

Greene, Macoupin, and Montgomery County  
3rd Delivery QAQC Report

Summary USGS National Geospatial Program  
Lidar Base Specification  
Version 1.2 Report

Quality level tested: QL2

Report generated on 12/18/2017

This document reports on compliance with the USGS National Geospatial Program Lidar Base Specification Version 1.2. The complete specification, which also contains a list of abbreviations, acronyms, and a glossary of related terms, can be found [here](#).

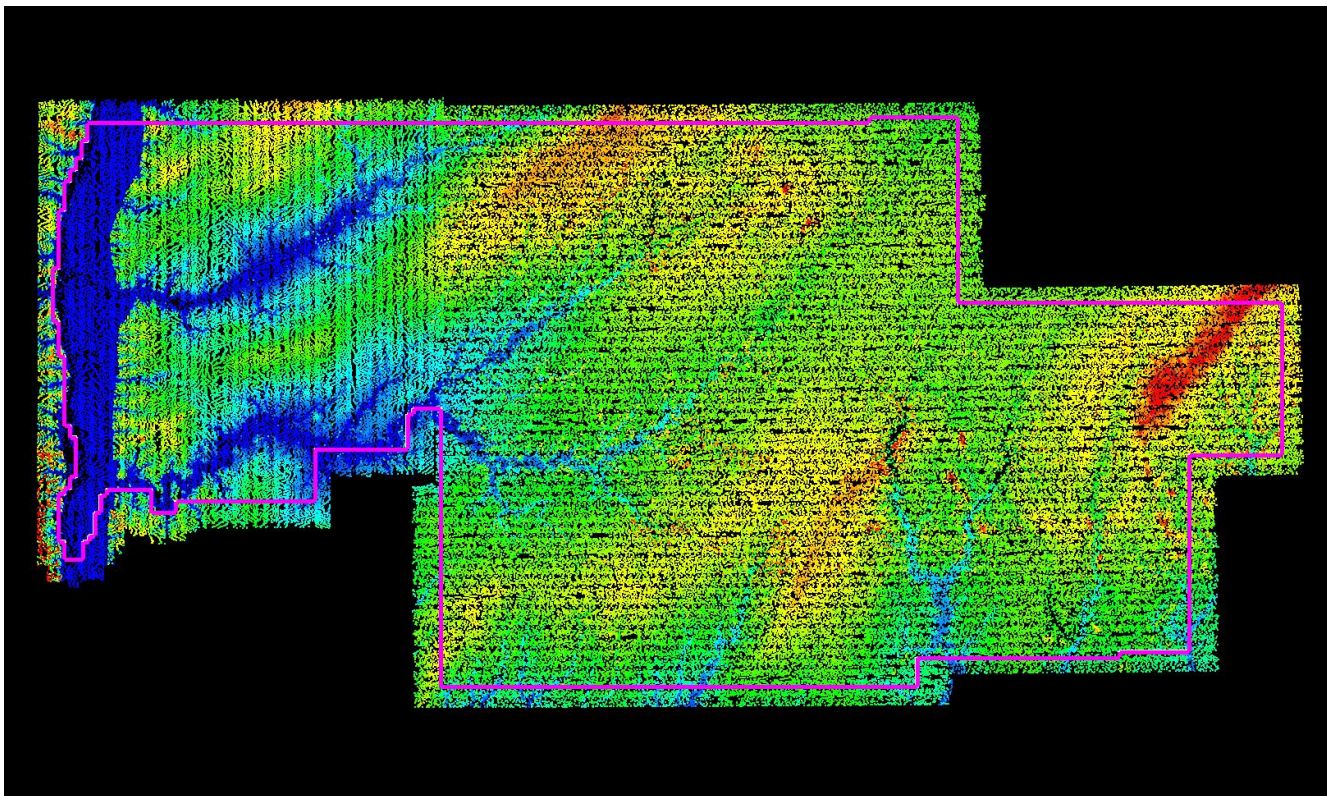
## *C-1 Report on Collection Area (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "The defined project area (DPA) shall be buffered by a minimum of 100 meters (m) to create a buffered project area (BPA). Data collection is required for the full extent of the BPA. In order for all products to be consistent to the edge of the DPA, all products shall be generated to the full extent of the BPA. Because data and products are generated for the complete BPA, they shall also be delivered to the customer."

The purpose of this section is to show swath lidar coverage to the extent of a 100 meter buffer of the defined project area boundary.

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](F:\boresight\RawSwath_las_1.4)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\C\\_1\CollectionArea\\_Swath.jpg](G:\Greene_Macoupin_Montgomery\QAQC\C_1\CollectionArea_Swath.jpg)



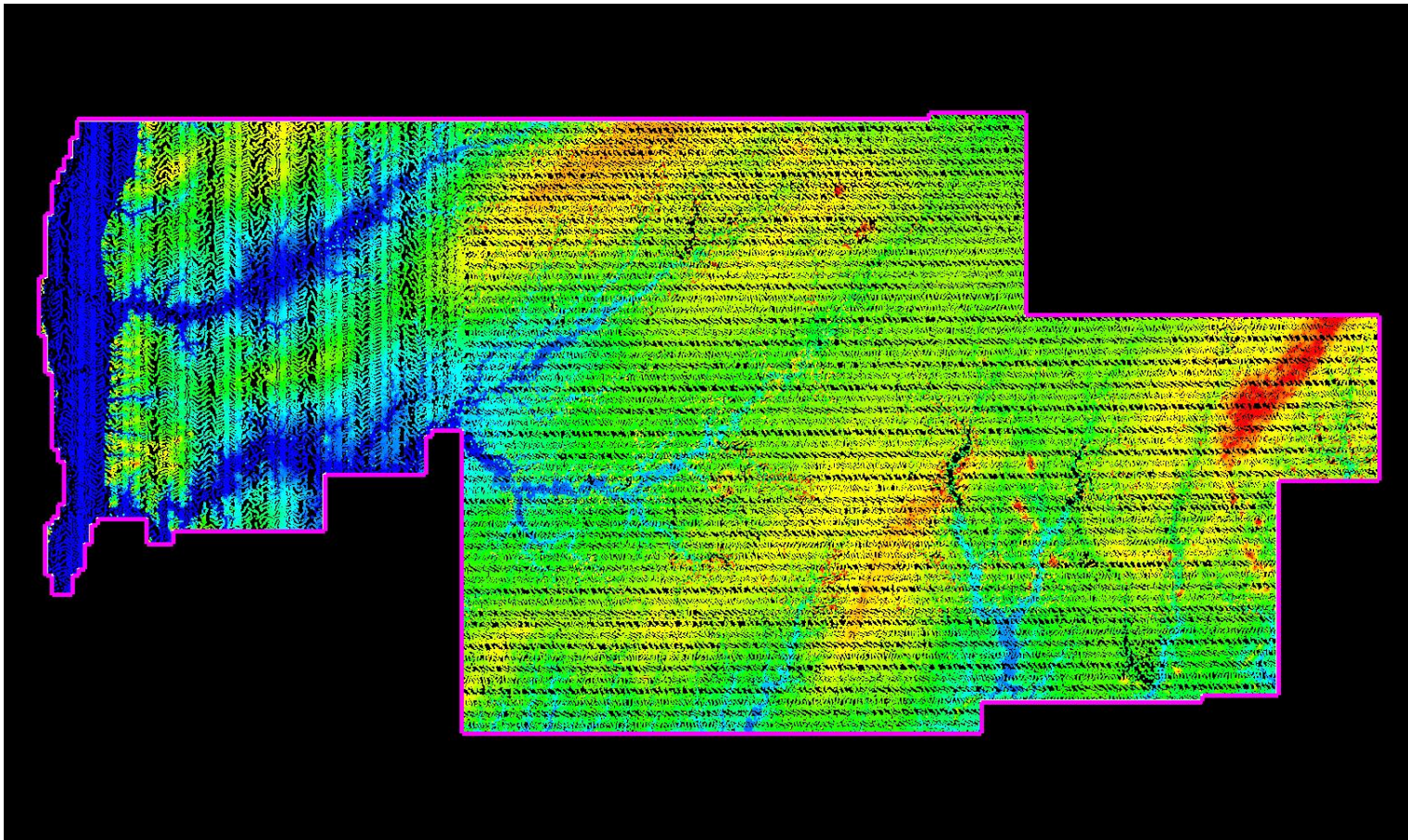
White polygon is defined project area (DPA) boundary  
Purple polygon is buffered project area (BPA) boundary

## C-1 Report on Collection Area (Tiled Data)

The purpose of this section is to show tiled lidar coverage to the extent of a 100 meter buffer of the defined project area boundary.

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\C\\_1\CollectionArea\\_Tiles.jpg](#)



White polygon is defined project area (DPA) boundary  
Purple polygon is buffered project area (BPA) boundary

## *C-2 Report on Multiple Discrete Returns (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "Deriving and delivering multiple discrete returns is required in all data collection efforts. Data collection shall be capable of at least three returns per pulse. Full waveform collection is acceptable and will be promoted; however, full waveform data are regarded as supplemental information."

The purpose of this section is to report on the presence and quantities of lidar returns in the LAS swath data. Empty return columns can indicate a collection or processing problem dealing with lidar return attribute information.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

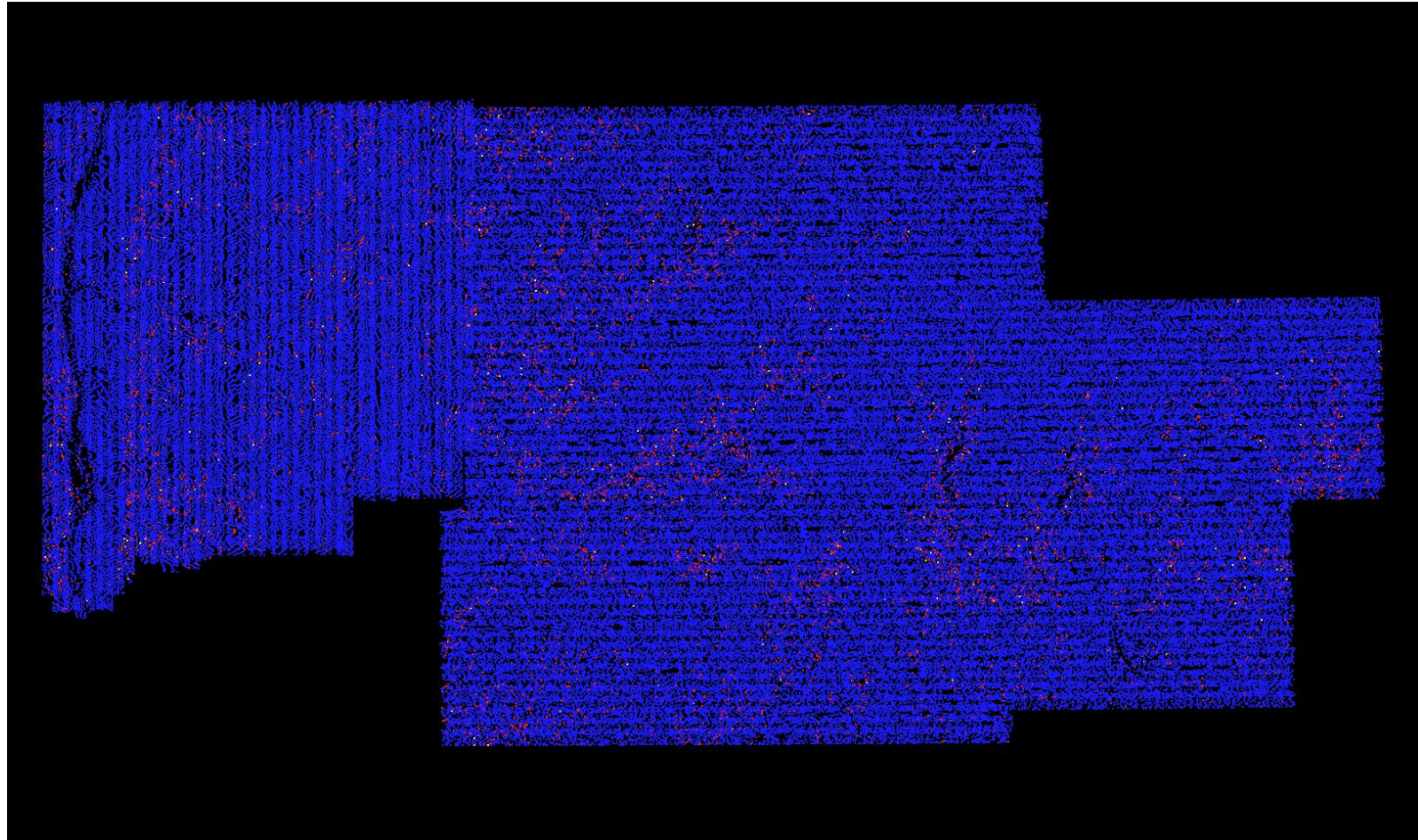
File	First return	Second return	Third return	Other returns	Total points
Total	26,623,298,446	977,756,249	46,350,339	421,427	27,647,826,461

## C-2 Report on Multiple Discrete Returns (Swath Data) - All Returns

The purpose of this section is to show a graphic of lidar swath data points colored by all returns. Blank flight lines can indicate a collection or processing problem dealing with lidar return attribute information.

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](F:\boresight\RawSwath_las_1.4)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\C\\_2\ColorByReturns\\_Boresighted.jpg](G:\Greene_Macoupin_Montgomery\QAQC\C_2\ColorByReturns_Boresighted.jpg)



## *C-2 Report on Multiple Discrete Returns (Tiled Data)*

The USGS Lidar Base Specification Version 1.2 states: "Deriving and delivering multiple discrete returns is required in all data collection efforts. Data collection shall be capable of at least three returns per pulse. Full waveform collection is acceptable and will be promoted; however, full waveform data are regarded as supplemental information."

