FEMA Vertical Accuracy Report for Southeast Wisconsin Regional Planning Commission (SEWRPC)

Washington and Waukesha Counties

Quantum Spatial Job #26119

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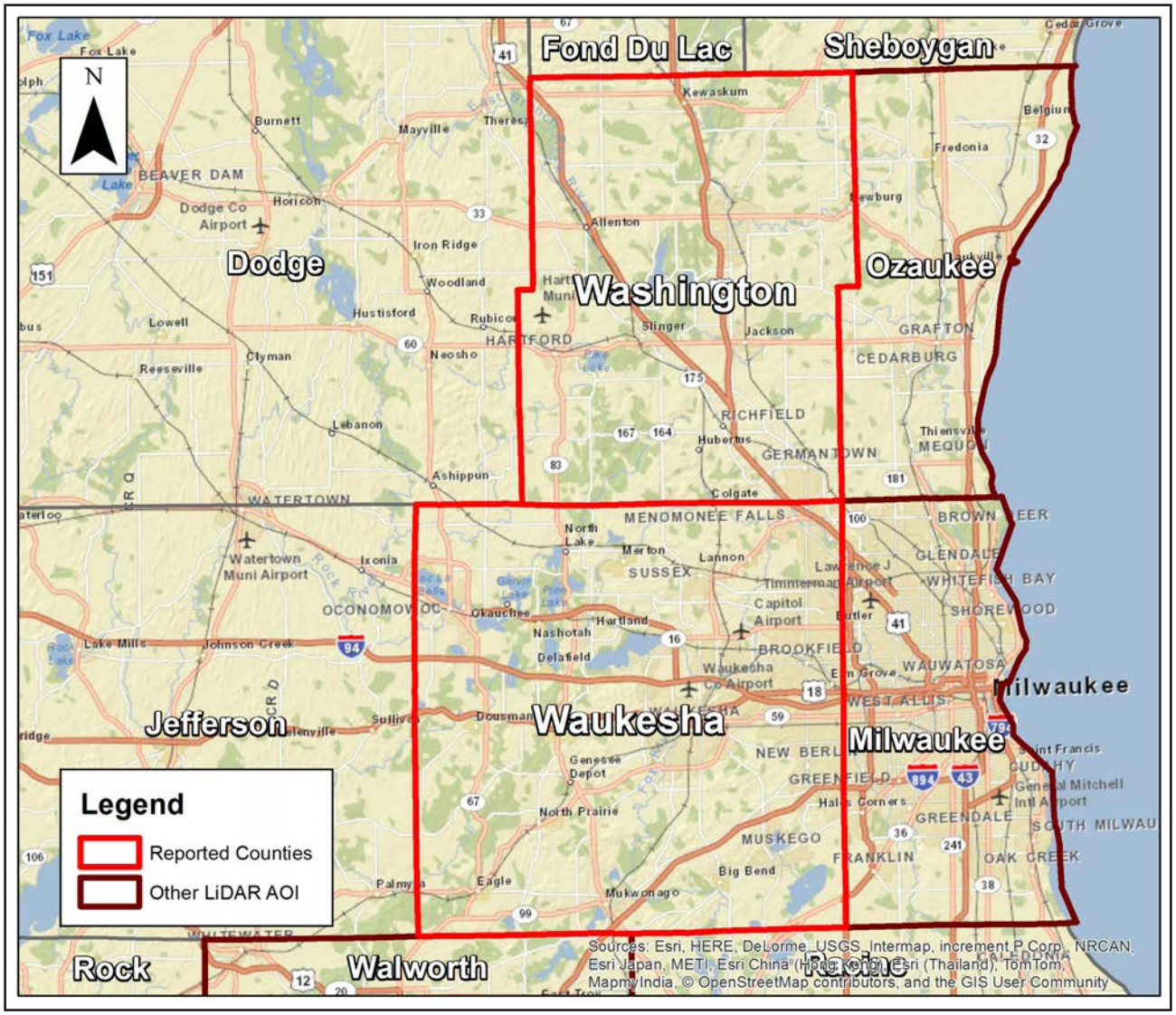
1. Purpose

This document provides information about the accuracy of the SEWRPC 2015 LiDAR dataset. The accuracy values in this report are reflective of only two counties in area of interest: Washington County and Waukesha (Figure 1).

