Airborne Topographic Lidar Report

Wisconsin WROC – 3DEP

Calumet County Lidar 2018

Prime contractor: Ayres Associates
Airborne lidar acquisition completed by Quantum Spatial

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1. SUMMARY / SCOPE

1.1. SUMMARY

This report contains a summary of the Wisconsin WROC – 3DEP 2018 Calumet County lidar acquisition task order, issued by Calumet County, Wisconsin. The task order yielded a project area covering 336 square miles over Calumet County, Wisconsin. The intent of this document is only to provide specific validation information for the data acquisition/collection, processing, and production of deliverables 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	2000 m	36°	30%	$\leq$ 10 cm

1.3. COVERAGE

The project boundary covers 336 square miles and encompasses Calumet County, Wisconsin. A buffer of 100 meters was created to meet task order specifications. Project extents are shown in Figure 1.

1.4. DURATION

Lidar data was acquired from May 13, 2018, to May 16, 2018, in four total lifts. See “Section: 2.4. Time Period” for more details.

1.5. ISSUES

There were no major issues to report for this project.

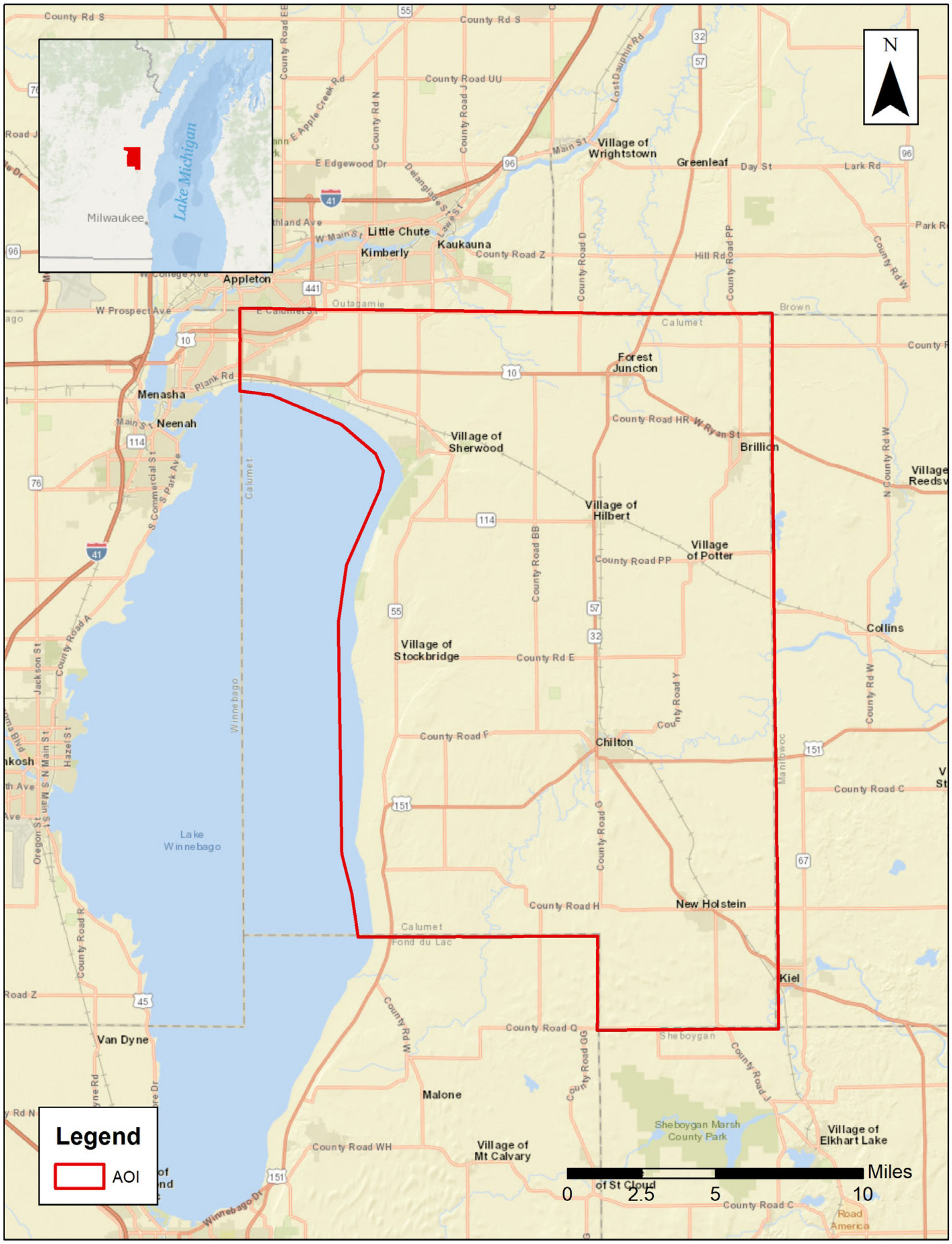
1.6. DELIVERABLES

The following products were produced and delivered:

- Lidar point cloud data, tiled, in LAS 1.4 format
- SBETs in .SOL format
- Trajectories in .TRJ format
- Flight logs and GPS/IMU statistics in .PDF format

All geospatial deliverables were produced with a horizontal datum/projection of Calumet County Coordinate System (WISCRS), NAD83 (2011) and a vertical datum/projection of NAVD88 (Geoid 12B), US Survey Feet. All tiled deliverables have a tile size of 4,500-ft x 4,500-ft.

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 31 planned flight lines (Figure 2).

2.2. LIDAR SENSOR

Quantum Spatial utilized a Leica ALS80 lidar sensor (Figure 3), serial number 8227, during the project. The Leica ALS 80 system is capable of collecting data at a maximum frequency of 1,000 kHz. The system utilizes a Multi-Pulse in the Air option (MPIA). The sensor also has the capacity for unlimited range returns from each outbound pulse. 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

