

ADDISON, VERMONT

ACCURACY ASSESSMENT REPORT

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1. GROUND CONTROL AND CHECK POINT COLLECTION

Photo Science completed a field survey of 100 blind QA points in five different land cover classifications as an independent test of the accuracy of this project. The land cover classifications were selected from the dominant classifications for this project area. These included:

- Bare earth and low grass
- High grass, weeds, and crops
- Brush lands and low trees
- Forested, fully covered by trees
- Urban areas

A combination of precise GPS surveying methods, including static and RTK observations, was used to establish the 3D position for 80 of these points – this included the four land cover classifications listed above other than the forested points. 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 derived 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 the goal for the blind QA points was a positional accuracy of 4 cm in terms of the RMSE.

Figure 1 shows the location of each calibration point for the project area. Table 1 depicts the Final Control Report for the LiDAR calibration points shown in Figure 1 as computed in TerraScan as a quality assurance check. Note that these results of the surface calibration are not an independent assessment of the accuracy of these project deliverables, but the statistical results do provide additional feedback as to the overall quality of the elevation surface.

The project is being delivered in two different horizontal projections. All reporting for the blind QA accuracy assessment is based on the UTM Zone 18 North, Meters projection for this dataset.

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 1.0 (2012) and the National Digital Elevation Program Guidelines (2004). The locations for all tested blind QA points are shown in Figure 2. The summary below provides the results of this testing:

Point Cloud Testing

- Raw Fundamental Vertical Accuracy (Raw FVA): The tested Raw FVA for the dataset was found to be 6.5 centimeters in terms of the RMSEz. The resulting FVA stated as the 95% confidence level ($RMSEz \times 1.96$) is 12.7 centimeters. This dataset *meets* the required FVA of 24.5 centimeters at the 95% confidence level, based on the calibrated, yet unclassified LiDAR swaths. This is summarized in Table 2.

Digital Elevation Model (DEM) Testing

- Fundamental Vertical Accuracy (FVA): The tested FVA for the dataset captured from the DEM using bi-linear interpolation to derive the DEM elevations was found to be 4.7 centimeters in terms of the RMSEz. The resulting accuracy stated as the 95% confidence level ($RMSEz \times 1.96$) is 9.2 centimeters. This dataset *meets* the required FVA of 24.5 cm at the 95% confidence level. This is summarized in Table 3.

- Supplemental Vertical Accuracy (SVA): The tested SVA accuracies for the dataset for each of the land cover classes other than open ground are summarized below. Bi-linear interpolation was used in all SVA classes to derive the DEM elevations. These results are stated in terms of the 95th percentile error for each of the land cover classes other than open ground.

The following land cover classes were tested and the resulting 95th percentile error values are listed below:

- Forested, Fully Covered by Trees: 0.147 m (Table 4)
 - Brush Lands and Low Trees: 0.328 m (Table 5)
 - High Grass, Weeds, and Crops: 0.674 m (Table 6)
 - Urban Areas: 0.042 m (Table 7)
- Consolidated Vertical Accuracy (CVA): The tested CVA for the dataset captured from the DEM using bi-linear interpolation for all classes (including the bare earth class) was found to be 34.5 centimeters, which is stated in terms of the 95th percentile error. Therefore the data *meets* the required CVA of 36.3 centimeters. This test was based on the 95th percentile error in all land cover categories combined.

This is also summarized in Table 8.