The purpose of this section is to report on the presence and quantities of lidar returns in the LAS tiled data. Empty return columns can indicate a collection or processing problem dealing with lidar return attribute information.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

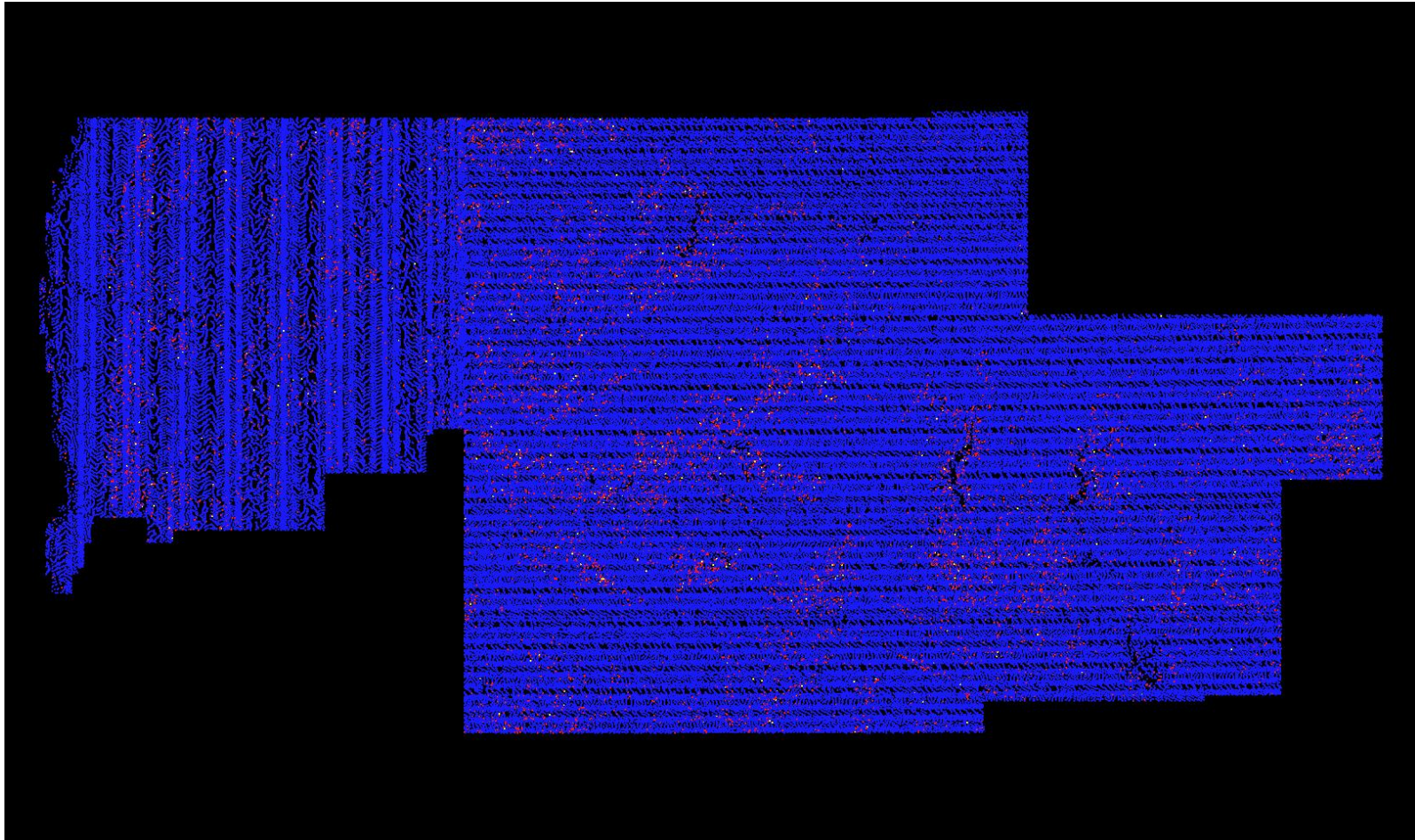
File	First return	Second return	Third return	Other returns	Total points
Total	23,096,608,930	841,295,033	40,824,817	380,728	23,979,109,508

## C-2 Report on Multiple Discrete Returns (Tiled Data) - All Returns

The purpose of this section is to show a graphic of lidar tiled data points colored by all returns. Blank tiles can indicate a collection or processing problem dealing with lidar return attribute information.

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\C\\_2\ColorByReturns\\_Classified.jpg](#)



First                      Second                      Third                      Fourth or other

### *C-3 Report on Intensity Values (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "Intensity values are required for each multiple discrete return. The values recorded in the LAS files shall be normalized to 16 bit, as described in the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011)."

The purpose of this section is to report on the presence and quantities of lidar intensity in the LAS swath data.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

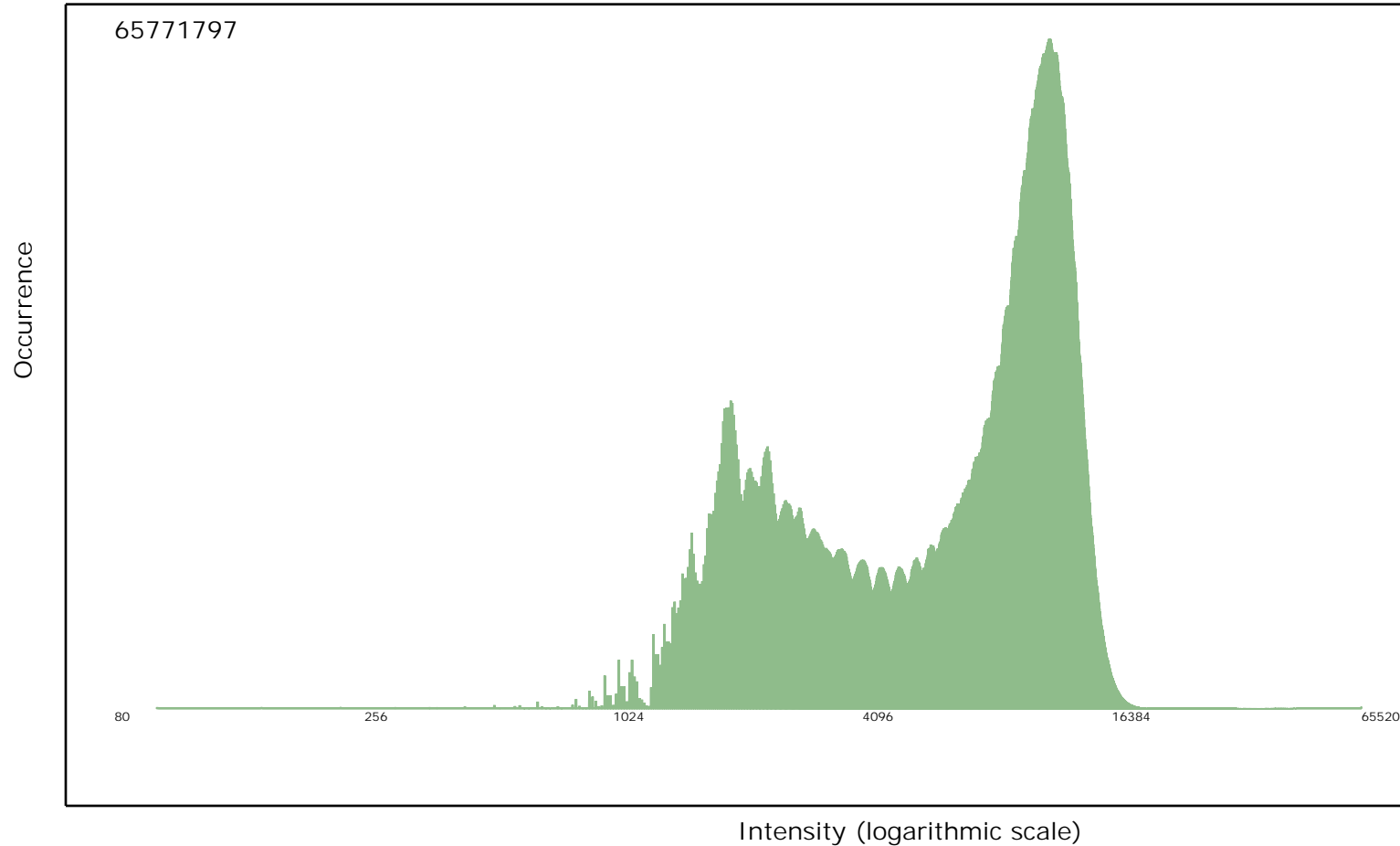
File	Minimum	Maximum	Mean	Median	Mode
Overall Statistics	80	65,520	9,741	10,544	11,600



## C-3 Report on Intensity Values (Swath Data) - continued

The purpose of this section is to show a frequency distribution chart of intensities throughout all of the lidar swath files. It is important to understand that 8-bit intensity lidar systems have a valid intensity range from 0-255, and 12-bit intensity lidar systems have a valid intensity range from 0-4095.

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](#)

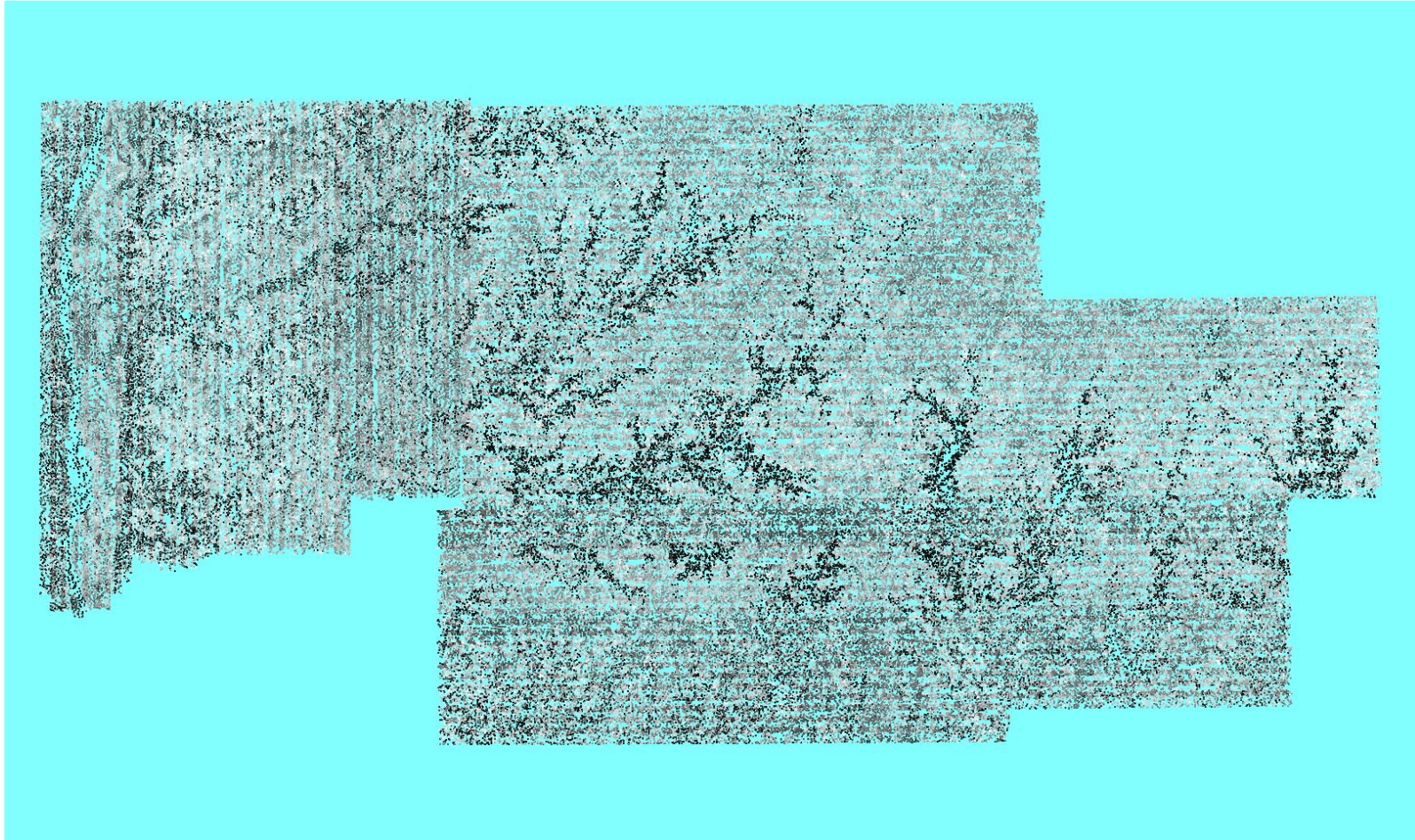


## *C-3 Report on Intensity Values (Swath Data) - continued*

The purpose of this section is to show a graphic of lidar swath data points colored by intensity. Blank tiles can indicate a processing problem dealing with lidar intensity attribute information.

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](F:\boresight\RawSwath_las_1.4)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\C\\_3\ColorByIntensity\\_Boresighted.jpg](G:\Greene_Macoupin_Montgomery\QAQC\C_3\ColorByIntensity_Boresighted.jpg)



### *C-3 Report on Intensity Values (Tiled Data)*

The USGS Lidar Base Specification Version 1.2 states: "Intensity values are required for each multiple discrete return. The values recorded in the LAS files shall be normalized to 16 bit, as described in the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011)."

The purpose of this section is to report on the presence and quantities of lidar intensity in the LAS tiled data.

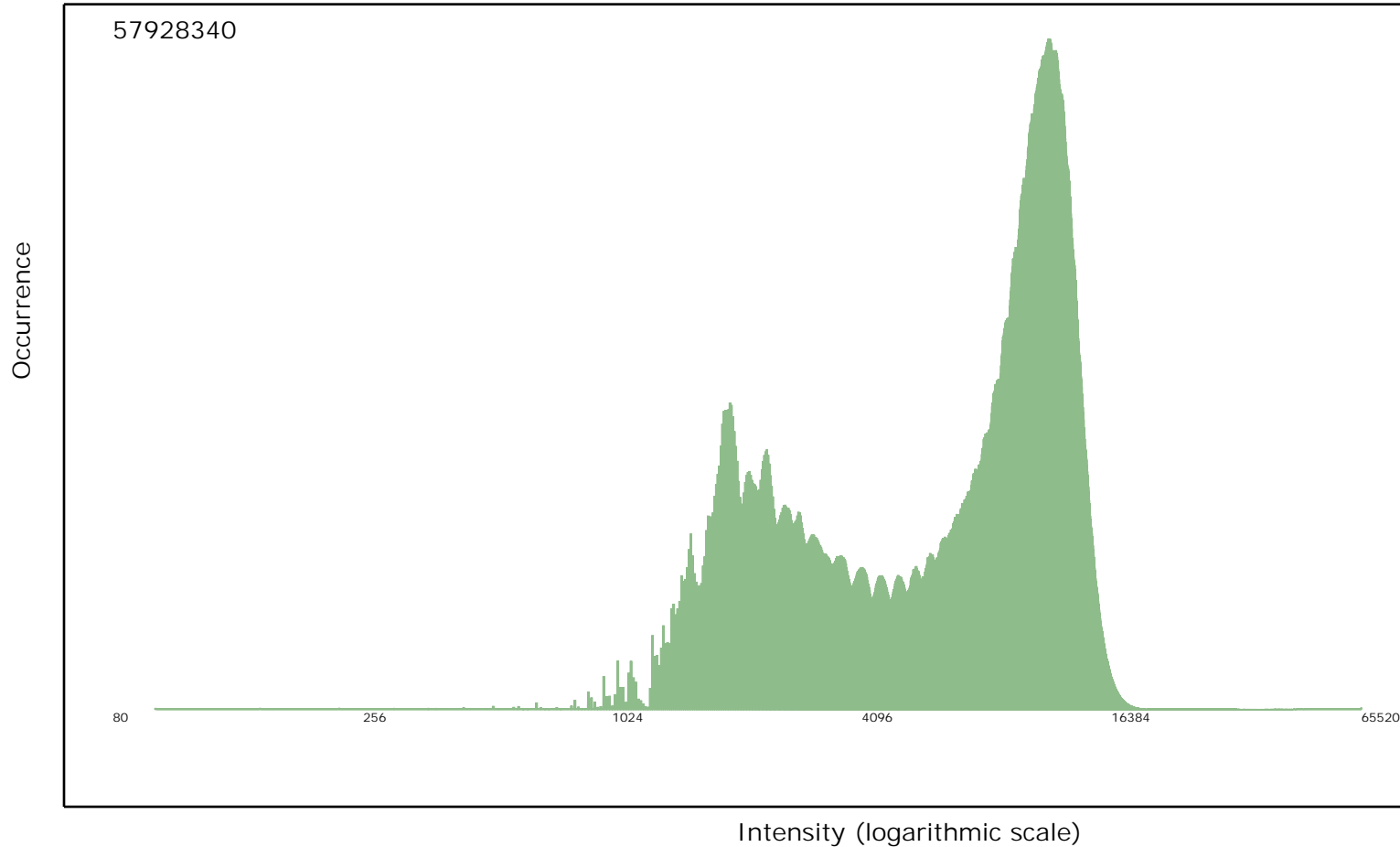
[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

File	Minimum	Maximum	Mean	Median	Mode
Overall Statistics	80	65,520	9,787	10,608	11,600

## C-3 Report on Intensity Values (Tiled Data) - continued

The purpose of this section is to show a frequency distribution chart of intensities throughout all of the lidar tiled files. It is important to understand that 8-bit intensity lidar systems have a valid intensity range from 0-255, and 12-bit intensity lidar systems have a valid intensity range from 0-4095.

