LiDAR Quality Assurance (QA) Report
Williamsburg County, South Carolina
March 12, 2009

Submitted to:
USGS
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EXECUTIVE SUMMARY

Reference: USGS Contract 07CRCN0004, Task Order 07004C0009, South Carolina 16 County LiDAR, dated January 17, 2008.

This report documents Dewberry's actions to quality assure the LiDAR deliverables of Williamsburg County, SC, produced by Dewberry's subcontractor, Fugro EarthData, under the referenced USGS task order. The LiDAR data was acquired in January of 2008 and delivered as LiDAR LAS point cloud data in five ASPRS LAS classes (class 1 = non-ground; class 2 = ground; class 8 = intelligently-thinned model key points; class 9 = water; and class 12 = overlap points not used in other classes). The LiDAR data was determined to be of excellent quality.

Completeness: Dewberry verified the completeness of the classified LiDAR points, intensity images, and an ESRI geodatabase containing a terrain (triangulated irregular network) and ground masspoints. Hydrographic breaklines were delivered separately by watershed. Dewberry verified that the high density mass point data has an average point spacing less than 1.4m, that 1152 tiles (each 5000 ft x 5000 ft) were delivered covering all of Williamsburg County, that all data was delivered in the correct file format and projected to the South Carolina State Plane Coordinate System in International feet, NAD83 HARN, with elevations in meters, NAVD88; and that the FGDC-complaint metadata satisfies project requirements.

Quantitative: Using checkpoints surveyed by the South Carolina Geodetic Survey, Dewberry tested the RMSEz, Fundamental Vertical Accuracy (FVA) in open terrain, Consolidated Vertical Accuracy (CVA) in all land cover categories, and Supplemental Vertical Accuracy (SVA) in each of three major land cover categories per FEMA requirements, and the accuracy easily surpassed the specified accuracy required, as summarized below, when tested per FEMA, NSSDA, NDEP and ASPRS guidelines.

Criterion	Checkpoints Required	Checkpoints Used	Accuracy Specification	Results Achieved
RMSEz	60	107	18.5 cm	8.4 cm
FVA	20	28	36.3 cm	15.8 cm
CVA	60	107	36.3 cm	14.1 cm
SVA-bare earth	20	28	36.3 cm	13.0 cm
SVA-vegetated	20	49	36.3 cm	13.8 cm
SVA-urban	20	30	36.3 cm	15.1 cm

Qualitative: Dewberry visually inspected 100% of the data; no remote-sensing data voids were found and the data is free of major systematic errors. The cleanliness of the bare earth model meets expectations; minor errors were found in less than 2% of the data, including negligible flight line ridges. All of the deliverables extend to the county boundaries where adjoining counties are not delivered; and where adjoining counties are delivered there is no clipping of the tiles.

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QA REPORT

1 Introduction

The following definitions are provided to distinguish between steps taken by Dewberry, as prime contractor, to provide Quality Assurance (QA) of the LiDAR data produced by Fugro EarthData, and steps taken by Fugro EarthData, as data producer, to perform Quality Control (QC) of the data that it provides to Dewberry. Collectively, this QA/QC process ensures that the LiDAR data delivered to USGS and its client (South Carolina Department of Natural Resources) are accurate, usable, and in conformance with the deliverables specified in the Scope of Work. These definitions are taken from the DEM Quality Assessment chapter of the 2nd edition of "Digital Elevation Model Technologies and Applications: The DEM Users Manual," published by the American Society for Photogrammetry and Remote Sensing (ASPRS), 2007:

> **Quality Assurance (QA)** — Steps taken: (1) to ensure the end client receives the quality products it pays for, consistent with the Scope of Work, and/or (2) to ensure an organization's Quality Program works effectively. Quality Programs include quality control procedures for specific products as well as overall Quality Plans that typically mandate an organization's communication procedures, document and data control procedures, quality audit procedures, and training programs necessary for delivery of quality products and services.

> **Quality Control (QC)** — Steps taken by data producers to ensure delivery of products that satisfy standards, guidelines and specifications identified in the Scope of Work. These steps typically include production flow charts with built-in procedures to ensure quality at each step of the work flow, in-process quality reviews, and/or final quality inspections prior to delivery of products to a client.

Dewberry's role is to provide overall project management as well as quality management that include QA of the data including a completeness validation of the LiDAR masspoints, vertical accuracy assessment and reporting, and a qualitative review of the derived bare earth surface. In addition, Dewberry provides an extensive review of other derived products such as 3D streamlines, TIN-terrain, and LiDAR intensity images.

First, the completeness verification is conducted at a project scale (files are considered as the entities) for all products. It consists of a file inventory and a validation of conformity to format, projection, and georeference specifications. At this point Dewberry also ensures that the data adequately covers the project area for all products. The LiDAR data review begins with the computation of general statistics over all fields per file, followed by an analysis of the results to identify anomalies, especially in the elevation fields and LAS class fields.

The quantitative analysis addresses the quality of the data based on absolute accuracy of a limited collection of discrete checkpoint survey measurements. Although only a small amount of points are actually tested through the quantitative assessment, there is an increased level of confidence with LiDAR data due to the relative accuracy. This relative accuracy in turn is based on how well one LiDAR point "fits" in comparison to surrounding LiDAR measurements as acquisition conditions remain similar from one point to the next.

To fully address the LiDAR data for overall accuracy and quality, a manual qualitative review for anomalies and artifacts is conducted on each tile. This includes creating pseudo-image products such as 3-dimensional models. The QA analyst uses multiple images and using overlays to find potential errors in the data as well as areas where the data meets and exceeds expectations.

Three fundamental questions are addressed during Dewberry's QA process:

- Was the data complete?
- Did the LiDAR system perform to specifications?
- Did the ground classification process yield desirable results for the intended bare-earth terrain product?

Under the referenced task order, LiDAR data was acquired for 16 counties in South Carolina (Figure 1). This report focuses on the deliverables covering Williamsburg County that are directly derived from the LiDAR. The hydrolines, derived from the LiDAR, are being delivered per watershed and thus will be discussed in a subsequent report. All quality assurance processes and results are given in the following sections.

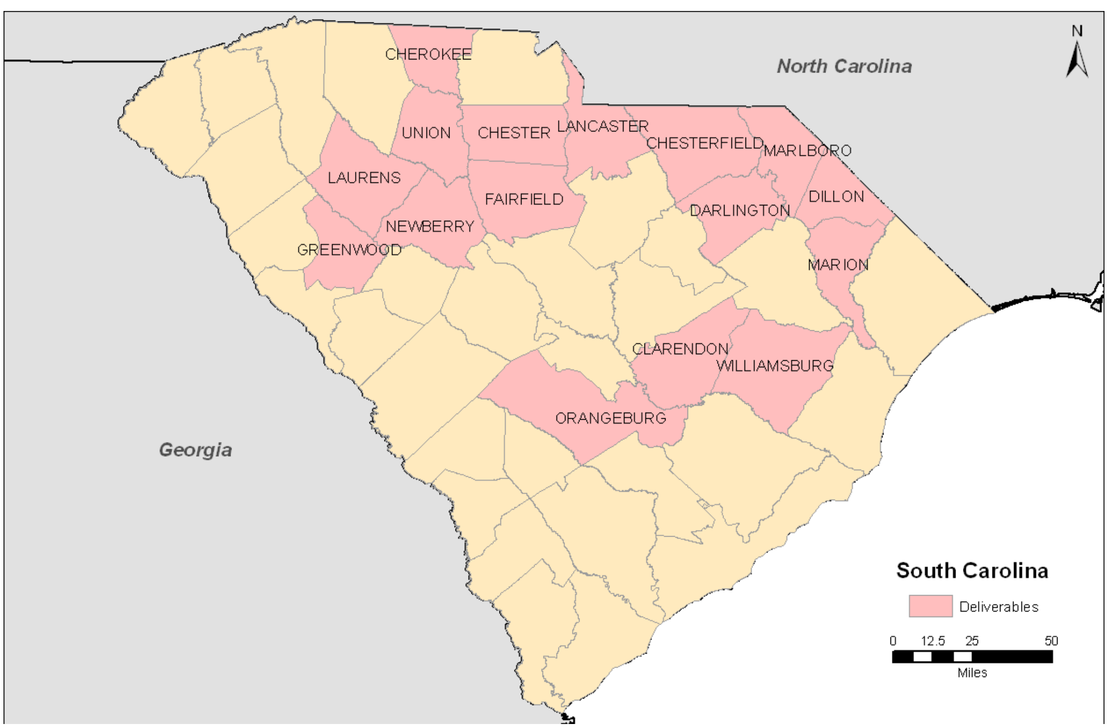

Figure 1 *– Project area; the 16 deliverable counties for the South Carolina project are shown in pink.*

