

# **PROJECT REPORT**

## **SALEM COUNTY (NON-CAFRA AREA), NJ**

**PREPARED FOR:**

**US GEOLOGICAL SURVEY**

**CONTRACT #07CRCN0014**

**TASK ORDER: G09PD00703**

**TASK ORDER NAME: SALEM COUNTY, NEW JERSEY (NON-CAFRA AREA)**

**LIDAR**

**AUGUST 11TH, 2009**

**PREPARED BY:**

**PHOTO SCIENCE, INC.**

**2670 WILHITE DRIVE**

**LEXINGTON, KY 40503**

**859-277-8700 (V)**



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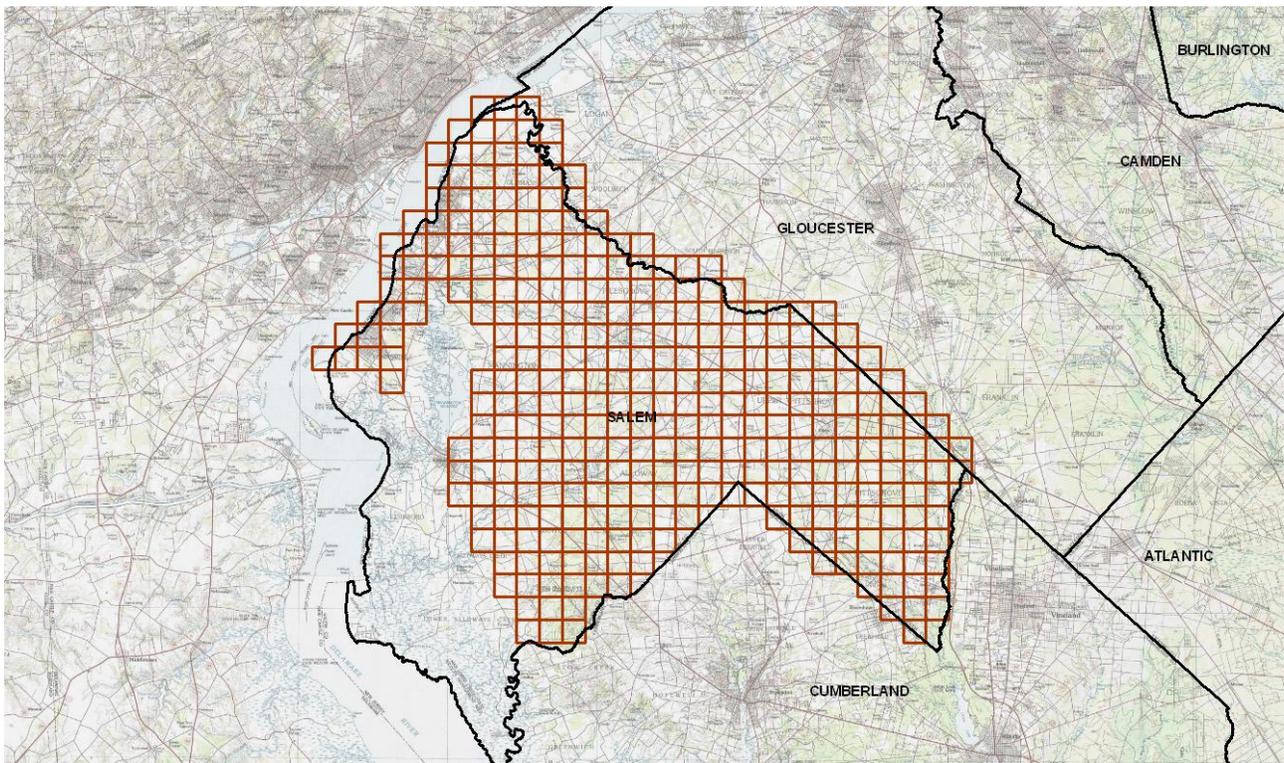
## Introduction

The following is a Project Report that details the technical parameters, procedures and results of Task Order G09PD00703 issued to Photo Science by the US Geological Survey (Contract #07CRCN0014) on March 16, 2009 to provide Light Detection and Ranging (LiDAR) collection and processing services for Salem County, NJ.