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

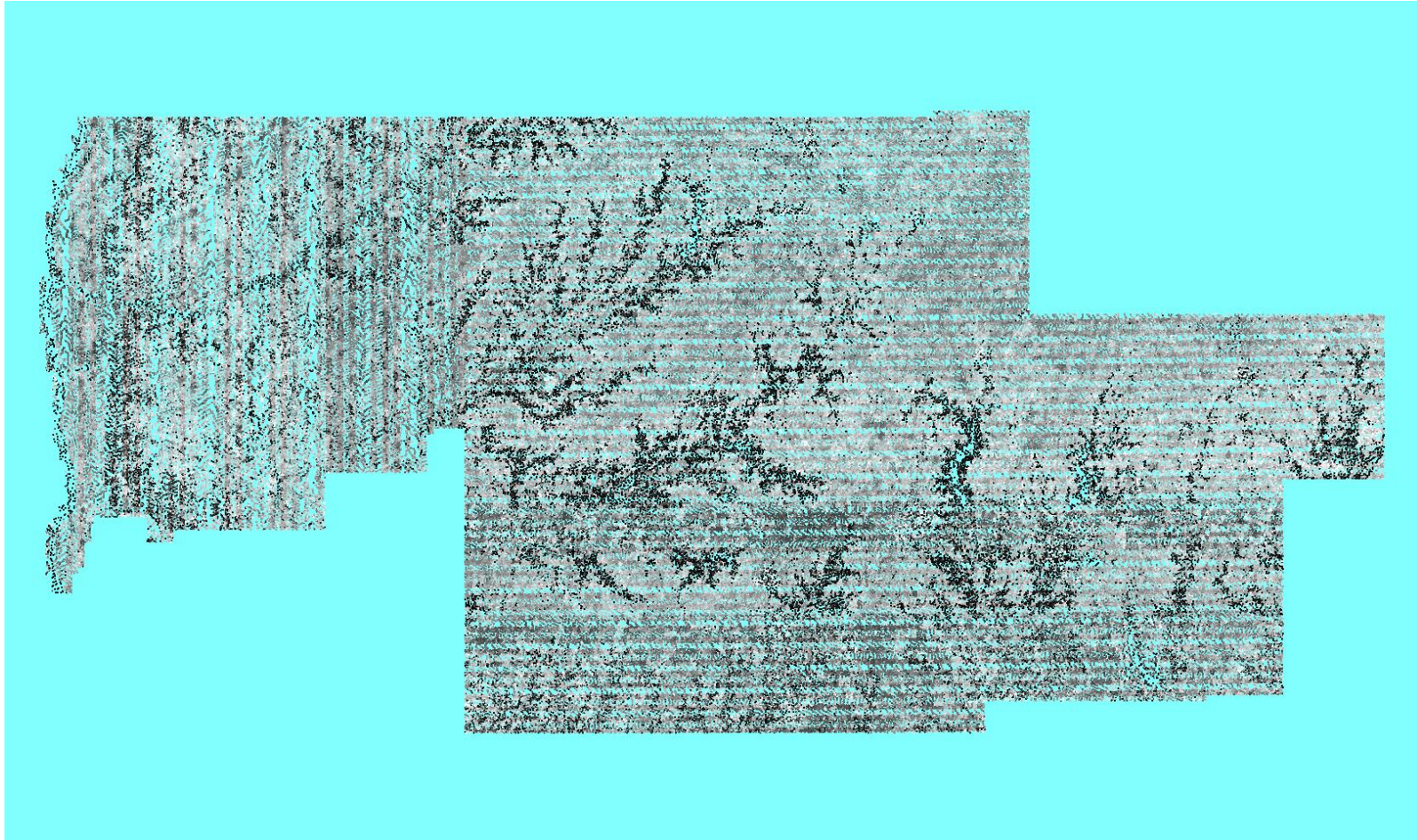


## *C-3 Report on Intensity Values (Tiled Data) - continued*

The purpose of this section is to show a graphic of lidar tiled data points colored by intensity. Blank tiles can indicate a processing problem dealing with lidar intensity attribute information.

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\C\\_3\ColorByIntensity\\_Classified.jpg](#)



## C-4 Report on Nominal Pulse Spacing (NPS)

The USGS Lidar Base Specification Version 1.2 states: "Assessment and reporting of the NPS is made against single swath, single instrument, first return only data, including only the geometrically usable part of the swath (typically the center 95 percent) and excluding acceptable data voids. Higher net densities of lidar point measurements are being achieved more often by using multiple coverages, creating a need for a separate new term to prevent confusion with NPS and NPD. This specification will use the terms aggregate nominal pulse spacing (ANPS) and aggregate nominal pulse density (ANPD) to describe the net overall pulse spacing and density, respectively. The table "Aggregate nominal pulse spacing and density, Quality Level 0–Quality Level 3" (table 1) lists the required ANPS and ANPD by QL. Dependent on the local terrain and land cover conditions in a project, a greater pulse density may be required on specific projects."

**Table 1. Aggregate nominal pulse spacing and density, Quality Level 0–Quality Level 3.**

[m, meters; pls/m<sup>2</sup>, pulses per square meter; ≤, less than or equal to; ≥, greater than or equal to]

Quality Level (QL)	Aggregate nominal pulse spacing (ANPS) (m)	Aggregate nominal pulse density (ANPD) (pls/m <sup>2</sup> )
QL0	≤0.35	≥8.0
QL1	≤0.35	≥8.0
QL2	≤0.71	≥2.0
QL3	≤1.41	≥0.5

The purpose of this section is to report on the lidar point density and nominal point spacing by swath file. Averages by swath files (not including overlap), project boundary polygons (including swath overlap), and aggregate project boundary polygons (including swath overlap) are reported.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

Quality level tested: QL2

Units: US Survey Feet

File	Number of First Returns	Area of Swath	Point Density	NPS
Average			2.831/0.263 <small>pp Square Meter/ pp Square US Survey Foot</small>	0.594/1.948 <small>Meter/ US Survey Feet</small>

## *C-4 Report on Nominal Pulse Spacing (NPS) - continued*

Boundary ID	Number of First Returns	Area of Swath	Point Density	NPS
Aggregate	23,060,415,299	61,904,000,000	4.015/0.373 <small>pp Square Meter/ pp Square US Survey Foot</small>	0.499/1.638 <small>Meter/ US Survey Feet</small>

## *C-5 Report on Data Voids*

The USGS Lidar Base Specification Version 1.2 states: "Data voids, in lidar, are gaps in the point cloud coverage, caused by surface absorbance or refraction of the lidar pulse (or both absorbance and refraction simultaneously), instrument or processing anomalies or failure, obstruction of the lidar pulse, or improper collection because of flight plans. A data void is considered to be any area greater than or equal to 4 (ANPS2), which is measured using first returns only. Data voids within a single swath are not acceptable, except in the following circumstances:

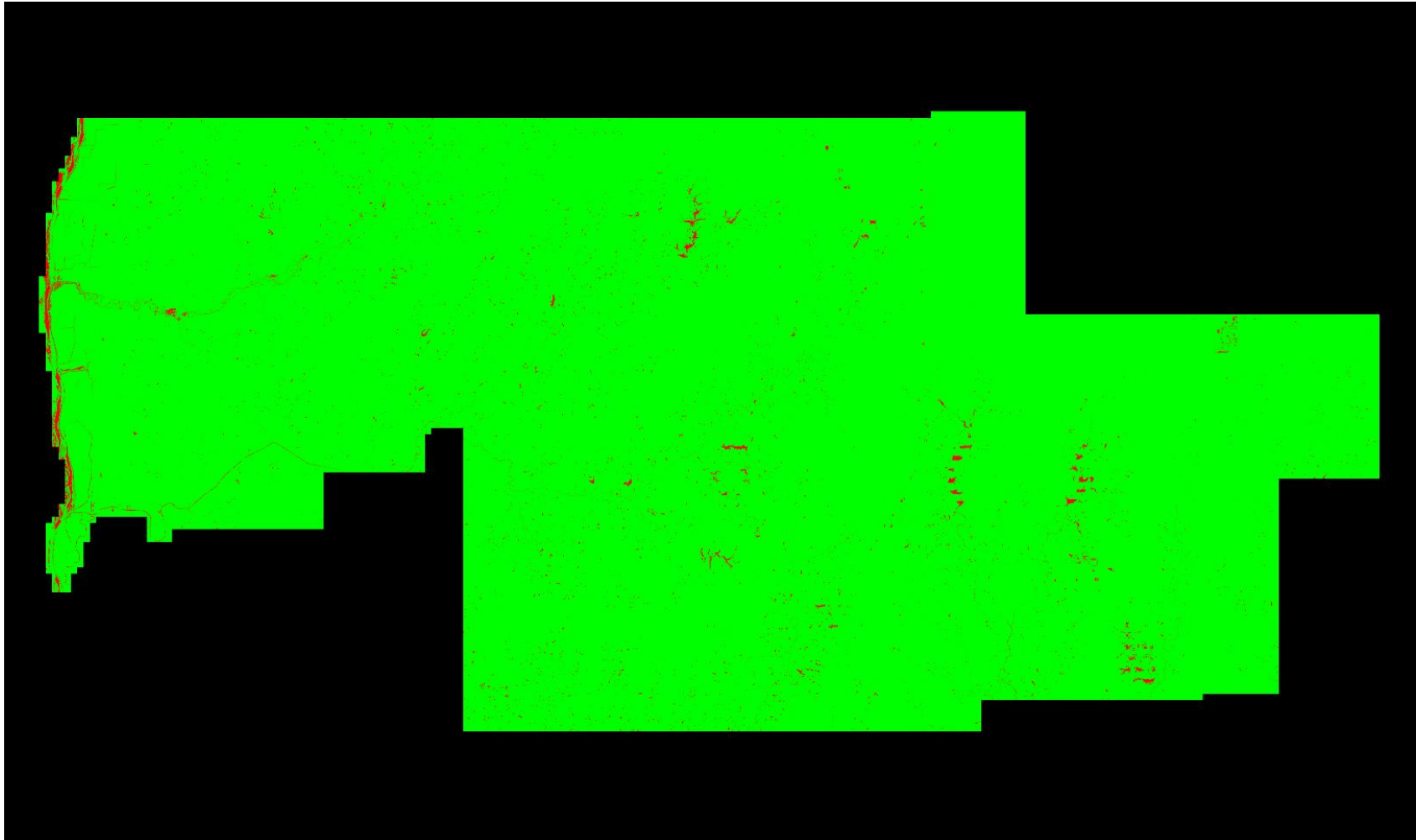
- (1) where caused by water bodies.
- (2) where caused by areas of low near infrared (NIR) reflectivity such as asphalt or composition roofing, or
- (3) where appropriately filled in by another swath. "

The purpose of this section is to show graphically where possible lidar data voids are located. Data voids can be caused by a lack of coverage at the time of collection, water bodies not reflecting the laser beam back to the receiver, lidar occlusions caused by objects above ground like tall buildings, etc. Not all data voids are problematic. The intention of this test is to isolate the first example of lidar data voids - a lack of coverage at the time of collection. A close inspection must be done on the results to determine if the lidar coverage was collected and processed to meet the intended specifications.

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](F:\boresight\RawSwath_las_1.4)  
[G:\Greene\\_Macoupin\\_Montgomery\QAQC\C\\_5\Boresighted\\_DataVoids\\_SingleFile.jp2](G:\Greene_Macoupin_Montgomery\QAQC\C_5\Boresighted_DataVoids_SingleFile.jp2)



## C-5 Report on Data Voids



Cell size: 9.318 US Survey Feet

- Green: Cells containing at least 1 first return lidar point (number of cells = 706,461,087)
- Red: Cells containing no first return lidar points (number of cells = 6,557,832)
- Background Color: Null data

## *C-6.1 Report on Spatial Distribution and Regularity*

The USGS Lidar Base Specification Version 1.2 states: "The spatial distribution of geometrically usable points will be uniform and regular. Although lidar instruments do not produce regularly gridded points, collections shall be planned and executed to produce an aggregate first return point cloud that approaches a regular lattice of points, rather than a collection of widely spaced, high-density profiles of the terrain. The regularity of the point pattern and density throughout the dataset is important and will be assessed by using the following steps:

- (1) Generating a density grid from the data with cell sizes equal to twice the design ANPS and a radius equal to the design ANPS.
- (2) Ensuring at least 90 percent of the cells in the grid contain at least one lidar point.
- (3) Using individual (single) swaths, with only the first return points located within the geometrically usable center part (typically 95 percent) of each swath.
- (4) Excluding acceptable data voids previously identified in this specification.

