U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE

DESCRIPTIVE REPORT

Type of Survey	**Hydrographic**
Field No.	**David Evans and Associates, Inc.**
Registry No.	**H12606**

LOCALITY

State	**New Jersey**
General Locality	**New Jersey Coast and Vicinity**
Sub-locality	**Barnegat Bay to Hereford Inlet**

2014

CHIEF OF PARTY

Carol Lockhart, David Evans and Associates, Inc.

LIBRARY & ARCHIVES

DATE

NOAA Form 77-28 (11 72)	U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	REGISTRY NUMBER:

HYDROGRAPHIC TITLE SHEET

H12606

INSTRUCTIONS: The Hydrographic Sheet should be accompanied by this form, filled in as completely as possible, when the sheet is forwarded to the Office.

State:	**New Jersey**
General Locality:	**New Jersey Coast and Vicinity**
Sub-Locality:	**Barnegat Bay to Hereford Inlet**
Scale:	**1:10,000**
Date of Survey:	**March 27, 2014 to April 3, 2014**
Instructions Dated:	**June 18, 2013**
Project Number:	**OPR-C308-KRL-13**
Field Unit:	**David Evans and Associates, Inc.**
Chief of Party:	**Carol Lockhart**
Soundings by:	**Chiroptera$_I$ Lidar System**
Imagery by:	**µEye UI-1480SE**
Verification by:	
Soundings Acquired in:	**meters at Mean Lower Low Water**
H-Cell Compilation Units:	

Remarks:

NAD 83, UTM Zone 18, Meters, Times are UTC. The purpose of the project is to provide contemporary surveys to update National Ocean Service (NOS) nautical charting products. This project is in response to different user group needs following Hurricane Sandy landfall.

The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charts. All separates are filed with the hydrographic data. Any revisions to the Descriptive Report (DR) generated during office processing are shown in bold red italic text. The processing branch maintains the DR as a field unit product, therefore, all information and recommendations within the body of the DR are considered preliminary unless otherwise noted. The final disposition of surveyed features is represented in the OCS nautical chart update products. All pertinent records for this survey, including the DR, are archived at the National Geophysical Data Center (NGDC) and can be retrieved via http://www.ngdc.noaa.gov/.

H12606 was divided into three survey areas. Upon compilation, H12606's three areas were each assigned an idividual registry number. Area 1 refers to H12808, Area 2 refers to H12606 and Area 6 refers to H12809.

TABLE OF CONTENTS

A. AREA SURVEYED 1
A.1 Survey Limits 1
A.2 Survey Purpose 3
A.3 Survey Quality 3
A.4 Survey Coverage 3
A.5 Survey Statistics 6
B. DATA ACQUISITION AND PROCESSING 7
B.1 Equipment 7
B.1.1 Airborne Data Acquisition 7
B.1.2 Data Processing 8
B.2 Quality Control 8
B.2.1 Crosslines 8
B.2.2 Uncertainty 9
B.2.3 Junctions 9
B.2.4 Environmental Issues 9
B.2.5 Data Coverage 10
B.2.6 Object Detection 11
B.3 Corrections to Soundings 12
B.4 Backscatter 12
B.5 Data Processing 12
B.5.1 Software Updates 12
B.5.2 Surfaces 12
B.5.3 RGB Imagery 13
B.5.4 Delivery Formats 13
C. VERTICAL AND HORIZONTAL CONTROL 14
C.1 Vertical Control 14
C.2 Horizontal Control 15
D. RESULTS AND RECOMMENDATIONS 15
D.1 Chart Comparison 15
D.1.1 Raster Charts 16
D.1.2 Electronic Navigational Charts 16
D.1.4 Dangers to Navigation 19
D.2 Additional Results 19
D.2.1 Shoreline 19
D.2.2 Prior Surveys 19
D.2.3 Aids to Navigation 20
D.2.4 Overhead Features 20
D.2.5 Submarine Features 20
D.2.6 Ferry Routes and Terminals 20

D.2.7 Platforms 20
D.2.8 Significant Features 20
D.2.9 Construction and Dredging 20
E. APPROVAL SHEET 20
F. TABLE OF ACRONYMS 22

List of Figures

Figure 1. General Locality of Nine Potential Areas for Survey H12606 2
Figure 2. H12606 Area 1 Survey Coverage 4
Figure 3. H12606 Area 2 Survey Coverage 5
Figure 4. H12606 Area 6 Survey Coverage 6
Figure 5. Area 2 MHW-MLLW Difference increases on eastern boundary (Blue, Purple) 15
Figure 6. Area 1 Difference Surface 17
Figure 7. Area 2 Difference Surface 18
Figure 8. Area 6 Difference Surface 19

List of Tables

Table 1. H12606, Area 1 Survey Limits 3
Table 2. H12606, Area 2 Survey Limits 3
Table 3. H12606, Area 6 Survey Limits 3
Table 4. H12606 Hydrographic Survey Statistics 6
Table 5. H12606 Dates of Hydrography 7
Table 6. CrossLine Point to Surface Results 8
Table 7. Crossline Surface Difference Results 9
Table 8. TPU Values Used for Every Point 9
Table 9. H12606 Secchi Depth Readings, DN 91 10
Table 10. Acquisition Parameters 10
Table 11. Submitted Surfaces 12
Table 12. GPS Reference Stations Established in NAD83 (2011) 14
Table 13. RNCs Compared to H12606 16
Table 14. ENCs Compared to H12606 16

List of Appendices

Appendix I – Tides and Water Levels
Appendix II – Supplemental Survey Records and Correspondence

Descriptive Report to Accompany Hydrographic Survey H12606
Project OPR-C308-KRL-13
Locality: New Jersey Coast and Vicinity, New Jersey
Sub-locality: Barnegat Bay to Hereford Inlet
Scale 1:10,000
March 2014 – April 2014
David Evans and Associates, Inc.
Chief of Party: Carol Lockhart

A. AREA SURVEYED

David Evans and Associates, Inc (DEA), in conjunction with Geomatics Data Solutions and Quantum Spatial, Inc., conducted hydrographic lidar survey operations along the New Jersey Coast, NJ, from Barnegat Bay to Hereford Inlet. Survey H12606 was conducted in accordance with the *Statement of Work, Hydrographic Lidar Surveying Services* (SOW), June 2013 and *Hydrographic Survey Project Instructions,* June 18 2013 for OPR-C308-KRL-13.

The *Hydrographic Survey Project Instructions* reference the *Hydrographic Surveys Specifications and Deliverables* (HSSD), April 2013 as the technical requirements for this project.

A.1 Survey Limits

Nine potential survey areas were identified by National Oceanic Atmospheric Administration (NOAA). The areas were numbered in order of priority with Area 1 being the highest priority and Area 9 being the lowest priority. The location of the potential survey areas are shown in Figure 1.

As defined in the project instructions, the project was limited to 20 hours of flying. Initially a reconnaissance flight acquired data over all areas to identify those with the best water clarity giving the most chance for success. Planned reconnaissance flight lines are also shown in Figure 1. Analysis of this reconnaissance data, along with the area priority, were used to determine which areas would be the focus for the remaining flight hours. Areas 1 and 2 were initially selected, having the best water clarity and being the highest priority areas. Upon completion of Areas 1 and 2 enough flight hours remained to complete a third area. Area 6 was selected, due to its promising water clarity during the reconnaissance flight and its proximity to the base airport. All areas selected were approved by the NOAA COTR in advance of data collection.