Figure 1. LiDAR Calibration Point Locations

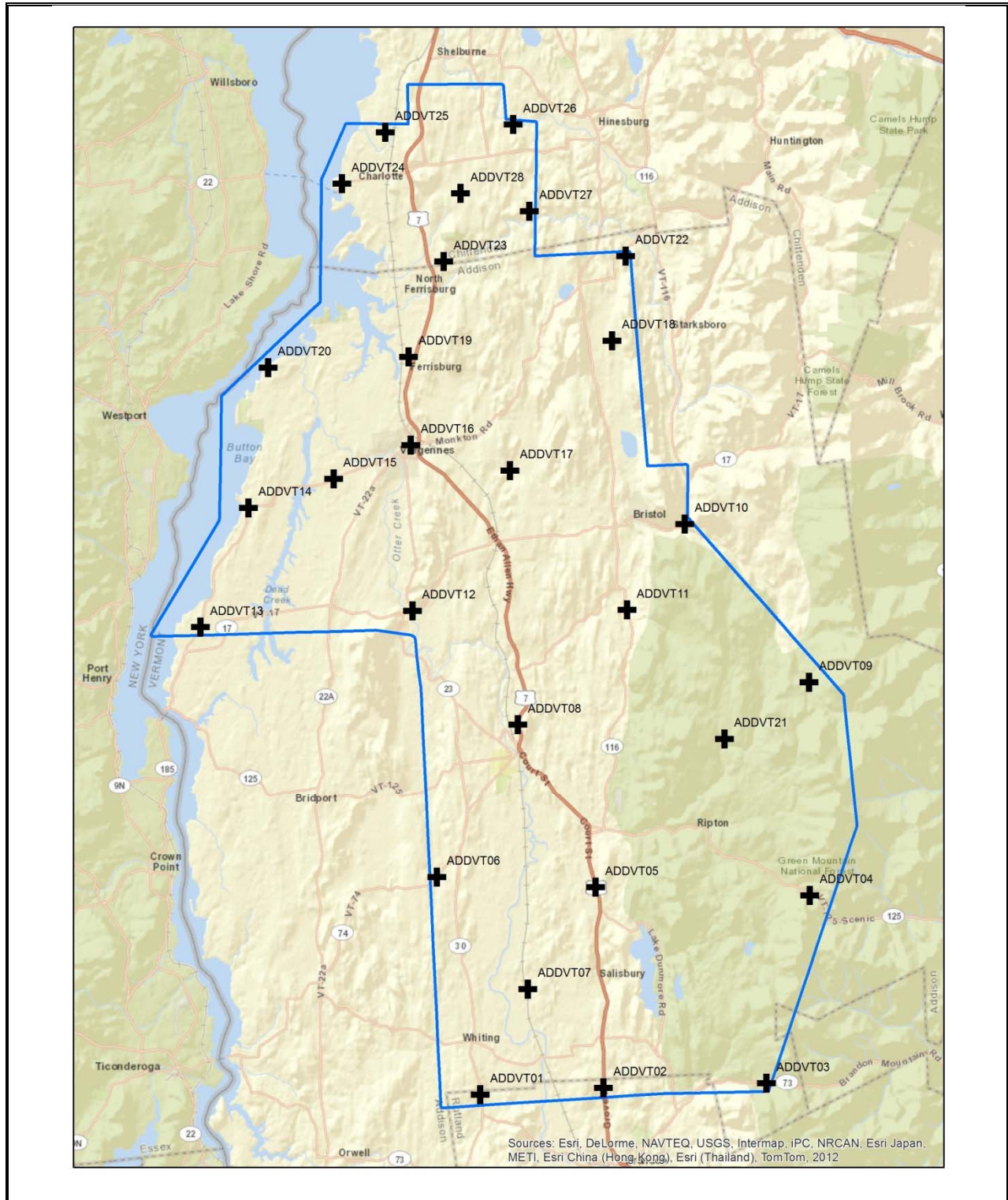


Figure 2. Blind QA/QC Points by Type

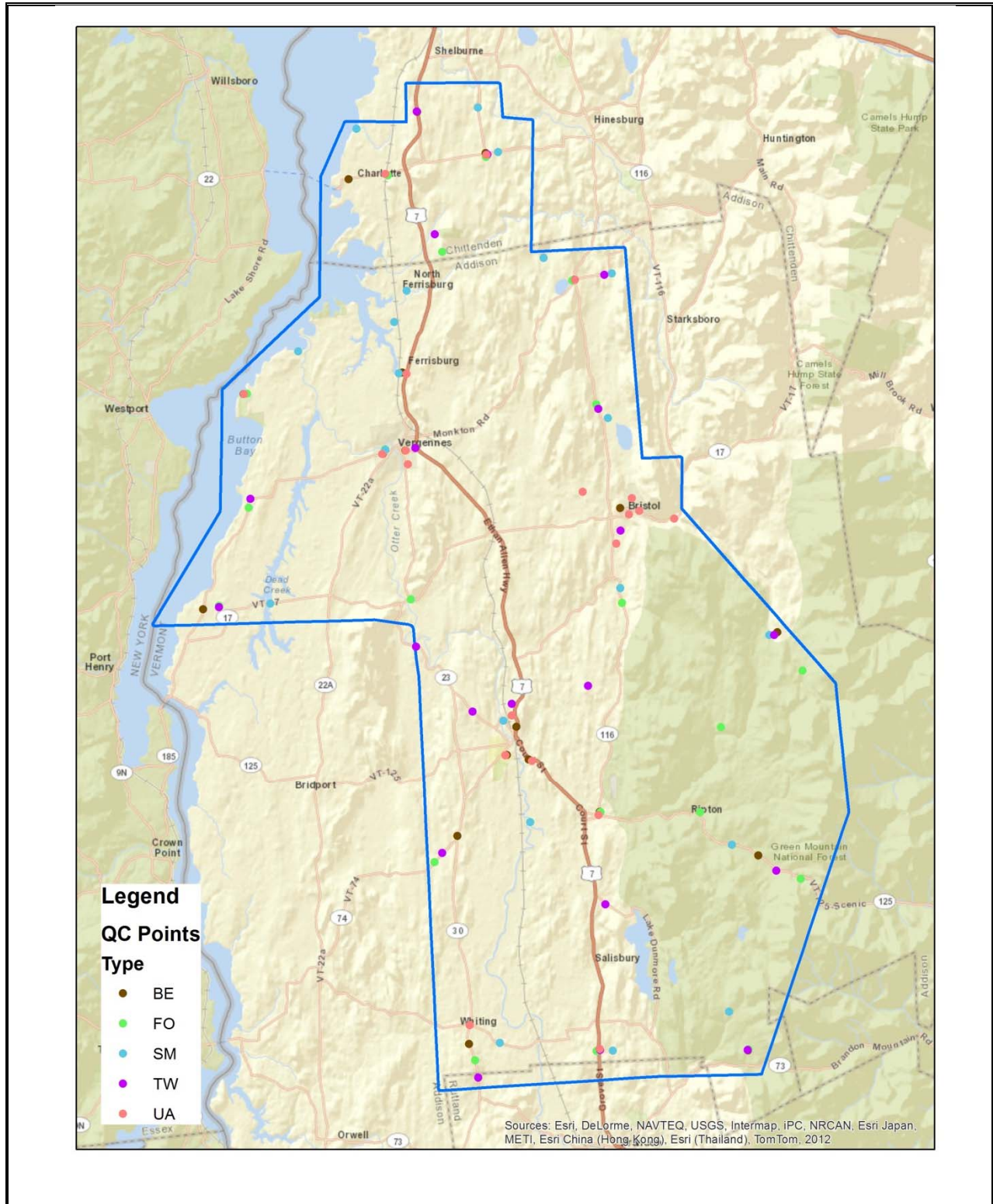


Table 1. Final LiDAR Calibration Control Fit (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
ADDVT01	645133.44	4855291.05	130.93	130.94	0.01
ADDVT02	652234.22	4855836.53	142.42	142.46	0.04
ADDVT03	661644.09	4856311.97	465.16	465.16	0.00
ADDVT04	663877.62	4867156.26	554.28	554.27	-0.01
ADDVT05	651514.36	4867324.86	134.20	134.20	0.00
ADDVT06	642364.98	4867702.88	103.94	103.94	0.00
ADDVT07	647745.73	4861398.99	111.71	111.65	-0.06
ADDVT08	646837.21	4876577.10	158.36	158.39	0.03
ADDVT09	663535.29	4879395.45	451.42	451.37	-0.05
ADDVT10	656167.58	4888275.04	187.84	187.74	-0.10
ADDVT11	652963.22	4883282.84	120.55	120.60	0.05
ADDVT12	640628.38	4882957.99	59.51	59.63	0.12
ADDVT13	628454.53	4881773.74	51.00	50.98	-0.02
ADDVT14	631090.79	4888649.69	52.78	52.70	-0.08
ADDVT15	635946.32	4890407.36	41.44	41.27	-0.17
ADDVT16	640330.40	4892423.90	55.10	55.12	0.02
ADDVT17	646062.65	4891094.44	85.33	85.32	-0.01