Figure 1. Washington and Waukesha Counties



2. Background

Quantum Spatial's vertical accuracy assessment for the SEWRPC project was carried out in accordance with two distinct methods based on the Root-Mean-Square-Error (RMSE) distribution of the dataset:

- The method defined in the National Standard for Spatial Data Accuracy (NSSDA)[1] guidelines, implemented by the Federal Emergency Management Agency (FEMA)[2], which makes the assumption that all errors follow a normal error distribution.

- The newer method used in the National Digital Elevation Program (NDEP)[3], implemented in the American Society for Photogrammetry and Remote Sensing (ASPRS)[4] which does not assume errors in vegetation categories are follow a normal error distribution.

Comparing the two methods helps determine the amount of systematic errors that may exist in the ground cover categories. Table 1 below summarizes the criteria used to evaluate the vertical data according to each of the two methods.

Table 1. DTM Acceptance Criteria

Organization	Criteria	Acceptable Value
NSSDA and FEMA Guidelines	RMSEz = NSSDA vertical accuracy statistic at 68% confidence level (1.0 x RMSEz)	0.30 ft for all ground cover categories combined
	Accuracyz = NSSDA vertical accuracy statistic at the 95% confidence level (1.96 x RMSEz)	0.60 ft (RMSEz x 1.9600) for all ground cover categories combined
	Fundamental Vertical Accuracy (FVA) in open terrain only = 95% confidence level	0.60 ft (RMSEz x 1.9600) for open terrain only
NDEP and ASPRS Guidelines	Supplemental Vertical Accuracy (SVA) in individual ground cover categories = 95% confidence level	0.60 ft (based on 95th percentile per category; this is a target value only, not mandatory)
	Consolidated Vertical Accuracy (CVA) in all ground cover categories combined = 95% confidence level	0.60 ft (based on combined 95th percentile)

3. Checkpoint Collection

The organizations included in each method of testing specify different checkpoint collection parameters. NSSDA and FEMA require a minimum of 20 checkpoints each in at least 3 different ground cover categories representative of the area of interest. NDEP and ASPRS require a minimum of 60 checkpoints, but prefer up to 100.

To meet both of these requirements, Quantum Spatial collected a total of 127 checkpoints in 5 different land cover categories:

- Bare Earth
- Tall Weeds
- Brush
- Forested
- Urban Areas

4. Testing Methodology

4.1. Process Overview

Quantum Spatial tested the digital vertical data using the following steps:

1. Ground survey personnel collected and processed GPS data for each of the ground cover checkpoints. These points were distributed throughout ground cover category areas within the project limits.

2. The checkpoints were compared to the digital vertical data using the TerraSolid, LTD program TerraScan. The program creates a TIN surface from the digital vertical data and computes vertical differences between the surface and the surveyed checkpoints. An output file records the vertical differences and associated statistics.

3. The results were analyzed by Quantum Spatial to assess the quality of the data. The overall descriptive statistics of each dataset were computed to assess any tendencies or inconsistencies.

The following sections further explain the testing methods used, and the standards for checkpoint collection and testing required with each method. Results are shown in the corresponding figures and tables.

4.2. Vertical Accuracy Testing: NDEP and ASPRS

The required Fundamental Vertical Accuracy (FVA) and the optional Supplemental Vertical Accuracy (SVA) and Consolidated Vertical Accuracy (CVA) are specified by the NDEP and ASPRS guidelines.

FVA determines how well the digital data was collected in open-terrain-type ground cover where all errors are presumed to be random.

For this project, FVA is calculated using only the checkpoints in the bare earth ground cover category. The digital data in this category is most likely to represent the actual ground surface (open terrain) and the random errors will follow a normal error distribution. The FVA shows how well the photogrammetric process used to produce the digital vertical data represents the actual ground. With a normal error distribution, the vertical accuracy at the 95% confidence level is computed as the vertical root mean square error (RMSEz) of the checkpoints x 1.9600, as specified in Appendix 3-A of the NSSDA guidelines.