2 Completeness of deliverables

Dewberry reviews the inventory of the data delivered by validating the format, projection, and georeferencing. County based deliverables are listed in **Table 1**.

Table 1 - County deliverables.

Dataset	Format	Spatial
LiDAR	LAS	Tiled
Intensity images	GeoTiff	Tiled
Terrain (bare earth)	ESRI feature class Terrain	1feature class
Ground masspoints	ESRI feature class multipoints	1feature class
Boundary	ESRI geodatabase feature class - polygons	3 feature classes (county/tile/LiDAR)

Clipping of the data along the county boundary was performed according to the following rules (Figure 2):

- a partial tile is delivered at the boundary with a county that is not part of the project,
- a full tile is delivered at the boundary with a county that is part of the project

LAS files and intensity images were delivered in tiles that adhere to these rules and to the State of South Carolina's 5000 ft x 5000 ft tile schema (see Figure 3). The LAS, the ground masspoint feature class, terrain, and intensity images extend outside the project boundary with a 50 ft buffer (Figure 4 and Figure 5) as expected.

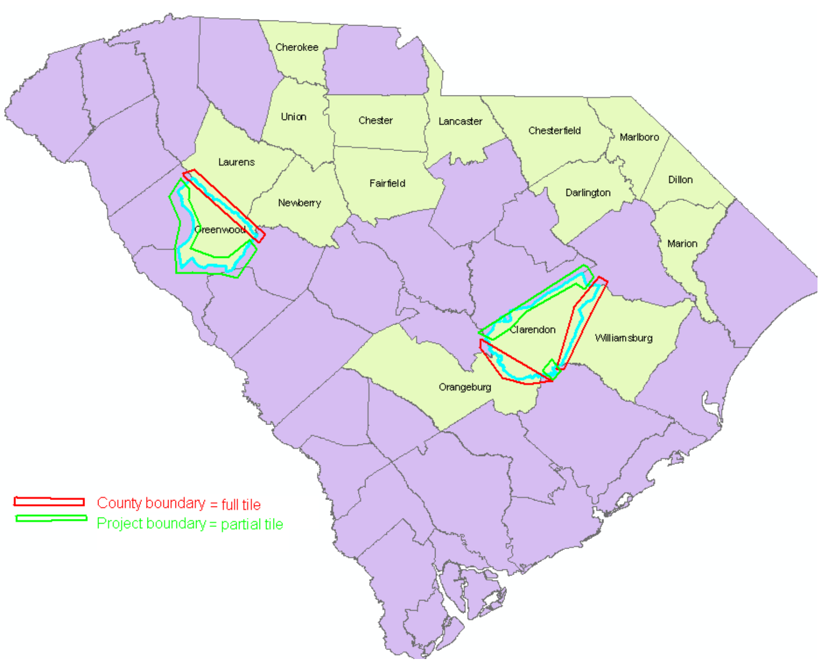

Figure 2 *– Convention used for the tile coverage: at the boundary of a county that is not part of the project, a partial tile is delivered; at the boundary of a county that is part of the project, a full tile is delivered.*

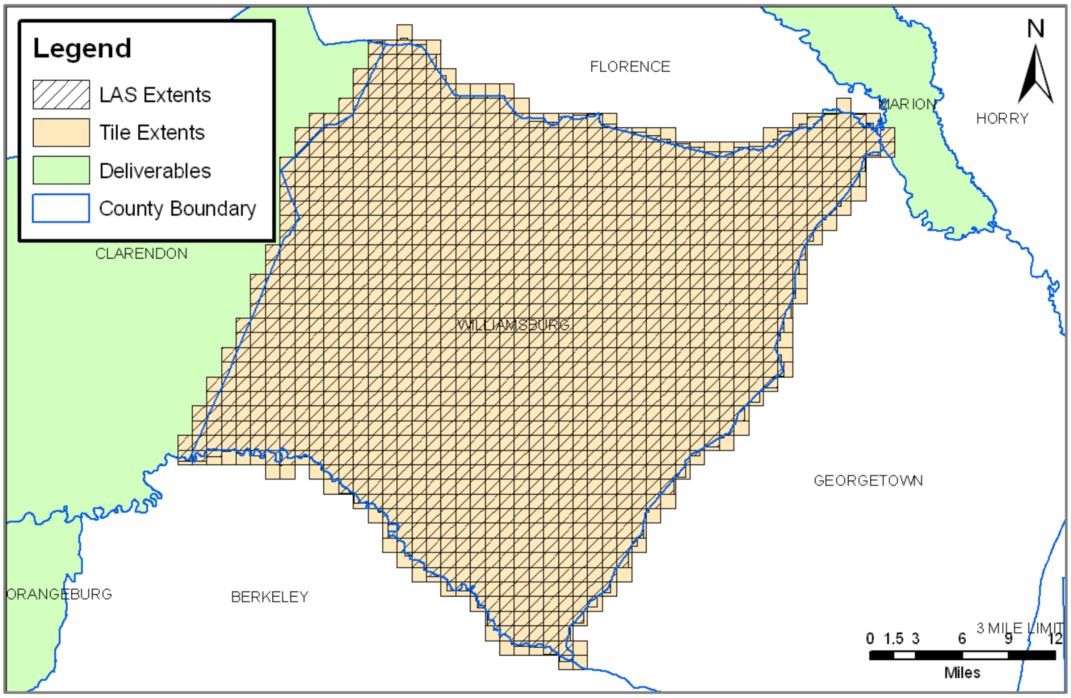

Figure 3 *– The LiDAR coverage of Williamsburg County. Neighboring deliverable counties are shown in green.*

