

# DPH-11 Report on Absolute Vertical Accuracy

The USGS Lidar Base Specification 2022 rev. A 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. Federal Emergency Management Agency (2003) identifies seven land cover types; National Digital Elevation Program (2004) and ASPRS (2004) reiterate the first five of those types. The way in which each of the seven classes was reported under the previous standards and how they are reported under the new ASPRS standards and by this specification are shown in table 3. Four 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;  $\leq$ , 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	$\leq 0.050$	$\leq 0.098$	$\leq 0.15$
QL1	$\leq 0.100$	$\leq 0.196$	$\leq 0.30$
QL2	$\leq 0.100$	$\leq 0.196$	$\leq 0.30$
QL3	$\leq 0.200$	$\leq 0.392$	$\leq 0.60$

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

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Units: Meter (/Feet)

Vertical Accuracy Class tested: 10-cm

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Check Points in defined project area (DPA):	61
Check Points with Lidar Coverage	61
Check Points with Lidar Coverage (NVA)	37
Check Points with Lidar Coverage (VVA)	24
Average Z Error (NVA)	-0.030/-0.100
Maximum Z Error (NVA)	0.052/0.172
Median Z Error (NVA)	-0.030/-0.098
Minimum Z Error (NVA)	-0.107/-0.352
Standard deviation of Vertical Error (NVA)	0.036/0.118
Skewness of Vertical Error (NVA)	0.024
Kurtosis of Vertical Error (NVA)	-0.201
Non-vegetated Vertical Accuracy (NVA) RMSE(z) <sup>1</sup>	0.047/0.153 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level +/- <sup>1</sup>	0.091/0.300 PASS
FGDC/NSSDA Vertical Accuracy at the 95% Confidence Level +/-	0.091/0.300
Non-vegetated Vertical Accuracy (NVA) RMSE(z) (DEM) <sup>2</sup>	0.044/0.146 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level (DEM) +/- <sup>2</sup>	0.087/0.286 PASS
Vegetated Vertical Accuracy (VVA) at the 95th Percentile (TIN) +/- <sup>1</sup>	0.099/0.324 PASS
Vegetated Vertical Accuracy (VVA) at the 95th Percentile (DEM) +/- <sup>2</sup>	0.110/0.360 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 = 4.7cm, equating to +/- 9.1cm at the 95% confidence level. Actual VVA accuracy was found to be +/- 11.0cm at the 95th percentile.

<sup>1</sup> This value is calculated from TIN-based testing of the lidar point cloud data.

<sup>2</sup> 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 2022 rev. A (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
2006	481090.414	5294953.47	Yes	429.179	429.144	-0.035	429.142	429.142	429.15	375	-2743	1,1,1		
2008	441873.64	5295563.611	Yes	420.395	420.322	-0.073	420.295	420.333	420.348	632	-1338	1,1,1		
2050	335805.074	5275136.559	Yes	441.564	441.571	0.007	441.567	441.576	441.577	825	-543	1,1,1		
2056	414568.073	5276274.714	Yes	413.718	413.696	-0.022	413.683	413.698	413.706	648	-1520	1,1,1		
2060	353458.261	5273639.988	Yes	427.277	427.249	-0.028	427.226	427.243	427.269	455	1335	1,1,1		
2062	392075.124	5292938.13	Yes	421.9	421.921	0.021	421.887	421.892	421.937	338	1054	1,1,1		
2071	370879.58	5283559.944	Yes	428.625	428.637	0.012	428.621	428.638	428.666	969	1468	1,1,1		
2072	453084.905	5303547.615	Yes	404.149	404.115	-0.034	404.095	404.124	404.144	608	-1599	1,1,1		
2089	425944.456	5296511.506	Yes	417.58	417.574	-0.006	417.55	417.574	417.587	641	2206	1,1,1		
2099	404980.872	5287868.163	Yes	418.395	418.396	0.001	418.373	418.375	418.403	318	903	1,1,1		
2100A	435449.879	5276941.003	Yes	413.54	413.518	-0.022	413.505	413.517	413.526	370	-76	1,1,1		
2102	474356.413	5294937.1	Yes	421.554	421.505	-0.049	421.47	421.5	421.509	619	-2136	1,1,1		
2117	493563.54	5291632.705	Yes	391.387	391.364	-0.023	391.338	391.346	391.379	417	-759	1,1,1		
2127	350074.01	5289992.714	Yes	412.964	412.914	-0.050	412.896	412.903	412.927	491	-370	1,1,1		
2155	450799.892	5287813.412	Yes	402.228	402.196	-0.032	402.157	402.168	402.206	168	-922	1,1,1		
2156	422008.121	5287793.425	Yes	404.621	404.568	-0.053	404.548	404.585	404.602	517	-1058	1,1,1		
2157	399029.772	5300130.728	Yes	430.233	430.267	0.034	430.252	430.266	430.269	409	-249	1,1,1		
2157A	392405.97	5303440.737	Yes	414.256	414.203	-0.053	414.192	414.207	414.229	326	-1091	1,1,1		
2161	441900.41	5278919.574	Yes	436.177	436.147	-0.030	436.129	436.135	436.149	249	-392	1,1,1		
2179	389030.059	5287353.228	Yes	434.269	434.274	0.005	434.272	434.273	434.29	706	986	1,1,1		
2180	408042.765	5279034.787	Yes	412.14	412.124	-0.016	412.116	412.117	412.132	470	200	1,1,1		
2181	358004.632	5283092.488	Yes	419.274	419.237	-0.037	419.231	419.26	419.27	783	-1338	1,1,1		
2190	373724.283	5303804.909	Yes	370.153	370.114	-0.039	370.11	370.113	370.146	477	-2304	1,1,1		
2190A	384812.112	5303528.54	Yes	404.594	404.487	-0.107	404.464	404.495	404.501	396	-1172	1,1,1		
2193	485494.166	5283507.473	Yes	419.803	419.796	-0.007	419.794	419.8	419.803	822	932	1,1,1		
2199	377465.038	5282747.173	Yes	428.714	428.642	-0.072	428.635	428.647	428.648	637	-2414	1,1,1		
2200	429662.947	5283181.871	Yes	415.68	415.633	-0.047	415.615	415.622	415.648	662	831	1,1,1		
2205	456963.097	5295054.316	Yes	404.972	404.876	-0.096	404.849	404.907	404.921	650	-567	1,1,1		
2208	492332.973	5302708.017	Yes	411.31	411.262	-0.048	411.25	411.263	411.263	580	662	1,1,1		
2209	441962.631	5302721.728	Yes	405.731	405.66	-0.071	405.651	405.661	405.68	374	2070	1,1,1		

