



LIDAR PROJECT REPORT

FEBRUARY 2022

CLIENT: Mid-Region Council of Governments (MRCOG) – New Mexico

ATLANTIC PROJECT NUMBER: 18001

TABLE OF CONTENTS

SECTION 1: PROJECT OVERVIEW AND PURPOSE	3
1.1 Aerial LiDAR Project.....	3
1.1.1 Project Overview	3
1.1.2 Project Purpose	4
1.1.3 Client Contact Information.....	5
1.1.4 Contract Deliverables.....	5
SECTION 2: FIELD OPERATIONS.....	7
2.1 Aerial LiDAR Project – Aerial Acquisition	7
2.1.1 Aircraft and Sensor Information	7
2.1.2 Sensor Acquisition Information.....	8
2.1.3 Flight Plan Execution.....	9
2.1.4 GNSS Reference Stations.....	9
2.2 Aerial LiDAR Project – Ground Acquisition	10
2.2.1 Ground Control Survey.....	10
SECTION 3: DATA PRODUCTION.....	17
3.1 Aerial LiDAR Project – Calibration/Classification	17
3.1.1 LiDAR Point Cloud Generation	17
3.1.2 Coordinate Reference System	17
3.1.3 LiDAR Point Cloud Statistics	17
3.1.4 Smooth Surface Repeatability (Interswath).....	17
3.1.5 LiDAR Calibration	17
3.1.6 LiDAR Classification.....	18
3.1.7 LiDAR Intensity Imagery.....	18
3.1.8 Hydro-line Collection/Conflation.....	18
3.1.9 Bare-Earth Surface – Digital Elevation Model (DEM)	18
SECTION 4: ACCURACY ASSESSMENT	19
4.1 Aerial LiDAR Project – Vertical Accuracy Assessment	19
4.1.1 Requirements	19
4.1.2 Results.....	19
SECTION 5: CERTIFICATION STATEMENTS.....	20
5.1 Aerial LiDAR Project.....	20
SECTION 6: CONTROL POINT ASSESSMENTS	21
6.1 Aerial LiDAR Project.....	21
6.1.1 Point Cloud Check Point Assessment	21
6.1.2 Digital Elevation Model (DEM) Check Point Assessment.....	25



SECTION 1: PROJECT OVERVIEW AND PURPOSE

1.1 Aerial LiDAR Project

1.1.1 Project Overview

Atlantic was contracted by MRCOG in 2018 to perform a multi-agency ortho and LiDAR project to include several derivatives from each product. The digital orthophotography and planimetric deliverables have been accepted. For the purpose of this report, Atlantic is strictly providing information as it relates to the LiDAR portion of the MRCOG program.

Project Area: covers the metropolitan area of Albuquerque to include urban, suburban, and rural landscapes in Bernalillo, Sandoval, Torrance, and Valencia Counties. Terrain varies across the area, with river valleys, sloping mesas, rugged foothills, and mountainous areas reaching over 10,000 feet in elevation. Per request of the client, a 100-meter buffered boundary was added to the contractual Area of Interest (AOI).

Project Areas	Approx. Sq. Miles	Deliverables
#1: Main Project Area	2,348.64	Main Deliverables
#2: Additional Classification	1,522.47	Additional Classification: Low, Medium, High Veg & Buildings
#3: Add Elevations to New Atlantic Building Footprints	521.85	Add elevations to new building footprints collected by Atlantic
#4: Add Elevations to 2014 Building Footprints	368.35	Add elevations to existing 2014 building footprints collected by another contractor

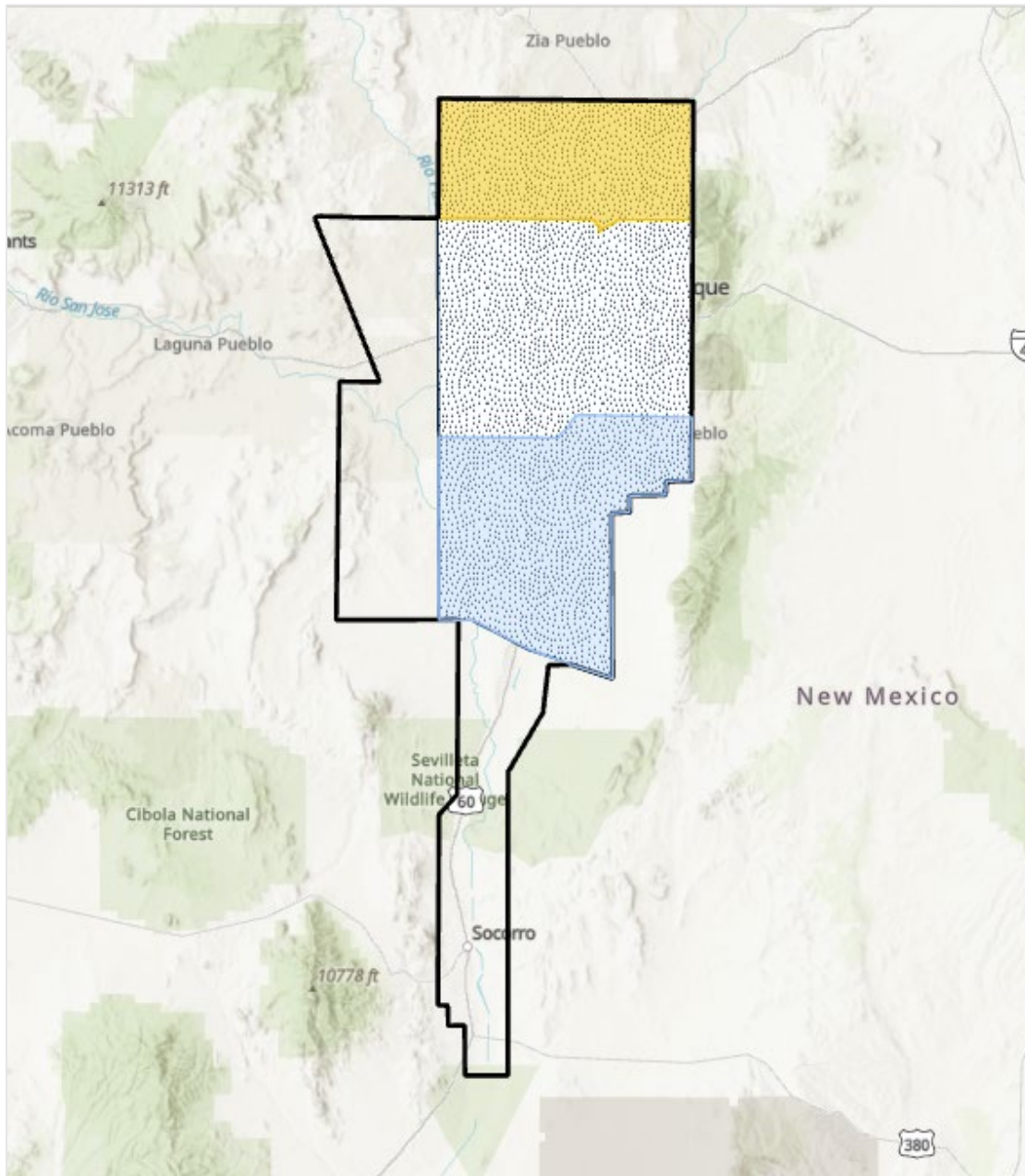


Figure 1: Aerial LiDAR Project Overview – Defined Project Area (DPA) and Associated Areas of Interest (AOIs)

1.1.2 Project Purpose

MRCOG coordinated a project with public and private entities to acquire QL2 or better LiDAR data in spring of 2018. The metropolitan area includes urban, suburban, and rural landscapes in Bernalillo, Sandoval, Torrance, and Valencia Counties. Terrain varies across the area, with river valleys, sloping mesas, rugged foothills, and mountainous areas reaching over 10,000 feet in elevation.

