

Connecticut River, Winnepesaukee River, and White Mountain National Forest 2015 LiDAR Project Report



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1. Summary / Scope

1.1. Summary

This report contains a summary of the Connecticut River Watershed / Winnepesaukee River Watershed / White Mountain National Forest 2015 LiDAR acquisition task order, issued by USGS National Geospatial Technical Operations Center (NGTOC) under their Geospatial Products and Services Contract proposed on August 1, 2015 and modified on November 9, 2015. The task order yielded a project area covering 5,233 square miles that includes several areas of interest in New Hampshire. 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	2,000 - 3,000 m	40°	30%	≤ 10 cm

1.3. Coverage

The modified LiDAR project boundaries consist of 3 areas of interest: 4,437 square miles over the Connecticut River watershed, 796 square miles over the Winnepesaukee River Watershed, and 181 square miles over portions of the White Mountain National Forest (WMNF) in New Hampshire for a total of 5,233 square miles (there is some overlap with these areas of interest). A processing boundary of 100-meters was created for this area. LiDAR extents are shown in Figure 1 on the following page.

1.4. Duration

LiDAR data was acquired from October 24, 2015 to November 23, 2015 in 29 total lifts. See “Section: 2.5. 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 for the Connecticut and Winnepesaukee River Watershed AOIs:

- Raw LiDAR point cloud data swaths in LAS 1.4 format
- Classified LiDAR point cloud data, tiled, in LAS 1.4 format
- 1-meter hydro-flattened bare-earth raster DEM, tiled, in GeoTIFF format
- 1-meter hydro-flattened bare-earth raster DEM mosaic in GeoTIFF format
- Hydro-flattened breaklines in Esri file geodatabase format
- Calibration and QC checkpoints in Esri shapefile format
- 1-meter intensity image, tiled, in GeoTIFF format
- QA/QC reports in Excel .XLS format
- Processing boundary in Esri shapefile format
- Tile index in Esri shapefile format
- Flightline swaths in Esri shapefile format
- Project-, deliverable-, and lift-level metadata in .XML format

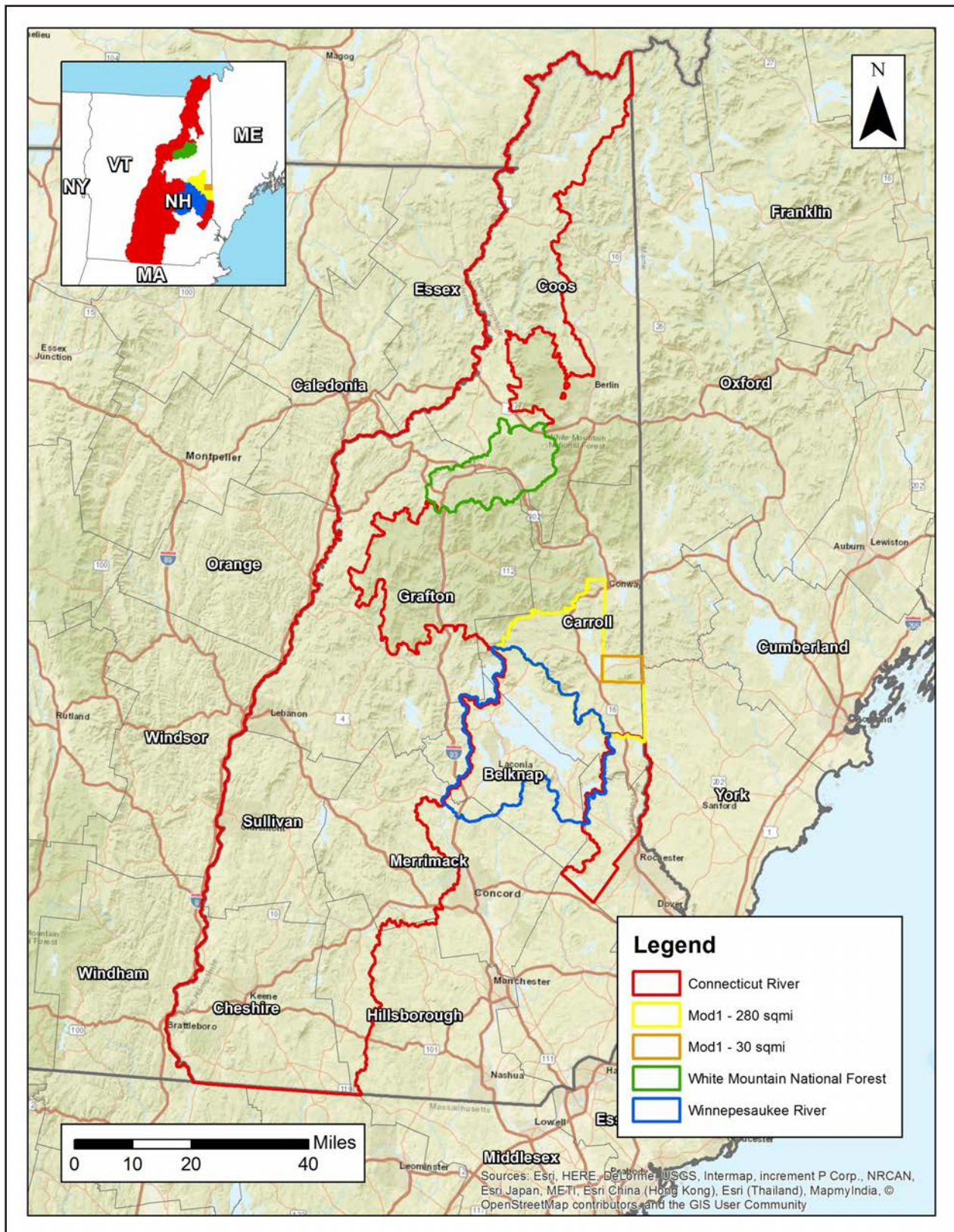
The following products were produced for the White Mountain AOI:

- Raw LiDAR point cloud data swaths in LAS 1.4 format
- Classified first and last LiDAR data, tiled, in LAS 1.4 and ASCII comma-delimited formats

All geospatial deliverables for the Connecticut River and Winnepesaukee project areas were produced in NAD83 (2011) UTM Zone 19, meters; NAVD88 (Geoid 12B), meters. Tiled deliverables have a tile size of 1,500-meters x 1,500-meters with tile names based on the US National Grid.

A secondary set of deliverables for the White Mountain National Forest project area were produced in NAD83 (2011) UTM Zone 19, meters; NAVD88 (Geoid 12B), meters. Tiled deliverables have a tile size of 2,000 meters x 2,000 meters, and follow the existing WMNF naming schema.

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 Mission Pro planning software. The entire target area was comprised of approximately 671 planned flight lines measuring approximately 12,869.24 total flight line miles (Figure 2).

2.2. LiDAR Sensor

Quantum Spatial utilized Leica ALS 70 LiDAR sensors (Figure 14), serial numbers 7161, 7178, 7169, and 7108, during the project. These systems are capable of collecting data at a maximum frequency of 500 kHz, which affords elevation data collection of up to 500,000 points per second. These systems utilize a Multi-Pulse in the Air option (MPIA). The sensors are 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