## Check Points Vertical Accuracy - continued

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Minimum Z	Median Z	Maximum Z	Intensity	Scan Angle Rank	Returns	Description	Comments
2211	463350.504	5277801.755	Yes	425.743	425.721	-0.022	425.713	425.719	425.733	509	1323	1,1,1		
2215	487608.077	5302842.964	Yes	412.844	412.771	-0.073	412.747	412.751	412.774	397	2707	1,1,1		
2220	371135.625	5295841.03	Yes	382.792	382.703	-0.089	382.664	382.693	382.732	385	-942	1,1,1		
2229	335582.873	5292098.901	Yes	394.633	394.608	-0.025	394.599	394.609	394.609	883	-1678	1,1,1		
2229A	340399.785	5291849.923	Yes	406.863	406.878	0.015	406.877	406.878	406.88	527	-849	1,1,1		
2232	402599.751	5271084.375	Yes	399.006	398.995	-0.011	398.989	398.997	398.998	727	616	1,1,1		
2251	383837.963	5276291.998	Yes	408.809	408.861	0.052	408.825	408.853	408.871	500	-930	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.

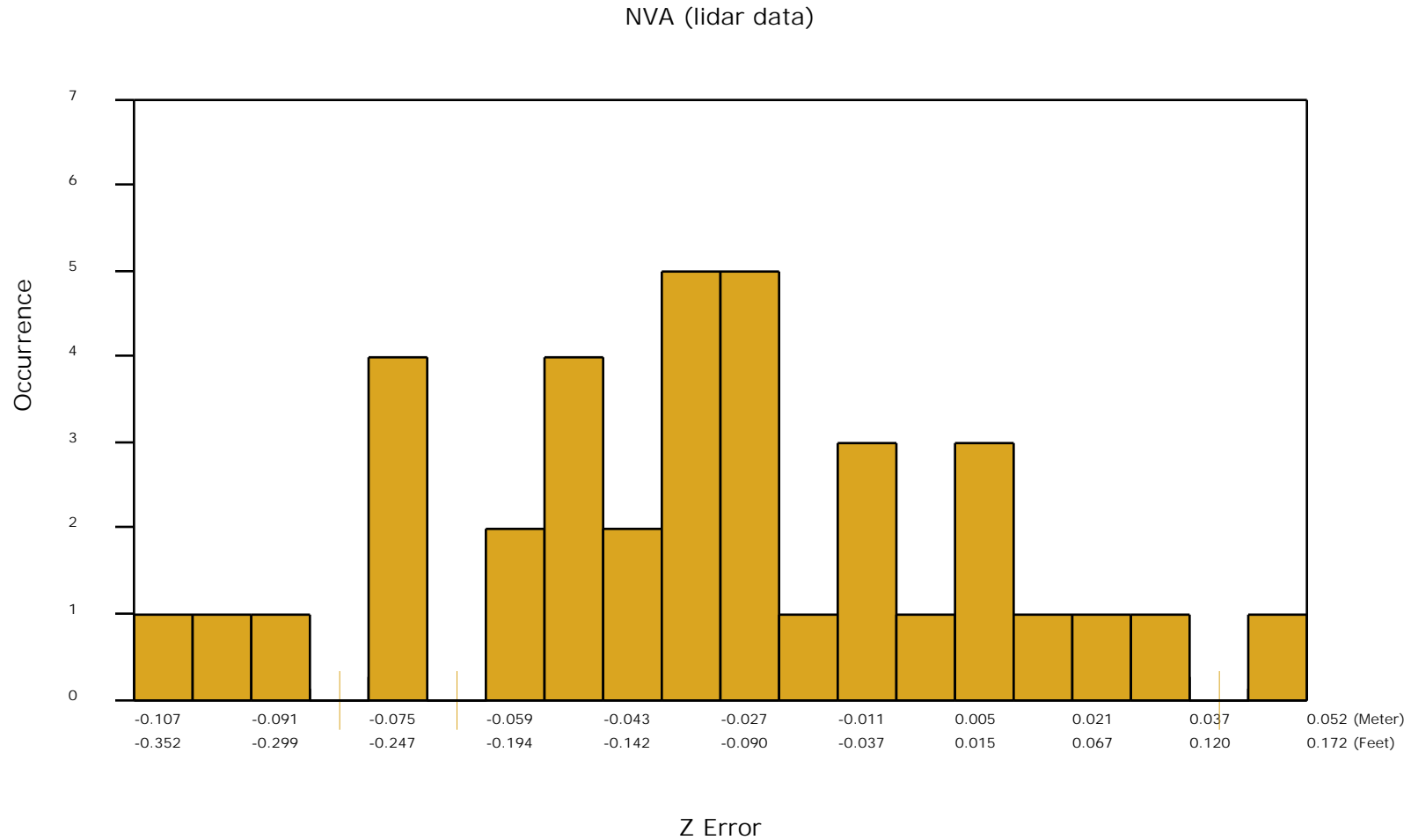
### VVA (lidar data)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Minimum Z	Median Z	Maximum Z	Intensity	Scan Angle Rank	Returns	Description	Comments
2224	363903.269	5301345.132	Yes	379.22	379.147	-0.073	379.128	379.137	379.164	380	556	1,1,1		
3006	481080.38	5294602.191	Yes	429.111	429.156	0.045	429.149	429.15	429.184	800	-1224	1,2,2		
3008	441903.067	5295893.734	Yes	420.179	420.177	-0.002	420.167	420.19	420.212	986	-1067	1,2,1		
3048	335800.934	5274247.901	Yes	433.034	433.133	0.099	433.107	433.12	433.153	644	-145	1,1,1		
3054	414576.299	5275761.332	Yes	405.49	405.5	0.010	405.496	405.501	405.503	247	920	3,3,3		
3057	353282.514	5274651.663	Yes	424.601	424.561	-0.040	424.499	424.563	424.576	282	49	3,5,2		
3067	370865.858	5283562.68	Yes	428.993	428.953	-0.040	428.946	428.966	428.997	1286	1438	1,1,1		
