DPH-11 Report on Absolute Vertical Accuracy

The USGS Lidar Base Specification Version 2.1 states: "Absolute vertical accuracy of the lidar data and the derived DEM will be assessed and reported in accordance with ASPRS (2014). Vegetated and nonvegetated land cover types shall be assessed for absolute vertical accuracy.
Three absolute accuracy values shall be assessed and reported:

1. NVA for the point data
2. VVA for the point data
3. NVA for the DEM
4. VVA for the DEM

The minimum NVA and VVA requirements for all data, using the ASPRS methodology, are listed in table 4. Both the NVA and VVA required values shall be met. NVA for the point data shall be assessed by comparing check points surveyed for NVA assessment to a triangulated irregular network (TIN) constructed from ground-classified lidar points in those areas. VVA for the point data shall be assessed by comparing check points surveyed for VVA assessment to a triangulated irregular network (TIN) constructed from ground-classified lidar points in those areas. NVA and VVA for the DEM are assessed by comparing check points to the final bare-earth surface. The minimum required thresholds for absolute and relative accuracy may be increased by the USGS–NGP when any of the following conditions are met:

- A demonstrable, substantial, and prohibitive increase in cost is needed to obtain this accuracy, which is often the case in heavily vegetated project areas.
- An alternate specification is needed to conform to previously contracted phases of a single larger overall collection effort such as for multiyear statewide collections
- The USGS–NGP agrees that the use of an alternate specification is reasonable and in the best interest of all stakeholders."

Table 4. Absolute vertical accuracy for light detection and ranging data and digital elevation models.

[QL, quality level, $RMSE_z$, root mean square error in the z direction; NVA, nonvegetated vertical accuracy; VVA, vegetated vertical accuracy; m, meter; ≤, less than or equal to]

Quality level	$RMSE_z$ (nonvegetated) (m)	NVA at the 95-percent confidence level (m)	VVA at the 95th percentile (m)
QL0	≤0.050	≤0.098	≤0.15
QL1	≤0.100	≤0.196	≤0.30
QL2	≤0.100	≤0.196	≤0.30
QL3	≤0.200	≤0.392	≤0.60

The purpose of this section is to report on the absolute vertical accuracy of the lidar data and DEMs generated from it by testing for NVA (Nonvegetated Vertical Accuracy) and VVA (Vegetated Vertical Accuracy) against surveyed ground check points.

DPH-11 Report on Absolute Vertical Accuracy - continued

Data Source - D:\00_Cherry\Control\NE_CBC_South_13NVA_11VVA_LidarCheckPts.shp
Units: Meter (/Feet)

Vertical Accuracy Class tested: 10-cm

Check Points in defined project area (DPA):	24
Check Points with Lidar Coverage	24
Check Points with Lidar Coverage (NVA)	13
Check Points with Lidar Coverage (VVA)	11
Average Z Error (NVA)	-0.004/-0.014
Maximum Z Error (NVA)	0.034/0.111
Median Z Error (NVA)	0.004/0.014
Minimum Z Error (NVA)	-0.057/-0.189
Standard deviation of Vertical Error (NVA)	0.029/0.095
Skewness of Vertical Error (NVA)	-0.634
Kurtosis of Vertical Error (NVA)	-0.741
Non-vegetated Vertical Accuracy (NVA) RMSE(z) [1]	0.028/0.092 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level +/- [1]	0.055/0.180 PASS
FGDC/NSSDA Vertical Accuracy at the 95% Confidence Level +/-	0.055/0.180
Non-vegetated Vertical Accuracy (NVA) RMSE(z) (DEM) [2]	0.031/0.103 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level (DEM) +/- [2]	0.061/0.201 PASS
Vegetated Vertical Accuracy (VVA) at the 95th Percentile (TIN) +/- [1]	0.168/0.551 PASS
Vegetated Vertical Accuracy (VVA) at the 95th Percentile (DEM) +/- [2]	0.157/0.514 PASS

This data set was tested to meet ASPRS Positional Accuracy Standard for Digital Geospatial Data (2014) for a 10-cm RMSEz Vertical Accuracy Class. Actual NVA accuracy was found to be RMSEz = 2.8cm, equating to +/- 5.5cm at the 95% confidence level. Actual VVA accuracy was found to be +/- 15.7cm at the 95th percentile.

[1] This value is calculated from TIN-based testing of the lidar point cloud data.