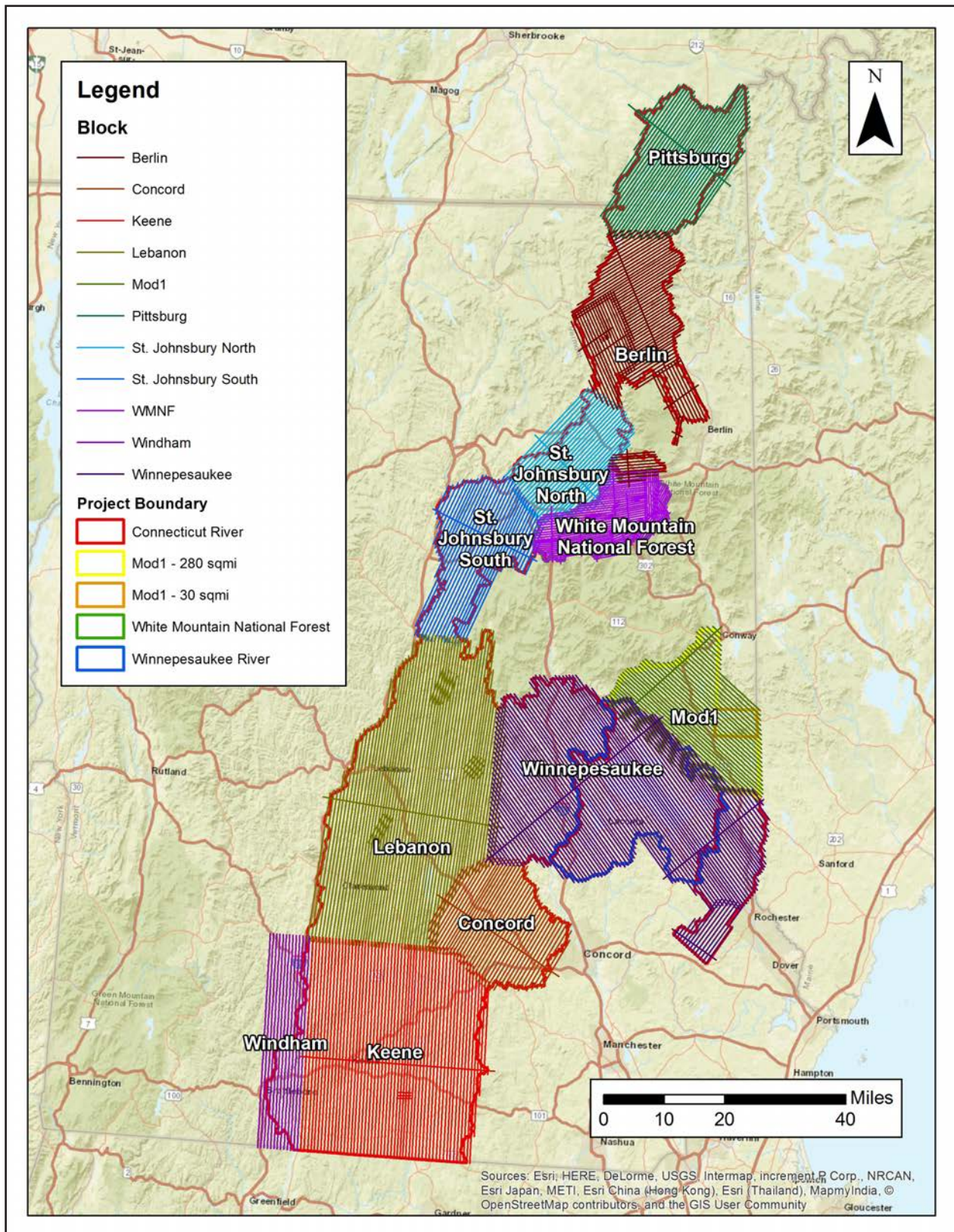


Figure 3. Planned Flight Lines - Berlin Block

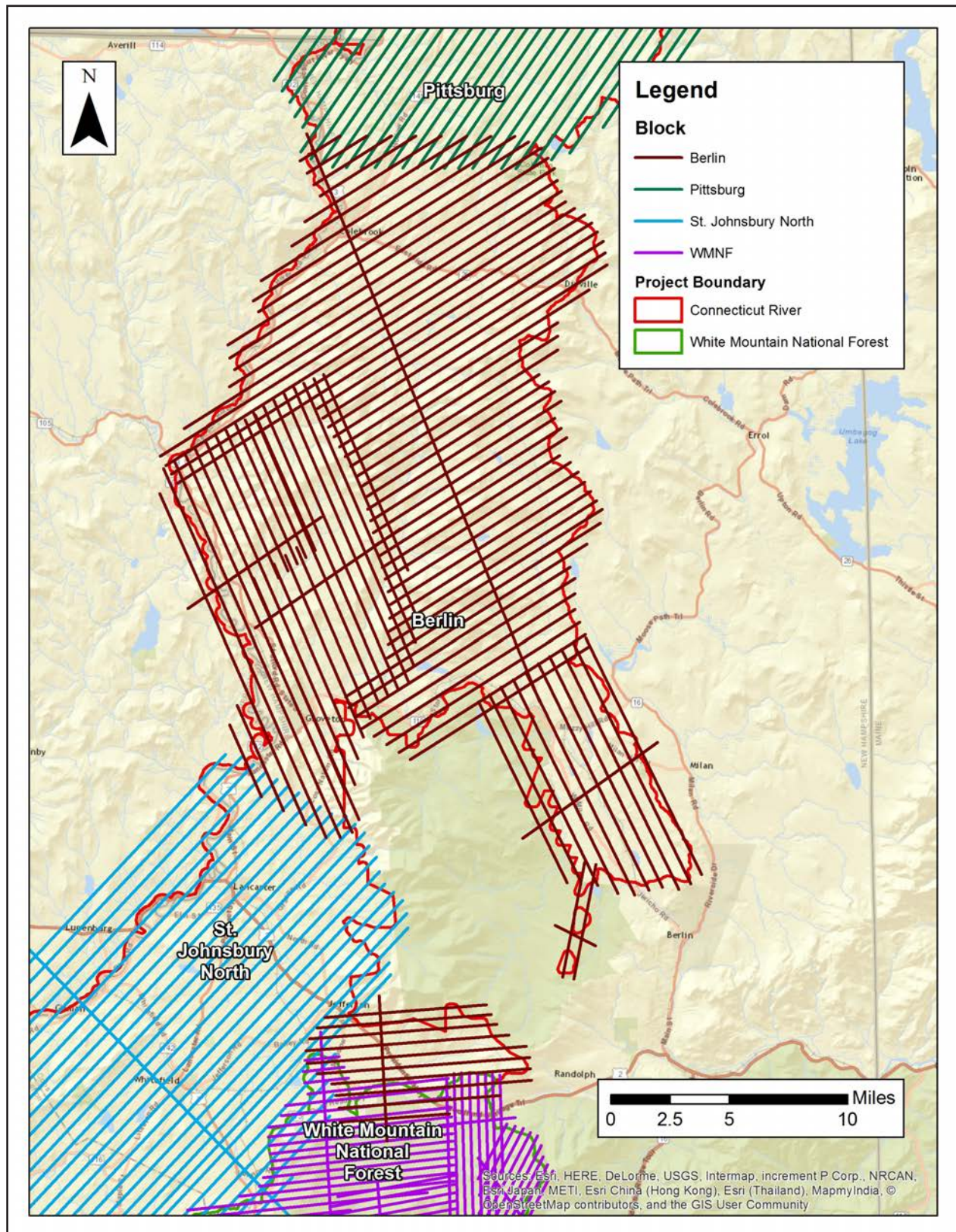


Figure 4. Planned Flight Lines - Concord Block

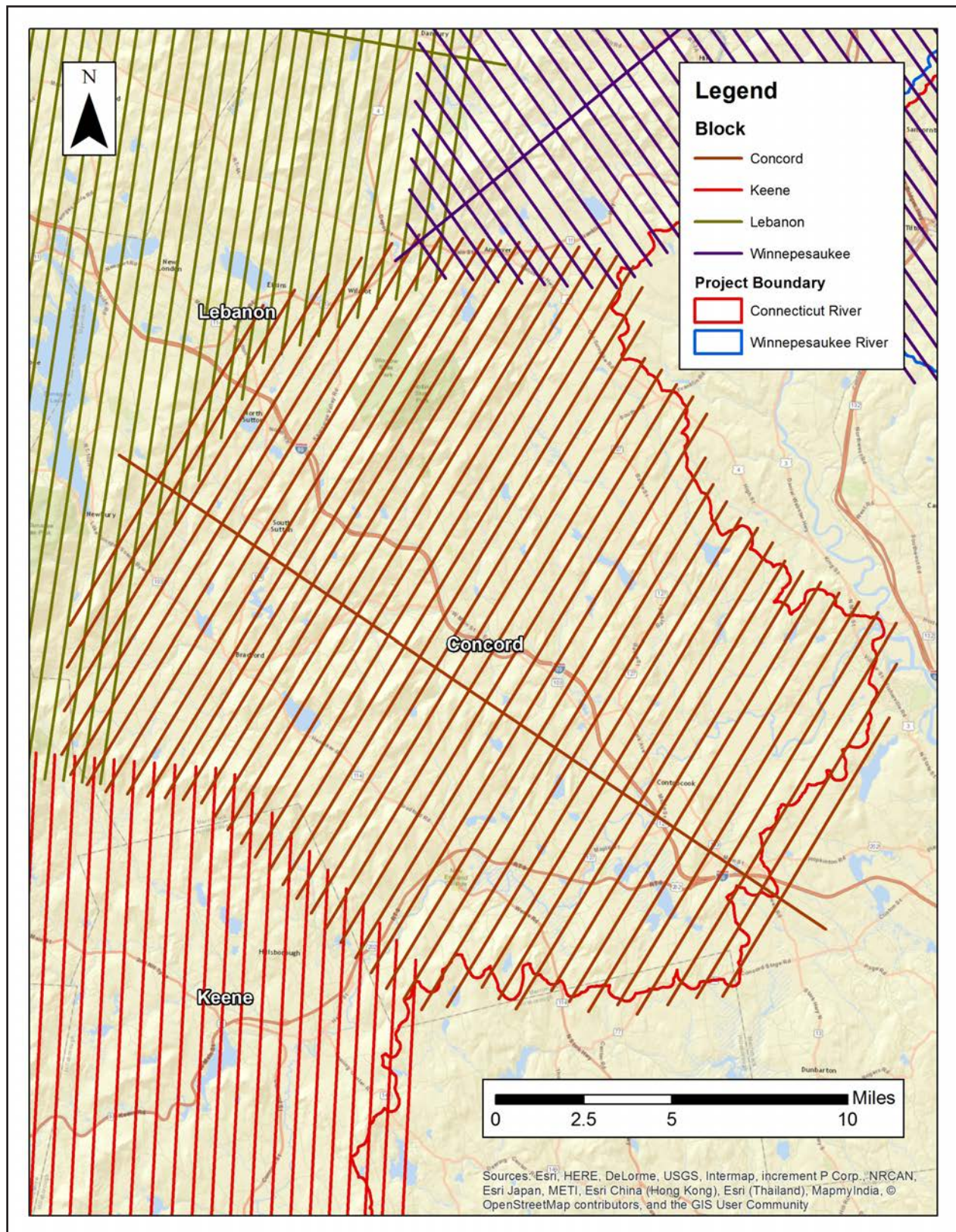


Figure 5. Planned Flight Lines - Keene Block

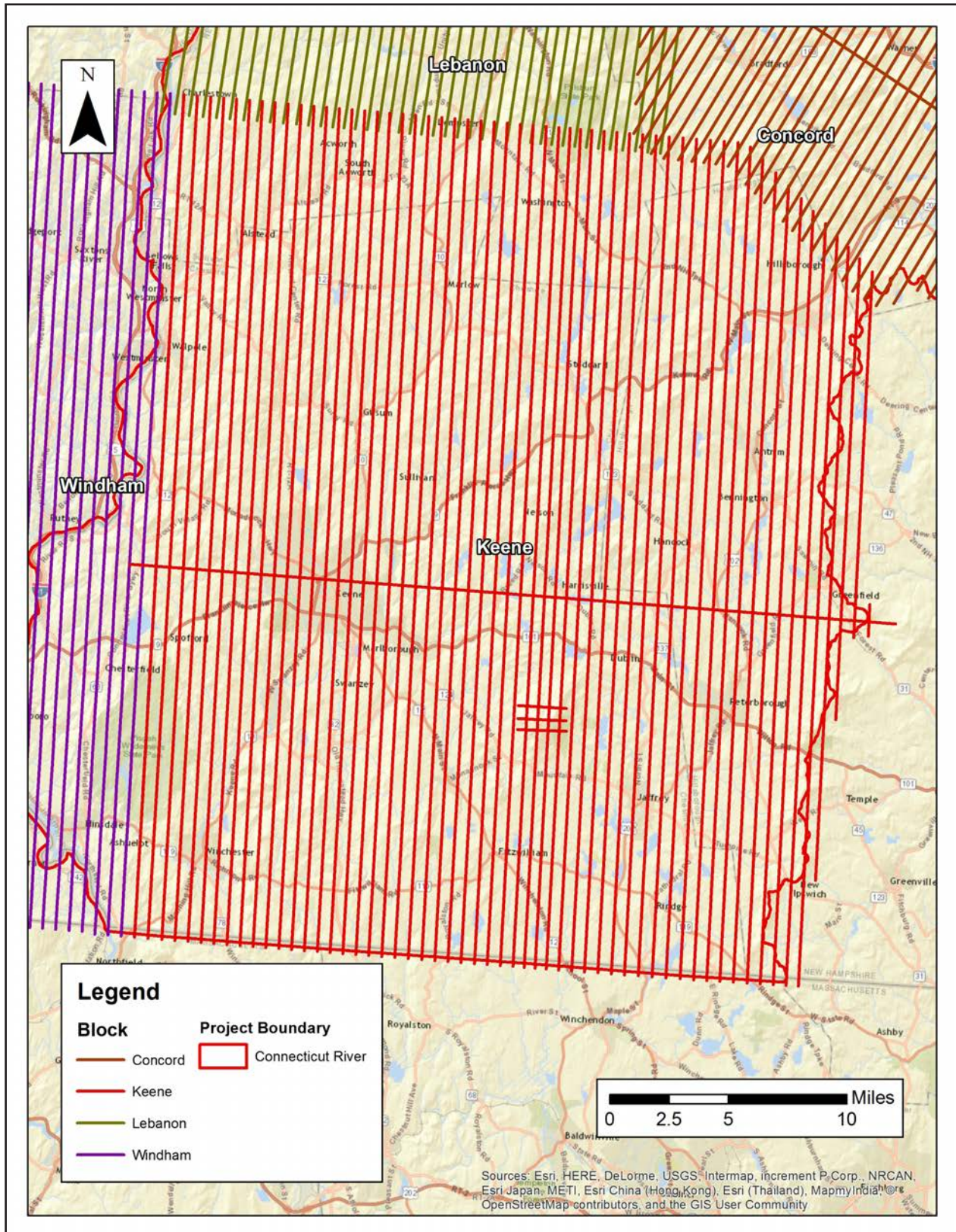


Figure 6. Planned Flight Lines - Lebanon Block

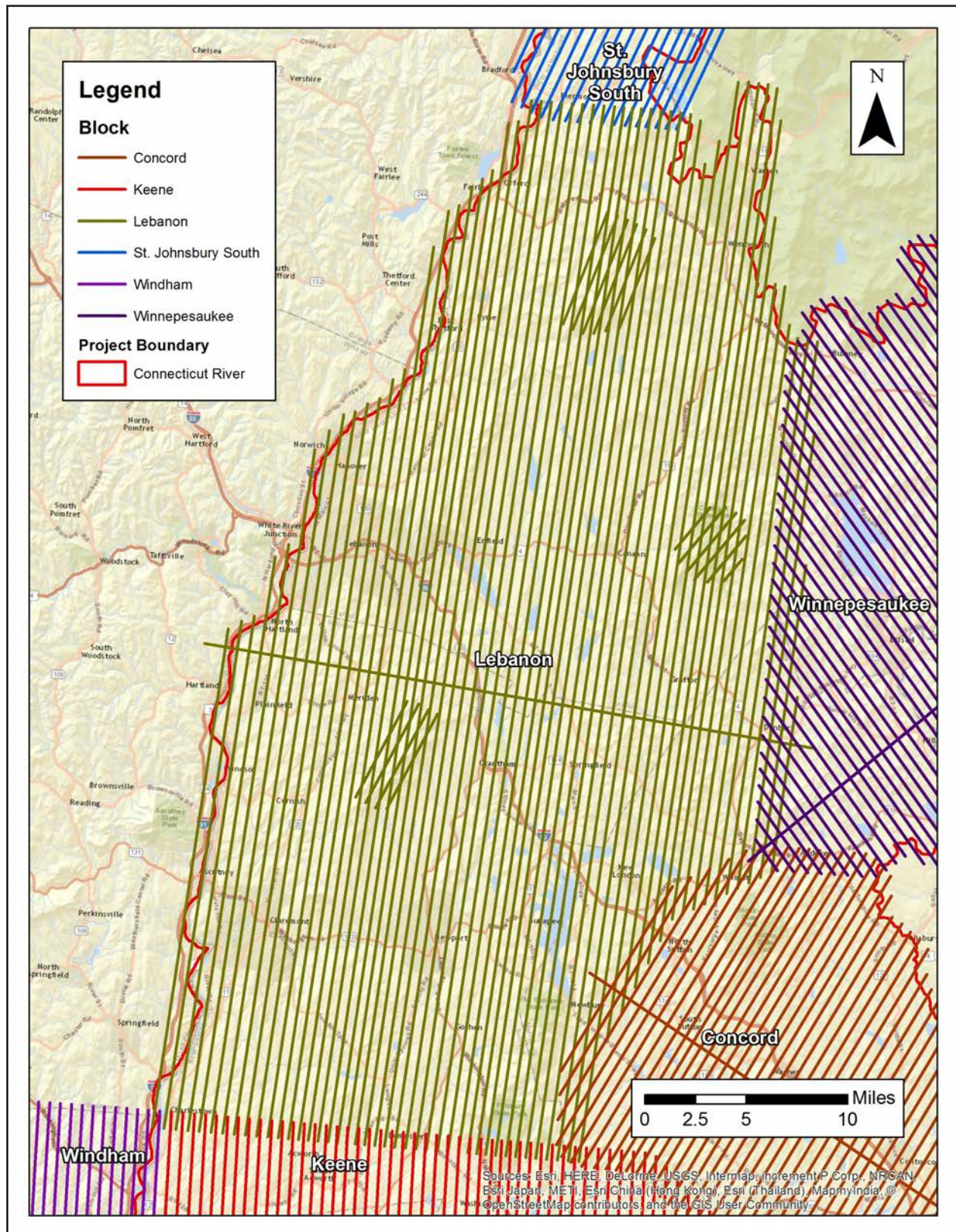


Figure 7. Planned Flight Lines - Mod1 Block

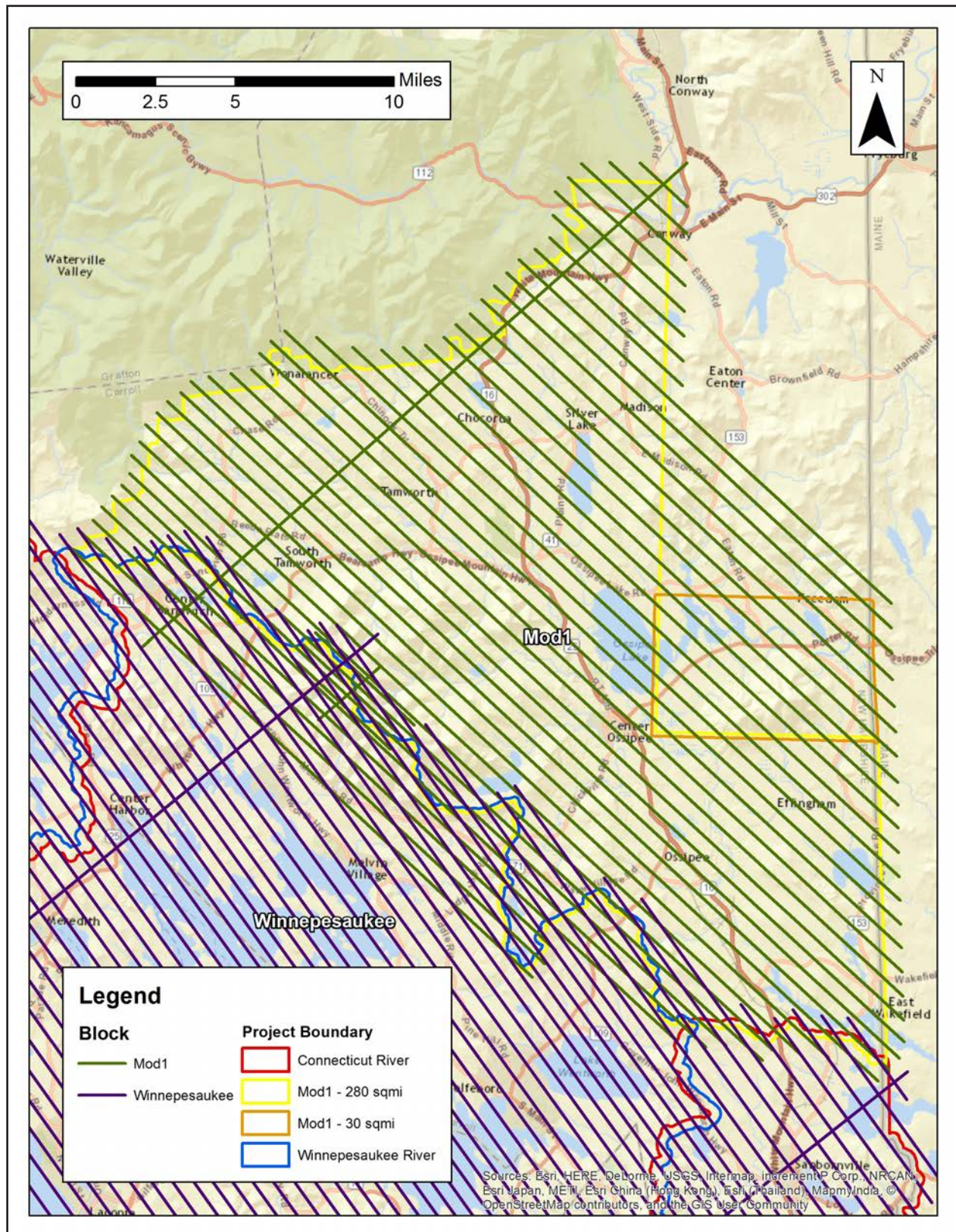


Figure 8. Planned Flight Lines - Pittsburg Block

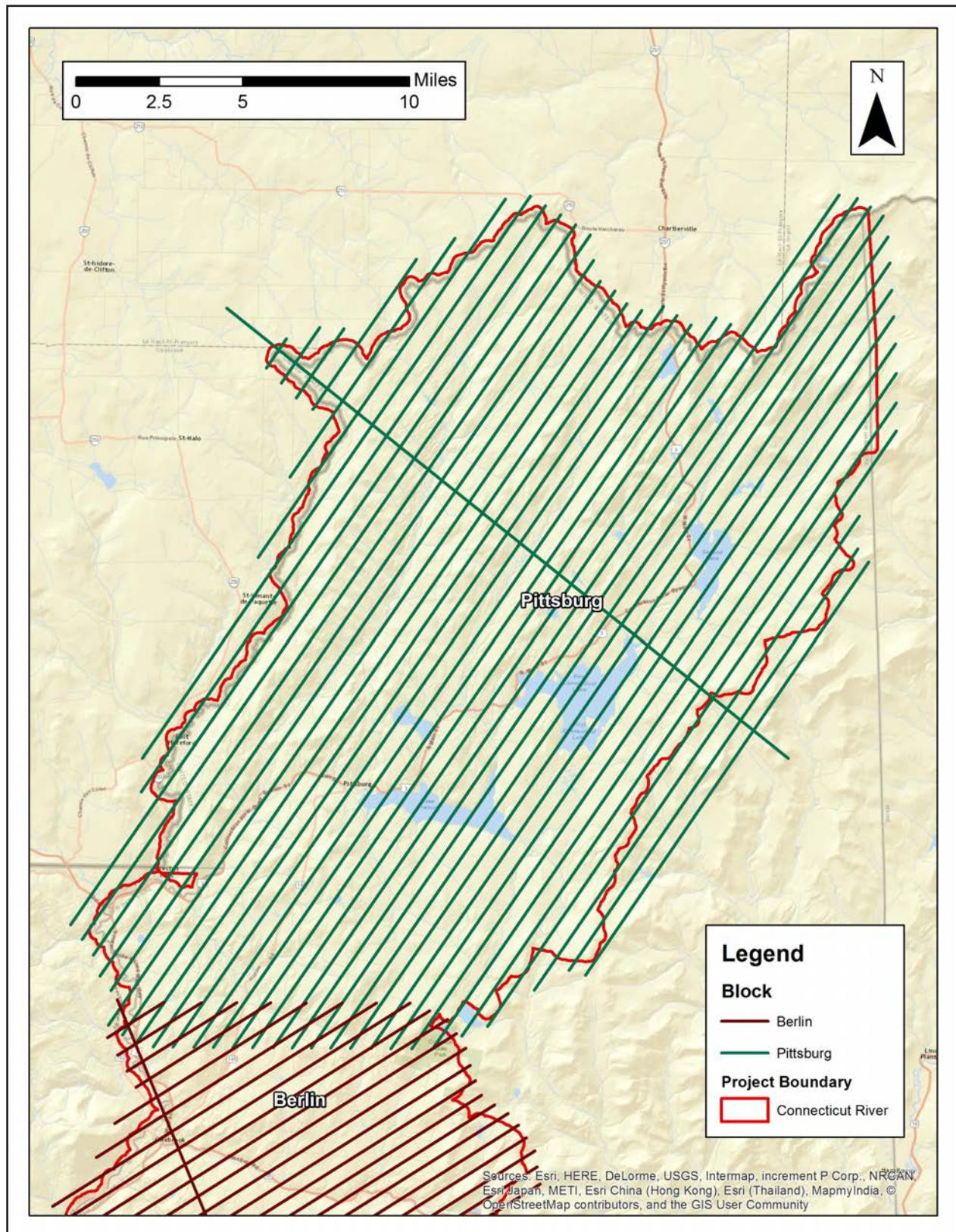


Figure 9. Planned Flight Lines - St. Johnsbury North Block

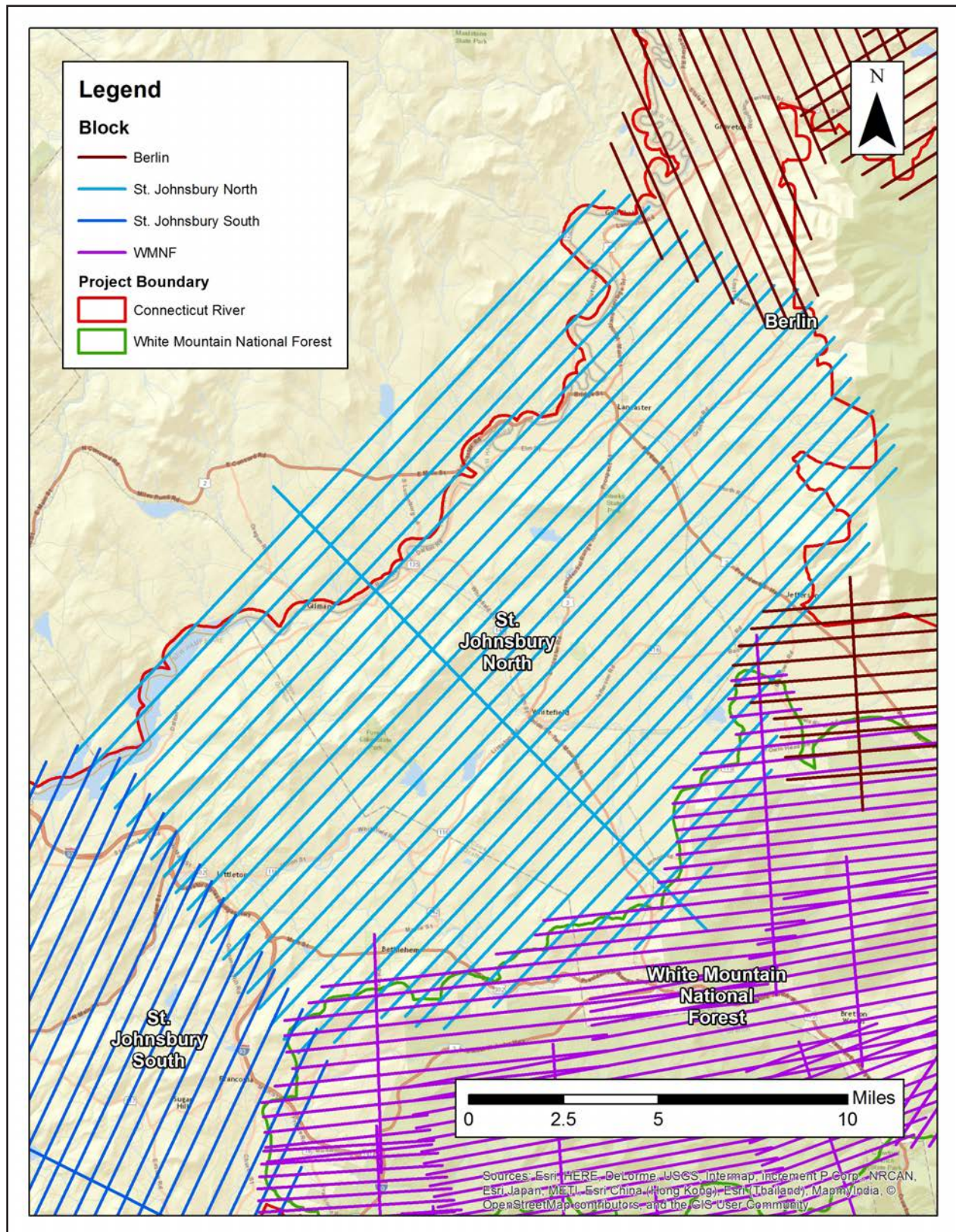


Figure 10. Planned Flight Lines - St. Johnsbury South Block

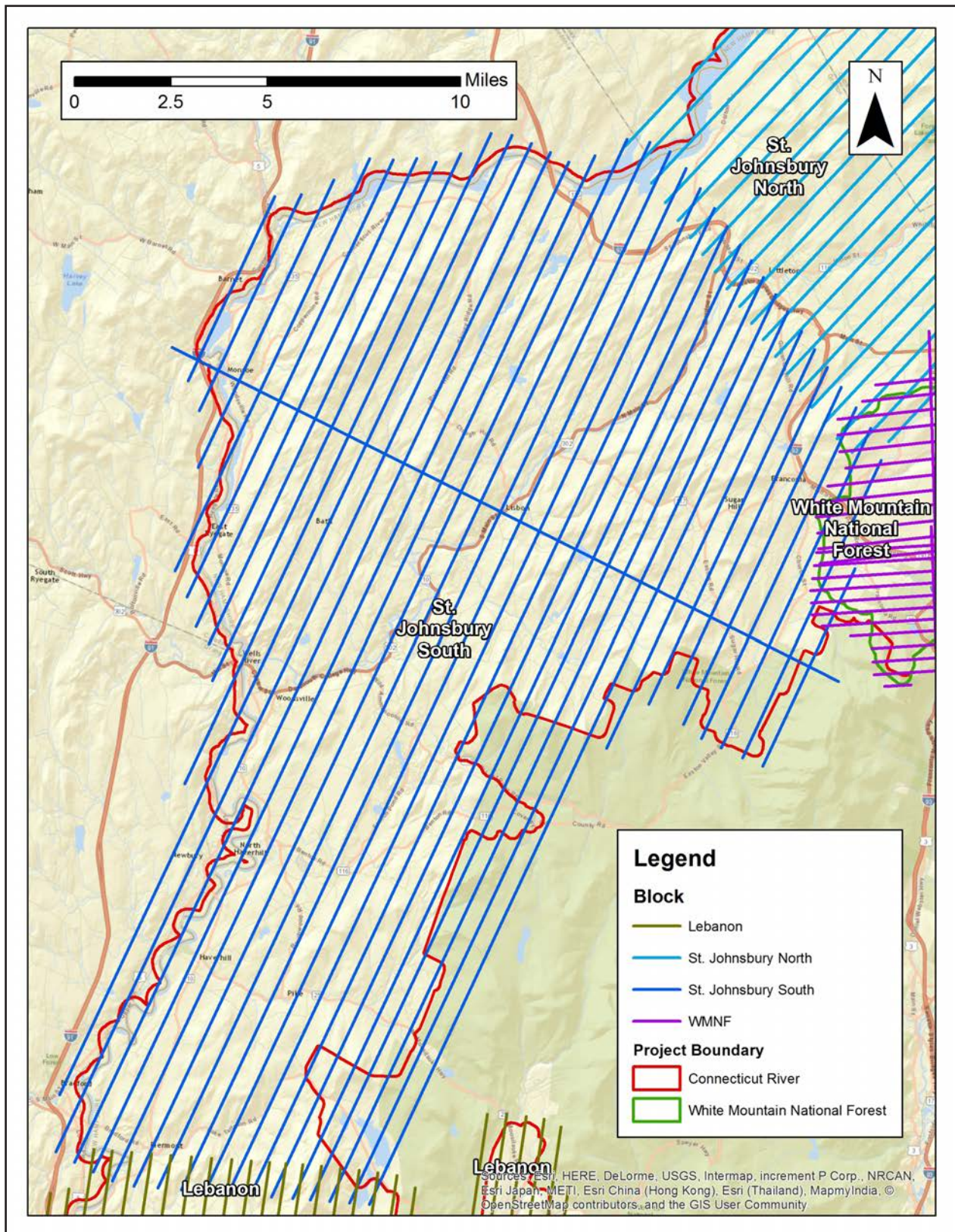


Figure 11. Planned Flight Lines - Windham Block

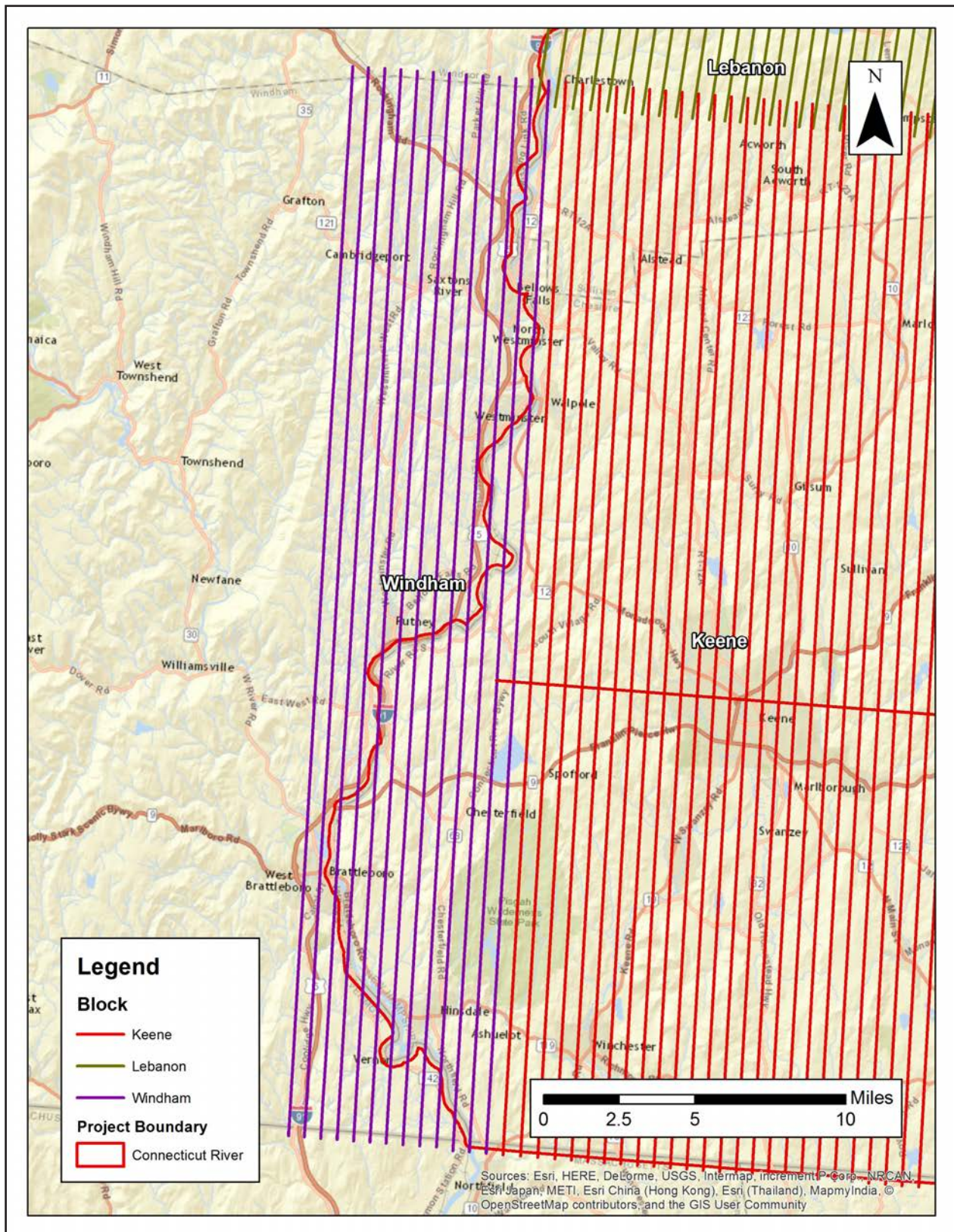


Figure 12. Planned Flight Lines - Winnepesaukee Block

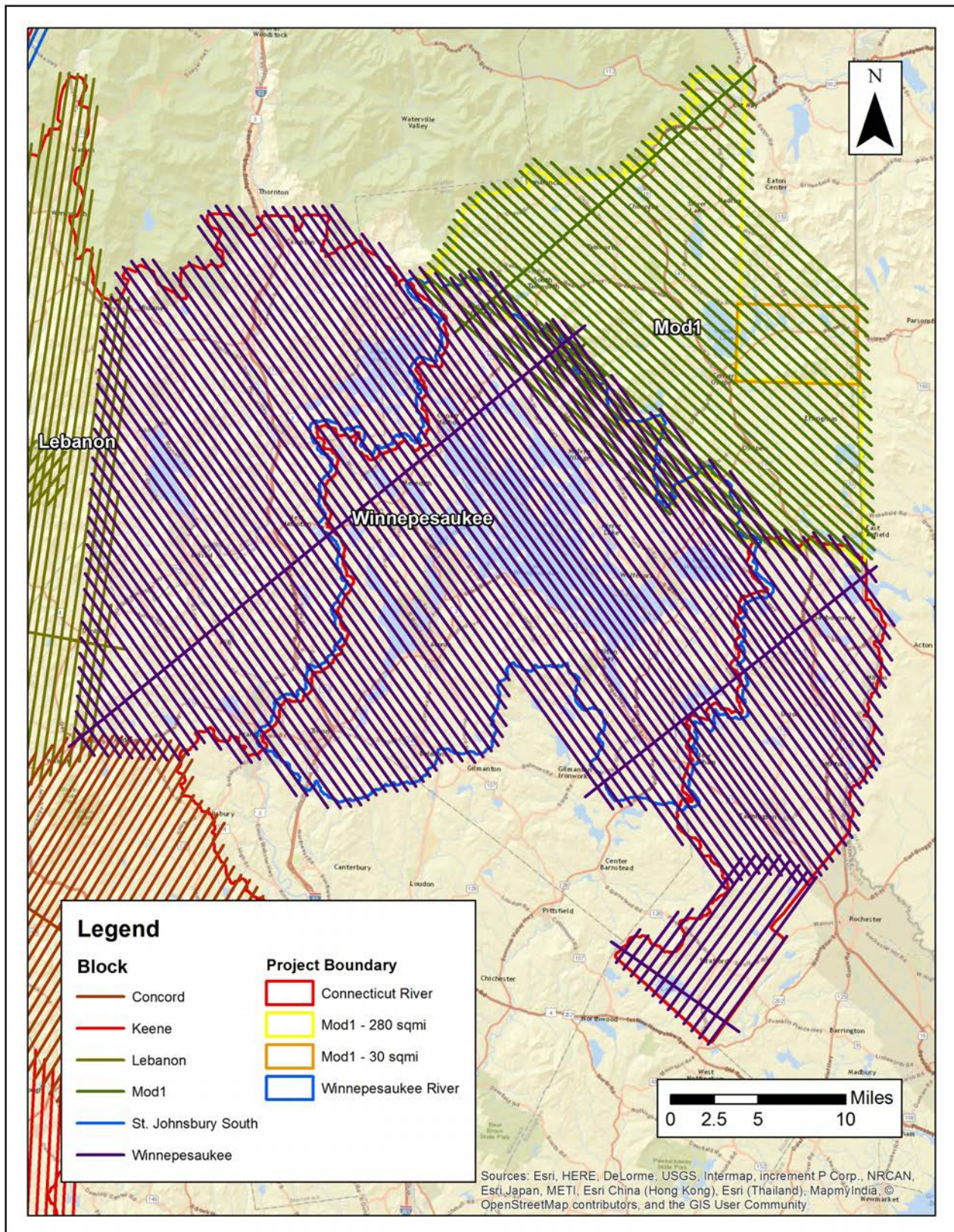