1.1.3 Client Contact Information

Client Contact Information	
Name of Contact	Forest B. Replogle
Telephone	(505) 843-1711
E-Mail Address	FReplogle@mrcog-nm.gov
Mailing Address	809 Copper Ave NW
City	Albuquerque
State or Province	New Mexico
Postal Code	87102

Table 1: Aerial LiDAR Client Contact Information

1.1.4 Contract Deliverables

- One (1) set of any new, tiled, DEM areas produced for this project:
 - ArcGIS ASCII grid format
 - ArcGIS shapefile format for point and line files.
 - ASCII/CAD In-.txt and pt-.txt format for points and lines
 - Complete FGDC compliant metadata

- LiDAR deliverables shall use the same tiling system and be according to USGS QL2 LBS v. 1.2 to include:
 - Swath LAS Files
 - Tiled LAS Files (classified) v. 1.4
 - Entire project area: in compliance with standard scheme; and
 - Building and high, medium, and low vegetation classes to the LAS files for 1,522.47 mi² (Veg_Building_Class_Area_102417_reprojected.shp)
 - Bare Earth DEM Files
 - Hydro Breakline Shapefiles/GDB
 - (water bodies > 2acres, stream & rivers >100ft nominal width)
 - Dz Orthos
 - Intensities
 - Control point shapefile
 - Check point shapefile
 - Project Reporting and Metadata in new USGS format

Note: MRCOG originally requested Federal Geographic Data Committee (FGDC) compliant (reference FGDCSTD-001-1998) metadata shall be provided for *each* component of the project

- **Update Elevations for Building Footprints:** original delivery date of ‘Final Data’ – 02/05/19
 - Buildings were delivered in shapefile along with building elevations for 2 separate areas within the full BPA. The areas are shown in Figure 1.
 - Orthometric height of the ground and the actual building height above ground.
 - Provide building footprints using the lidar data, Ortho data, or combination of both for 521.85 mi² (NEW_Building_Ftprints_&_Elevations.shp). Elevations were derived from the Lidar and added to footprints shapefile as an attribute.

- Provide elevations for existing 2014 building footprints using the newly acquired lidar data for 368.35 mi² (Add_Elevations_to_Existing_Buildings.shp).

Note: these were originally sent via email on 02/05/2019.

- **Pro-Bono Lidar Addons** (not included in original contract): additional pro bono products after the data is accepted/approved by the USGS.
 - ESRI Terrain Dataset of all Class 2 - (ground) points and
 - RGB Lidar Fusion Dataset (RGB values applied to the LAS point cloud, essentially a 3D ortho)

Item	Specification/Format
LAS Swaths	.las
LAS Tiles	.las
DEMs	.tif
HydroLines	.gdb
Control Point Shapefile	.shp
Check Point Shapefile	.shp
Survey Report	.pdf
LiDAR Report	.pdf
FGDC Metadata	.xml
Dz Orthos	.tif
Intensities	.tif

Table 2: Aerial LiDAR Contract Deliverables

SECTION 2: FIELD OPERATIONS

2.1 Aerial LiDAR Project – Aerial Acquisition

2.1.1 Aircraft and Sensor Information

Atlantic operated a Cessna (N732JE) outfitted with a Leica ALS70-HP LiDAR system during the collection of the project area. The specifications of this system are presented in the following table:

Parameter	Specification
Model	ALS70-HP
Manufacturer	Leica
Platform	Fixed-Wing
Scan Pattern	Sine, Triangle, Raster
Maximum Scan Rate (Hz)	Sine: 200 Triangle: 158 Raster: 120
Field of View (°)	0 – 75 (Full Angle, User Adjustable)
Maximum Pulse Rate (kHz)	500
Maximum Flying Height (m AGL)	3500
Number of Returns	Unlimited
Number of Intensity Measurements	3 (First, Second, Third)
Roll Stabilization (Automatic Adaptive, °)	75 - Active FOV
Storage Media	Removable 500 GB SSD
Storage Capacity (Hours @ Max Pulse Rate)	6
Size (cm)	Scanner: 37 W x 68 L x 26 H Control Electronics: 45 W x 47 D x 36 H
Weight (kg)	Scanner: 43 Control Electronics: 45
Operation Temperature (°C)	0 – 40
Flight Management	FCMS
Power Consumption	927 @ 22.0 – 30.3 VDC

Table 3: System Specifications – ALS70-HP

2.1.2 Sensor Acquisition Information

The following table illustrates project specific system parameters for LiDAR acquisition on this project:

Parameter	Specification
System	Leica ALS70-HP
Nominal Pulse Spacing (m)	0.66
Nominal Pulse Density (pls/m²)	2.2
Nominal Flight Height (AGL meters)	2255
Nominal Flight Speed (kts)	130
Pass Heading (°)	Varies
Sensor Scan Angle (°)	40-30
Scan Frequency (Hz)	34.7
Pulse Rate of Scanner (kHz)	249.2
Line Spacing (m)	1185
Pulse Duration of Scanner (ns)	4
Pulse Width of Scanner (m)	0.48
Central Wavelength of Sensor Laser (nm)	1064
Sensor Operated with Multiple Pulses	Yes
Beam Divergence (mrad)	0.22
Nominal Swath Width (m)	1061
Nominal Swath Overlap (%)	20
Scan Pattern	Triangle

Table 4: Aerial LiDAR Sensor Acquisition Parameters

2.1.3 Flight Plan Execution

Atlantic acquired 131 passes of the AOI as a series of perpendicular and/or adjacent flight-lines executed in 17 flight missions conducted between March 18, 2018 and April 7, 2018. Onboard differential Global Navigation Satellite System (GNSS) unit(s) recorded sample aircraft positions at 2 hertz (Hz) or more frequency. LiDAR data was only acquired when a minimum of six (6) satellites were in view.

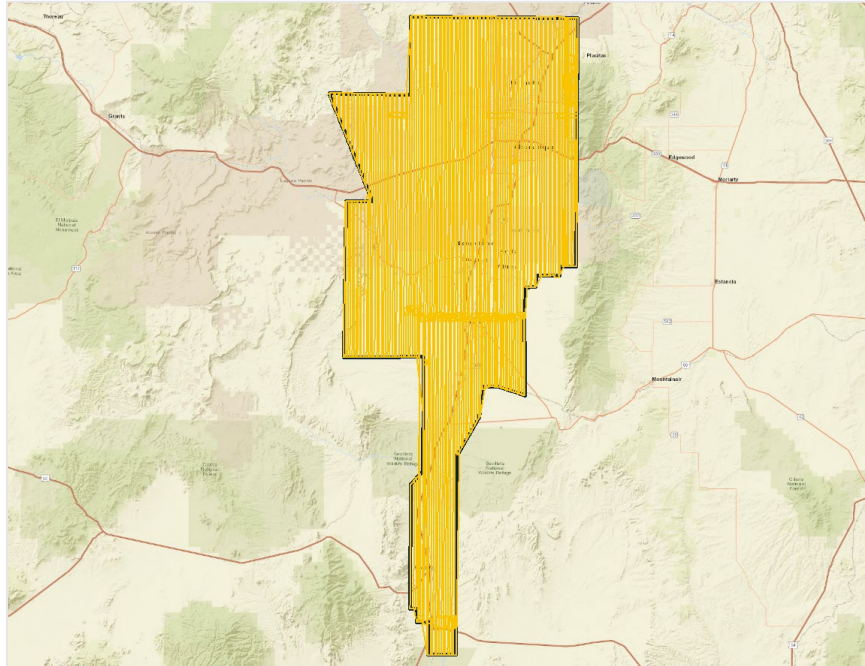


Figure 2: Orientation of Executed Flight-lines and LiDAR DPA

2.1.4 GNSS Reference Stations

Four Continuously Operating Reference Stations (CORS) were used to control the LiDAR acquisition for the defined project area. The coordinates provided in below are in NAD83 (2011), Geographic Coordinate System, Ellipsoid, Meters.

Designation	Type	PID	Latitude (N)	Longitude (W)	Elevation
NMSF	CORS	DF4369	35 40 25.62398	105 57 30.93089	2097.239
NMGR	CORS	DIO438	35 12 59.64999	107 55 48.36832	2021.631
ZAB1	CORS	DE6386	35 10 24.85464	106 34 02.41357	1620.623
ZAB2	CORS	DE6388	35 10 24.85235	106 34 02.19263	1620.690

Table 5: GNSS Reference Stations

2.2 Aerial LiDAR Project – Ground Acquisition

2.2.1 Ground Control Survey

A total of 177 ground survey points were collected in support of this project, including 37 LiDAR Control Points (LCP), 79 Non-vegetated Vertical Accuracy (NVA) and 61 Vegetated Vertical Accuracy (VVA).

Point cloud data accuracy was tested against a Triangulated Irregular Network (TIN) constructed from LiDAR points in clear and open areas. A clear and open area can be characterized with respect to topographic and ground cover variation such that a minimum of five (5) times the Nominal Pulse Spacing (NPS) exists with less than 1/3 of the RMSEZ deviation from a low-slope plane. Slopes that exceed ten (10) percent were avoided.

Each land cover type representing ten (10) percent or more of the total project area were tested and reported with a VVA. In land cover categories other than dense urban areas, the tested points did not have obstructions forty-five (45) degrees above the horizon to ensure a satisfactory TIN surface. The VVA value is provided as a target. It is understood that in areas of dense vegetation, swamps, or extremely difficult terrain, this value may be exceeded.

The NVA value is a requirement that must be met, regardless of any allowed “busts” in the VVA(s) for individual land cover types within the project. Checkpoints for each assessment (NVA and VVA) are required to be well-distributed throughout the land cover type, for the entire project area.