ADDVT18	651748.20	4898647.72	161.91	161.90	-0.01
ADDVT19	640107.05	4897463.64	54.48	54.47	-0.01
ADDVT20	632052.33	4896683.20	40.22	40.29	0.07
ADDVT21	658733.86	4876037.45	452.80	452.72	-0.08
ADDVT22	652402.53	4903494.89	152.08	152.01	-0.07
ADDVT23	641994.11	4902941.52	106.25	106.20	-0.05
ADDVT24	636060.80	4907247.06	51.23	51.27	0.04
ADDVT25	638496.50	4910239.72	56.77	56.71	-0.05
ADDVT26	645802.07	4910835.35	111.99	111.93	-0.06
ADDVT27	646835.54	4905916.53	121.34	121.39	0.06
ADDVT28	642880.43	4906844.10	104.40	104.46	0.06
Average dz	+0.000 m				
Minimum dz	-0.157 m				
Maximum dz	+0.146 m				
Root Mean Square	0.062 m				
95% Confidence	0.121 m				

NOTE: The statistical results for the calibration of the elevation surface do not represent an independent analysis of the data as these points were used in the calibration of the surface.

Table 2. FVA - Bare Earth and Low Grass QA Points – Unclassified swaths (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
BE01	647713.06	4873859.19	109.98	110.070	+0.087
BE02	646432.79	4874112.23	121.37	121.420	+0.046
