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

HORIZONTAL AND VERTICAL CONTROL REPORT

Type of Survey	**Hydrographic**
Project	**OPR-E349-KR-07-DEA**
Contract No	**DG133C-05CQ-1078**
Task Order No	**T0003**
Time Frame	**May 2007 - September 2007**

LOCALITY

State	**Virginia**
General Locality	**Central Chesapeake Bay**

2007

CHIEF OF PARTY

Jonathan L. Dasler, David Evans and Associates, Inc.

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DATE

NOAA FORM 77-28 (11-72)

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

REGISTRY No

H11653, H11654, H11655, H11656, H11657

HYDROGRAPHIC TITLE SHEET

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

FIELD No

David Evans and Associates, Inc.

State: Virginia

General Locality: Central Chesapeake Bay

Sub-Locality: Rappahannock Spit

Scale: 1:10,000

Date of Survey: May 22, 2007 to September 28, 2007

Instructions dated: February 22, 2007

Project No.: OPR-E349-KR-07

Vessel: R/V Sealth

Chief of party: Jonathan L. Dasler, PE (OR) , PLS (OR,CA)

Surveyed by: Jason Creech, John Staly

Soundings by echo sounder, hand lead, pole: RESON 7125-B, EdgeTech 4200-FS, EdgeTech 4200-HFL

Graphic record scaled by: N/A

Graphic record checked by: N/A

Automated Plot: N/A

Verification by:

Soundings in: Meters at MLLW

REMARKS: All times are UTC.

The purpose of this contract is to provide NOAA with modern, accurate hydrographic survey data with which to update the nautical charts of the assigned area.

SUBCONSULTANTS: Global Seas, LLC, 2001 Sixth Ave Suite 3420, Seattle, WA 98121

John Oswald and Associates, 2000 E Dowling Road, Suite 10, Anchorage, AK 99507

NOAA FORM 77-28 SUPERSEDES FORM C&GS-537

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Acronyms and Abbreviations

ARP	Antenna Reference Point
CORS	Continuously Operating Reference Station
CO-OPS	Center for Operational Oceanographic Products and Services
DAPR	Data Acquisition and Processing Report
DEA	David Evans and Associates, Inc.
DGPS	Differential Global Positioning System
GPS	Global Positioning System
kHz	kilo Hertz
MBES	Multibeam Echo Sounder
MHW	Mean High Water
MLLW	Mean Lower Low Water
NAD83	North American Datum of 1983
NOS	National Ocean Service
NWLON	National Water Level Observation Network
POS/MV	Position and Orientation System for Marine Vessels
R/V	Research Vessel
USCG	United States Coast Guard
UTC	Coordinated Universal Time

Horizontal and Vertical Control Report
OPR-E349-KR-07-DEA
Central Chesapeake Bay, Virginia
May 2007 – September 2007
R/V Sealth
David Evans and Associates, Inc
Lead Hydrographer: Jonathan L. Dasler, P.E., P.L.S.

INTRODUCTION

This report applies to surveys H11653, H11654, H11655, H11656 and H11657 located in Central Chesapeake Bay, Virginia. These contract surveys were performed under OPR-E349-KR-07-DEA as specified in the Statement of Work dated February 22, 2007. In general, survey methods meet or exceed requirements as defined in the National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables (April 2007).* Project instruction requirements were met with 200% side scan sonar (SSS) coverage acquired in conjunction with multibeam echosounder (MBES) data.

A. VERTICAL CONTROL

The tidal datum for this project is chart datum, Mean Lower Low Water (MLLW) and Mean High Water (MHW). All soundings are referenced to MLLW. No heights were referenced as part of this project. All data (tidal, position, attitude, sonar, survey logs, etc.) were collected in Coordinated Universal Time (UTC).

A1. Tide and Water Level Corrections

The Tide and Water Level Data and Predicted Tidal Zoning requirements in the *Statement of Work* specified that the operating National Water Level Observation Network (NWLON) station at Windmill Point, VA (863-6580) serve as datum control for the project. The Tides and Water Levels requirement is included in Appendix II.