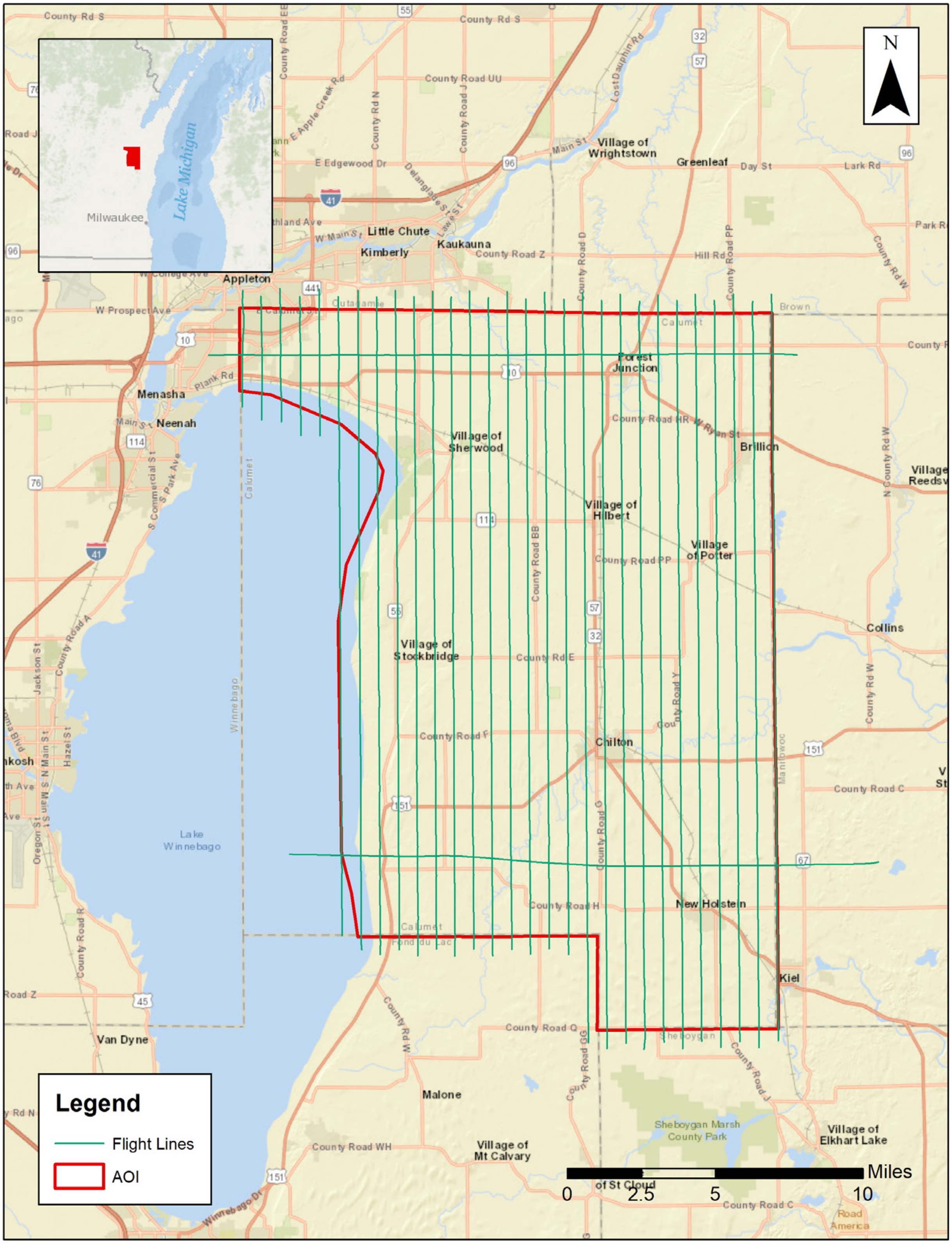


Table 2. Lidar System Specifications

Terrain and Aircraft Scanner	Flying Height	2000 m
	Recommended Ground Speed	150 kts
Scanner	Field of View	36°
	Scan Rate Setting Used	50 Hz
Laser	Laser Pulse Rate Used	300 kHz
	Multi Pulse in Air Mode	yes
Coverage	Full Swath Width	1457 m
	Line Spacing	1020 m
Point Spacing and Density	Average Point Spacing	0.71 m
	Average Point Density	2 pts / m^2

Figure 3. Leica ALS80 Lidar Sensor

2.3. AIRCRAFT

All flights for the project were accomplished through the use of a customized plane. Plane type and tail numbers are listed below.

Lidar Collection Planes

- Piper Navajo (twin-piston) PA31, Tail Number: N22GE

This aircraft provided an ideal, stable aerial base for lidar acquisition. This aerial platform has a relatively fast cruise speed which is 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 ALS80 lidar system. 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 one month. Four aircraft lifts were completed. Accomplished lifts are listed below.

- May 13, 2018-A (N22GE, SN8227)
- May 15, 2018-A1 (N22GE, SN8227)
- May 15, 2018-A2 (N22GE, SN8227)
- May 16, 2018-A (N22GE, SN8227)