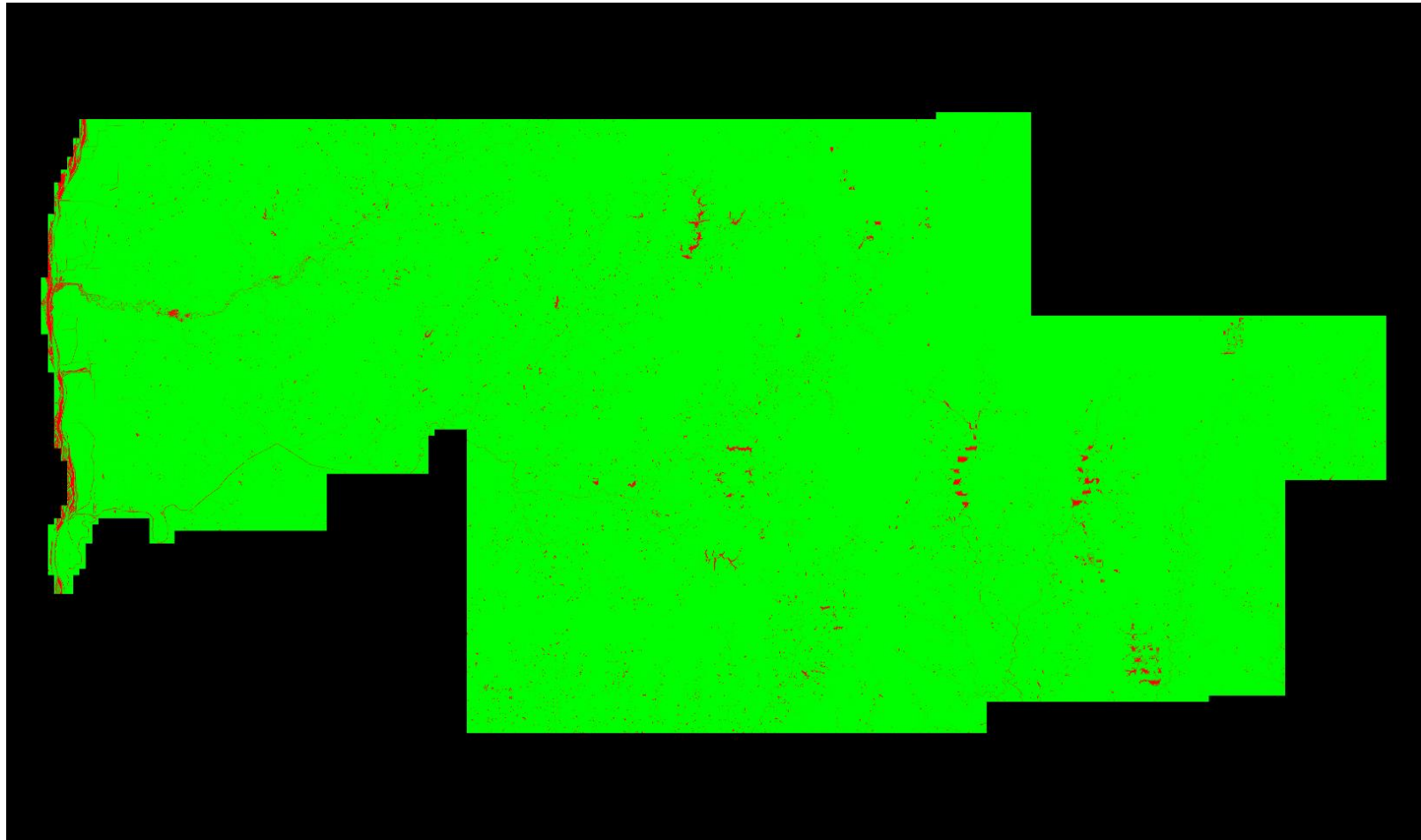
The process described in this section relates only to regular and uniform point distribution. The process does not relate to, nor can it be used for, the assessment of NPS or ANPS. The USGS-NGP may allow lower passing thresholds for this requirement in areas of substantial relief where maintaining a regular and uniform point distribution is impractical."

The purpose of this section is to show graphically where unacceptable lidar spatial distributions are located. Lidar spatial distribution can be affected by problems in flight planning (e.g., incorrect scan frequency / pulse rate pairing) or flight execution (e.g., strong headwinds or tailwinds), a lack of coverage at the time of collection, water bodies not reflecting the laser beam back to the receiver, lidar occlusions caused by objects above ground like tall buildings, etc. Not all lidar spatial distribution violations are truly problematic. The intention of this test is to isolate the first example of lidar spatial distribution violations - problems in flight planning or flight execution. A close inspection must be done on the results to determine if the lidar spatial distribution was collected and processed to meet the intended specifications.

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](#)

[G:\Greene Macoupin Montgomery\QAQC\C\\_6\Boresighted\\_SpatialDistribution\\_SingleFile.jp2](#)

## C-6.1 Report on Spatial Distribution and Regularity - continued



Cell size: 4.659 US Survey Feet

■ Green: Cells containing at least one first return lidar point (number of cells = 1,480,388,799)

■ Red: Cells not containing at least one first return lidar point (number of cells = 37,555,561)

■ Background Color: Null data

Percentage of cells in the grid that contain at least one first return lidar point = 102.60% (Requirement is typically 90%)

See JPG2000 file for full resolution results

## *C-6.2 Report on Spatial Distribution and Regularity of Individual Swaths*

Swath

Percentage of Cells  
that Contain  $\geq 1$

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Pass: 95 files (percentage  $\geq 90\%$ )

Fail: 2 files (percentage  $< 90\%$ )

## C-7 Report on Collection Conditions

The USGS Lidar Base Specification Version 1.2 states: "Conditions for collection of lidar data will follow these guidelines: (1) Atmospheric conditions shall be cloud and fog free between the aircraft and ground during all collection operations. (2) Ground conditions shall be snow free. Very light, undrifted snow may be acceptable in special cases, with prior approval. (3) Ground conditions shall be free of extensive flooding or any other type of inundation

*Note: Other collection condition requirements are also listed but are unable to be automatically derived with this reporting tool.*

The purpose of this section is to provide a hyperlink to a NOAA website that shows the snow depth map for the extent of the lidar at the time of collection.

### Ground Conditions:

Flight Date: 04/07/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=7&dh=20&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=7&dh=20&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

Flight Date: 04/08/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=8&dh=20&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=8&dh=20&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

Flight Date: 04/12/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=12&dh=22&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=12&dh=22&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

Flight Date: 04/15/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=15&dh=15&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=15&dh=15&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

## C-7 Report on Collection Conditions - Continued

### Ground Conditions:

Flight Date: 04/19/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=19&dh=1&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=19&dh=1&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

Flight Date: 04/22/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=22&dh=23&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=22&dh=23&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

Flight Date: 04/23/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=23&dh=23&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=23&dh=23&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

Flight Date: 04/24/2017

[http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm\\_depth&dy=2017&dm=4&dd=24&dh=19&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min\\_x=-90.6458225779317&min\\_y=38.9741834895454&max\\_x=-89.0980154998598&max\\_y=39.5483958465918&coord\\_x=-89.8719190388958&coord\\_y=39.2612896680686&zbox\\_n=&zbox\\_s=&zbox\\_e=&zbox\\_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h\\_o=0&font=0&js=1&uc=0](http://www.nohrsc.noaa.gov/interactive/html/map.html?mode=pan&extents=us&zoom=&loc=39.2612896680686+N%2C+89.8719190388958+W&ql=station&var=ssm_depth&dy=2017&dm=4&dd=24&dh=19&snap=1&o5=1&o6=1&o11=1&o9=1&o13=1&lbl=m&o7=1&min_x=-90.6458225779317&min_y=38.9741834895454&max_x=-89.0980154998598&max_y=39.5483958465918&coord_x=-89.8719190388958&coord_y=39.2612896680686&zbox_n=&zbox_s=&zbox_e=&zbox_w=&metric=0&bgvar=dem&shdvar=shading&width=800&height=450&nw=800&nh=450&h_o=0&font=0&js=1&uc=0)

## DPH-1.1 Report on ASPRS LAS File Format (Swath Data) - Compliance

The USGS Lidar Base Specification Version 1.2 states: "All processing will be carried out with the understanding that all point deliverables are required to be fully compliant with ASPRS LAS Specification, version 1.4, using Point Data Record Format 6, 7, 8, 9 or 10. Data producers are encouraged to review the LAS Specification version 1.4 in detail (American Society for Photogrammetry and Remote Sensing, 2011)."

The purpose of this section is to show a table of LAS 1.4 compliance test results for each swath file.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

File	LAS Version/PDRF	System ID	Legacy Point Count	Legacy Return Counts	PSID/FSID Match	Global Encoding	VLRs / EVLRs	WKT	Intensity	Point Count with Bad Return Info
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Pass: 97 files

Fail: 0 files

## DPH-1.1 Report on ASPRS LAS File Format (Tiled Data) - Compliance

The USGS Lidar Base Specification Version 1.2 states: "All processing will be carried out with the understanding that all point deliverables are required to be fully compliant with ASPRS LAS Specification, version 1.4, using Point Data Record Format 6, 7, 8, 9 or 10. Data producers are encouraged to review the LAS Specification version 1.4 in detail (American Society for Photogrammetry and Remote Sensing, 2011)."

The purpose of this section is to show a table of LAS 1.4 compliance test results for each tiled file.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\Merrick\Classified\\_las\\_1.4](#)

File	LAS Version/PDRF	System ID	Legacy Point Count	Legacy Return Counts	File Source ID	Global Encoding	VLRs / EVLRs	WKT	Intensity	Point Count with Bad Return Info
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Pass: 15483 files

Fail: 0 files



## DPH-1.2 Report on ASPRS LAS File Format (Swath Data) - File Integrity

The purpose of this section is to show a table of LAS 1.4 file integrity test results for each swath file.

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File	Number of Points Outside Extent	Offset To Point Data	Offset To EVLR	Number Of Points	Number of Points by Return	Number of Duplicate Points
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Pass: 97 files

Fail: 0 files

## DPH-1.2 Report on ASPRS LAS File Format (Tiled Data) - File Integrity

The purpose of this section is to show a table of LAS 1.4 file integrity test results for each tiled file.

File	Number of Points Outside Extent	Offset To Point Data	Offset To EVLR	Number Of Points	Number of Points by Return	Number of Duplicate Points
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Pass: 15483 files

Fail: 0 files

## DPH-1.3 Report on ASPRS LAS File Format (Swath Data) - Informational

The purpose of this section is to show a table of LAS 1.4 file informational test results for each swath file.

File	(Xmin, Ymin, Zmin)	(Xmax, Ymax, Zmax)	Extended Scan Angle	Scan Angle Rank	Scanner Channel	Scan Direction	Edge of Flight Line	User Data	Counts for Synthetic	Keypoints	Withheld	Overlap
	(2160362.173,840590.921,-398.602)	(2597928.46,1051160.768,1365.624)	[-3500, 3940]	[-21, 23.64]	[0, 0]	[0, 1]	[0, 1]	[0, 0]	0	0	400935219	10327640534

## DPH-1.3 Report on ASPRS LAS File Format (Tiled Data) - Informational

The purpose of this section is to show a table of LAS 1.4 file informational test results for each tiled file.

File	(Xmin, Ymin, Zmin)	(Xmax, Ymax, Zmax)	Extended Scan Angle	Scan Angle Rank	Scanner Channel	Scan Direction	Edge of Flight Line	User Data	Counts for Synthetic	Keypoints	Withheld	Overlap
	(2166000,848000,-398.602)	(2589999.999,1043999.999,9000.093)	[-30626, 3500]	[-183.756, 21]	[0, 0]	[0, 1]	[0, 1]	[0, 0]	0	6482883633	306596176	9199775501

## *DPH-2 Report on Full Waveform (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "If full waveform data are recorded during collection, the waveform packets shall be delivered. LAS Specification version 1.4 deliverables including waveform data shall use external auxiliary files with the extension .wdp to store waveform packet data. See the LAS Specification version 1.4 for additional information (American Society for Photogrammetry and Remote Sensing, 2011)."

The purpose of this section is to show the presence of waveform data for the lidar swath data.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

All LAS swath files have no waveform data present.

## *DPH-2 Report on Full Waveform (Tiled Data)*

The purpose of this section is to show the presence of waveform data for the lidar tiled data.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

All LAS tiled files have no waveform data present.

## *DPH-3 Report on Time of Global Positioning System Data (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "The time of global positioning system (GPS) data shall be recorded as Adjusted GPS Time, at a precision sufficient to allow unique timestamps for each pulse. Adjusted GPS Time is defined to be Standard (or satellite) GPS time minus 109. See the LAS Specification version 1.4 for additional information (American Society for Photogrammetry and Remote Sensing, 2013)."

The purpose of this section is to show the GPS time type within the LAS files for the lidar swath data.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

All LAS swath files are formatted as Adjusted GPS Time.

## *DPH-3 Report on Time of Global Positioning System Data (Tiled Data)*

The purpose of this section is to show the GPS time type within the LAS files for the lidar tiled data.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

All LAS tiled files are formatted as Adjusted GPS Time.



## *DPH-4 Report on Datums (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "All data collected shall be tied to the datums listed below: For the Conterminous United States (CONUS), unless otherwise specified by the user and agreed to in advance by the USGS-NGP: The horizontal datum for latitude and longitude and ellipsoid heights will be the North American Datum of 1983 (NAD 83) using the most recently published adjustment of the National Geodetic Survey (NGS) (currently NAD 83, epoch 2010.00). The vertical datum for orthometric heights will be the North American Vertical Datum of 1988 (NAVD 88). The geoid model used to convert between ellipsoid heights and orthometric heights will be the latest hybrid geoid model of NGS, supporting the latest realization of NAD 83 (currently GEOID12B model)."

The purpose of this section is to show the datums of the LAS files for the lidar swath data.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

All LAS swath files are defined as:

Horizontal Datum = NAD83 (National Spatial Reference System 2011)  
Horizontal EPSG Code = 1116  
Vertical Datum = North American Vertical Datum 1988  
Vertical EPSG Code = 5103

## *DPH-4 Report on Datums (Tiled Data)*

The purpose of this section is to show the datums of the LAS files for the lidar tiled data.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

All LAS tiled files are defined as:

Horizontal Datum = NAD83 (National Spatial Reference System 2011)

Horizontal EPSG Code = 1116

Vertical Datum = North American Vertical Datum 1988

Vertical EPSG Code = 5103

## *DPH-5 Report on Coordinate Reference System (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "Lidar data for CONUS will be processed and delivered in the most accurate Coordinate Reference System (CRS) available for a project location, usually State Plane Coordinate System (SPCS) or a state system. Universal Transverse Mercator (UTM) also may be used, particularly when a single suitable local SPCS is not available, UTM is needed for compatibility with existing data for the area, or is needed for other reasons. Other CRSs may be used with prior approval from the USGS–NGP. For Alaska, American Samoa, Commonwealth of the Northern Mariana Islands, Guam, Hawaii, Puerto Rico, U.S. Virgin Islands, and other areas, the horizontal and vertical CRS (specifically including the units) shall be specified and agreed to in advance of collection by the USGS–NGP and all collection partners. In all cases, the CRS that is used shall be recognized and published by the European Petroleum Survey Group (EPSG) and correctly recognized by industry standard geographic information system (GIS) software applications."

The purpose of this section is to show the coordinate reference systems of the LAS files for the lidar swath data.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

All LAS swath files are defined as:

EPSG Code = 6457

Coordinate Reference System = NAD83(2011) / Illinois West (ftUS)

## *DPH-5 Report on Coordinate Reference System (Tiled Data)*

The purpose of this section is to show the projections of the LAS files for the lidar tiled data.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

All LAS tiled files are defined as:

EPSG Code = 6457

Coordinate Reference System = NAD83(2011) / Illinois West (ftUS)

## *DPH-6 Report on Units of Reference (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "All references to the unit of measure 'Feet' or 'Foot' shall specify 'International', 'Intl', 'U.S. Survey', or 'US'."

The purpose of this section is to show the horizontal and vertical units of the LAS files for the lidar swath data.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](F:\boresight\RawSwath_las_1.4)

All LAS swath files are defined as:

Horizontal Unit = US Survey Foot

Vertical Unit = US survey foot

## *DPH-6 Report on Units of Reference (Tiled Data)*

The purpose of this section is to show the horizontal and vertical units of the LAS files for the lidar tiled data.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

All LAS tiles files are defined as:

Horizontal Unit = US Survey Foot

Vertical Unit = US survey foot

## *DPH-7 Report on Swath Identification*

The USGS Lidar Base Specification Version 1.2 states: "At the time of its creation and prior to any further processing, each swath shall be assigned a unique File Source Identification (ID), and each point within the swath shall be assigned a Point Source ID equal to the File Source ID. The Point Source ID on each point will be persisted unchanged throughout all processing and delivery. See the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011)."