David Evans and Associates, Inc. (DEA) has observed that data from Windmill Point is problematic with data outages and noisy data, possibly due to a seiche effect resulting from the narrow entrance into the harbor where the gauge is located. Further, the U.S. Army Corps of Engineers (USACE) which conducts dredging surveys in the Rappahannock channel has reported periodic large errors (close to 1-foot) in tidal zoning from this station. Though not required by the project instructions, a subordinate water level station was installed at the Rappahannock Range Front Light, Virginia (863-2837) to evaluate the severity of the zoning errors from Windmill Point and served as an alternate source for water level reducers for this project. Based on analysis of zoning from both stations, DEA found the water level correctors from the Rappahannock Range Front Light, Virginia (863-2837) provided a more accurate zoning model of localized tidal conditions for several of the survey areas.

A2. Subordinate Tide Stations

A subordinate water level station was installed at Rappahannock Range Front Light (863-2837) in Central Chesapeake Bay, VA by the field unit as a supplemental station to the Windmill Point station. The Rappahannock Range Front Light station is located at 37-32-18.5N, 76-00-51.0W and was operated from May 10, 2007 (DN 130) to October 2, 2007 (DN 275).

The gauges installed at Rappahannock Range Front Light included two Design Analysis digital bubblers; (DAA) H350XL, with H355 pumps, and H222 (Signal Engineering) GOES radios, with Yagi antennas. Both gauges have a range from 0 to 30 psi. Each gauge system was powered by three 12VDC batteries, charged with 40 watt solar cells. Separate Global Positioning System (GPS) modules provide time syncing for each gauge.

All raw pressure observations from the Rappahannock Range Front Light station were corrected for water density to determine water levels. Outliers were then removed from the data set by smoothing with a two hour third degree polynomial. Daily high and low readings were then picked from the data set and compared to verify high and low readings from the station at Windmill Point. From the comparisons a Monthly Means was computed. The Rappahannock Range Front Light station datum (adjusted to MLLW) was then applied to the smoothed tide file.

Another subordinate tide gauge was installed at Gaskins Creek (863-2869) to verify the information from the subordinate water level station at Rappahannock Range Front Light. The tide station was installed at the end of a dock on the Pruitt property, along the north side of Occohannock Creek in Belle Haven, VA. It was located at 37-33-21.7N, 75-55-14.2W and operated from May 13, 2007 (DN133) to October 10, 2007 (DN275). Although it was used to corroborate the data from Rappahannock Front Range Light, the water level correctors from Gaskins Creek were not applied to the data.

Two gauges were installed at Gaskins Point (863-2869). Gauge #1 was a Design Analysis (DAA) H360 radar sensor with H522 DCP/SE GOES radio and Yagi antenna. Gauge #2 was an Aquatrak sensor in a 4” stilling well connected to a Vitel VX100 DCP and GOES radio with Yagi antenna. The Vitel VX100 DCP was replaced with a Sutron XLite 9210 on July 25, 2007. Each gauge system was powered by one 12vdc battery, charged with separate 1.5 amp automatic charger plugged into an AC receptacle at the tide house. Separated GPS modules provide time syncing for each gauge.

Tide zoning for Rappahannock Front Range Light (863-2837) was created by modifying the Preliminary CO-OPS zoning files tied to Windmill Point, Virginia (863-6580). Zone boundaries were not modified, but new time and range correctors were back calculated from zone SCB67. Time correctors were calculated by adjusting the average time corrector (ATC) for zone SCB67 which surrounds gauge 863-2837 from -36 minutes (zoned from 863-6580) to zero minutes. Similarly, the range corrector was adjusted from 1.47 to 1.00. From this average time correctors were calculated for each zone relative to 863-2837 by calculating the difference between the ATC relative to 863-6580 for the zone in question and -36 (the ATC for SCB67). Range correctors were calculated by dividing the range corrector for the zone in question by 1.47 (the range value for SCB67 relative to 863-6580). A HIPS zone definition file (ZDF) was then

created that used gauge 863-2837 as the primary gauge for all zones except for SCB 94 and SCB 88 which used 863-6580 as the primary station. The Appendix III *Final Tide Note* includes a listing of the final zoning schemes for each survey.

