LiDAR Quality Assurance (QA) Report
Fairfield County, South Carolina
February 13, 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 Fairfield, County, SC, produced by Dewberry's subcontractor, Fugro EarthData, under the referenced USGS task order. The LiDAR data was acquired in January, 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 high 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 866 tiles (each 5000 ft x 5000 ft) were delivered covering all of Fairfield 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	108	18.5 cm	6.8 cm
FVA	20	33	36.3 cm	11.4 cm
CVA	60	108	36.3 cm	14.7 cm
SVA-bare earth	20	33	36.3 cm	10.6 cm
SVA-vegetated	20	42	36.3 cm	15.4 cm
SVA-urban	20	33	36.3 cm	13.1 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 misclassification and point bunching. 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 Fairfield 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.

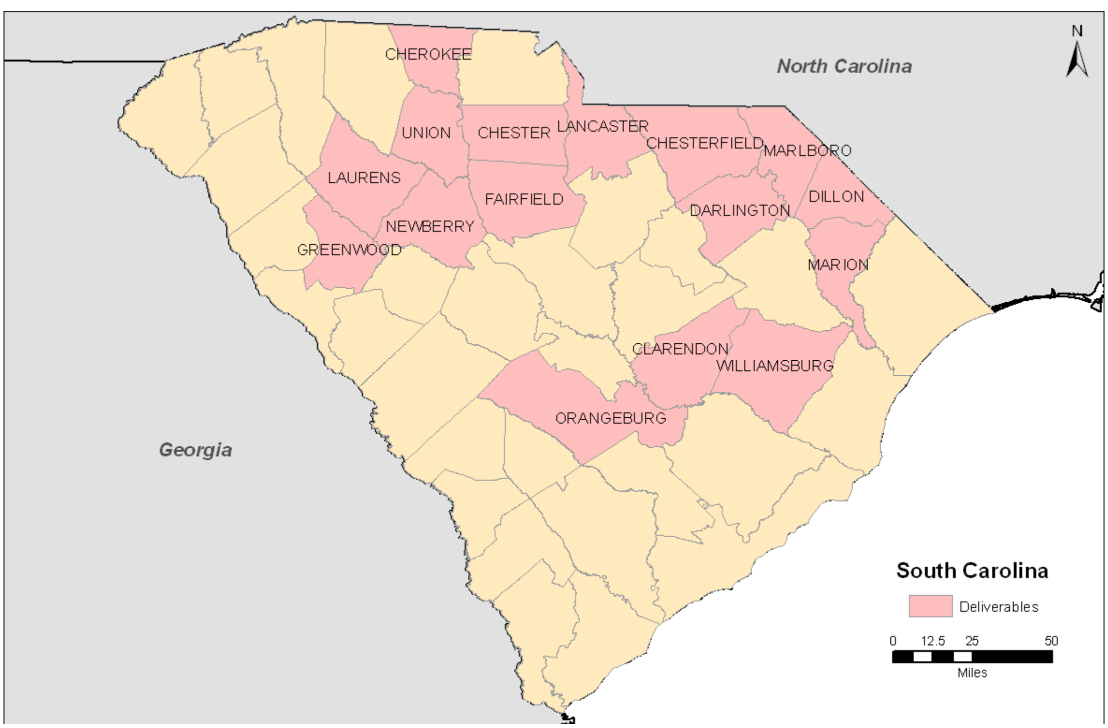

Figure 1 *– Project area; the 16 deliverable counties for the South Carolina project are shown in pink.*

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, the terrain, and the intensity images extend outside the project boundary with a 50 ft buffer (Figure 4 and Figure 5) as expected.

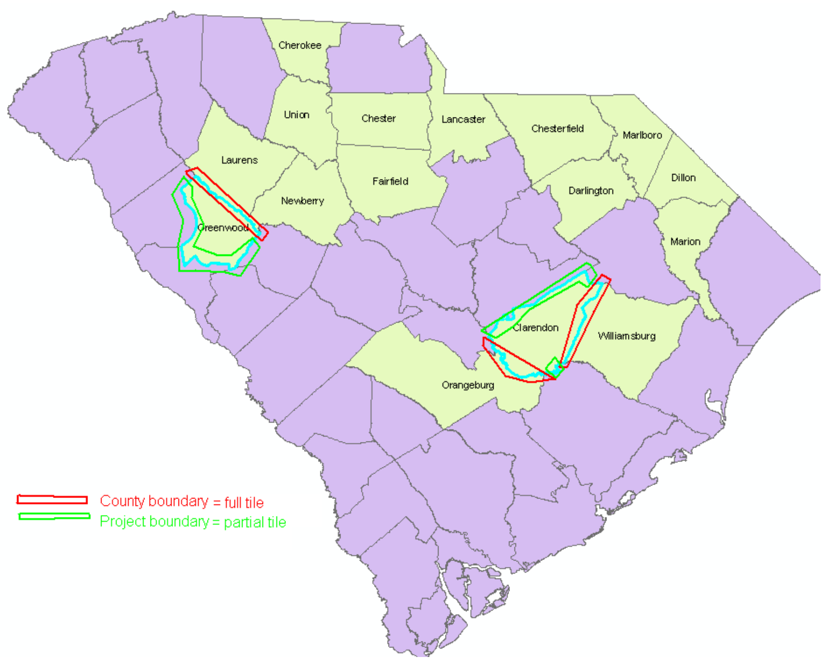

Figure 2 *– Convention used for the tile coverage: at the boundary of a county that is not part of the project, a partial tile is delivered; at the boundary of a county that is part of the project, a full tile is delivered.*