BE03	646957.53	4875753.06	118.60	118.750	+0.151
BE04	651939.67	4870879.18	124.55	124.580	+0.032
BE05	652224.33	4857093.27	159.23	159.250	+0.018
BE06	643649.70	4869297.79	114.35	114.440	+0.090
BE07	661258.68	4868573.52	439.55	439.600	+0.055
BE08	652715.12	4888615.33	174.85	174.970	+0.119
BE09	640130.88	4891689.52	51.17	51.200	+0.027
BE10	638799.94	4891453.94	53.30	53.380	+0.080
BE11	639864.35	4896194.17	53.71	53.790	+0.079
BE12	630654.21	4894773.23	40.77	40.760	-0.013
BE13	628538.66	4882216.36	57.94	57.920	-0.016
BE14	649742.84	4901808.35	182.97	183.010	+0.045
BE15	644420.01	4909033.12	110.70	110.700	+0.004
BE16	640395.25	4911335.03	110.96	110.940	-0.023
BE17	636504.22	4907343.87	43.18	43.230	+0.047
BE18	644589.07	4857236.77	138.08	138.150	+0.073
BE19	660938.58	4857228.82	479.82	479.840	+0.016
BE20	662038.35	4881612.50	398.60	398.640	+0.043
Average dz	+0.048 m				
Minimum dz	-0.023 m				
Maximum dz	+0.151 m				
Root Mean Square	0.065 m				
95% Confidence	0.127 m				

NOTE: The elevation values shown in this table for the LiDAR surface were derived from the calibrated, but unclassified swaths.

