Gratiot County, MI 2015
QL2 LiDAR Project Report

USGS Contract # G10PC00026
Requisition # 0040209177
Task Order # G15PD00343

Submitted: October 29, 2015

Prepared by:

Quantum Spatial, Inc
523 Wellington Way, Suite 375
Lexington, KY 40503
859-277-8700

Contents

List of Figures

List of Tables

List of Appendices

1. Summary / Scope

1.1. Summary

This report contains a summary of the Gratiot County, MI 2015 LiDAR acquisition task order, issued by USGS National Geospatial Technical Operations Center, under their Spatial Product and Services Contract on April 21, 2015. The task order yielded a project area covering approximately 572 square miles over the entirety of Gratiot County, Wisconsin. The intent of this document is to only provide specific validation information for the LiDAR 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
2.4 pts / m^2	2100 m	40°	30%	≤ 10 cm

1.3. Coverage

The LiDAR project boundary covers approximately 572 square miles over Gratiot County in central Michigan. LiDAR extents are shown in Figure 1 on the following page. A processing boundary of 500 feet was created for the project.

1.4.Duration

LiDAR data was acquired from April 18, 2015 to April 19, 2015 in 3 total lifts. See “Section: 2.6. Time Period” for more details.

1.5. Issues

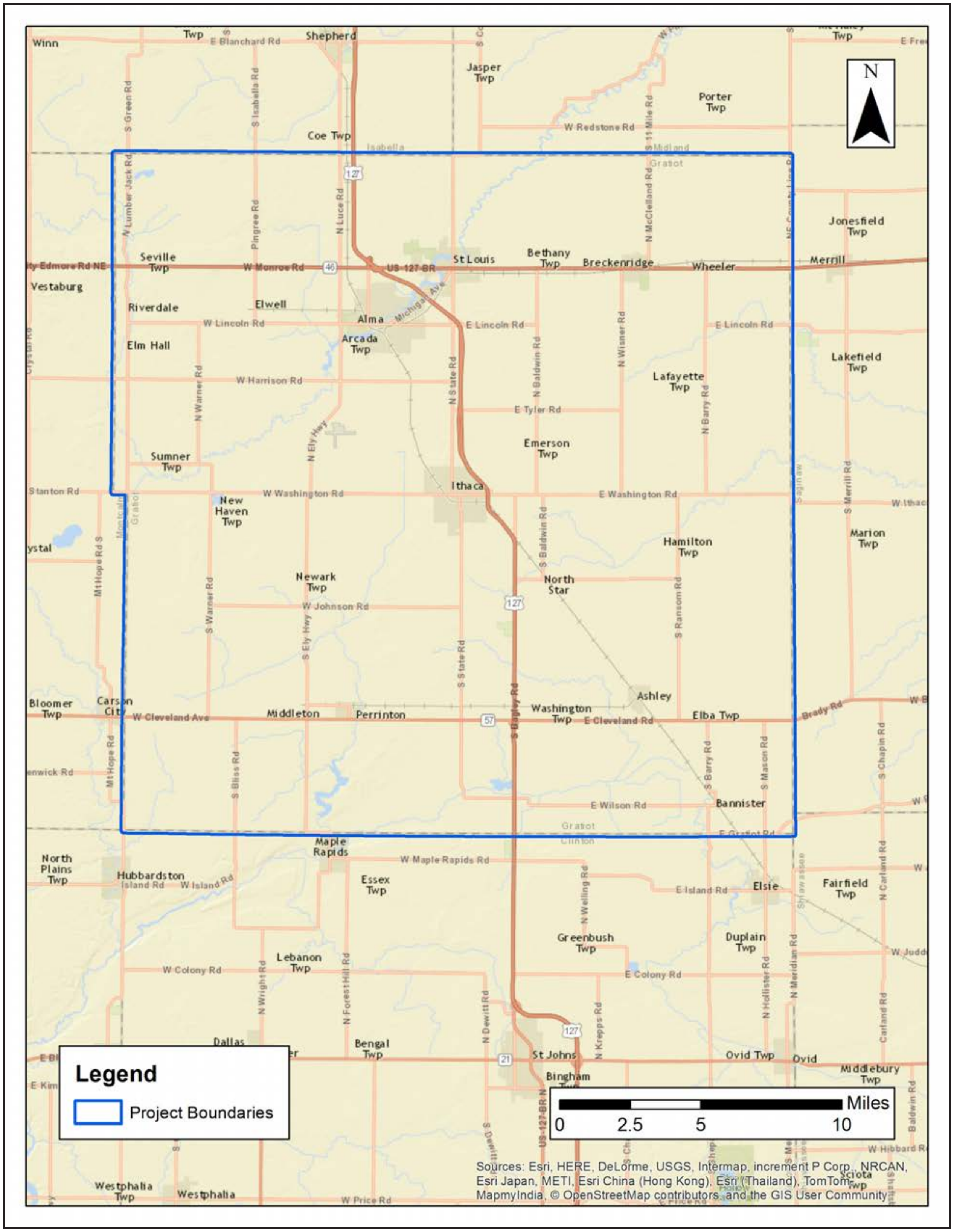
There were no issues with this project.

1.6. Deliverables

The following products were produced and delivered:

- Unclassified raw point cloud swath LAS in version 1.4 format
- Classified point cloud tiled LAS in version 1.4 format
- Hydro flattened raster DEM in ERDAS .IMG format
- Hydro flattened breaklines in Esri File Geodatabase format
- Ground control points in shapefile format
- Intensity Images in GeoTIFF format
- Processing boundary in shapefile format
- As-flown flightlines in shapefile format
- Tile index in shapefile format
- Project and deliverable level metadata in XML format

Figure 1. Gratiot Co., MI 2015 LiDAR 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. Please note that certain values in the table below are listed as "Variable" due to the various flight plans used, as described in "Section: 1.5. Issues" of this document.

Detailed project flight planning calculations were performed for the project name or area project using Leica Mission Pro planning software.

The entire target area was comprised of 40 planned flight lines measuring approximately total 1,006.78 flight line miles for the LiDAR acquisition (Figure 2).