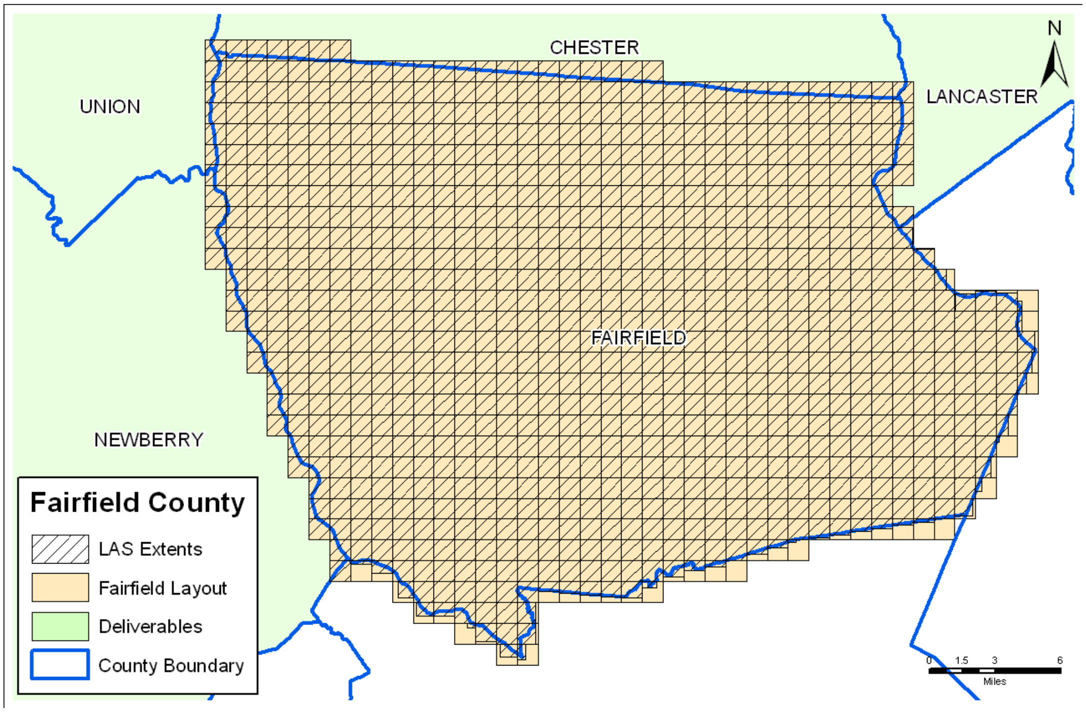

Figure 3 *– The LiDAR coverage of Fairfield County. Neighboring deliverable counties are shown in green.*

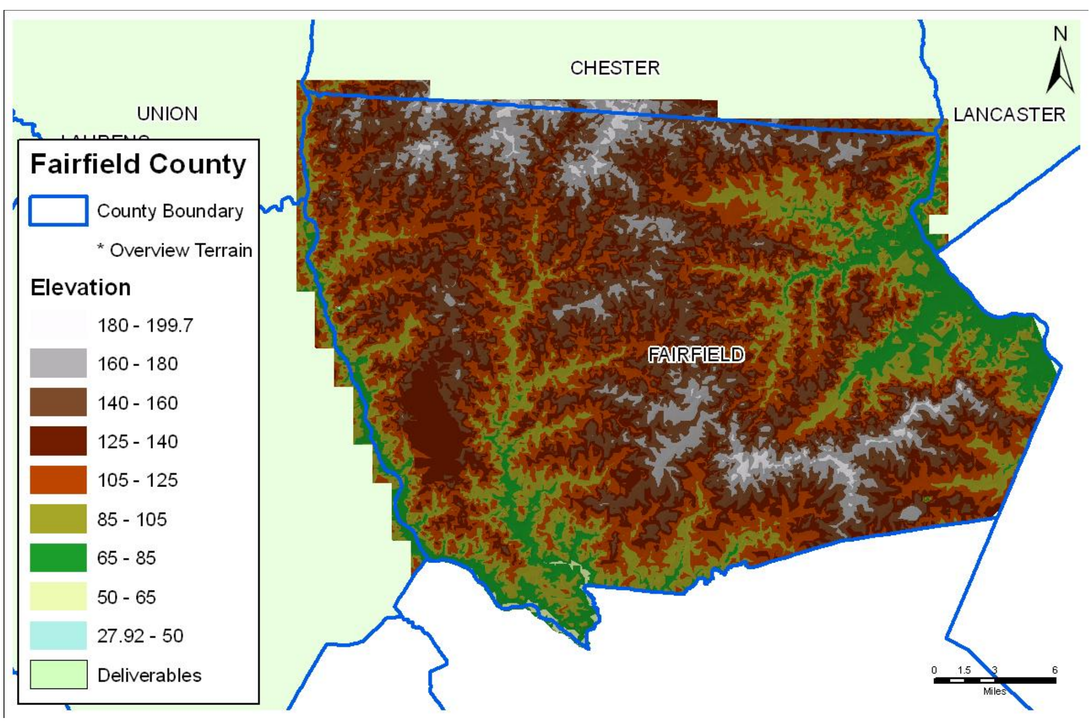

Figure 4 *– The terrain for Fairfield has a 50 ft buffer outside of the project boundary.*