Figure 13. Planned Flight Lines - White Mountain National Forest Block

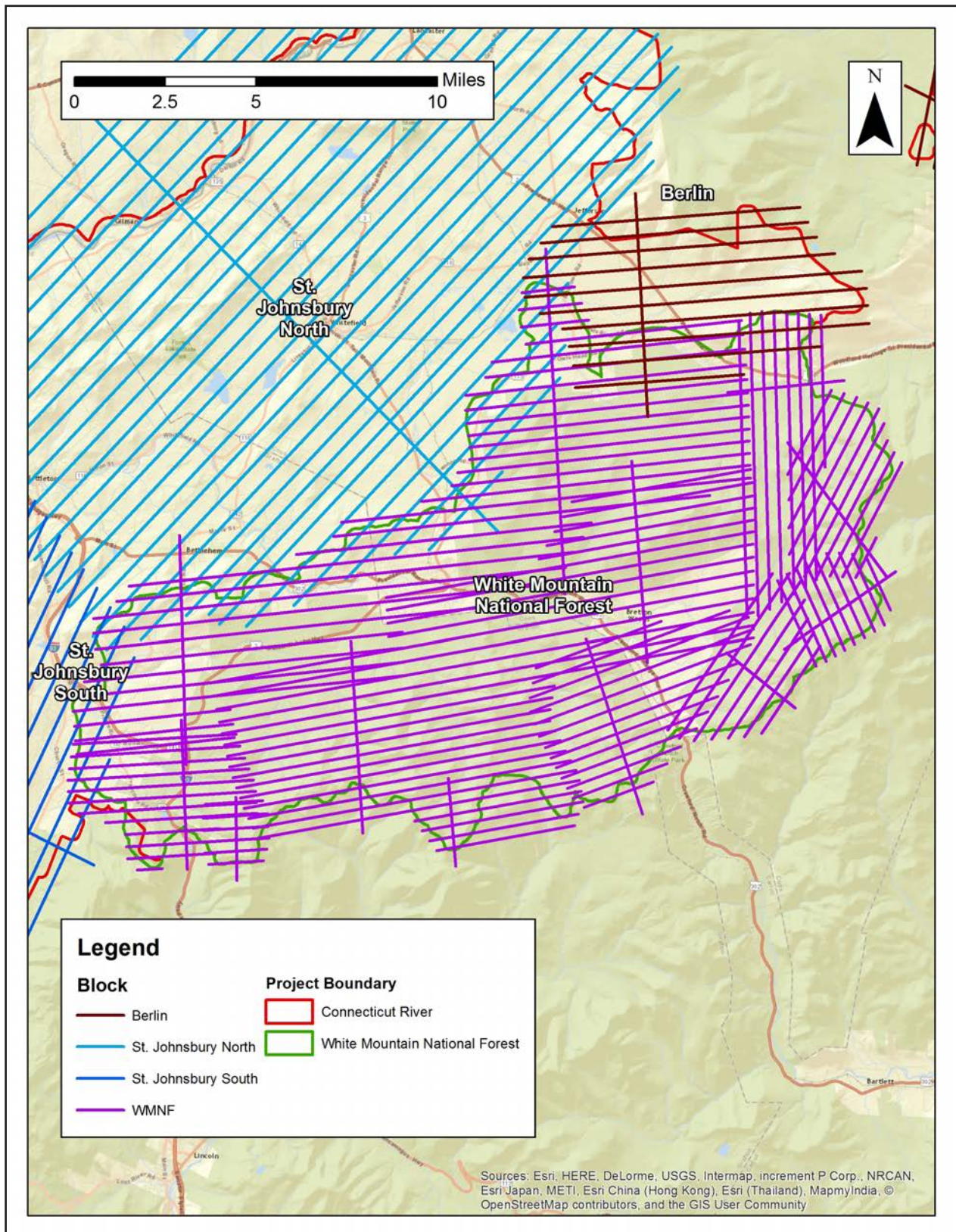


Table 2. Lidar System Specifications, part 1

		Berlin	Concord	Keene	Lebanon	Pittsburg
Terrain and Aircraft Scanner	Flying Height (m)	1,197 - 2,075	1,264 - 2,207	1,179 - 2,075	1,176 - 2,075	1,292 - 2,075
	Recommended Ground Speed (kts)	160	160	160	160	160
Scanner	Field of View (deg)	40.0	40.0	40.0	40.0	40.0
	Scan Rate Setting Used (Hz)	40.7	40.7	40.7	40.7	40.7
Laser	Laser Pulse Rate Used (kHz)	264.0	264.0	264.0	264.0	264.0
	Multi Pulse in Air Mode	Enabled	Enabled	Enabled	Enabled	Enabled
Coverage	Full Swath Width (m)	1,510.48	1,510.48	1,510.48	1,510.48	1,510.48
	Line Spacing (m)	757.10	803.24	744.71	742.64	822.53
Point Spacing and Density	Maximum Point Spacing Along Track (m)	1.01	1.01	1.01	1.01	1.01
	Maximum Point Spacing Along Track (m)	1.01	1.01	1.01	1.01	1.01
	Average Point Density (pts / m ²)	2.12	2.12	2.12	2.12	2.12