It is difficult to associate a precise vertical error due to tides. Errors observed are a composite from various sources such as measurement error, tides, heave, refraction, transducer draft, and settlement and squat. Small vertical offsets may be observed in the data; however there are no areas that exceed the maximum allowable error of 20 cm to 45 cm for water levels. The largest contributing factor to water level errors in the Chesapeake Bay is meteorological influences which can not be accounted for by zoning.

Four bench marks were recovered and one new bench mark (8632869-C) was established during the installation of the Gaskin Point Tide Station. The newly established bench mark is a punch mark in the top of a rounded 9/16" diameter stainless steel rod driven 19.51 m (64.00ft) in the front yard of the Pruitt residence, 61.66 m (202.3 ft) SE of bench mark 863 2869 B, 32.22 m (105.7 ft) SSW of the SE corner of the Pruitt house, 28.10 m (92.2 ft) SSW of bench mark 863 2869 PRUITT, 27.37 m (89.8 ft) SE of the SW corner of the raised porch of the Pruitt house, 21.37 m (70.1 ft) east of a metal flagpole, and 17.98 m (59.0 ft) NNE of the top of the bank of Occohannock Creek..

Three bench marks were recovered and one new bench mark (8632837-D) was established during the installation of the Rappahannock Light Tide Station. The newly established bench mark is a chiseled cross stamped into the highest part of the top of the a round steel fender pipe (SE'ly most of five) each with a hard black rubber strip on the seaward side of the SW side of the lower boat landing platform on the light structure, 3.34 m (10.96 ft) SE of the NW'ly most fender pipe, 1.66 m (5.54 ft) SE of the center of the center fender pipe and bench mark 8632837 C, and 0.5 m (1.6 ft) above the steel grating floor of the lower platform.

For both tide gauges, elevations were established and leveled based on the NOS publication *User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Level Stations* (1987). The orifices were measured to directly from the bench marks. A static GPS survey was used to determine the ellipsoidal height of the primary bench mark in accordance with CO-OPS Users Guide for GPS Observations.

The final tide reports submitted to CO-OPs comprise Appendix I *Final Tide Reports* of this report which includes comparison of monthly means, site descriptions, abstracts of leveling, photos, site sketches and a tide reports. The Final Tide Notes, which include a listing of final zoning schemes for each survey, are included in Appendix III.

B. HORIZONTAL CONTROL

The temporary control station MARINA_ROOF (also listed as DVL-Marina) was installed at the Deltaville Boatyard located on Jackson Creek on May 11, 2007 and established as the reference base station for kinematic GPS post processing. Dual frequency (L1/L2) data acquisition at this site began on May 20, 2007 (DN 140) and continued until October 4, 2007 (DN 277). A Trimble

NetRs (Serial Number 4706128342) with Zephyr antenna (Serial Number 60187064) configured to allow remote download of data via an internet connection logged raw dual frequency GPS observables at one second intervals and recorded to an internal data card. Data were downloaded to the processing office in Portland, Oregon on a weekly basis via the internet connection.

Data from the DVL-Marina station was used during post-processing of all OPR-E349-KR-07 MBES data. In addition, the National Geodetic Survey (NGS) continuously operating reference station (CORS) station VIMS was used along with the MARINA_ROOF station during post-processing of H11656 and H11657 due to the long baseline distance between the survey areas and the DVL-Marina station. The CORS station VIMS is located in the town of Wachapreague, Virginia on the Eastern Shore of Virginia. The NGS permanent identifier (PID) for the antenna reference point (ARP) is AI3289.

The coordinates of MARINA_ROOF are based on an adjustment of a 24 hour GPS session using a single point constraint which held the NGS coordinates (NAD83(93)) of Station J 458 (PID GV0008). The VIMS coordinates are the NGS published values for the site. The coordinates of the antenna reference points used during post processing are listed in Table 1.