The purpose of this section is to report on the File Source ID and Point Source ID values for the lidar swath data. Note that sub-swaths of original swaths (see DPH-9) may violate the unique values specification described in this test.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

There are 97 unique Point Source IDs.

There are 97 unique File Source IDs.

0 files are in violation with duplicated File Source ID or Point Source ID values.

## *DPH-8 Report on Point Families (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "Point families (multiple return 'children' of a single 'parent' pulse) will be maintained throughout all processing before tiling. Multiple returns from a given pulse will be stored in sequential (collected) order."

The purpose of this section is to report on the presence and integrity of point families for the lidar swath data.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](F:\boresight\RawSwath_las_1.4)

All LAS swath files have point families present.



## *DPH-8 Report on Point Families (Tiled Data)*

The purpose of this section is to report on the presence and integrity of point families for the lidar tiled data.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

All LAS tiled files have point families present.

## DPH-9 Report on Swath Size and Segmentation (Swath Data)

The USGS Lidar Base Specification Version 1.2 states: "The widespread adoption of 64-bit operating systems in mainstream computing (most notably Windows-7, 64-bit or newer operating systems) has obviated the earlier need for 2 GB limits on swath file sizes. Unless otherwise required by the data producer, lidar swaths may be of any file size supported within a 64-bit computing system. In cases where segmentation of the swaths is required by the data producer, the following requirements apply:

- (1) Subswath segments of a given original swath will be of comparable size.
- (2) Each subswath shall retain the File Source ID of the original complete swath.
- (3) Points within each subswath shall retain the Point Source ID of the original complete swath.
- (4) Each subswath file shall be named identically to the original complete swath, with the addition of an ordered alphabetic suffix to the name ("-a," "-b," ..., "-n"). The order of the named subswaths shall be consistent with the collection order of the points ("-a" will be the first subswath; "-n" will be the last subswath).
- (5) Point families will be maintained intact within each subswath.
- (6) Subswaths will be broken at the edge of the scan line."

The purpose of this section is to show the file sizes of the LAS files for the lidar swath data.

### [Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

File	File Size (bytes)	MB	GB
00004.las	12,160,781,055	11597.425	11.326
00005.las	10,759,500,513	10261.059	10.021
00006.las	11,774,125,615	11228.681	10.966
00007.las	10,583,738,061	10093.439	9.857
00012.las	8,503,979,877	8110.027	7.920
00013.las	7,158,804,647	6827.168	6.667
00014.las	8,363,043,087	7975.619	7.789
00015.las	10,301,243,659	9824.032	9.594
00016.las	12,379,102,827	11805.632	11.529
00017.las	10,118,088,523	9649.361	9.423
00018.las	12,197,126,817	11632.087	11.359
00019.las	10,016,153,947	9552.149	9.328
00020.las	12,231,618,009	11664.980	11.392
00021.las	10,150,217,501	9680.002	9.453
00022.las	12,122,916,509	11561.314	11.290
00026.las	10,139,002,425	9669.306	9.443
00032.las	6,679,802,267	6370.356	6.221
00033.las	6,700,514,857	6390.109	6.240
00034.las	4,923,223,867	4695.152	4.585
00035.las	5,639,820,105	5378.552	5.252
00036.las	5,848,181,849	5577.261	5.447
00037.las	6,827,015,763	6510.750	6.358
00038.las	6,244,495,013	5955.215	5.816
00039.las	7,023,969,703	6698.580	6.542
00040.las	5,894,701,799	5621.626	5.490
00041.las	6,825,330,443	6509.142	6.357
00042.las	6,010,370,215	5731.936	5.598
00043.las	6,894,193,655	6574.815	6.421
00044.las	5,825,370,309	5555.506	5.425
00045.las	6,792,257,045	6477.601	6.326
00046.las	5,691,427,411	5427.768	5.301

## *DPH-9 Report on Swath Size and Segmentation (Swath Data) - continued*

File	File Size (bytes)	MB	GB
00047.las	6,573,779,015	6269.244	6.122
00048.las	5,521,867,469	5266.063	5.143
00049.las	6,604,592,655	6298.630	6.151
00060.las	5,612,044,277	5352.062	5.227
00061.las	6,806,409,643	6491.098	6.339
00062.las	5,672,846,141	5410.048	5.283
00063.las	6,616,509,425	6309.995	6.162
00064.las	5,644,303,153	5382.827	5.257
00065.las	6,456,511,229	6157.409	6.013
00066.las	5,699,643,849	5435.604	5.308
00067.las	6,427,231,519	6129.486	5.986
00068.las	5,792,186,217	5523.859	5.394
00075.las	7,879,921,229	7514.878	7.339
00076.las	4,789,033,481	4567.178	4.460
00077.las	6,712,362,191	6401.407	6.251
00078.las	4,710,497,563	4492.281	4.387
00079.las	6,470,312,669	6170.571	6.026
00080.las	4,736,952,835	4517.510	4.412
00081.las	6,175,900,349	5889.798	5.752
00089.las	5,391,373,729	5141.615	5.021
00090.las	5,161,845,801	4922.720	4.807
00091.las	5,367,328,953	5118.684	4.999
00092.las	5,125,418,295	4887.980	4.773
00093.las	4,709,587,819	4491.413	4.386
00104.las	10,537,531,325	10049.373	9.814
00105.las	13,265,238,143	12650.717	12.354
00106.las	10,461,883,393	9977.229	9.743
00107.las	13,359,746,793	12740.847	12.442
00108.las	10,743,344,157	10245.651	10.006
00109.las	13,254,614,467	12640.585	12.344
00118.las	11,674,837,009	11133.992	10.873
00119.las	15,188,924,729	14485.287	14.146
00120.las	11,448,913,745	10918.535	10.663
00121.las	15,126,141,003	14425.412	14.087
00122.las	11,442,282,311	10912.211	10.656
00123.las	15,025,475,905	14329.410	13.994
00124.las	11,396,531,779	10868.580	10.614
00125.las	14,771,836,409	14087.521	13.757
00126.las	11,443,318,325	10913.199	10.657
00127.las	14,608,721,729	13931.963	13.605
00128.las	11,435,293,761	10905.546	10.650
00134.las	14,398,477,137	13731.458	13.410
00135.las	11,551,953,045	11016.801	10.759
00136.las	14,130,395,623	13475.795	13.160
00137.las	11,376,477,461	10849.454	10.595
00138.las	13,797,422,745	13158.248	12.850
00139.las	11,426,839,565	10897.483	10.642

## *DPH-9 Report on Swath Size and Segmentation (Swath Data) - continued*

File	File Size (bytes)	MB	GB
00140.las	13,771,176,473	13133.217	12.825
00146.las	8,990,528,523	8574.036	8.373
00147.las	7,611,705,439	7259.088	7.089
00148.las	8,960,895,039	8545.775	8.345
00149.las	7,571,813,783	7221.044	7.052
00150.las	8,809,753,409	8401.636	8.205
00151.las	7,507,129,921	7159.357	6.992
00155.las	7,783,988,131	7423.390	7.249
00156.las	7,216,131,789	6881.840	6.721
00157.las	7,914,769,757	7548.113	7.371
00158.las	7,255,551,429	6919.433	6.757
00159.las	7,719,778,673	7362.155	7.190
00160.las	7,264,367,849	6927.841	6.765
00161.las	7,775,353,009	7415.154	7.241
00162.las	7,356,084,115	7015.308	6.851
00163.las	7,854,999,301	7491.111	7.316
00164.las	7,363,034,177	7021.937	6.857
00165.las	7,742,740,579	7384.053	7.211
00166.las	7,309,070,875	6970.473	6.807

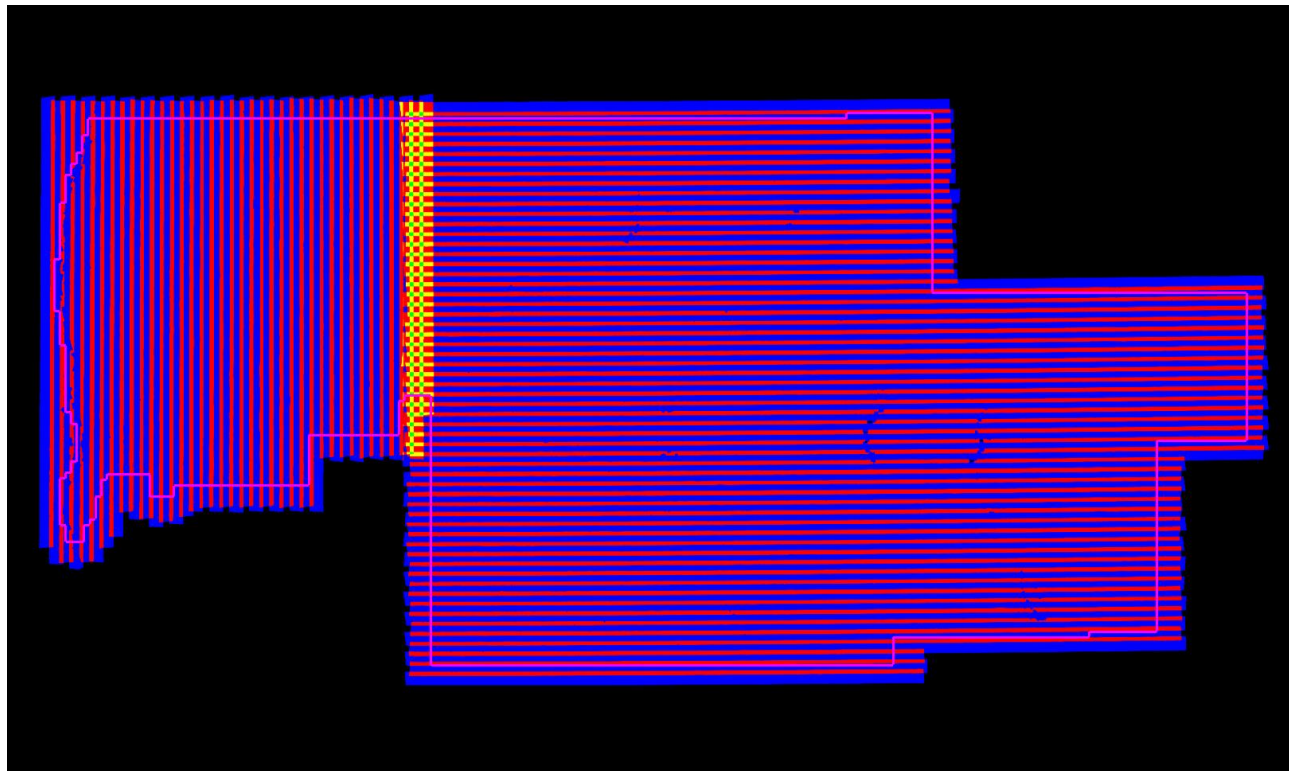
## DPH-10 Report on Scope of Collection

The USGS Lidar Base Specification Version 1.2 states: "All collected swaths shall be delivered as part of the Raw Data Deliverable, including, calibration swaths and cross-ties. All collected returns within each swath shall also be delivered. No points are to be deleted from the swath LAS files. Exceptions to this rule are the extraneous data outside of the BPA (such as aircraft turns, transit between the collection area and airport, and transit between fill-in areas)."

The purpose of this section is to show collection scan overlap. Lack of overlap would be displayed as black polygons or slivers between collection scans.

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](#)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\DPH\\_10\Flightline\\_Coverage\\_Overlap.jp2](#)



Purple polygon is buffered project area (BPA) boundary

Single	Double	Triple	Quadruple coverage or more
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## DPH-11.1.1 Report on Smooth Surface Repeatability (intraswath)

The USGS Lidar Base Specification Version 1.2 states: "In ideal theoretical conditions, smooth surface repeatability is a measure of variations documented on a surface that would be expected to be flat and without variation. Users of lidar technology commonly refer to these variations as "noise." Single-swath data will be assessed using only single returns in nonvegetated areas. Repeatability will be evaluated by measuring departures from planarity of single returns from hard planar surfaces, normalizing for actual variation in the surface elevation. Repeatability of only single returns will then be assessed at multiple locations within hard surfaced areas (for example, parking lots or large rooftops). Each sample area will be evaluated using a signed difference raster (maximum elevation - minimum elevation) at a cell size equal to twice the ANPS, rounded up to the next integer. Sample areas will be approximately 50 square meters. The maximum acceptable variations within sample areas at each QL are listed in the table "Relative vertical accuracy for lidar-swath data, Quality Level 0–Quality Level 3" (table 2). Isolated noise is expected within the sample areas and will be disregarded."

**Table 2.** Relative vertical accuracy for lidar-swath data, Quality Level 0–Quality Level 3.  
[cm, centimeter]

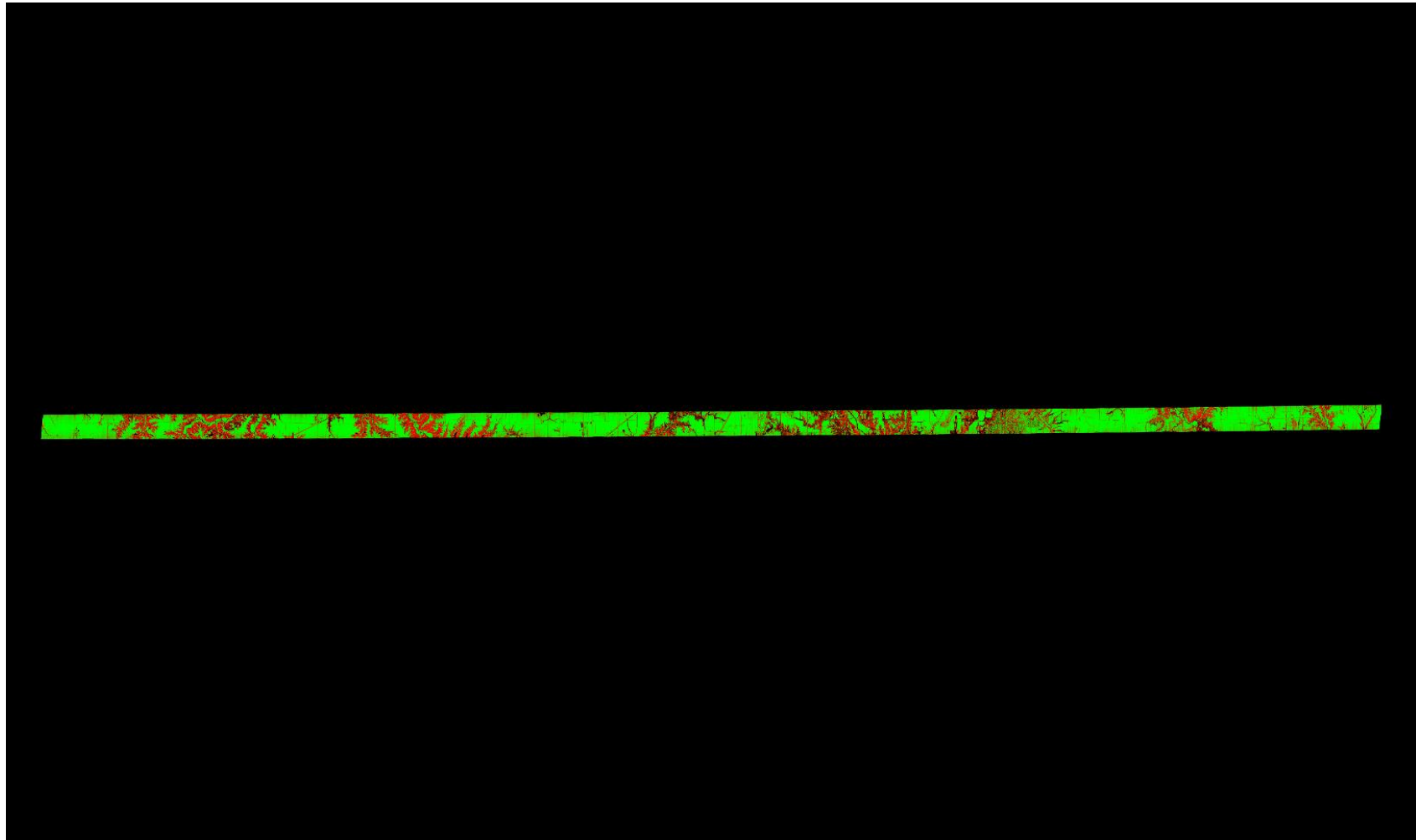
Quality Level (QL)	Smooth surface repeatability (cm)
QL0	≤3
QL1	≤6
QL2	≤6
QL3	≤12

The purpose of this section is to evaluate smooth surface repeatability by measuring departures from planarity of single returns from hard planar surfaces, normalizing for actual variation in the surface elevation. Repeatability of only single returns is then assessed at multiple locations within hard surfaced areas (for example, parking lots or large rooftops).

