but Unclassified – These points would be the catch all for points that do not fit any of the other deliverable classes. This would cover features such as vegetation, cars, etc.
- Class 2 – Bare-Earth Ground – This is the bare earth surface
- Class 6 – Buildings – Points falling on buildings.
- Class 7 – Low Noise – Low points, manually identified below the surface that could be noise points in point cloud.
- Class 9 – In-land Water – Points found inside of inland lake/ponds
- Class 10 – Ignored Ground – Points found to be close to breakline features. Points are moved to this class from the Class 2 dataset. This class is ignored during the DEM creation process in order to provide smooth transition between the ground surface and hydro flattened surface.
- Class 17 – Bridge Decks – Points falling on bridge decks.
- Class 18 – High Noise – High points, manually identified above the surface that could be noise points in point cloud.

3.4. Classified LAS Processing

The bare earth surface is then manually reviewed to ensure correct classification on the Class 2 (Ground) points. After the bare- earth surface is finalized; it is then used to generate all hydro-breaklines through heads-up digitization.

All ground (ASPRS Class 2) LiDAR data inside of the Lake Pond and Double Line Drain hydro flattening breaklines were then classified to water (ASPRS Class 9) using TerraScan macro functionality. A buffer of 3 feet was also used around each hydro flattened feature to classify these ground (ASPRS Class 2) points to Ignored ground (ASPRS Class 10). All Lake Pond Island and Double Line Drain Island features were checked to ensure that the ground (ASPRS Class 2) points were reclassified to the correct classification after the automated classification was completed.

All overlap data was processed through automated functionality provided by TerraScan to classify the overlapping flight line data to approved classes by USGS. The overlap data was identified using the Overlap Flag, per LAS 1.4 specifications.

All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper is used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for all point cloud data. Quantum Spatial proprietary software was used to perform final statistical analysis of the classes in the LAS files, on a per tile level to verify final classification metrics and full LAS header information.

3.5. Hydro-Flattened Breakline Creation

Class 2 LiDAR was used to create a bare earth surface model. The surface model was then used to heads-up digitize 2D breaklines of Inland Streams and Rivers with a 100 foot nominal width and Inland Ponds and Lakes of 2 acres or greater surface area.

Elevation values were assigned to all Inland Ponds and Lakes, Inland Pond and Lake Islands, Inland Streams and Rivers and Inland Stream and River Islands using TerraModeler functionality.

Elevation values were assigned to all Inland streams and rivers using Quantum Spatial proprietary software.

All ground (ASPRS Class 2) LiDAR data inside of the collected inland breaklines were then classified to water (ASPRS Class 9) using TerraScan macro functionality. A buffer of 3 feet was also used around each hydro flattened feature. These points were moved from ground (ASPRS Class 2) to Ignored Ground (ASPRS Class 10).

The breakline files were then translated to Esri file geodatabase format using Esri conversion tools.

3.6. Hydro-Flattened Raster DEM Creation

Class 2 LiDAR in conjunction with the hydro breaklines were used to create a 5-foot raster DEM. Using automated scripting routines within ArcMap, an ERDAS Imagine .IMG file was created for each tile. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

3.7. Intensity Image Creation

GeoCue software was used to create the deliverable Intensity Images. All overlap classes were ignored during this process. This helps to ensure a more aesthetically pleasing image. The GeoCue software was then used to verify full project coverage as well. TIF/TWF files with a 5-foot cell size were then provided as the deliverable for this dataset requirement.