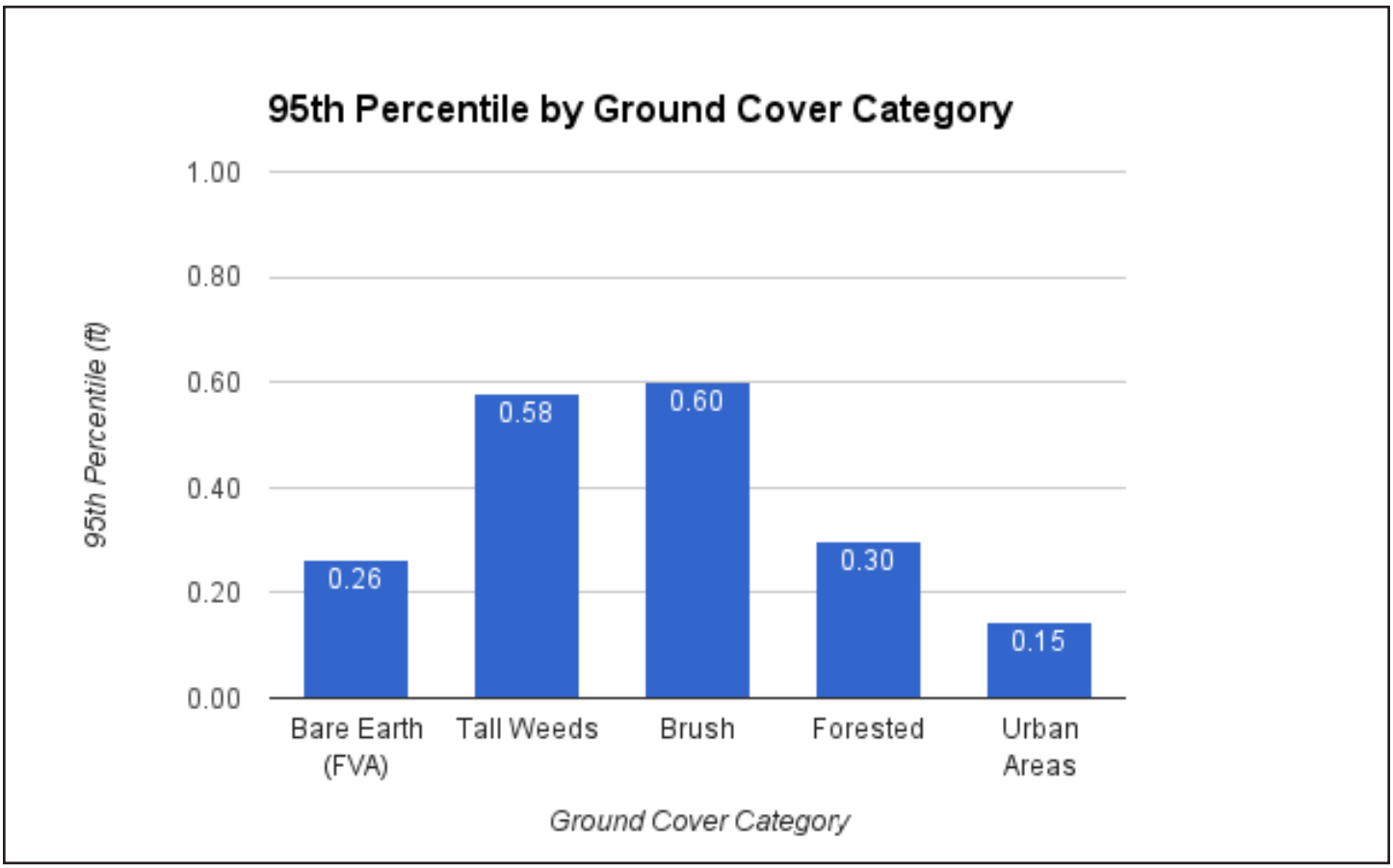
SVA tests how well the digital data represents the actual ground in each of the ground cover categories.

SVA computed for each ground cover category separately. There is a possibility that the digital vertical data may yield errors that do not follow a normal error distribution. Systematic errors per

ground cover category are identified. For each category, the SVA at the 95% confidence level equals the 95th percentile error for all checkpoints in each individual ground cover category.