3068	453360.072	5304015.113	Yes	403.162	403.177	0.015	403.164	403.206	403.23	1047	-942	1,1,1		
3085	425650.504	5296511.491	Yes	418.309	418.362	0.053	418.347	418.361	418.381	961	2031	1,1,1		
3087A	392436.01	5303439.419	Yes	413.874	413.867	-0.007	413.821	413.877	413.89	1235	-1058	1,1,1		
3094	405123.455	5286433.618	Yes	421.326	421.421	0.095	421.413	421.43	421.435	754	-1753	1,1,1		
3097	472335.396	5295225.411	Yes	424.16	424.152	-0.008	424.141	424.141	424.155	1303	-298	1,1,1		
3120	350113.546	5291577.874	Yes	411.075	411.238	0.163	411.229	411.238	411.239	607	-219	1,1,3		
3120A	349170.756	5294827.147	Yes	409.05	409.133	0.083	409.123	409.152	409.177	942	1193	1,1,1		
3145	450801.131	5288895.062	Yes	402.775	402.794	0.019	402.77	402.775	402.807	999	-631	1,1,1		
3146	422018.669	5286922.342	Yes	411.66	411.602	-0.058	411.587	411.591	411.607	720	1070	3,1,1		
3147	392697.577	5293580.142	Yes	425.132	425.131	-0.001	425.107	425.132	425.132	891	-1999	1,1,3		
3151	442199.907	5282117.393	Yes	430.673	430.743	0.070	430.741	430.743	430.745	910	-493	2,1,1		
3167	493226.867	5291677.379	Yes	395.142	395.074	-0.068	395.046	395.072	395.081	1043	-1001	1,1,1		
3168	389014.796	5287349.347	Yes	432.842	432.901	0.059	432.871	432.906	432.91	502	1026	2,2,2		
3171	491927.278	5302765.913	Yes	410.753	410.801	0.048	410.772	410.793	410.858	299	1128	3,3,2		
3172	463367.802	5277811.955	Yes	424.971	425.027	0.056	425.011	425.028	425.039	583	1316	2,2,2		
3175	371192.39	5296515.808	Yes	389.462	389.484	0.022	389.472	389.485	389.487	1111	749	1,1,1		
3177	403633.048	5271005.933	Yes	399.569	399.634	0.065	399.625	399.649	399.655	1005	220	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.