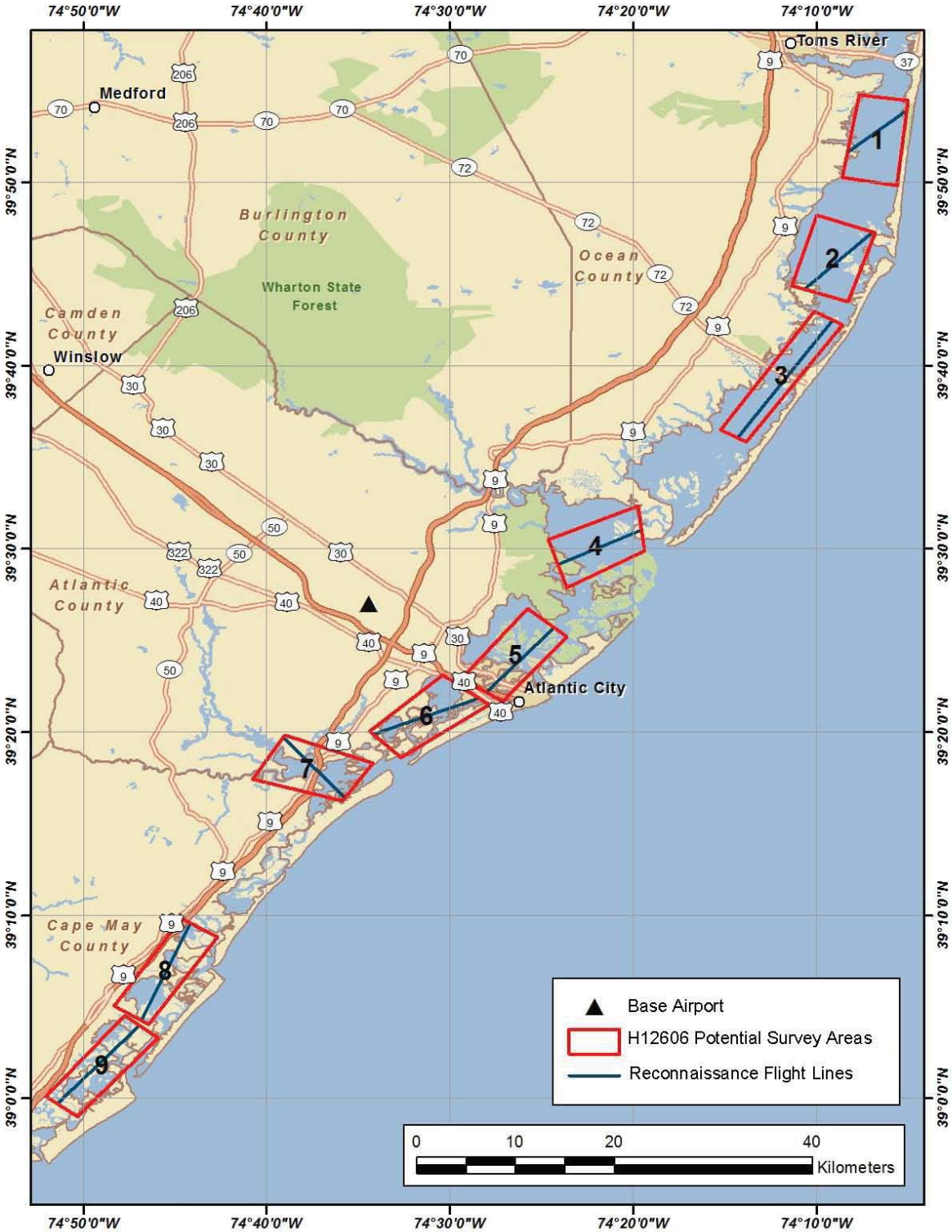

Figure 1. General Locality of Nine Potential Areas for Survey H12606

The extents of the three areas surveyed are listed below in Tables 1, 2 and 3.

Table 1. H12606, Area 1 Survey Limits

H12606 Area 1 (4)	Latitude	Longitude
NW Corner	39° 54' 43.49" N	074° 07' 39.76" W
NE Corner	39° 54' 26.02" N	074° 04' 59.90" W
SE Corner	39° 49' 47.75" N	074° 05' 37.28" W
SW Corner	39° 50' 15.63" N	074° 08' 35.70" W

Table 2. H12606, Area 2 Survey Limits

H12606 Area 2 (4)	Latitude	Longitude
NW Corner	39° 48' 09.92" N	074° 09' 59.08" W
NE Corner	39° 47' 13.58" N	074° 06' 49.54" W
SE Corner	39° 43' 28.03" N	074° 08' 17.12" W
SW Corner	39° 44' 19.03" N	074° 11' 21.60" W

Table 3. H12606, Area 6 Survey Limits

H12606 Area 6 (4)	Latitude	Longitude
NW Corner	39° 23' 06.08" N	074° 30' 24.83" W
NE Corner	39° 21' 27.78" N	074° 27' 53.15" W
SE Corner	39° 18' 35.64" N	074° 32' 41.91" W
SW Corner	39° 20' 00.66" N	074° 34' 23.88" W

A.2 Survey Purpose

The purpose of this survey is to provide contemporary surveys to update National Ocean Service (NOS) nautical charting products. This project is in response to different user group needs following Hurricane Sandy landfall. Specifically these data will adjoin updated shoreline, address the need for updated bathymetry for inundation modeling, and help identify marine debris for potential removal.

A.3 Survey Quality

The entire survey is adequate to supersede previous surveys.

A.4 Survey Coverage

The project instructions specified 200% bathymetric lidar coverage at a 1m x 1m laser spot spacing up to Mean High Water (MHW). The parameters used to conduct this survey produced a nominal pulse spacing of 0.75 meters for the bathymetric laser, 0.25 meters for the topographic laser and a ground sample distance of 25 centimeters for the rectified imagery mosaic for 100% coverage. All areas were flown to provide 200% coverage up to MHW and out to the extent of the bathymetric lidar capabilities under the conditions encountered.

Figures 2, 3 and 4 depict the survey coverage over priority Areas 1, 2 and 6 respectively. Coverage is explained in detail in section B.2.5 Data Coverage**.**