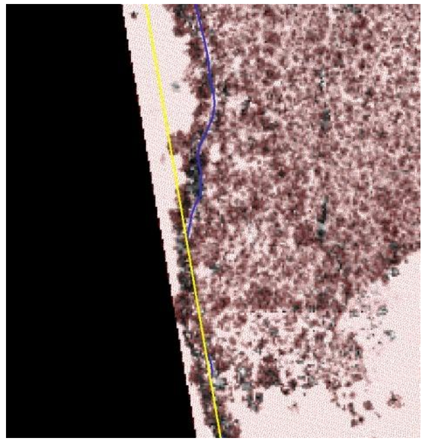

Figure 5 *- Ground masspoints (red) and intensity images extend 50 feet outside the project boundary in yellow. The LAS and terrain do the same. Hydrolines are clipped at the project boundary and the watershed boundary.*

3 QA of intensity images

866 intensity images in GeoTiff format were delivered for Fairfield 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 ft 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: 0807-01.tif File Information: Standard : : TIFF File Format : : Byte integers (8 bits) Pixels per Line : 1250 Number of Lines : 1250 Samples per pixel : 1 File bits per sample : 8 Actual bits per sample : 8 Untiled file Number of overviews : 0 Scanning device resolution : 72 : lines/inch Orientation : 4 : Row major order, origin at top left NO scan line headers : non-scannable file Packet size (16-bit words) : 0 Free vlt space (16-bit words) : 2000000000 Free packet space (16-bit words) : 2000000000 Raster to UOR matrix: Unspecified or All Zero Matrix Raster to World Matrix: Units: Feet amx[0]= 4, amx[1]= 0, amx[2]= 2000000 amx[3]= 0, amx[4]= -4, amx[5]= 880000 2000000 , 880000 2005000 , 880000 2005000 , 875000 2000000 , 875000	Geotiff_Information: Version: 1 Key_Revision: 1.0 Tagged_Information: ModelTiepointTag (2,3): 0 0 0 2000000 880000 0 ModelPixelScaleTag (1,3): 4 4 0 End_Of_Tags. Keyed_Information: GTModelTypeGeoKey (Short,1): ModelTypeProjected GTRasterTypeGeoKey (Short,1): RasterPixelIsArea ProjectedCSTypeGeoKey (Short,1): Unknown-3361 ProjLinearUnitsGeoKey (Short,1): Linear_Foot End_Of_Keys. End_Of_Geotiff. PCS = 3361 (name unknown) Projection Linear Units: 9002/foot (0.304800m) Corner Coordinates: Upper Left (2000000.000, 880000.000) Lower Left (2000000.000, 875000.000) Upper Right (2005000.000, 880000.000) Lower Right (2005000.000, 875000.000) Center (2002500.000, 877500.000)

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 866 LiDAR files covering the Fairfield 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 Fairfield County is around 4.9 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. The red tiles in the south western corner of the county are located over the Monticello Reservoir which explains the lower number of points in this area.

To first identify incorrect elevations, the z-minimum and z-maximum values for the ground class were reviewed. With maximum values between 73.9m and 199.7m, 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.

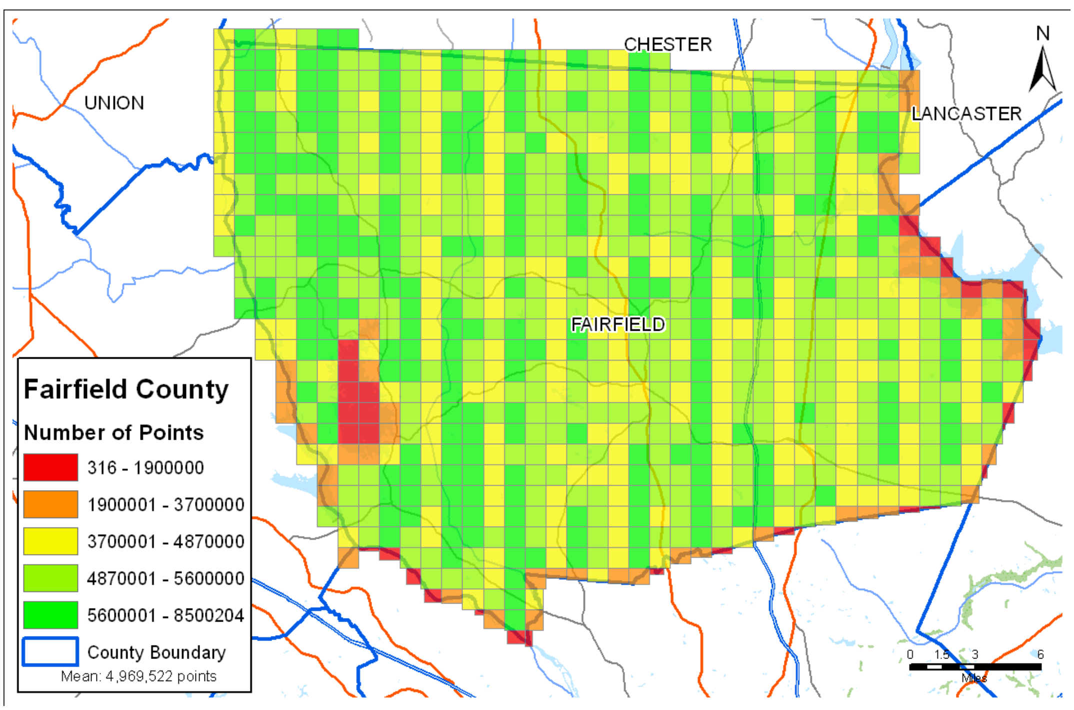

Figure 6 *– Number of points per tile. The red tiles at the border are expected to have fewer points.*