The following tables and figures outline the coordinate values and distribution of LCP, NVA and VVA points collected in support of this project:

Point ID	Easting [X]	Northing [Y]	Elevation [Z]	Point Type
BE01	1445209.433	1323615.082	4902.931	NVA
BE02	1386463.962	1468723.859	5635.641	NVA
BE03	1405259.322	1513606.978	5768.032	NVA
BE04	1458674.842	1543786.971	6142.186	NVA
BE05	1477851.076	1554935.523	5978.769	NVA
BE06	1529769.723	1556509.551	5169.921	NVA
BE07	1536819.012	1512018.88	5128.285	NVA
BE10	1519700.296	1381899.123	5041.944	NVA
BE11	1501243.128	1352010.695	4834.994	NVA
BE12	1490941.386	1294263.781	4867.786	NVA
BE13	1460420.682	1216369.06	4726.052	NVA
BE14	1446599.825	1163380.872	4659.144	NVA
BE15	1457588.312	1097563.888	4636.014	NVA
BE16	1468508.633	1253579.764	4737.779	NVA
BE17	1457165.23	1053473.005	4539.378	NVA
BE18	1445198.171	1128701.435	4626.072	NVA
BE19	1432127.594	1375709.326	5142.181	NVA
BE20	1439024.611	1416765.196	5622.291	NVA
BE21	1476507.244	1487504.651	5766.823	NVA

BE22	1482129.225	1416394.566	5087.511	NVA
BE23	1509795.446	1308629.499	4979.627	NVA
BE24	1456956.975	1338252.192	5198.326	NVA
BE25	1520909.668	1323649.182	5041.988	NVA
BE26	1427107.605	1375848.852	5121.957	NVA
BE27	1517690.202	1443159.16	4980.675	NVA
BE28	1510245.235	1342497.024	4998.98	NVA
BR01	1445112.287	1323625.934	4902.375	VVA
BR02	1406170.441	1387292.583	5108.255	VVA
BR03	1502066.751	1374316.583	4841.343	VVA
BR04	1537609.602	1426253.007	5234.245	VVA
BR05	1495780.2	1420554.219	5022.986	VVA
BR06	1466902.426	1568948.693	6179.257	VVA
BR07	1528635.231	1386755.587	5127.32	VVA
BR08	1388182.576	1487008.847	5590.751	VVA
BR09	1458478.431	1532655.058	6126.222	VVA
BR10	1546242.48	1556423.186	5034.815	VVA
BR11	1553010.656	1506309.965	5498.097	VVA
BR12	1525206.323	1460667.437	5194.093	VVA
BR13	1463481.504	1319751.492	5188.035	VVA
BR14	1449313.204	1386129.092	5353.15	VVA
BR15	1460948.776	1211476.666	4717.781	VVA
BR16	1451178.226	1044657.521	4532.85	VVA
BR17	1455646.639	1106878.754	4627.486	VVA
BR18	1471438.035	1263256.197	4763.901	VVA
BR19	1496555.89	1482641.544	5125.675	VVA
BR20	1546011.696	1577324.741	5157.69	VVA
HG01	1376858.933	1431335.424	5445.181	VVA
HG02	1403628.348	1458532.251	5491.615	VVA
HG03	1438060.488	1487917.067	5358.768	VVA
HG04	1442746.742	1140967.151	4667.607	VVA
HG05	1442871.222	1189845.702	4680.075	VVA
HG06	1473276.74	1274051.814	4757.063	VVA
HG07	1464162.031	1417065.878	5443.682	VVA
HG08	1386340.687	1517249.069	5775.518	VVA
HG10	1555327.132	1380216.172	5515.021	VVA
HG11	1514210.707	1416945.462	4883.956	VVA
HG12	1517480.859	1518682.714	4986.335	VVA
HG13	1488146.351	1585458.329	5980.66	VVA

HG14	1463614.144	1552132.169	6116.91	VVA
HG15	1506354.995	1542562.748	5390.882	VVA
HG16	1431729.244	1466043.55	5275.823	VVA
HG17	1399255.692	1399571.64	5231.761	VVA
HG18	1515441.581	1369451.862	5016.724	VVA
HG19	1555734.56	1528854.207	5643.769	VVA
HG20	1478665.136	1501263.049	5799.698	VVA
HG21	1454480.934	1366299	5299.598	VVA
HG22	1460005.838	1558854.341	6251.003	VVA
HG23	1431980.046	1420584.512	5632.975	VVA
HG24	1457632.815	1097535.19	4636.343	VVA
LCP03	1386565.297	1471426.399	5617.09	Control
LCP06	1526469.203	1472110.519	5155.712	Control
LCP07	1458405.512	1475104.295	5864.843	Control
LCP08	1409579.542	1479091.391	5622.887	Control
LCP10	1506704.296	1408699.592	4876.267	Control
LCP15	1415573.851	1381099.273	5052.046	Control
LCP16	1464709.146	1301941.646	5176.017	Control
LCP17	1486132.788	1285005.823	4790.122	Control
LCP18	1473998.159	1243730.231	4737.174	Control
LCP21	1452525.477	1060308.546	4557.679	Control
LCP22	1422451.03	1465353.356	5513.226	Control
LCP23	1509972.157	1460953.313	4926.714	Control
LCP24	1406472.161	1506265.361	5638.418	Control
LCP25	1450298.553	1061703.801	4621.874	Control
LCP26	1441038.128	1108441.63	4764.129	Control
LCP27	1441048.546	1108426.742	4764.727	Control
LCP28	1472959.511	1544017.483	5995.753	Control
LCP29	1427185.9	1375610.589	5114.856	Control
LCP30	1427192.656	1375645.882	5115.961	Control
LCP31	1416310.248	1490339.492	5464.576	Control
LCP32	1471613.946	1476783.635	5765.587	Control
OT01	1376918.037	1431325.346	5446.475	NVA
OT02	1395287.43	1414816.319	5301.526	NVA
OT03	1386469.866	1468752.882	5635.619	NVA
OT04	1438002.384	1487945.955	5358.011	NVA
OT05	1443491.325	1153849.23	4629.54	NVA
OT06	1462686.952	1286959.042	5092.354	NVA
OT07	1465497.05	1389045.978	5329.046	NVA

OT08	1416286.237	1490374.684	5465.932	NVA
OT09	1401180.409	1394627.647	5134.026	NVA
OT10	1458427.278	1442428.551	5594.245	NVA
OT11	1518664.997	1545231.547	5317.038	NVA
OT12	1491183.857	1524260.896	5545.916	NVA
OT13	1469197.45	1508556.969	5864.396	NVA
OT14	1479572.672	1581587.507	6066.825	NVA
OT15	1536482.687	1532554.168	5009.103	NVA
OT16	1501208.652	1459851.793	4926.413	NVA
OT17	1460085.867	1422140.413	5471.382	NVA
OT18	1507224.767	1573576.217	5681.784	NVA
OT19	1494054.226	1319034.584	4844.224	NVA
OT20	1476523.031	1316643.847	4896.761	NVA
OT21	1442338.522	1184523.321	4662.949	NVA
OT22	1447201.698	1085679.332	4594.936	NVA
OT23	1447136.478	1202135.905	4812.139	NVA
OT24	1481807.41	1344741.015	4816.471	NVA
OT25	1468643.68	1457369.861	5650.01	NVA
OT26	1512269.433	1485968.865	4952.283	NVA
OT27	1484597.271	1363829.1	4829.23	NVA
PID01	1427149.101	1375951.089	5120.607	NVA
PID02	1386598.4	1471439.132	5616.209	NVA
PID03	1452107.276	1051444.583	4535.32	NVA
PID04	1442601.594	1114297.873	4622.211	Control
PID05	1461186.07	1217135.876	4733.341	NVA
PID08	1486693.045	1392689.35	4976.06	Control
PID11	1531246.804	1495873.989	5088.053	Control
PID12	1531246.77	1495873.958	5088.039	Control
PID13	1531246.769	1495873.975	5088.045	Control
PID17	1459130.393	1459659.726	5765.648	Control
PID18	1497658.377	1532751.95	5414.225	Control
PID20	1548855.299	1522446.337	5429.781	Control
PID21	1548842.123	1522440.703	5429.418	Control
PID25	1480008.696	1319829.644	4814.909	Control
PID28	1549953.542	1384231.336	5402.478	Control
PID31	1502092.326	1574100.692	5718.552	Control
PID32	1518094.955	1298295	5075.129	Control
PID33	1416618.246	1382042.535	5058.016	Control
PID34	1402715.524	1391999.68	5134.595	Control