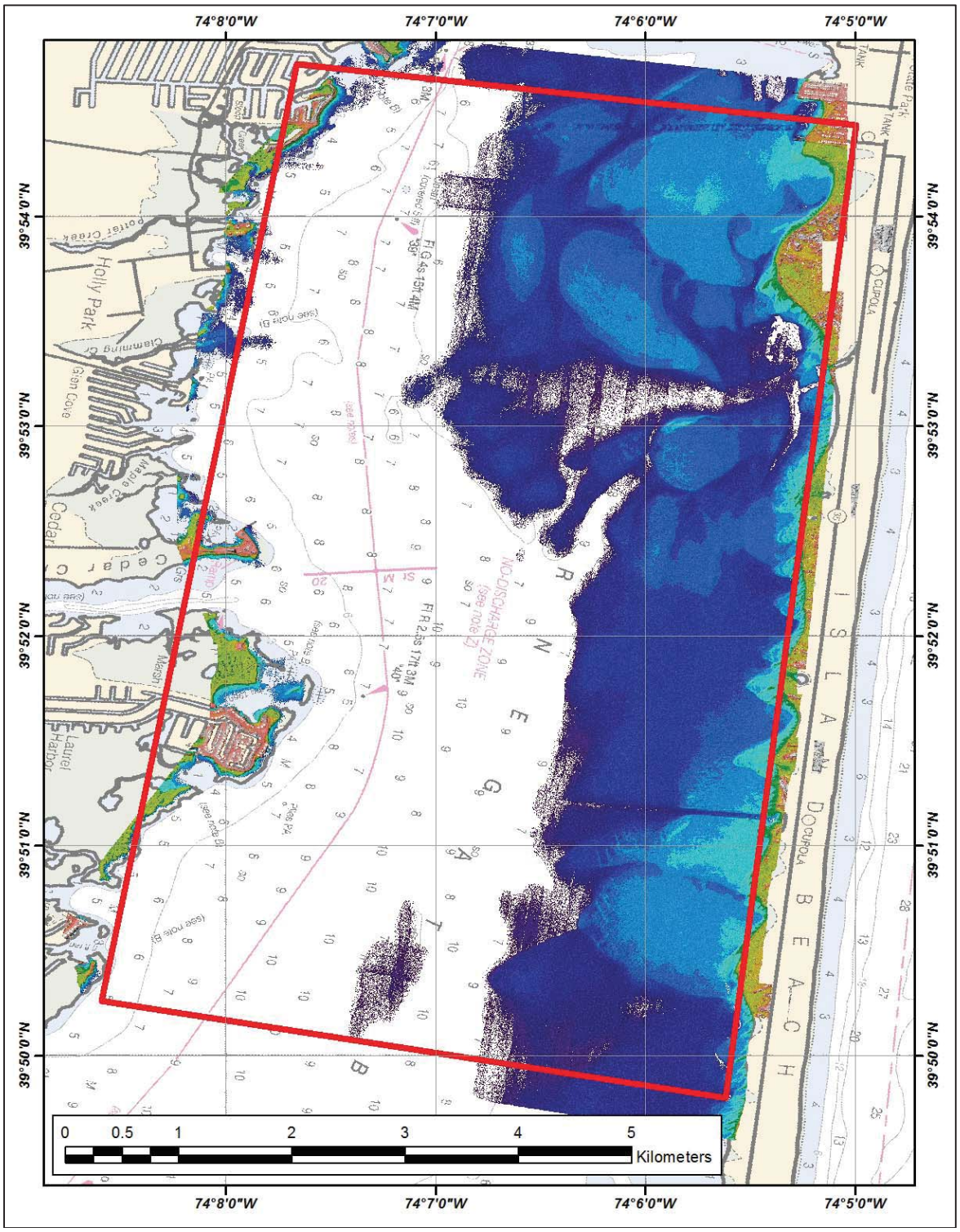

Figure 2. H12606 Area 1 Survey Coverage

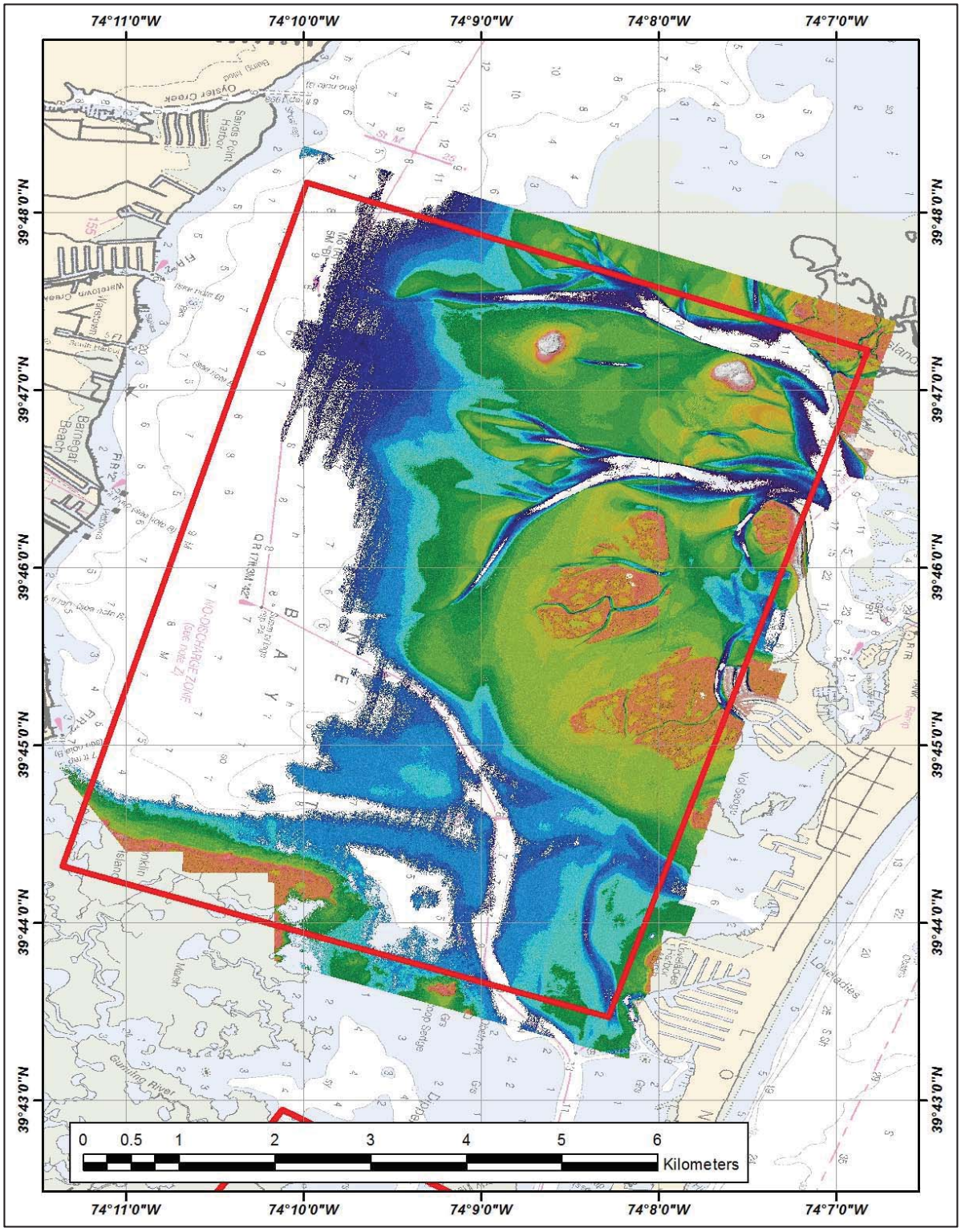

Figure 3. H12606 Area 2 Survey Coverage

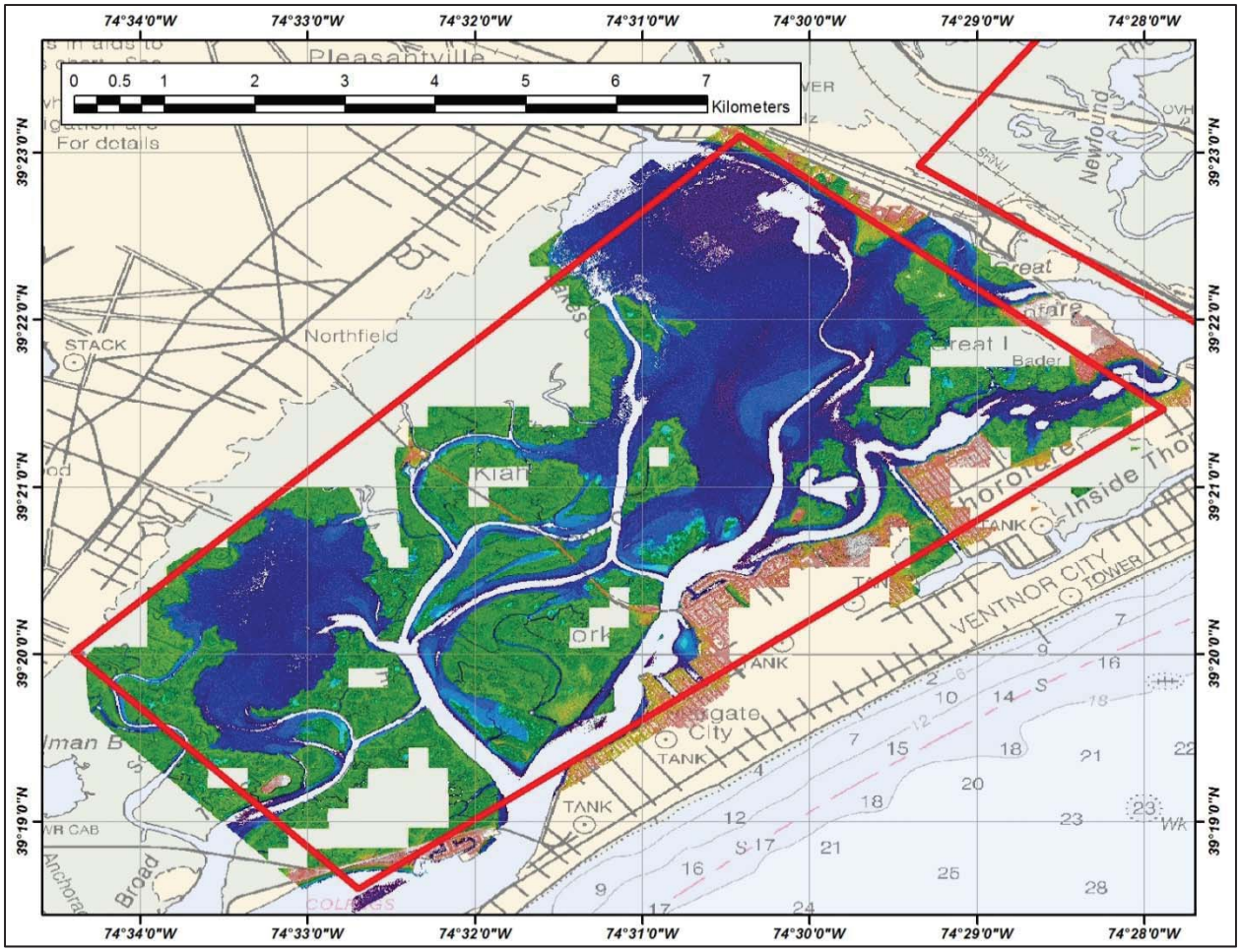

Figure 4. H12606 Area 6 Survey Coverage

A.5 Survey Statistics

The following table lists the mainscheme and crossline acquisition mileage for this survey:

Table 4. H12606 Hydrographic Survey Statistics

	Area 1	Area 2	Area 6
Lidar mainscheme (nm)	170.81	170.38	171.10
Lidar Crosslines (nm)	17.64	15.34	17.99
Number of item investigations required additional survey effort	0	0	0
Number of bottom samples	N/A	N/A	N/A
Total number of square nautical miles	10.09	10.10	10.08

The reconnaissance flight was conducted on March 27, 2014. Data acquisition of Areas 1, 2 and 6 was conducted from April 1, 2014 to April 3, 2014 as provided in **Error! Reference source not found.**.

Table 5. H12606 Dates of Hydrography

Date	Flight Number	Julian Day Number (DN)	Flight Time (hours)	Description
March 27, 2014	1	86	1.87	Reconnaissance
April 1, 2014	2	91	3.50	Area1 – Low Tide
April 2, 2014	3, 4	92	9.38	Area 2 – Low Tide, Area 1 & 2 - High Tide
April 3, 2014	4, 5	93	7.10	Area 6 - High Tide, Area 6 - Low Tide
Total H12606 Flight Hours			**21.85**	

B. DATA ACQUISITION AND PROCESSING

B.1 Equipment

The OPR-C308-KRL-13 *Data Acquisition and Processing Report* (DAPR) submitted under separate cover, details the equipment, data acquisition and processing procedures used during this survey. There were no equipment configurations used during data acquisition that deviated from those described in the DAPR.

B.1.1 Airborne Data Acquisition

The Chiroptera$_I$ Lidar System was installed in a single engine Cessna 206 (Tail N7266Z) for the project. The aircraft has a transit speed of approximately 160 knots and an endurance of up to five hours. Data collection was conducted from a 400-meter altitude at around 97 knots.

The Chiroptera$_I$ simultaneously acquired bathymetric lidar at 35 kHz, topographic lidar at 300 kHz and digital camera imagery at one frame per second. The bathymetric and topographic lasers are independent and do not share an optical chain or receivers; each system is optimized for the role it performs. Both the topographic and bathymetric sensors produce an elliptical scan pattern of laser points, providing multiple look angles on a single pass.

The system included an IGI AEROControl Inertial Measurement Unit (IMU) and GPS antenna for sensor position and attitude measurements. This data along with GPS base station data were used to compute a post-processed trajectory solution for use in processing.

Trimble R7 GPS receivers were used to acquire the GPS reference station data and ground control for Quality Control (QC) purposes. CORS stations were also used as reference stations for some flights, as detailed in the DAPR.

B.1.2 Data Processing

Data were initially processed in the field for coverage review. Raw airborne data were combined with preliminary processed trajectory information and preliminary calibration values in Lidar Survey Studio (LSS) to produce a lidar point cloud. Field data were reviewed in LSS for coverage and also to ensure there were no potential system issues.

Final data processing was conducted in the office after field operations were completed. Processing and QA was conducted using LSS v2.00.07, Terrascan v014.013, Fledermaus (FM) v7.3.6 and ArcGIS 10.2.2. VDatum v3.3 was used to convert data from NAD83 (2011) elevations to MLLW. Final products were created with CARIS Bathy DataBASE Editor v4.1 and Inpho's OrthoMaster and OrthoVista v5.5.

B.2 Quality Control

Internal consistency of the data was checked using crossline analysis, while absolute checks were conducted using ground control collected in both Frankfort, KY and in Area 1 of H12606, NJ. Additional ground points placed along parking lot lines were also used to assess absolute horizontal position accuracy.

Results from all QC checks indicate good internal consistency of the lidar data.

B.2.1 Crosslines

A total of 50.97 nautical miles of crosslines, or 9.9% of all survey lines, were run for analysis of survey accuracy. Crosslines were run in a direction perpendicular to main scheme lines across the entire surveyed area, providing a good representation for analysis of consistency. All crosslines were used for crossline comparisons.