## Project Description

Photo Science provided professional mapping services necessary to collect and processes 2.0 points per square meter (0.7m GSD) LiDAR data for Salem County, New Jersey consisting of approximately 275 sq. miles. Photo Science was responsible for complete acquisition of the project area at the required data density and for the processing of data to bare earth as well as production of additional derivative products described herein. The lineage (metadata), positional, content (completeness), attribution, logical consistency, and accuracies of all digital elevation data produced in this Task Order conform to the specifications as stated in Task Order Sections C.1.a through C.1.f.

The general project area is shown in the graphic below.



## **Aerial Platform / LiDAR Sensor**

All flights for the project were accomplished with customized single-engine Cessna 206s which provide an ideal, stable aerial base for Lidar acquisition. This platform has relatively fast cruise speeds that are beneficial for project mobilization / demobilization while maintaining relatively slow stall speeds which can prove ideal for collection of a high-density, consistent data posting.

Photo Science utilized one of our Leica ALS50II LiDAR scanners on this project. Both systems are capable of collecting data at a maximum frequency of 150 kHz, which affords elevation data collection of up to 150,000 points per second. Also, both systems utilize Multi-Pulse in the Air option (MPIA). These sensors are also equipped with the ability to measure up to 4 returns per outgoing pulse from the laser and these come in the form of 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and last returns. The intensity of the first three returns is also captured during the aerial acquisition. Specifically, this project was flown with our Leica SN019 sensor.

See appendix B for system calibration information.

## **Flight Parameters**

Detailed project planning was performed for this project. This planning was based on project specific requirements and the characteristics of the project site. The basis of this planning included the required accuracies, type of development, amount and type of vegetation within the project area, the required data posting, and potential altitude restrictions for flights in the general area. A brief summary of the aerial acquisition parameters for this project are shown in the table below:

<b>Parameter</b>	<b>Value</b>
Flying Height (AMT)	6500 feet
Nominal ground speed	105 knots
Full Angle Field of View	32°
Laser Scan Rate	42.5 Hz
Pulse Rate	117,900 Hz
Maximum Cross Track Posting	1.27 meters
Maximum Along Track Posting	1.27 meters
Average Point Spacing	0.72 meters
Nominal Sidelap	40%
Ground Conditions	Leaf Off

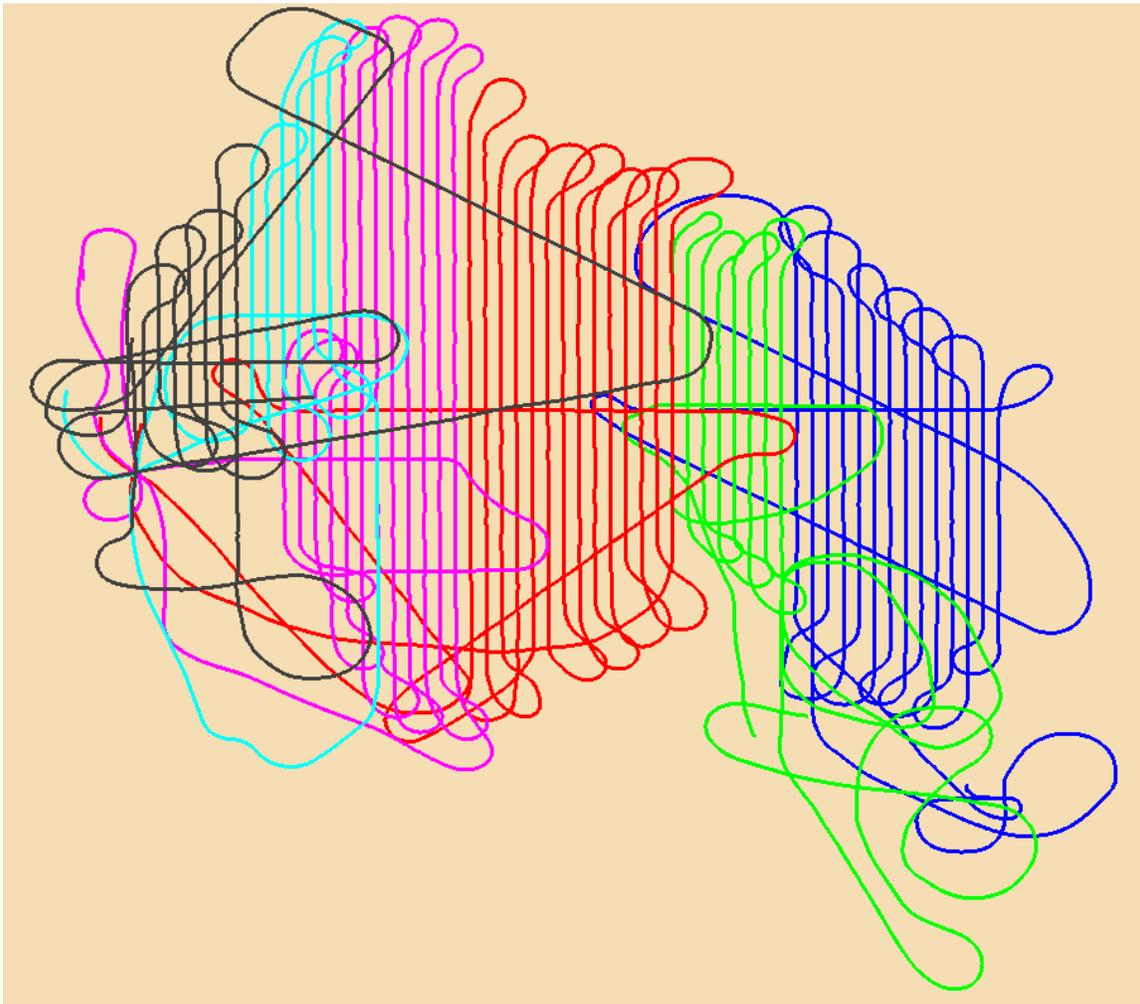
These collection parameters resulted in a swath width of 3,727 feet and an average point distribution of 1.92 points per square meter.