PID35	1402723.126	1391985.545	5134.627	Control
TR01	1406097.043	1387356.774	5105.213	VVA
TR02	1403620.815	1458489.509	5491.523	VVA
TR03	1450556.64	1135727.979	4613.995	VVA
TR04	1456529.349	1077022.831	4558.186	VVA
TR05	1458512.176	1241130.902	4741.154	VVA
TR06	1478985.951	1302033.16	4795.599	VVA
TR07	1486550.38	1388656.37	4963.761	VVA
TR08	1403267.766	1391064.521	5130.762	VVA
TR10	1433912.246	1412951.441	5582.384	VVA
TR11	1459090.292	1466566.127	5787.677	VVA
TR12	1491344.961	1572873.267	5856.167	VVA
TR13	1538577.528	1567130.499	5198.56	VVA
TR14	1545882.665	1490057.26	5290.325	VVA
TR15	1519786.318	1502337.386	4971.81	VVA
TR16	1519800.116	1502337.079	4971.803	VVA
TR17	1491553.316	1463644.763	5148.081	VVA
TR18	1496236.546	1396622.029	4863.324	VVA
TR19	1490867.645	1329924.229	4805.968	VVA
UR02	1457355.421	1070039.36	4554.534	NVA
UR03	1441500.189	1110831.82	4705.706	NVA
UR04	1453785.882	1124841.215	4622.291	NVA
UR05	1476184.982	1297282.333	4820.002	NVA
UR06	1520826.887	1424482.24	5246.661	NVA
UR07	1500096.628	1446468.825	4909.069	NVA
UR08	1530988.167	1485263.095	5183.155	NVA
UR09	1371946.366	1518056.607	6394.645	NVA
UR10	1463953.419	1374039.41	5286.817	NVA
UR11	1506981.602	1396465.65	4862.101	NVA
UR12	1550481.76	1565906.562	5050.585	NVA
UR13	1455194.794	1504354.642	6002.252	NVA
UR15	1542148.464	1386666.516	5271.57	NVA
UR16	1498062.949	1509029.375	5323.261	NVA
UR17	1520810.125	1299872.668	5051.902	NVA
UR18	1481840.946	1356916.967	4829.155	NVA
UR19	1461119.581	1236991.327	4735.637	NVA
UR20	1469483.31	1535978.614	5903.875	NVA
UR21	1434107.201	1477511.795	5303.083	NVA
UR22	1388319.839	1421867.527	5345.615	NVA

UR25	1517233.816	1341338.66	5014.38	NVA
UR26	1518060.647	1298290.078	5075.645	NVA

Table 6: LiDAR Control/Check Point Coordinates

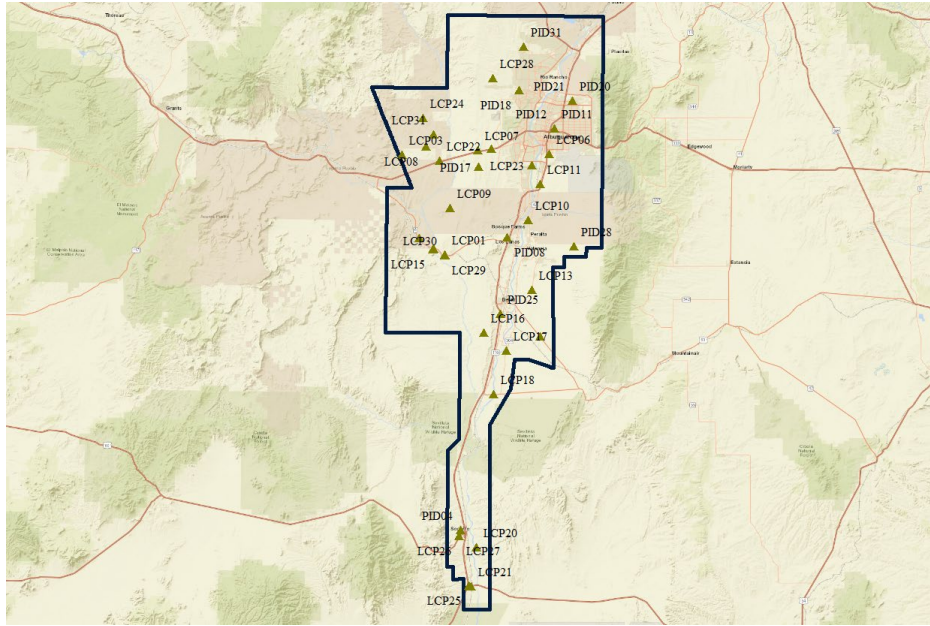


Figure 3: LiDAR Control Point Distribution

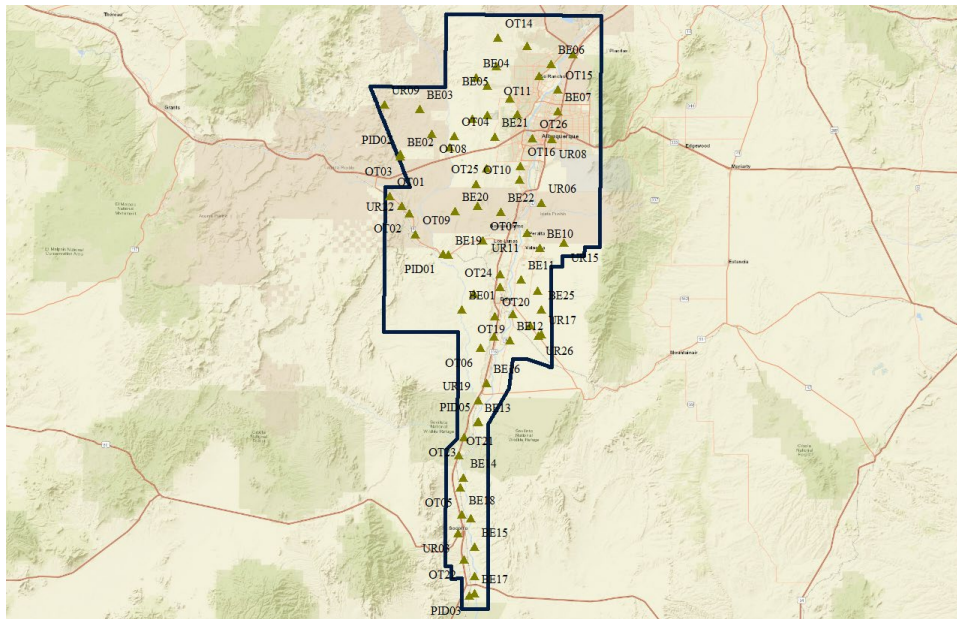


Figure 4: Non-Vegetated Vertical Accuracy (NVA) Point Distribution

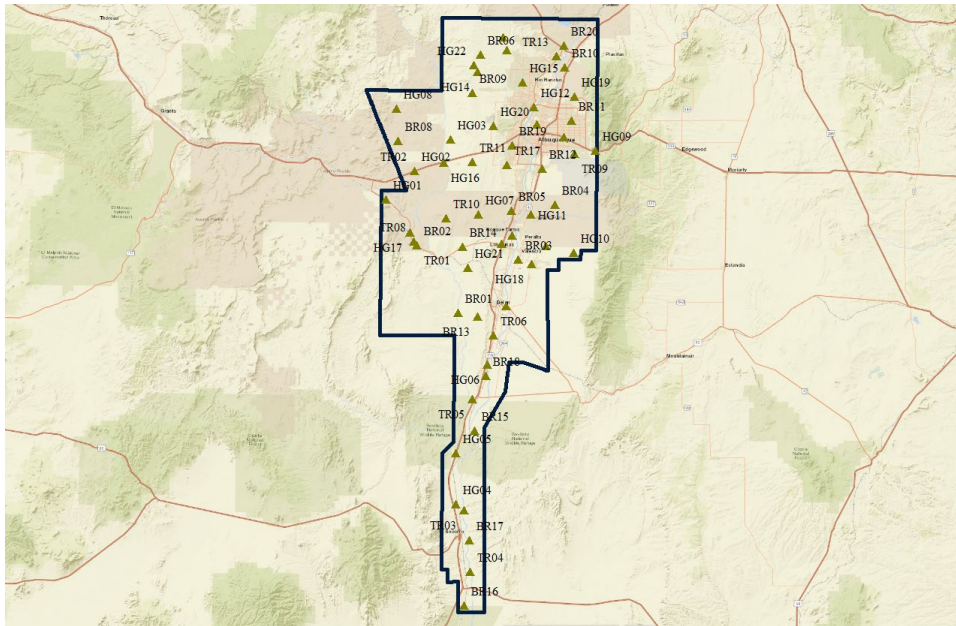


Figure 5: Vegetated Vertical Accuracy (VVA) Point Distribution

SECTION 3: DATA PRODUCTION

3.1 Aerial LiDAR Project – Calibration/Classification

3.1.1 LiDAR Point Cloud Generation

Atlantic used Leica software products to download the IPAS ABGNSS/IMU data and raw laser scan files from the airborne system. Waypoint Inertial Explorer is used to extract the raw IPAS ABGNSS/IMU data, which is further processed in combination with controlled base stations to provide the final Smoothed Best Estimate Trajectory (SBET) for each mission. The SBETs are combined with the raw laser scan files to export the LiDAR ASCII Standard (*.las) formatted swath point clouds.