Crossline analysis was performed using the Fledermaus CrossCheck tool. Crossline point data were compared to a 1m gridded surface of the main scheme survey lines and statistics generated. For each line, a histogram of the point comparison was reviewed in CrossCheck to ensure there was a normal distribution of data. A summary of the CrossCheck results is provided in Table 6. The full CrossCheck results are included in Separate II *Digital Data*. The results of the analysis meet the requirements as stated in the NOSHSSD, 2013.

Table 6. CrossLine Point to Surface Results

	Area 1	Area 2	Area 6
No. of Points Compared	11209981	14484774	44650882
Mean Difference (MD) in m	-0.006	-0.006	0.005
Standard Deviation (StDev)	0.067	0.067	0.063
Mean + 2* StdDev	0.140	0.140	0.131

In addition, 1 meter surfaces were created for the crosslines, and surface differences generated between the crossline and mainscheme surfaces. Statistics for the difference surfaces were generated. Results matched those from the CrossCheck analysis, as shown in Table 7.

Table 7. Crossline Surface Difference Results

	Area 1	Area 2	Area 6
MD (m)	0.00	-0.01	0.01
StDev	0.05	0.05	0.05

B.2.2 Uncertainty

In order to maximize survey flight hours, with the project having a limit of 20 hours, independent Total Propagated Uncertainty (TPU) Lines were not acquired. Therefore TPU values were derived based on crossline analysis, absolute horizontal and vertical accuracy checks, and any errors associated with datum conversions. A description of how the uncertainty values were calculated is provided in the DAPR.

Both TVU and THU values are well within the International Hydrographic Organization (IHO) Order 1 accuracy requirements, as shown in Table 8.

Table 8. TPU Values Used for Every Point

	Area 1	Area 2	Area 6
TVU	0.122	0.122	0.120
THU	0.780	0.780	0.780

Absolute vertical accuracy checks were also conducted using ground truth points acquired both in Frankfort, KY and H12606 Area 2. These ground truth points were not used in any system calibration process and were collected independently using RTK GPS methods. Details of the checks are provided in the DAPR. Results from the final edited data in Area 1 give a mean difference of -0.013 meters and StDev of 0.016. Results indicate a high level of absolute accuracy, well within IHO Order 1 requirements for the project.

B.2.3 Junctions

No survey junctions were provided for this project in the Project Instructions.

B.2.4 Environmental Issues

Sea conditions were generally calm through all acquisition days and did not affect data collection or data quality.

Historical water clarity was reviewed prior to survey using the Aqua-MODIS 490 nautical mile (nm) band. Analysis indicated the best times to survey would be March to June, or October, with an expected depth penetration of between 2.5 to 3 meters. In addition to reviewing Aqua-MODIS imagery, water clarity was monitored throughout the survey using the USGS Water Gage (01408167) located north of Area 1 at 40°02'26"N, 74°03'17"W.

A storm traveled through New Jersey after the reconnaissance flight on March 27, 2014 (DN 86). The turbidity was monitored at the gage and survey was postponed until clarity improved on April 1, 2014 (DN 91). Secchi depth readings were also taken around Areas 1 and 2 on April 1, 2014 (DN 91) as provided below.

Table 9. H12606 Secchi Depth Readings, DN 91

Secchi Observation	Latitude	Longitude	Secchi Depth (m)	Water Depth (m)
1	39°44'59.55"N	74°11'32.10"W	0.8	1.0
2	39°47'39.30"N	74°10'59.66"W	1.5	1.5
3	39°52'16.32"N	74° 9'5.91"W	1.5	1.5
4	39°53'8.68"N	74° 8'8.60"W	1.0	1.0
5	39°55'7.22"N	74° 6'35.97"W	1.5	1.5
6	39°55'12.10"N	74° 4'57.81"W	1.5	1.5
7	39°45'17.69"N	74° 6'56.46"W	2.3	2.5
8	39°45'42.59"N	74° 6'37.84"W	2.0	Unknown

Clarity was generally stable throughout the survey areas and did not vary significantly during acquisition. One exception is the first flight conducted on April 3, 2014 over Area 6 during high tide. This flight showed marginal water clarity and the data proved to be noisier than the data collected during low tide.

All data collection was conducted around slack tides to reduce the likelihood of sediment in the water column during tide runs.

Water salinity and temperature were also monitored at the US Geological Survey (USGS) water gage (01408167) and the average values during each flight were used, along with the laser wavelength of 532nm, to calculate an index of refraction number for use in processing of the bathymetric lidar data within the survey areas.

B.2.5 Data Coverage

The project required 200% bathymetric lidar coverage at a 1 meter by 1 meter laser spot spacing. To achieve this, hydrographic lidar flights were planned using the parameters provided in Table 10.

Table 10. Acquisition Parameters

Sensor	Chiroptera$_{I}$
Survey Altitude (AGL)	400m
Pulse Repetition Frequency (PRF)	35kHz Bathy, 300kHz Topo
Swath Width	290m
Coverage	200%
Nominal Spot Spacing	0.75 x 0.75m Bathy, 0.25m x 0.25m Topo
Maximum Number of Returns per Pulse	4

Data were collected at high tide and low tide for each area. One flight plan was created for each area at high tide, using a 225-meter line spacing to provide 122% coverage. A second flight plan was created for the low tide flights, with lines offset by 112.5 meters from the high tide lines. This would provide the maximum number of look angles available for the project while providing the required 200% coverage.

Due to the limited number of flight hours for the project, no re-flights were conducted in any of the areas.

In general lidar coverage was not achieved in the western parts of Areas 1 and 2, or in the deeper channels of Areas 1, 2 and 6. In all cases the laser extinction depth was regularly between 2.5 to 3 meters, indicating consistent water clarity throughout the areas and meeting the historical expectations.

Data collected from the bathymetric laser in Area 6 during the high tide flight were found to be noisier than the other data sets. In cases where the data was significantly noisier than the low tide flight this data was removed, leaving 100% coverage.

Data were initially acquired on the North American Datum of 1983 (NAD83) (2011) ellipsoid. During the course of processing, VDatum was used to convert vertical data from NAD83 (2011) to Mean Lower Low Water (MLLW). The VDatum model did not cover the entire extent of each area surveyed. Therefore final data coverage is clipped at the extents of the VDatum model, as agreed with NOAA. All areas surveyed are affected by this, but Area 6 is affected the most. This is discussed in more detail in the DAPR.

Final coverage for each area are shown in section A.4 Survey Coverage.

B.2.6 Object Detection

Bathymetric lidar data were collected at a planned nominal pulse spacing of 0.75 meters or a density of 1.5 points per m^2, while topographic lidar data were collected at a nominal pulse spacing of 0.25m or greater than 10 points per m^2. Since data were captured at 200% coverage, this density is essentially doubled.

The size of the bathymetric laser footprint on the water surface is approximately 1.2 meters in diameter, ensuring full illumination of the seafloor in a single pass, even in very shallow water. The topographic footprint on the surface is only 0.20 meters in diameter. Therefore, where valid topographic lidar data existed, bathymetric lidar data were removed as the topographic data is more accurate. The parameters of both lasers should allow illumination of IHO Order 1A objects within the areas of coverage provided.

In addition the $Chiroptera_I$ system provides up to four returns per pulse. All valid returns were used during data editing to aid in identification of small features above the seafloor.

B.3 Corrections to Soundings

A description of the corrections to soundings for survey H12606 are detailed in the DAPR. No additional calibration tests were conducted beyond those discussed in the DAPR.

B.4 Backscatter

Backscatter was not required for this project. Raw lidar intensity data is included in the raw and processed LAS files. No corrections have been made to the intensity values for losses in the water column. To aid in data review, 1 meter resolution intensity images are provided with the project data.

B.5 Data Processing

B.5.1 Software Updates

No software updates occurred after submission of the DAPR.

B.5.2 Surfaces

A bathymetric grid was created relative to MLLW) in Combined Uncertainty and Bathymetry Estimator (CUBE) format at 1m resolution for each area. Due to limitations with the LAS files in CARIS Hydrographic Information Processing System (HIPS), CUBE surfaces were created in the FM Pure File Magic (PFM) format and a Bathymetric Attributed Grids (BAG) was exported for each area. The following surfaces were generated for the survey:

Table 11. Submitted Surfaces

Surface Name	Surface Type	Resolution	Depth Range	Surface Parameter	Purpose
H12606_Area1_Lidar_1m_MLLW	BAG	1.0m	-11.81 – 3.27m	n/a	Full Coverage
H12606_Area2_Lidar_1m_MLLW	BAG	1.0m	-6.14 – 12.34m	n/a	Full Coverage
H12606_Area6_Lidar_1m_MLLW	BAG	1.0m	-12.07 – 4.08m	n/a	Full Coverage
H12606_Area1_Lidar_1m_MLLW_final	CSAR	1.0m	-0.14 – 3.27m	n/a	Data below MHW
H12606_Area2_Lidar_1m_MLLW_final	CSAR	1.0m	-0.15 – 12.34m	n/a	Data below MHW
H12606_Area6_Lidar_1m_MLLW_final	CSAR	1.0m	-1.23 – 4.08m	n/a	Data below MHW

Designated soundings (referred to as feature soundings in Fledermaus) were added to the CUBE surfaces as necessary in order to accurately represent the seafloor in accordance with NOS HSSD. These are also correctly reflected in the BAGs.

B.5.3 RGB Imagery

Digital RGB imagery was acquired during each flight. This imagery was used to assist in lidar data editing and quality control. The acquired images were used to generate an orthorectified mosaic. A set of mosaic tiles exists for each area at low tide and high tide. The mosaics were generated at a 0.25-meter ground sample distance with an accuracy of less than 0.75 meters at a 95% confidence level. Mosaics were created in both geotiff and JPEG 2000 format.