2.2. LiDAR Sensor

Quantum Spatial utilized a Leica ALS70 LiDAR sensor (Figure 3), serial number 7161, during the project. The 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 LiDAR Flight Lines

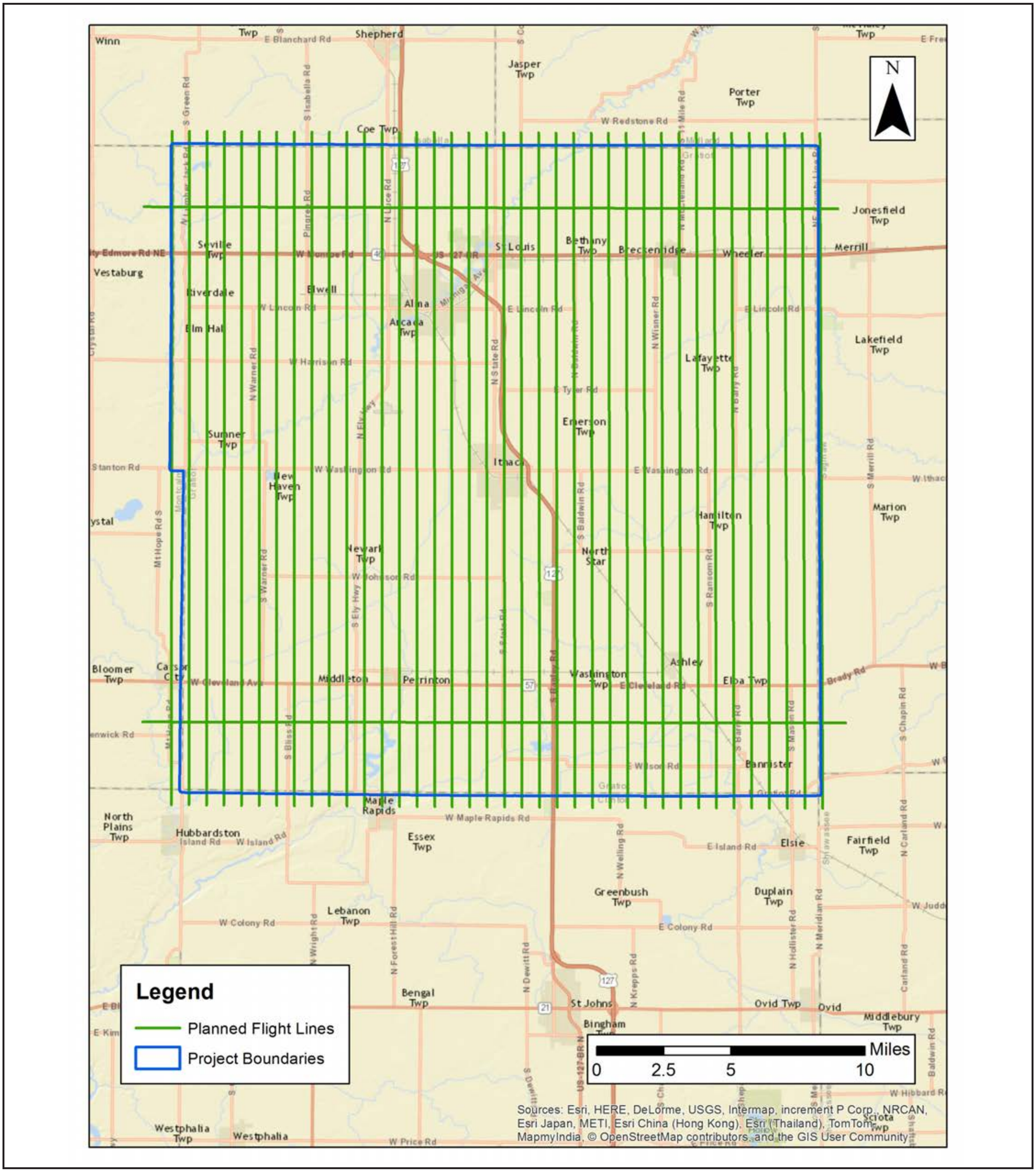


Table 2. Lidar System Specifications

Terrain and Aircraft Scanner	Flying Height (m)	2017 - 2100
	Recommended Ground Speed (kts)	140
Scanner	Field of View (deg)	40.0
	Scan Rate Setting Used (Hz)	37.7
Laser	Laser Pulse Rate Used (kHz)	261
	Multi Pulse in Air Mode	Enabled
Coverage	Full Swath Width (m)	1528.67
	Line Spacing (m)	1321.80
Point Spacing and Density	Maximum Point Spacing Along Track (m)	0.95
	Maximum Point Spacing Along Track (m)	0.95
	Average Point Density (pts / m^2)	2.37

Figure 3. Leica ALS70 LiDAR Sensor

2.4. Aircraft

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

LiDAR Collection Planes
- Piper Navajo (twin-piston), Tail Number: N812TB

These aircraft provided an ideal, stable aerial base for LiDAR acquisition. These 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 ALS70 LiDAR system. Some of the operating aircraft can be seen in Figure 4 below.