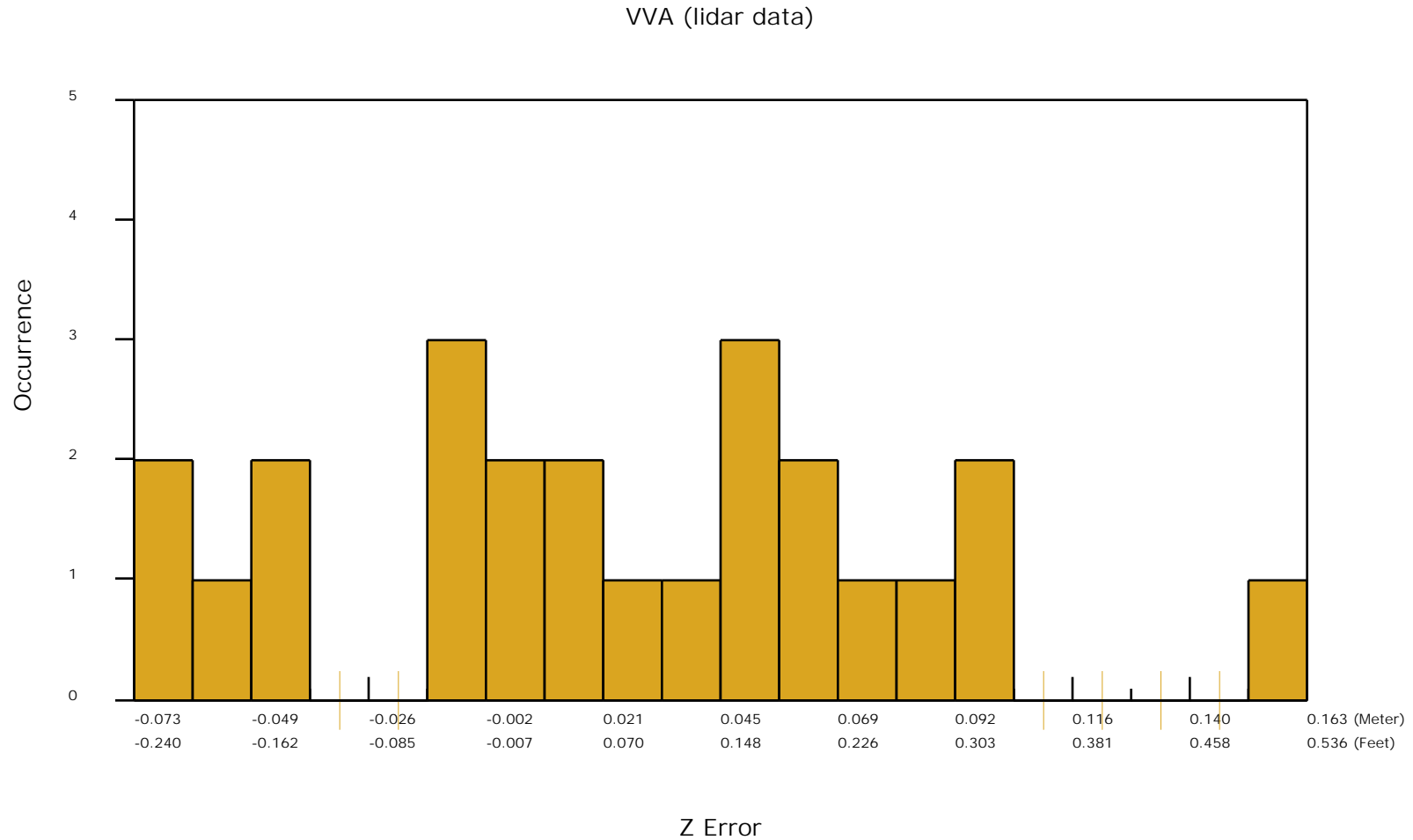
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# DPH-11 Report on Absolute Vertical Accuracy - continued

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.

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## 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
2006	481090.414	5294953.47	Yes	429.179	429.143	-0.036		
2008	441873.64	5295563.611	Yes	420.395	420.343	-0.052		
2050	335805.074	5275136.559	Yes	441.564	441.554	-0.010		
2056	414568.073	5276274.714	Yes	413.718	413.698	-0.020		
2060	353458.261	5273639.988	Yes	427.277	427.263	-0.014		
2062	392075.124	5292938.13	Yes	421.9	421.896	-0.004		
2071	370879.58	5283559.944	Yes	428.625	428.636	0.011		
2072	453084.905	5303547.615	Yes	404.149	404.124	-0.025		
2089	425944.456	5296511.506	Yes	417.58	417.597	0.017		
2099	404980.872	5287868.163	Yes	418.395	418.407	0.012		
2100A	435449.879	5276941.003	Yes	413.54	413.525	-0.015		
2102	474356.413	5294937.1	Yes	421.554	421.505	-0.049		
2117	493563.54	5291632.705	Yes	391.387	391.350	-0.037		
2127	350074.01	5289992.714	Yes	412.964	412.912	-0.052		
2155	450799.892	5287813.412	Yes	402.228	402.174	-0.054		
2156	422008.121	5287793.425	Yes	404.621	404.571	-0.050		
2157	399029.772	5300130.728	Yes	430.233	430.267	0.034		
2157A	392405.97	5303440.737	Yes	414.256	414.222	-0.034		
2161	441900.41	5278919.574	Yes	436.177	436.128	-0.049		
2179	389030.059	5287353.228	Yes	434.269	434.284	0.015		
2180	408042.765	5279034.787	Yes	412.14	412.123	-0.017		
2181	358004.632	5283092.488	Yes	419.274	419.257	-0.017		
2190	373724.283	5303804.909	Yes	370.153	370.144	-0.009		
2190A	384812.112	5303528.54	Yes	404.594	404.495	-0.099		
2193	485494.166	5283507.473	Yes	419.803	419.793	-0.010		
2199	377465.038	5282747.173	Yes	428.714	428.642	-0.072		
2200	429662.947	5283181.871	Yes	415.68	415.621	-0.059		
2205	456963.097	5295054.316	Yes	404.972	404.907	-0.065		
2208	492332.973	5302708.017	Yes	411.31	411.258	-0.052		
2209	441962.631	5302721.728	Yes	405.731	405.664	-0.067		