Table 3. Lidar System Specifications, part 2

		St. Johnsbury North	St. Johnsbury South	Winnepesaukee	WMNF
Terrain and Aircraft Scanner	Flying Height (m)	1,267 - 2,075	1,364 - 2,075	1,244 - 2,075	981 - 2,075
	Recommended Ground Speed (kts)	160	160	160	160
Scanner	Field of View (deg)	40.0	40.0	40.0	28.0
	Scan Rate Setting Used (Hz)	40.7	40.7	40.7	49.6
Laser	Laser Pulse Rate Used (kHz)	264.0	264.0	264.0	273.0
	Multi Pulse in Air Mode	Enabled	Enabled	Enabled	Enabled
Coverage	Full Swath Width (m)	1,510.48	1,510.48	1,510.48	1,034.71
	Line Spacing (m)	805.31	872.11	789.47	391.42
Point Spacing and Density	Maximum Point Spacing Along Track (m)	1.01	1.01	1.01	0.83
	Maximum Point Spacing Along Track (m)	1.01	1.01	1.01	0.83
	Average Point Density (pts / m ²)	2.12	2.12	2.12	3.21

Figure 14. Leica ALS 70 LiDAR Sensor


2.3. Aircraft

Quantum Spatial partnered with Precision Aerial Surveys and Woolpert, Inc. to collect data for this project. All flights for the project were accomplished through the use of the customized planes listed below.

LiDAR Collection Planes

- Piper Navajo (twin-piston), Tail Numbers: N22GE, N6GR, N812TB
- Cessna 310 (twin-piston), Tail Number: N1107Q
- Cessna 206 Stationair (piston-single), Tail Number: N1107Q

These aircraft provided an ideal, stable aerial base for LiDAR and orthoimagery 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 state-of-the-art Leica ALS 70 LiDAR systems. Some Quantum Spatial's of the operating aircraft can be seen in Figure 15 below.

Figure 15. Some of Quantum Spatial's Planes



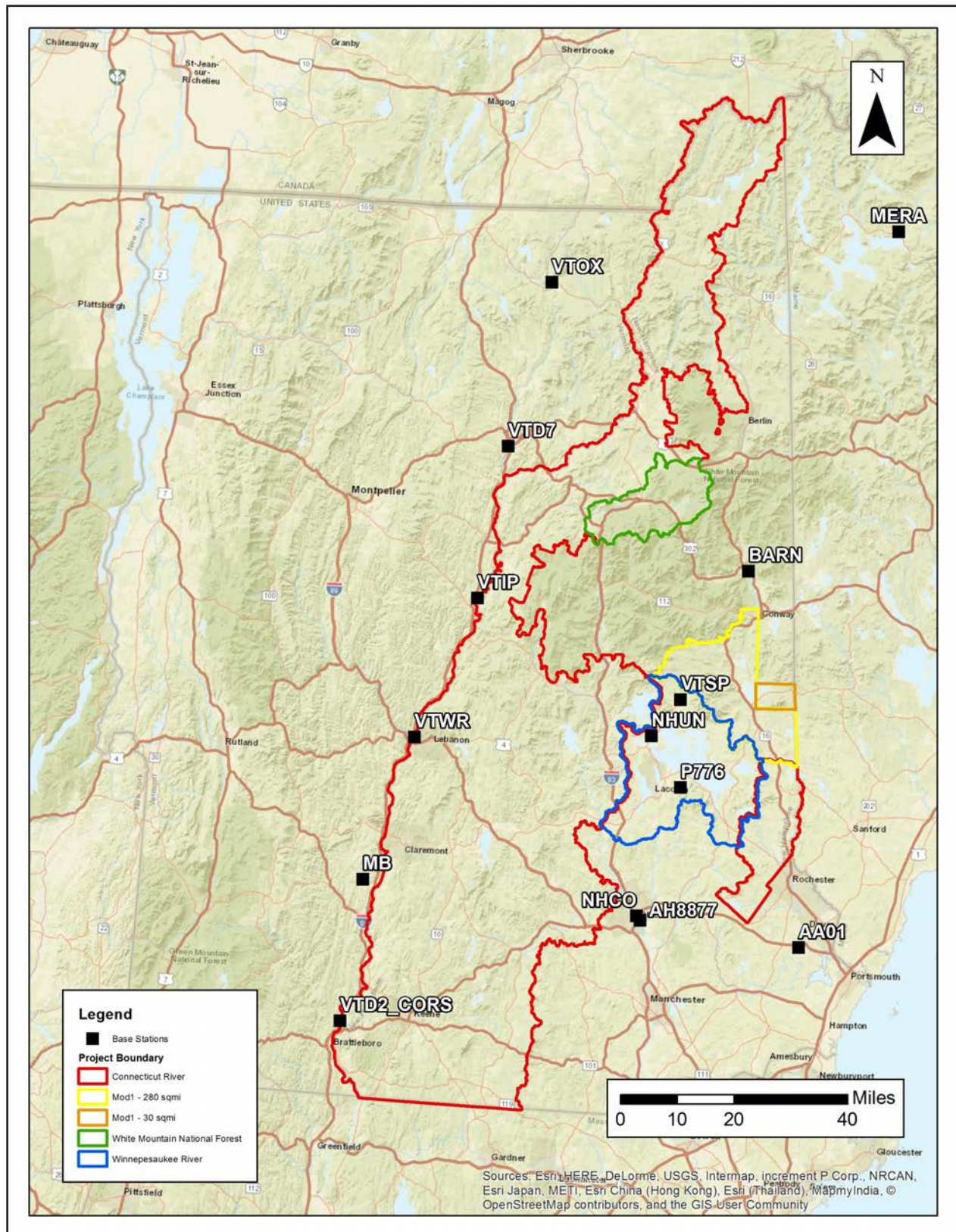
2.4. Base Station Information

GPS base stations were utilized during all phases of flight (Table 4). The base station locations were verified using NGS OPUS service and subsequent surveys. Base station locations are depicted in Figure 16. Data sheets, graphical depiction of base station locations or log sheets used during station occupation are available in Appendix A.

Table 4. Base Station Locations

Base Station	Latitude	Longitude	Ellipsoid Height (m)
MERA	44° 58' 25.33352"	70° 39' 10.58376"	489.568
VTD7	44° 23' 52.31066"	72° 1' 32.69267"	166.528
VTIP	44° 49' 12.18043"	71° 53' 25.83872"	341.732
BARN	44° 5' 56.68362"	71° 9' 34.39925"	140.793
VTOX	44° 0' 28.16564"	72° 6' 51.60957"	126.405
NHUN	43° 8' 33.17927"	70° 57' 6.86279"	9.116
AA01	43° 40' 21.87219"	71° 29' 10.5411"	221.099
NHCO	43° 12' 46.19587"	71° 31' 11.47551"	89.43
VTWR	43° 38' 56.56909"	72° 19' 2.6683"	97.616
VTD2_CORS	42° 55' 6.10798"	72° 32' 6.4414"	98.04
AH8877	43° 12' 7.23201"	71° 30' 20.69798"	74.193
MB	43° 46' 4.16098"	71° 23' 12.42431"	147.018
VTSP	43° 16' 53.24114"	72° 28' 39.23841"	156.441
P776	43° 32' 35.72074"	71° 22' 42.7891"	478.115

Figure 16. Base Station Locations



Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

2.5. Time Period

Project specific flights were conducted over several months. Forty-five sorties, or aircraft lifts were completed. Accomplished sorties are listed below.

- Oct 24, 2015-B (N22GE, SN7178)
- Oct 26, 2015-A (N22GE, SN7178)
- Oct 27, 2015-A (N6GR, SN7161)
- Oct 27, 2015-B (N6GR, SN7161)
- Oct 27, 2015-C (N6GR, SN7161)
- Oct 31, 2015-A (N22GE, SN7178)
- Oct 31, 2015-A (N6GR, SN7161)
- Oct 31, 2015-B (N6GR, SN7161)
- Oct 31, 2015-C (N6GR, SN7161)
- Nov 04, 2015-A (N6GR, SN7161)
- Nov 04, 2015-B (N6GR, SN7161)
- Nov 05, 2015-A (N6GR, SN7161)
- Nov 05, 2015-B (N22GE, SN7178)
- Nov 05, 2015-B (N6GR, SN7161)
- Nov 08, 2015-A (N22GE, SN7178)
- Nov 08, 2015-A (N6GR, SN7161)
- Nov 09, 2015-A (N22GE, SN7178)
- Nov 09, 2015-A (N6GR, SN7161)
- Nov 09, 2015-B (N22GE, SN7178)
- Nov 09, 2015-B (N6GR, SN7161)
- Nov 09, 2015-C (N6GR, SN7161)
- Nov 10, 2015-A (N22GE, SN7178)
- Nov 10, 2015-A (N6GR, SN7161)
- Nov 10, 2015-B (N22GE, SN7178)
- Nov 15, 2015-A (N1107Q, SN7108)
- Nov 15, 2015-A (N22GE, SN7178)
- Nov 15, 2015-A (N799AC, SN7169)
- Nov 15, 2015-B (N799AC, SN7169)
- Nov 15, 2015-C (N799AC, SN7169)
- Nov 16, 2015-A (N1107Q, SN7108)
- Nov 16, 2015-A (N22GE, SN7178)
- Nov 16, 2015-A (N799AC, SN7169)
- Nov 16, 2015-B (N22GE, SN7178)
- Nov 17, 2015-A (N1107Q, SN7108)
- Nov 17, 2015-A (N22GE, SN7178)
- Nov 17, 2015-A (N799AC, SN7169)
- Nov 17, 2015-B (N22GE, SN7178)
- Nov 17, 2015-B (N799AC, SN7169)
- Nov 20, 2015-A (N1107Q, SN7108)
- Nov 20, 2015-B (N1107Q, SN7108)
- Nov 21, 2015-A (N1107Q, SN7108)
- Nov 21, 2015-A (N6GR, SN7161)
- Nov 21, 2015-B (N6GR, SN7161)
- Nov 23, 2015-A (N6GR, SN7161)
- Apr 29, 2016-B (N812TB, SN7161)

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. All relevant graphs produced in the Inertial Explorer processing environment for each sortie during the 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 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 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 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 1 meter 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 was 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-Flattened Breakline Creation

For the CT River and Winnepesaukee River AOIs, 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 30 meter 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 1 meter 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 formats using ESRI conversion tools for the Connecticut and Winnepesaukee River Watershed areas of interest.

3.6. Hydro-Flattened Bare-Earth Raster DEM Creation

For the CT River and Winnepesaukee River AOIs, class 2 LiDAR in conjunction with the hydro breaklines were used to create a 1-meter Raster DEM. Using automated scripting routines within ArcMap, a GeoTIFF file was created for each tile. Additionally, a mosaic was created for the entire area of interest. Each surface is reviewed using Global Mapper to check for any surface anomalies or incorrect elevations found within the surface.

3.7. Bare Earth Raster DEM Creation

For the WMNF AOI, class 2 LiDAR was used to create a 1-meter Raster DEM. Using automated scripting routines within ArcMap, an Esri grid 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.

3.8. Intensity Image Creation

For the CT River and Winnepesaukee River AOIs, 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. 1-meter TIF/TWF files were then provided as the deliverable for this dataset requirement.

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 17.