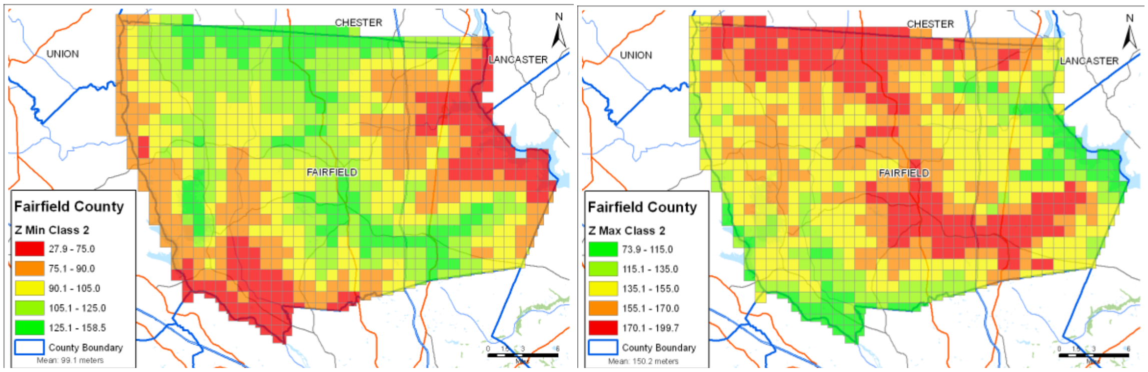

***Figure 7** – Z min and Z max elevation by tile for ground points (Class 2).*

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 108 points were collected, as presented in Table 3, with 42 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 Appendix A. 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	33
b - Bush	0	14
h - High Grass	10	14
w - Woods	10	14
u - Urban	20	33
Total	**60**	**108**

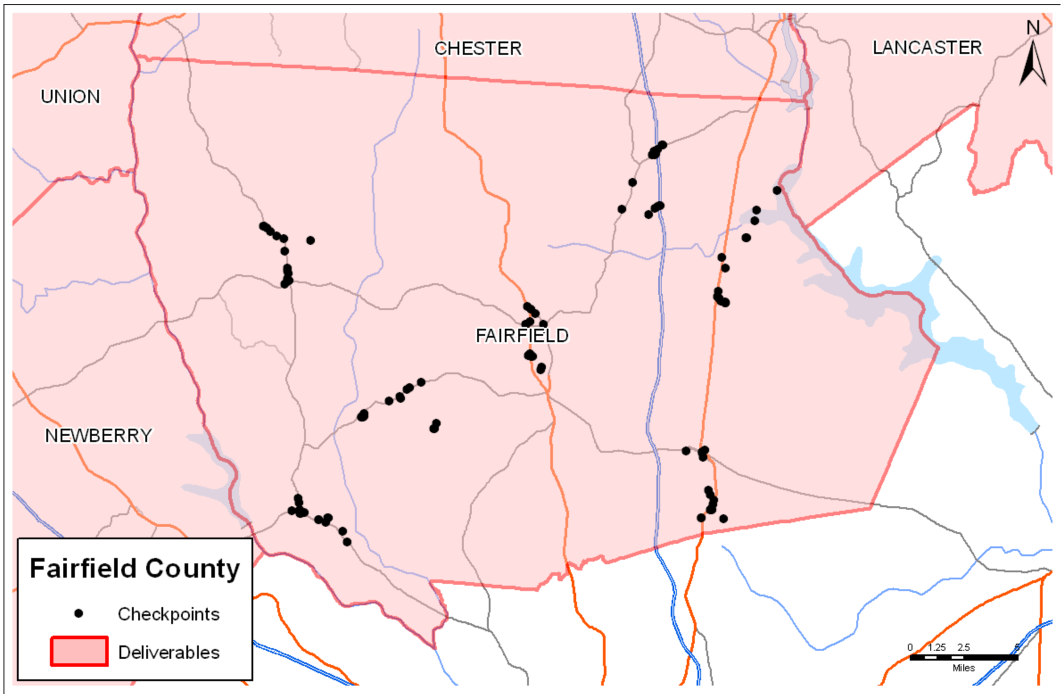

Figure 8 *– Survey checkpoints from South Carolina Geodetic Survey.*

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 95th 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 95th 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 Fairfield 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 (0.068 m) x 1.9600, or 0.133 m (13.3 cm).

Table 4 - Final statistics for Fairfield 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	0.068	0.028	0.016	0.528	0.063	108	-0.099	0.191
Open Terrain	0.058	0.026	0.020	0.537	0.053	33	-0.073	0.164
Vegetated	0.080	0.039	0.031	0.199	0.071	42	-0.099	0.191
Urban	0.061	0.014	0.006	0.993	0.060	33	-0.090	0.184

Table 5 shows the complete results of the Fairfield data set run through the NDEP/ASPRS process; the CVA value is 0.147 m (14.7 cm). The similar results between the two methods (13.3 cm and 14.7 cm) demonstrate that the errors approximate a normal error distribution. All of the calculated statistics for Fairfield County fall well below the specifications.

Table 5 - Final statistics for Fairfield 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	108		14.7	
Bare Earth	33	11.4		10.6
Vegetated	42			15.4
Urban	33			13.1