Table 3. FVA - Bare Earth and Low Grass QA Points – Derived DEMs (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
BE01	647713.06	4873859.19	109.98	110.00	0.02
BE02	646432.79	4874112.23	121.37	121.36	-0.01
BE03	646957.53	4875753.06	118.60	118.69	0.09
BE04	651939.67	4870879.18	124.55	124.51	-0.04
BE05	652224.33	4857093.27	159.23	159.22	-0.01
BE06	643649.70	4869297.79	114.35	114.39	0.04
BE07	661258.68	4868573.52	439.55	439.56	0.01
BE08	652715.12	4888615.33	174.85	174.86	0.01
BE09	640130.88	4891689.52	51.17	51.16	-0.01
BE10	638799.94	4891453.94	53.30	53.35	0.05
BE11	639864.35	4896194.17	53.71	53.73	0.02
BE12	630654.21	4894773.23	40.77	40.75	-0.02
BE13	628538.66	4882216.36	57.94	57.89	-0.05
BE14	649742.84	4901808.35	182.97	182.98	0.01
BE15	644420.01	4909033.12	110.70	110.71	0.01
BE16	640395.25	4911335.03	110.96	110.94	-0.02
BE17	636504.22	4907343.87	43.18	43.21	0.03
BE18	644589.07	4857236.77	138.08	138.12	0.04
BE19	660938.58	4857228.82	479.82	479.82	0.00
BE20	662038.35	4881612.50	398.60	398.57	-0.03
Average dz	+0.001 m				
Minimum dz	-0.045 m				
Maximum dz	+0.147 m				
Root Mean Square	0.047 m				
95% Confidence	0.092 m				

NOTE: The elevation values shown in this table for the LiDAR surface were derived from the project DEMs.

Table 4. Forested, Fully Covered by Trees -- Derived DEMs (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
FO01R	640620.04	4883046.58	66.18	66.18	0.00
FO02R	652944.36	4883111.94	117.28	117.40	0.12
FO03R	663560.23	4879407.27	452.51	452.56	0.05
FO04R	658883.63	4876001.59	458.25	458.21	-0.04
FO05	663764.86	4867260.85	560.01	559.91	-0.10
FO06R	660939.15	4857289.87	481.41	481.39	-0.02
FO07R	652061.26	4856978.80	150.56	150.57	0.00
FO08R	645041.71	4856324.62	148.04	148.04	0.00
FO09R	642338.79	4867752.51	103.27	103.34	0.07
FO10R	651968.99	4870845.15	124.92	124.99	0.07
FO11R	629456.92	4882444.91	47.35	47.31	-0.04
FO12R	631087.80	4888167.53	47.14	47.18	0.04
FO13R	630843.74	4894788.86	39.19	39.11	-0.08
FO14R	638942.81	4891713.81	48.12	48.10	-0.02
FO15R	649623.07	4901773.46	167.76	167.90	0.15
FO16R	644456.17	4908808.33	127.72	127.69	-0.03
FO17R	638765.76	4907621.14	52.64	52.59	-0.04
FO18R	642035.27	4903254.90	120.52	120.48	-0.03
FO19R	657788.77	4870976.10	332.13	332.18	0.05
FO20R	651183.97	4894607.56	144.64	144.81	0.17
Average dz	+0.020 m				
Minimum dz	-0.099 m				
Maximum dz	+0.175 m				
95 th Percentile	0.147 m				

NOTE: The elevation values shown in this table for the LiDAR surface were derived from the project DEMs.