Figure 4. Some of Quantum Spatial's Planes

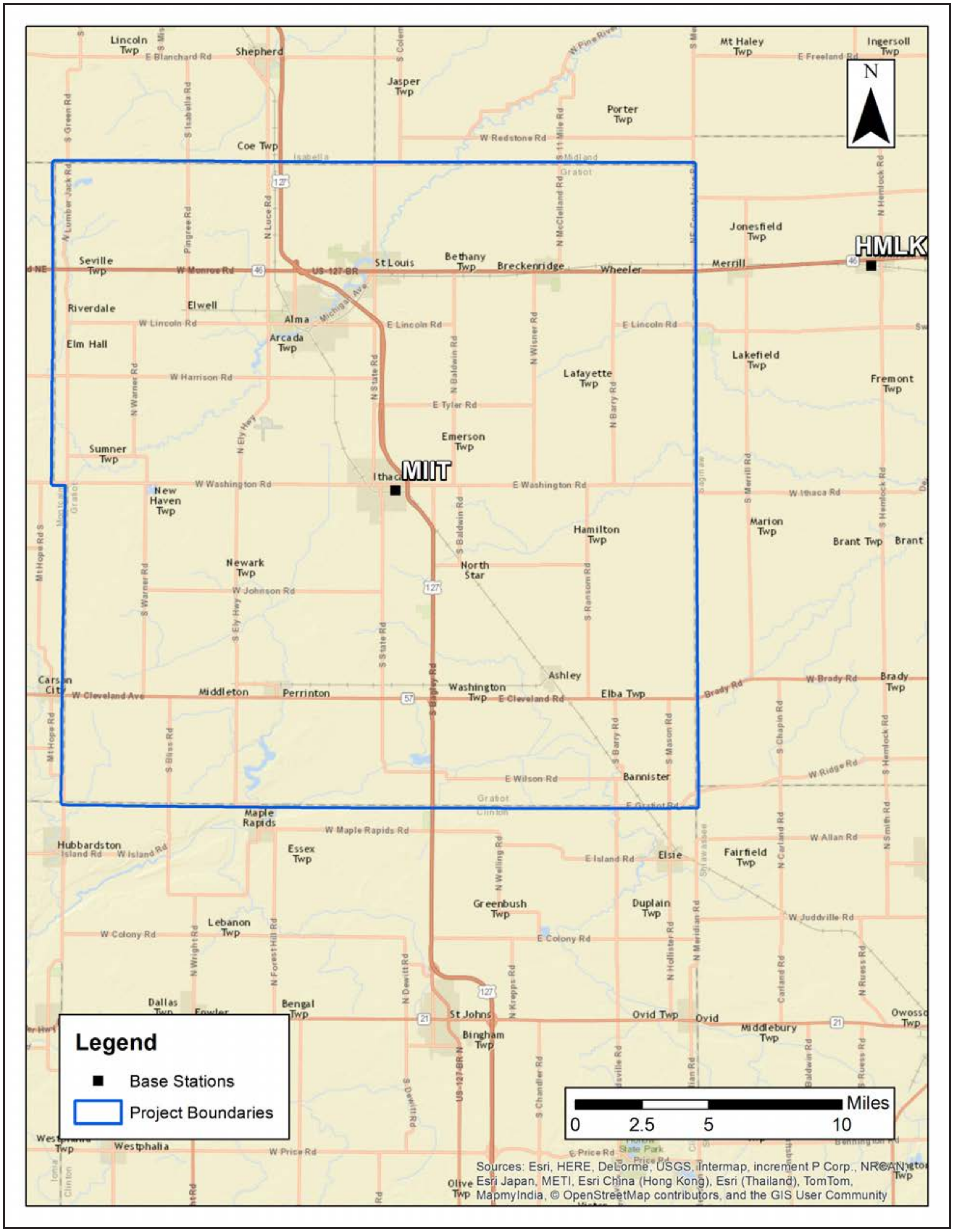
2.4. Base Station Information

GPS base stations were utilized during all phases of flight (Table 3). The base station locations were verified using NGS OPUS service and subsequent surveys. Base station locations are depicted in Figure 5. Data sheets, graphical depiction of base station locations or log sheets used during station occupation are available in Appendix A.

Table 3. Base Station Locations

Base Station	Latitude	Longitude	Ellipsoid Height (m)
MIIT	43° 17′ 20.53352″	84° 35′ 29.45735″	200.927
HMLK	43° 24′ 41.08302″	84° 14′ 14.48462″	171.442

Figure 5. Base Station Locations



2.6. Time Period

Project specific flights were conducted over several months. Three LiDAR sorties, or aircraft lifts were completed. Accomplished LiDAR sorties are listed below.

LiDAR Sorties

- Apr 18, 2015-A (7161)
- Apr 18, 2015-B (7161)
- Apr 19, 2015-A (7161)

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

Applanix + POSPac Mobile Mapping Suite 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. POSPac 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 Applanix POSPac 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. All relevant graphs produced in the POSPac processing environment for each sortie during the Photo Science project mobilization are available in Appendix A.

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 ALS Post Processor 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 will manually be reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. Global Mapper will be 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 will then used to perform final statistical analysis of the classes in the LAS files.

Metadata was generated for the project on a deliverable level.

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 7 – Low Noise – Low points, manually identified above or 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 or below 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 bridge decks were classified to Class 17.

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 us used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable industry-standard LAS files for both the All Point Cloud Data and the Bare Earth. 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-Flattening Breakline Process

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 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-Flattening Raster DEM Process

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.