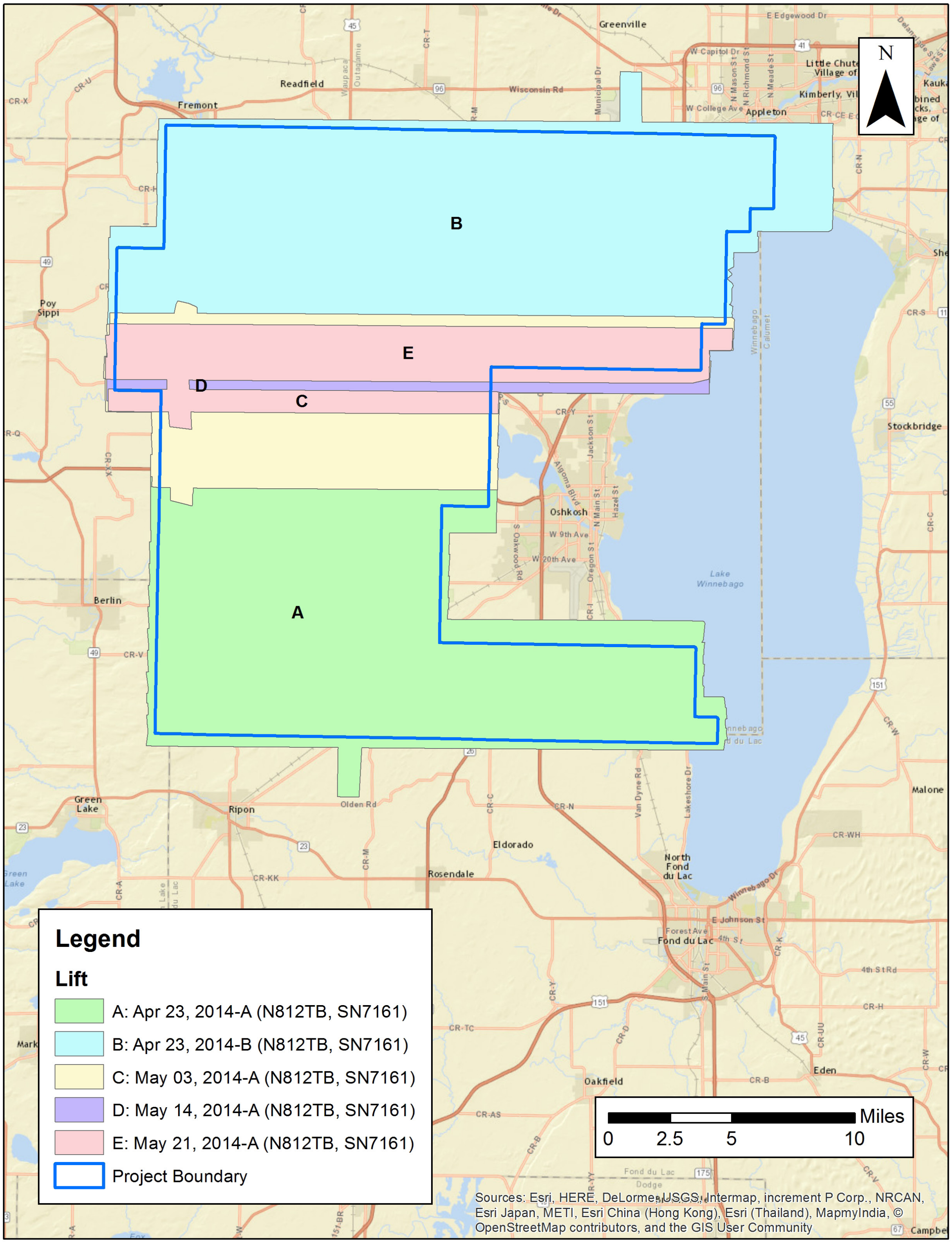
3.8. Contour Creation

Using automated scripting routines within ArcMap, a terrain surface was created using the ground (ASPRS Class 2) LiDAR data as well as the hydro breaklines. This surface was then used to generate the final continuous 2-foot contour dataset in Esri file geodatabase format.

4. Project Coverage Verification

Coverage verification was performed by comparing coverage of processed .LAS files captured during project collection to generate project shape files depicting boundaries of specified project areas. Please refer to Figure 5.

Figure 5. Flightline Swath LAS File Coverage



5. Ground Control and Check Point Collection

Quantum Spatial completed a field survey of 21 ground control (calibration) points along with 100 blind QA points in Vegetated and Non-Vegetated land cover classifications (total of 121 points) as an independent test of the accuracy of this project. In this document, horizontal coordinates are reported in NAD83 (2011) Wisconsin Coordinate Reference System (WISCRS) Calumet, Fond du Lac, Outagamie and Winnebago Counties, US survey feet; NAVD88 (GEOID12B), US survey feet.

5.1. Calibration Control Point Testing

Figure 6 shows the location of each bare earth calibration point for the project area. Table 3 depicts the Control Report for the LiDAR bare earth calibration points, as computed in TerraScan as a quality assurance check. Note that these results of the surface calibration are not an independent assessment of the accuracy of these project deliverables, but the statistical results do provide additional feedback as to the overall quality of the elevation surface.

5.2. Point Cloud Testing

The project specifications require that only Non-Vegetated Vertical Accuracy (NVA) be computed for raw lidar point cloud swath files. The required accuracy (ACCz) is: 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on RMSE of 10 cm in the "bare earth" and "urban" land cover classes. The NVA was tested with 40 checkpoints located in bare earth and urban (non-vegetated) areas. These check points were not used in the calibration or post processing of the lidar point cloud data. The checkpoints were distributed throughout the project area and were surveyed using GPS techniques. See survey report for additional survey methodologies.

Elevations from the unclassified lidar surface were measured for the x,y location of each check point. Elevations interpolated from the lidar surface were then compared to the elevation values of the surveyed control points. AccuracyZ has been tested to meet 19.6 cm or better Non-Vegetated Vertical Accuracy at 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASRPS Guidelines. See Figure 7 and Table 4.