[2] This value is calculated from RAM-based grid testing of the lidar data. The grid cells are sized according to the Quality Level selected, and are defined in the USGS NGP Lidar Base Specification Version 2.1 (Table 6).

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to report the results of measuring the lidar point cloud data against surveyed ground NVA (nonvegetated vertical accuracy) check points. All XY coordinates and Z values reported are in the selected data units.

NVA (lidar data)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Minimum Z	Median Z	Maximum Z	Intensity	Scan Angle Rank	Returns	Description	Comments
3001	442456.288	4563222.765	Yes	749.918	749.938	0.020	749.89	749.945	749.978	6660	1726	1,1,1		
3002	419231.276	4546822.058	Yes	821.412	821.355	-0.057	821.324	821.341	821.401	4640	-1516	1,1,1		
3003	442547.366	4545092.873	Yes	758.339	758.373	0.034	758.349	758.373	758.385	4300	1375	1,1,1		
3004	420289.494	4556641.247	Yes	880.108	880.114	0.006	880.082	880.117	880.13	3693	-45	1,1,1		
3005	399725.594	4563814.315	Yes	930.348	930.374	0.026	930.358	930.358	930.395	3315	2749	1,1,1		
3006	401653.758	4545266.513	Yes	845.181	845.13	-0.051	845.127	845.129	845.155	3697	2578	1,1,1		
3007	432407.548	4558112.117	Yes	793.211	793.218	0.007	793.199	793.206	793.247	4676	-29	1,1,1		
3007A	434616.855	4555872.328	Yes	786.774	786.795	0.021	786.782	786.809	786.813	4390	-3008	1,1,1		
3008	436088.988	4547105.559	Yes	818.309	818.293	-0.016	818.266	818.29	818.309	3220	-5	1,1,1		
3009	411528.171	4560547.366	Yes	859.882	859.879	-0.003	859.843	859.875	859.9	2669	2879	1,1,1		
3010	400110.603	4553613.412	Yes	892.962	892.966	0.004	892.951	892.957	892.977	2351	-574	1,1,1		
3011	420369.974	4564791.47	Yes	827.686	827.676	-0.010	827.636	827.669	827.681	3232	-1035	1,1,1		
3011A	420403.214	4561962.569	Yes	833.447	833.412	-0.035	833.404	833.452	833.469	2698	-2993	1,1,1		

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to report the results of measuring the lidar point cloud data against surveyed ground VVA (vegetated vertical accuracy) check points. All XY coordinates and Z values reported are in the selected data units.