3.1.2 Coordinate Reference System

Parameter	Specification
Horizontal Datum	NAD 1983 HARN 1992
Coordinate System	State Plane New Mexico Central
Vertical Datum	NAVD 88
Geoid Model	12B
EPSG Code	2903
Units of Reference	US Survey Feet

Table 7: Coordinate Reference System

3.1.3 LiDAR Point Cloud Statistics

Category	Value
Total Points	25,092,268,912
Nominal Pulse Spacing (ft)	1.6162
Nominal Pulse Density (pls/ft²)	0.3828
Aggregate Total Points	21,650,815,789
Aggregate Nominal Pulse Spacing (ft)	1.5104
Aggregate Nominal Pulse Density (pls/ft²)	0.4384

Table 8: LiDAR Point Cloud Statistics

3.1.4 Smooth Surface Repeatability (Interswath)

Departures from planarity of first returns within single swaths in non-vegetated areas were assessed at multiple locations with hard surface areas (parking lots or large rooftops) inside the project area. Each area was evaluated using signed difference rasters (maximum elevation – minimum elevation) at a cell size equal to 2 x ANPS, rounded to the next integer.

3.1.5 LiDAR Calibration

Using a combination of GeoCue, TerraScan and TerraMatch; overlapping swath point clouds are corrected for any orientation or linear deviations to obtain the best fit swath-to-swath calibration. Relative calibration was evaluated using advanced plane-matching analysis and parameter corrections derived. This process was repeated interactively until residual errors between overlapping swaths, across all project missions, was reduced to ≤ 2 cm. A final analysis of the calibrated lidar is performed using a TerraMatch tie line report for an overall statistical model of the project area. Individual control point assessments for this project can be found in Section VI of this report.

Upon completion of the data calibration, a complete set of elevation difference intensity rasters (dZ Orthos) are produced. A user-defined color ramp is applied depicting the offsets between overlapping swaths based on project specifications. The dZ orthos provide an opportunity to review the data calibration in a qualitative manner. Atlantic assigns green to all offset values that fall below the required RMSDz requirement of the project. A yellow color is assigned for offsets that fall between the RMSDz value and 1.5x of that value. Finally, red values are assigned to all values that fall beyond 1.5x of the RMSDz requirements of the project.

3.1.6 LiDAR Classification

Multiple automated filtering routines are applied to the calibrated LiDAR point cloud identifying and extracting bare-earth and above ground features. GeoCue, TerraScan, and TerraModeler software was used for the initial batch processing, visual inspection and any manual editing of the LiDAR point clouds. Atlantic utilized collected breakline data to preform classification for class 9 (Water).

Code	Description
1	Unclassified
2	Ground
3	Low Vegetation
4	Medium Vegetation
5	High Vegetation
6	Building
7	Low Point (Noise)
9	Water
10	Ignored Ground
17	Bridges
18	High Point (Noise)
Flags	Overlap & Withheld

Table 9: LiDAR Point Classification Codes and Descriptions

3.1.7 LiDAR Intensity Imagery

LiDAR intensity imagery was created from the final calibrated and classified lidar point cloud. Intensity images were produced from all classified points and posted to a 2.0-foot cell size. Intensity images were cut to match the tile index and its corresponding tile names and delivered in GeoTIFF format.

3.1.8 Hydro-line Collection/Conflation

Hydro breaklines were compiled using LiDAR intensity data and surface terrain models of the entire project area. After the collection, all delineated hydro features were validated for monotonicity and vertical variance. This procedure ensures that no points were floating above ground. Hydro-lines were then encoded into the LiDAR surface and used to hydro-enforce/flatten all significant water bodies. These final hydro-lines were then used in the production of bare Earth digital models to hydro flatten significant water bodies. This product was delivered as an ESRI geodatabase for the entire project area.

3.1.9 Bare-Earth Surface – Digital Elevation Model (DEM)

Bare earth Digital Elevation Models (DEMs) were derived using the hydro-lines and bare earth (ground) LiDAR points. All DEMs were created with a grid spacing of 2.0-feet. DEMs for this project were cut to match the tile index and its corresponding tile names and delivered in 32-bit floating point .tif format.

SECTION 4: ACCURACY ASSESSMENT

4.1 Aerial LiDAR Project – Vertical Accuracy Assessment

4.1.1 Requirements

Per the table below, the Vertical Accuracy Assessment utilized the required parameters for Vertical Data Accuracy Class IV.

Vertical Data Accuracy Class	RMSEz in Non-Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% Confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95th Percentile (cm)
I	1.0	2.0	2.9
II	2.5	4.9	7.4
III	5.0	9.8	14.7
IV	10.0	19.6	29.4
V	12.5	24.5	36.8
VI	20.0	39.2	58.8
VII	33.3	65.3	98.0
VIII	66.7	130.7	196.0
IX	100.0	196.0	294.0
X	333.3	653.3	980.0

Table 10: Vertical Accuracy Standards, Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014)

*The terms NVA and VVA are from the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data v1.0 (2014). The term NVA refers to assessments in clear, open areas (which typically produce only single LiDAR returns); the term VVA refers to assessments in vegetated areas (typically characterized by multiple return LiDAR).

4.1.2 Results

An overall statistical assessment of the check points can be found in the following two tables (values provided in U.S. Survey Feet):

Broad Land Cover Type	Points (#)	RMSEz	Confidence Level (95%)	Percentile (95th)
NVA (Point Cloud)	79	0.3008	0.5895	0.5218
NVA (DEM)	79	0.3150	0.6174	0.5295
VVA (Point Cloud)	61	0.4271	0.8371	0.8140
VVA (DEM)	61	0.4100	0.8037	0.5071

Table 11: NVA/VVA Accuracies

SECTION 5: CERTIFICATION STATEMENTS

5.1 Aerial LiDAR Project

This accuracy assessment confirms that the data may be used for the intended applications stated in Section I of this document. This dataset may also be used as a topographic input for other applications, but the user should be aware that this LiDAR dataset was designed with a specific purpose and was not intended to meet specifications and/or requirements of users outside of the United States Geological Survey.

It should also be noted that LiDAR points do not represent a continuous surface model. LiDAR points are discrete measurements of the surface and any values derived within a triangle of three LiDAR points are interpolated. As such, the user should not use the resultant LiDAR dataset for vertical placement of a planimetric feature such as a headwall, building footprint or any other planimetric feature unless there is an associated LiDAR point that can be reasonably located on this structure.

Consideration should be given by the end user of this dataset to the fact that this LiDAR dataset was developed differently and separately than previous LiDAR datasets that may be available for this geographic location. It is likely that the data in this project was created using different geodetic control, a different Geoid, newer LiDAR technology and more up-to-date processing techniques. As such, any direct comparative analysis performed between this dataset and previous datasets could result in misleading or inaccurate results. Users are encouraged to proceed with caution while performing this type of comparative analysis and to completely understand the variables that make each of these datasets unique and not corollary.

It is encouraged that the user refers to the full FGDC Metadata and project reports for a complete understanding on the content of this dataset.

I, hereby, certify to the extent of my knowledge that the statements and statistics represented in this document are true and factual.