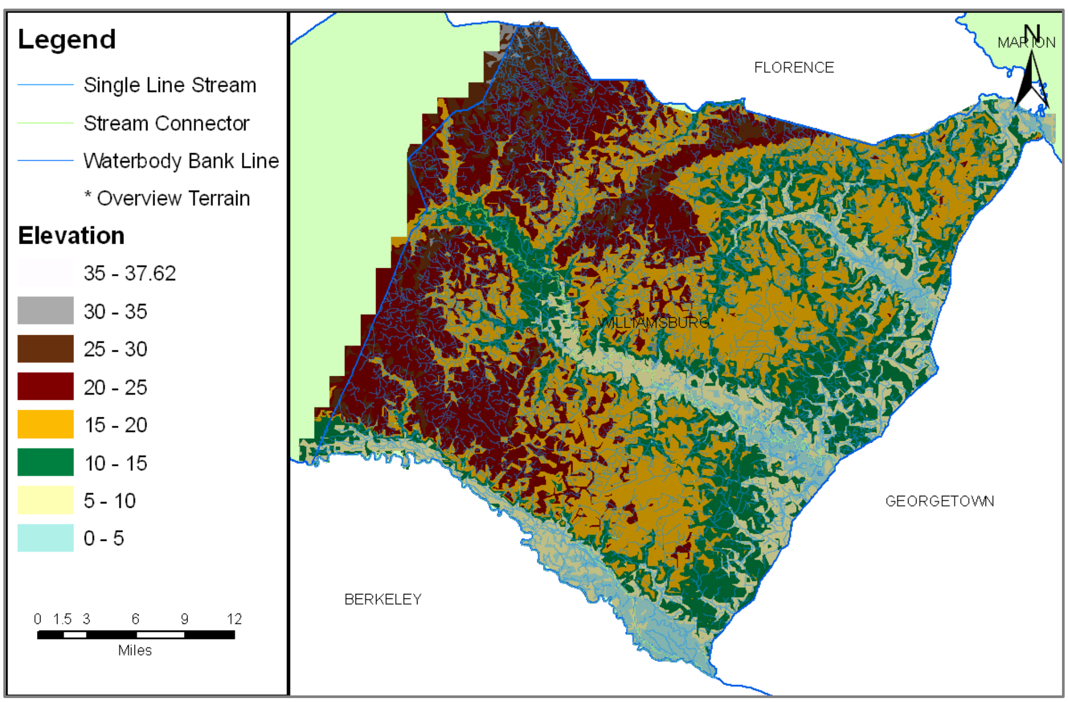

Figure 4 *– The terrain for Williamsburg has a 50 ft buffer outside of the project boundary.*

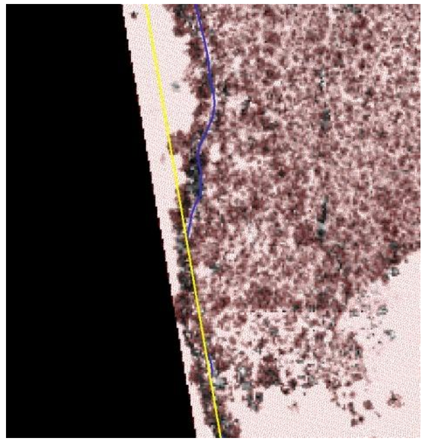

Figure 5 *- Ground masspoints (red) and intensity images extend 50 feet outside the project boundary in yellow. The LAS and terrain do the same. Hydrolines are clipped at the project boundary and the watershed boundary.*

3 QA of intensity images

1152 intensity images in GeoTiff format were delivered for Williamsburg County. An automated script was used to validate that intensity values are integers ranging between 0 and 255, that the cell size is 4 ft, and that the column and row count is 1250. 1250 multiplied by 4 (the pixel size in feet) equals 5000 feet which is the required size of the tiles: 5000 ft x 5000 ft. Another automated script was used to validate the header information on all of the GeoTiffs. There were no issues with these checks. An example of the header is shown in Table 2.

Table 2 – Intensity header.

File Name: 2670-01.tif	Geotiff_Information:
File Information:	Version: 1
Standard : : TIFF File	Key_Revision: 1.0
Format : : Byte integers (8 bits)	Tagged_Information:
Pixels per Line : 1250	ModelTiepointTag (2,3):
Number of Lines : 1250	0 0 0
Samples per pixel : 1	2270000 610000 0
File bits per sample : 8	ModelPixelScaleTag (1,3):
Actual bits per sample : 8	4 4 0
Untiled file	End_Of_Tags.
Number of overviews : 0	Keyed_Information:
Scanning device resolution : 72 : lines/inch	GTModelTypeGeoKey (Short,1): ModelTypeProjected
Orientation : 4 : Row major order, origin at top left	GTRasterTypeGeoKey (Short,1): RasterPixelIsArea
NO scan line headers : non-scannable file	ProjectedCSTypeGeoKey (Short,1): Unknown-3361
Packet size (16-bit words) : 0	ProjLinearUnitsGeoKey (Short,1): Linear_Foot
Free vlt space (16-bit words) : 2000000000	End_Of_Keys.
Free packet space (16-bit words) : 2000000000	End_Of_Geotiff.
Raster to UOR matrix:	PCS = 3361 (name unknown)
Unspecified or All Zero Matrix	Projection Linear Units: 9002/foot (0.304800m)
Raster to World Matrix:	Corner Coordinates:
Units: Feet	Upper Left (2270000.000, 610000.000)
amx[0]= 4, amx[1]= 0, amx[2]= 2270000	Lower Left (2270000.000, 605000.000)
amx[3]= 0, amx[4]= -4, amx[5]= 610000	Upper Right (2275000.000, 610000.000)
2270000 , 610000	Lower Right (2275000.000, 605000.000)
2275000 , 610000	Center (2272500.000, 607500.000)
2275000 , 605000	
2270000 , 605000	

Dewberry also visually checked the tile-matching in ArcMap. Overall, the intensity is consistent between adjacent tiles. Tiles over the boundary between two delivered counties are delivered in full for each county. Tiles over the outside project boundary are partial; the section outside the buffered project area is filled with black pixels (value 0).

4 Metadata

Dewberry verified the metadata and all of the xml files were FGDC compliant. Metadata is delivered for the project, terrain, intensity images, and the LAS.

5 LiDAR QA

5.1 Completeness

5.1.1 LAS inventory

Dewberry received 1152 LiDAR files covering the Williamsburg County area. They are in the correct format and projection:

- LAS version: 1.1
- Point data format: 1
- Projection set in the header:
  - NAD_1983_HARN_StatePlane_South_Carolina_FIPS_3900_Feet_Intl;
  - Horizontal unit: linear feet;
  - NAVD88 - Geoid03;
  - Vertical unit: meters

The point spacing matches the requirement of an average point spacing of 1.4 meters.

Each record includes the following fields:

- XYZ coordinates
- Flight line
- Intensity
- Return number, number of return, scan direction, edge of a flight line and scan angle
- Classification:
  - class 1 for non-ground,
  - class 2 for ground (must be combined with class 8 to be complete),
  - class 8 for (intelligently-thinned) model key points,
  - class 9 for water,
  - class 12 for overlap
- GPS time (this is expressed in second of the week; note that the date of collection will be given in the metadata file because the date contained in the LAS header is the file creation date according to LAS standard)

5.1.2 Statistical analysis of LAS tile content

To verify the content of the data and to validate the data integrity, a statistical analysis was performed on all the data. This process allows Dewberry to statistically review 100% of the data to identify any gross outliers. This statistical analysis consists of:

1. Extracting the header information

2. Reading the actual records and computing the number of points, minimum, maximum and mean elevation for each class. Minimum and maximum for other relevant variables are also evaluated.

Each tile was queried to extract the number of LiDAR points. With a nominal point spacing of less than 1.4m, the number of points per tile should be around 3.9 million. The mean in Williamsburg County is around 5.2 million which proves that the average density is more than what is required. All tiles are within the anticipated size range except for where fewer points are expected (near the external project boundary where tiles are clipped or over large rivers and lakes) as illustrated in Figure 6.

To first identify incorrect elevations, the z-minimum and z-maximum values for the ground class were reviewed. With maximum values between 3.7m and 37.3m, no noticeable anomalies were identified because this is consistent with the expected range of elevation in the county. Figure 7 (right) shows the spatial distribution of these elevations, following the anticipated terrain topography. Lower elevations are found near hydrographic features; see Figure 7 (left) for the Z min elevations.