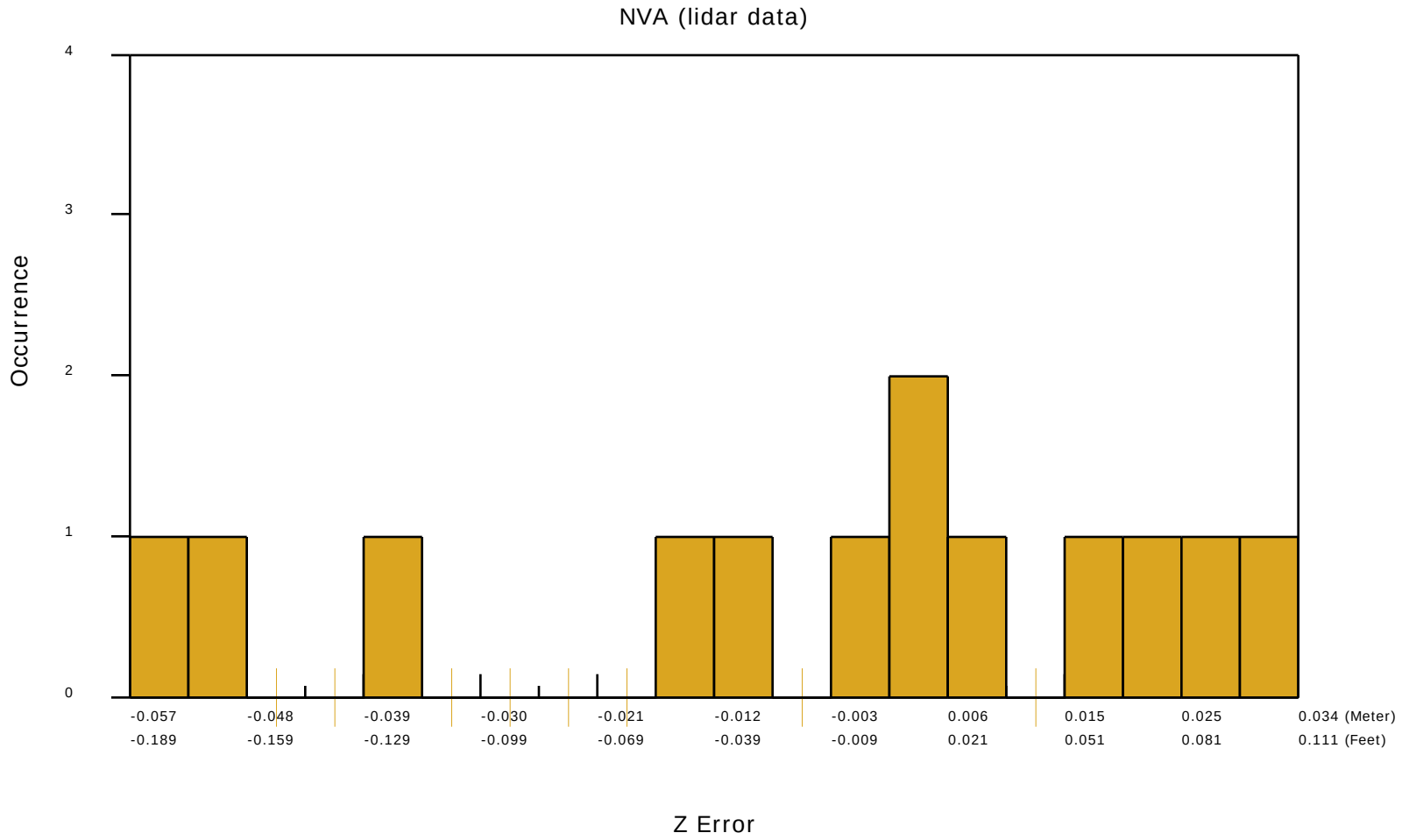
VVA (lidar data)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Minimum Z	Median Z	Maximum Z	Intensity	Scan Angle Rank	Returns	Description	Comments
2001	442449.216	4563384.974	Yes	753.077	753.182	0.105	753.167	753.187	753.193	6837	2244	1,1,1		
2002	418461.715	4546903.279	Yes	824.991	825.04	0.049	825.016	825.03	825.052	5092	-1293	1,1,1		
2003	442508.146	4545104.088	Yes	757.655	757.725	0.070	757.707	757.727	757.728	6862	1350	1,1,1		
2004	420282.372	4556668.429	Yes	878.196	878.344	0.148	878.34	878.341	878.365	7657	16	1,1,1		
2005	399725.096	4563773.885	Yes	928.834	928.945	0.111	928.923	928.93	928.993	7639	2508	1,1,1		
2006	401608.144	4545282.872	Yes	845.473	845.573	0.100	845.56	845.567	845.601	5719	2960	1,1,1		
2007	431641.304	4558774.66	Yes	796.165	796.148	-0.017	796.147	796.15	796.158	5759	-2710	1,1,1		
2007A	434633.964	4555862.188	Yes	786.339	786.458	0.119	786.441	786.444	786.479	7371	-2601	1,1,1		
2008	400194.047	4554934.564	Yes	891.752	891.94	0.188	891.912	891.923	891.976	8700	1299	1,1,1		
2009	420247.102	4564365.469	Yes	835.531	835.537	0.006	835.503	835.536	835.543	6278	411	1,1,1		
2009A	420360.752	4561981.283	Yes	830.827	830.919	0.092	830.911	830.918	830.927	7338	-2027	1,1,1		

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a frequency distribution chart of the non-vegetated vertical accuracy (NVA) of the lidar point cloud data measured against surveyed ground check points.