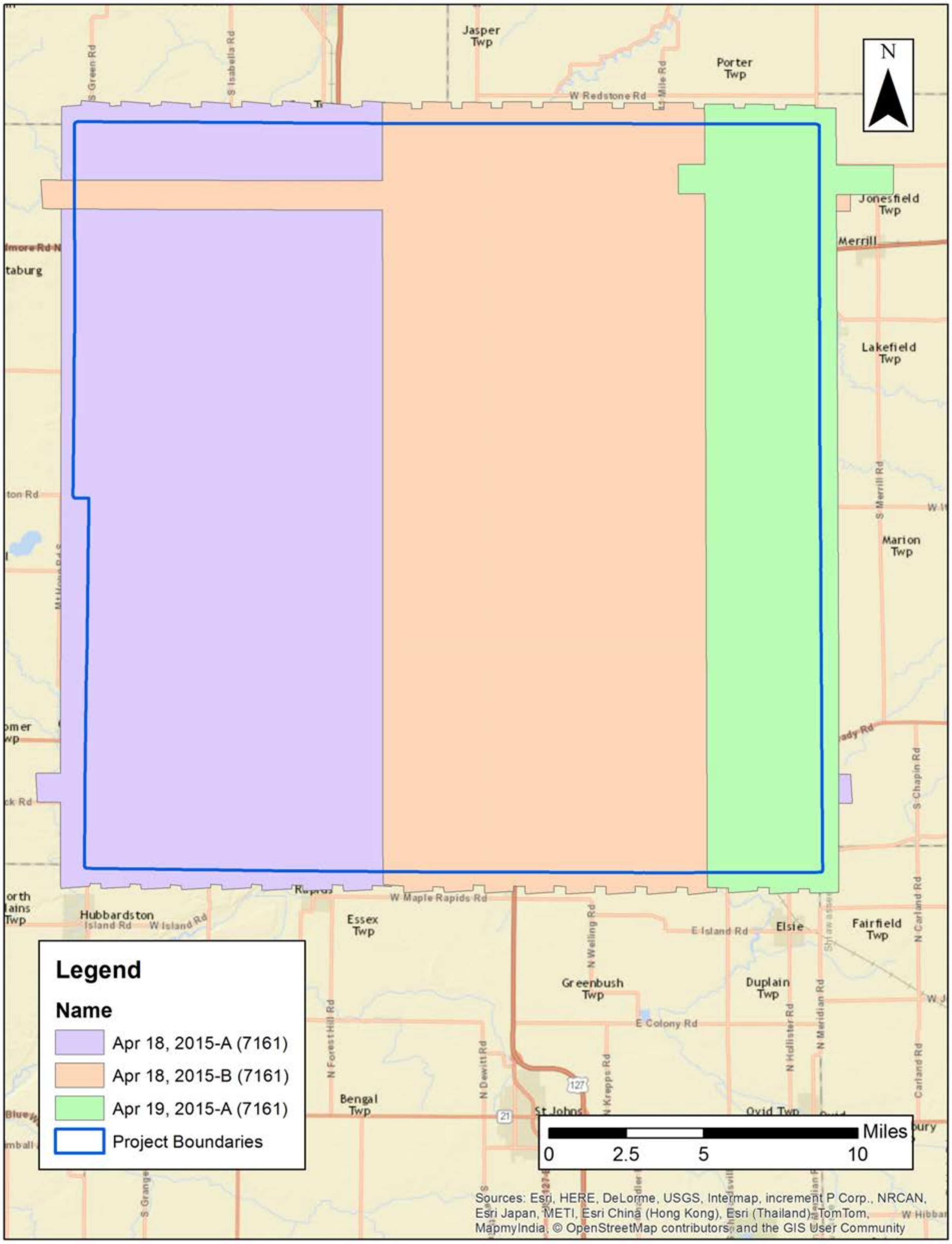
3.7 Intensity Image Creation Process

GeoCue software was used to create the deliverable Intensity Images. The GeoCue software was then used to verify full project coverage as well. TIF/TWF files were then provided as the deliverable for this dataset requirement.

4. Project Coverage Verification

The project name or area project area 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. Flightline Swath LAS File Coverage



5. Ground Control and Check Point Collection

Quantum Spatial completed a field survey of 20 ground control (calibration) points along with 70 QA points in Non-Vegetated and Vegetated land cover classifications (total of 90 points) as an independent test of the accuracy of this project.

A combination of precise GPS surveying methods, including static and RTK observations were used to establish the 3D position of ground calibration points and QA points for the point classes above. GPS was not an appropriate methodology for surveying in the forested areas during the leaf-on conditions for the actual field survey (which was accomplished after the LiDAR acquisition). Therefore the 3D positions for the forested points were acquired using a GPS-derived offset point located out in the open near the forested area, and using precise offset surveying techniques to derive the 3D position of the forested point from the open control point. The explicit goal for these surveys was to develop 3D positions that were three times greater than the accuracy requirement for the elevation surface. In this case of the QA points the goal was a positional accuracy of 5 cm in terms of the RMSE.

Figure 7 shows the location of each bare earth calibration point for the project area. Table 4 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.

The project was delivered in NAD83 (2011) Michigan State Plane South, International Feet; NAVD88 (Geoid12A), International Feet. The accuracy values listed in the tables on the following pages are also in NAD83 (2011) Michigan State Plane South, International Feet; NAVD88 (Geoid12A), International Feet.

The required accuracy testing was performed on the LiDAR dataset (both the LiDAR point cloud and derived DEMs) according to the USGS LiDAR Base Specification Version 1.2 (2014). The summaries below provide the results of this testing.

5.1. Point Cloud Testing

Raw Non-Vegetated Vertical Accuracy (Raw NVA): The tested Raw NVA for the dataset was found to be 0.158 Int'l Ft. (4.816 cm) in terms of the RMSEz. The resulting NVA stated as the 95% confidence level (RMSEz x 1.96) is 0.309 Int'l Ft (9.418 cm). This dataset meets the required NVA of 0.643 Int'l Ft. (19.6 cm) at the 95% confidence level (according to the National Standard for Spatial Database Accuracy (NSSDA)), based on TINs derived from the final calibrated and controlled LiDAR swath data. This is visualized in Figure 8 and summarized in Table 5.

5.2. Digital Elevation Model (DEM) Testing

The tested Non-Vegetated Vertical Accuracy (NVA) for the dataset captured from the DEM using bi-linear interpolation to derive the DEM elevations was found to be 0.162 Int'l Ft. (4.938 cm) in terms of the RMSEz. The resulting accuracy stated as the 95% confidence level (RMSEz x 1.96) is 0.318 Int'l Ft. (9.693 cm). This dataset meets the required NVA of 0.643 Int'l Ft. (19.6 cm) at the 95% confidence level (based on NSSDA). See Figure 9 and Table 6 for more information.

The tested Vegetated Vertical Accuracy (VVA) for the dataset captured from the DEM using bi-linear interpolation for all classes (including the bare earth class) was found to be 0.234 Int'l Ft. (7.132 cm), which is stated in terms of the 95th percentile error. Therefore the data meets the required VVA of 0.965 Int'l Ft. (29.4 cm). This test was based on the 95th percentile error (based on ASPRS guidelines) across all land cover categories. These points are shown in Figure 10 and Table 7.