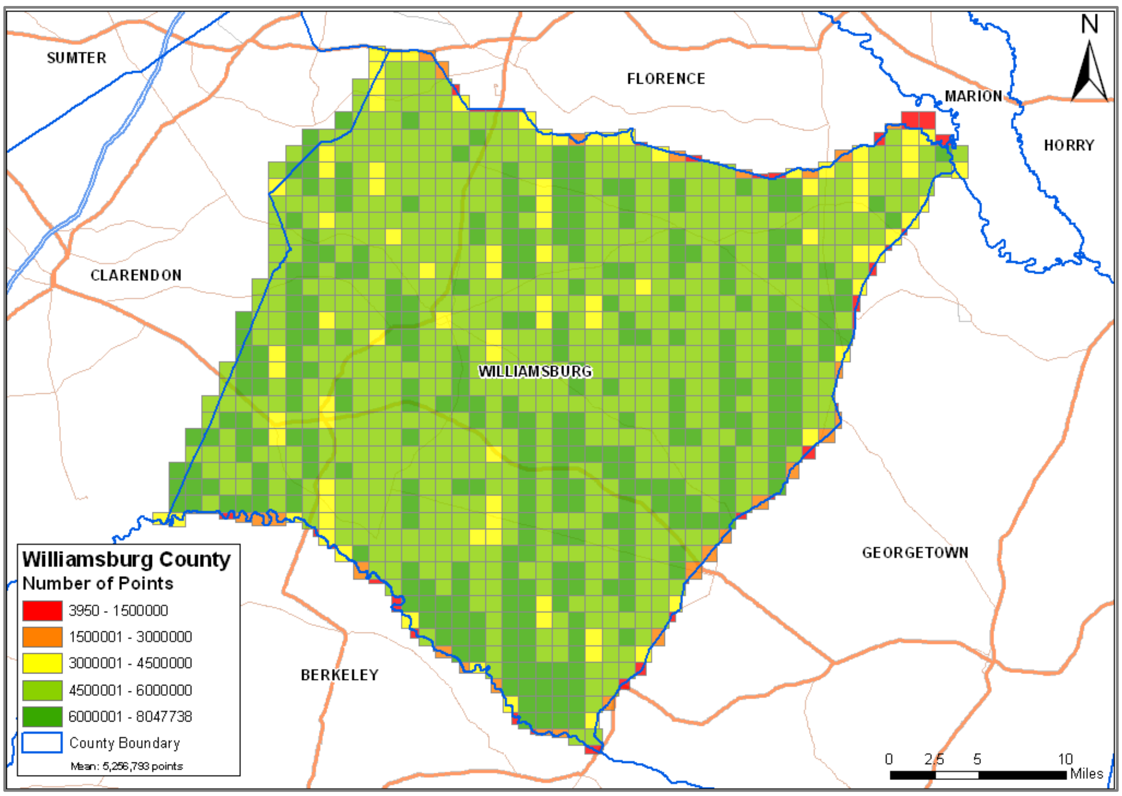

Figure 6 *– Number of points per tile. The red tiles at the border are expected to have fewer points.*

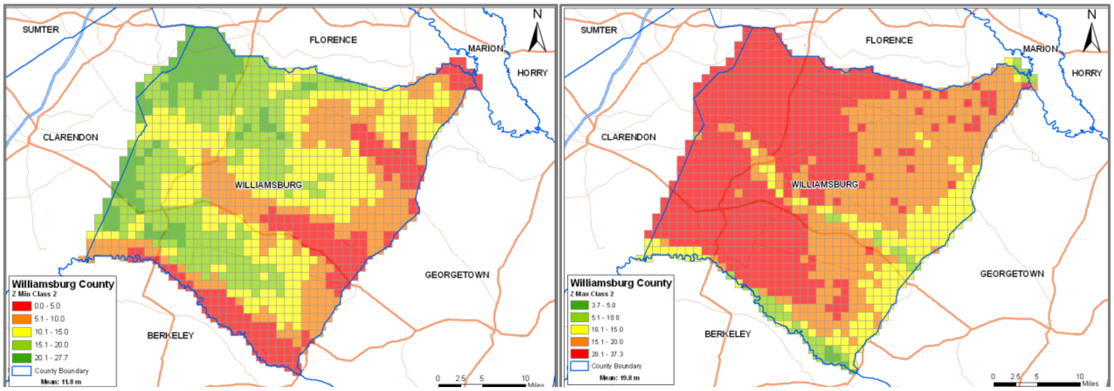

***Figure 7** – Z min and Z max elevation by tile for ground points (class 2).*

5.2 LiDAR Quantitative Assessment

5.2.1 Checkpoint inventory

Typically for this type of data collection, a ground truth survey is conducted following the *FEMA Guidelines and Specifications for Flood Hazard Mapping Partners Appendix A: Guidance for Aerial mapping and Surveying* which is based on the NSSDA. This methodology collects a minimum of 20 points for each of the predominant land cover types (i.e. bare-earth, weeds and crop, forest, urban etc.) for a minimum of three land cover classes. By verifying the data in these different classes, the data accuracy is tested, but it also tests whether the classification of the LiDAR was performed correctly at those test point locations. In this project the predominant land covers selected are bare-earth, mixed vegetation, and urban.

The field survey was conducted and prepared by the South Carolina Geodetic Survey in April 2008. The guidelines were to collect 60 checkpoints in 3 different land covers: 20 points in Urban Areas, 20 points in Open Terrain, and 20 points divided equally in Medium Vegetation and Forested Areas.

In reality 107 points were collected, as presented in Table 3, with 49 vegetation points instead of 20, including an additional class (bush). All the checkpoints used for the vertical assessment of the LiDAR data are available in 0. Figure 8 shows the distribution of the checkpoints throughout the area. The points are grouped together in clusters. In some cases the checkpoints within a cluster are less than 100 ft apart which is not ideal but still acceptable.

Table 3 - Number of points required and acquired.

Class	Guidelines	Acquired
o - Open Terrain	20	28
b - Bush	0	17
h - High Grass	10	18
w - Woods	10	14
u - Urban	20	30
Total	**60**	**107**