Figure 17. Flightline Swath LAS File Coverage

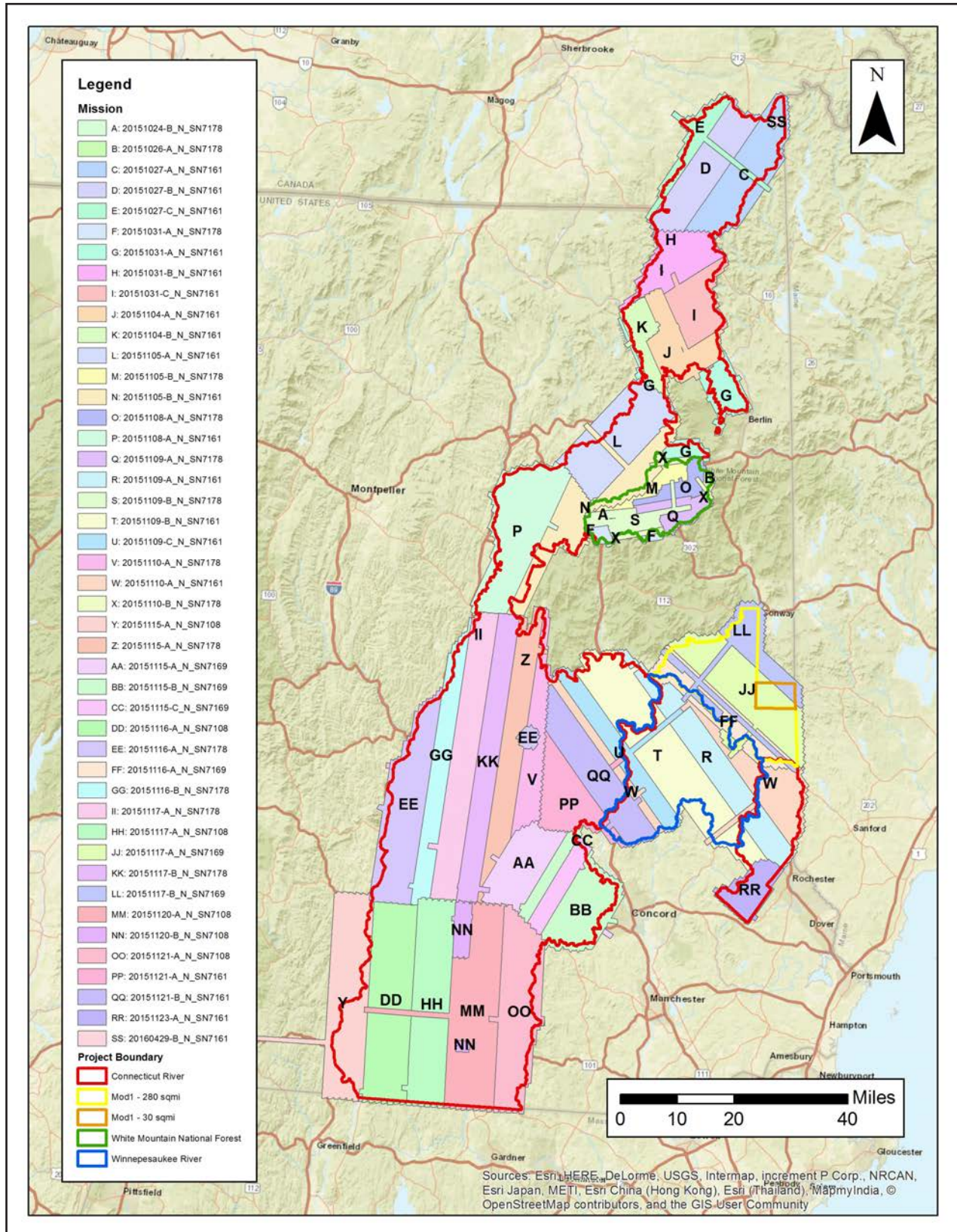


Figure 18. Flightline Swath LAS File Coverage - Part 1

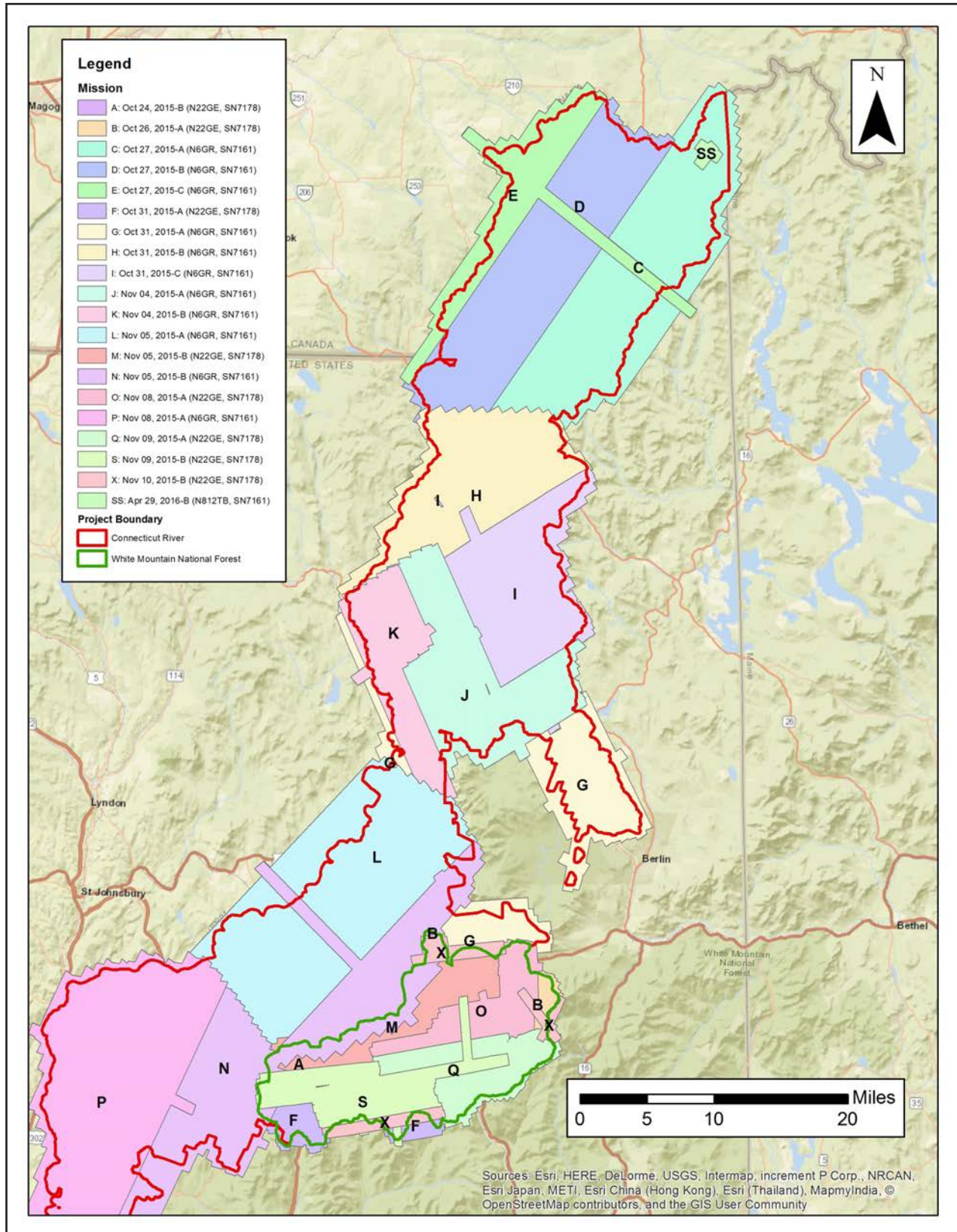


Figure 19. Flightline Swath LAS File Coverage - Part 2

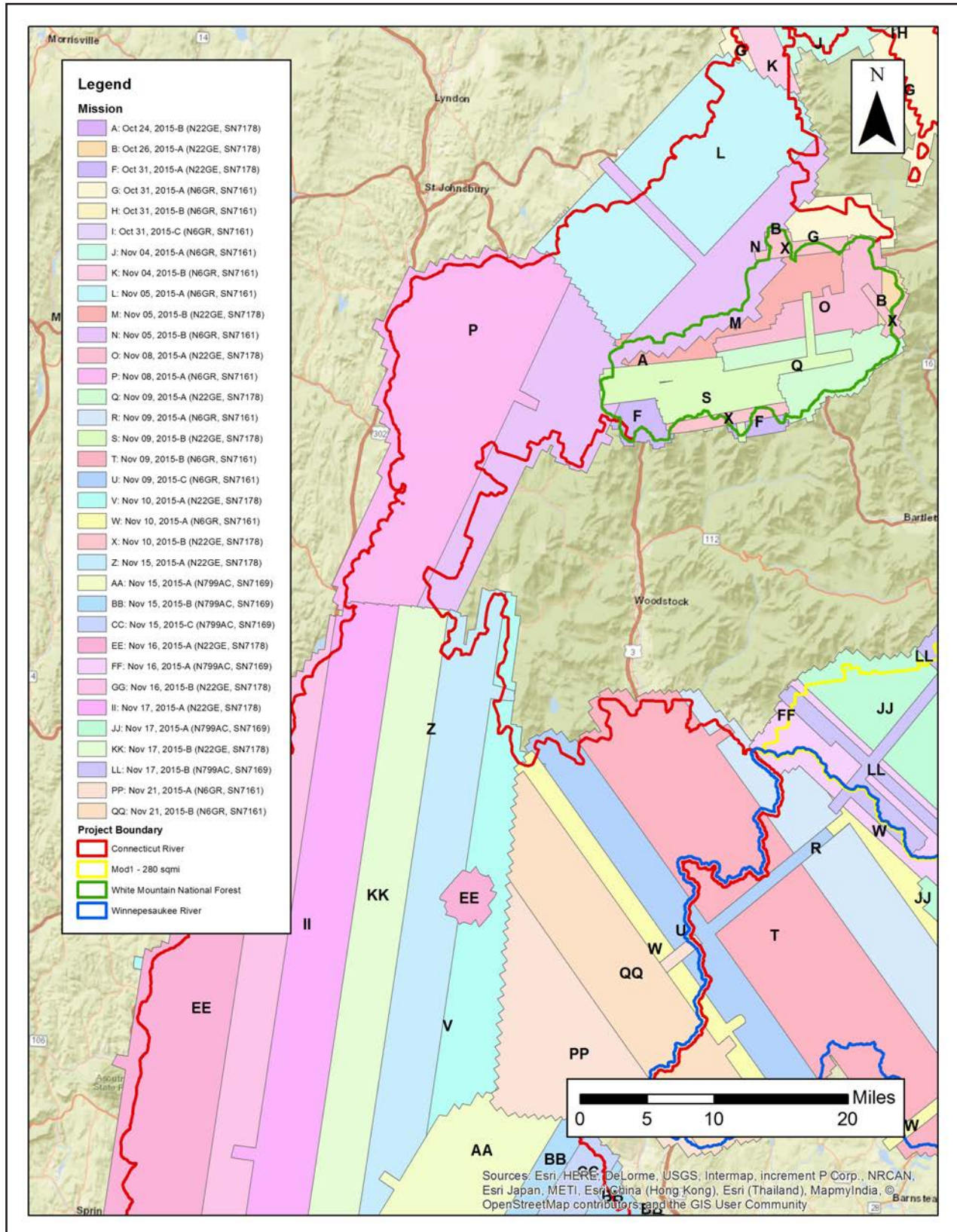


Figure 20. Flightline Swath LAS File Coverage - Part 3

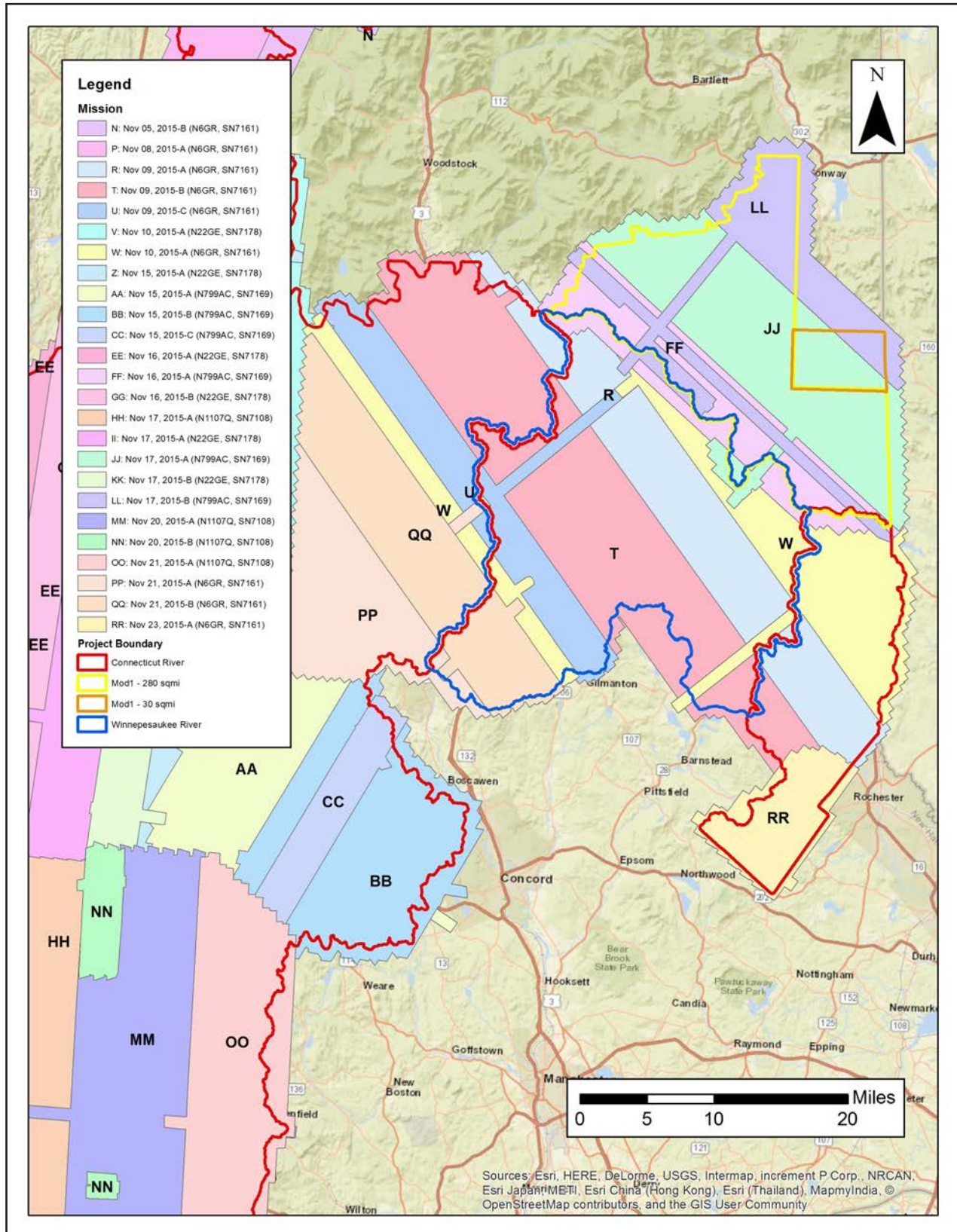
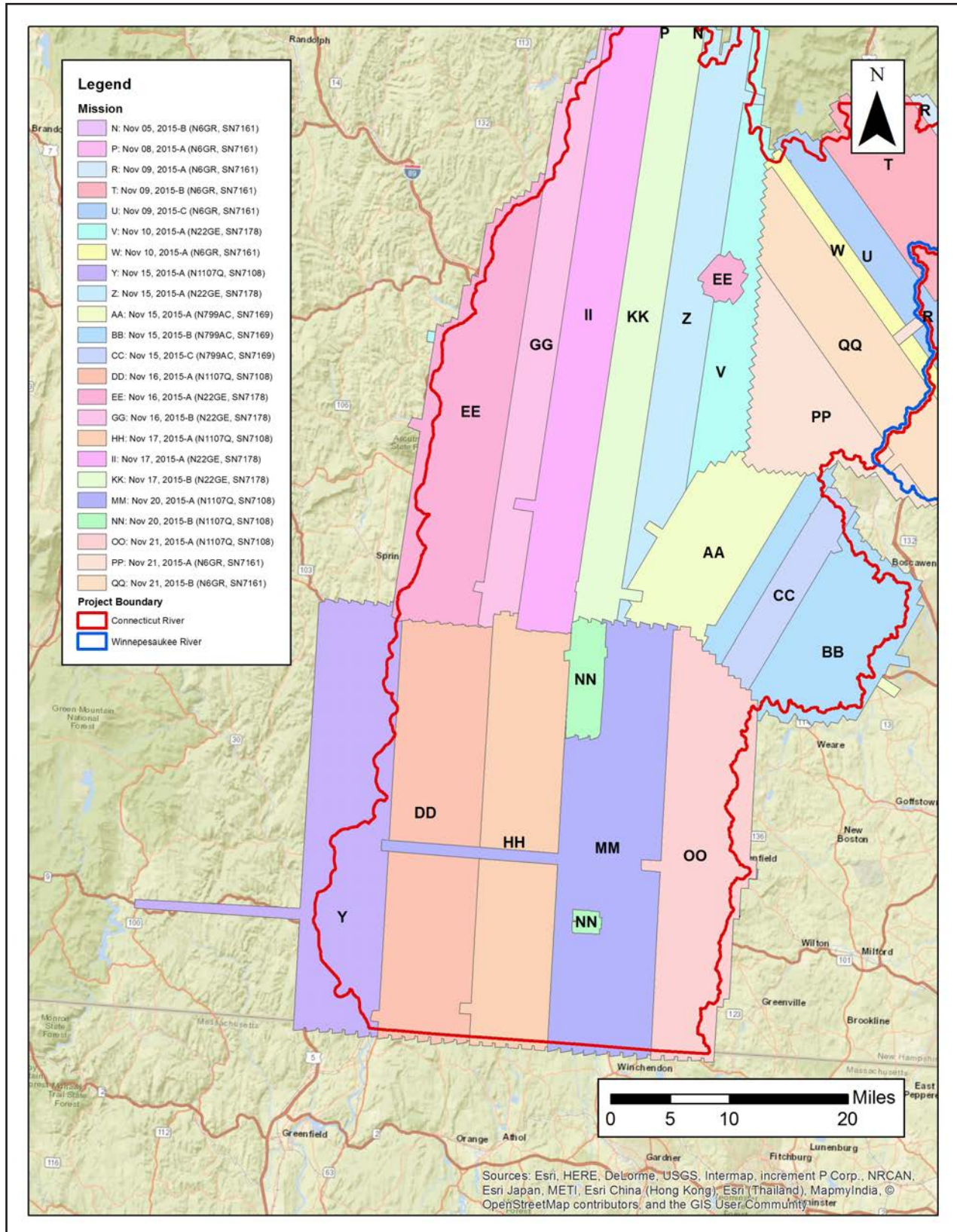


Figure 21. Flightline Swath LAS File Coverage - Part 4



5. Ground Control and Check Point Collection

Quantum Spatial completed a field survey of 155 ground control (calibration) points along with 252 blind QA points in Vegetated and Non-Vegetated land cover classifications (total of 407 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 blind QA points the goal was a positional accuracy of 5 cm in terms of the RMSE.

For more information, see the Survey Report in Appendix B.

The required accuracy testing was performed on the LiDAR dataset (both the LiDAR point cloud and derived DEM's) according to the USGS LiDAR Base Specification Version 1.2 (2014). In this document, horizontal coordinates for ground control and QA points for all LiDAR classes are reported in NAD83 (2011) UTM Zone 19, meters; NAVD88 (Geoid 12B), meters.

5.1. Calibration Control Point Testing

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.

5.2. Point Cloud Testing

Raw Nonvegetated Vertical Accuracy (Raw NVA): The tested Raw NVA for the dataset was found to be 0.047 meters in terms of the RMSEz. The resulting NVA stated as the 95% confidence level (RMSEz x 1.96) is 0.093 meters. This dataset meets the required FVA of ≤ 0.196 meters 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. See Figure 8 and 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 0.047 meters in terms of the RMSEz. The resulting accuracy stated as the 95% confidence level (RMSEz x 1.96) is 0.092 meters. This dataset meets the required NVA of 0.196 meters at the 95% confidence level (based on NSSDA). See Figure 9 and Table 6.

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 0.284 meters, which is stated in terms of the 95th percentile error. Therefore the data meets the required VVA of 0.294 meters. This test was based on the 95th percentile error (based on ASPRS guidelines) across all land cover categories. See Figure 10 and Table 7.