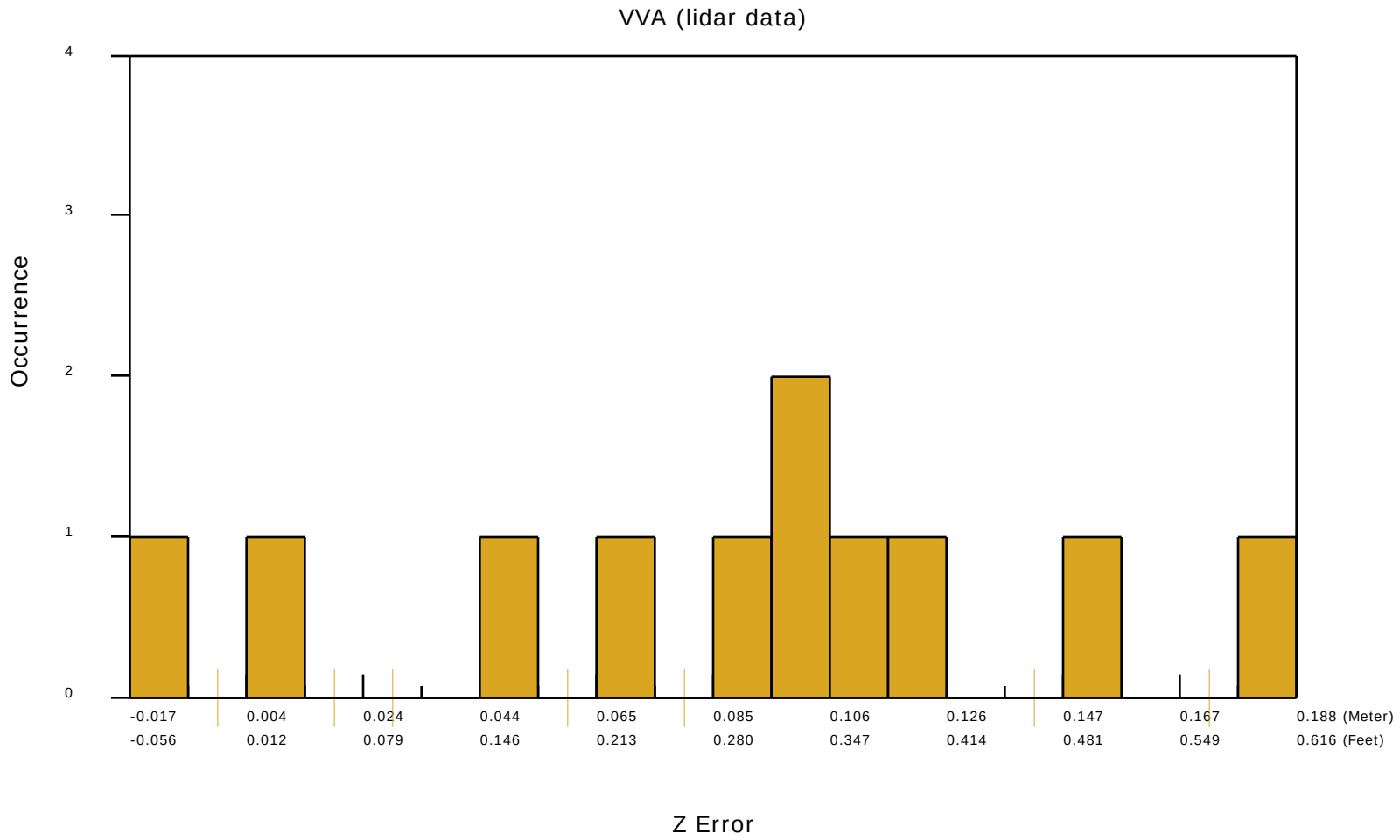
Data Source - D:\00_Cherry\tilecls



DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a frequency distribution chart of the vegetated vertical accuracy (VVA) of the lidar point cloud data measured against surveyed ground check points.

Data Source - D:\00_Cherry\tilecls



DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to report the results of measuring the DEM data against surveyed ground NVA (nonvegetated vertical accuracy) check points. All XY coordinates and Z values reported are in the selected data units.