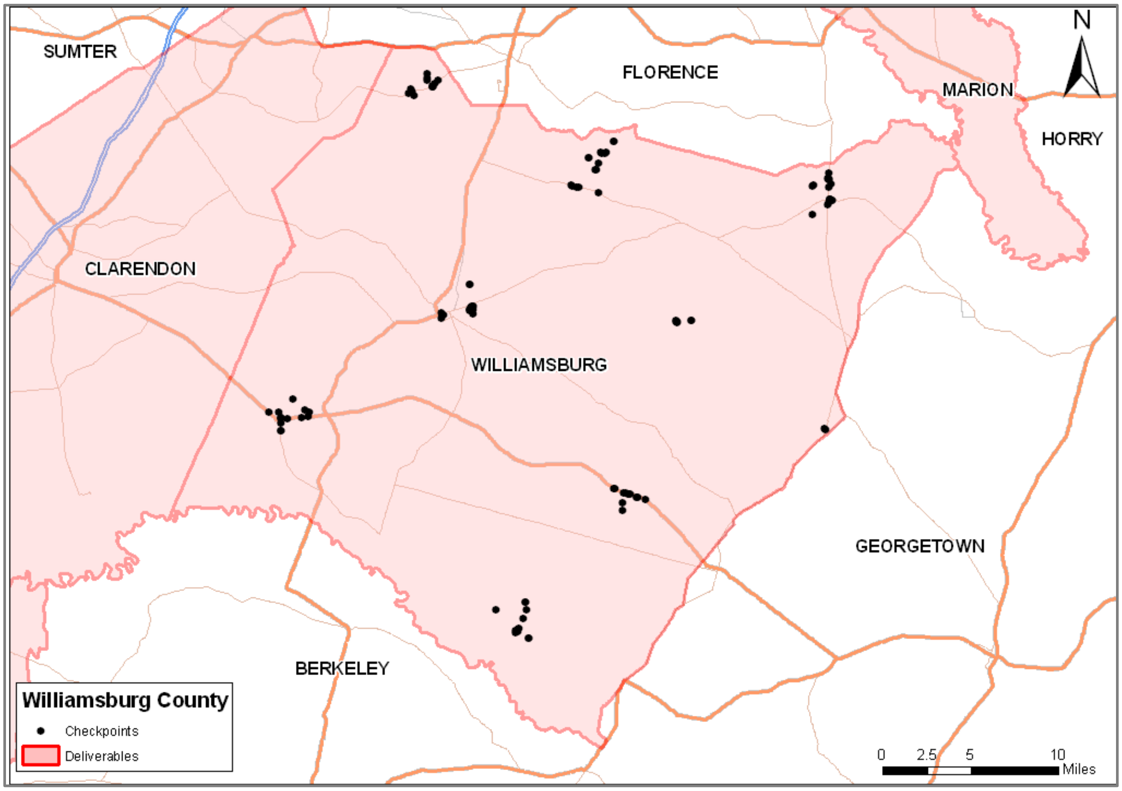

Figure 8 *– Survey checkpoints from South Carolina Geodetic Survey.*

5.2.2 Vertical Accuracy Assessment Methodologies

The first method of testing vertical accuracy used the FEMA specifications which follows the National Standard for Spatial Data Accuracy (NSSDA) procedures. The accuracy is reported at the 95% confidence level using the Root Mean Square Error (RMSE) which is valid when errors follow a normal distribution. By this method, vertical accuracy at the 95% confidence level equals RMSEz x 1.9600. This methodology measures the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points. The vertical accuracy assessment compares the measured survey checkpoint elevations with those of the TIN as generated from the bare-earth LiDAR. The X/Y locations of the survey checkpoints are overlaid on the TIN and the interpolated Z values are recorded. These interpolated Z values are then compared with the survey checkpoint Z values and this difference represents the amount of error between the measurements.

The second method of testing vertical accuracy, endorsed by the National Digital Elevation Program (NDEP) and American Society for Photogrammetry and Remote Sensing (ASPRS) uses the same (RMSE) method in open terrain only; an alternative method uses the 95^{th} percentile to report vertical accuracy in each of the other land cover categories (defined as Supplemental Vertical Accuracy – SVA) and all land cover categories combined (defined as Consolidated Vertical Accuracy – CVA). The 95^{th} percentile method is used when vertical errors may not follow a normal error distribution, as in vegetated terrain.

The Fundamental Vertical Accuracy (FVA) is the same for both methods; both methods utilize RMSE x 1.9600 in open terrain where there is no reason for LiDAR errors to depart from a normal error distribution.

The following tables and graphs outline the vertical accuracy and the statistics of the associated errors as computed by the different methods.

Table 4 shows the complete results of the Williamsburg County data set run through the FEMA/NSSDA process; vertical accuracy at the 95% confidence level equals the RMSE x 1.9600. By this method, the consolidated vertical accuracy equals the RMSE (0.084 m) x 1.9600, or 0.165 m (16.5 cm).

Table 4 - Final statistics for Williamsburg County using FEMA/NSSDA processes.

100 % of Totals	RMSE (m) Spec=0.185m	Mean (m)	Median (m)	Skew	Std Dev (m)	# of Points	Min (m)	Max (m)
Consolidated	0.084	-0.024	-0.038	0.619	0.080	107	-0.173	0.225
Bare Earth	0.081	-0.045	-0.054	0.438	0.068	28	-0.167	0.125
Vegetated	0.081	0.007	-0.025	0.586	0.082	49	-0.123	0.225
Urban	0.089	-0.057	-0.070	0.627	0.070	30	-0.173	0.103

Table 5 shows the complete results of the Williamsburg data set run through the NDEP/ASPRS process; the CVA value is 0.141 m (14.1 cm). The similar results between the two methods 16.5 cm and 14.1cm demonstrate that the errors approximate a normal error distribution. All of the calculated statistics for Williamsburg County fall well below the specifications.

Table 5 - Final statistics for Williamsburg County using NDEP/ASPRS processes.

Land Cover Category	# of Points	FVA — Fundamental Vertical Accuracy (RMSEz x 1.9600) Spec=36.3 cm	CVA — Consolidated Vertical Accuracy (95th Percentile) Spec=36.3 cm	SVA — Supplemental Vertical Accuracy (95th Percentile) Target=36.3 cm
Consolidated	107		14.1	
Bare Earth	28	15.8		13.0
Vegetated	49			13.8
Urban	30			15.1

Figure 9 illustrates the distribution of the elevation differences between the LiDAR data and the surveyed checkpoints. The majority of delta Z values are below zero which indicates a slightly negative error distribution.

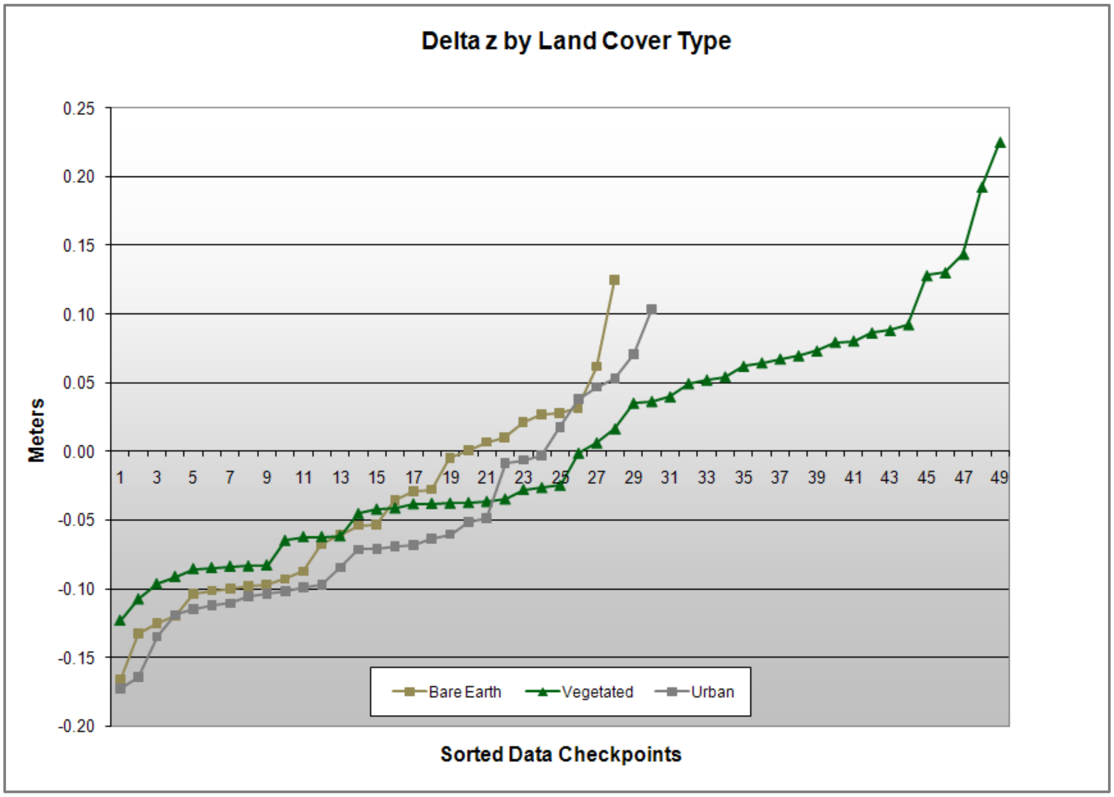

Figure 9 - *Checkpoints shown per land cover type and sorted by errors (DeltaZ).*

Given the good results and the high number of checkpoints used, Dewberry is confident that the data meets the accuracy requirements despite the less than ideal spatial dispersion of the checkpoints.