Brian J. Mayfield, ASPRS Certified Photogrammetrist #R1276

SECTION 6: CONTROL POINT ASSESSMENTS

6.1 Aerial LiDAR Project

6.1.1 Point Cloud Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	Laser (Z)	Delta (Z)	Report Point Type
BE01	1445209.4330	1323615.0820	4902.9310	4902.6640	-0.2670	NVA
BE02	1386463.9620	1468723.8590	5635.6410	5635.4200	-0.2210	NVA
BE03	1405259.3220	1513606.9780	5768.0320	5767.5910	-0.4410	NVA
BE04	1458674.8420	1543786.9710	6142.1860	6142.1330	-0.0530	NVA
BE05	1477851.0760	1554935.5230	5978.7690	5978.7770	0.0080	NVA
BE06	1529769.7230	1556509.5510	5169.9210	5170.0030	0.0820	NVA
BE07	1536819.0120	1512018.8800	5128.2850	5128.2480	-0.0370	NVA
BE10	1519700.2960	1381899.1230	5041.9440	5042.0080	0.0640	NVA
BE11	1501243.1280	1352010.6950	4834.9940	4834.7230	-0.2710	NVA
BE12	1490941.3860	1294263.7810	4867.7860	4867.2890	-0.4970	NVA
BE13	1460420.6820	1216369.0600	4726.0520	4726.1120	0.0600	NVA
BE14	1446599.8250	1163380.8720	4659.1440	4659.1400	-0.0040	NVA
BE15	1457588.3120	1097563.8880	4636.0140	4636.6190	0.6050	NVA
BE16	1468508.6330	1253579.7640	4737.7790	4737.8530	0.0740	NVA
BE17	1457165.2300	1053473.0050	4539.3780	4539.9790	0.6010	NVA
BE18	1445198.1710	1128701.4350	4626.0720	4625.7180	-0.3540	NVA
BE19	1432127.5940	1375709.3260	5142.1810	5141.9140	-0.2670	NVA
BE20	1439024.6110	1416765.1960	5622.2910	5622.1290	-0.1620	NVA
BE21	1476507.2440	1487504.6510	5766.8230	5766.9530	0.1300	NVA
BE22	1482129.2250	1416394.5660	5087.5110	5088.0240	0.5130	NVA
BE23	1509795.4460	1308629.4990	4979.6270	4979.2720	-0.3550	NVA
BE24	1456956.9750	1338252.1920	5198.3260	5198.3340	0.0080	NVA
BE25	1520909.6680	1323649.1820	5041.9880	5041.8630	-0.1250	NVA
BE26	1427107.6050	1375848.8520	5121.9570	5121.8720	-0.0850	NVA
BE27	1517690.2020	1443159.1600	4980.6750	4980.9750	0.3000	NVA
BE28	1510245.2350	1342497.0240	4998.9800	4999.0150	0.0350	NVA
BR01	1445112.2870	1323625.9340	4902.3750	4901.8120	-0.5630	VVA
BR02	1406170.4410	1387292.5830	5108.2550	5108.0410	-0.2140	VVA
BR03	1502066.7510	1374316.5830	4841.3430	4841.0350	-0.3090	VVA
BR04	1537609.6020	1426253.0070	5234.2450	5234.1620	-0.0830	VVA
BR05	1495780.2000	1420554.2190	5022.9860	5022.5410	-0.4450	VVA
BR06	1466902.4260	1568948.6930	6179.2570	6179.1070	-0.1500	VVA
BR07	1528635.2310	1386755.5870	5127.3200	5127.3480	0.0280	VVA
BR08	1388182.5760	1487008.8470	5590.7510	5591.5650	0.8140	VVA

BR09	1458478.4310	1532655.0580	6126.2220	6126.2370	0.0150	VVA
BR10	1546242.4800	1556423.1860	5034.8150	5035.3230	0.5080	VVA
BR11	1553010.6560	1506309.9650	5498.0970	5498.3010	0.2040	VVA
BR12	1525206.3230	1460667.4370	5194.0930	5194.1160	0.0230	VVA
BR13	1463481.5040	1319751.4920	5188.0350	5188.0330	-0.0020	VVA
BR14	1449313.2040	1386129.0920	5353.1500	5353.4820	0.3320	VVA
BR15	1460948.7760	1211476.6660	4717.7810	4718.8380	1.0570	VVA
BR16	1451178.2260	1044657.5210	4532.8500	4532.9670	0.1170	VVA
BR17	1455646.6390	1106878.7540	4627.4860	4627.8670	0.3810	VVA
BR18	1471438.0350	1263256.1970	4763.9010	4764.4890	0.5880	VVA
BR19	1496555.8900	1482641.5440	5125.6750	5125.1160	-0.5590	VVA
BR20	1546011.6960	1577324.7410	5157.6900	5158.1610	0.4710	VVA
HG01	1376858.9330	1431335.4240	5445.1810	5445.3690	0.1880	VVA
HG02	1403628.3480	1458532.2510	5491.6150	5491.4970	-0.1180	VVA
HG03	1438060.4880	1487917.0670	5358.7680	5358.8080	0.0400	VVA
HG04	1442746.7420	1140967.1510	4667.6070	4667.3700	-0.2370	VVA
HG05	1442871.2220	1189845.7020	4680.0750	4680.6100	0.5350	VVA
HG06	1473276.7400	1274051.8140	4757.0630	4757.9470	0.8840	VVA
HG07	1464162.0310	1417065.8780	5443.6820	5443.7970	0.1150	VVA
HG08	1386340.6870	1517249.0690	5775.5180	5775.3230	-0.1950	VVA
HG10	1555327.1320	1380216.1720	5515.0210	5515.7240	0.7030	VVA
HG11	1514210.7070	1416945.4620	4883.9560	4884.7300	0.7740	VVA
HG12	1517480.8590	1518682.7140	4986.3350	4986.9760	0.6410	VVA
HG13	1488146.3510	1585458.3290	5980.6600	5980.7180	0.0580	VVA
HG14	1463614.1440	1552132.1690	6116.9100	6116.5890	-0.3210	VVA
HG15	1506354.9950	1542562.7480	5390.8820	5390.6510	-0.2310	VVA
HG16	1431729.2440	1466043.5500	5275.8230	5276.7320	0.9090	VVA
HG17	1399255.6920	1399571.6400	5231.7610	5231.8660	0.1050	VVA
HG18	1515441.5810	1369451.8620	5016.7240	5017.3190	0.5950	VVA
HG19	1555734.5600	1528854.2070	5643.7690	5644.1510	0.3820	VVA
HG20	1478665.1360	1501263.0490	5799.6980	5800.0640	0.3660	VVA
HG21	1454480.9340	1366299.0000	5299.5980	5299.3380	-0.2600	VVA
HG22	1460005.8380	1558854.3410	6251.0030	6250.8980	-0.1050	VVA
HG23	1431980.0460	1420584.5120	5632.9750	5632.6790	-0.2960	VVA
HG24	1457632.8150	1097535.1900	4636.3430	4636.8300	0.4870	VVA
OT01	1376918.0370	1431325.3460	5446.4750	5446.3970	-0.0780	NVA
OT02	1395287.4300	1414816.3190	5301.5260	5301.7600	0.2340	NVA
OT03	1386469.8660	1468752.8820	5635.6190	5635.2200	-0.3990	NVA
OT04	1438002.3840	1487945.9550	5358.0110	5357.9640	-0.0470	NVA

OT05	1443491.3250	1153849.2300	4629.5400	4629.2650	-0.2750	NVA
OT06	1462686.9520	1286959.0420	5092.3540	5092.5660	0.2120	NVA
OT07	1465497.0500	1389045.9780	5329.0460	5329.1590	0.1130	NVA
OT08	1416286.2370	1490374.6840	5465.9320	5465.7860	-0.1460	NVA
OT09	1401180.4090	1394627.6470	5134.0260	5133.9860	-0.0400	NVA
OT10	1458427.2780	1442428.5510	5594.2450	5594.2800	0.0350	NVA
OT11	1518664.9970	1545231.5470	5317.0380	5317.4040	0.3660	NVA
OT12	1491183.8570	1524260.8960	5545.9160	5545.6820	-0.2340	NVA
OT13	1469197.4500	1508556.9690	5864.3960	5864.1730	-0.2230	NVA
OT14	1479572.6720	1581587.5070	6066.8250	6066.7230	-0.1020	NVA
OT15	1536482.6870	1532554.1680	5009.1030	5009.4160	0.3130	NVA
OT16	1501208.6520	1459851.7930	4926.4130	4925.9690	-0.4440	NVA
OT17	1460085.8670	1422140.4130	5471.3820	5471.6070	0.2250	NVA
OT18	1507224.7670	1573576.2170	5681.7840	5681.3400	-0.4440	NVA
OT19	1494054.2260	1319034.5840	4844.2240	4843.3990	-0.8250	NVA
OT20	1476523.0310	1316643.8470	4896.7610	4896.8460	0.0850	NVA
OT21	1442338.5220	1184523.3210	4662.9490	4662.6150	-0.3340	NVA
OT22	1447201.6980	1085679.3320	4594.9360	4594.8100	-0.1260	NVA
OT23	1447136.4780	1202135.9050	4812.1390	4811.9680	-0.1710	NVA
OT24	1481807.4100	1344741.0150	4816.4710	4816.7020	0.2310	NVA
OT25	1468643.6800	1457369.8610	5650.0100	5650.0250	0.0150	NVA
OT26	1512269.4330	1485968.8650	4952.2830	4952.1650	-0.1180	NVA
OT27	1484597.2710	1363829.1000	4829.2300	4829.8710	0.6410	NVA
PID01	1427149.1010	1375951.0890	5120.6070	5120.5620	-0.0450	NVA
PID02	1386598.4000	1471439.1320	5616.2090	5616.0160	-0.1930	NVA
PID03	1452107.2760	1051444.5830	4535.3200	4535.3960	0.0760	NVA
PID05	1461186.0700	1217135.8760	4733.3410	4733.5780	0.2370	NVA
TR01	1406097.0430	1387356.7740	5105.2130	5105.1270	-0.0860	VVA
TR02	1403620.8150	1458489.5090	5491.5230	5491.7960	0.2730	VVA
TR03	1450556.6400	1135727.9790	4613.9950	4614.1290	0.1340	VVA
TR04	1456529.3490	1077022.8310	4558.1860	4558.8900	0.7040	VVA
TR05	1458512.1760	1241130.9020	4741.1540	4741.7160	0.5620	VVA
TR06	1478985.9510	1302033.1600	4795.5990	4796.0110	0.4130	VVA
TR07	1486550.3800	1388656.3700	4963.7610	4964.1820	0.4210	VVA
TR08	1403267.7660	1391064.5210	5130.7620	5130.5550	-0.2070	VVA
TR10	1433912.2460	1412951.4410	5582.3840	5582.2310	-0.1530	VVA
TR11	1459090.2920	1466566.1270	5787.6770	5787.3900	-0.2870	VVA
TR12	1491344.9610	1572873.2670	5856.1670	5855.7300	-0.4370	VVA
TR13	1538577.5280	1567130.4990	5198.5600	5199.2410	0.6810	VVA