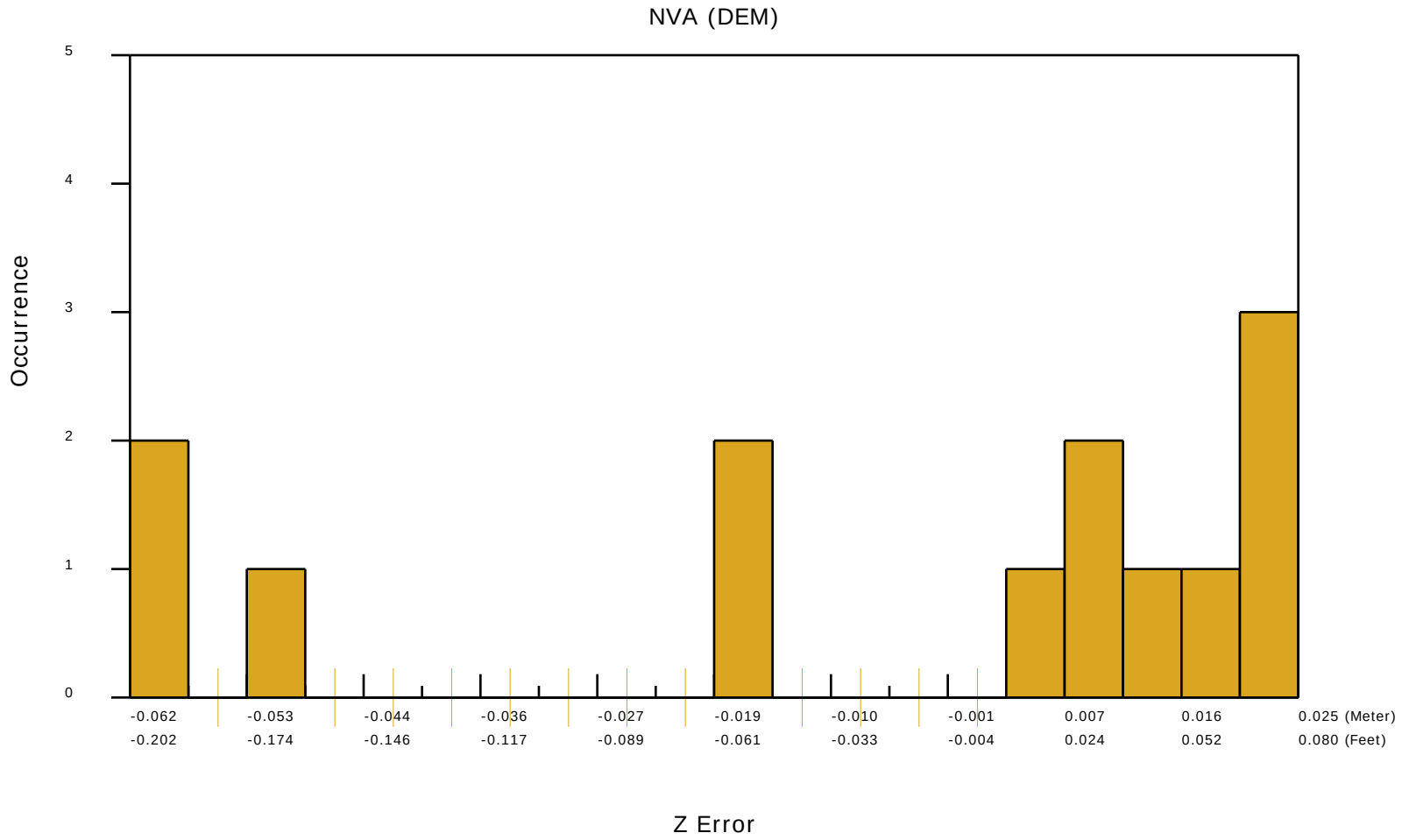
NVA (DEM)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
3001	442456.288	4563222.765	Yes	749.918	749.938	0.020		
3002	419231.276	4546822.058	Yes	821.412	821.350	-0.062		
3003	442547.366	4545092.873	Yes	758.339	758.364	0.025		
3004	420289.494	4556641.247	Yes	880.108	880.116	0.008		
3005	399725.594	4563814.315	Yes	930.348	930.372	0.024		
3006	401653.758	4545266.513	Yes	845.181	845.130	-0.051		
3007	432407.548	4558112.117	Yes	793.211	793.221	0.010		
3007A	434616.855	4555872.328	Yes	786.774	786.797	0.023		
3008	436088.988	4547105.559	Yes	818.309	818.321	0.012		
3009	411528.171	4560547.366	Yes	859.882	859.865	-0.017		
3010	400110.603	4553613.412	Yes	892.962	892.968	0.006		
3011	420369.974	4564791.47	Yes	827.686	827.628	-0.058		
3011A	420403.214	4561962.569	Yes	833.447	833.432	-0.015		

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a frequency distribution chart of the non-vegetated vertical accuracy (NVA) of the DEM data measured against surveyed ground check points.

Data Source - D:\00_Cherry\tilecls



DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to report the results of measuring the DEM data against surveyed ground VVA (vegetated vertical accuracy) check points. All XY coordinates and Z values reported are in the selected data units.