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

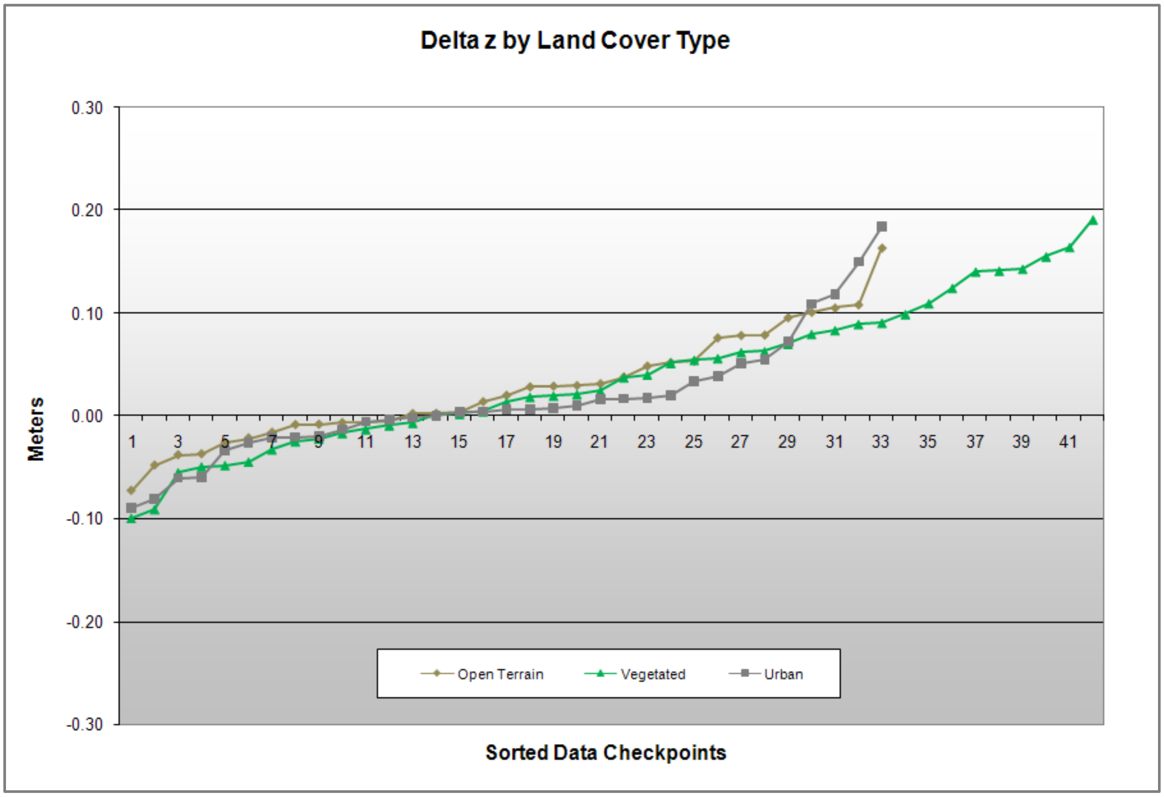

Figure 9 - *Checkpoints shown per land cover type and sorted by errors (deltaZ).*

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 11.4 cm Fundamental Vertical Accuracy at 95% confidence level in open terrain using RMSEz x 1.9600 (FEMA/NSSDA and NDEP/ASPRS methodologies).
- Tested 13.3 cm Consolidated Vertical Accuracy at 95% confidence level in all land cover categories combined using RMSEz x 1.9600 (FEMA/NSSDA methodology).
- Tested 14.7 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.

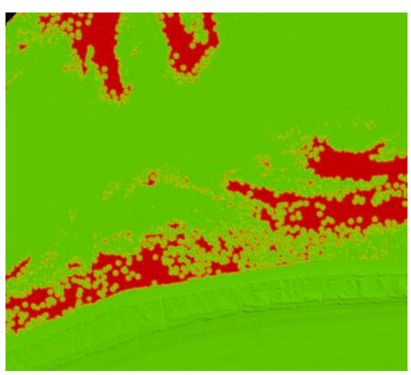

***Figure 10** – Ground model with density information (red means sparse data).*

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.

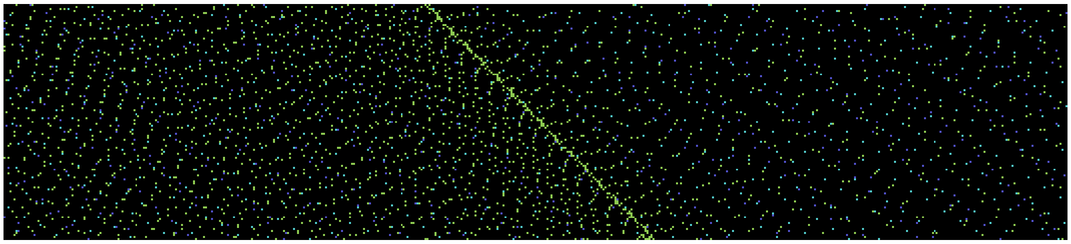

Figure 11 *– Detail of LiDAR points colored by flight line. Note the variations in the scan pattern.*