3. PROCESSING SUMMARY

3.1. LIDAR PROCESSING

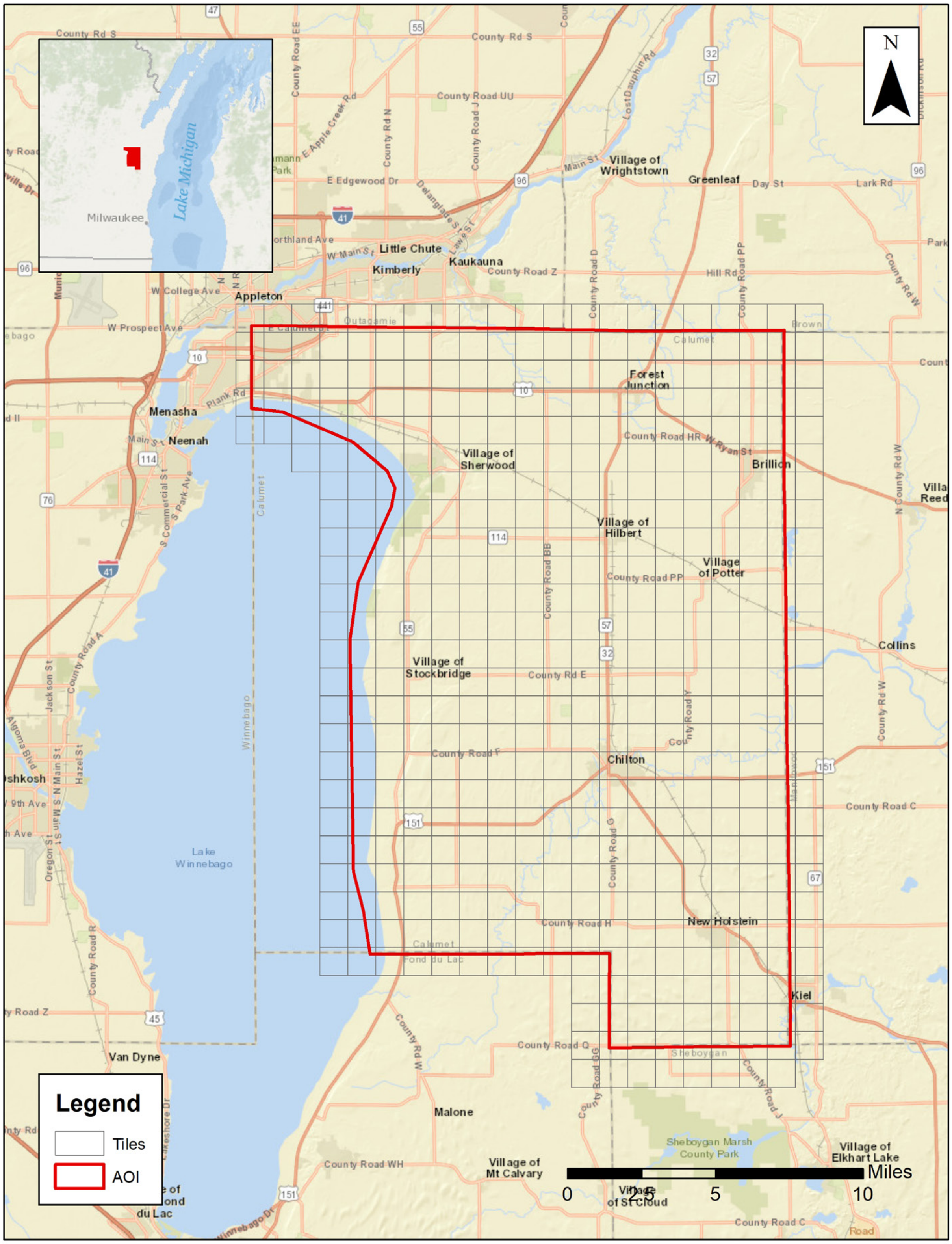
Inertial Explorer software was used for post-processing of airborne GPS and inertial data (IMU), which is critical to the positioning and orientation of the lidar sensor during all flights. Inertial Explorer combines aircraft raw trajectory data with stationary GPS base station data yielding a "Smoothed 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.