B.5.4 Delivery Formats

Due to the unique nature of this project, using a new class of lidar sensor, it was not possible to convert data into CARIS HIPS. This required the development of a new workflow in order to allow suitable data QC by NOAA and also provide a true hydrographic deliverable. During this process, a set of deliverables was agreed with NOAA as follows:

- Raw Data:
  - Acquired lidar data in native format
  - Raw trajectory data from aircraft and GPS base stations
- Unedited data:
  - Unedited, processed lidar data (trajectory applied, processed in LSS, waveform information included in LSS format)
- Edited data: There will be 3 LAS datasets:
  - NAD83 elevations, including all data (accepted, system rejected and user rejected data). This dataset is not clipped at the VDatum extents
  - MLLW depths including all data (accepted, system rejected and user rejected data). This dataset is clipped at the VDatum extents
  - MHW heights including only accepted data. This dataset is clipped at the VDatum extents
- Fledermaus Projects: these allow for data review and include:
  - FM Project directory
  - PFM CUBE surfaces with underlying accepted and user rejected data points
  - Imagery mosaics
- Bag Surfaces:
  - MLLW CUBE surfaces exported from Fledermaus. Each BAG will contain a depth and uncertainty layer
- CARIS BASE Surfaces: The BAG files will be imported into CARIS Bathy Database (BDB) to be finalized in *.csar format. Each BASE Surface will contain a depth and uncertainty layer.
- S-57 Feature File: This contains:
  - M_COVR depicting coverage limit
  - Detected submerged features
  - Uncharted detected navigational aids
  - Shoreline generated from the MHW PFM in FM
  - Baring features: Piles, exposed wrecks (if present)
  - Piers compiled as line features
- Ortho Imagery: Imagery will be provided as mosaics in *.jp2 and *.tiff format.

C. VERTICAL AND HORIZONTAL CONTROL

There were no specific vertical or horizontal control requirements for this project.

All horizontal and vertical data for this project were acquired on the NAD83 (2011) ellipsoid. During processing data were transformed to Universal Transverse Mercator Zone 18N in meters and to MLLW. The vertical transformation was conducted using VDatum and Geoid12A.

Four GPS reference points were established for use during project acquisition. Of these, only two points, along with established CORS data, were used for final system trajectory processing.

Each point established was observed over multiple sessions on different days and coordinates for each session computed via the NGS OPUS website. The average of these coordinates was used for trajectory data processing.

Table 12. GPS Reference Stations Established in NAD83 (2011)

Point	Latitude (N)	Longitude (W)	Height	Comment
84980850	38° 10'54.38789"	84° 54' 10.53167"	201.943	Used for Calibration
OCS_NJ_01	39° 51' 21.56179"	74° 07' 57.11542"	-31.721	Not Used
OCS_NJ_02	39° 46' 32.45195"	74° 11' 11.94764"	-32.243	Used
OCS_NJ_03	39° 39' 04.49093"	74° 11' 06.98918"	-32.653	Not Used
DN8307	39° 24' 45.56553"	74° 29' '29.95957"	-32.567	Used

Trajectory data were processed using IGI AEROoffice_v5.3e, which included GrafNav 8.40 for GPS processing. All trajectory data had an Average Easting/Northing Position StDev of less than 0.025 meters and an Average Height Position StDev less than 0.053 meters. Final trajectory data were used for processing of the lidar data in LSS.

C.1 Vertical Control

The vertical datum for this project is MLLW. All data were acquired relative to the ellipsoid and LAS format data were converted to MLLW using VDatum. During this conversion Geoid12A was used.

LAS data were also converted to MHW using VDatum in order to inspect the difference between the MHW and MLLW across each of the areas and to generate a MHW line. It is important to note that this difference varies across each of the areas. Average values for MHW above MLLW are:

Area1 = 0.14 meters
Area2 = 0.15 meters
Area6 = 1.24 meters

Area 1 has a low variance (StDev=0.01) with the value being consistent across the area. Area 2 also has a low variance throughout the survey area, with the exception of two sections on the eastern boundary as shown in Figure 5, where the MHW-MLLW difference changes to approximately 0.30 meters. Area 6 has a low variance (StDev=0.01) with the value being consistent across the area.

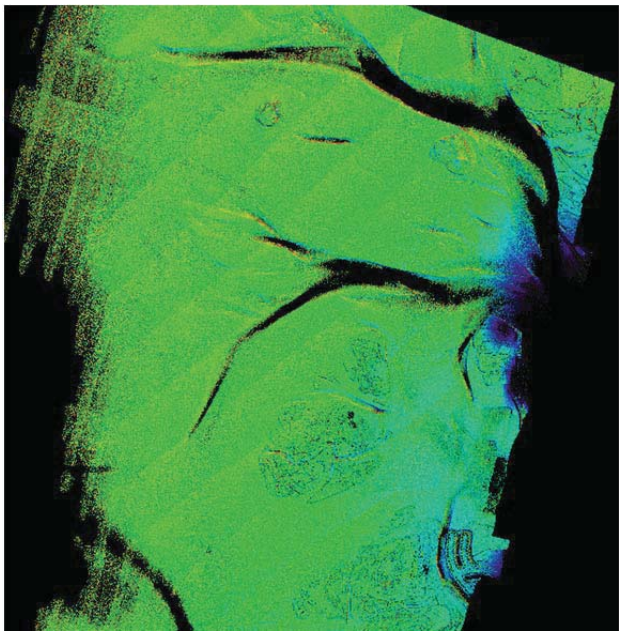

Figure 5. Area 2 MHW-MLLW Difference increases on eastern boundary (Blue, Purple)

In all cases the MHW contour was generated from the MHW data, so that it correctly represents the location of the MHW line for the datasets.

C.2 Horizontal Control

The horizontal datum for this project is North American Datum of 1983 (NAD83) 2011 projected in Universal Transverse Mercator (UTM) Zone 18 North. All data were acquired in NAD83 (2011) and converted to UTM Zone 18N in meters during processing.

D. RESULTS AND RECOMMENDATIONS

The results for H12606 accompany this report in the format of an S-57 feature file, BAG, BASE Surface, georeferenced imagery and intensity images.

D.1 Chart Comparison

The majority of the chart comparison was performed by comparing H12606 depths to a digital surface generated from electronic navigational charts (ENCs) covering the survey area. ENCs at the same scale band were merged prior to surface creation in an attempt to build a continuous model over the survey area. A 50-meter product surface was then generated from a triangular irregular network (TIN) created from the soundings, depth contours, and depth features for each ENC scale. A 50-meter HIPS product surface for Areas 1, 2 and 6 was generated from the finalized 1 meter BASE surface. The chart comparison was conducted by creating and reviewing the resultant difference surface.

D.1.1 Raster Charts

The raster chart comparison was performed by comparing the raster navigational charts (RNCs) covering the survey area to the corresponding ENCs which were subsequently compared to H12606 using difference surface techniques. These RNCs are listed in Table 13.

Table 13. RNCs Compared to H12606

Chart	Scale	Edition Number	Edition Date	LNM Date	NM Date
12324	1:40,000	35	03/2012	03/06/2012	03/17/2012
12316	1:40,000	35	10/2012	05/29/2012	06/092012

D.1.2 Electronic Navigational Charts

Table 14 lists the ENCs compared to H12606.

Table 14. ENCs Compared to H12606

ENC Name	Scale	Edition Number	Update Application Date	Issue Date
US5NJ30M	1:40,000	15	02/26/2013	05/06/2013
US5NJ20M	1:40,000	13	11/08/2012	05/06/2013
US5NJ25M	1:20,000	4	06/25/2012	07/17/2012
US5NJ24M	1:40,000	10	11/08/2012	05/06/2013
US4NJ22M	1:80,000	14	01/10/2013	05/02/2013
Note: US4NJ22M did not overlap any of the surveyed areas, therefore no comparison was conducted.				

<u>Area 1</u>

The mean difference between the 50m Product Surface and the US5NJ Charts was 0 feet, with a standard deviation of 0.98 feet. The largest difference occurred to the northeast of the survey area, where a 9-foot sounding sits between the shoreline and a 1 foot sounding. In this area, the difference observed was 7.9 feet. The difference surface for Area 1 can be seen in Figure 7.