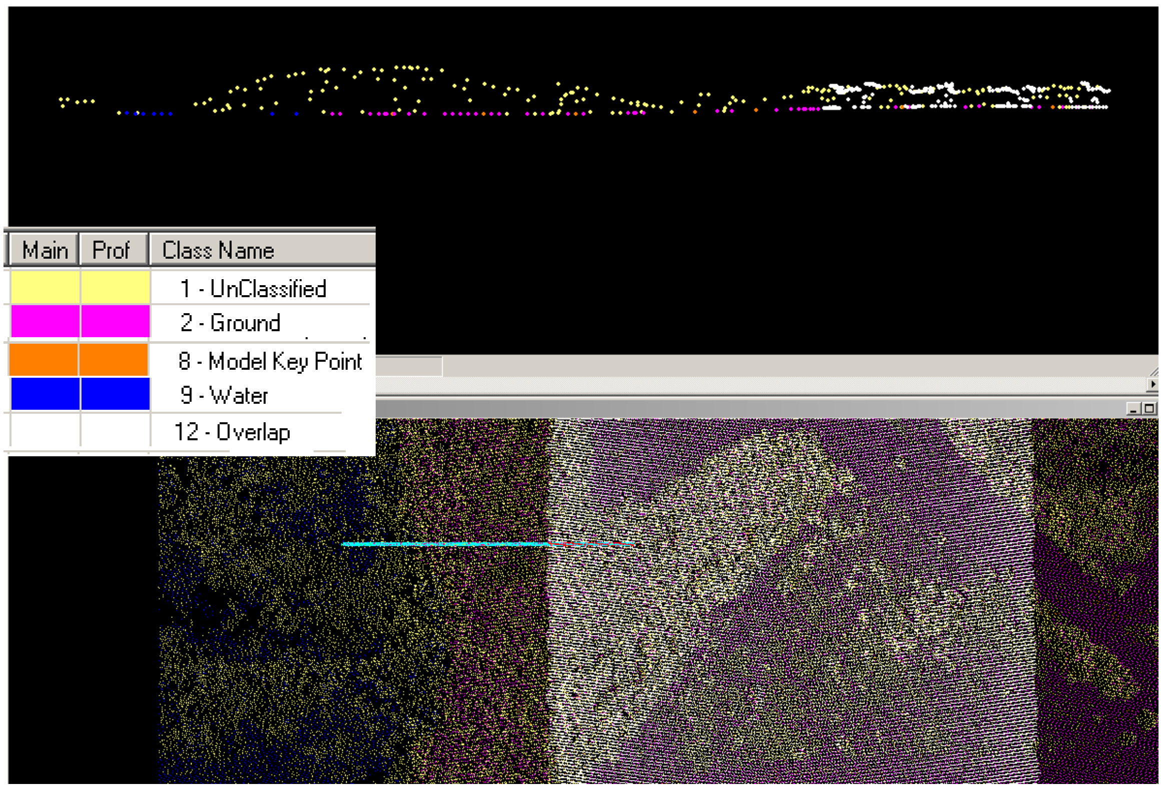

Figure 12 *- Full point cloud colored by classification.*

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 majority of the calls are due to minor misclassifications and point bunching. However, these issues are not serious enough to render the data unusable.

Misclassification

There were several instances in the Fairfield LiDAR were the classification process was in error and ground points were erroneously left in class 1 (unclassified). This issue is minor however and is easily fixable. Examples of this type of error are shown in Figure 13 and Figure 14.

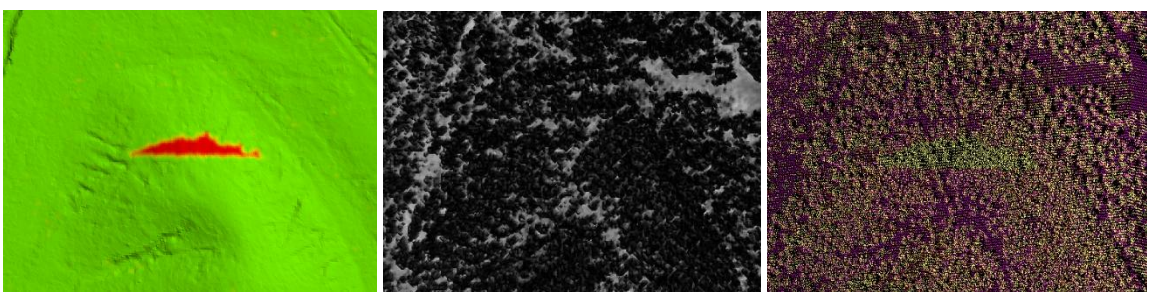

Figure 13 *– 9847-01 Misclassification of ground points. Left image is ground density model and middle is full point cloud with intensity. Right image is full point cloud colored by classification, yellow is unclassified (class 1) and purple is ground (class 2).*

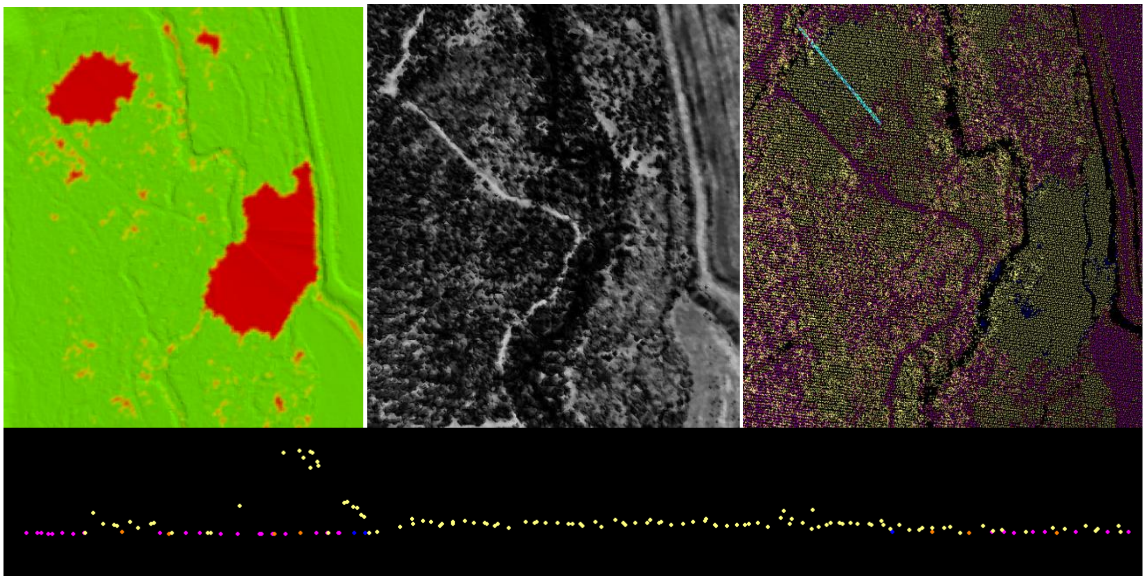

Figure 14 *– 9935-01 Misclassification of ground points. Left image is ground density model and middle is full point cloud with intensity. Right image is full point cloud colored by classification, yellow is unclassified (class 1) and purple is ground (class 2). Bottom is profile of cross-section.*

Point Bunching

A few instances of the bunching of points were found in the data. This type of error is usually caused by windy conditions during acquisition. Wind can alter the pitch of the plane producing wider scanlines when the nose of the plane is pushed up, and more narrow scanlines when the nose of the plane goes down. Sometimes this variation in pitch can result in vertical inconsistencies between scans however the point bunching seen in the Fairfield data did not have this affect and the elevation values were homogeneous.