Figure 7. LiDAR Ground Control Points Used in Calibration

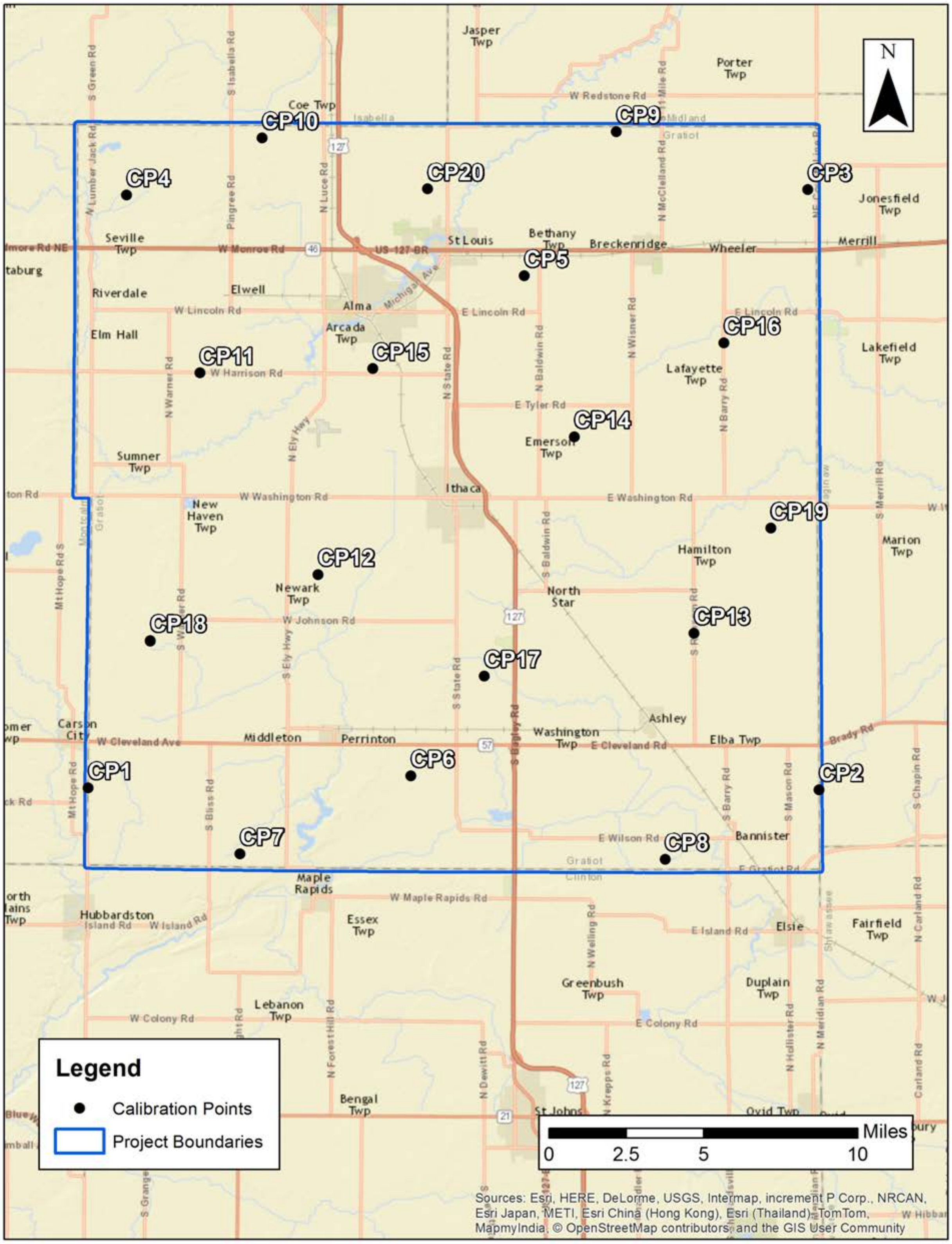


Figure 8. Raw NVA QA Point Locations

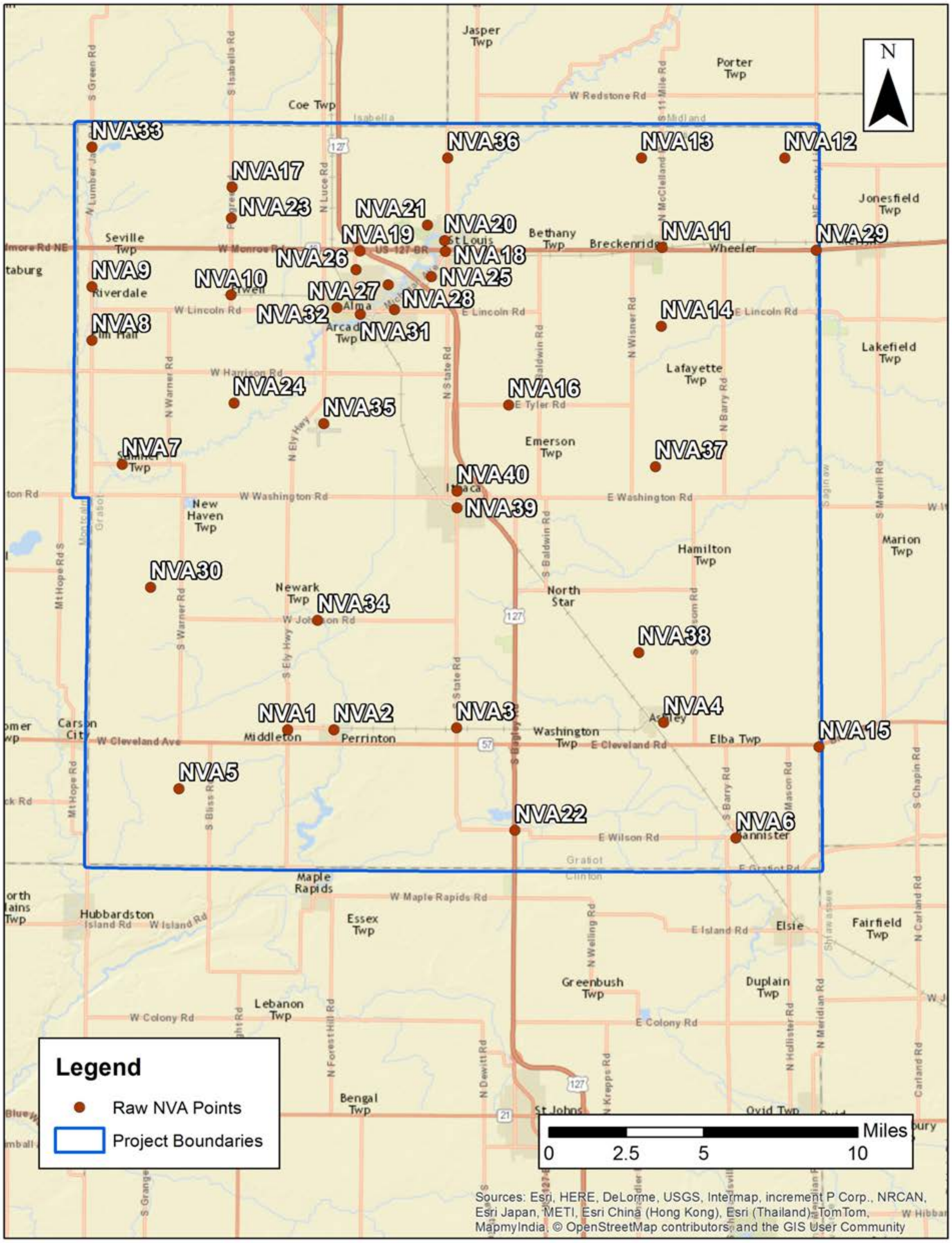


Figure 9. NVA QA Point Locations

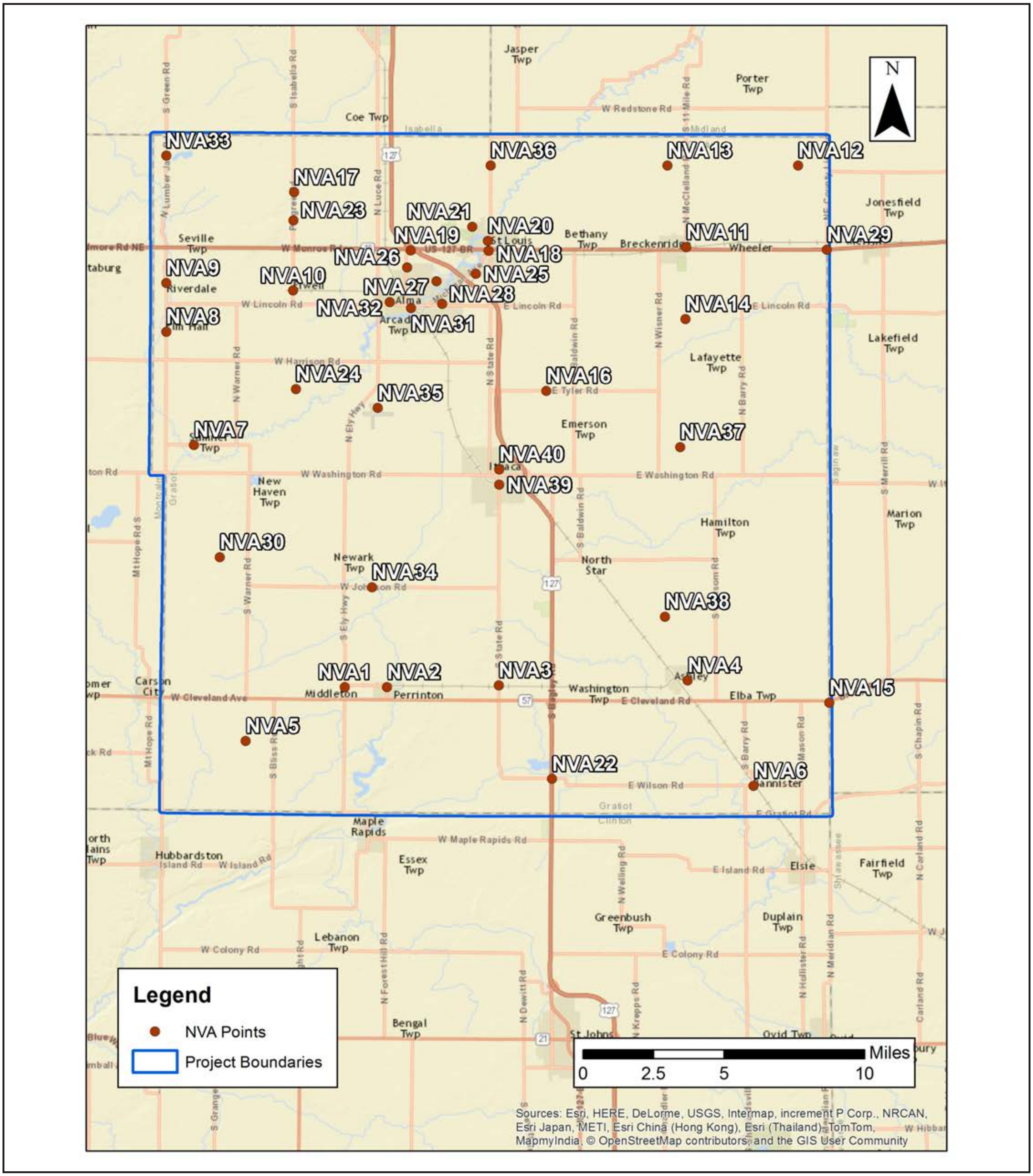


Figure 10. VVA QA Point Locations

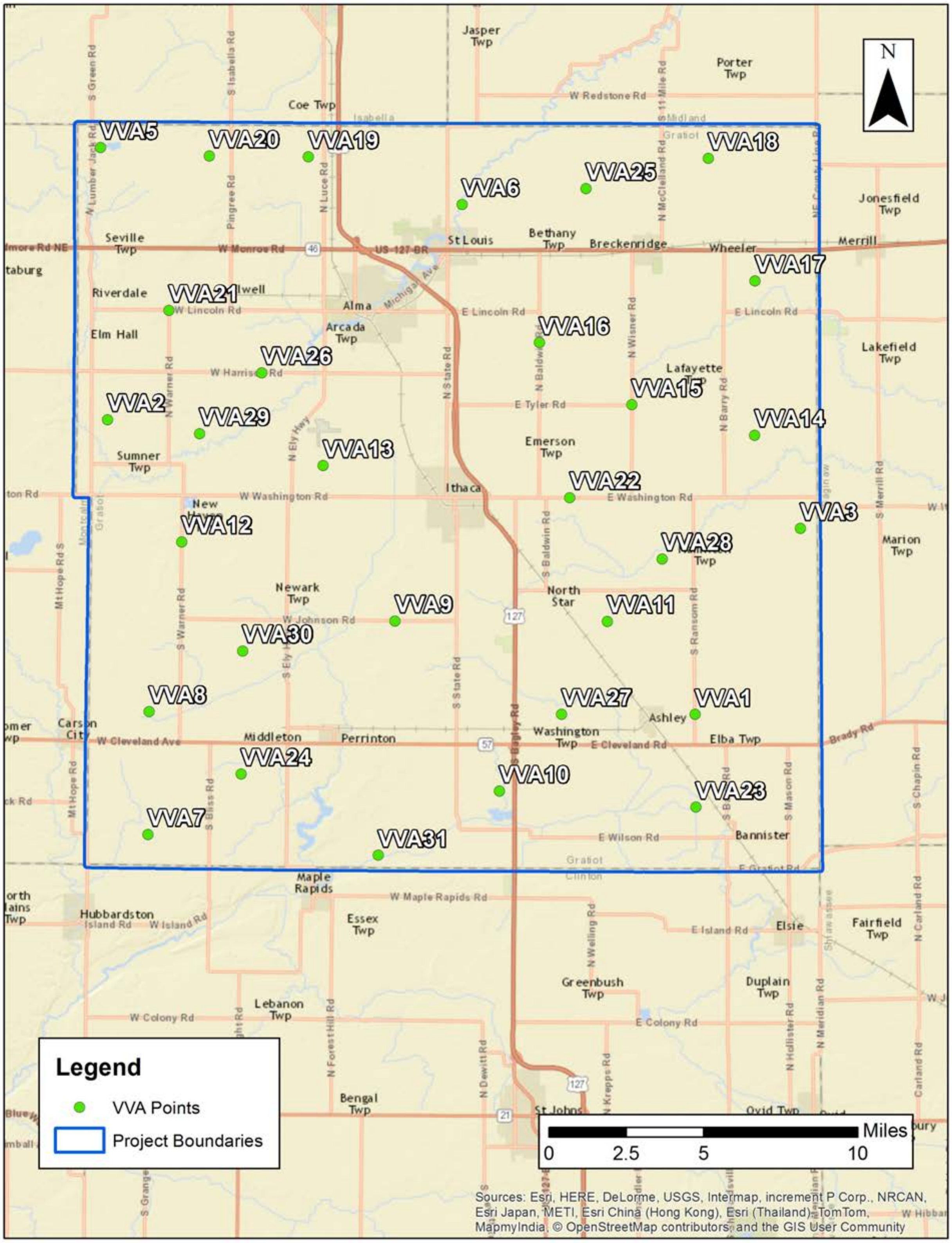


Table 4. LiDAR Ground Control Point Report

Units = International Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
CP1	12997963.50	603526.12	762.97	763.02	0.05
CP2	13122952.38	603199.46	660.08	660.11	0.03
CP3	13120998.91	705788.28	684.97	684.84	-0.13
CP4	13004552.38	704863.58	813.24	813.25	0.01
CP5	13072514.93	691068.47	730.97	731.03	0.06
CP6	13053164.84	605594.42	709.94	709.94	0.00
CP7	13023939.45	592250.72	736.03	735.81	-0.22
CP8	13096609.94	591311.01	680.69	680.68	-0.01
CP9	13088285.08	715680.39	700.04	700.24	0.20
CP10	13027699.06	714634.94	790.08	789.91	-0.17
CP11	13017085.08	674439.77	780.95	780.81	-0.14
CP12	13037273.45	639963.96	747.73	747.59	-0.14
CP13	13101549.56	629903.10	679.86	679.77	-0.09