5.3. Digital Elevation Model (DEM) Testing

The project specifications require the accuracy (ACCz) of the derived DEM be calculated and reported in two ways:

1. The required NVA is: 19.6 cm at a 95% confidence level, derived according to NSSDA, i.e., based on RMSE of 10 cm in the "bare earth" and "urban" land cover classes. This is a required accuracy. The NVA was tested with 40 checkpoints located in bare earth and urban (non-vegetated) areas. See Figure 8 and Table 5.

2. Vegetated Vertical Accuracy (VVA): VVA shall be reported for “brushlands”, “forest”, and “tall weeds” land cover classes. The target VVA is: 29.4 cm at the 95th percentile, derived according to ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data, i.e., based on the 95th percentile error in all vegetated land cover classes combined. This is a target accuracy. The VVA was tested with 60 checkpoints located in brushlands, forest, and tall weeds (vegetated) areas. The checkpoints were distributed throughout the project area and were surveyed using GPS techniques. See Figure 9 and Table 6.

See survey report for additional survey methodologies. AccuracyZ has been tested to meet 19.6 cm or better Non-Vegetated Vertical Accuracy at 95% confidence level using RMSE(z) x 1.9600 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASRPS Guidelines.

Figure 6. Calibration Control Point Locations

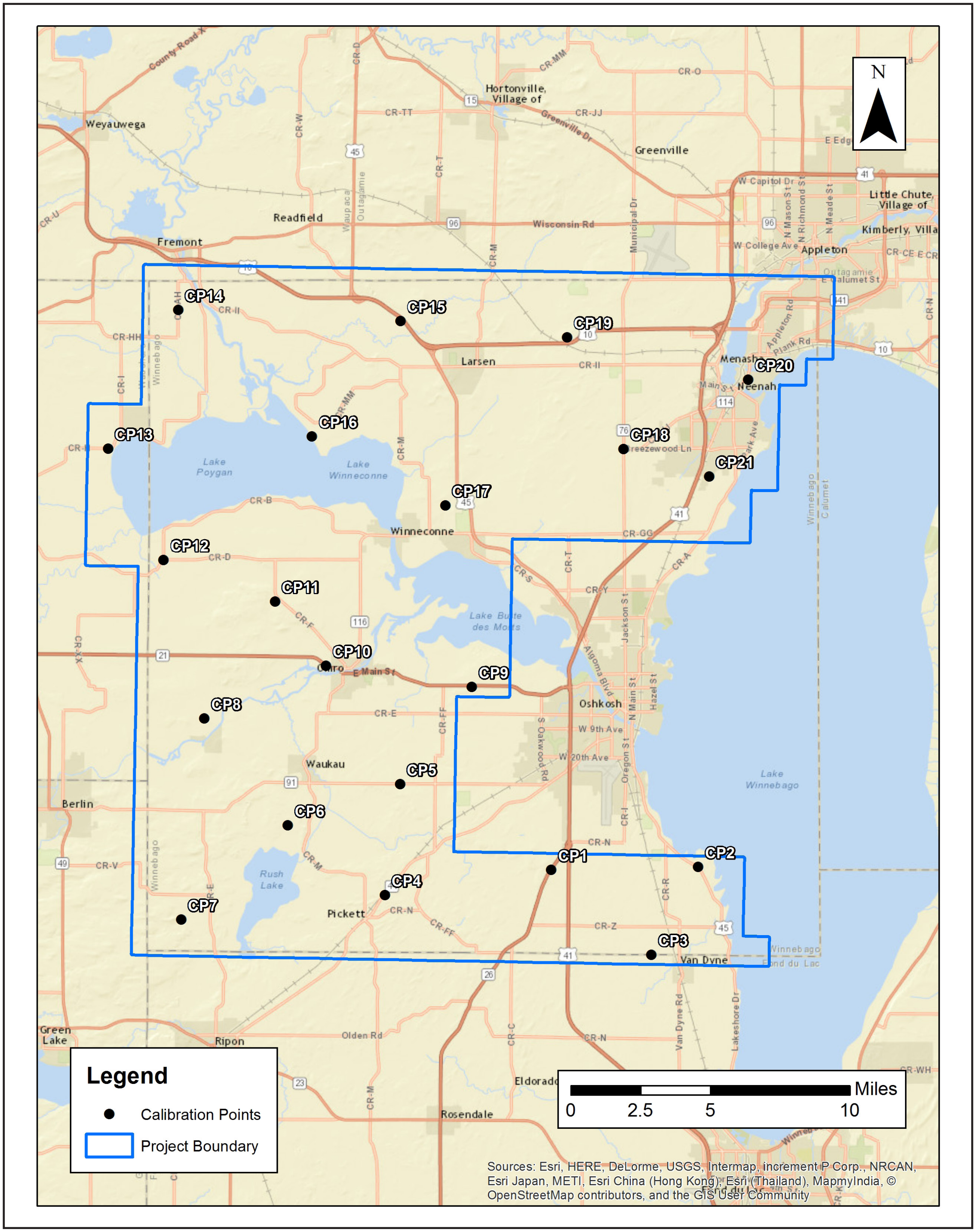


Table 3. Calibration Control Point Report

Units = U.S. Survey Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
CP1	777707.316	444119.879	908.79	908.43	-0.36
CP2	805518.306	444647.943	761.10	760.97	-0.13
CP3	796660.615	428028.270	810.62	810.61	-0.01
CP4	746249.075	439344.376	858.57	858.53	-0.04
CP5	749125.540	460328.831	837.55	837.40	-0.15
CP6	727918.154	452543.206	838.21	838.01	-0.20
CP7	707713.666	434677.064	869.57	869.53	-0.04
CP8	712099.047	472714.016	792.49	792.49	0.00
CP9	762691.465	478686.656	847.83	847.74	-0.09
CP10	735116.156	482690.817	763.89	763.90	0.01
CP11	725498.611	494830.459	828.81	828.81	0.00
CP12	704392.955	502744.382	762.60	762.67	0.07
CP13	693897.130	523782.283	756.66	756.85	0.19
CP14	707164.063	550003.265	781.62	781.64	0.02
CP15	749213.990	547896.036	760.67	760.71	0.04
CP16	732474.284	526058.694	751.02	751.54	0.52
CP17	757688.015	513017.891	797.07	797.28	0.21
CP18	791427.139	523686.818	843.28	843.47	0.19
CP19	780697.943	544824.375	839.92	839.81	-0.11
CP20	814957.639	536803.336	755.25	755.11	-0.14
CP21	807587.810	518475.498	763.22	763.27	0.05

Average Dz	0.00 ft
Minimum Dz	-0.356 ft
Maximum Dz	0.518 ft
Root Mean Square	0.175 ft
Std. Deviation	0.179 ft