Table 5. Brush Lands and Low Trees -- Derived DEMs (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
SM01	639660.89	4896165.72	51.38	51.51	0.14
SM02	633761.06	4897296.09	30.48	30.53	0.05
SM03	638966.61	4891701.27	49.18	49.28	0.10
SM04	632445.36	4882620.10	30.88	30.90	0.02
SM05	646179.33	4876099.04	95.97	96.17	0.20
SM06	647887.34	4870197.55	104.74	104.93	0.19
SM07	646387.83	4857321.10	105.13	105.34	0.21
SM08	653023.32	4857026.25	135.81	135.97	0.15
SM09	659759.16	4859456.33	506.43	506.40	-0.03
SM10	659700.40	4869147.02	396.02	396.05	0.03
SM11	661573.11	4881441.60	386.13	386.26	0.13
SM12	652829.85	4883962.18	100.56	100.63	0.07
SM13	651872.81	4893831.28	142.76	142.84	0.08
SM14	651908.40	4902224.53	132.00	132.32	0.33
SM15	647922.17	4903038.07	122.02	122.13	0.12
SM16	639317.84	4899124.27	32.68	32.75	0.07
SM17	636894.11	4910287.54	29.26	29.26	-0.01
SM18	643925.77	4911653.73	70.43	70.40	-0.03
SM19	645142.85	4909103.85	124.83	125.17	0.34
SM20	639992.01	4900947.67	31.17	31.40	0.24
Average dz	+0.120 m				
Minimum dz	-0.031 m				
Maximum dz	+0.341 m				
95th Percentile	0.328 m				

NOTE: The elevation values shown in this table for the LiDAR surface were derived from the project DEMs.

Table 6 High Grass, Weeds, and Crops -- Derived DEMs (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
TW01	645174.19	4855285.74	129.07	129.47	0.40
TW02	652270.89	4857042.07	161.46	161.37	-0.09
TW03	660904.11	4857257.64	480.09	480.22	0.14
TW04	662333.35	4867716.62	449.28	449.63	0.34
TW05	652378.46	4865513.35	127.74	127.98	0.25
TW06	642776.49	4868276.95	77.55	77.88	0.33
TW07	644380.20	4876575.34	126.30	126.54	0.24
TW08	646650.80	4877084.56	119.18	119.31	0.14
TW09	651080.48	4878237.86	139.85	140.21	0.36
TW10	661864.23	4881453.64	393.20	393.69	0.50
TW11	652771.37	4887310.61	117.55	117.73	0.18
TW12	640988.91	4880286.23	51.27	51.47	0.20
TW13	629450.84	4882346.98	46.31	46.44	0.13
TW14	631160.52	4888682.40	50.84	51.04	0.21
TW15	640703.89	4891829.86	49.16	49.96	0.81
TW16	651308.20	4894343.19	144.69	144.86	0.17
TW17	651472.85	4902139.04	135.70	135.99	0.29
TW18	641565.44	4904264.87	89.94	90.23	0.29
TW19	644536.51	4908947.64	114.21	114.32	0.10
TW20	640382.36	4911354.10	110.85	111.52	0.67
Average dz	+0.28 m				
Minimum dz	-0.086 m				
Maximum dz	+0.809 m				
95th Percentile	0.674 m				

NOTE: The elevation values shown in this table for the LiDAR surface were derived from the project DEMs.

Table 7. Urban Areas -- Derived DEMs (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
UA01	647897.79	4873782.36	112.80	112.78	-0.03
UA02	646351.53	4874075.20	119.92	119.86	-0.05
UA03	646660.64	4876405.06	117.23	117.24	0.01
UA04	651869.03	4870695.35	124.25	124.24	-0.01
UA05	652253.13	4857107.15	161.59	161.63	0.04
UA06	644606.25	4858327.14	119.80	119.79	-0.01
UA07	655888.64	4888070.35	186.86	186.81	-0.05
UA08	652535.95	4886539.81	110.57	110.61	0.04
UA09	653237.40	4888260.70	140.78	140.75	-0.03
UA10	653827.37	4888474.92	173.13	173.08	-0.05
UA11	653377.26	4889200.07	173.33	173.27	-0.06
UA12	650516.12	4889511.02	133.35	133.37	0.02
UA13	640306.55	4890886.19	59.75	59.66	-0.09
UA14	640152.89	4891679.93	51.67	51.62	-0.05
UA15	638778.68	4891448.72	53.39	53.44	0.04
UA16	630680.22	4894773.87	40.44	40.44	0.00
UA17	640102.04	4896125.88	59.01	58.95	-0.06
UA18	649784.57	4901802.84	181.56	181.51	-0.05
UA19	638636.11	4907705.80	50.23	50.18	-0.04
UA20	644459.32	4908923.80	118.46	118.44	-0.02
Average dz	-0.020 m				
Minimum dz	-0.088 m				
Maximum dz	+0.043 m				
95th Percentile	0.042 m				

NOTE: The elevation values shown in this table for the LiDAR surface were derived from the project DEMs.