Compared with the 36.3 cm specification for vertical accuracy at the 95% confidence level, equivalent to 2-foot contours, the dataset passes by all methods of accuracy assessment:

- Tested 15.8 cm Fundamental Vertical Accuracy at 95% confidence level in open terrain using RMSEz x 1.9600 (FEMA/NSSDA and NDEP/ASPRS methodologies).
- Tested 16.5 cm Consolidated Vertical Accuracy at 95% confidence level in all land cover categories combined using RMSEz x 1.9600 (FEMA/NSSDA methodology).
- Tested 14.1 cm Consolidated Vertical Accuracy at 95th percentile in all land cover categories combined (NDEP/ASPRS methodology).

5.3 LiDAR Qualitative Assessment

5.3.1 Protocol

The goal of Dewberry's qualitative review is to assess the continuity and the level of cleanliness of the bare earth product. Each LiDAR tile is expected to meet the following acceptance criteria:

- The point density is homogeneous and sufficient to meet the user's needs;
- The ground points have been correctly classified (no manmade structures and vegetation remains, no gap except over water bodies);
- The ground surface model exhibits a correct definition (no aggressive classification, no over-smoothing, no inconsistency in the post-processing);
- No obvious anomalies due to sensor malfunction or systematic processing artifact is present (data holidays, spikes, divots, ridges between tiles, cornrows…);
- 90% or more of the artifacts have been removed, 95% of the outliers, 95% of the vegetation, and 98% of the buildings.

Dewberry analysts, experienced in evaluating LIDAR data, performed a visual inspection of the bare-earth digital elevation model (bare-earth DEM). LiDAR masspoints were first gridded with a grid distance of 2x the full point cloud resolution. Then, a triangulated irregular network (TIN) was built based on this gridded DEM and displayed as a 3D surface. A shaded relief effect was applied which enhances 3D rendering. The software used for visualization allows the user to navigate, zoom and rotate models and to display elevation information with an adaptive color coding in order to better identify anomalies.

One of the variables established when creating the models is the threshold for missing data. For each individual triangle, the point density information is stored; if it meets the threshold, the corresponding surface will be displayed in green, if not it will be displayed in red (see Figure 10). It should also be noted that if this density model is created with the ground points only, it is expected to have void areas where buildings exist or in water; vegetation can also reduce the number of points hitting the ground, resulting in more distanced points.

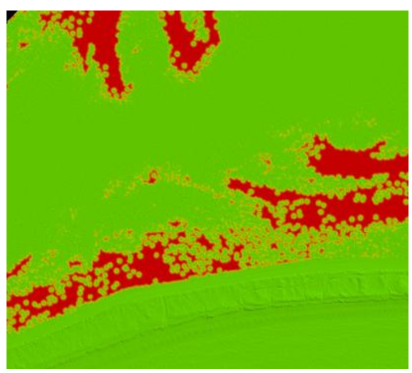

Figure 10 *– Ground model with density information (red means sparse data).*

The first step of Dewberry's qualitative workflow was to verify the point distribution by systematically loading a percentage of the tiles as masspoints colored by flight line (Figure 11) or by class (Figure 12). This particular type of display helps us visualize and better understand the scan pattern, the flight line orientation, flight coverage, and gives an additional confirmation that all classes are present and seem to logically represent the terrain.

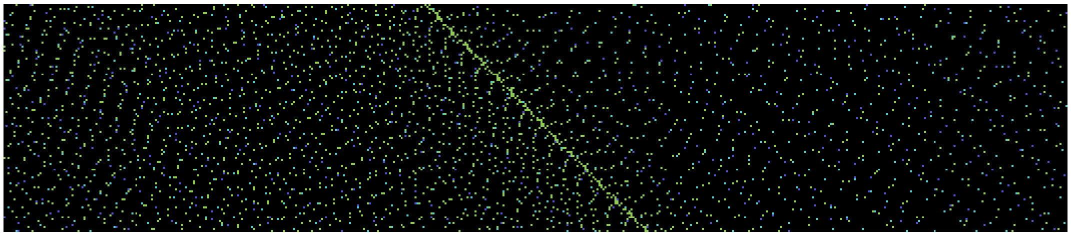

Figure 11 *– Detail of LiDAR points colored by flight line. Note the variations in the scan pattern.*

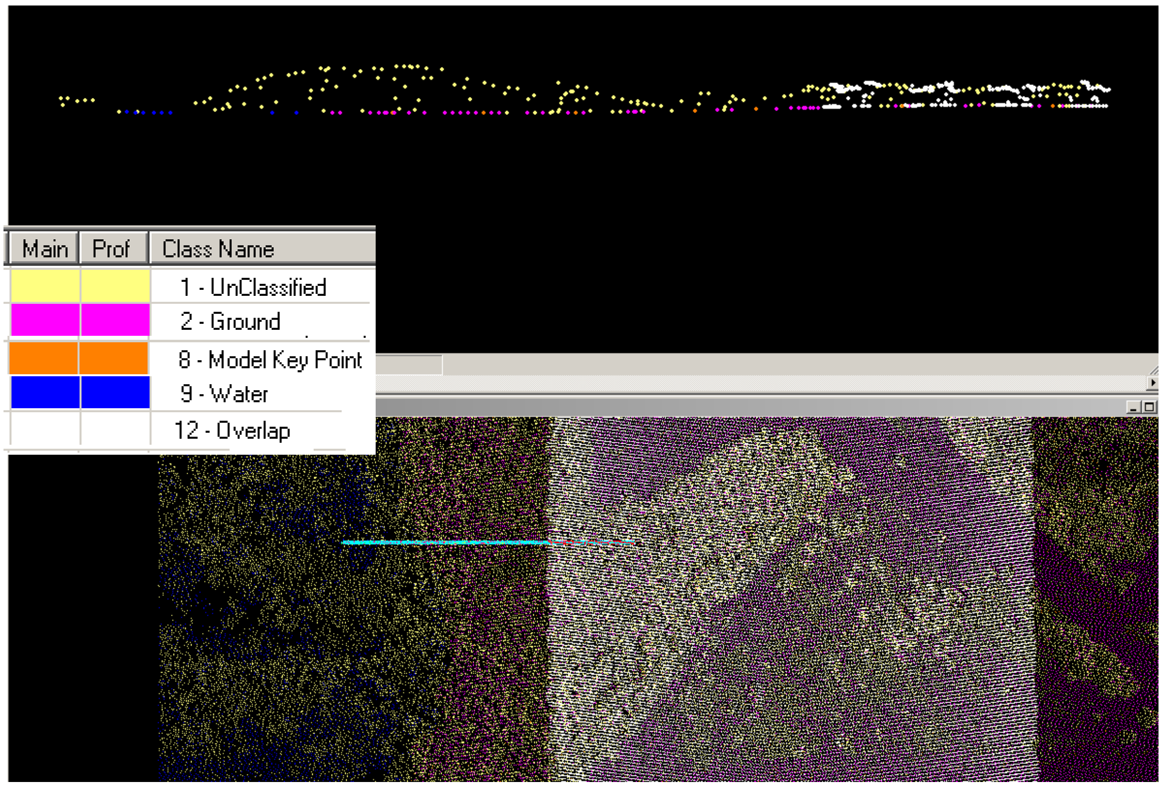

Figure 12 *- Full point cloud colored by classification.*

The second step was to verify data completeness and continuity using the bare-earth DEM with density information, displayed at a macro level. If, during this macro review of the ground models, potential artifacts or large voids are found, the digital surface model (DSM) based on the full point cloud including vegetation and buildings will be used to pinpoint the extent and the cause of the issue. Moreover, the intensity information stored in the LiDAR data can be visualized over this surface model, helping in interpretation of the terrain. Finally, if the analyst suspects a systematic error relating to data collection, a visualization of the 3D raw masspoints is performed, rather than visualizing as a surface.