Figure 2 illustrates the SVA values calculated for each ground cover category.

Figure 2. SVA Values per Ground Cover Category



CVA determines the accuracy of all the ground categories combined in one test. It is calculated with all the checkpoints in all the ground cover categories combined. There is a possibility that the digital vertical data may yield errors that do not follow a normal distribution. CVA at the 95% confidence level equals the 95th percentile error for all checkpoints in all ground cover categories combined.

Table 2 summarizes the results of FVA, SVA, and CVA testing for this dataset. The digital vertical data for this project meets all mandatory and target specifications of 0.5 feet RMSEz.

Table 2. FVA, CVA, and SVA Accuracies at the 95% Confidence Level

Ground Cover Category	# of Points	FVA	CVA	SVA
Bare Earth	37	0.264 ft	-	-
Tall Weeds	22	-	-	0.577 ft
Brush	21	-	-	0.603 ft
Forested	23	-	-	0.299 ft
Urban Areas	24	-	-	0.145 ft
Total Combined	127	-	0.475 ft	-

4.3. Vertical Accuracy Testing: NSSDA and FEMA

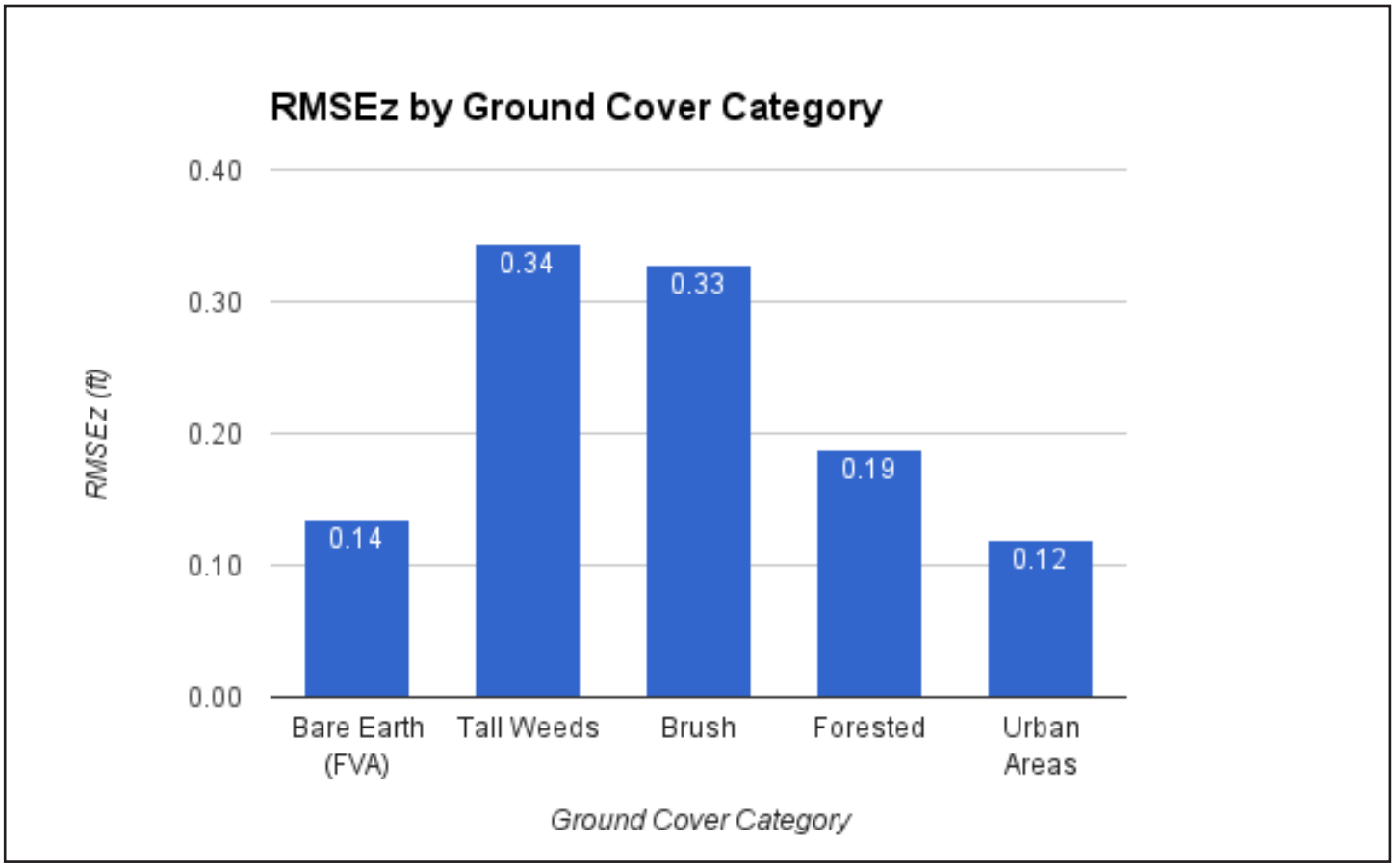
The NSSDA and FEMA guidelines were both published before it was recognized that digital data errors do not always follow a normal error distribution. Future changes to these guidelines are expected to follow those of the NDEP and ASPRS. In order to comply with FEMA's current requirements, RMSEz and other statistics were computed in all five ground cover categories, individually and combined.