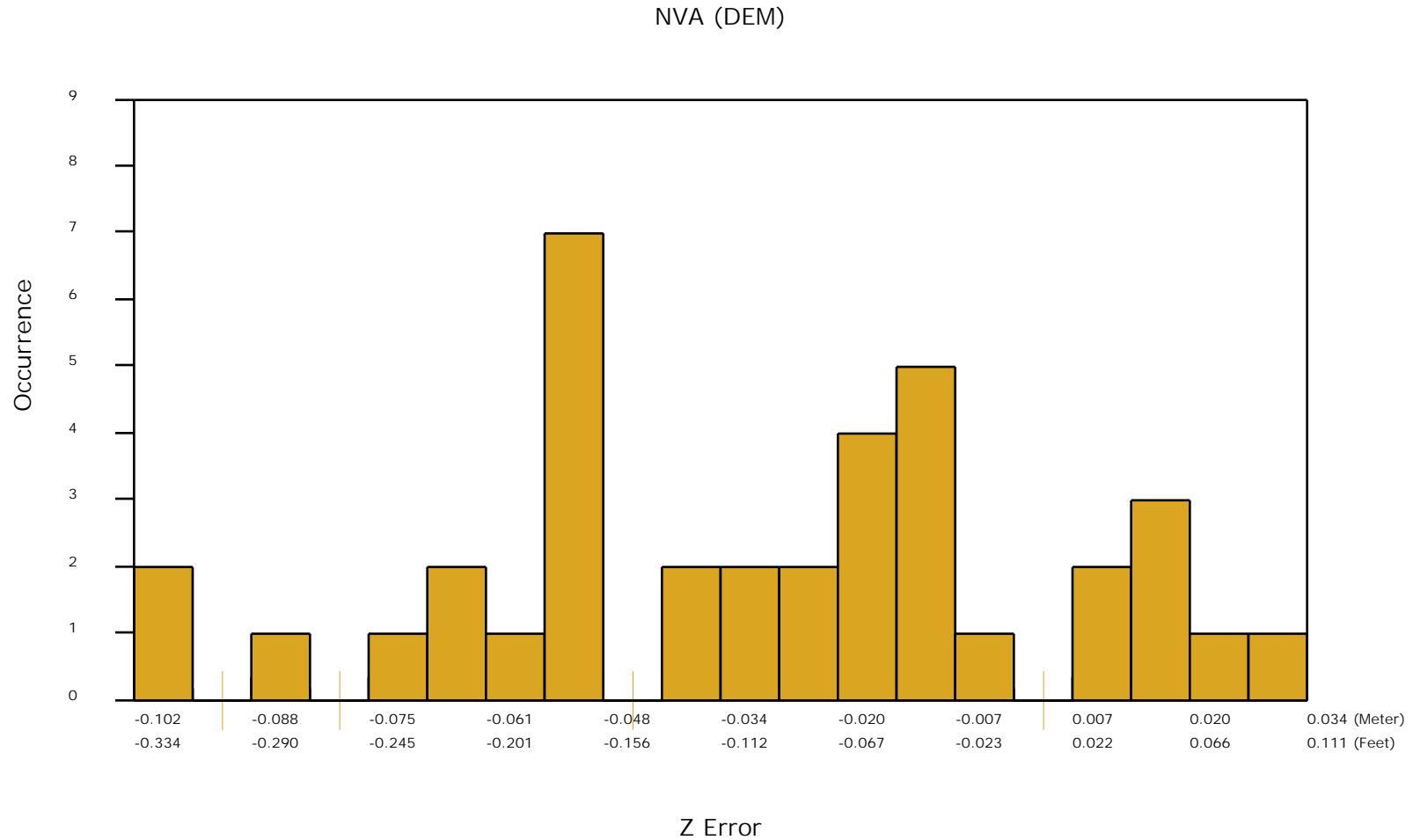
## Check Points Vertical Accuracy - continued

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
2211	463350.504	5277801.755	Yes	425.743	425.712	-0.031		
2215	487608.077	5302842.964	Yes	412.844	412.742	-0.102		
2220	371135.625	5295841.03	Yes	382.792	382.709	-0.083		
2229	335582.873	5292098.901	Yes	394.633	394.606	-0.027		
2229A	340399.785	5291849.923	Yes	406.863	406.880	0.017		
2232	402599.751	5271084.375	Yes	399.006	398.995	-0.011		
2251	383837.963	5276291.998	Yes	408.809	408.831	0.022		

# 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.

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## 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.