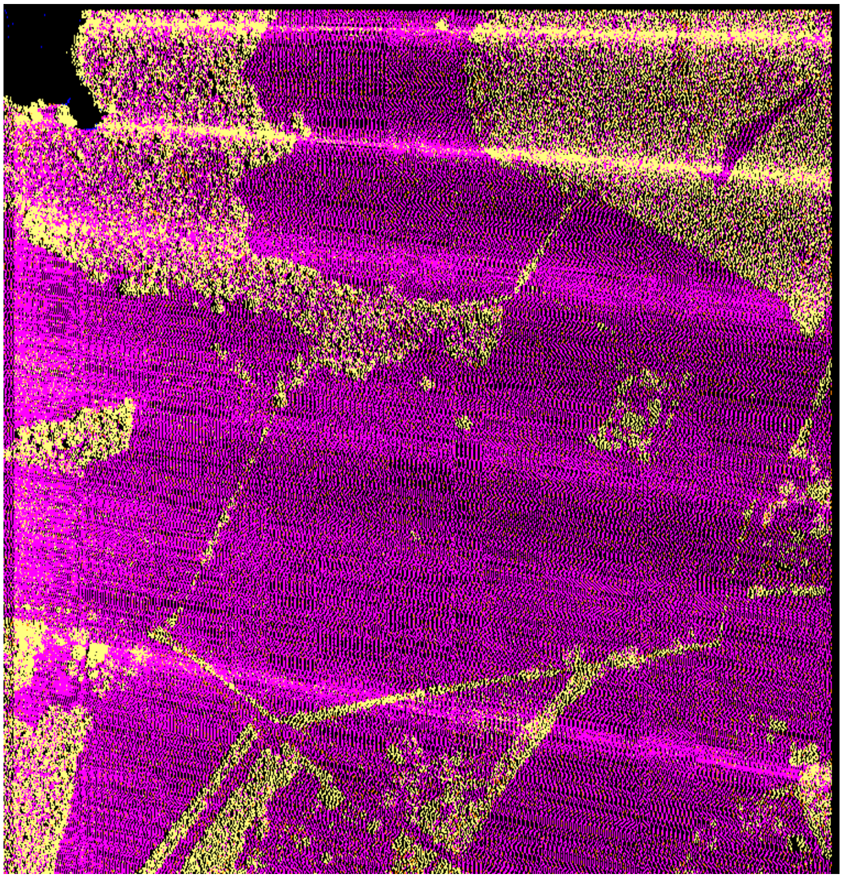

Figure 15 *- 9901-02 Point bunching, full point cloud colored by classification (yellow is unclassified, purple is ground).*

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 user should be aware of the areas of minor misclassification when focusing on portions of the data, but the data set as a whole is of excellent quality. 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.

Appendix A 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	DeltaZ
b12-1-4	1863166.876	1082796.885	162.527	162.671	0.144
b12-1-8	1871037.874	1086184.871	176.301	176.283	-0.018
b12-2-4	1890597.034	1043547.699	180.747	180.835	0.088
b12-2-8	1895298.981	1053185.750	188.815	188.992	0.177
b12-3-2	1879981.093	1005944.003	127.171	127.247	0.076
b12-3-5	1885342.155	1003771.437	133.525	133.650	0.125
b12-4-1	1940953.759	1040725.231	171.000	170.996	-0.004
b12-4-8	1927197.120	1047361.534	149.771	149.827	0.056
b12-5-6	1951407.294	995698.637	182.432	182.355	-0.077
b12-5-9	1960520.368	1000642.302	154.841	154.885	0.043
b12-6-2	2028288.355	1000581.561	152.233	152.295	0.062
b12-6-6	2031303.269	998591.136	119.467	119.520	0.053
b12-7-3	2028420.929	1055758.284	174.398	174.482	0.084
b12-7-4	2026994.948	1050097.993	157.286	157.282	-0.004
b12-8-2	1979219.918	1079596.775	173.756	173.816	0.060
b12-8-3	1984794.507	1077432.238	163.970	164.027	0.056
h12-1-3	1863786.334	1087370.620	158.332	158.389	0.056
h12-1-5	1863977.717	1080670.326	162.118	162.152	0.034
h12-2-1	1895280.524	1041777.054	177.917	177.981	0.064
h12-2-3	1891606.721	1043653.826	174.186	174.220	0.034
h12-4-4	1939807.245	1052396.076	166.090	166.156	0.066
h12-4-7	1933230.189	1047746.013	146.130	146.194	0.064
h12-5-5	1949130.268	996104.027	181.501	181.605	0.103
h12-5-8	1954734.254	993870.926	182.432	182.492	0.060
h12-6-3	2028264.015	1001546.918	159.785	159.764	-0.021
h12-6-8	2028040.207	991325.856	105.671	105.675	0.003
h12-7-2	2028422.884	1056430.592	178.388	178.467	0.079
h12-8-5	1984040.854	1064820.733	184.809	184.940	0.131
hBRAINERDRESET	1940198.028	1045955.801	184.500	184.584	0.084
hFISHINGCREEK	1979593.088	1079315.679	176.450	176.636	0.186
hWOLFE	2028151.204	1059041.008	176.258	176.303	0.045
o12004	2028041.598	1000469.449	159.075	159.003	-0.072