The Aeroplan sensor report is included in Appendix C.

### Dates Flown

Leaf Off collection occurred as weather permitted beginning March 25, 2009. Six lifts were flown ending on March 31, 2009.

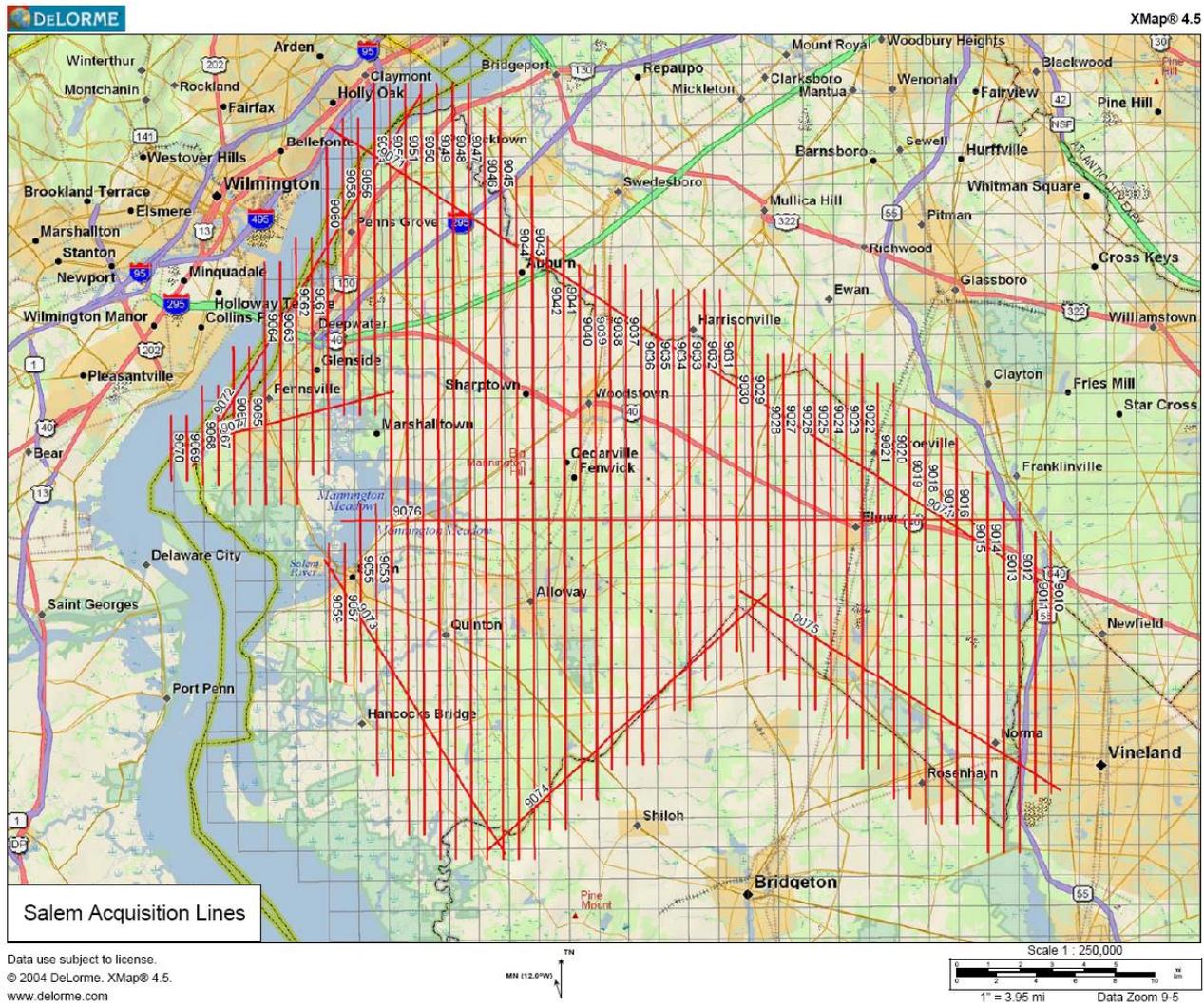
The graphic below represents the flight paths flown. **Blue** represents March 25, Lift A; **Green** represents March 25, Lift b; **Red** represents March 27, Lift A; **Magenta** represents March 27, Lift B; **Cyan** represents March 31, Lift A; **Gray** represents March 31, Lift B;