Figure 7. QC Checkpoint Locations - Raw NVA

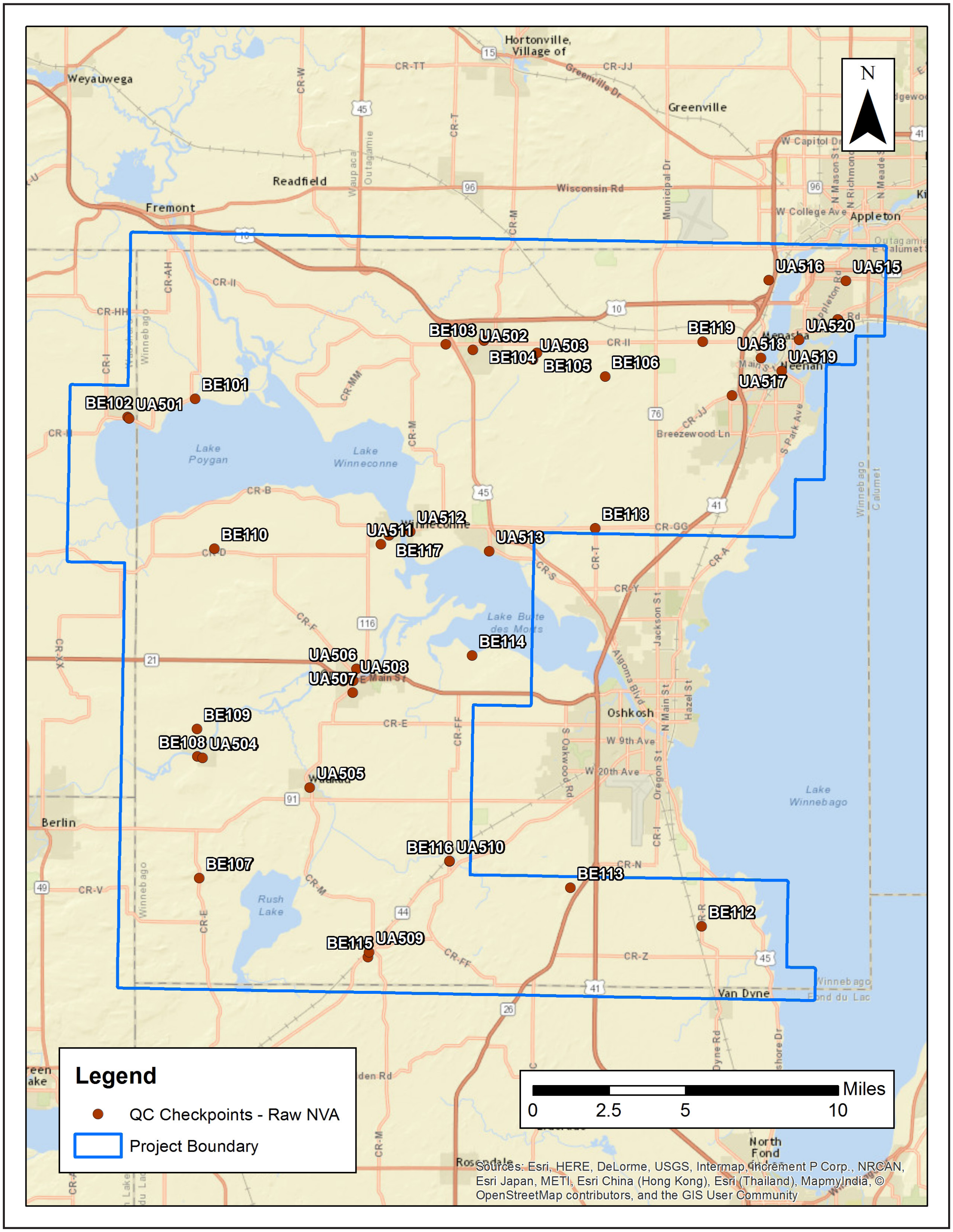


Table 4. QC Checkpoint Report - Raw NVA

Units = US Survey Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
BE101	711759.416	529850.148	754.73	754.59	-0.14
BE102	700083.340	526672.965	754.66	754.54	-0.12
BE103	755104.672	539263.044	763.71	763.61	-0.10
BE104	761723.817	539892.014	811.21	811.29	0.08
BE105	770852.195	537788.953	760.93	760.84	-0.09
BE106	782661.463	533650.128	854.71	854.58	-0.13
BE107	712443.788	446975.628	867.17	867.23	0.06
BE108	712148.970	467999.962	756.22	756.31	0.09
BE109	712052.392	472780.280	791.96	792.01	0.05
BE110	715112.725	503916.530	762.13	762.24	0.11
BE111	737340.767	481010.027	758.90	758.97	0.07
BE112	799353.177	438665.399	783.16	783.14	-0.02
BE113	776631.736	445317.332	947.54	947.46	-0.08
BE114	759641.599	485437.287	753.24	753.29	0.05
BE115	741616.182	433326.135	875.24	875.31	0.08
BE116	755765.163	449886.600	837.40	837.45	0.05
BE117	745318.728	506233.487	749.14	749.35	0.21
BE118	780962.968	507441.509	837.77	838.04	0.27
BE119	799522.455	539703.467	822.18	822.15	-0.03
BE120	822920.532	543483.315	749.52	749.52	0.00