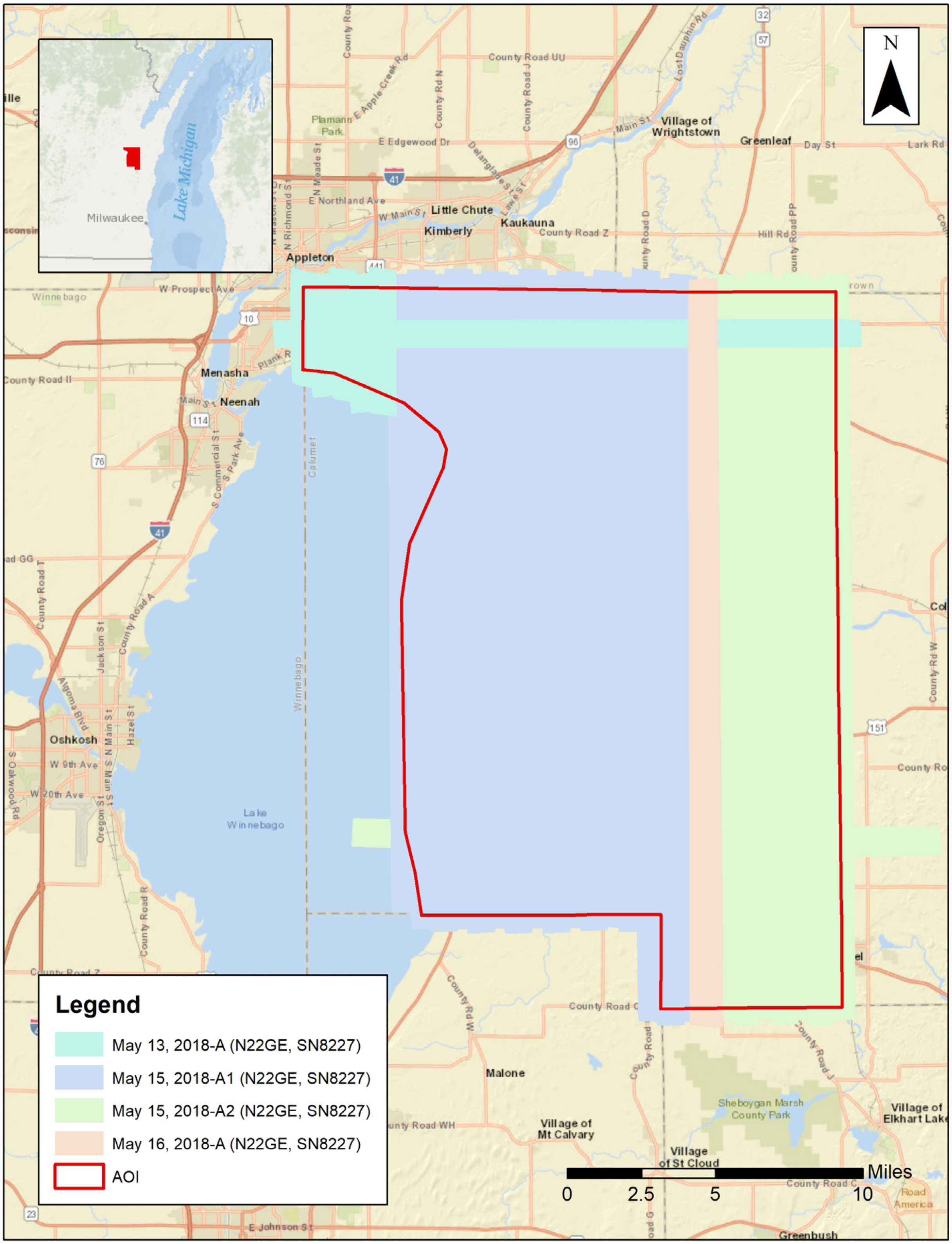
Figure 5. Lidar Tile Layout



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 6.

Figure 6. Lidar Flightline Coverage



5. GROUND CONTROL AND CHECK POINT COLLECTION

Quantum Spatial used 12 ground control (calibration) points collected by Ayres Associates as an independent test of the accuracy of this project.

5.1. CALIBRATION CONTROL POINT TESTING

Figure 7 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.