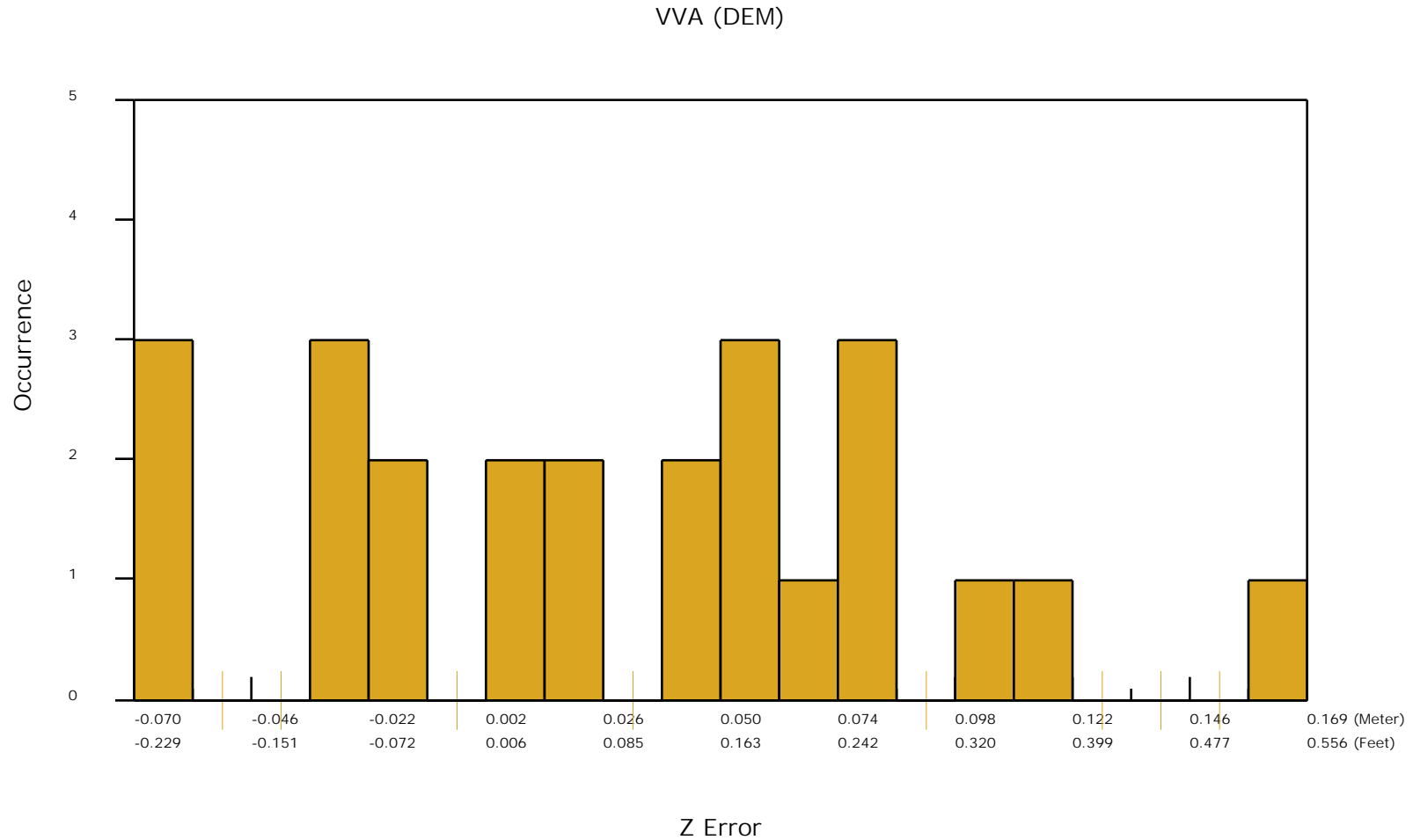
### VVA (DEM)