Table 1. ARP Base Station Coordinates (NAD83)

Name	Latitude	Longitude	Ellipsoid Height (m)
MARINA_ROOF	37-32-59.05977 N	076-19-47.04808 W	-24.129
VIMS	37-36-30.04548 N	075-41-13.20712 W	-27.739

As discussed in the Descriptive Reports for surveys H11656 and H11657, data from the station VIMS was not available for navigation post processing for several days of data acquisition. During these days data were post processed in single base mode (using the DVL-Marina station) rather than multi base mode (using both the VIMS and DVL-Marina stations) which was used to process the remainder of the OPR-E349-KR-07-DEA survey data. The performance of the single base post processing was evaluated and found to be much better than the real time differential global positioning system (DGPS) navigation solution even with the long baseline distance between the survey area and the DVL-Marina station. Post processing methodology is discussed in detail in the *OPR-E349-KR-07 Data Acquisition and Processing Report* (DAPR).

The horizontal datum for this project is the North American Datum of 1983 (NAD83). All horizontal positioning for soundings followed the Statement of Work, February 22, 2007, and the NOS *Hydrographic Surveys Specifications and Deliverables*, April 2007.

No aids to navigation or prominent landmarks were positioned during the survey.

B1. Differential Corrections

Real-time primary positioning for this survey was achieved with an Applanix Position and Orientation System for Marine Vessels (POS/MV) combined inertial and Differential Global

Positioning System (DGPS) using differential corrections obtained from the U.S. Coast Guard (USCG) Maritime DGPS Service. A Trimble ProBeacon receiver, acquiring corrections from the U.S. Coast Guard beacon located at Driver, Virginia (broadcasting at 289 kHz) or Annapolis, MD (broadcasting at 301 kHz) provided differential corrections for both the primary and secondary positioning systems.

The POS/MV was configured to log dual frequency GPS observables during acquisition via the ethernet logging option. All logging groups required for POSPAC processing were recorded. MBES real-time navigation was overwritten with post processed kinematic navigation during data processing.

B2. Positioning System Confidence Checks

In addition to the primary positioning supplied by the POS/ MV, a secondary positioning system consisting of a Trimble DSM 132 DGPS was used during the survey to provide real-time quality control. This system also received DGPS correctors from Driver, Virginia.

A weekly comparison between positions from the primary positioning system (Applanix POS/MV320 version 4, Serial Number 2204) and the secondary positioning system (Trimble DSM 132 DGPS, Serial Number 224094182) was documented while the vessel was stationary in port. After accounting for antenna offsets the greatest computed difference between the two positions was 1.68 meters, which is well within the NOS specification of hydrographic positioning.

A GPS Site Confirmation was performed in accordance with 3.2.2 of the NOS *Hydrographic Surveys Specifications and Deliverables* (April 2007) to evaluate the site for multipath or other site specific problems that would negatively impact generation of GPS correctors from the reference station. Concurrent 24 hour static GPS occupations of MARINA_ROOF and J 458 (PID GV0008) occurred from May 10, 2007 to May 11, 2007 and were processed using the same methodology used to post process MBES navigation data. MARINA_ROOF was used as the reference station and data acquired from J 458 was used as the observation station. A scatter plot of the post processed GPS positions from J458 relative to the published coordinates for this benchmark is included in Appendix 4 *GPS Site Confirmation*. 99.6 percent of all observations are within 1.5 centimeters of the published position of J 458. The site was confirmed as a GPS reference station and was used during kinematic GPS post processing which improved positioning for this project.

C. APPROVAL SHEET

DAVID EVANS AND ASSOCIATES INC.

LETTER OF APPROVAL

OPR-E349-KR-07-DEA
Horizontal and Vertical Control Report

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-E349-KR-07-DEA were conducted under my direct supervision with frequent personal checks of progress and adequacy. This report and associated data have been closely reviewed and are considered complete and adequate as per the OPR-E349-KR-07 *Statement of Work* (February 22, 2007).

Digitally signed by Jon Dasler
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Jonathan L. Dasler, PE (OR), PLS (OR,CA)
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Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
September 2007