Dewberry's micro-level qualitative review is the process of importing, comparing and analyzing these two later types of models (DSM with intensity and raw masspoints), along with cross section extraction, surface measurements, and density evaluation.

5.3.2 Quality report

Dewberry's qualitative review consists of a micro visual inspection of all the tiles. There is no automated toolset more effective than the manual inspection by a GIS analyst to find errors in automated processing of LiDAR data. The analyst will inspect the data for processing anomalies, classification errors, and full point cloud artifacts remaining in the ground surface models.

After closely examining the dataset, the bare earth model was determined to be of excellent quality. Dewberry found very few errors in the data as outlined in the text and images below. The only notable anomaly seen in the Williamsburg LiDAR data was negligible flight lines which does not affect the usability of the data.

Negligible Flight Line Ridges

A few tiles within the dataset included small ridges at seam lines caused by a vertical mismatch between two adjacent flight lines. Since the overlap is stored in a different class, no real blending of flight lines is done and a seam line is used to cut the data from one line to the next. The result is two flight lines that do not precisely match vertically. Although they are easily visible in the shaded ground model with vertical exaggeration, these ridges are below the commonly accepted threshold of 20 cm and are therefore minor. See Figure 13.

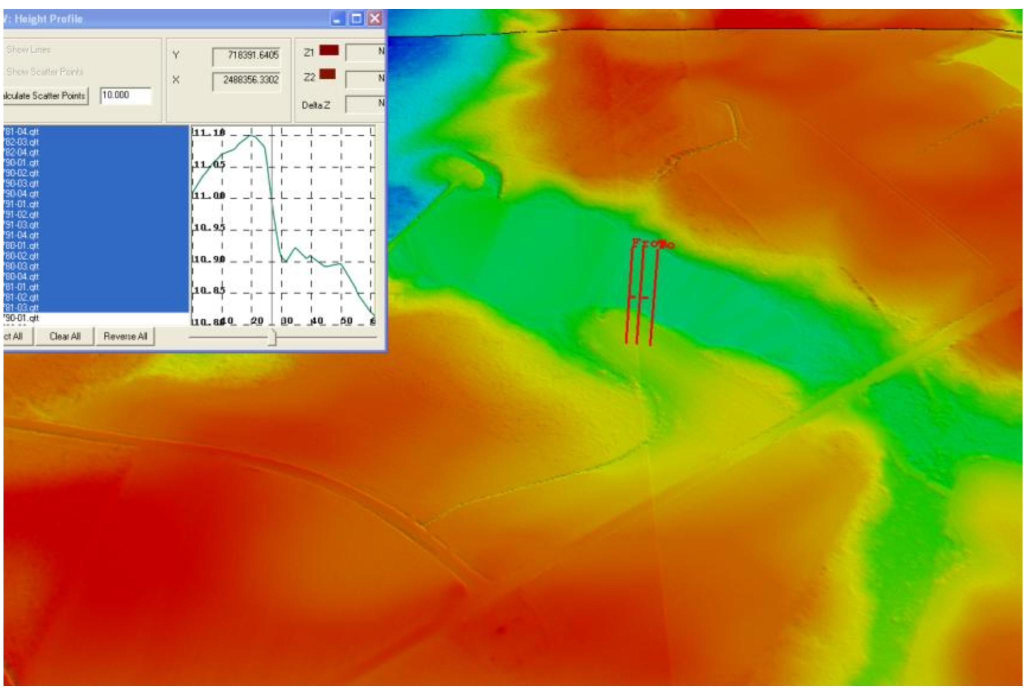

Figure 13 *- 4781-02 Negligible flight line offset*

Conclusion

Overall the LiDAR data meets the minimum standards for absolute and relative accuracy. The level of cleanliness for the bare-earth terrain easily meets the specifications and no major anomalies were found. The processing performed exceptionally well given the low relief terrain. The figures highlighted above are a sample of the minor issues that were encountered and are not representative of the majority of the data. The intensity images meet specifications and the terrain and multipoint entities are correctly derived from the classified bare earth LiDAR points.

Checkpoints

The horizontal coordinate system is South Carolina State Plane **International feet,** horizontal datum NAD83 **HARN** with **elevation in meters** (NAVD88).

The point numbering scheme uses a three digit sequence starting with the county number (SC numbers its counties in alphabetical order), a dash, followed by zone number, a dash and then a sequence number corresponding to order of collection within the zone, the land cover code was concatenated in front of the number.

pointNo	easting	northing	elevation	zLidar	LandCoverType	DeltaZ	AbsDeltaZ
O45-3-2	2414990.681	613120.794	12.7	12.5333	Bare Earth	-0.167	0.167
O45-6-13	2402361.021	711513.274	20.597	20.4748	Bare Earth	-0.122	0.122
O45-5-13	2472739.553	702258.985	16.8	16.6788	Bare Earth	-0.121	0.121
O45 086	2414685.922	613140.736	13.996	13.8761	Bare Earth	-0.12	0.12
O45-5-15	2473167.432	702390.27	17.04	16.9359	Bare Earth	-0.104	0.104
O45-3-10 045 039	2407965.451	615764.094	13.272	13.1702	Bare Earth	-0.102	0.102
O45-6-15	2397098.826	706323.788	23.516	23.4158	Bare Earth	-0.1	0.1
O45-6-5	2395097.806	706677.709	23.178	23.0797	Bare Earth	-0.098	0.098
O45-4-5	2426518.77	666086.247	16.114	16.0164	Bare Earth	-0.098	0.098
O45-2-3	2378985.594	572711.865	15.464	15.3764	Bare Earth	-0.088	0.088
O45-4-6	2426868.884	665918.194	16.632	16.5468	Bare Earth	-0.085	0.085
O45-8-2	2364899.292	670059.357	21.384	21.3064	Bare Earth	-0.078	0.078
OLAMB AZ MK	2407734.25	719774.865	23.061	23.0006	Bare Earth	-0.06	0.06
O45-8-1	2365111.901	670343.763	20.916	20.8619	Bare Earth	-0.054	0.054
O45-5-3	2472316.185	710356.131	13.45	13.3966	Bare Earth	-0.053	0.053
O45-2-50 SUTTON RM 7	2378121.622	572677.119	16.367	16.3378	Bare Earth	-0.029	0.029
O45-1-CP1	2307901.424	637011.284	24.565	24.536	Bare Earth	-0.029	0.029
O45-1-11	2307734.624	632993.859	22.425	22.397	Bare Earth	-0.028	0.028
O021 056 AZ MK	2472203.666	708455.062	16.489	16.4789	Bare Earth	-0.01	0.01
O45-5-17	2472377.81	701575.618	16.087	16.09	Bare Earth	0.003	0.003
O45-8-16	2365494.547	670388.012	21.424	21.4338	Bare Earth	0.01	0.01
O45-7-11	2353439.433	736375.201	25.733	25.7479	Bare Earth	0.015	0.015
OWINKIES CROSSROA	2347229.217	734759.478	26.018	26.0446	Bare Earth	0.027	0.027
O45-1-1	2307727.804	636828.635	24.899	24.9302	Bare Earth	0.031	0.031
O045 052 AZ MK	2381468.942	579265.278	14.306	14.3433	Bare Earth	0.037	0.037
O45-7-2	2354081.524	737352.653	26.77	26.8317	Bare Earth	0.062	0.062
O45-8-13 K L CONTROL GPS 2	2364351.77	677014.477	21.509	21.6185	Bare Earth	0.11	0.11
U45-6-11	2405352.937	716716.386	23.86	23.6874	Urban	-0.173	0.173
U45-3-12	2410655.063	614481.718	13.677	13.5128	Urban	-0.164	0.164
U45-5-9	2472649.371	702685.656	16.382	16.2474	Urban	-0.135	0.135
U45-6-8	2403209.19	704393.405	17.208	17.082	Urban	-0.126	0.126