ID	X	Y	Coverage	Z	Z From Lidar	Z Error	Description	Comments
2224	363903.269	5301345.132	Yes	379.22	379.161	-0.059		
3006	481080.38	5294602.191	Yes	429.111	429.152	0.041		
3008	441903.067	5295893.734	Yes	420.179	420.194	0.015		
3048	335800.934	5274247.901	Yes	433.034	433.139	0.105		
3054	414576.299	5275761.332	Yes	405.49	405.500	0.010		
3057	353282.514	5274651.663	Yes	424.601	424.571	-0.030		
3067	370865.858	5283562.68	Yes	428.993	428.968	-0.025		
3068	453360.072	5304015.113	Yes	403.162	403.147	-0.015		
3085	425650.504	5296511.491	Yes	418.309	418.349	0.040		
3087A	392436.01	5303439.419	Yes	413.874	413.885	0.011		
3094	405123.455	5286433.618	Yes	421.326	421.437	0.111		
3097	472335.396	5295225.411	Yes	424.16	424.144	-0.016		
3120	350113.546	5291577.874	Yes	411.075	411.244	0.169		
3120A	349170.756	5294827.147	Yes	409.05	409.131	0.081		
3145	450801.131	5288895.062	Yes	402.775	402.826	0.051		
3146	422018.669	5286922.342	Yes	411.66	411.595	-0.065		
3147	392697.577	5293580.142	Yes	425.132	425.099	-0.033		
3151	442199.907	5282117.393	Yes	430.673	430.743	0.070		
3167	493226.867	5291677.379	Yes	395.142	395.072	-0.070		
3168	389014.796	5287349.347	Yes	432.842	432.895	0.053		
3171	491927.278	5302765.913	Yes	410.753	410.813	0.060		
3172	463367.802	5277811.955	Yes	424.971	425.048	0.077		
3175	371192.39	5296515.808	Yes	389.462	389.477	0.015		
3177	403633.048	5271005.933	Yes	399.569	399.649	0.080		

# 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 - V:\Mapping\Projects\65221273\\_MN\\_UpperMSRiver\Production\Final\\_Client\\_Deliverables\230958\MN\\_UpperMSRiver\\_2\\_B22\\_300138\point\\_cloud\tilecls](#)

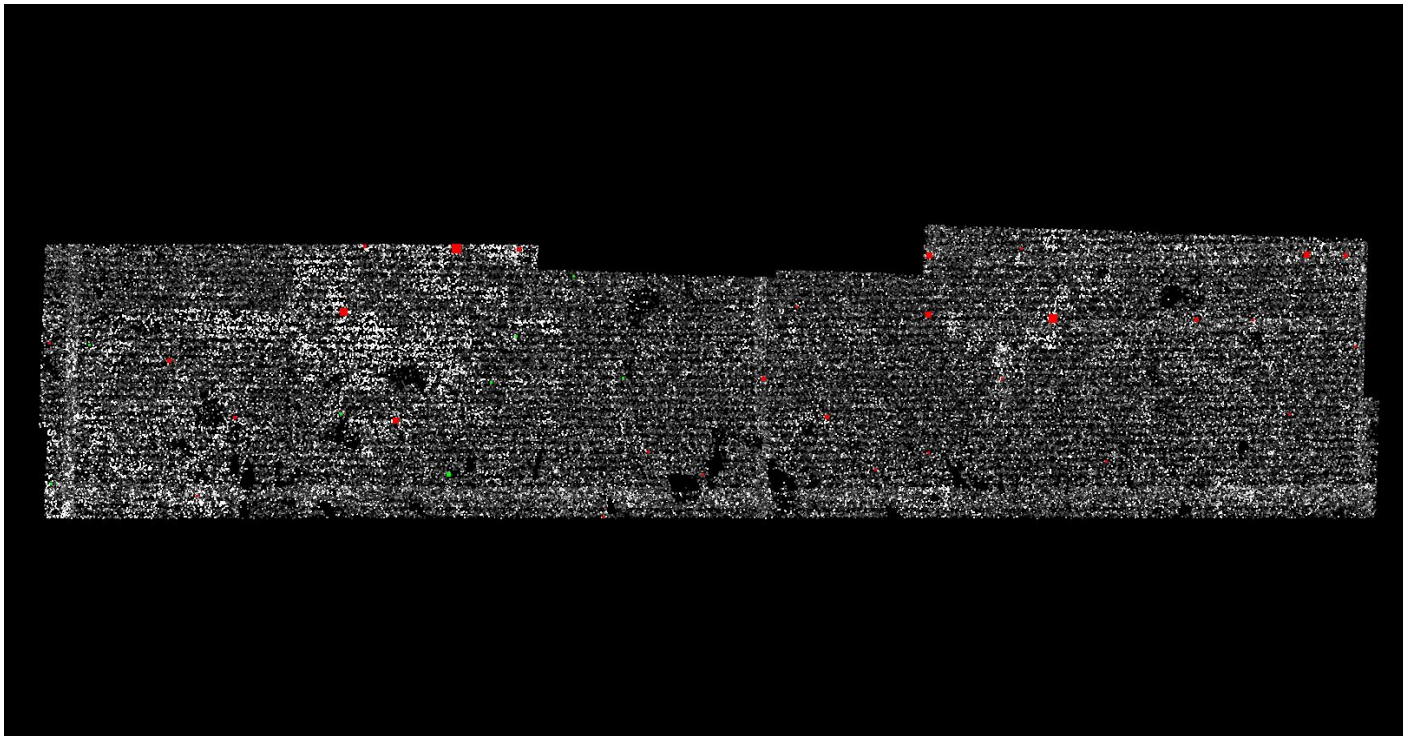


## *DPH-11 Report on Absolute Vertical Accuracy - continued*

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 - Y:\Mapping\Projects\65221273\\_MN\\_UpperMSRiver\Production\Final\\_Client\\_Deliverables\230958\MN\\_UpperMSRiver\\_2\\_B22\\_300138\point\\_cloud\tilecls](Y:\Mapping\Projects\65221273_MN_UpperMSRiver\Production\Final_Client_Deliverables\230958\MN_UpperMSRiver_2_B22_300138\point_cloud\tilecls)

[Result Path - Y:\Mapping\Projects\65221273\\_MN\\_UpperMSRiver\Admin\QA\\_OC\MN\\_UpperMSRiver\\_2\\_B22\\_300138\\_OC\DPH\\_11\ColorByIntensity\\_CheckPoints\\_NVA.jpg](Y:\Mapping\Projects\65221273_MN_UpperMSRiver\Admin\QA_OC\MN_UpperMSRiver_2_B22_300138_OC\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).