Table 8. Consolidated Vertical Accuracy (CVA - 5 Land Cover Classes) -- Derived DEMs (units = meters)

Number	Easting	Northing	Known Z	LiDAR Z	Dz
BE01	647713.06	4873859.19	109.98	110.00	0.02
BE02	646432.79	4874112.23	121.37	121.42	0.05
BE03	646957.53	4875753.06	118.60	118.75	0.15
BE04	651939.67	4870879.18	124.55	124.51	-0.04
BE05	652224.33	4857093.27	159.23	159.22	-0.02
BE06	643649.70	4869297.79	114.35	114.43	0.08
BE07	661258.68	4868573.52	439.55	439.55	0.01
BE08	652715.12	4888615.33	174.85	174.86	0.01
BE09	640130.88	4891689.52	51.17	51.13	-0.04
BE10	638799.94	4891453.94	53.30	53.37	0.07
BE11	639864.35	4896194.17	53.71	53.72	0.00
BE12	630654.21	4894773.23	40.77	40.75	-0.02
BE13	628538.66	4882216.36	57.94	57.89	-0.04
BE14	649742.84	4901808.35	182.97	182.98	0.01
BE15	644420.01	4909033.12	110.70	110.70	0.00
BE16	640395.25	4911335.03	110.96	110.94	-0.02
BE17	636504.22	4907343.87	43.18	43.21	0.02
BE18	644589.07	4857236.77	138.08	138.10	0.02
BE19	660938.58	4857228.82	479.82	479.81	-0.02
BE20	662038.35	4881612.50	398.60	398.55	-0.05
FO01R	640620.04	4883046.58	66.18	66.18	0.00
FO02R	652944.36	4883111.94	117.28	117.40	0.12
FO03R	663560.23	4879407.27	452.51	452.56	0.05
FO04R	658883.63	4876001.59	458.25	458.21	-0.04
FO05	663764.86	4867260.85	560.01	559.91	-0.10
FO06R	660939.15	4857289.87	481.41	481.39	-0.02
FO07R	652061.26	4856978.80	150.56	150.57	0.00
FO08R	645041.71	4856324.62	148.04	148.04	0.00
FO09R	642338.79	4867752.51	103.27	103.34	0.07
FO10R	651968.99	4870845.15	124.92	124.99	0.07
FO11R	629456.92	4882444.91	47.35	47.31	-0.04
FO12R	631087.80	4888167.53	47.14	47.18	0.04
FO13R	630843.74	4894788.86	39.19	39.11	-0.08
FO14R	638942.81	4891713.81	48.12	48.10	-0.02
FO15R	649623.07	4901773.46	167.76	167.90	0.15
FO16R	644456.17	4908808.33	127.72	127.69	-0.03
FO17R	638765.76	4907621.14	52.64	52.59	-0.04
FO18R	642035.27	4903254.90	120.52	120.48	-0.03
FO19R	657788.77	4870976.10	332.13	332.18	0.05
FO20R	651183.97	4894607.56	144.64	144.81	0.17
SM01	639660.89	4896165.72	51.38	51.51	0.14
SM02	633761.06	4897296.09	30.48	30.53	0.05
SM03	638966.61	4891701.27	49.18	49.28	0.10
SM04	632445.36	4882620.10	30.88	30.90	0.02
SM05	646179.33	4876099.04	95.97	96.17	0.20
SM06	647887.34	4870197.55	104.74	104.93	0.19
SM07	646387.83	4857321.10	105.13	105.34	0.21
SM08	653023.32	4857026.25	135.81	135.97	0.15
SM09	659759.16	4859456.33	506.43	506.40	-0.03
SM10	659700.40	4869147.02	396.02	396.05	0.03