Figure 22. Calibration Points

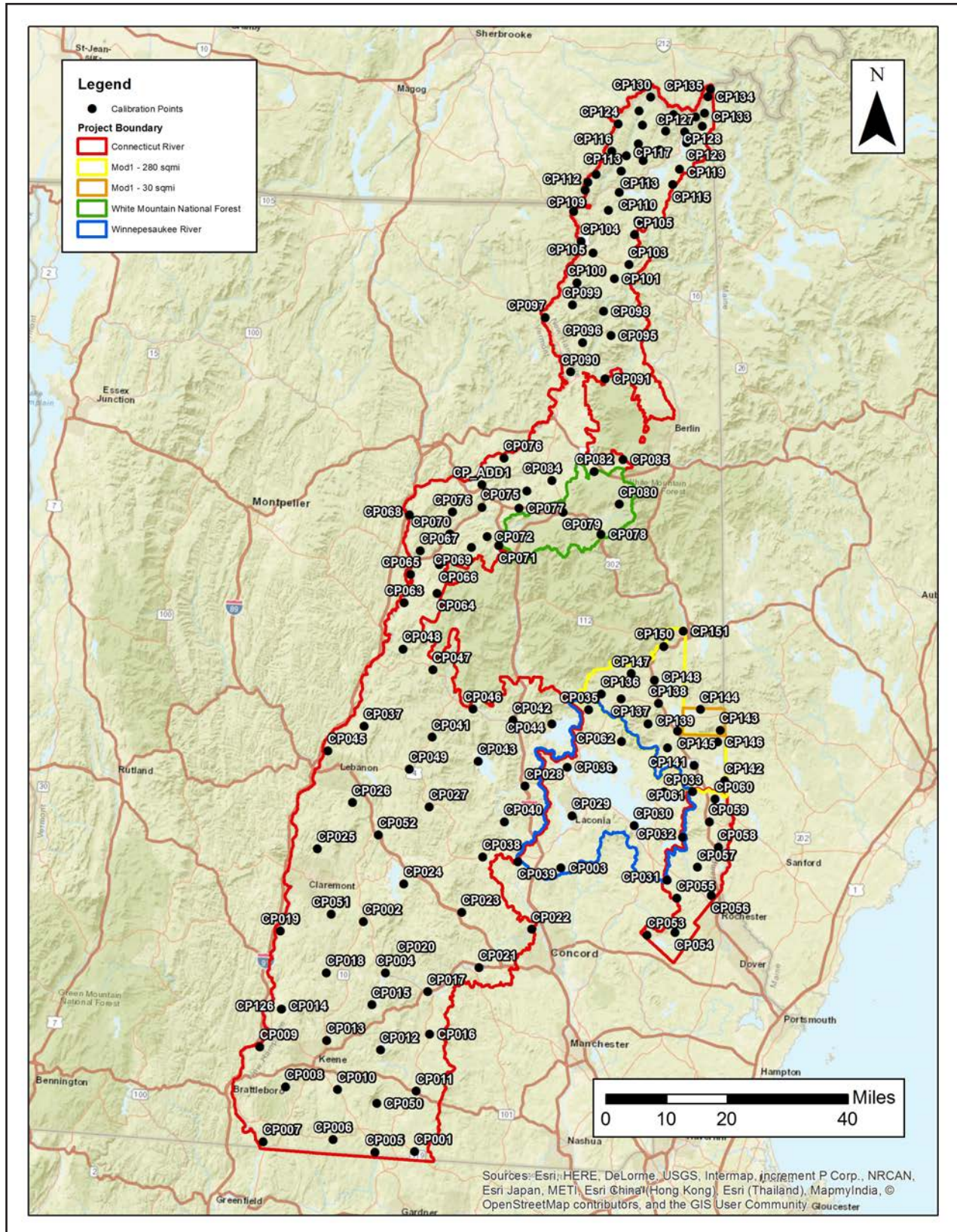


Table 5. Calibration Point Report

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
CP_ADD1	275738.950	4912792.066	311.29	311.26	-0.03
CP_ALT1	306065.696	4995423.458	364.02	364.16	0.14
CP_ALT2	791253.797	4962595.555	601.78	outside	*
CP001	257755.227	4735224.945	367.07	367.10	0.03
CP002	244106.225	4796493.574	310.27	310.25	-0.02
CP003	296704.233	4810795.458	244.71	244.82	0.11
CP004	250024.216	4782805.299	447.24	447.31	0.07
CP005	247244.065	4734985.566	274.84	274.89	0.05
CP006	236089.403	4738430.248	327.99	327.92	-0.07
CP007	217489.862	4737815.631	93.97	93.92	-0.05
CP008	223433.839	4752444.282	221.57	221.60	0.03
CP009	216604.771	4763107.747	113.38	113.34	-0.04
CP010	237307.958	4751714.819	202.69	202.67	-0.02
CP011	258151.054	4751306.220	242.75	242.73	-0.02
CP012	248705.148	4762279.681	434.15	434.17	0.02
CP013	234368.117	4764777.001	247.85	247.82	-0.03
CP014	222356.069	4773129.785	208.29	208.30	0.02
CP015	246412.994	4774300.616	437.46	437.47	0.01
CP016	261783.327	4766482.507	191.41	191.45	0.04
CP017	261220.740	4777782.764	210.08	210.16	0.08
CP018	234237.681	4782825.059	423.48	423.39	-0.09
CP019	222047.613	4793966.701	117.69	117.74	0.05
CP020	253110.277	4786472.275	316.51	316.56	0.05
CP021	274875.222	4784218.171	141.54	141.57	0.03
CP022	288977.857	4794412.081	102.50	102.52	0.02
CP023	270296.592	4798909.064	238.40	238.37	-0.03
CP024	254939.906	4806513.525	414.73	414.71	-0.02
CP025	231909.337	4815830.158	289.58	289.53	-0.05
CP026	241286.198	4828173.479	441.28	441.29	0.01
CP027	261711.609	4827056.023	253.62	253.62	0.00
CP028	287136.499	4832550.936	166.19	166.27	0.09
CP029	299711.350	4824657.756	153.83	153.81	-0.02

Number	Easting	Northing	Known Z	Laser Z	Dz
CP030	316195.549	4822062.446	199.24	199.33	0.09
CP031	325022.812	4807498.412	331.22	331.19	-0.03
CP032	329081.015	4818906.017	257.65	257.67	0.02
CP033	324221.037	4830997.692	180.27	180.29	0.02
CP034	310589.646	4837082.923	154.42	154.37	-0.05
CP035	304094.647	4852892.377	188.71	188.67	-0.04
CP036	298443.531	4837612.322	154.78	154.75	-0.03
CP037	244346.249	4848557.680	318.07	318.12	0.06
CP038	275902.901	4813683.880	194.97	194.99	0.02
CP039	285224.060	4812401.481	98.65	98.64	-0.01
CP040	281694.533	4823068.424	138.16	138.17	0.01
CP041	262475.350	4845586.555	411.48	411.48	0.00
CP042	283985.918	4850108.504	165.74	165.74	0.00
CP043	274687.942	4839156.226	202.97	202.97	0.00
CP044	294294.477	4849094.548	184.34	184.35	0.01
CP045	234688.932	4841941.434	151.36	151.34	-0.02
CP046	273360.126	4853090.037	160.04	159.99	-0.05
CP047	262663.620	4863525.704	276.37	276.34	-0.03
CP048	254700.348	4869028.991	351.79	351.68	-0.11
CP049	256421.771	4837099.720	288.59	288.64	0.05
CP050	247707.129	4748009.531	417.90	417.91	0.01
CP051	235562.260	4798426.724	445.28	445.30	0.02
CP052	248095.967	4819542.318	312.69	312.73	0.04
CP053	319622.833	4792893.888	183.92	183.97	0.05
CP054	327055.368	4793566.513	179.94	179.96	0.02
CP055	327593.470	4802747.184	262.14	262.11	-0.03
CP056	336711.786	4803401.133	89.89	89.85	-0.04
CP057	333102.327	4810939.827	180.35	180.33	-0.02
CP058	338643.936	4816243.077	139.98	139.97	-0.01
CP059	336207.071	4823006.189	167.13	167.17	0.04
CP060	337691.645	4829105.602	186.74	186.79	0.05
CP061	331739.320	4831055.308	303.67	303.67	0.00
CP062	312884.996	4844469.140	382.97	382.93	-0.04
CP063	255021.692	4881267.980	151.03	151.00	-0.03
CP064	263725.033	4883807.620	401.54	401.48	-0.06

Number	Easting	Northing	Known Z	Laser Z	Dz
CP065	256640.448	4888822.975	145.96	145.94	-0.02
CP066	264336.225	4891427.292	245.79	245.77	-0.02
CP067	259261.219	4895152.053	194.67	194.72	0.05
CP068	256397.901	4904721.127	160.738	160.72	-0.02
CP069	272922.544	4896003.194	414.24	414.16	-0.08
CP070	267109.502	4899636.315	170.37	170.38	0.01
CP070	267109.503	4899636.317	170.39	170.38	-0.01
CP071	280194.115	4896515.877	299.23	299.22	-0.01
CP072	277117.505	4898915.101	474.23	474.30	0.07
CP073	267879.874	4905435.862	203.12	203.08	-0.04
CP074	275653.700	4906693.041	215.25	215.19	-0.06
CP075	287680.547	4911035.333	322.94	322.98	0.04
CP076	281580.311	4919790.449	302.65	302.63	-0.02
CP076	267879.874	4905435.883	203.10	203.08	-0.02
CP077	285558.964	4906428.506	439.85	439.84	-0.01
CP078	307374.570	4899497.628	575.96	575.96	0.00
CP079	297268.971	4905411.339	432.39	432.42	0.03
CP080	312241.621	4907525.163	916.20	916.17	-0.03
CP081	770544.183	4923681.510	362.57	362.57	0.00
CP082	305566.994	4916230.938	358.54	358.58	0.04
CP083	767399.507	4929280.631	255.93	255.90	-0.03
CP084	294285.734	4913875.330	350.88	350.90	0.02
CP085	313217.390	4919429.050	669.37	669.39	0.02
CP086	779057.178	4925480.607	337.79	337.76	-0.03
CP087	776172.035	4931341.783	308.93	308.89	-0.04
CP088	772510.520	4937124.010	265.76	265.79	0.04
CP090	299249.852	4942775.329	271.85	271.87	0.02
CP091	308431.662	4940949.867	293.225	293.2	-0.03
CP092	795465.831	4946245.533	403.779	403.8	0.02
CP093	797517.687	4937133.403	371.433	371.44	0.01
CP094	792060.307	4954358.603	445.083	445.04	-0.04
CP095	310101.398	4952479.950	599.381	599.35	-0.03
CP096	302459.436	4950627.950	489.126	489.13	0.00
CP097	292485.071	4957271.076	269.882	269.88	0.00
CP098	308036.648	4958957.680	497.241	497.16	-0.08

Number	Easting	Northing	Known Z	Laser Z	Dz
CP099	299793.546	4960683.231	524.49	524.41	-0.08
CP100	300993.638	4966526.380	575.039	575.1	0.06
CP101	310936.439	4967615.146	529.373	529.45	0.08
CP103	314785.357	4971431.159	453.935	453.92	-0.01
CP104	302103.824	4977566.400	317.185	317.2	0.01
CP105	305301.741	4974430.384	360.883	360.93	0.05
CP105	316319.269	4979315.484	690.222	690.3	0.08
CP106	300119.496	4985573.092	313.272	313.27	0.00
CP107	309382.012	4985823.953	511.602	511.62	0.02
CP108	317216.873	4983063.823	640.781	640.84	0.06
CP109	303150.093	4991236.473	338.98	339.01	0.03
CP110	312229.359	4990565.999	427.048	426.89	-0.16
CP111	320418.969	4986935.909	537.608	537.61	0.00
CP112	303840.259	4993309.100	339.046	339.12	0.07
CP113	312749.202	4996329.011	422.952	422.94	-0.01
CP113	312749.201	4996329.018	422.968	422.94	-0.03
CP114	318482.482	4993557.760	442.123	442.03	-0.09
CP115	326509.945	4992697.084	667.216	667.22	0.00
CP116	310230.700	5001595.067	543.884	543.92	0.04
CP117	314148.438	5000390.959	429.714	429.6	-0.11
CP118	318657.623	4999061.643	495.87	495.94	0.07
CP119	328306.703	4996826.673	666.816	666.82	0.00
CP121	317310.352	5003578.758	557.391	557.41	0.02
CP122	323032.967	5001970.684	616.208	616.25	0.04
CP123	330209.836	5003845.283	588.211	588.15	-0.06
CP124	311984.890	5008842.841	513.002	512.97	-0.03
CP125	318444.661	5008557.624	532.89	532.93	0.04
CP126	222356.072	4773129.747	208.292	208.3	0.01
CP126	324606.318	5006947.925	805.795	805.81	0.01
CP127	329708.299	5006733.536	584.588	584.69	0.10
CP128	334359.773	5008248.258	645.659	645.65	-0.01
CP129	317560.353	5012356.322	464.787	464.88	0.09
CP130	320636.475	5016036.017	587.203	587.2	0.00
CP131	326676.861	5011339.494	687.139	687.11	-0.03
CP132	332527.989	5010677.449	841.139	841.11	-0.03

Number	Easting	Northing	Known Z	Laser Z	Dz
CP133	334983.852	5011693.79	730.112	730.09	-0.02
CP134	335880.666	5016078.925	654.068	654.03	-0.04
CP135	336489.766	5018135.525	704.792	704.67	-0.12
CP136	307418.025	4857072.158	206.039	206.03	-0.01
CP137	312735.203	4855760.892	178.9	178.9	0.00
CP138	322651.965	4854644.505	134.949	134.93	-0.02
CP139	319959.111	4849106.148	277.091	277.09	0.00
CP140	325135.542	4842709.368	205.244	205.28	0.04
CP141	332196.67	4838023.753	152.466	152.47	0.00
CP142	340328.134	4833993.313	181.567	181.58	0.01
CP143	339127.925	4847441.728	176.984	176.96	-0.02
CP144	333807.538	4853001.782	140.876	140.89	0.01
CP145	327738.278	4847231.904	130.403	130.38	-0.02
CP146	338379.78	4844369.651	128.918	128.85	-0.07
CP147	315423.775	4862523.9	226.759	226.76	0.00
CP148	321599.248	4860800.685	161.161	161.15	-0.01
CP150	324053.564	4869764.116	207.047	207	-0.05
CP151	329264.326	4873700.342	150.157	150.15	-0.01
Average Dz		0.00 m			
Minimum Dz		-0.158 m			
Maximum Dz		0.138 m			
Root Mean Square		0.046 m			
Std. Deviation		0.091 m			

*Point CP_ALT2 was removed as it was located outside of the project AOI.

Figure 23. Raw NVA Points

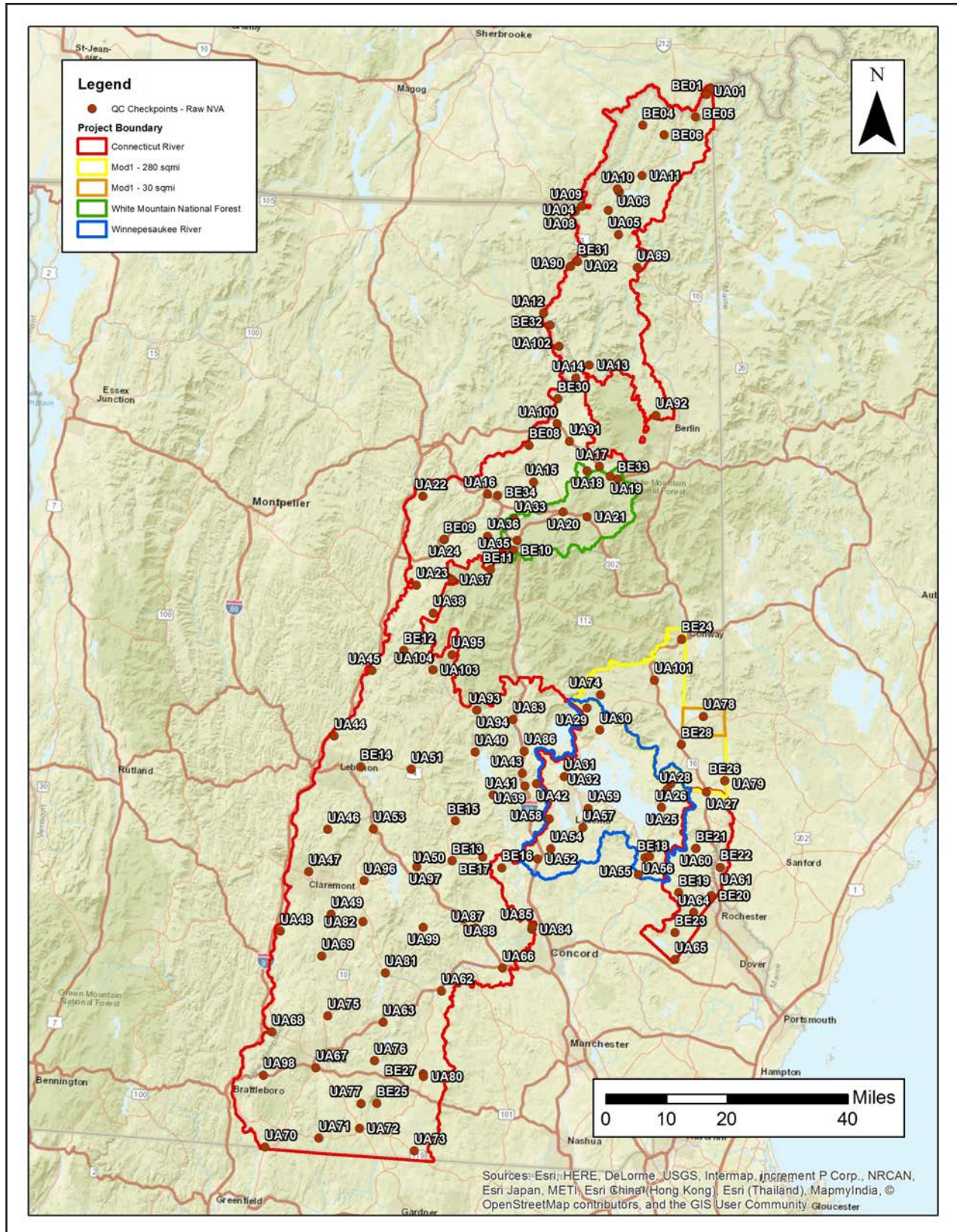


Table 6. NVA Point Report

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
BE01	336505.758	5018136.639	707.21	707.1	-0.11
BE02	312269.109	4990729.708	405.97	405.99	0.02
BE03	312269.118	4990729.725	405.98	405.98	0.00
BE04	318518.102	5008532.211	536.88	536.83	-0.05
BE05	332538.721	5010671.255	842.29	842.21	-0.08
BE06	324193.475	5005919.543	775.44	775.37	-0.07
BE07	312026.826	4979383.922	513.85	513.89	0.04
BE08	288242.122	4923229.060	260.38	260.38	0.00
BE09	265605.514	4898152.491	182.41	182.36	-0.05
BE10	284060.329	4895334.122	611.82	611.85	0.03
BE11	277959.761	4890102.081	452.20	452.27	0.07
BE12	254903.055	4868735.517	340.89	340.86	-0.03
BE13	267754.905	4812688.359	199.06	199.09	0.03
BE14	243399.285	4837714.101	231.12	231.12	0.00
BE15	268607.584	4823282.338	249.24	249.25	0.01
BE16	280958.512	4810827.099	216.70	outside	*
BE17	275915.481	4813686.898	195.54	195.56	0.02
BE18	319079.772	4813434.574	200.09	200.02	-0.07
BE19	328082.085	4804163.634	206.65	206.60	-0.05
BE20	336709.194	4803372.598	89.59	89.50	-0.09
BE21	332611.465	4815942.124	233.09	233.03	-0.06
BE22	339170.016	4810924.561	128.73	128.72	-0.01
BE23	327060.438	4793569.951	180.00	179.99	-0.01
BE24	328911.705	4871669.517	143.83	143.82	-0.01
BE25	247705.130	4748018.485	418.16	418.13	-0.03
BE26	340330.228	4834000.184	181.71	181.70	-0.01
BE27	260073.894	4755878.863	211.13	211.13	0.00
BE28	328774.170	4843631.124	183.28	183.32	0.04
BE30	295924.767	4935641.237	272.29	272.28	-0.01
BE31	301169.659	4972178.904	310.61	310.78	0.17
BE32	293866.918	4955303.740	294.44	294.40	-0.04
BE33	311811.257	4914280.644	447.49	447.49	0.00