CP14	13081078.78	663506.76	728.02	728.05	0.03
CP15	13046645.04	675164.23	757.43	757.30	-0.13
CP16	13106682.90	679575.43	706.47	706.42	-0.05
CP17	13065663.81	622665.80	719.36	719.53	0.17
CP18	13008558.53	628679.87	774.96	774.78	-0.18
CP19	13114664.56	647870.82	666.79	666.80	0.01
CP20	13055980.05	705917.09	749.58	749.54	-0.04
	Average Dz	-0.04			
	Minimum Dz	-0.220			
	Maximum Dz	0.200			
	Root Mean Square	0.117			
	Std. Deviation	0.113			

Table 5. LiDAR QA Point Report: Raw NVA

Units = International Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
NVA1	13032116.92	613407.42	742.18	741.95	-0.23
NVA2	13040008.95	613401.88	733.85	733.64	-0.21
NVA3	13060950.88	613684.73	718.21	718.16	-0.05
NVA4	13096395.30	614656.73	666.15	665.96	-0.19
NVA5	13013522.86	603296.26	754.88	754.60	-0.28
NVA6	13108726.33	594864.54	670.86	670.86	0.00
NVA7	13003818.87	658739.78	763.48	763.48	0.00
NVA8	12998604.32	679979.98	800.64	800.45	-0.19
NVA9	12998598.78	689139.77	795.62	795.46	-0.16
NVA10	13022375.81	687713.83	773.96	773.77	-0.19