Number	Easting	Northing	Known Z	Laser Z	Dz
SM11	661573.11	4881441.60	386.13	386.26	0.13
SM12	652829.85	4883962.18	100.56	100.63	0.07
SM13	651872.81	4893831.28	142.76	142.84	0.08
SM14	651908.40	4902224.53	132.00	132.32	0.33
SM15	647922.17	4903038.07	122.02	122.13	0.12
SM16	639317.84	4899124.27	32.68	32.75	0.07
SM17	636894.11	4910287.54	29.26	29.26	-0.01
SM18	643925.77	4911653.73	70.43	70.40	-0.03
SM19	645142.85	4909103.85	124.83	125.17	0.34
SM20	639992.01	4900947.67	31.17	31.40	0.24
TW01	645174.19	4855285.74	129.07	129.47	0.40
TW02	652270.89	4857042.07	161.46	161.37	-0.09
TW03	660904.11	4857257.64	480.09	480.22	0.14
TW04	662333.35	4867716.62	449.28	449.63	0.34
TW05	652378.46	4865513.35	127.74	127.98	0.25
TW06	642776.49	4868276.95	77.55	77.88	0.33
TW07	644380.20	4876575.34	126.30	126.54	0.24
TW08	646650.80	4877084.56	119.18	119.31	0.14
TW09	651080.48	4878237.86	139.85	140.21	0.36
TW10	661864.23	4881453.64	393.20	393.69	0.50
TW11	652771.37	4887310.61	117.55	117.73	0.18
TW12	640988.91	4880286.23	51.27	51.47	0.20
TW13	629450.84	4882346.98	46.31	46.44	0.13
TW14	631160.52	4888682.40	50.84	51.04	0.21
TW15	640703.89	4891829.86	49.16	49.96	0.81
TW16	651308.20	4894343.19	144.69	144.86	0.17
TW17	651472.85	4902139.04	135.70	135.99	0.29
TW18	641565.44	4904264.87	89.94	90.23	0.29
TW19	644536.51	4908947.64	114.21	114.32	0.10
TW20	640382.36	4911354.10	110.85	111.52	0.67
UA01	647897.79	4873782.36	112.80	112.78	-0.03
UA02	646351.53	4874075.20	119.92	119.86	-0.05
UA03	646660.64	4876405.06	117.23	117.24	0.01
UA04	651869.03	4870695.35	124.25	124.24	-0.01
UA05	652253.13	4857107.15	161.59	161.63	0.04
UA06	644606.25	4858327.14	119.80	119.79	-0.01
UA07	655888.64	4888070.35	186.86	186.81	-0.05
UA08	652535.95	4886539.81	110.57	110.61	0.04
UA09	653237.40	4888260.70	140.78	140.75	-0.03
UA10	653827.37	4888474.92	173.13	173.08	-0.05
UA11	653377.26	4889200.07	173.33	173.27	-0.06
UA12	650516.12	4889511.02	133.35	133.37	0.02
UA13	640306.55	4890886.19	59.75	59.66	-0.09
UA14	640152.89	4891679.93	51.67	51.62	-0.05
UA15	638778.68	4891448.72	53.39	53.44	0.04
UA16	630680.22	4894773.87	40.44	40.44	0.00
UA17	640102.04	4896125.88	59.01	58.95	-0.06
UA18	649784.57	4901802.84	181.56	181.51	-0.05
UA19	638636.11	4907705.80	50.23	50.18	-0.04
UA20	644459.32	4908923.80	118.46	118.44	-0.02

Average dz	+0.080 m
Minimum dz	-0.099 m
Maximum dz	+0.809 m
95 th Percentile	0.345 m

NOTE: The elevation values shown in this table for the LiDAR surface were derived from the project DEMs.