Number	Easting	Northing	Known Z	Laser Z	Dz
BE34	279833.751	4909844.444	254.76	254.73	-0.03
UA01	335399.899	5016675.403	726.93	726.95	0.02
UA02	302971.364	4974334.813	311.75	311.79	0.04
UA03	300495.653	4985509.207	319.97	319.83	-0.14
UA04	302304.686	4986919.443	330.21	330.25	0.04
UA05	309342.018	4985835.769	510.73	510.67	-0.06
UA06	311747.735	4991491.441	406.05	405.92	-0.13
UA08	300495.669	4985509.205	319.96	319.83	-0.13
UA09	302304.702	4986919.442	330.21	330.25	0.04
UA10	311747.745	4991491.459	406.06	405.91	-0.15
UA100	295734.269	4928974.255	275.71	275.76	0.05
UA101	321597.723	4860785.050	161.53	161.56	0.03
UA102	296190.195	4949600.904	287.31	287.34	0.03
UA103	262653.459	4863526.842	276.94	276.95	0.01
UA104	262653.459	4863526.842	276.94	276.95	0.01
UA11	318334.513	4995040.378	476.25	removed	*
UA12	292165.325	4958429.704	295.07	295.15	0.08
UA13	304269.644	4944588.868	285.76	285.70	-0.06
UA14	300681.551	4941121.068	266.27	266.24	-0.03
UA15	289414.719	4913481.005	339.94	339.97	0.03
UA16	277213.596	4910224.439	244.57	244.61	0.04
UA17	306957.164	4917576.845	415.12	415.1	-0.02
UA18	303673.450	4916467.292	335.94	335.92	-0.02
UA19	309871.457	4914920.188	477.54	477.53	-0.01
UA20	297313.802	4905425.457	433.86	433.9	0.04
UA21	303682.662	4904179.211	477.54	477.55	0.01
UA22	259986.540	4909615.385	249.20	249.26	0.06
UA23	258250.294	4885984.480	151.94	151.94	0.00
UA24	265598.214	4898201.782	177.60	177.60	0.00
UA25	323467.577	4826938.543	210.13	210.12	-0.01
UA26	326003.780	4833157.518	188.17	188.15	-0.02
UA27	335413.563	4830969.091	287.03	287.03	0.00
UA28	324981.466	4831668.175	170.74	170.72	-0.02
UA29	303681.576	4853392.864	205.72	205.68	-0.04
UA30	307078.208	4847530.490	188.57	188.68	0.11

Number	Easting	Northing	Known Z	Laser Z	Dz
UA31	297600.631	4835118.343	193.51	193.54	0.03
UA32	298473.189	4837631.339	154.99	154.99	0.00
UA33	284339.953	4903603.880	465.72	465.75	0.03
UA35	285070.582	4897945.398	464.05	464.08	0.03
UA36	277237.964	4899036.865	477.93	477.94	0.01
UA37	267777.494	4887431.041	388.76	388.8	0.04
UA38	262734.492	4878514.639	242.27	242.27	0.00
UA39	287173.254	4832571.587	166.00	166.07	0.07
UA40	273901.499	4841661.392	189.36	189.38	0.02
UA41	278693.939	4830188.264	140.45	140.49	0.04
UA42	290230.935	4833211.033	177.49	177.5	0.01
UA43	286427.875	4835974.049	156.27	156.22	-0.05
UA44	236419.666	4845889.949	160.60	160.58	-0.02
UA45	246459.573	4863349.348	133.29	133.37	0.08
UA46	234672.309	4821051.657	258.19	258.21	0.02
UA47	229612.339	4809775.647	194.99	194.99	0.00
UA48	222074.308	4793949.343	118.73	118.78	0.05
UA49	235569.705	4798440.043	445.56	445.58	0.02
UA50	267746.046	4812676.027	199.91	199.92	0.01
UA51	256926.967	4837036.323	288.23	288.29	0.06
UA52	290534.454	4813133.170	138.43	138.48	0.05
UA53	246868.720	4821187.317	313.09	313.09	0.00
UA54	293977.280	4815899.163	161.42	161.44	0.02
UA55	317356.086	4808995.769	266.71	266.71	0.00
UA56	320320.351	4813876.695	171.74	171.79	0.05
UA57	302535.783	4821500.460	229.99	230	0.01
UA58	293656.119	4823788.386	263.32	263.34	0.02
UA59	303967.853	4826658.910	162.93	162.96	0.03
UA60	332590.142	4815959.534	233.40	233.37	-0.03
UA61	339171.908	4810927.529	128.89	128.9	0.01
UA62	264976.413	4777967.136	171.40	171.44	0.04
UA63	249453.422	4769678.764	392.04	392.05	0.01
UA64	332035.720	4798949.754	206.53	206.53	0.00
UA65	327078.458	4786381.667	154.30	154.26	-0.04
UA66	281167.298	4784092.750	146.76	146.78	0.02

Number	Easting	Northing	Known Z	Laser Z	Dz
UA67	231538.276	4757540.811	143.24	143.26	0.02
UA68	219853.097	4767045.177	125.35	125.35	0.00
UA69	233048.737	4787263.158	254.37	254.38	0.01
UA70	217903.429	4736405.229	90.10	90.07	-0.03
UA71	232248.053	4738761.293	323.83	323.84	0.01
UA72	243094.207	4741343.588	348.64	348.64	0.00
UA73	257675.001	4735374.956	366.23	366.29	0.06
UA74	307271.920	4856911.692	210.30	210.32	0.02
UA75	234697.981	4771327.525	268.52	268.49	-0.03
UA76	247152.163	4759422.280	408.49	408.49	0.00
UA77	243586.458	4747975.899	376.33	376.38	0.05
UA78	334626.894	4851157.999	126.88	126.89	0.02
UA79	340339.881	4834022.646	182.30	182.31	0.01
UA80	260141.004	4755181.942	231.04	231.06	0.02
UA81	250015.550	4782804.482	446.86	446.92	0.06
UA82	244056.689	4796450.970	310.30	310.26	-0.04
UA83	283966.144	4850349.291	171.72	171.71	-0.01
UA84	288987.095	4794406.171	102.57	102.6	0.03
UA85	289047.175	4795231.483	102.24	102.31	0.07
UA86	286997.202	4841883.633	160.74	160.73	-0.01
UA87	273968.258	4794768.344	131.82	131.81	-0.01
UA88	270927.387	4797275.279	181.20	181.18	-0.02
UA89	317067.583	4970579.814	570.33	570.29	-0.04
UA90	299320.069	4970933.092	321.95	321.97	0.02
UA91	298954.213	4924280.287	317.72	317.76	0.04
UA92	322005.778	4931185.277	378.13	378.2	0.07
UA93	274315.697	4852803.807	158.28	158.21	-0.07
UA94	274315.697	4852803.807	158.28	158.21	-0.07
UA95	267780.387	4867558.750	232.79	232.84	0.05
UA96	244365.129	4807387.027	258.93	258.94	0.01
UA97	258370.578	4811123.215	394.14	394.12	-0.02
UA98	217514.480	4755550.642	231.41	231.41	0.00
UA99	260085.191	4794923.201	208.63	208.62	0.00

Number	Easting	Northing	Known Z	Laser Z	Dz
	Average Dz	0.00 m			
	Minimum Dz	-0.151 m			
	Maximum Dz	0.169 m			
	Root Mean Square	0.047 m			
	95th Percentile	0.093 m			

*Points BE16 and UA 11 were removed as they were located outside of the project AOI.

Figure 24. NVA Points

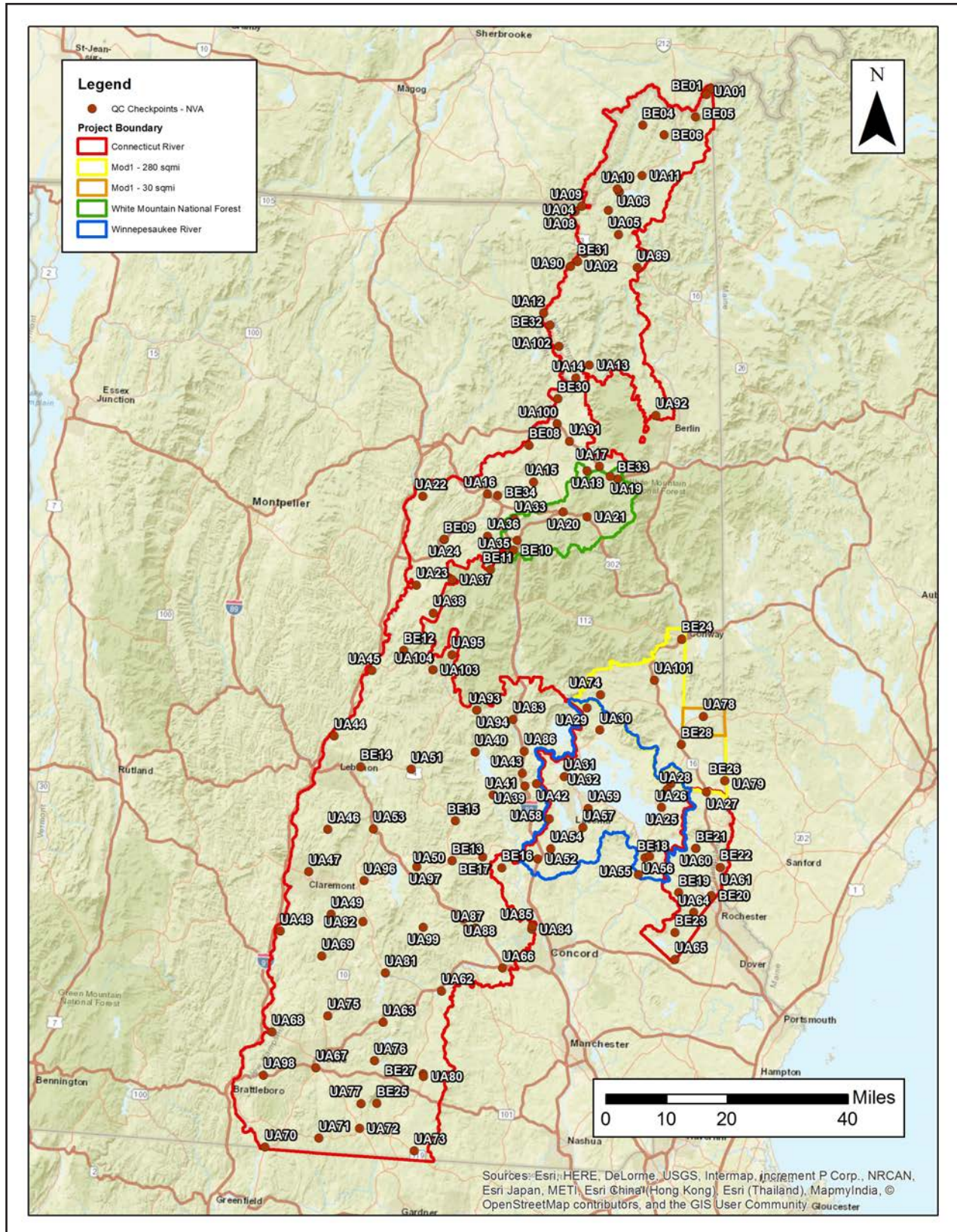


Table 7. NVA Point Report

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
BE01	336505.758	5018136.639	707.21	707.07	-0.14
BE02	312269.109	4990729.708	405.97	405.88	-0.08
BE03	312269.118	4990729.725	405.98	405.88	-0.10
BE04	318518.102	5008532.211	536.88	536.73	-0.15
BE05	332538.721	5010671.255	842.29	842.25	-0.04
BE06	324193.475	5005919.543	775.44	775.37	-0.07
BE07	312026.826	4979383.922	513.85	513.86	0.01
BE08	288242.122	4923229.060	260.38	260.39	0.01
BE09	265605.514	4898152.491	182.41	182.36	-0.05
BE10	284060.329	4895334.122	611.82	611.85	0.03
BE11	277959.761	4890102.081	452.20	452.28	0.08
BE12	254903.055	4868735.517	340.89	340.87	-0.02
BE13	267754.905	4812688.359	199.06	199.06	0.00
BE14	243399.285	4837714.101	231.12	231.11	-0.01
BE15	268607.584	4823282.338	249.24	249.26	0.01
BE16	280958.512	4810827.099	216.70	outside	*
BE17	275915.481	4813686.898	195.54	195.56	0.01
BE18	319079.772	4813434.574	200.09	200.02	-0.07
BE19	328082.085	4804163.634	206.65	206.60	-0.05
BE20	336709.194	4803372.598	89.59	89.55	-0.04
BE21	332611.465	4815942.124	233.09	233.01	-0.08
BE22	339170.016	4810924.561	128.73	128.74	0.01
BE23	327060.438	4793569.951	180.00	179.99	-0.01
BE24	328911.705	4871669.517	143.83	143.82	-0.01
BE25	247705.130	4748018.485	418.16	418.19	0.03
BE26	340330.228	4834000.184	181.71	181.69	-0.01
BE27	260073.894	4755878.863	211.13	211.14	0.01
BE28	328774.170	4843631.124	183.28	183.30	0.03
BE30	295924.767	4935641.237	272.29	272.27	-0.02
BE31	301169.659	4972178.904	310.61	310.73	0.12
BE32	293866.918	4955303.740	294.44	294.46	0.02
BE33	311811.257	4914280.644	447.49	447.49	0.00

Number	Easting	Northing	Known Z	Laser Z	Dz
BE34	279833.751	4909844.444	254.76	254.80	0.04
UA01	335399.899	5016675.403	726.93	726.96	0.03
UA02	302971.364	4974334.813	311.75	311.79	0.04
UA03	300495.653	4985509.207	319.97	319.86	-0.11
UA04	302304.686	4986919.443	330.21	330.23	0.02
UA05	309342.018	4985835.769	510.73	510.64	-0.10
UA06	311747.735	4991491.441	406.05	405.93	-0.12
UA08	300495.669	4985509.205	319.96	319.86	-0.10
UA09	302304.702	4986919.442	330.21	330.23	0.02
UA10	311747.745	4991491.459	406.06	405.93	-0.13
UA100	295734.269	4928974.255	275.71	275.77	0.06
UA101	321597.723	4860785.050	161.53	161.56	0.02
UA102	296190.195	4949600.904	287.31	287.34	0.03
UA103	262653.459	4863526.842	276.94	276.93	-0.01
UA104	262653.459	4863526.842	276.94	276.93	-0.01
UA11	318334.513	4995040.378	476.25	476.26	0.02
UA12	292165.325	4958429.704	295.07	295.14	0.07
UA13	304269.644	4944588.868	285.76	285.72	-0.04
UA14	300681.551	4941121.068	266.27	266.24	-0.03
UA15	289414.719	4913481.005	339.94	339.98	0.04
UA16	277213.596	4910224.439	244.57	244.61	0.04
UA17	306957.164	4917576.845	415.12	415.10	-0.02
UA18	303673.450	4916467.292	335.94	335.92	-0.02
UA19	309871.457	4914920.188	477.54	477.53	0.00
UA20	297313.802	4905425.457	433.86	433.88	0.03
UA21	303682.662	4904179.211	477.54	477.56	0.02
UA22	259986.540	4909615.385	249.20	249.25	0.05
UA23	258250.294	4885984.480	151.94	151.96	0.02
UA24	265598.214	4898201.782	177.60	177.60	0.00
UA25	323467.577	4826938.543	210.13	210.12	-0.01
UA26	326003.780	4833157.518	188.17	188.16	-0.02
UA27	335413.563	4830969.091	287.03	287.05	0.02
UA28	324981.466	4831668.175	170.74	170.73	-0.01
UA29	303681.576	4853392.864	205.72	205.68	-0.03
UA30	307078.208	4847530.490	188.57	188.60	0.03