UA501	700349.804	526414.728	752.08	752.19	0.12
UA502	759785.461	538266.423	858.78	858.68	-0.10
UA503	770141.095	536638.398	773.67	773.37	-0.30
UA504	713020.462	467773.514	767.29	767.30	0.01
UA505	731593.085	462601.239	827.24	827.22	-0.02
UA506	739640.975	483153.410	782.53	782.60	0.07
UA507	739027.593	479010.048	805.06	805.30	0.24
UA508	739085.256	481106.343	758.82	758.78	-0.04
UA509	741848.330	434147.654	871.22	871.12	-0.10
UA510	755716.542	449938.007	839.28	839.15	-0.13
UA511	743900.016	504695.184	757.76	758.05	0.29
UA512	748957.172	506896.230	768.26	768.44	0.18

Number	Easting	Northing	Known Z	Laser Z	Dz
UA513	762570.492	503441.617	787.80	788.19	0.39
UA514	822863.216	543547.258	749.45	749.92	0.47
UA515	824306.087	550232.974	787.52	787.41	-0.11
UA516	810945.317	550350.199	753.74	753.73	-0.01
UA517	804601.362	530384.797	772.54	772.46	-0.08
UA518	809580.571	536871.750	748.23	748.17	-0.06
UA519	813205.748	534658.411	753.70	753.54	-0.16
UA520	816239.587	540034.612	760.22	760.18	-0.04

Average Dz	0.030 ft
Minimum Dz	-0.298 ft
Maximum Dz	0.473 ft
Root Mean Square	0.157 ft
95% Confidence Level	0.309 ft