Figure 7. Calibration Control Point Locations

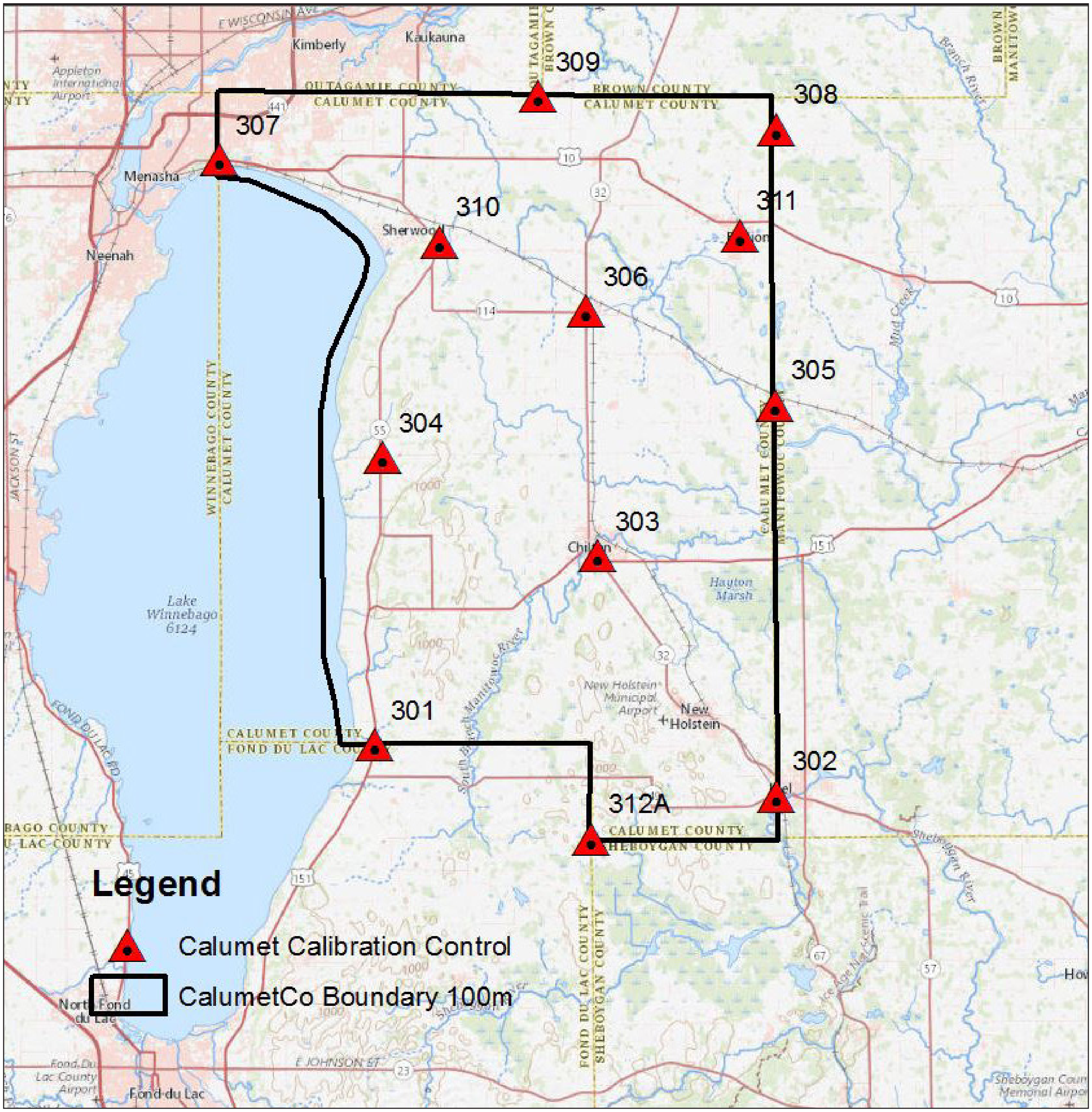


Table 3. Calibration Control Point Report
Units = US survey feet

Number	Easting	Northing	Known Z	Laser Z	Dz
301	854882.536	443569.536	801.043	801.170	+0.127
302	923851.618	434856.625	910.175	910.170	-0.005
303	893254.144	476102.967	909.209	909.000	-0.209
304	856167.984	493019.396	829.127	829.080	-0.047
305	923667.010	502007.741	832.992	832.910	-0.082
306	891257.432	518230.125	837.224	837.270	+0.046
307	828153.385	544284.323	751.255	751.350	+0.095
308	923990.790	549465.507	944.088	944.200	+0.112
309	883027.792	555194.580	799.551	799.480	-0.071
310	866001.758	530057.903	889.702	889.710	+0.008
311	917642.088	531233.675	827.073	827.160	+0.087
312A	892108.463	427422.071	950.643	950.570	-0.073

Average Dz	-0.001 ft
Minimum Dz	-0.209 ft
Maximum Dz	0.127 ft
Root Mean Square	0.096 ft
Std Deviation	0.100 ft