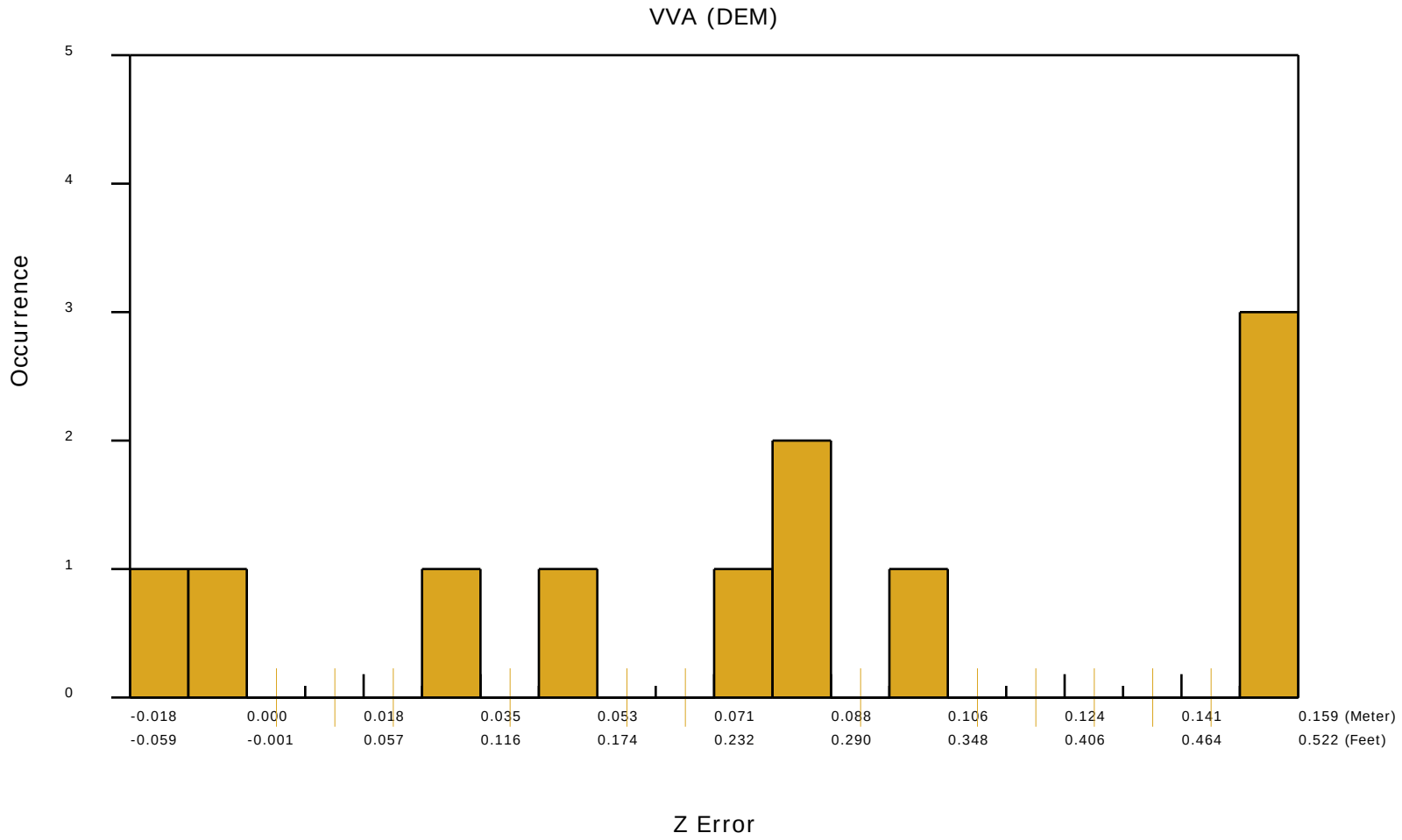
VVA (DEM)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
2001	442449.216	4563384.974	Yes	753.077	753.152	0.075		
2002	418461.715	4546903.279	Yes	824.991	825.038	0.047		
2003	442508.146	4545104.088	Yes	757.655	757.688	0.033		
2004	420282.372	4556668.429	Yes	878.196	878.347	0.151		
2005	399725.096	4563773.885	Yes	928.834	928.919	0.085		
2006	401608.144	4545282.872	Yes	845.473	845.556	0.083		
2007	431641.304	4558774.66	Yes	796.165	796.147	-0.018		
2007A	434633.964	4555862.188	Yes	786.339	786.493	0.154		
2008	400194.047	4554934.564	Yes	891.752	891.911	0.159		
2009	420247.102	4564365.469	Yes	835.531	835.528	-0.003		
2009A	420360.752	4561981.283	Yes	830.827	830.926	0.099		

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a frequency distribution chart of the vegetated vertical accuracy (VVA) of the DEM data measured against surveyed ground check points.