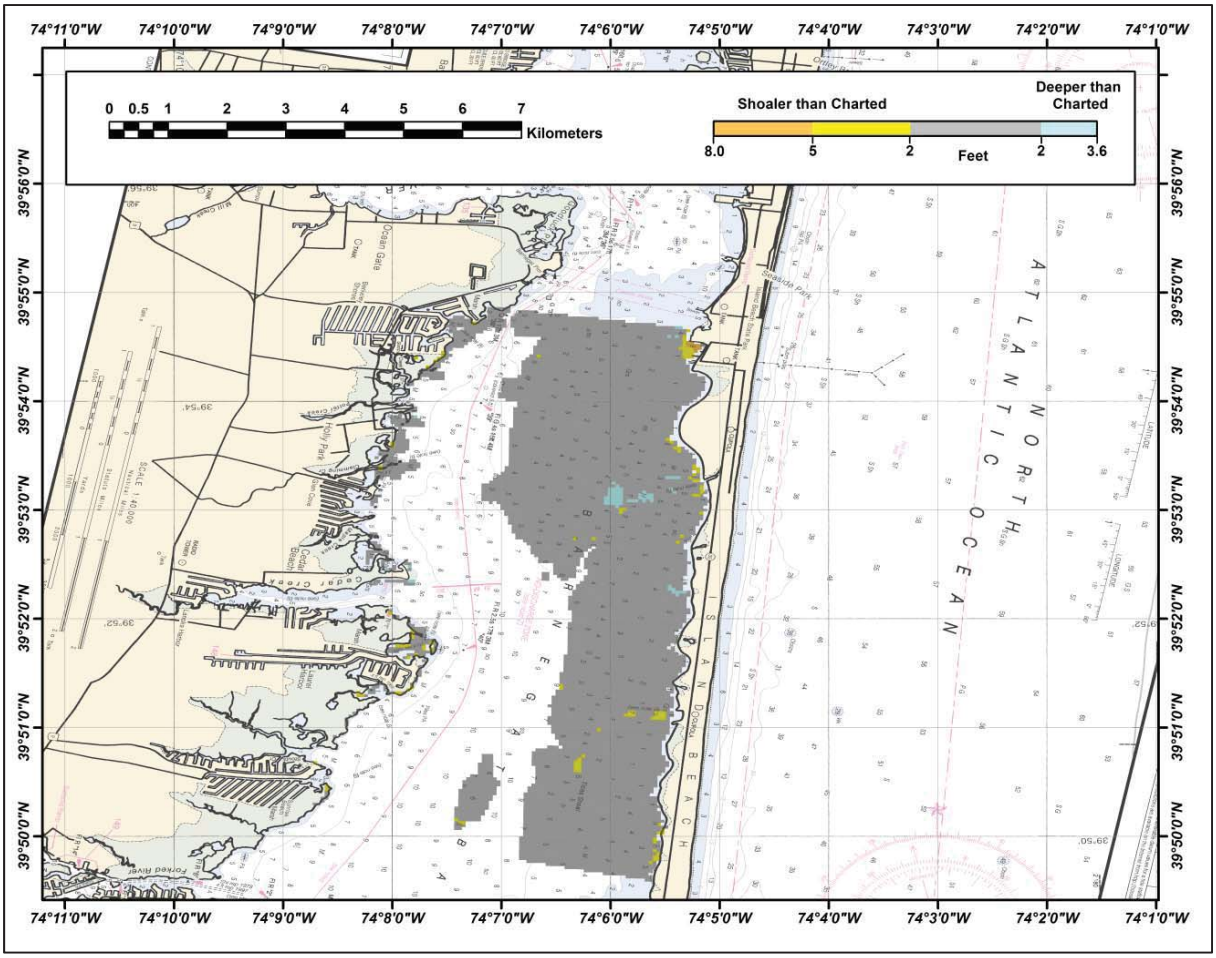

Figure 6. Area 1 Difference Surface

<u>Area 2</u>

The mean difference observed for Area 2 was 0.3 feet, with a standard deviation of 1.64 feet. The largest difference observed was west Barnegat Inlet. The charted soundings indicate a 21-foot hole; the difference observed was 20.3 feet. The difference surface for Area 2 can be seen in Figure 8.

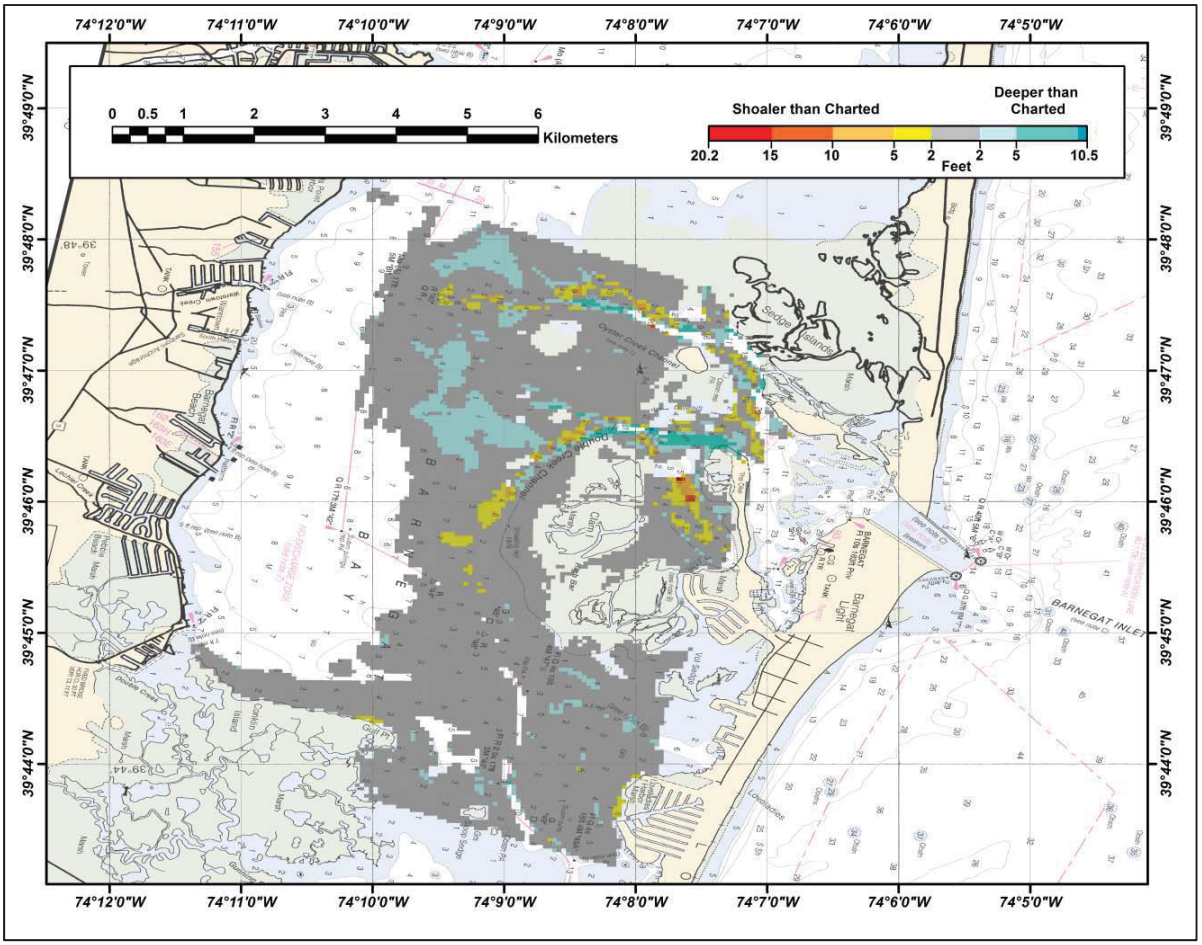

Figure 7. Area 2 Difference Surface

<u>Area 6</u>

The mean difference observed for Area 6 was -0.66 feet with a standard deviation of 3.28 feet. This area is mostly composed of shallow marsh land with numerous channels running throughout. The largest difference occurs in the middle of this area, between Jonas Island and Whirlpool Island, where a charted channel of approximately 8 to 16 feet deep connects with a 29-foot sounding. This channel was surveyed at approximately 1.6 feet deep, making a difference of 27.5 feet at it deepest point. Other significant differences in this area occur on the edges of charted channels and holes, where the survey data did not reach, the surveyed depths in these areas represent only on the shallow edges of these channels and holes. The difference surface for Area 6 can be seen in Figure 9.

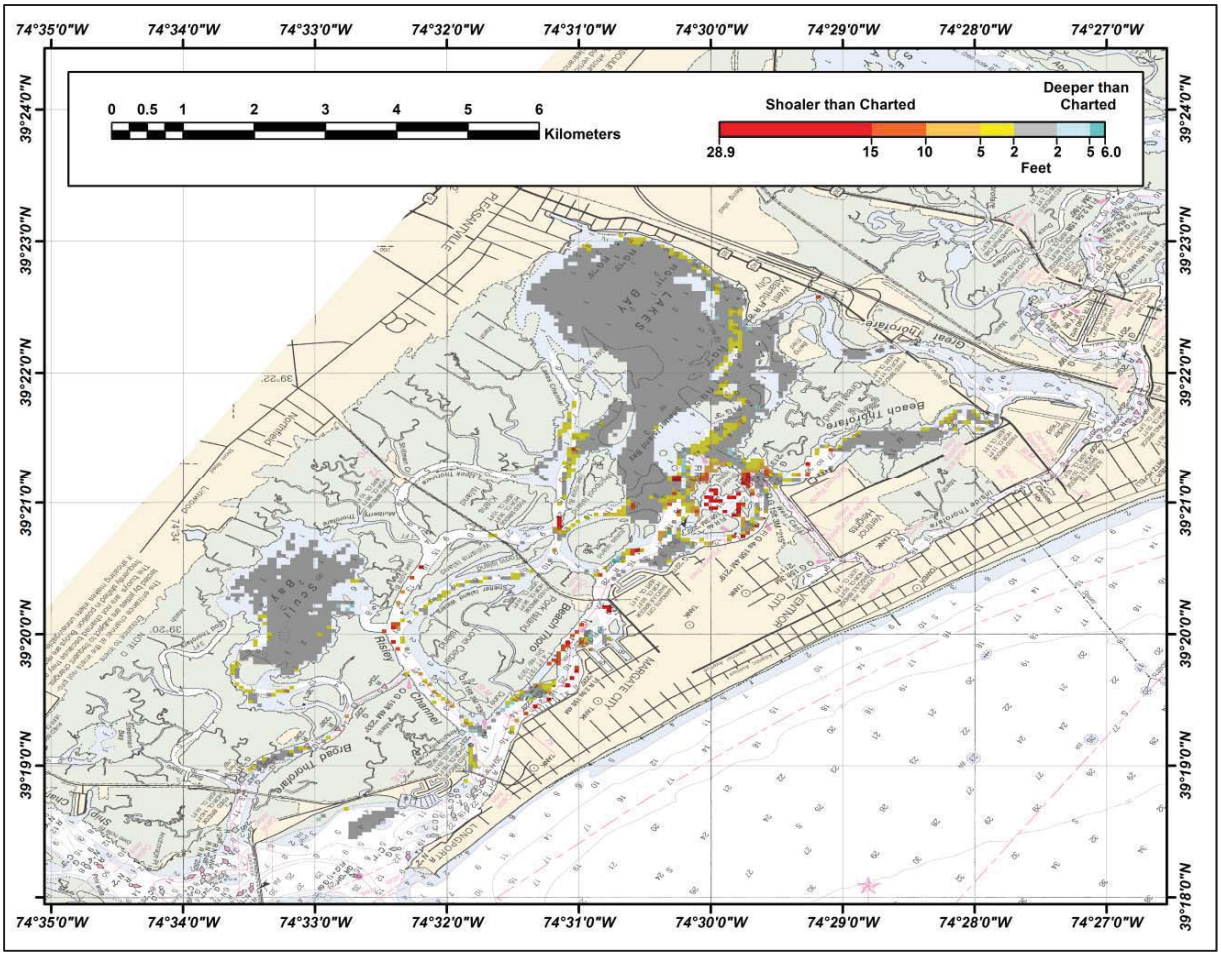

Figure 8. Area 6 Difference Surface

D.1.3 Automated Wreck and Obstruction Information System (AWOIS) Items

There are no AWOIS items assigned for investigation within survey H12606.