NVA11	13096084.93	695849.54	726.39	726.25	-0.14
NVA12	13117112.95	711164.21	694.55	694.47	-0.08
NVA13	13092559.29	711185.72	708.02	707.89	-0.13
NVA14	13095983.75	682355.36	720.51	720.29	-0.22
NVA15	13122947.13	610471.37	656.85	656.80	-0.05
NVA16	13069862.69	668886.55	744.68	744.78	0.10
NVA17	13022600.84	706183.11	834.40	834.20	-0.20
NVA18	13059076.78	695179.13	734.16	734.24	0.08
NVA19	13044470.42	695261.47	768.01	767.87	-0.14
NVA20	13058936.21	697024.52	723.13	722.96	-0.17
NVA21	13055975.17	699726.03	756.96	756.95	-0.01
NVA22	13070944.22	596144.32	661.57	661.62	0.05
NVA23	13022435.44	700912.93	797.37	797.14	-0.23
NVA24	13022894.22	669198.65	752.33	752.09	-0.24
NVA25	13056675.09	690887.07	736.13	736.11	-0.02
NVA26	13043792.00	692065.60	769.52	769.24	-0.28
NVA27	13049317.60	689500.26	736.86	736.71	-0.15
NVA28	13050345.02	685196.28	745.92	745.97	0.05
NVA29	13122436.57	695376.61	684.86	684.76	-0.10
NVA30	13008648.52	637661.20	773.08	772.93	-0.15
NVA31	13044513.63	684415.33	733.09	733.03	-0.06
NVA32	13040552.67	685546.14	759.62	759.50	-0.12