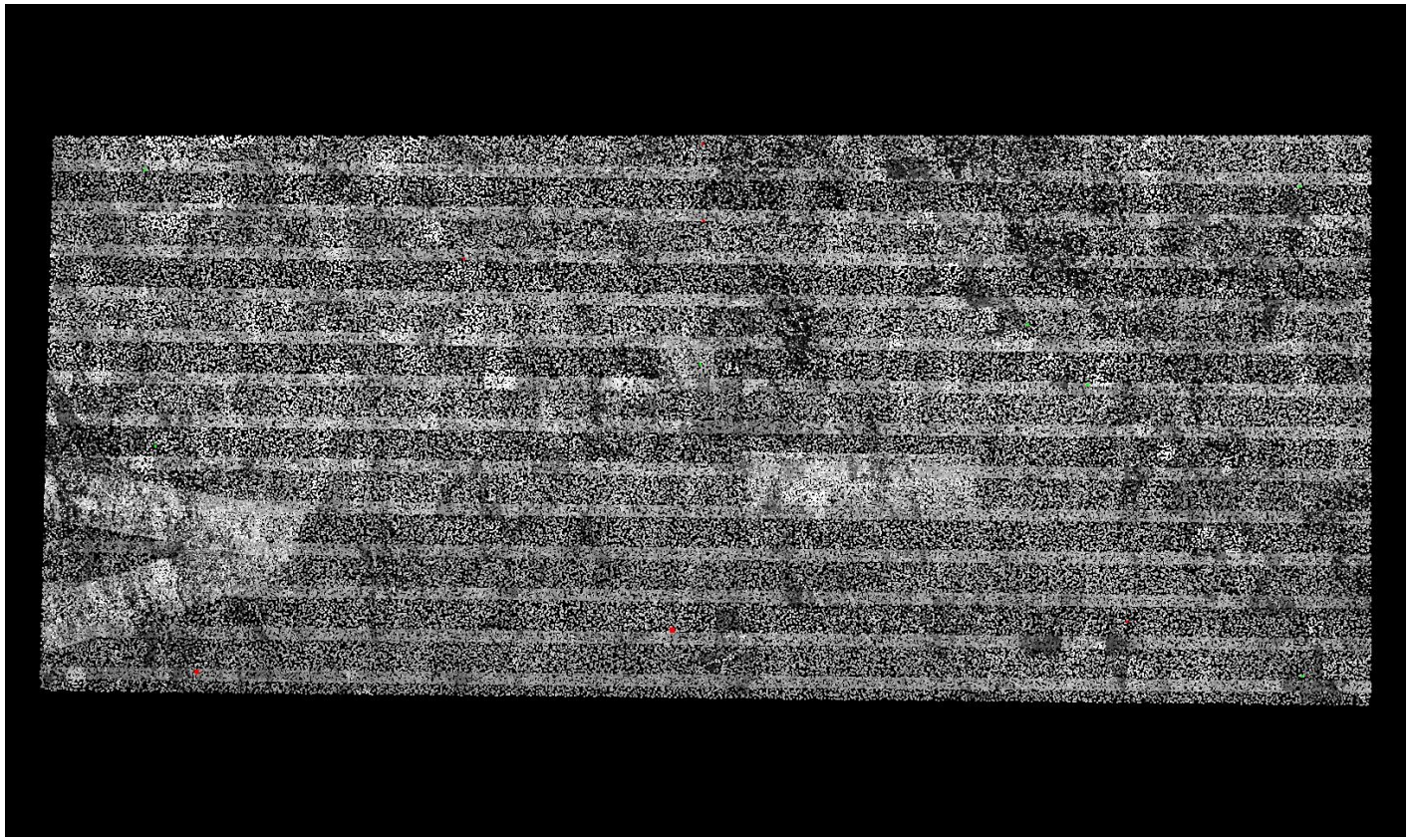
Data Source - D:\00_Cherry\tilecls



DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a graphic of lidar data points colored by intensity with NVA check points rendered "thematically" showing the green and red squares sized by Z error.

Data Source - D:\00_Cherry\tilecls
Result Path - D:\00_Cherry\NE_CherryBrownCuster_South_Block_QC\DPH_11\ColorByIntensity_CheckPoints_NVA.jpg



Green represents where the lidar surface is above the check point (positive elevation error).