D.1.4 Dangers to Navigation

No Dangers to Navigation (DtoNs) were reported for this survey.

D.2 Additional Results

D.2.1 Shoreline

There is no shoreline verification requirement for this project.

D.2.2 Prior Surveys

Comparison with prior surveys was not required under this Task Order.

D.2.3 Aids to Navigation

Several public aids to navigation were located within the survey area and appear to be serving their intended purpose.

D.2.4 Overhead Features

H12606 contains several bridges. Bridge clearance was not determined for this survey.

D.2.5 Submarine Features

There were no submarine features found within the survey area.

D.2.6 Ferry Routes and Terminals

There were no ferry routes or terminals within the survey area.

D.2.7 Platforms

There were no platforms found within the survey area.

D.2.8 Significant Features

There were no navigationally significant features found within the survey area.

D.2.9 Construction and Dredging

There were no construction or dredging activities observed during survey operations.

E. APPROVAL SHEET

The letter of approval for this report and accompanying data follows on the next page.

DAVID EVANS AND ASSOCIATES INC.

LETTER OF APPROVAL
OPR-C308-KRL-13
REGISTRY NO. H12606

As Chief of Party, field operations for this hydrographic lidar survey were conducted under my direct supervision, with frequent personal checks of progress and adequacy. I have reviewed the attached survey data and reports.

All field sheets, this Descriptive Report, and all accompanying records and data are approved. All records are forwarded for final review and processing to the Processing Branch.

The survey data meets or exceeds requirements as set forth in the NOS Hydrographic Surveys and Specifications Deliverables Manual, Statement of Work Hydrographic Lidar Survey Services, and Hydrographic Survey Project Instructions. These data are adequate to supersede charted data in their common areas. This survey is complete and no additional work is required with the exception of deficiencies noted in the Descriptive Report.

Report Name	Report Date Sent
Data Acquisition and Processing Report	2014-08-28

Approver Name	Approver Title	Approval Date	Signature
Carol Lockhart	Chief of Party	2014-08-28	Digitally signed by Carol Lockhart DN: cn=Carol Lockhart, o, ou, email=carol@geomaticsds.com, c=US Date: 2014.08.28 16:00:28 -07'00'
Jonathan L. Dasler, PE, PLS, CH	NSPS/THSOA Certified Hydrographer, Lead Hydrographer	2014-08-28	Digitally signed by Jon Dasler DN: cn=Jon Dasler, o=David Evans and Associates, Inc., ou=Marine Services Division, email=jld@deainc.com, c=US Date: 2014.08.28 16:00:52 -07'00'

F. TABLE OF ACRONYMS

AGL	Survey Altitude
AWOIS	Automated Wreck and Obstruction Information System
BAG	Bathymetric Attributed Grids
BDB	Bathy Database
CUBE	Combined Uncertainty and Bathymetry Estimator
DAPR	Data Acquisition and Processing Report
DEA	David Evans and Associates, Inc
DN	Day Number
DtoN	Danger to Navigation
ENC	Electronic Navigational Charts
FM	Fledermaus
HSSD	Hydrographic Surveys Specifications and Deliverables
IHO	International Hydrographic Organization
IMU	Inertial Measurement Unit
LNM	Local Notice to Mariners
MD	Mean Difference
MHW	Mean High Water
MLLW	Mean Lower Low Water
LSS	Lidar Survey Studio
NAD83	North American Datum of 1983
NM	Nautical Mile
NOAA	National Oceanic Atmospheric Administration
NOS	National Ocean Service
NSPS	National Society of Professional Surveyors
PE	Professional Engineer, Professional Engineer
PFM	Pure File Magic
PLS	Professional Land Surveyor
PRF	Project Reference File
QC	Quality Control
RNC	Raster Navigational Chart
SOW	Statement of Work
StdDev	Standard Deviation
THSOA	The Hydrographic Society of America
TIN	Triangular Irregular Network
TPU	Total Propagated Uncertainty
UTM	Universal Transverse Mercator

APPENDIX I

TIDES AND WATER LEVELS

Project: OPR-C308-KRL-13 Registry No: H12606
Contractor Name: David Evans and Associates, Inc.
Date: April 3, 2014
Inclusive Dates: March 27 - April 3, 2014

Time (UTC)

Day Number	Date	Start Time	End Time
086	03/27/2014	18:20:08	19:34:27
091	04/01/2014	11:09:59	19:46:10
092	04/02/2014	11:11:27	21:30:53
093	04/03/2014	13:45:13	22:31:30

H12606

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: April 3, 2014

PROCESSING BRANCH: Atlantic Hydrographic Branch

HYDROGRAPHIC PROJECT: OPR-C308-KRL-13

HYDROGRAPHIC SHEET: H12606

LOCALITY: New Jersey Coast and Vicinity

SUB-LOCALITY: Barnegat Bay to Hereford Inlet

TIME PERIOD:	March	27
	April	1-3

TIDE STATIONS USED: None

PLANE OF REFERENCE (MEAN LOWER LOW WATER): 0.000 meters

HEIGHT OF MEAN HIGH WATER ABOVE PLANE OF REFERENCE (AVERAGE[1]):
Area1 = 0.14 meters
Area2 = 0.15 meters
Area6 = 1.24 meters

[1] Average value of MHW above MLLW for areas 1, 2, and 3 was computed with VDatum.

APPENDIX II

SUPPLEMENTAL SURVEY RECORDS AND CORRESPONDENCE

Jon Dasler

From: Corey Allen - NOAA Federal [corey.allen@noaa.gov]
Sent: Tuesday, December 17, 2013 5:32 AM
To: Jason Creech
Cc: Mark Lathrop - NOAA Federal; Jon Dasler
Subject: Re: OPR-C308-KRL-13 TOMIS

Jason,
OPR-C308-KRL-13 isn't contingent on testing of the Riegl. Assuming no cost difference (and subsequent reduced coverage) relative to what was expected with the Riegl, you are approved to use the AHAB system. Please let me know if you have any questions or additional concerns.

Cheers, Corey

On Mon, Dec 16, 2013 at 9:24 AM, Jason Creech <Jasc@deainc.com> wrote:

Corey

TOMIS shows final deliverables are due for the OPR-C308-KRL-13 Lidar project by 12/31/13. Can TOMIS be updated to reflect that the survey has been postponed? I believe we are still planning to perform the survey in March when conditions will hopefully be more favorable. I believe we had planned to deliver the survey 2 months after acquisition.

I also left you a message last week inquiring if it would be acceptable to use the AHAB Chiroptera rather than the Riegl system? We aren't sure if the survey is contingent on testing the Riegl system. Given the depths and environmental conditions we may be able to get a better survey with the new AHAB system.

Thanks,

Jason

Jason Creech

Nautical Charting Program Manager

David Evans and Associates, Inc. | Marine Services Division

2801 SE Columbia Way, Ste. 130 | Vancouver, WA 98661

jasc@deainc.com | Office: 804.516.7829 | Cell: 804.516.7829 | Fax: 360.314.3250

--
J. Corey Allen
Operations Branch Team Lead
Hydrographic Surveys Division
Office of Coast Survey, NOAA
Corey.Allen@noaa.gov
301.713.2777 x119 (Office)
301.717.7271 (Cell)

Jason Creech

From: Lori Powdrell - NOAA Federal <lori.powdrell@noaa.gov>
Sent: Wednesday, April 16, 2014 6:26 AM
To: Jason Creech
Cc: Jon Dasler
Subject: LiDAR Project Instruction change

Jason,

You can disregard the Preliminary Deliverables Requirement in the Project Instructions to provide a preliminary data set to the COR within 10 days following the completion of acquisition. It is not necessary to provide preliminary deliverables for this project.

Thank you,
Lori

Jason Creech

From: Lori Powdrell - NOAA Federal <lori.powdrell@noaa.gov>
Sent: Wednesday, July 16, 2014 11:52 AM
To: Jason Creech; Jon Dasler
Cc: Corey Allen; Michael Gonsalves - NOAA Federal
Subject: Re: OPR-C308-KRL-13 extension

Jason,

I just spoke to Elizabeth Lotz, AGO, she is going to change the delivery date from July 31 to August 31. She is going to give you a call to let you know that you don't have to sign the current one.

I will let you know if I need anything from you.