See the Trajectory Report in Appendix D for graphical depictions and reports for each mission.

### Flight Line Layout

The flight line layout is shown in the graphic below. A total of 68 flight lines totaling 755 flight line miles were required to cover the project area. The manually recorded flight logs have been included as Appendix A to this report.



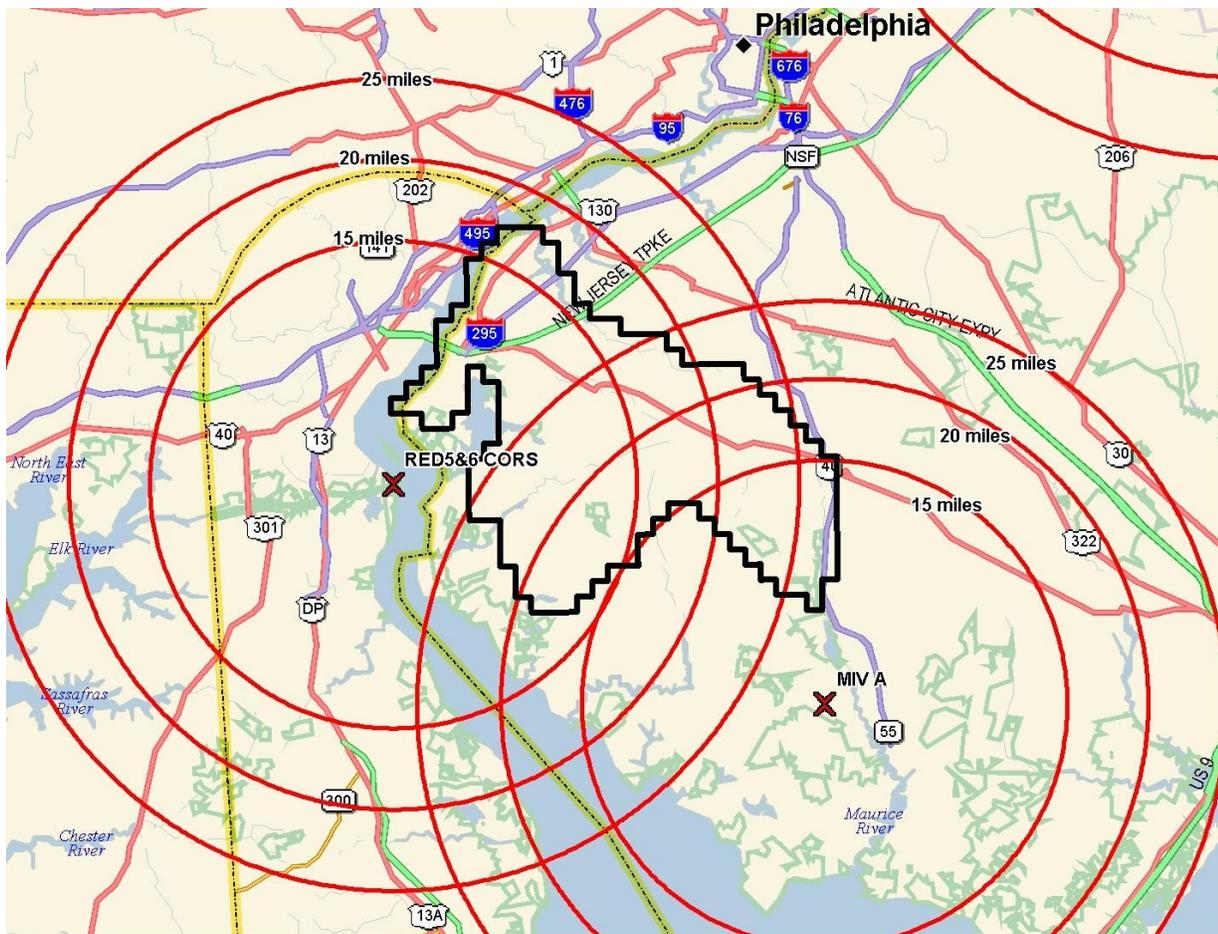
### Projection / Datum

All data for this project were reduced to NAD83 – New Jersey State Plane Coordinate System, US Survey Feet, to at least two decimal places. All elevations were presented as orthometric heights using NAVD 88. Horizontal and vertical units were survey feet to two decimal places.

## GPS Base Stationing

In support of the airborne collection phase, ground observations utilized Trimble 5700 data collection units, logging at 2 hertz, paired with Trimble Zephyr Geodetic antennas, which were mounted on variable height tripods with the H.I. measured at the beginning and end of each logging session.

The overall study area utilized two base stations, "MIV A" at Millville Airport and "RED5&6CORS". The figure below depicts the base station in relation to the project area. See Appendix E for CORS station values.



## Limiting Factors of LIDAR Collection

There are several limiting factors to LiDAR data collection which include:

Weather: there can be no clouds, excess moisture (rain, fog or excessive humidity) between the sensor and the ground we are profiling. Additionally, high winds which if blowing perpendicular to the line of flight could provide for excessive crab resulting in "slivers" or "holidays" between flight lines as well as unsafe flight conditions such as wind shear or clear air turbulence.

Ground Conditions: Such as standing water from recent heavy rains, excessive "ponding" or "pooling" of water will affect the accuracy of the LiDAR returns as will snow and Ice. This is especially apparent in ditches with high water and along roadways and fence lines with drifting snow.