Number	Easting	Northing	Known Z	Laser Z	Dz
UA31	297600.631	4835118.343	193.51	193.54	0.03
UA32	298473.189	4837631.339	154.99	154.99	-0.01
UA33	284339.953	4903603.880	465.72	465.72	0.01
UA35	285070.582	4897945.398	464.05	464.06	0.01
UA36	277237.964	4899036.865	477.93	477.90	-0.03
UA37	267777.494	4887431.041	388.76	388.80	0.04
UA38	262734.492	4878514.639	242.27	242.27	0.00
UA39	287173.254	4832571.587	166.00	166.06	0.06
UA40	273901.499	4841661.392	189.36	189.38	0.02
UA41	278693.939	4830188.264	140.45	140.49	0.05
UA42	290230.935	4833211.033	177.49	177.50	0.01
UA43	286427.875	4835974.049	156.27	156.21	-0.06
UA44	236419.666	4845889.949	160.60	160.58	-0.01
UA45	246459.573	4863349.348	133.29	133.37	0.08
UA46	234672.309	4821051.657	258.19	258.26	0.07
UA47	229612.339	4809775.647	194.99	194.98	0.00
UA48	222074.308	4793949.343	118.73	118.78	0.05
UA49	235569.705	4798440.043	445.56	445.57	0.01
UA50	267746.046	4812676.027	199.91	199.89	-0.02
UA51	256926.967	4837036.323	288.23	288.27	0.04
UA52	290534.454	4813133.170	138.43	138.48	0.04
UA53	246868.720	4821187.317	313.09	313.08	-0.01
UA54	293977.280	4815899.163	161.42	161.44	0.02
UA55	317356.086	4808995.769	266.71	266.70	-0.01
UA56	320320.351	4813876.695	171.74	171.80	0.06
UA57	302535.783	4821500.460	229.99	230.01	0.02
UA58	293656.119	4823788.386	263.32	263.35	0.03
UA59	303967.853	4826658.910	162.93	162.96	0.04
UA60	332590.142	4815959.534	233.40	233.37	-0.02
UA61	339171.908	4810927.529	128.89	128.89	0.00
UA62	264976.413	4777967.136	171.40	171.41	0.02
UA63	249453.422	4769678.764	392.04	392.06	0.02
UA64	332035.720	4798949.754	206.53	206.54	0.01
UA65	327078.458	4786381.667	154.30	154.24	-0.06
UA66	281167.298	4784092.750	146.76	146.78	0.03

Number	Easting	Northing	Known Z	Laser Z	Dz
UA67	231538.276	4757540.811	143.24	143.26	0.02
UA68	219853.097	4767045.177	125.35	125.37	0.02
UA69	233048.737	4787263.158	254.37	254.38	0.01
UA70	217903.429	4736405.229	90.10	90.09	-0.02
UA71	232248.053	4738761.293	323.83	323.84	0.01
UA72	243094.207	4741343.588	348.64	348.64	0.00
UA73	257675.001	4735374.956	366.23	366.29	0.06
UA74	307271.920	4856911.692	210.30	210.32	0.02
UA75	234697.981	4771327.525	268.52	268.48	-0.04
UA76	247152.163	4759422.280	408.49	408.49	0.00
UA77	243586.458	4747975.899	376.33	376.39	0.07
UA78	334626.894	4851157.999	126.88	126.86	-0.02
UA79	340339.881	4834022.646	182.30	182.31	0.01
UA80	260141.004	4755181.942	231.04	231.04	0.00
UA81	250015.550	4782804.482	446.86	446.92	0.07
UA82	244056.689	4796450.970	310.30	310.25	-0.05
UA83	283966.144	4850349.291	171.72	171.68	-0.04
UA84	288987.095	4794406.171	102.57	102.61	0.03
UA85	289047.175	4795231.483	102.24	102.32	0.08
UA86	286997.202	4841883.633	160.74	160.72	-0.02
UA87	273968.258	4794768.344	131.82	131.81	-0.01
UA88	270927.387	4797275.279	181.20	181.17	-0.02
UA89	317067.583	4970579.814	570.33	570.30	-0.03
UA90	299320.069	4970933.092	321.95	321.98	0.04
UA91	298954.213	4924280.287	317.72	317.76	0.04
UA92	322005.778	4931185.277	378.13	378.20	0.07
UA93	274315.697	4852803.807	158.28	158.22	-0.06
UA94	274315.697	4852803.807	158.28	158.22	-0.06
UA95	267780.387	4867558.750	232.79	232.83	0.04
UA96	244365.129	4807387.027	258.93	258.95	0.02
UA97	258370.578	4811123.215	394.14	394.12	-0.02
UA98	217514.480	4755550.642	231.41	231.43	0.02
UA99	260085.191	4794923.201	208.63	208.61	-0.01

Number	Easting	Northing	Known Z	Laser Z	Dz
	Average Dz	0.00 m			
	Minimum Dz	-0.148 m			
	Maximum Dz	0.117 m			
	Root Mean Square	0.047 m			
	95% Confidence Interval	0.092 m			

*Point BE16 was removed as it was located outside of the project AOI.

Figure 25. VVA Points

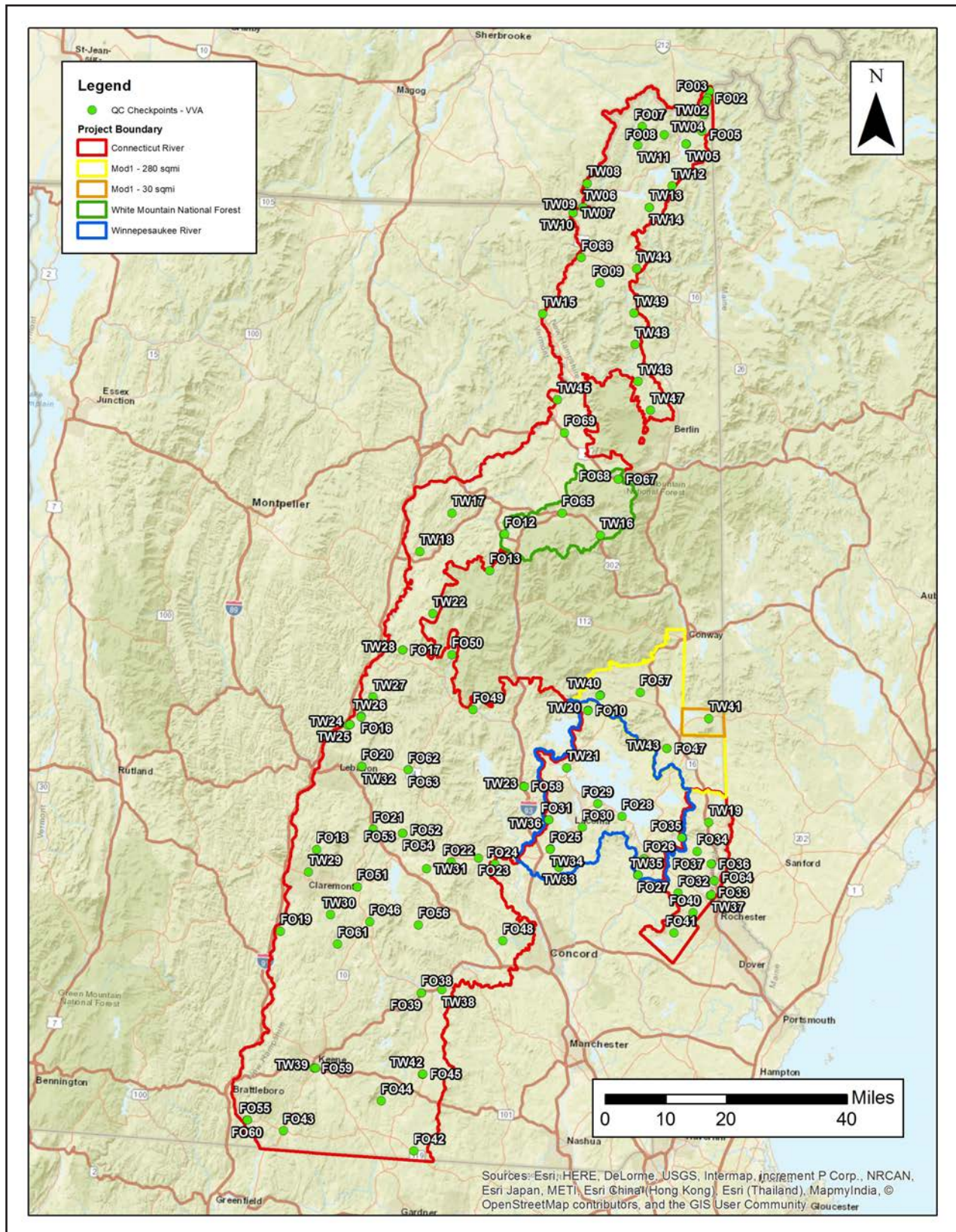


Table 8. VVA Point Report

Units = Meters

Number	Easting	Northing	Known Z	Laser Z	Dz
FO01	336400.707	5018000.046	717.33	717.30	-0.03
FO02	335962.931	5016135.119	651.99	651.92	-0.07
FO03	335962.938	5016135.140	652.00	651.92	-0.08
FO04	335425.722	5014571.053	644.41	644.40	-0.01
FO05	334465.848	5007264.587	650.44	650.51	0.07
FO06	330253.865	5003861.897	590.30	590.33	0.03
FO07	318545.590	5008539.453	537.07	537.13	0.06
FO08	324371.331	5006384.040	782.02	782.30	0.28
FO09	307310.437	4966789.878	452.72	452.84	0.12
FO10	304073.177	4852856.769	185.09	185.23	0.14
FO12	281867.403	4899761.552	301.73	301.77	0.04
FO13	277923.330	4890079.253	450.15	450.27	0.12
FO15	240116.599	4848935.708	137.7579956	137.83	0.08
FO16	243640.019	4851423.963	215.6490021	215.74	0.09
FO17	254698.405	4869048.043	354.9609985	354.75	-0.21
FO18	231793.880	4815781.262	281.78	281.87	0.09
FO19	222098.257	4793986.036	118.77	118.87	0.10
FO20	243813.744	4837912.941	235.00	235.13	0.13
FO21	246874.144	4821199.537	312.90	313.04	0.14
FO22	267596.230	4812438.565	195.73	195.88	0.15
FO23	274908.440	4813465.415	191.00	191.03	0.04
FO24	279264.598	4811849.579	269.05	outside	*
FO25	294020.964	4815922.815	159.74	159.93	0.19
FO26	319056.496	4813420.814	200.43	200.50	0.08
FO27	317364.170	4808977.399	265.95	266.06	0.11
FO28	313132.626	4824609.072	206.78	206.92	0.14
FO29	306642.201	4827988.399	154.77	154.98	0.21
FO30	302588.324	4821705.301	230.70	230.87	0.17
FO31	293636.429	4823734.694	264.34	264.48	0.14
FO32	328107.353	4804174.620	203.07	203.07	0.00
FO33	336687.016	4803468.974	87.02	87.10	0.08
FO34	333191.387	4815300.552	223.34	223.31	-0.03

Number	Easting	Northing	Known Z	Laser Z	Dz
FO35	329066.934	4818922.355	257.09	257.31	0.22
FO36	336940.291	4812005.017	295.66	295.76	0.10
FO37	336931.747	4811999.887	295.20	295.37	0.17
FO38	259652.201	4777546.406	248.24	248.27	0.04
FO39	259652.201	4777546.406	248.24	248.27	0.04
FO40	332051.162	4798955.930	207.76	207.80	0.03
FO41	326937.473	4793565.535	174.80	174.89	0.09
FO42	257642.473	4735384.168	365.99	366.05	0.06
FO43	222903.374	4740774.430	132.71	132.85	0.14
FO43	307318.201	4856983.981	209.03	209.03	0.00
FO44	248974.289	4748715.927	368.85	368.98	0.14
FO45	260006.050	4755867.713	211.18	211.25	0.07
FO46	245904.289	4796545.709	390.59	390.81	0.22
FO47	325125.933	4842756.836	202.81	202.95	0.14
FO48	281388.283	4791441.582	115.33	115.41	0.09
FO49	273381.018	4853092.936	160.37	160.41	0.03
FO50	267835.475	4867744.004	233.63	233.78	0.14
FO51	242595.454	4805825.118	239.00	238.94	-0.07
FO52	254733.744	4820184.549	442.44	442.45	0.02
FO53	254733.744	4820184.549	442.44	442.45	0.02
FO54	254733.744	4820184.549	442.44	442.45	0.02
FO55	213310.045	4743647.455	68.42	68.39	-0.02
FO56	258889.434	4795693.382	224.50	224.57	0.08
FO57	318040.992	4857705.348	145.37	145.41	0.03
FO58	286972.805	4832643.834	178.00	178.05	0.05
FO59	231073.603	4757549.576	142.58	142.65	0.07
FO60	213322.285	4743628.530	68.31	68.36	0.05
FO61	237354.419	4790538.570	335.96	336.35	0.38
FO62	256197.241	4837063.437	303.06	303.04	-0.03
FO63	256197.241	4837063.437	303.06	303.04	-0.03
FO64	337687.373	4807457.846	125.11	125.20	0.08
FO65	297252.680	4905399.000	430.09	430.23	0.14
FO66	302262.909	4973557.623	309.42	309.57	0.16
FO67	312113.448	4914422.039	466.11	466.20	0.09
FO68	312113.448	4914422.039	466.11	466.20	0.09

Number	Easting	Northing	Known Z	Laser Z	Dz
FO69	297770.732	4926815.404	323.20	323.39	0.19
TW01	336459.613	5018033.057	707.25	707.38	0.13
TW02	335901.593	5016068.511	652.34	652.36	0.02
TW03	335620.190	5015346.893	642.37	642.55	0.18
TW04	334986.343	5011710.175	728.18	728.35	0.17
TW05	330191.844	5003847.380	588.10	588.31	0.21
TW06	302776.216	4986956.596	327.41	327.59	0.17
TW07	300120.530	4985548.491	312.66	312.74	0.09
TW08	303891.192	4993330.156	338.77	339.27	0.50
TW09	302776.232	4986956.595	327.40	327.59	0.18
TW10	300120.546	4985548.490	312.65	312.74	0.09
TW11	317326.977	5003570.987	558.83	559.11	0.28
TW12	326505.431	4992703.051	666.73	666.98	0.24
TW13	320424.199	4986962.465	537.21	537.22	0.01
TW14	320411.477	4986940.030	536.98	537.04	0.06
TW15	292076.419	4958502.395	290.33	290.49	0.15
TW16	307364.466	4899512.546	574.71	574.82	0.12
TW17	267875.828	4905411.103	202.83	203.13	0.30
TW18	259255.436	4895158.137	194.07	194.28	0.22
TW19	336203.539	4822997.866	166.97	167.04	0.07
TW20	304078.058	4852804.018	184.06	184.40	0.33
TW21	298439.552	4837593.483	154.41	154.58	0.16
TW22	262741.226	4878549.423	239.93	240.19	0.26
TW23	287143.058	4832556.871	166.04	166.14	0.09
TW24	240647.361	4849085.184	174.07	174.34	0.27
TW25	240647.361	4849085.184	174.07	174.34	0.27
TW26	243626.153	4851131.386	211.24	211.40	0.16
TW27	246790.587	4856496.527	164.46	164.64	0.18
TW28	254689.141	4869026.764	350.94	350.83	-0.11
TW29	229627.802	4809779.473	197.08	197.25	0.17
TW30	235472.619	4798425.970	441.49	441.57	0.09
TW31	261060.512	4810679.408	296.43	296.72	0.28
TW32	243821.572	4837917.296	235.53	235.64	0.11
TW33	296328.449	4811083.427	223.83	224.01	0.18
TW34	294002.486	4815885.173	162.09	162.24	0.15

Number	Easting	Northing	Known Z	Laser Z	Dz
TW35	317383.686	4808962.619	264.84	264.99	0.15
TW36	293670.204	4823738.338	264.88	265.17	0.28
TW37	336926.263	4803734.272	98.82	99.03	0.20
TW38	265164.038	4778393.107	172.64	172.83	0.19
TW39	231508.408	4757531.879	142.65	142.77	0.12
TW40	307247.859	4856916.168	210.89	211.05	0.17
TW41	336280.000	4850742.752	121.16	121.25	0.09
TW42	260089.460	4755894.343	210.91	211.00	0.09
TW43	325132.327	4842737.075	204.82	204.98	0.16
TW44	317042.277	4970571.097	567.24	567.31	0.07
TW45	295920.370	4935628.578	271.80	271.90	0.09
TW46	317392.303	4940521.286	298.82	299.40	0.58
TW47	320712.185	4932816.085	370.47	370.69	0.22
TW48	316660.872	4950339.002	440.17	440.46	0.29
TW49	316365.554	4958719.155	600.56	600.76	0.20
Average Dz		0.12 m			
Minimum Dz		-0.209 m			
Maximum Dz		0.581 m			
Root Mean Square		0.165 m			
95% Confidence Interval		0.284 m			

***Point FO24 was removed as it was located outside of the project AOI.**