Number	Easting	Northing	Known Z	Laser Z	Dz
NVA33	12998589.93	713060.39	842.43	842.31	-0.12
NVA34	13037230.91	632021.50	741.36	740.96	-0.40
NVA35	13038253.49	665669.80	752.34	752.27	-0.07
NVA36	13059427.70	711209.36	735.07	734.95	-0.12
NVA37	13095001.40	658312.48	711.48	711.36	-0.12
NVA38	13092129.58	626585.02	682.25	682.22	-0.03
NVA39	13061011.27	651302.96	764.82	764.72	-0.10
NVA40	13061023.89	654165.96	773.40	773.41	0.01

Average Dz	-0.12
Minimum Dz	-0.400
Maximum Dz	0.100
Root Mean Square	0.158
95% Confidence	0.309

Table 6. LiDAR QA Point Report: NVA

Units = International Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
NVA1	13032116.92	613407.42	742.18	741.95	-0.23
NVA2	13040008.95	613401.88	733.85	733.62	-0.23
NVA3	13060950.88	613684.73	718.21	718.21	0.00
NVA4	13096395.30	614656.73	666.15	666.04	-0.11
NVA5	13013522.86	603296.26	754.88	754.58	-0.30
NVA6	13108726.33	594864.54	670.86	670.88	0.02
NVA7	13003818.87	658739.78	763.48	763.52	0.04
NVA8	12998604.32	679979.98	800.64	800.50	-0.14
NVA9	12998598.78	689139.77	795.62	795.51	-0.11
NVA10	13022375.81	687713.83	773.96	773.76	-0.20
NVA11	13096084.93	695849.54	726.39	726.24	-0.15
NVA12	13117112.95	711164.21	694.55	694.40	-0.15
NVA13	13092559.29	711185.72	708.02	707.85	-0.17
NVA14	13095983.75	682355.36	720.51	720.24	-0.27
NVA15	13122947.13	610471.37	656.85	656.81	-0.04
NVA16	13069862.69	668886.55	744.68	744.75	0.07
NVA17	13022600.84	706183.11	834.40	834.20	-0.20
NVA18	13059076.78	695179.13	734.16	734.31	0.15
NVA19	13044470.42	695261.47	768.01	767.83	-0.18
NVA20	13058936.21	697024.52	723.13	723.06	-0.07
NVA21	13055975.17	699726.03	756.96	756.99	0.03
NVA22	13070944.22	596144.32	661.57	661.72	0.15
NVA23	13022435.44	700912.93	797.37	797.13	-0.24
NVA24	13022894.22	669198.65	752.33	752.07	-0.26
NVA25	13056675.09	690887.07	736.13	736.13	0.00
NVA26	13043792.00	692065.60	769.52	769.22	-0.30
NVA27	13049317.60	689500.26	736.86	736.76	-0.10
NVA28	13050345.02	685196.28	745.92	745.85	-0.07
NVA29	13122436.57	695376.61	684.86	684.82	-0.04
NVA30	13008648.52	637661.20	773.08	772.89	-0.19
NVA31	13044513.63	684415.33	733.09	733.02	-0.07
NVA32	13040552.67	685546.14	759.62	759.43	-0.19

Number	Easting	Northing	Known Z	Laser Z	Dz
NVA33	12998589.93	713060.39	842.43	842.35	-0.08
NVA34	13037230.91	632021.50	741.36	741.04	-0.32
NVA35	13038253.49	665669.80	752.34	752.17	-0.17
NVA36	13059427.70	711209.36	735.07	734.93	-0.14
NVA37	13095001.40	658312.48	711.48	711.36	-0.12
NVA38	13092129.58	626585.02	682.25	682.19	-0.06
NVA39	13061011.27	651302.96	764.82	764.73	-0.09
NVA40	13061023.89	654165.96	773.40	773.48	0.08

Average Dz	-0.11
Minimum Dz	-0.324
Maximum Dz	0.148
Root Mean Square	0.162
95% Confidence	0.318

Table 7. LiDAR QA Point Report: VVA

Units = International Feet

Number	Easting	Northing	Known Z	Laser Z	Dz
VVA1	13101772.30	616003.90	666.98	666.93	-0.05
VVA2	13001288.31	666356.40	777.47	777.08	-0.39
VVA3	13119726.46	647739.59	670.65	670.50	-0.15
VVA5	13000109.94	712999.85	814.31	814.37	0.05
VVA6	13061879.81	703221.95	702.57	702.76	0.19
VVA7	13008178.24	595457.57	750.58	750.62	0.05
VVA8	13008392.64	616496.81	760.83	760.63	-0.20
VVA9	13050447.00	631928.40	759.45	759.24	-0.21
VVA10	13068282.17	602867.44	670.87	670.96	0.08
VVA11	13086764.07	631832.34	688.31	688.42	0.12
VVA12	13013958.39	645465.88	773.47	773.23	-0.24
VVA13	13038160.38	658504.34	757.80	757.84	0.04
VVA14	13111929.42	663718.23	690.25	690.48	0.24
VVA15	13090920.31	668925.39	718.19	718.25	0.06
VVA16	13075091.31	679545.21	735.79	736.05	0.26
VVA17	13112002.36	690126.26	699.48	699.55	0.07
VVA18	13103975.29	711110.28	708.07	708.22	0.15
VVA19	13035637.73	711388.94	774.89	774.80	-0.10
VVA20	13018662.79	711504.11	809.84	809.94	0.09
VVA21	13011758.43	685101.80	795.84	795.70	-0.14
VVA22	13080320.76	653001.38	724.88	725.11	0.23
VVA23	13101863.32	600127.49	657.74	657.95	0.21
VVA24	13024100.93	605832.43	744.64	744.59	-0.05
VVA25	13083099.19	705928.88	713.20	713.24	0.04
VVA26	13027643.06	674424.15	761.09	760.81	-0.28
VVA27	13078925.76	616050.19	688.85	688.96	0.11
VVA28	13096104.61	642557.75	700.15	700.07	-0.07
VVA29	13016997.27	664001.43	756.81	756.66	-0.15
VVA30	13024394.14	626844.04	750.44	750.26	-0.18
VVA31	13047567.93	591897.77	654.28	654.07	-0.21

Number	Easting	Northing	Known Z	Laser Z	Dz
	Average Dz	-0.02			
	Minimum Dz	-0.395			
	Maximum Dz	0.256			
	Root Mean Square	0.171			
	95th Percentile	0.234			