TR14	1545882.6650	1490057.2600	5290.3250	5290.0780	-0.2470	VVA
TR15	1519786.3180	1502337.3860	4971.8100	4971.7810	-0.0290	VVA
TR16	1519800.1160	1502337.0790	4971.8030	4971.7860	-0.0170	VVA
TR17	1491553.3160	1463644.7630	5148.0810	5147.8260	-0.2550	VVA
TR18	1496236.5460	1396622.0290	4863.3240	4863.0400	-0.2840	VVA
TR19	1490867.6450	1329924.2290	4805.9680	4805.5490	-0.4190	VVA
UR02	1457355.4210	1070039.3600	4554.5340	4555.0030	0.4690	NVA
UR03	1441500.1890	1110831.8200	4705.7060	4705.2010	-0.5050	NVA
UR04	1453785.8820	1124841.2150	4622.2910	4622.5440	0.2530	NVA
UR05	1476184.9820	1297282.3330	4820.0020	4820.0620	0.0600	NVA
UR06	1520826.8870	1424482.2400	5246.6610	5246.4160	-0.2450	NVA
UR07	1500096.6280	1446468.8250	4909.0690	4908.5160	-0.5530	NVA
UR08	1530988.1670	1485263.0950	5183.1550	5183.1290	-0.0260	NVA
UR09	1371946.3660	1518056.6070	6394.6450	6394.3350	-0.3100	NVA
UR10	1463953.4190	1374039.4100	5286.8170	5287.5520	0.7350	NVA
UR11	1506981.6020	1396465.6500	4862.1010	4861.7930	-0.3080	NVA
UR12	1550481.7600	1565906.5620	5050.5850	5050.5050	-0.0800	NVA
UR13	1455194.7940	1504354.6420	6002.2520	6002.1770	-0.0750	NVA
UR15	1542148.4640	1386666.5160	5271.5700	5271.7790	0.2090	NVA
UR16	1498062.9490	1509029.3750	5323.2610	5322.6680	-0.5930	NVA
UR17	1520810.1250	1299872.6680	5051.9020	5051.7460	-0.1560	NVA
UR18	1481840.9460	1356916.9670	4829.1550	4829.4310	0.2760	NVA
UR19	1461119.5810	1236991.3270	4735.6370	4735.9190	0.2820	NVA
UR20	1469483.3100	1535978.6140	5903.8750	5903.8760	0.0010	NVA
UR21	1434107.2010	1477511.7950	5303.0830	5303.2440	0.1610	NVA
UR22	1388319.8390	1421867.5270	5345.6150	5345.6190	0.0040	NVA
UR25	1517233.8160	1341338.6600	5014.3800	5014.7830	0.4030	NVA
UR26	1518060.6470	1298290.0780	5075.6450	5075.7230	0.0780	NVA

Table 12: Point Cloud Check Point Assessment

6.1.2 Digital Elevation Model (DEM) Check Point Assessment

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BE01	1445209.4330	1323615.0820	4902.9310	4902.6520	0.2790	NVA
BE02	1386463.9620	1468723.8590	5635.6410	5635.3629	0.2781	NVA
BE03	1405259.3220	1513606.9780	5768.0320	5767.6059	0.4261	NVA
BE04	1458674.8420	1543786.9710	6142.1860	6142.0888	0.0972	NVA
BE05	1477851.0760	1554935.5230	5978.7690	5978.7931	-0.0241	NVA
BE06	1529769.7230	1556509.5510	5169.9210	5170.0147	-0.0937	NVA
BE07	1536819.0120	1512018.8800	5128.2850	5128.2644	0.0206	NVA
BE10	1519700.2960	1381899.1230	5041.9440	5042.0458	-0.1018	NVA
BE11	1501243.1280	1352010.6950	4834.9940	4834.7408	0.2532	NVA
BE12	1490941.3860	1294263.7810	4867.7860	4867.2348	0.5512	NVA
BE13	1460420.6820	1216369.0600	4726.0520	4726.1351	-0.0831	NVA
BE14	1446599.8250	1163380.8720	4659.1440	4659.1280	0.0160	NVA
BE15	1457588.3120	1097563.8880	4636.0140	4636.5855	-0.5715	NVA
BE16	1468508.6330	1253579.7640	4737.7790	4737.9497	-0.1707	NVA
BE17	1457165.2300	1053473.0050	4539.3780	4539.9342	-0.5562	NVA
BE18	1445198.1710	1128701.4350	4626.0720	4625.6888	0.3832	NVA
BE19	1432127.5940	1375709.3260	5142.1810	5141.8825	0.2985	NVA
BE20	1439024.6110	1416765.1960	5622.2910	5622.1765	0.1145	NVA
BE21	1476507.2440	1487504.6510	5766.8230	5766.9221	-0.0991	NVA
BE22	1482129.2250	1416394.5660	5087.5110	5087.8040	-0.2930	NVA
BE23	1509795.4460	1308629.4990	4979.6270	4979.2578	0.3692	NVA
BE24	1456956.9750	1338252.1920	5198.3260	5198.4839	-0.1579	NVA
BE25	1520909.6680	1323649.1820	5041.9880	5041.8940	0.0940	NVA
BE26	1427107.6050	1375848.8520	5121.9570	5121.8035	0.1535	NVA
BE27	1517690.2020	1443159.1600	4980.6750	4980.9889	-0.3139	NVA
BE28	1510245.2350	1342497.0240	4998.9800	4999.0370	-0.0570	NVA
OT01	1376918.0370	1431325.3460	5446.4750	5446.3436	0.1314	NVA
OT02	1395287.4300	1414816.3190	5301.5260	5301.7005	-0.1745	NVA
OT03	1386469.8660	1468752.8820	5635.6190	5635.3835	0.2355	NVA
OT04	1438002.3840	1487945.9550	5358.0110	5357.9690	0.0420	NVA
OT05	1443491.3250	1153849.2300	4629.5400	4629.3253	0.2147	NVA
OT06	1462686.9520	1286959.0420	5092.3540	5092.5945	-0.2405	NVA
OT07	1465497.0500	1389045.9780	5329.0460	5329.2210	-0.1750	NVA
OT08	1416286.2370	1490374.6840	5465.9320	5465.7894	0.1426	NVA
OT09	1401180.4090	1394627.6470	5134.0260	5133.9473	0.0787	NVA
OT10	1458427.2780	1442428.5510	5594.2450	5594.2114	0.0336	NVA
OT11	1518664.9970	1545231.5470	5317.0380	5317.3551	-0.3171	NVA