## DPH-11.1.1 Report on Smooth Surface Repeatability (intraswath) - continued

[Data Source - F:\boresight\RawSwath\\_las\\_1.4](#)

[G:\Greene\\_Macoupin\\_Montgomery\QAQC\DPH\\_11\\_1\\_1\Individual\\_00004\\_GRID.jp2](#)



A maximum vertical separation cutoff has been applied to this graphic for the purpose of masking out disruptive features that do not show calibration issues between flight lines (e.g., trees, moving cars, etc.).

## DPH-11.1.2 Report on Overlap Consistency (interswath)

The USGS Lidar Base Specification Version 1.2 states: "Overlap consistency is a measure of geometric alignment of two overlapping swaths; the principles used with swaths can be applied to overlapping lifts and projects as well. Overlap consistency is the fundamental measure of the quality of the calibration or boresight adjustment of the data from each lift, and is of particular importance as the match between the swaths of a single lift is a strong indicator of the overall geometric quality of the data, establishing the quality and accuracy limits of all downstream data and products.

Overlap consistency will be assessed at multiple locations within overlap in nonvegetated areas of only single returns. The overlap areas that will be tested are those between the following:

- (1) Adjacent, overlapping parallel swaths within a project,
- (2) Cross-tie swaths and the intersecting project swaths, and
- (3) Adjacent, overlapping lifts.

Each overlap area will be evaluated using a signed difference raster with a cell size equal to twice the ANPS, rounded up to the next integer. The difference rasters will be visually examined using a bicolor ramp from the negative acceptable limit to the positive acceptable limit. Although isolated excursions beyond the limits are expected and accepted, differences in the overlaps shall not exceed the limits listed in table 2 for the QL of information that is being collected. The difference rasters will be statistically summarized to verify that root mean square difference in z (RMSDz) values do not exceed the limits set forth in the table "Relative vertical accuracy for lidar-swath data, Quality Level 0–Quality Level 3" (table 2) for the QL of information that is being collected. Consideration will be given for the effect of the expected isolated excursions over limits."

**Table 2.** Relative vertical accuracy for lidar-swath data, Quality Level 0–Quality Level 3.

[cm, centimeter; RMSD<sub>z</sub>, root mean square difference in z; ≤, less than or equal to; ±, plus or minus]

Quality Level (QL)	Swath overlap difference, RMSD <sub>z</sub> (cm)	Swath overlap difference, maximum (cm)
QL0	≤4	±8
QL1	≤8	±16
QL2	≤8	±16
QL3	≤16	±32

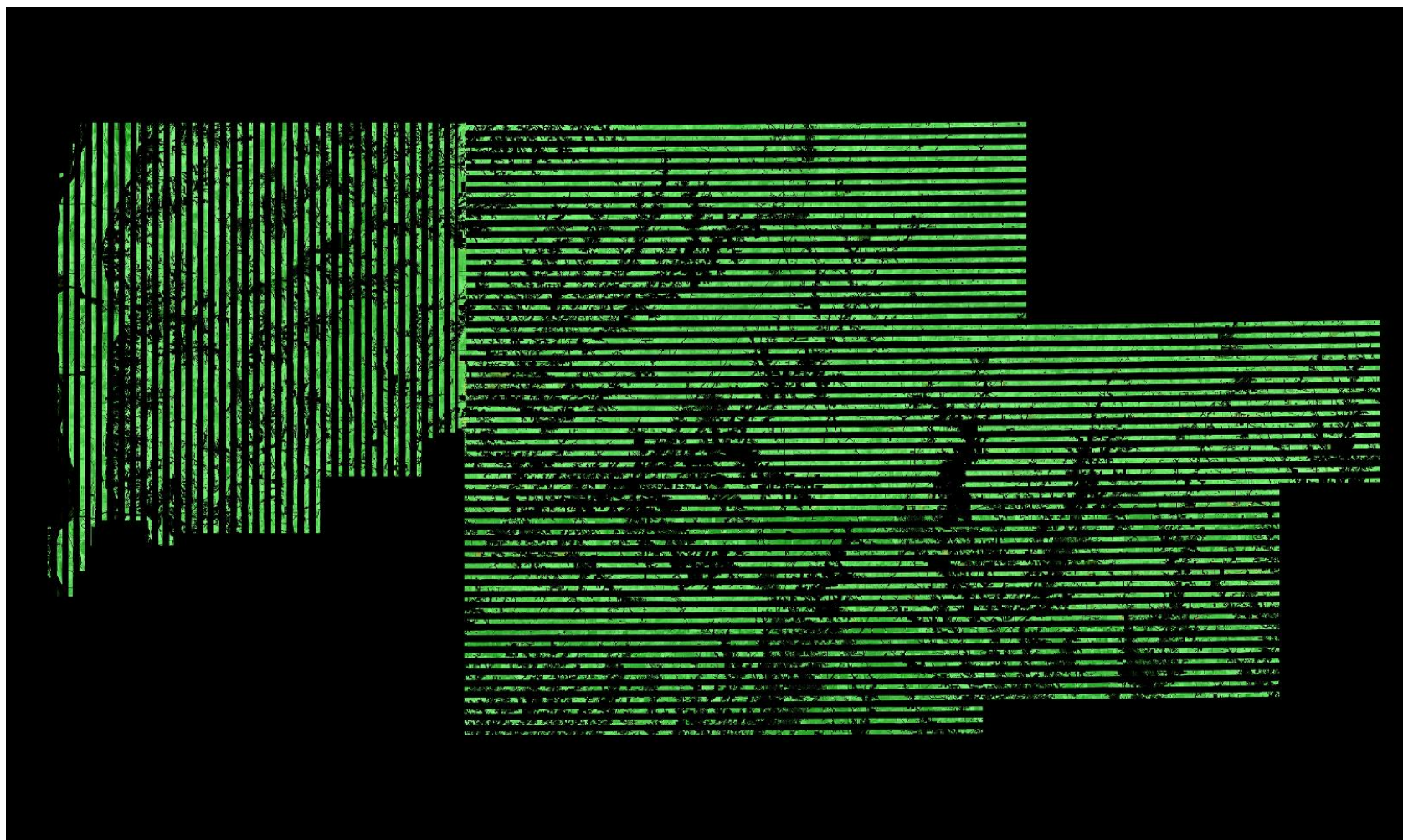
The purpose of this section is to show a graphic of the flight line separation raster for all of the data processed. This grid/image shows the vertical separation of flight lines by thematically coloring the separation magnitude on a color ramp based on absolute distance. This color thematic rendering is modulated by intensity to show land cover features. If there is no flight line overlap, the raster is displayed as grayscale intensity alone.



## DPH-11.1.2 Report on Overlap Consistency (interswath) - continued

Data Source - F:\boresight\RawSwath\_las\_1.4

G:\Greene\_Macoupin\_Montgomery\QAQC\DPH\_11\_1\_2\Boresighted\_FlightlineSeparation\_SingleFile\_Measurable\_TIN.jp2



A maximum vertical separation cutoff has been applied to this graphic for the purpose of masking out disruptive features that do not show calibration issues between flight lines (e.g., trees, moving cars, etc.).

## *DPH-11.2 Report on Check Points*

The USGS Lidar Base Specification Version 1.2 states: "The Positional Accuracy Standards for Digital Geospatial Data (American Society for Photogrammetry and Remote Sensing, 2014) ties the required number of check points for vertical accuracy assessment to the areal extent of the project. Data producers are encouraged to carefully review the new and revised requirements in that document. Check points for NVA assessments shall be surveyed in clear, open areas (which typically produce only single lidar returns), devoid of vegetation and other vertical artifacts (such as boulders, large riser pipes, and vehicles). Ground that has been plowed or otherwise disturbed is not acceptable. The same check points may be used for NVA assessment of the point cloud and DEM. Check points for VVA assessments shall be surveyed in vegetated areas (typically characterized by multiple return lidar). Although the nature of vegetated areas makes absolute definition of a suitable test area difficult, these areas will meet the requirements below. As stated in the National Standards for Spatial Data Accuracy (NSSDA) (Federal Geographic Data Committee, 1998) and reiterated in the ASPRS Positional Accuracy Standards for Digital Geospatial Data (American Society for Photogrammetry and Remote Sensing, 2014), it is unrealistic to prescribe detailed requirements for check point locations, as many unpredictable factors will affect field operations and decisions, and the data producer must often have the freedom to use their best professional judgment. The quantity and location of check points shall meet the following requirements, unless alternative criteria are approved by the USGS–NGP in advance:

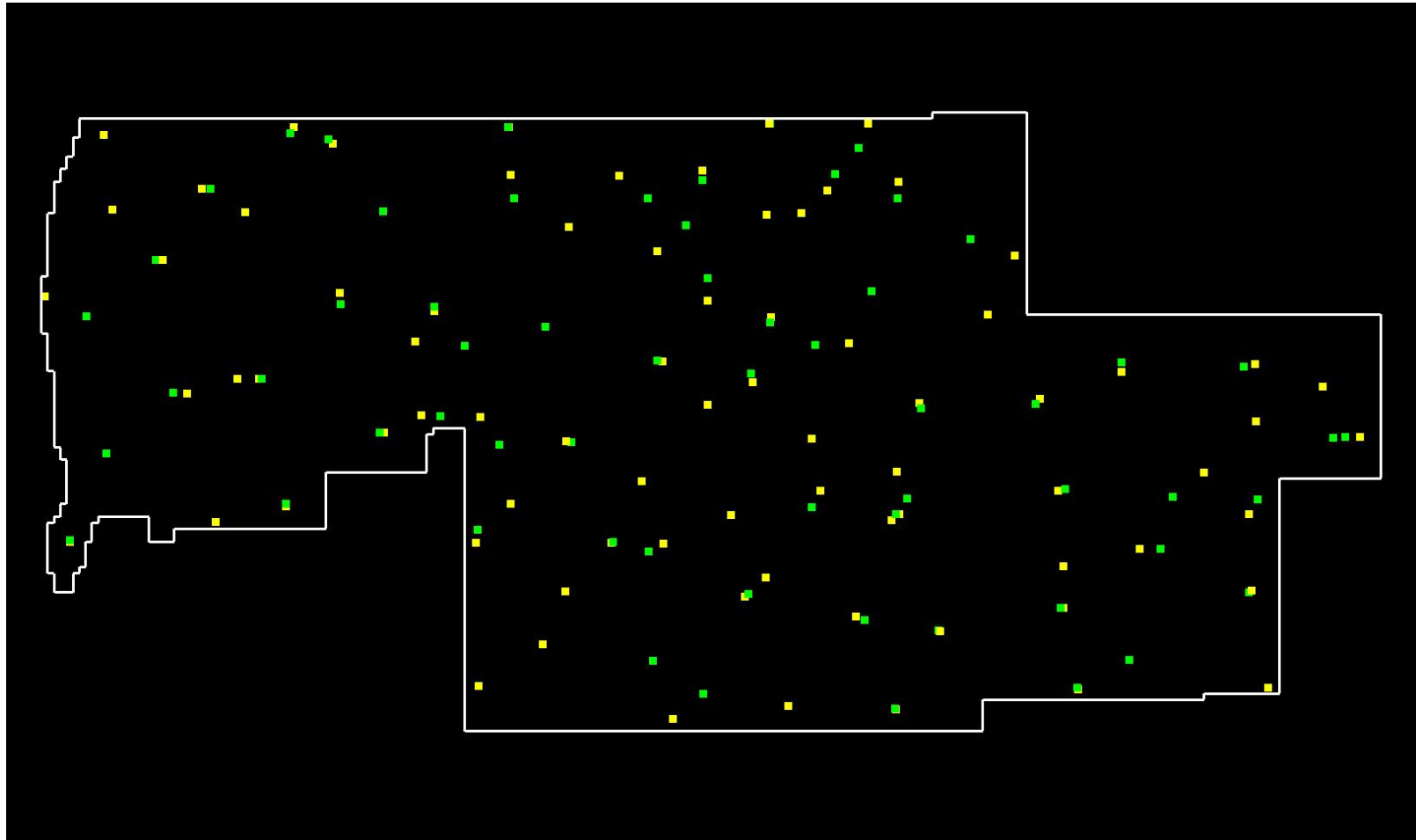
- The ASPRS-recommended total number of check points for a given project size shall be met.
- The ASPRS-recommended distribution of the total number of check points between NVA and VVA assessments shall be met.
- Check points within each assessment type (NVA and VVA) will be well-distributed across the entire project area. See the glossary at the end of this specification for a definition of "well-distributed."
- Within each assessment type, check points will be distributed among all constituent land cover types in approximate proportion to the areas of those land cover types (American Society for Photogrammetry and Remote Sensing, 2014)."

The purpose of this section is to show check points (NVA and VVA).