Thanks,
Lori

On Mon, Jul 14, 2014 at 3:47 PM, Jason Creech <Jasc@deainc.com> wrote:
Hi Lori and Corey

I'm following up to see if extending the LiDAR project until the end of August is possible? I sent Gene the sample data today and don't think we will be able to submit everything by the end of the month considering the unknowns. We hope to be able to get in well before the end of August but are asking for this date just incase something else comes up.

Thanks,
Jason

Jason Creech

From: Castle Parker - NOAA Federal <castle.e.parker@noaa.gov>
Sent: Wednesday, July 23, 2014 8:57 AM
To: James Guilford
Cc: Carol@geomaticsds.com; Jason Creech; Matthew Jaskoski - NOAA Federal; Lori Powdrell - NOAA Federal
Subject: RE: NOAA23 - Deliverables

Blast from the Past! Good to hear from ya! Your name was dropped the other day and wondered what's happening with ya :>) like a boomerang!

I've read your proposal and discussed with AHB Chief Matt Jaskoski and think that most of your recommendations are appropriate and will work for AHB. I do have a few questions and will detail below toward the bottom of this email.

-The raw data more than likely will not be used by AHB, but will be forwarded as normal to NGDC for public access. This is a standard submission; AHB rarely goes back to raw data, not saying never, but rarely.

-The Fledermaus project appears to be the same as with the test data set that I worked with last week. Not being a Fledermaus user on a consistent basis, I've refreshed myself with the programs operations; mainly via button pushing, trial and error, and the user guide. Progress was made and I'm confident that AHB will be able to validate the submitted BAG files via the IVS project and PFM, even if I have to do the survey review.

-The BAG suggestions are acceptable. I did work through the process with the test data set of export to BAG via Fledermaus and generating CARIS *.csar grids, adding the density, mean, and Std_dev child layers. Technically, the BAG could be the grid considered as source. The *.csar submission would not be mandatory since the BAG covers the requirement for bathy grid. I'm not saying the CARIS grid would have to be required, but would be optional deliverable if DEA wants to submit. If this is the case, then the CARIS csar grid could be considered the "official deliverable," if selected and documented.

-The alternative Option for BAG need not be clipped (MLLW +2m elevated) as you suggested.

-The S57 Feature File recommendations are all good. I think that your suggestions within the feature file is all that we would need and could use. Regarding the shoreline, since the project instructions didn't detail shoreline assignment (Composite Source File) and the level of effort separating the coastline from the shoreline construction could be a big time sink and a lot of effort, AHB would accept the shoreline as COALNE. The coastline line work at the MHW value and I'm assuming would also include the shoreline constructions such as piers and bulkheads that would be at the same datum or above would provide a component for compilation; if necessary, the AHB Compile Team can separate the natural shoreline from that which is manmade and make the necessary revisions for ENC/HCell product.

-Imagery: Submission in two formats - The TIFF images submitted with the test data works; Tiff format works best across the board between CARIS HIPS and BDB version 4.0.9; AHB hasn't evolved to BDB 4.1 yet with the exception of one recent project with NOAA Lidar data. If the TIFF is RGB then BDB 4.1 will be used. JP2 works in CARIS HIPS 7.1, but not in BDB 4.0.9 and BDB 4.1. So, it's up to you guys if you submit both image versions. From my viewpoint the TIFF works best.

-AHB does not have a problem with clipping the products to the VDatum grid limits.

?The LAS files NAD83 to MHW (via VDatum correction): does this mean that these LAS file will not contain accepted data points below MHW? And only contain data points that are elevated above MHW?

? When you reference NAD83 elevation, does this mean ellipsoid heights (ERS datum/ orthometric heights)?

-With the test data set I referenced the MLLW LAS files with accepted and rejected, imported to CSAR grid and found that this does not help us much at all. It's a deliverable that AHB will not reference as there is no output product that can be used for navigational products. The MLLW LAS files will be archived and submitted to NGDC as the final processed data. Anyone outside (other users) this project can use the data however they choose.

AHB will not duplicate the Fledermaus project sourcing these MLLW LAS file. Our intent is to us the Fledermaus project for grid validation and if in the event we are required to edit data points for one reason or another, the IVS project would continue to be the data set to derive a final grid. It seems the LAS files with MHW heights including only accepted data would be good for the shoreline and possibly to other users, but the MLLW depths with accepted and rejected data I envision will have limited AHB use.

So, overall, AHB will accept the deliverable recommendations with deviations as discussed above. If not clear and I haven't responded appropriately, the please let me know and can clarify.

As usual, I always have more data than I can deal with, and we'll add this to the mix. Thank goodness the AHB SAR Team has grown and our staff is the largest it's been in years. All the data keeps me busy, job security, and out of trouble. But that's only a matter of opinion! I can get into trouble so easily!... just by speaking my mind! Whoops!

Thanks for your input and the team efforts.
Cheers,
Gene

Castle Eugene Parker
NOAA Office of Coast Survey
Atlantic Hydrographic Branch
Hydrographic Team Lead/ Physical Scientist
castle.e.parker@noaa.gov
office (757) 441-6746 x115

From: James Guilford [mailto:JGuilford@deainc.com]
Sent: Tuesday, July 22, 2014 10:01 PM
To: castle.e.parker@noaa.gov
Cc: Carol@GeomaticsDS.com; Jason Creech
Subject: NOAA23 - Deliverables

Hey Gene,

How are you?
I've been working on the NOAA23 deliverables with Carol. We would like to propose a deliverables list for your signoff. This will be a slightly different deliverable set than what Jason discussed with you.

Raw Data:

- Acquired lidar data in native format.
- Raw GPS/Inertial from aircraft and GPS from Base Stations

Unedited data:

- Unedited, processed lidar data (GPS/Inertial applied, depth processed in LSS software, waveform information included in LSS format)

Edited data:

- LAS files (edited in Terrascan). There will be 3 datasets:
  - NAD83 elevations. LAS files containing accepted data as well as system and user rejected data.
  - MLLW depths (conversion from NAD83 to MLLW in VDatum). LAS files containing accepted data as well as system and user rejected data. Dataset clipped to VDatum grid limits.
  - MHW heights (conversion from NAD83 to MHW in VDatum). LAS files containing accepted data only. Dataset clipped to VDatum grid limits.

Fledermaus Projects:

- The provided project will allow for data review and will include:
  - IVS Project directory
  - PFM Cube surfaces containing accepted and user rejected data.
  - Imagery mosaics

Bag Surfaces:

- MLLW PFM Cube surfaces will be exported from Fledermaus in BAG format. Each BAG will contain a depth and uncertainty layer.
  - The Depth layer will be created from the PFM Cube surface that has designated (feature) soundings applied. Where permanent piers are present, the surface will represent the pier deck. Floating docks will be removed from surface. The surface will contain elevations above MHW.
  - The Uncertainty layer. Each sounding will be assigned the same uncertainty value during the creation of the PFM in Fledermaus. During export to the BAG from Fledermaus, the Uncertainty value of each grid node will be propagated based upon the sounding distance to the node and the number of samples contributing to the node.

BASE Surfaces:

- The BAG files will be imported into CARIS BDB to be finalized in *.csar format. Each BASE Surface will contain a depth and uncertainty layer.
  - The Depth layer will be finalized so it can be clipped to a value that approximately represents the MHW Line (this is not an exact number as the MLLW-MHW difference varies from location to location). This may result in seawalls and (other near vertical) manmade shoreline not being represented in the BAG surface.
    - ALTERNATIVE OPTION: The Depth layer could be clipped at an agreed upon elevation such as 2.0m above MLLW.
  - The Uncertainty layer will match values contained in the BAG

S-57 Feature File:

- The S-57 Feature file will contain:
  - M_COVR depicting coverage limit
  - Detected submerged features
  - Uncharted detected navigational aids
  - Shoreline generated from the MHW PFM in Fledermaus
    - QUESTIONS: Do you want shoreline?
    - Do you want the shoreline captured using S-57 objects COALNE and SLCONS? (This will require editing where there is transition from natural shoreline to manmade shoreline such as where seawalls are present)

- Baring features: Piles, exposed wrecks (if present)…
- Piers compiled as line features.

Ortho Imagery:

- Imagery will be provided as mosaics in *.jp2 and *.tiff format

Let me know if you think this will be OK. We can give you a ring tomorrow morning if there is anything you would like to discuss.

Hope all is well on the East Coast!
James

James Guilford | Lead Hydrographer
David Evans and Associates, Inc. | Marine Services Division | www.deamarine.com
t: 360.314.3200 | c: 937-903-6276 | jguilford@deainc.com

DAVID EVANS AND ASSOCIATES INC. MARINE SERVICES

Follow us on LinkedIn | Twitter | Facebook | YouTube

Please consider the environment before printing this email.

APPENDIX III

SURVEY FEATURES REPORT

(No AWOIS items, DToNs, Wrecks or Maritime Boundaries)

APPROVAL PAGE

H12808

Data meet or exceed current specifications as certified by the OCS survey acceptance review process. Descriptive Report and survey data except where noted are adequate to supersede prior surveys and nautical charts in the common area.

The following products will be sent to NGDC for archive

- H12808_DR.pdf
- Collection of depth varied resolution BAGS
- Processed survey data and records
- H12808_GeoImage.pdf

The survey evaluation and verification has been conducted according current OCS Specifications, and the survey has been approved for dissemination and usage of updating NOAA's suite of nautical charts.

Approved: Digitally signed by Jasmine Cousins
DN: cn=Jasmine Cousins, o=NOAA, ou=Atlantic Hydrographic Branch, email=jasmine.cousins@noaa.gov, c=US
Date: 2015.08.12 12:55:06 -04'00'

Lieutenant Commander Matthew Jaskoski, NOAA
Chief, Atlantic Hydrographic Branch