Figure 8. QC Checkpoint Locations - NVA

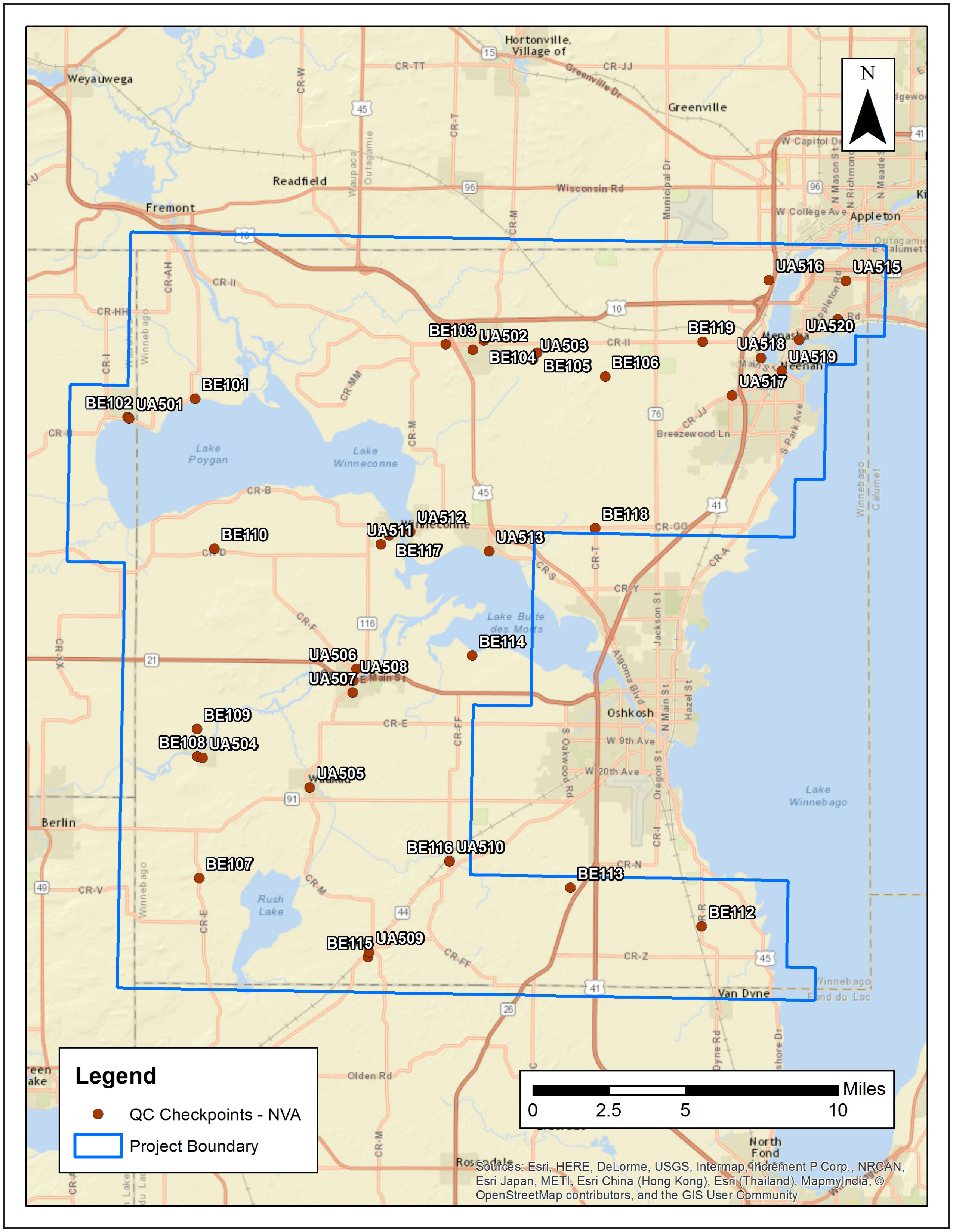


Table 5. QC Checkpoint Report - NVA

Units = US Survey Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
BE101	711759.42	529850.15	754.73	754.63	-0.10
BE102	700083.34	526672.96	754.66	754.62	-0.04
BE103	755104.67	539263.04	763.71	763.64	-0.07
BE104	761723.82	539892.01	811.21	811.33	0.12
BE105	770852.20	537788.95	760.93	760.75	-0.18
BE106	782661.46	533650.13	854.71	854.64	-0.08
BE107	712443.79	446975.63	867.17	867.19	0.01
BE108	712148.97	467999.96	756.22	756.32	0.10
BE109	712052.39	472780.28	791.96	791.95	-0.01
BE110	715112.73	503916.53	762.13	762.30	0.17
BE111	737340.77	481010.03	758.90	758.92	0.03
BE112	799353.18	438665.40	783.16	783.17	0.01
BE113	776631.74	445317.33	947.54	947.46	-0.08
BE114	759641.60	485437.29	753.24	753.29	0.04
BE115	741616.18	433326.14	875.24	875.32	0.09
BE116	755765.16	449886.60	837.40	837.40	0.00
BE117	745318.73	506233.49	749.14	749.38	0.24
BE118	780962.97	507441.51	837.77	837.95	0.18
BE119	799522.46	539703.47	822.18	822.17	-0.01
BE120	822920.53	543483.32	749.52	749.56	0.04
UA501	700349.80	526414.73	752.08	752.18	0.11
UA502	759785.46	538266.42	858.78	858.70	-0.08
UA503	770141.09	536638.40	773.67	773.46	-0.21
UA504	713020.46	467773.51	767.29	767.34	0.06
UA505	731593.09	462601.24	827.24	827.26	0.02
UA506	739640.97	483153.41	782.53	782.48	-0.05
UA507	739027.59	479010.05	805.06	805.09	0.03
UA508	739085.26	481106.34	758.82	758.91	0.09
UA509	741848.33	434147.65	871.22	871.11	-0.12
UA510	755716.54	449938.01	839.28	839.15	-0.13
UA511	743900.02	504695.18	757.76	758.06	0.30
UA512	748957.17	506896.23	768.26	768.44	0.18