## DPH-11.2 Report on Check Points - continued

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\check\\_points.csv](E:\Greene_Macoupin_Montgomery\merrick\check_points.csv)

[Check Point Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\DPH\\_11\\_2\CheckPoints.jpg](G:\Greene_Macoupin_Montgomery\QAQC\DPH_11_2\CheckPoints.jpg)



Yellow points are NVA, green points are VVA.  
White polygon is defined project area (DPA) boundary

## DPH-11.2 Report on Check Points - continued

Total check points: 144

Check points in defined project area (DPA): 144

Total NVA check points in defined project area (DPA): 83

Total VVA check points in defined project area (DPA): 61

Total defined project area (DPA): 5751.093 square KM

Density of check points in defined project area (DPA): 0.025 points per square KM

TABLE C.1 RECOMMENDED NUMBER OF CHECKPOINTS BASED ON AREA

Project Area (Square Kilometers)	Horizontal Accuracy Testing of Orthoimagery and Planimetrics	Vertical and Horizontal Accuracy Testing of Elevation Data sets		
	Total Number of Static 2D/3D Checkpoints (clearly-defined points)	Number of Static 3D Checkpoints in NVA*	Number of Static 3D Checkpoints in VVA	Total Number of Static 3D Checkpoints
≤500	20	20	5	25
501-750	25	20	10	30
751-1000	30	25	15	40
1001-1250	35	30	20	50
1251-1500	40	35	25	60
1501-1750	45	40	30	70
1751-2000	50	45	35	80
2001-2250	55	50	40	90
2251-2500	60	55	45	100

\*Although vertical check points are normally not well defined, where feasible, the horizontal accuracy of lidar data sets should be tested by surveying approximately half of all NVA check points at the ends of paint stripes or other point features that are visible and can be measured on lidar intensity returns.

Source: ASPRS Positional Accuracy Standards for Digital Geospatial Data (Edition 1, Version 1.0. - November 2014)

## DPH-11.3 Report on Absolute Vertical Accuracy

The USGS Lidar Base Specification Version 1.2 states: "Absolute vertical accuracy of the lidar data and the derived DEM will be assessed and reported in accordance with the ASPRS Positional Accuracy Standards for Digital Geospatial Data (American Society for Photogrammetry and Remote Sensing, 2014). Two broad land cover types shall be assessed: vegetated and nonvegetated. Three absolute accuracy values shall be assessed and reported: NVA for the point cloud, NVA for the DEM, and VVA for the DEM. The minimum NVA and VVA requirements for all data, using the ASPRS methodology, are listed in the tables 'Absolute vertical accuracy for lidar-swath data, Quality Level 0–Quality Level 3' (table 4) and 'Absolute vertical accuracy for digital elevation models, Quality Level 0–Quality Level 3' (table 5). Both the NVA and VVA required values shall be met. For projects dominated by dense forests, the USGS–NGP may accept higher VVA values."

**Table 4.** Absolute vertical accuracy for lidar-swath data, Quality Level 0–Quality Level 3.

[RMSE<sub>z</sub>, root mean square error in z; cm, centimeter; NVA, nonvegetated vertical accuracy; ≤, less than or equal to]

Quality Level (QL)	RMSE <sub>z</sub> (nonvegetated) (cm)	NVA at 95-percent confidence level (cm)
QL0	≤5.0	≤9.8
QL1	≤10.0	≤19.6
QL2	≤10.0	≤19.6
QL3	≤20.0	≤39.2

**Table 5.** Absolute vertical accuracy for digital elevation models, Quality Level 0–Quality Level 3.

[RMSE<sub>z</sub>, root mean square error in z; cm, centimeter; NVA, nonvegetated vertical accuracy; VVA, vegetated vertical accuracy; ≤, less than or equal to]

Quality Level (QL)	RMSE <sub>z</sub> (nonvegetated) (cm)	NVA at 95-percent confidence level (cm)	VVA at 95th percentile (cm)
QL0	≤5.0	≤9.8	≤14.7
QL1	≤10.0	≤19.6	≤29.4
QL2	≤10.0	≤19.6	≤29.4
QL3	≤20.0	≤39.2	≤58.8

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

## DPH-11.3 Report on Absolute Vertical Accuracy - continued

[E:\Greene\\_Macoupin\\_Montgomery\merrick\check\\_points.csv](E:\Greene_Macoupin_Montgomery\merrick\check_points.csv)

Units: Meter (/US Survey Feet)

Vertical Accuracy Class tested: 10-cm

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Check Points in defined project area (DPA):	144
Check Points with Lidar Coverage	144
Check Points with Lidar Coverage (NVA)	83
Check Points with Lidar Coverage (VVA)	61
Average Z Error (NVA)	0.003/0.011
Maximum Z Error (NVA)	0.171/0.561
Median Z Error (NVA)	-0.004/-0.013
Minimum Z Error (NVA)	-0.125/-0.410
Standard deviation of Vertical Error (NVA)	0.050/0.163
Skewness of Vertical Error (NVA)	0.464
Kurtosis of Vertical Error (NVA)	0.613
Non-vegetated Vertical Accuracy (NVA) RMSE(z) <sup>1</sup>	0.049/0.162 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level +/- <sup>1</sup>	0.097/0.317 PASS
FGDC/NSSDA Vertical Accuracy at the 95% Confidence Level +/-	0.097/0.317
Non-vegetated Vertical Accuracy (NVA) RMSE(z) (DEM) <sup>2</sup>	0.049/0.162 PASS
Non-vegetated Vertical Accuracy (NVA) at the 95% Confidence Level (DEM) +/- <sup>2</sup>	0.097/0.318 PASS
Vegetated Vertical Accuracy (VVA) at the 95th Percentile (DEM) +/- <sup>2</sup>	0.182/0.598 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 = 4.937cm, equating to +/- 9.676cm at the 95% confidence level. Actual VVA accuracy was found to be +/- 18.224cm at the 95th percentile.

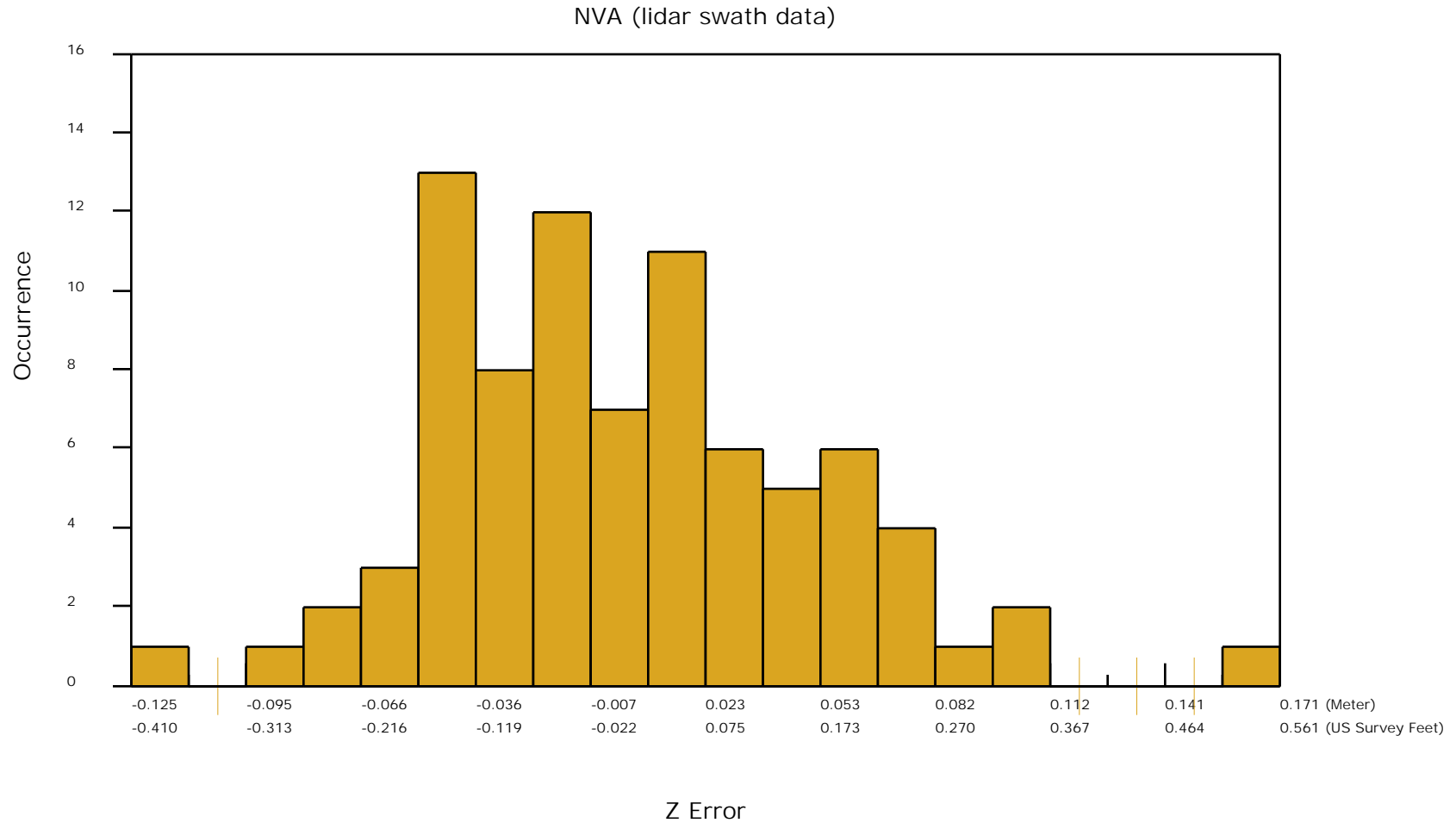
<sup>1</sup> This value is calculated from TIN-based testing of the raw swath lidar point cloud data.

<sup>2</sup> This value is calculated from RAM-based grid testing of the classified tiled lidar data. The grid cells are sized according to the Quality Level selected, and are defined in the USGS NGP Lidar Base Specification Version 1.2 (page 15, Table 7).

## DPH-11.3 Report on Absolute Vertical Accuracy - continued

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

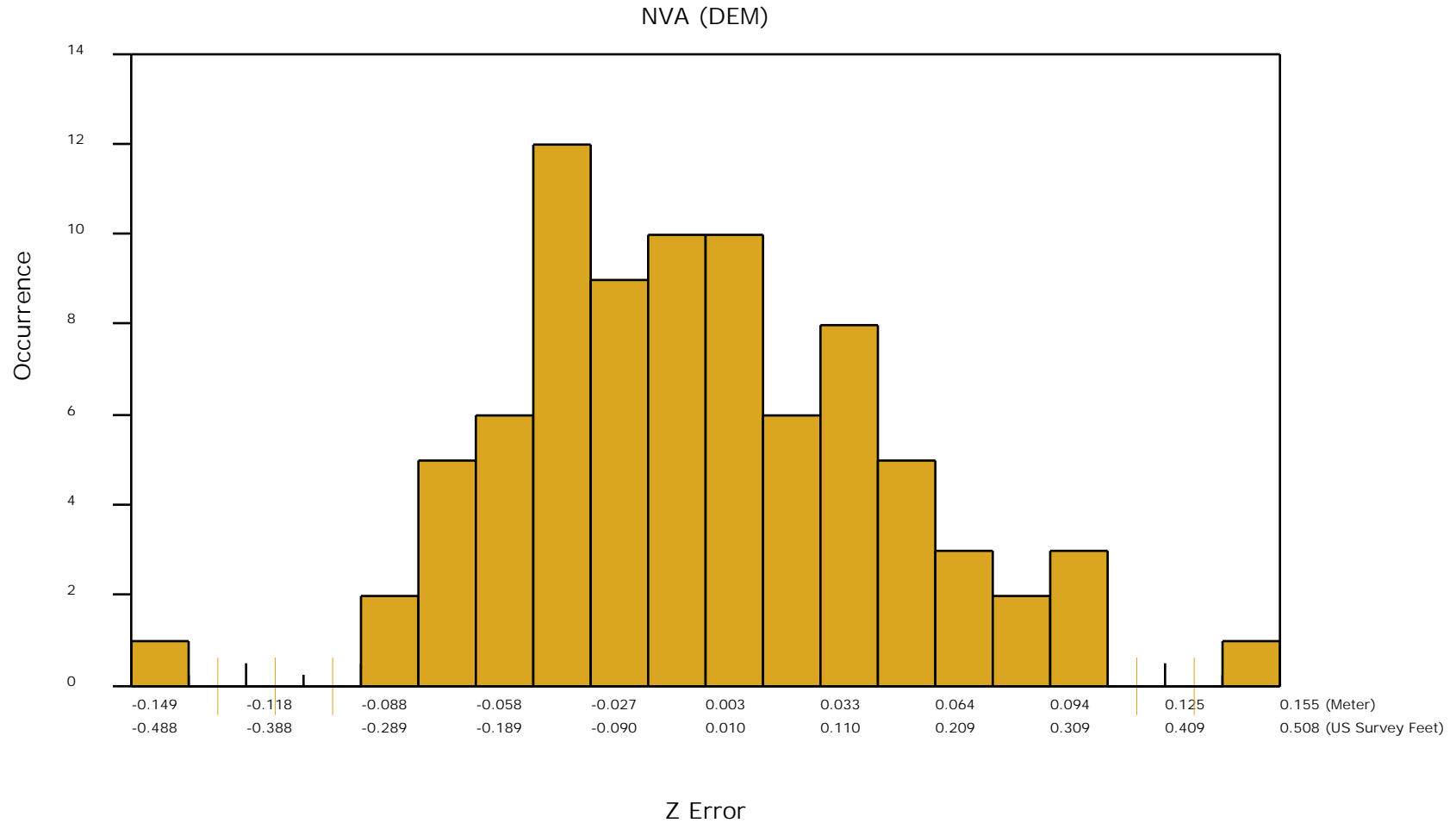
[Data Source - F:\boresight\RawSwath\\_las\\_1.4](#)