U45-6-14	2402314.125	711369.098	21.363	21.2441	Urban	-0.119	0.119
U45-6-12	2403256.255	713353.368	23.258	23.1394	Urban	-0.119	0.119
U45-3-11	2407700.236	615728.681	12.864	12.7534	Urban	-0.111	0.111
U45-3-9	2417079.832	612455.6	11.661	11.5556	Urban	-0.105	0.105
U45-8-14	2364356.162	676946.057	21.581	21.4777	Urban	-0.103	0.103
U45-3-6	2411301.758	614410.725	11.592	11.49	Urban	-0.102	0.102
U45-5-8	2471866.453	700785.867	15.938	15.8365	Urban	-0.102	0.102
U45-5-10	2472735.32	702697.797	16.576	16.4791	Urban	-0.097	0.097
U45-2-52	2378939.124	573471.338	16.219	16.1345	Urban	-0.085	0.085
U45-1-10	2307862.554	633057.068	23.096	23.0241	Urban	-0.072	0.072
U45-2-51	2378255.652	573021.274	16.44	16.3686	Urban	-0.071	0.071
U45-5-16	2472618.762	702690.105	16.338	16.2671	Urban	-0.071	0.071
U45-5-14	2473240.498	702296.183	16.767	16.6987	Urban	-0.068	0.068
U45-1-12	2307073.079	638615.573	23.146	23.0827	Urban	-0.063	0.063
U45-4-8	2426356.252	665849.528	16.49	16.4388	Urban	-0.051	0.051
U45-8-15	2365519.537	668122.983	22.485	22.436	Urban	-0.049	0.049
U45-5-12	2472793.496	707078.4	16.273	16.2245	Urban	-0.049	0.049
U45-2-8	2372279.301	579471.513	17.685	17.6723	Urban	-0.013	0.013
U45-1-9	2307764.22	635475.841	23.36	23.3515	Urban	-0.008	0.008
U45-4-3	2430872.988	666185.202	15.795	15.7886	Urban	-0.006	0.006
U45-8-9	2355998.421	668354.882	17.426	17.4435	Urban	0.018	0.018
U45-7-6	2346006.502	734184.524	25.968	26.006	Urban	0.038	0.038
U45-1-8	2304308.002	638582.444	23.406	23.4511	Urban	0.045	0.045
U45-8-10	2356375.114	667918.265	12.662	12.7099	Urban	0.048	0.048
U45-7-12	2354997.629	738424.123	26.806	26.8657	Urban	0.06	0.06
U45-7-9	2351820.12	738411.169	26.293	26.3963	Urban	0.103	0.103
H45-3-8	2410321.849	609052.963	14.433	14.3101	Vegetated	-0.123	0.123
W45-3-1	2414576.128	613066.196	14.028	13.9279	Vegetated	-0.1	0.1
H45-6-4	2400144.217	715023.892	19.016	18.9198	Vegetated	-0.096	0.096
H45-8-4	2364552.312	669338.201	19.695	19.6097	Vegetated	-0.085	0.085
H45-2-5	2382093.034	570923.187	12.879	12.7955	Vegetated	-0.083	0.083
H45-6-7	2396657.621	706272.181	23.79	23.7067	Vegetated	-0.083	0.083
W45-8-8	2365312.78	669248.145	21.57	21.4911	Vegetated	-0.079	0.079
H45-3-3	2412529.248	613972.736	11.334	11.2674	Vegetated	-0.067	0.067
B45-2-4	2382249.08	570988.522	12.891	12.829	Vegetated	-0.062	0.062
W45-6-9	2405176.788	716257.624	24.662	24.6	Vegetated	-0.062	0.062
H45-5-2	2471803.586	708845.351	15.332	15.2733	Vegetated	-0.059	0.059
B45-6-3	2400082.759	715117.371	18.894	18.8488	Vegetated	-0.045	0.045
H45-8-7	2365355.403	669345.949	21.627	21.585	Vegetated	-0.042	0.042
B45-6-1	2403892.264	716493.216	22.204	22.1628	Vegetated	-0.041	0.041
H45-2-6	2381054.099	581627.403	16.943	16.9054	Vegetated	-0.038	0.038
W45-6-2	2404023.809	716466.516	23.206	23.1685	Vegetated	-0.037	0.037

W45-2-2	2379156.128	573758.97	14.455	14.4178	Vegetated	-0.037	0.037
H045 027 AZ MK	2353402.816	736404.699	25.919	25.8826	Vegetated	-0.036	0.036
B45 119	2471041.623	633649.234	11.201	11.1727	Vegetated	-0.028	0.028
B45-2-1	2380491.227	576760.932	16.273	16.2452	Vegetated	-0.028	0.028
H45-5-4	2472154.203	706046.157	16.366	16.3397	Vegetated	-0.026	0.026
H45-4-7	2426673.813	665667.721	15.966	15.943	Vegetated	-0.023	0.023
H45-4-2 045 009	2430825.226	666095.904	15.803	15.7974	Vegetated	-0.006	0.006
H45-1-3	2313901.907	637138.019	22.062	22.0622	Vegetated	0	0
W45-7-8	2351736.516	740227.027	26.353	26.3592	Vegetated	0.006	0.006
W45-5-7	2467388.041	697930.393	15.631	15.64	Vegetated	0.009	0.009
W45-7-4	2346815.392	735529.083	27.165	27.1805	Vegetated	0.015	0.015
H45-7-3	2347148.985	734953.698	26.014	26.0304	Vegetated	0.016	0.016
B45-8-6	2364787.322	669093.613	20.941	20.9578	Vegetated	0.017	0.017
W45-2-7	2381300.333	581689.213	17.277	17.3124	Vegetated	0.035	0.035
B45-4-1	2471160.712	633521.28	10.943	10.9794	Vegetated	0.036	0.036
W45-6-6	2395437.896	706542.668	23.161	23.1984	Vegetated	0.037	0.037
B45-5-5	2467513.109	706794.778	15.217	15.2567	Vegetated	0.04	0.04
W45-1-6	2315171.374	639216.045	20.788	20.8373	Vegetated	0.049	0.049
W45-1-4	2315948.861	637292.465	22.568	22.6222	Vegetated	0.054	0.054
B45-3-5	2411934.75	614039.6	12.016	12.0713	Vegetated	0.055	0.055
B45-8-5	2364569.217	669248.376	20.115	20.1831	Vegetated	0.068	0.068
H45-7-1	2353481.755	736644.575	25.823	25.8926	Vegetated	0.07	0.07
H45-1-5	2316195.952	638791.42	20.588	20.6611	Vegetated	0.073	0.073
H45-8-11	2356470.194	667776.341	12.144	12.2244	Vegetated	0.08	0.08
W45-3-4	2412403.301	614132.877	10.945	11.0286	Vegetated	0.084	0.084
B45-1-7	2311413.976	642568.39	22.432	22.52	Vegetated	0.088	0.088
B45-3-7	2410373.637	611385.831	14.031	14.1232	Vegetated	0.092	0.092
B45-7-7	2351811.403	738995.818	25.877	26.005	Vegetated	0.128	0.128
B45-5-1	2472151.051	708663.508	15.828	15.9586	Vegetated	0.131	0.131
B45-8-3	2364521.152	669490.557	19.769	19.9126	Vegetated	0.144	0.144
B45-7-5	2347641.62	733721.161	25.69	25.8354	Vegetated	0.145	0.145
B45-1-2	2309726.046	636768.865	22.765	22.9575	Vegetated	0.192	0.192
W45-8-12	2355997.65	666753.512	11.968	12.1681	Vegetated	0.2	0.2