Number	Easting	Northing	Known Z	Laser Z	Dz
UA513	762570.49	503441.62	787.80	788.20	0.40
UA514	822863.22	543547.26	749.45	749.90	0.45
UA515	824306.09	550232.97	787.52	787.39	-0.13
UA516	810945.32	550350.20	753.74	753.73	-0.01
UA517	804601.36	530384.80	772.54	772.43	-0.11
UA518	809580.57	536871.75	748.23	748.19	-0.04
UA519	813205.75	534658.41	753.70	753.57	-0.13
UA520	816239.59	540034.61	760.22	760.22	-0.01

Average Dz	0.030 ft
Minimum Dz	-0.211 ft
Maximum Dz	0.454 ft
Root Mean Square	0.147 ft
95% Confidence Level	0.288 ft

Figure 9. QC Checkpoint Locations - VVA

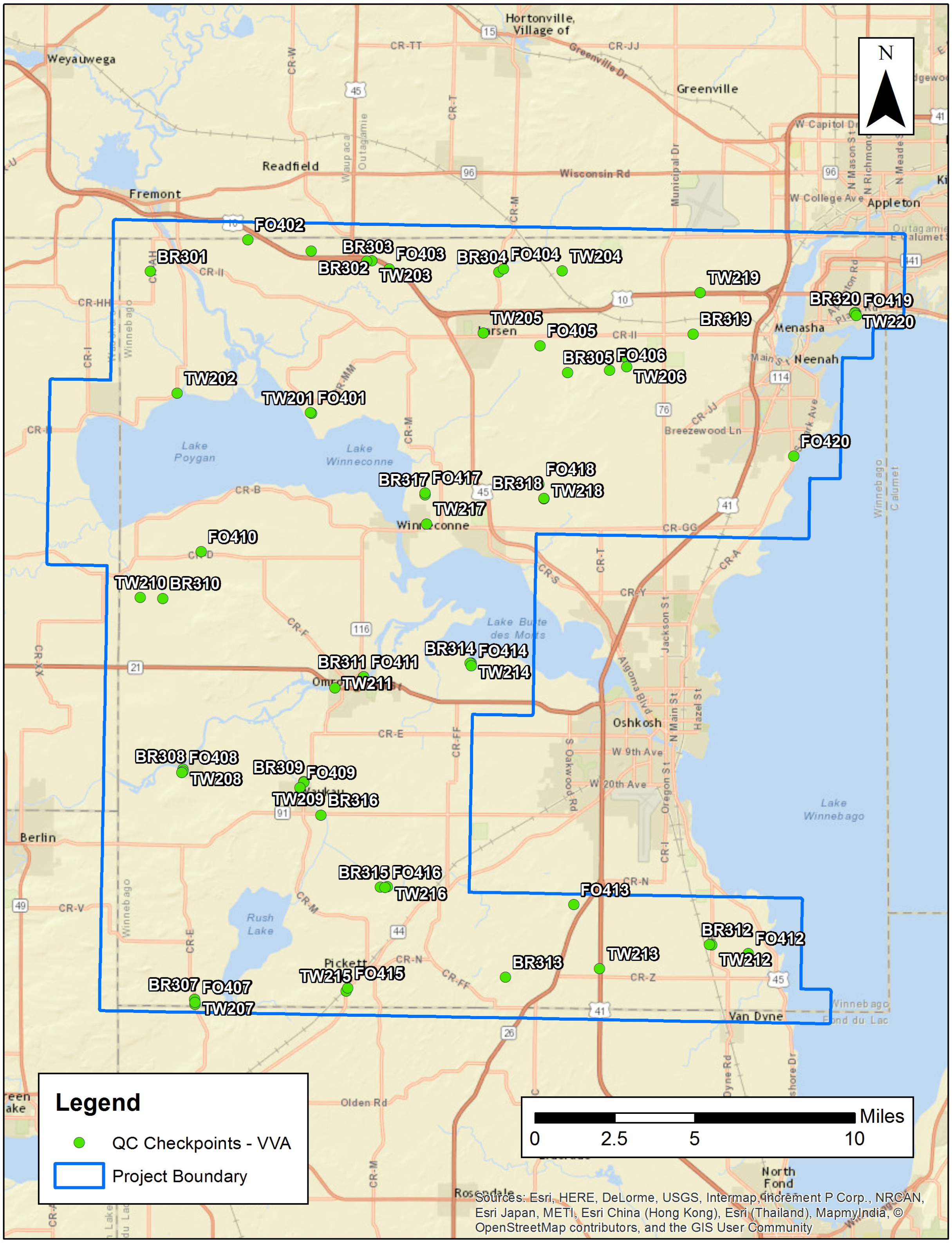


Table 6. QC Checkpoint Report - VVA

Units = US Survey Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
TW201	733295.76	526644.75	751.08	751.54	0.46
TW202	711116.91	529944.66	759.03	759.25	0.22
TW203	743249.47	551818.69	774.76	774.98	0.23
TW204	774682.60	550128.73	758.38	758.47	0.09
TW205	761612.29	539917.59	807.78	807.81	0.03
TW206	785280.49	534303.71	867.79	867.64	-0.14
TW207	714077.57	429028.12	850.45	850.67	0.23
TW208	712063.63	467894.99	754.23	754.65	0.43
TW209	732015.70	465828.47	824.99	824.99	0.01
TW210	705009.43	496212.60	749.37	750.06	0.69
TW211	737162.29	481265.91	750.79	751.03	0.24
TW212	799359.82	438843.77	782.72	782.82	0.10
TW213	780830.27	434912.45	867.29	867.27	-0.01
TW214	759663.72	485375.98	754.00	754.28	0.29
TW215	739023.09	431211.48	877.20	877.53	0.33
TW216	745832.14	448465.34	825.71	825.87	0.16
TW217	752264.45	508353.02	754.08	755.05	0.97
TW218	771669.41	512515.77	806.95	807.09	0.14
TW219	797446.51	546575.01	819.42	819.53	0.11
TW220	823026.17	543269.22	753.93	753.93	0.00
BR301	706716.37	550060.63	780.34	780.54	0.20
BR302	733217.96	553394.56	775.67	775.76	0.09
BR303	742419.03	551735.91	766.92	767.74	0.83
BR304	764219.61	549971.56	759.94	760.06	0.13