OT12	1491183.8570	1524260.8960	5545.9160	5545.7173	0.1987	NVA
OT13	1469197.4500	1508556.9690	5864.3960	5864.2682	0.1278	NVA
OT14	1479572.6720	1581587.5070	6066.8250	6066.7074	0.1176	NVA
OT15	1536482.6870	1532554.1680	5009.1030	5009.3895	-0.2865	NVA
OT16	1501208.6520	1459851.7930	4926.4130	4925.9305	0.4825	NVA
OT17	1460085.8670	1422140.4130	5471.3820	5471.5431	-0.1611	NVA
OT18	1507224.7670	1573576.2170	5681.7840	5681.3785	0.4055	NVA
OT19	1494054.2260	1319034.5840	4844.2240	4843.4109	0.8131	NVA
OT20	1476523.0310	1316643.8470	4896.7610	4896.8904	-0.1294	NVA
OT21	1442338.5220	1184523.3210	4662.9490	4662.5669	0.3821	NVA
OT22	1447201.6980	1085679.3320	4594.9360	4594.8076	0.1284	NVA
OT23	1447136.4780	1202135.9050	4812.1390	4811.8936	0.2454	NVA
OT24	1481807.4100	1344741.0150	4816.4710	4816.7527	-0.2817	NVA
OT25	1468643.6800	1457369.8610	5650.0100	5650.0288	-0.0188	NVA
OT26	1512269.4330	1485968.8650	4952.2830	4952.1683	0.1147	NVA
OT27	1484597.2710	1363829.1000	4829.2300	4829.8538	-0.6238	NVA
PID01	1427149.1010	1375951.0890	5120.6070	5120.6036	0.0034	NVA
PID02	1386598.4000	1471439.1320	5616.2090	5616.0103	0.1987	NVA
PID03	1452107.2760	1051444.5830	4535.3200	4535.4196	-0.0996	NVA
PID05	1461186.0700	1217135.8760	4733.3410	4733.5779	-0.2369	NVA
UR02	1457355.4210	1070039.3600	4554.5340	4555.1111	-0.5771	NVA
UR03	1441500.1890	1110831.8200	4705.7060	4705.1789	0.5271	NVA
UR04	1453785.8820	1124841.2150	4622.2910	4622.5889	-0.2979	NVA
UR05	1476184.9820	1297282.3330	4820.0020	4820.1986	-0.1966	NVA
UR06	1520826.8870	1424482.2400	5246.6610	5246.3367	0.3243	NVA
UR07	1500096.6280	1446468.8250	4909.0690	4908.5095	0.5595	NVA
UR08	1530988.1670	1485263.0950	5183.1550	5183.1445	0.0105	NVA
UR09	1371946.3660	1518056.6070	6394.6450	6394.4066	0.2384	NVA
UR10	1463953.4190	1374039.4100	5286.8170	5287.4752	-0.6582	NVA
UR11	1506981.6020	1396465.6500	4862.1010	4861.7747	0.3263	NVA
UR12	1550481.7600	1565906.5620	5050.5850	5050.4855	0.0995	NVA
UR13	1455194.7940	1504354.6420	6002.2520	6002.1205	0.1315	NVA
UR15	1542148.4640	1386666.5160	5271.5700	5271.7452	-0.1752	NVA
UR16	1498062.9490	1509029.3750	5323.2610	5322.6777	0.5833	NVA
UR17	1520810.1250	1299872.6680	5051.9020	5051.6908	0.2112	NVA
UR18	1481840.9460	1356916.9670	4829.1550	4830.0658	-0.9108	NVA
UR19	1461119.5810	1236991.3270	4735.6370	4735.9450	-0.3080	NVA
UR20	1469483.3100	1535978.6140	5903.8750	5904.0618	-0.1868	NVA
UR21	1434107.2010	1477511.7950	5303.0830	5303.2230	-0.1400	NVA
UR26	1518060.6470	1298290.0780	5075.6450	5345.5825	0.0325	NVA

Point ID	Given (X)	Given (Y)	Given (Z)	DEM (Z)	DEM (DZ)	Report Point Type
BR01	1445112.2870	1323625.9340	4902.3750	4902.0278	0.3472	VVA
BR02	1406170.4410	1387292.5830	5108.2550	5108.0516	0.2034	VVA
BR03	1502066.7510	1374316.5830	4841.3430	4841.3042	0.0388	VVA
BR04	1537609.6020	1426253.0070	5234.2450	5234.1800	0.0650	VVA
BR05	1495780.2000	1420554.2190	5022.9860	5022.3892	0.5968	VVA
BR06	1466902.4260	1568948.6930	6179.2570	6179.1049	0.1521	VVA
BR07	1528635.2310	1386755.5870	5127.3200	5127.3381	-0.0181	VVA
BR08	1388182.5760	1487008.8470	5590.7510	5591.6637	-0.9127	VVA
BR09	1458478.4310	1532655.0580	6126.2220	6126.2320	-0.0100	VVA
BR10	1546242.4800	1556423.1860	5034.8150	5035.2316	-0.4166	VVA
BR11	1553010.6560	1506309.9650	5498.0970	5498.4301	-0.3331	VVA
BR12	1525206.3230	1460667.4370	5194.0930	5194.4733	-0.3803	VVA
BR13	1463481.5040	1319751.4920	5188.0350	5187.9970	0.0380	VVA
BR14	1449313.2040	1386129.0920	5353.1500	5353.2918	-0.1418	VVA
BR15	1460948.7760	1211476.6660	4717.7810	4718.3339	-0.5529	VVA
BR16	1451178.2260	1044657.5210	4532.8500	4532.9681	-0.1181	VVA
BR17	1455646.6390	1106878.7540	4627.4860	4628.0346	-0.5486	VVA
BR18	1471438.0350	1263256.1970	4763.9010	4764.2737	-0.3727	VVA
BR19	1496555.8900	1482641.5440	5125.6750	5125.0734	0.6016	VVA
BR20	1546011.6960	1577324.7410	5157.6900	5158.1176	-0.4276	VVA
HG01	1376858.9330	1431335.4240	5445.1810	5445.2488	-0.0678	VVA
HG02	1403628.3480	1458532.2510	5491.6150	5491.4964	0.1186	VVA
HG03	1438060.4880	1487917.0670	5358.7680	5358.8136	-0.0456	VVA
HG04	1442746.7420	1140967.1510	4667.6070	4667.3659	0.2411	VVA
HG05	1442871.2220	1189845.7020	4680.0750	4680.5163	-0.4413	VVA
HG06	1473276.7400	1274051.8140	4757.0630	4757.9124	-0.8494	VVA
HG07	1464162.0310	1417065.8780	5443.6820	5443.8618	-0.1798	VVA
HG08	1386340.6870	1517249.0690	5775.5180	5775.2336	0.2844	VVA
HG10	1555327.1320	1380216.1720	5515.0210	5515.7587	-0.7377	VVA
HG11	1514210.7070	1416945.4620	4883.9560	4884.7376	-0.7816	VVA
HG12	1517480.8590	1518682.7140	4986.3350	4986.9740	-0.6390	VVA
HG13	1488146.3510	1585458.3290	5980.6600	5980.7046	-0.0446	VVA
HG14	1463614.1440	1552132.1690	6116.9100	6116.6413	0.2687	VVA
HG15	1506354.9950	1542562.7480	5390.8820	5390.5584	0.3236	VVA
HG16	1431729.2440	1466043.5500	5275.8230	5276.4246	-0.6016	VVA
HG17	1399255.6920	1399571.6400	5231.7610	5231.8560	-0.0950	VVA
HG18	1515441.5810	1369451.8620	5016.7240	5017.2969	-0.5729	VVA
HG19	1555734.5600	1528854.2070	5643.7690	5644.0827	-0.3137	VVA

HG20	1478665.1360	1501263.0490	5799.6980	5799.9406	-0.2426	VVA
HG21	1454480.9340	1366299.0000	5299.5980	5299.3634	0.2346	VVA
HG22	1460005.8380	1558854.3410	6251.0030	6250.8713	0.1317	VVA
HG23	1431980.0460	1420584.5120	5632.9750	5632.6010	0.3740	VVA
HG24	1457632.8150	1097535.1900	4636.3430	4636.9162	-0.5732	VVA
TR01	1406097.0430	1387356.7740	5105.2130	5105.1018	0.1112	VVA
TR02	1403620.8150	1458489.5090	5491.5230	5491.8060	-0.2830	VVA
TR03	1450556.6400	1135727.9790	4613.9950	4614.1373	-0.1423	VVA
TR04	1456529.3490	1077022.8310	4558.1860	4559.1365	-0.9505	VVA
TR05	1458512.1760	1241130.9020	4741.1540	4741.6587	-0.5047	VVA
TR06	1478985.9510	1302033.1600	4795.5990	4796.0842	-0.4852	VVA
TR07	1486550.3800	1388656.3700	4963.7610	4964.1995	-0.4385	VVA
TR08	1403267.7660	1391064.5210	5130.7620	5130.5891	0.1729	VVA
TR10	1433912.2460	1412951.4410	5582.3840	5582.2988	0.0852	VVA
TR11	1459090.2920	1466566.1270	5787.6770	5787.3103	0.3667	VVA
TR12	1491344.9610	1572873.2670	5856.1670	5855.6599	0.5071	VVA
TR13	1538577.5280	1567130.4990	5198.5600	5198.9824	-0.4224	VVA
TR14	1545882.6650	1490057.2600	5290.3250	5290.0551	0.2699	VVA
TR15	1519786.3180	1502337.3860	4971.8100	4971.8063	0.0037	VVA
TR16	1519800.1160	1502337.0790	4971.8030	4971.7198	0.0832	VVA
TR17	1491553.3160	1463644.7630	5148.0810	5147.8362	0.2448	VVA
TR18	1496236.5460	1396622.0290	4863.3240	4862.8153	0.5087	VVA
TR19	1490867.6450	1329924.2290	4805.9680	4805.5583	0.4097	VVA

Table 13: DEM Check Point Assessment