Satellite Configuration: Typically one does not want to collect LiDAR during time of high Positional Dilution of Precision (PDOP), as this would result in the GPS configuration providing accuracy less than desired. Higher values for the PDOP indicate less than ideal geometric configuration of the satellites. For this project there was no data collection during periods of PDOP above 3.5 or periods with less than 6 visible satellites. To these ends, PDOP was checked each morning with a fresh almanac and newly updated satellite health status from the US Coast Guard Navigation Center website.

## Airborne GPS Collection Parameters

Collection parameters for this project included the following:

Parameter	Value
Maximum PDOP	3.5
Minimum number of SVs	6
Ground collection epoch	2 Hz (0.5 sec)

## Ground Control Surveys

Photo Science's control approach to this task order involved the establishment of both supplemental ground control and ground control quality check points. Ground control surveys were conducted by Photo Science Subconsultant, Dewberry & Davis. A separate control report was delivered to USGS on May 7<sup>th</sup>, 2009.

**Supplemental Ground Control:** GPS ground control was established to supplement and check the Airborne GPS positional adjustment. A total of 22 points dispersed throughout the project were collected for this purpose.

**Ground Control Quality Check Points:** As required, Dewberry & Davis collected 20 ground control QA check points. These points were used by the Government for validation. The points are dispersed over the project area to verify fundamental vertical accuracy. Fundamental vertical accuracy checkpoints are located only in open terrain, where there is a high probability that the sensor has detected the ground surface without influence from surrounding vegetation. Checkpoints are located on flat or uniformly sloping terrain and were at least five (5) meters away from any break line where this is a change in slope. The checkpoint accuracy satisfied a Local Network accuracy of 5-centimeters at the 95% confidence level. These control values were sent directly to USGS without being incorporated into Photo Science's production process.