BR305	775533.12	533367.69	785.98	786.30	0.31
BR306	784760.74	535959.29	871.91	872.01	0.10
BR307	713978.96	429836.27	848.70	849.36	0.66
BR308	712050.75	467504.26	757.26	757.51	0.25
BR309	731992.31	465721.95	820.84	821.17	0.33
BR310	708753.05	496054.35	750.09	750.88	0.79
BR311	741809.05	483100.83	750.58	750.59	0.01
BR312	798950.77	438892.22	783.42	783.42	0.00

Number	Easting	Northing	Known Z	Laser Z	Dz
BR313	765313.50	433492.70	866.12	866.12	0.00
BR314	759482.00	485382.59	753.13	753.23	0.10
BR315	744676.53	448386.82	827.15	827.34	0.19
BR316	734824.83	460284.51	815.58	815.76	0.18
BR317	752026.28	513179.93	778.83	779.39	0.57
BR318	771644.17	512590.42	806.62	807.08	0.47
BR319	796288.96	539723.42	834.12	834.28	0.15
BR320	822967.27	543151.63	752.74	753.34	0.61
FO401	733118.70	526718.50	750.42	750.77	0.36
FO402	722790.57	555282.89	755.30	755.57	0.28
FO403	746098.87	550484.69	766.63	767.03	0.40
FO404	765003.18	550455.99	758.14	758.18	0.04
FO405	770994.12	537803.49	761.31	761.18	-0.12
FO406	782496.54	533747.17	858.69	858.74	0.05
FO407	714041.84	429359.92	849.93	850.01	0.08
FO408	711905.55	467330.46	757.56	758.03	0.47
FO409	731344.21	464814.81	777.78	777.97	0.19
FO410	715058.83	503783.61	756.67	756.93	0.26
FO411	741912.38	483135.44	751.17	751.57	0.40
FO412	805393.37	437434.66	763.88	763.96	0.08
FO413	776557.02	445477.05	941.70	942.00	0.31
FO414	759631.18	484943.81	758.18	758.44	0.25
FO415	739264.53	431697.82	875.26	875.38	0.12
FO416	745418.56	448335.64	824.33	824.65	0.32
FO417	752011.23	513494.44	784.84	785.53	0.69
FO418	770792.14	514890.82	799.94	800.12	0.18
FO419	823195.67	542786.57	752.32	752.17	-0.15
FO420	812902.24	519551.37	748.75	748.56	-0.19

Average Dz	0.240 ft
Minimum Dz	-0.185 ft
Maximum Dz	0.974 ft
Root Mean Square	0.345 ft
95th Percentile	0.697 ft