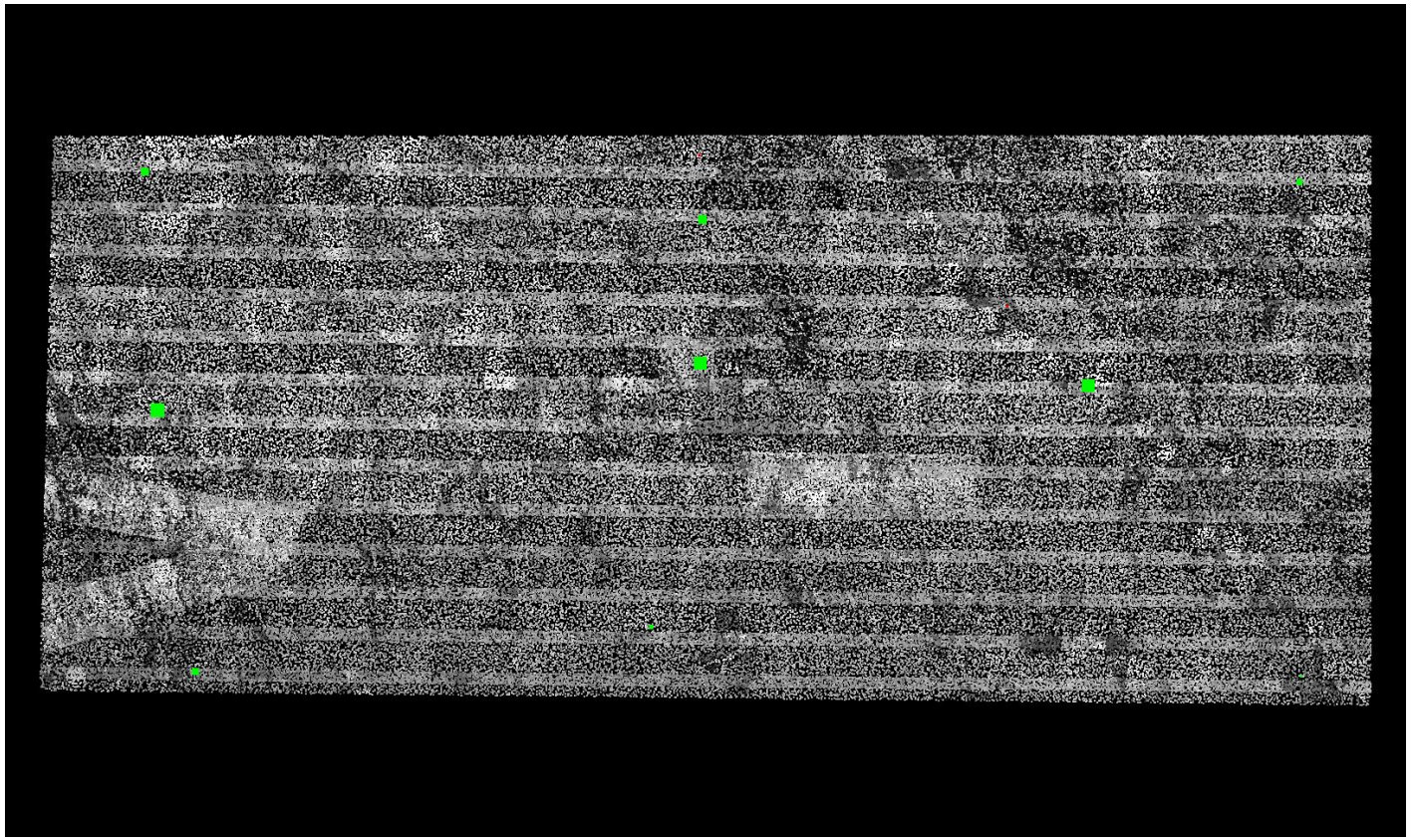
Red represents where the lidar surface is below the check point (negative elevation error).

The size of the square symbol represents the absolute value magnitude of error.

DPH-11 Report on Absolute Vertical Accuracy - continued

The purpose of this section is to show a graphic of lidar data points colored by intensity with VVA check points rendered "thematically" showing the green and red squares sized by Z error.

Data Source - D:\00_Cherry\tilecls
Result Path - D:\00_Cherry\NE_CherryBrownCuster_South_Block_QC\DPH_11\ColorByIntensity_CheckPoints_VVA.jpg



Green represents where a DEM of the lidar surface is above the check point (positive elevation error).

Red represents where a DEM of the lidar surface is below the check point (negative elevation error).

The size of the square symbol represents the absolute value magnitude of error.