## **Data Processing**

Leica software was used in the post-processing of the airborne GPS and inertial data that is critical to the positioning of the sensor during all flights. This software suite includes Applanix's PosPac and Waypoint's GrafNav solutions. PosPac provides the smoothed best estimate of trajectory (SBET) that is necessary for Leica's post processor to develop the point cloud from the Lidar missions. The point cloud is the mathematical three dimensional collection of all returns from all laser pulses as determined from the aerial mission. At this point this data is ready for analysis, classification, and filtering to generate a bare earth surface model in which the above ground features are removed from the data set.

The point cloud was created using Leica's ALS Post Processor software. GeoCue was used in the creation of some of the files needed in downstream processing, as well as in the tiling of the dataset into more manageable file sizes. The TerraScan and TerraModeler software packages are then used for the automated data classification, manual cleanup, and bare earth generation from this data. Project specific macros were used to classify the ground and to remove the side overlap between parallel flight lines. All data was manually reviewed and any remaining artifacts removed using functionality provided by TerraScan and TerraModeler. QT Modeler was used as a final check of the bare earth dataset. GeoCue was then used to create the deliverable LAS 1.1 files for both the All Point Cloud Data and the Bare Earth. In-house software was then used to perform final statistical analysis of the classes in the LAS files as a quality control measure.

## Hydro Enforcement

Utilizing the provided 1:2,400-scale digital hydrography, the Photo Science Team developed 3-dimensional breaklines from lidargrammetry and the intensity images. The Team created LiDAR stereo-mates using GeoCue LiDAR Pak software, and then used Socet Set and lidargrammetry to stereo-compile the hydro breaklines. Lidargrammetry, described on pages 227-230 of "Digital Elevation Model Technologies and Applications: The DEM Users Manual," 2nd edition, is a new technology that we have found superior for 3D breakline generation from LiDAR data. The breaklines are topologically correct and maintain monotonicity to ensure the downward flow of water. These breaklines were also used to classify water features in the LAS data.

## Hydro Enforced DEM Development

The bare-earth DEM was hydro-enforced utilizing the criteria stated in Task Order Items C.1.b(iii) and C.1.c (i) but was supplemented by the criteria in Appendix F - Data Dictionary and Hydro Breakline Stereo Compilation Rules to better match the final product of the 2-0 meter DEM. Due to the small grid size of 2 meters, criteria such as "Streams are considered Double line streams when the width of the stream measures ¼ inch or more based on a 1:24,000 scale" would have produce a result whereby a single line stream would be 500 feet or less. Therefore a single line stream could only be represented by the width of one cell which would only be 2 meters, which would not have been a good representation of the stream width. Appendix F defines the criteria for which all hydro lines were collected to ensure that streams flow downhill, that double line streams be flattened, that water course shall be connected through bridges and culverts and that puddling or false depressions be resolved.

## File Format Information

State of New Jersey's digital orthophoto tiling schema (5,000' x 5,000') was utilized to format and deliver the required LAS and ArcGrid DEM file formats. The file naming schema is based on the NJ tile index provided. The formats for the files are in the table below:

<b>Deliverable Dataset</b>	<b>File Type</b>	<b>Count</b>
LAS v1.1 files	*.las	334 of 334 Tiles – All Returns 334 of 334 Tiles - Bare Earth only
2.0 meter DEM files	*.adf	334 of 334 ESRI Grid files

## **Deliverables Summary**

The following data deliverables were produced and delivered to USGS on August 12, 2009:

### **1. All Return Data:**

- Data tiles in LAS format 1.1
- All returns are classified

### **2. Variable Spaced Bare Earth Data:**

- Data tiles in LAS format 1.1
- Are hydro-enforced
- All elevation data points represent the topographic surface (i.e. last-return bare earth) and are reported to the nearest hundredth of a foot, or two (2) decimal places, for a vertical unit of measure.

### **3. 2.0-Meter DEMs:**

- Are hydro enforced
- Are 2.0-meter post regularly spaced grid
- Are delivered in ArcGrid format

### **4) Project Level Metadata:**

- Is FGDC compliant
- Each data type listed below has one (1) corresponding metadata file in .XML format:
  - 1 file for LAS all returns
  - 1 file for Bare Earth LAS
  - 1 file for 2.0 meter DEM

# Appendix

**Appendix A: Flight Logs**

**Appendix B: System Calibration Reports**

**Appendix C: Aeroplan Sensor Report**

**Appendix D: Trajectory Report (by flight date)**

**Appendix E: CORS and Base Station Reports**

**Appendix F: Data Dictionary for Hydro Collection**