Table 3 shows a breakdown of the overall descriptive statistics by ground cover. Figure 3 depicts a graphical representation of the RMSEz values listed in Table 3.

Table 3. Overall Descriptive Statistics by Ground Cover Category

Ground Cover Category	# of Points	Mean *(ft)*	Median *(ft)*	Min. *(ft)*	Max. *(ft)*	RMSEz *(ft)*	Std. Dev. *(ft)*	Skew
Bare Earth	37	0.00	0.01	-0.276	0.292	0.135	0.136	0.05
Tall Weeds	22	0.23	0.21	-0.314	0.968	0.344	0.266	0.63
Brush	21	0.18	0.14	-0.286	0.985	0.328	0.279	1.12
Forested	23	0.08	0.05	-0.126	0.540	0.188	0.173	0.85
Urban Areas	24	-0.05	-0.06	-0.245	0.170	0.120	0.111	0.43
Consolidated	127	0.08	0.05	-0.314	0.985	0.230	0.218	1.36

Figure 3. RMSEz Statistics by Ground Cover Category



5. Conclusion

The vertical accuracy testing methods derived from the NSSDA/FEMA and NDEP/ASPRS guidelines, when applied to the Washington and Waukesha County project, verify that the digital vertical data provided by Quantum Spatial is well suited for the production of 1 ft contours.

- Per NSSDA/FEMA guidelines:
  RMSEz x 1.9600 = 95% confidence level 0.135 x 1.9600 = 0.264 ft

- Per NDEP/ASPRS guidelines:
  95th percentile (CVA) = 95% confidence level = 0.475 ft

Both of the 95% confidence level test results exceed the required 0.5 ft accuracy level.

6. Acronyms

ASPRS: American Society of Photogrammetry and Remote Sensing

CVA: Consolidated Vertical Accuracy

FEMA: Federal Emergency Management Agency

FVA: Fundamental Vertical Accuracy

NDEP: Natioanl Digital Elevation Program

NSSDA: National Standard for Spatial Data Accuracy

RMSE: Root Mean Square Error

RMSEz: Vertical Root Mean Square Error

SVA: Supplemental Vertical Accuracy

7. References

1. Part 3: National Standards for Spatial Data Accuracy (NSSDA), "Geospatial Positioning Accuracy Standards," published by the Federal Geographic Data Committee (FGDC), 1998

2. Appendix A, Guidance for Aerial Mapping and Surveying, "Guidelines and Specifications for Flood Hazard Mapping Partners," published by the Federal Emergency Management Agency (FEMA), April 2003

3. Guidelines for Digital Elevation Data, Version 1.0, published by the National Digital Elevation Program (NDEP), May 2004

4. ASPRS Guidelines, Vertical Accuracy Reporting for Lidar Data, published by the American Society for Photogrammetry and Remote Sensing (ASPRS), May 2004