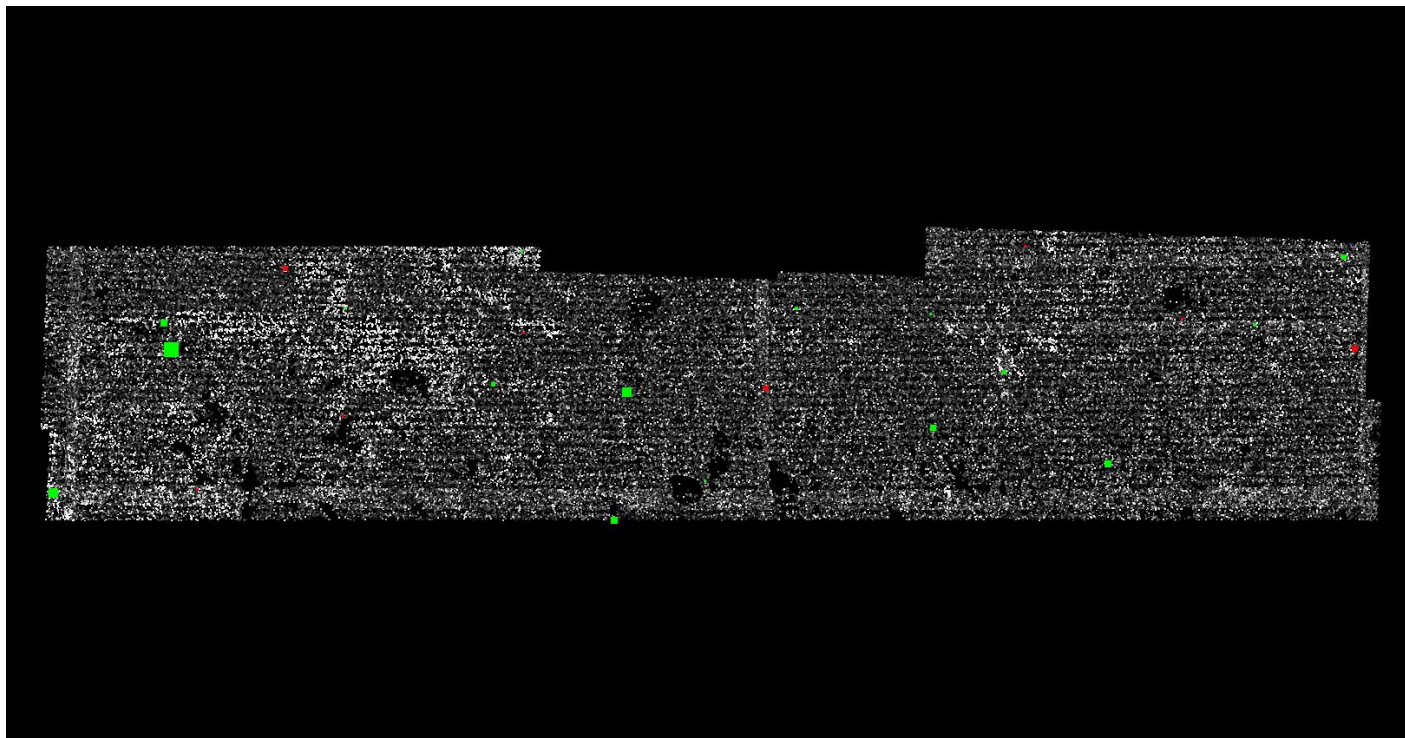
The size of the square symbol represents the absolute value magnitude of error.

## *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 - Y:\Mapping\Projects\65221273\\_MN\\_UpperMSRiver\Production\Final\\_Client\\_Deliverables\230958\MN\\_UpperMSRiver\\_2\\_B22\\_300138\point\\_cloud\tilecls](Y:\Mapping\Projects\65221273_MN_UpperMSRiver\Production\Final_Client_Deliverables\230958\MN_UpperMSRiver_2_B22_300138\point_cloud\tilecls)

[Result Path - Y:\Mapping\Projects\65221273\\_MN\\_UpperMSRiver\Admin\QA\\_OC\MN\\_UpperMSRiver\\_2\\_B22\\_300138\\_OC\DPH\\_11\ColorByIntensity\\_CheckPoints\\_VVA.jpg](Y:\Mapping\Projects\65221273_MN_UpperMSRiver\Admin\QA_OC\MN_UpperMSRiver_2_B22_300138_OC\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.