o12-1-2	1864625.167	1087394.210	154.231	154.200	-0.031
o12-2-5	1885113.309	1050904.076	169.363	169.466	0.103
o12-3-6	1885040.508	998214.676	138.913	139.045	0.132
o12-4-3	1942510.964	1045997.423	180.477	180.477	-0.001
o12-5-3	1953984.267	990703.898	186.865	186.868	0.003
o12-6-5	2028386.733	1002177.721	157.244	157.306	0.062
o12-7-5	2027018.674	1043936.190	149.898	149.850	-0.048
o12-7-7	2032191.708	1043963.679	157.572	157.575	0.003
o12-8-10	1969803.541	1072984.148	173.843	173.815	-0.028
o12-8-7	1977317.913	1070462.169	174.726	174.697	-0.029
o40516	1929987.448	1044414.859	152.644	152.627	-0.017
o40883	2028469.308	1002090.709	158.652	158.744	0.092
o40884	2030288.819	1042109.901	162.353	162.271	-0.082
o41247	1940284.148	1045904.310	185.351	185.380	0.029
o41249	2028257.295	1001971.623	160.712	160.702	-0.010
o41251	1977123.573	1081512.641	175.246	175.265	0.019
o41615	2031090.479	1042059.553	162.960	162.786	-0.174
o41977	1935940.686	1045292.640	162.744	162.759	0.014
o43438	1936322.623	1044075.650	148.694	148.705	0.011
oBLACKSTOCK	1954557.881	991510.563	196.507	196.463	-0.044
oC28	1879500.918	1005998.297	131.785	131.611	-0.174
oFISHINGCREEK	1979593.031	1079315.594	176.450	176.634	0.184
oFRIENDSHIPCHURC	1940340.692	1039898.713	164.831	164.901	0.070
oPAULSBOUTIQUE	1897792.907	1042093.149	173.167	173.207	0.040
oPECKNEL	2030344.581	1042199.498	163.326	163.263	-0.063
oTANYARDBRANCH	1930067.485	1044421.737	152.522	152.489	-0.034
u12006	2032295.771	1005950.535	115.162	115.128	-0.034
u12-1-9	1864461.169	1075160.837	133.201	133.214	0.013
u12-2-7	1895734.848	1053327.945	188.353	188.466	0.113
u12-2-9	1895590.648	1045462.788	185.328	185.467	0.139
u12-3-1	1879445.495	1005967.335	131.281	131.363	0.082
u12-4-2	1942454.761	1046013.953	179.958	179.968	0.010
u12-4-9	1936176.076	1044706.461	154.103	154.108	0.005
u12-5-2	1954063.606	990906.300	185.812	185.805	-0.007
u12-5-4	1953509.082	992363.324	187.786	187.776	-0.011
u12-6-1	2028241.148	1000732.404	154.967	154.995	0.028
u12-6-7	2032758.964	996407.159	147.973	147.996	0.023
u12-7-6	2031513.655	1043318.849	163.786	163.763	-0.023
u12-7-8	2032320.153	1043929.210	157.804	157.799	-0.005
u12-8-1	1979630.679	1079334.613	177.016	177.004	-0.012
u12-8-9	1973660.752	1068697.949	174.231	174.237	0.006
u40519	2030345.228	1042262.445	163.964	163.814	-0.150

u40881	1930075.765	1044565.079	151.878	151.839	-0.039
u40885	1977248.515	1081537.260	174.229	174.209	-0.020
u41250	2030995.884	1042035.920	163.318	163.173	-0.145
u41612	1936710.138	1045038.398	153.613	153.608	-0.005
u41614	2028951.322	1001725.846	158.540	158.567	0.027
u41616	1959892.460	1070352.296	169.980	169.967	-0.013
u41980	2031636.482	1041495.130	157.717	157.752	0.035
u42342	1936054.867	1045342.982	159.876	159.873	-0.003
u42708	1935790.142	1045052.018	167.191	167.242	0.051
u43073	1935643.294	1044906.524	165.679	165.755	0.076
w12-1-6	1866962.932	1077140.875	135.272	135.338	0.066
w12-1-7	1869002.937	1078382.744	149.477	149.411	-0.066
w12-2-2	1894318.229	1041216.332	174.761	174.990	0.229
w12-2-6	1885296.201	1051929.144	175.604	175.680	0.076
w12-3-3	1874858.029	999186.645	137.661	137.612	-0.049
w12-3-4	1873146.273	996928.872	91.685	91.612	-0.073
w12-4-5	1937421.409	1052154.663	170.218	170.326	0.108
w12-4-6	1931187.739	1050886.367	160.916	161.043	0.127
w12-5-1	1954598.793	991640.001	195.917	195.924	0.007
w12-5-7	1951457.710	995787.929	182.180	182.380	0.200
w12-6-4	2028401.339	1001737.435	160.342	160.451	0.109
w12-6-9	2028652.289	993546.188	138.409	138.521	0.112
w12-7-1	2028252.294	1057221.991	179.191	179.106	-0.085
w12-7-9	2035827.612	1049142.557	158.210	158.161	-0.049
w12-8-4	1986440.333	1068447.359	181.293	181.407	0.114
w12-8-6	1979400.723	1071836.287	169.584	169.728	0.144
w12-8-8	1973738.957	1068667.817	174.481	174.595	0.114