## DPH-11.3 Report on Absolute Vertical Accuracy - continued

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

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

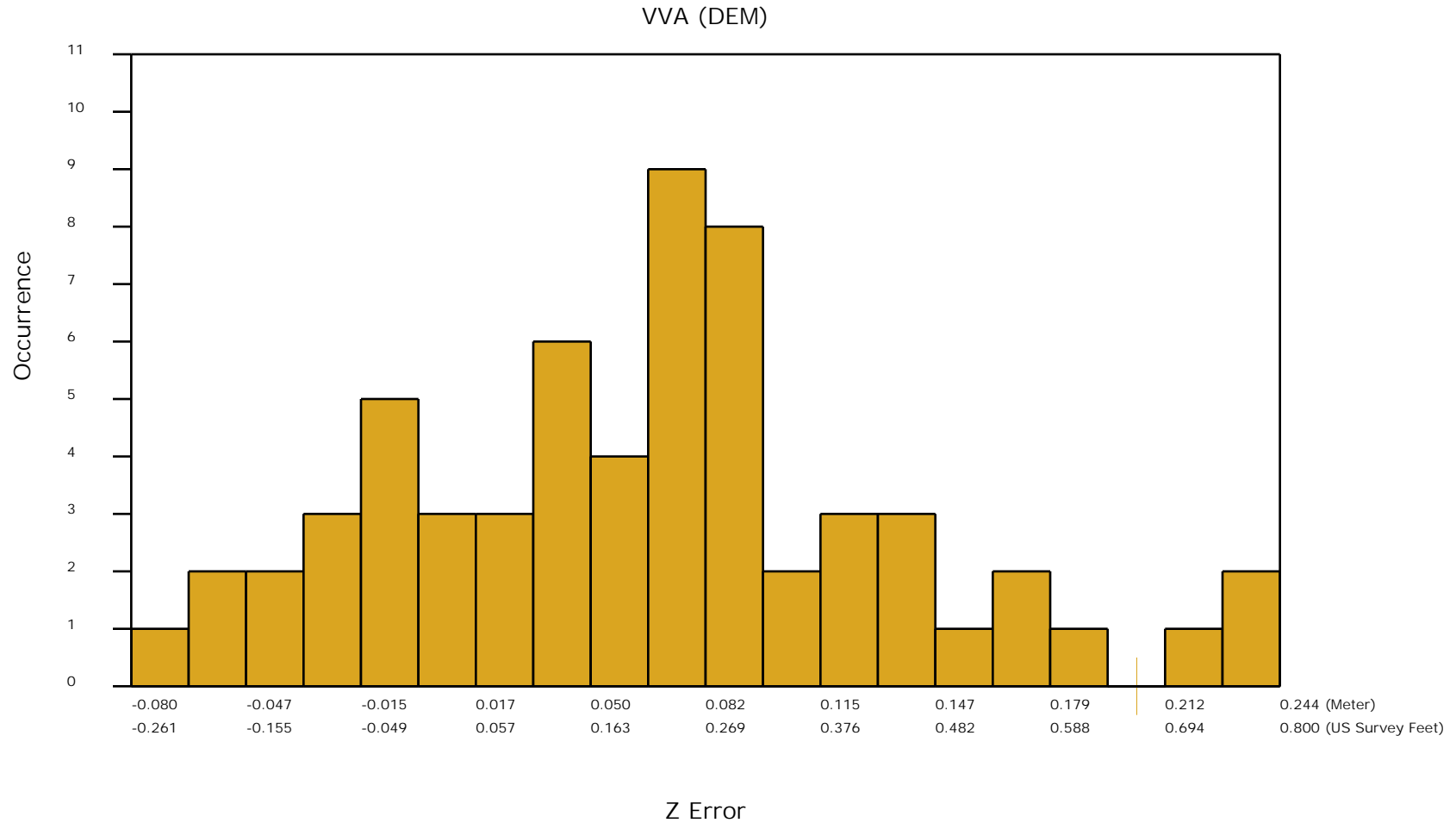




## DPH-11.3 Report on Absolute Vertical Accuracy - continued

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 - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)



## *DPH-12 Report on Use of the LAS Withheld Flag (Swath Data)*

The USGS Lidar Base Specification Version 1.2 states: "Outliers, blunders, noise points, geometrically unreliable points near the extreme edge of the swath, and other points the data producer deems unusable are to be identified using the Withheld Flag, as defined in the LAS Specification version 1.4 (American Society for Photogrammetry and Remote Sensing, 2011). The Withheld Flag is primarily used to denote points identified during preprocessing or through automated post-processing routines as geometrically unusable. Noise points subsequently identified during manual classification and quality assurance/quality control (QA/QC) are typically assigned the appropriate standard LAS classification values for noise—Class 7 is used for Low Noise and Class 18 is used for High Noise."

The purpose of this section is to list the presence and quantities of points flagged as Withheld for all lidar swath data files.

[Boresighted Files - F:\boresight\RawSwath\\_las\\_1.4](#)

Total Withheld points (all classes, all swaths)	400935219
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## *DPH-12 Report on Use of the LAS Withheld Flag (Tiled Data)*

The purpose of this section is to list the presence and quantities of points flagged as Withheld for all lidar tiled data files.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

Total Withheld points (all classes, all tiles)	306596176
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## DPH-14 Report on Point Classification

The USGS Lidar Base Specification Version 1.2 states: "The minimum scheme required for lidar point clouds is listed in the table 'Minimum classified pointcloud classification scheme' (table 6). All points not identified as Withheld (WH) shall be classified. "

**Table 6.** Minimum classified point cloud classification scheme.

Code	Description
1	Processed, but unclassified.
2	Bare earth.
7	Low noise.
9	Water.
10	Ignored ground (near a breakline).
17	Bridge decks.
18	High noise.

The purpose of this section is to report total numbers of points for each class within the tile based LAS files.

## DPH-14 Report on Point Classification - Class Totals

The purpose of this section is to list the number of points in each classification so that the user can determine if any points exist in unintended classes.

[Classified Files - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

Class	Total	MKP	Class	Total	MKP	Class	Total	MKP	Class	Total	MKP
0 (Total)	00	00	63	00	00	128	00	00	192	00	00
0 (WH)	00		64	00	00	129	00	00	193	00	00
0 (non-WH)	00		65	00	00	130	00	00	194	00	00
1	3,105,318,036	00	66	00	00	131	00	00	195	00	00
2	19,182,049,827	6,482,883,633	67	00	00	132	00	00	196	00	00
3	298,494,470	00	68	00	00	133	00	00	197	00	00
4	659,317,798	00	69	00	00	134	00	00	198	00	00
5	909,848,035	00	70	00	00	135	00	00	199	00	00
6	67,632,436	00	71	00	00	136	00	00	200	00	00
7	17,824	00	72	00	00	137	00	00	201	00	00
8	00	00	73	00	00	138	00	00	202	00	00
9	59,197,735	00	74	00	00	139	00	00	203	00	00
10	3,005,691	00	75	00	00	140	00	00	204	00	00
11	00	00	76	00	00	141	00	00	205	00	00
12	00	00	77	00	00	142	00	00	206	00	00
13	00	00	78	00	00	143	00	00	207	00	00
14	00	00	79	00	00	144	00	00	208	00	00
15	00	00	80	00	00	145	00	00	209	00	00
16	00	00	81	00	00	146	00	00	210	00	00
17	805,765	00	82	00	00	147	00	00	211	00	00
18	18,067	00	83	00	00	148	00	00	212	00	00
19	00	00	84	00	00	149	00	00	213	00	00
20	00	00	85	00	00	150	00	00	214	00	00
21	00	00	86	00	00	151	00	00	215	00	00
22	00	00	87	00	00	152	00	00	216	00	00
23	00	00	88	00	00	153	00	00	217	00	00
24	00	00	89	00	00	154	00	00	218	00	00
25	00	00	90	00	00	155	00	00	219	00	00
26	00	00	91	00	00	156	00	00	220	00	00
27	00	00	92	00	00	157	00	00	221	00	00
28	00	00	93	00	00	158	00	00	222	00	00
29	00	00	94	00	00	159	00	00	223	00	00
30	00	00	95	00	00	160	00	00	224	00	00
31	00	00	96	00	00	161	00	00	225	00	00
32	00	00	97	00	00	162	00	00	226	00	00
33	00	00	98	00	00	163	00	00	227	00	00
34	00	00	99	00	00	164	00	00	228	00	00
35	00	00	100	00	00	165	00	00	229	00	00
36	00	00	101	00	00	166	00	00	230	00	00
37	00	00	102	00	00	167	00	00	231	00	00
38	00	00	103	00	00	168	00	00	232	00	00
39	00	00	104	00	00	169	00	00	233	00	00
40	00	00	105	00	00	170	00	00	234	00	00
41	00	00	106	00	00	171	00	00	235	00	00
42	00	00	107	00	00	172	00	00	236	00	00
43	00	00	108	00	00	173	00	00	237	00	00
44	00	00	109	00	00	174	00	00	238	00	00
45	00	00	110	00	00	175	00	00	239	00	00
46	00	00	111	00	00	176	00	00	240	00	00
47	00	00	112	00	00	177	00	00	241	00	00
48	00	00	113	00	00	178	00	00	242	00	00
49	00	00	114	00	00	179	00	00	243	00	00
50	00	00	115	00	00	180	00	00	244	00	00
51	00	00	116	00	00	181	00	00	245	00	00
52	00	00	117	00	00	182	00	00	246	00	00
53	00	00	118	00	00	183	00	00	247	00	00
54	00	00	119	00	00	184	00	00	248	00	00
55	00	00	120	00	00	185	00	00	249	00	00
56	00	00	121	00	00	186	00	00	250	00	00
57	00	00	122	00	00	187	00	00	251	00	00
58	00	00	123	00	00	188	00	00	252	00	00
59	00	00	124	00	00	189	00	00	253	00	00
60	00	00	125	00	00	190	00	00	254	00	00
61	00	00	126	00	00	191	00	00	255	00	00
62	00	00	127	00	00						

**Bold** – point counts in 'Minimum classified point cloud classification scheme' (see table on previous page)

**###** – point counts in Classes beyond the minimum

**###** – disallowed point counts per USGS spec

## *DPH-15 Report on Classification Accuracy*

The USGS Lidar Base Specification Version 1.2 states: "Following classification processing, no nonwithheld points will remain in Class 0.

- For QL3 data, within any 1 square km, no more than 2 percent of nonwithheld points will have demonstrable errors in the classification value.
- For QL2 data, within any 1 square km, no more than 1 percent of nonwithheld points will have demonstrable errors in the classification value.
- For QL1 and QL0 data, within any 1 square km, no more than 0.5 percent of nonwithheld points will have demonstrable errors in the classification value.
- Points remaining in Class 1 that should be classified in any other required class are subject to these accuracy requirements and will be counted towards the percentage thresholds."

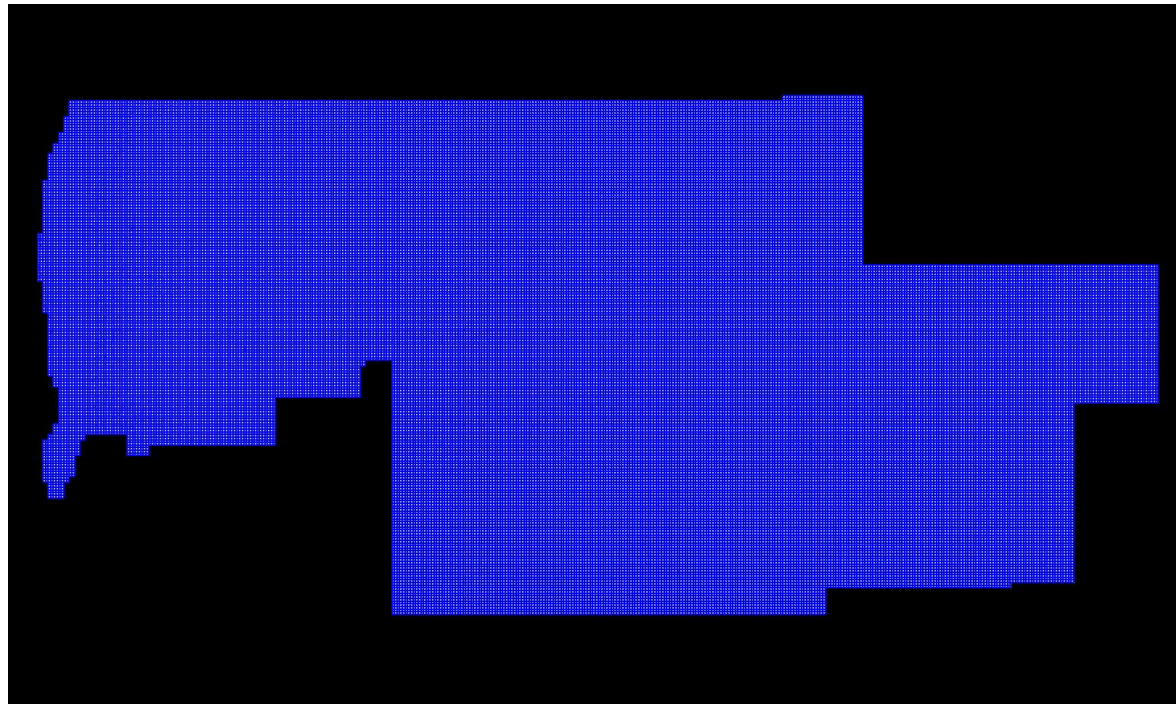
The USGS-NGP may relax these requirements to accommodate collections in areas where classification is particularly difficult.

The purpose of this section is to overlay a 1km x 1km tile scheme over the bare earth surface hillshade product to use for ground filter QC inspection.

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\DPH\\_15\\_16\Hillshade\\_SingleFile.jp2](#)

[Tile Shapefile - G:\Greene\\_Macoupin\\_Montgomery\QAQC\DPH\\_15\\_16\tile.shp](#)



## *DPH-16 Report on Classification Consistency*

The USGS Lidar Base Specification Version 1.2 states: "Point classification is to be consistent across the entire project. Noticeable variations in the character, texture, or quality of the classification between tiles, swaths, lifts, or other non-natural divisions will be cause for rejection of the entire deliverable."

The purpose of this section is to show the bare earth surface hillshade product for classification consistency inspection.

[Data Source - E:\Greene\\_Macoupin\\_Montgomery\merrick\Classified\\_las\\_1.4](#)

[Result Path - G:\Greene\\_Macoupin\\_Montgomery\QAQC\DPH\\_15\\_16\Hillshade\\_SingleFile.jp2](#)



## DPH-17 Report on Tiles

The USGS Lidar Base Specification Version 1.2 states: "A single non-overlapping project tiling scheme will be established and agreed upon by the data producer and the USGS-NGP before collection. This scheme will be used for all tiled deliverables: The tiling scheme shall use the same coordinate reference system and units as the data. The tile size shall be an integer multiple of the cell size for raster deliverables. The tiles shall be indexed in x and y to an integer multiple of the x and y dimensions of the tile. The tiled deliverables shall edge-match seamlessly and without gaps. The tiled deliverables shall conform to the project tiling scheme without added overlap."

The purpose of this section is to report on the unallowed presence of overlap in the project tile scheme.

[Tile File: E:\Greene\\_Macoupin\\_Montgomery\merrick\ESRI\\_shp\ISGS\\_TileIndex\\_1547\\_6total.shp](#)

Units: US Survey Feet

The following lists tiles that are overlapped.

<u>Tile</u>	<u>Width</u>	<u>Height</u>	<u>Overlap</u>
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NONE

The following lists tile widths/heights in the project.

2000.000/2000.000



## *Skipped Tests*

DPH-13 Use of the LAS Overlap Flag

### USGS LBS 1.2 QC Module Input Requirements Matrix

Test number	Boresighted LAS (Swath Data)	Classified LAS (Tiled Data)	Tile Scheme Shapefile	Project Boundary Shapefile	LiDAR Check Points
C-1	X	X		X	
C-2	X	X			
C-3	X	X			
C-4	X			O	
C-5	X			O	
C-6	X			O	
C-7	X	X			
DPH-1	X	X			
DPH-2	X	X			
DPH-3	X	X			
DPH-4	X	X			
DPH-5	X	X			
DPH-6	X	X			
DPH-7	X				
DPH-8	X	O			
DPH-9	X				
DPH-10	X			X	
DPH-11.1.1	X				
DPH-11.1.2	X			X	
DPH-11.2				X	X
DPH-11.3	X	X		X	X
DPH-12	X	X			
DPH-13	X	X			
DPH-14		X			
DPH-15		X			
DPH-16		X			
DPH-17			X		

X = Will use Boresighted (Swath) LAS, Classified (Tiled) LAS, or both, depending on availability

X = Required to run test

X = Will use Boresighted (Swath) LAS if available, otherwise Classified (Tiled) LAS

O = Optional

O = Optional for single-area density reporting, but required for multi-area (multiple boundary) reporting of individual and aggregate areas