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-10**
Contract No	**DG133C08CQ0006**
Task Order No	**T0005**
Time Frame	**July 2010 - November 2010**

LOCALITY

State	**Maryland and Virginia**
General Locality	**Central Chesapeake Bay, MD and VA**

2010

CHIEF OF PARTY

Jonathan L. Dasler, PE (OR), PLS (OR,CA)

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NOAA FORM 77-28
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U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HYDROGRAPHIC TITLE SHEET

REGISTRY No
H12238
H12239
H12240
H12241
H12242

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, MD and VA

Sub-Locality: East of Pt Look-in, Maryland to 3nm SW of Smith Island, Virginia

Scale: 1:10,000 Date of Survey: July 3, 2010 to November 15, 2010

Instructions dated: July 1, 2010 Project No.: OPR-E349-KR-10

Vessel: R/V *Theory* and R/V *Chinook*

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

Surveyed by: David Evans and Associates, Inc.

Soundings by echo sounder, hand lead, pole: RESON 7125, R2Sonic 2042, 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 nautical charts of the assigned area.

SUBCONSULTANTS: Zephyr Marine, P.O. Box 1575, Petersburg, AK 99833

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

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Acronyms and Abbreviations

ARP	Antenna Reference Point
CH	Research Vessel *Chinook*
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Station
CUBE	Combined Uncertainty Bathymetric Estimator
DAA	Design Analysis and Associates, Inc.
DCP	Data Collection Platform
DEA	David Evans and Associates, Inc.
DGPS	Differential Global Positioning System
DN	Julian Day Number
ERS	Ellipsoidal Referenced Survey
GOES	Geostationary Operations Environmental Satellite
GPS	Global Positioning System
HIPS	Hydrographic Information Processing System
HSD	Hydrographic Surveys Division
IAKAR	Inertially Aided Kinematic Ambiguity Resolution
ITRF	International Terrestrial Reference Frame
JOA	John Oswald and Associates, Inc
kHz	kilo Hertz
LMSL	Local Mean Sea Level
MCU	Maximum Cumulative Uncertainty
MHHW	Mean Higher High Water
MHW	Mean High Water
MLLW	Mean Lower Low Water
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NAVO	Naval Oceanographic Office
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NTDE	National Tidal Datum Epoch
NWLON	National Water Level Observation Network
OPUS	Online Positioning User Service
PDOP	Positional Dilution of Precision
POS/MV	Position and Orientation System for Marine Vessels
PPK	Post Processed Kinematic
RMS	Root Mean Square
R/V	Research Vessel

SBET	Smoothed Best Estimate Trajectory
STND	Station Datum
TBYT	Tide by Tide
TH	Research Vessel *Theory*
TPE	Total Propagated Error
TPU	Total Propagated Uncertainty
USCG	U.S. Coast Guard
UTC	Universal Time Coordinated
UTM	Universal Transversal Mercator

OPR-E349-KR-10
Horizontal and Vertical Control Report
Central Chesapeake Bay, Maryland and Virginia
July 2010 – November 2010
R/V *Theory* and R/V *Chinook*
David Evans and Associates, Inc.
Lead Hydrographer, Jonathan L. Dasler, P.E., P.L.S.
ACSM/THSOA Certified Inshore Hydrographer

INTRODUCTION

This report applies to surveys H12238, H12239, H12240, H12241, and H12242 located on the Central Chesapeake Bay in Maryland and Virginia. These contract surveys were performed by David Evans and Associates, Inc. (DEA) under project *OPR-E349-KR-10 Central Chesapeake Bay, Maryland and Virginia* as specified in the *Statement of Work* dated April 2010 and Task Order Number 0005 dated June 23, 2010. All survey methods meet or exceed requirements as defined in the National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables (April 2010)*. On October 26, 2010, DEA was directed to use Ellipsoidal Referenced Survey (ERS) methods for the reduction of survey data to chart datum via a signed memo from the Chief, Hydrographic Surveys Division (HSD). Approval of these methods was granted based on recommendations included with DEA's interim deliverables (submitted September 23, 2010) for the ERS/VDatum/Tide Buoy Validation components of OPR-E349-KR-10 specified in the *Hydrographic Survey Project Instructions* (July 2010). A copy of this memo is included in Appendix V *Supplemental Records and Correspondence* of each survey's *Descriptive Report*.

This Horizontal and Vertical Control Report outlines the methodology for collecting and applying Global Positioning System (GPS) water level correctors and the results obtained during project OPR-E349-KR-10.

A. HORIZONTAL CONTROL

The horizontal datum for this project is the North American Datum of 1983 with the Continuously Operating Reference Stations 1996, Epoch 2002 adjustment North American Datum of 1983 (NAD83 (CORS96, Epoch 2002)). Position data consists of both geographic coordinates and projected coordinates. Projected coordinates are in meters using the Universal Transverse Mercator (UTM) Zone 18 projection. All horizontal positioning for soundings followed the *OPR-E349-KR-10 Statement of Work (April 2010)* and the NOS *Hydrographic Surveys Specifications and Deliverables (April 2010*).

Differential Global Positioning System (DGPS) was used for real-time survey navigation. DGPS was acquired during survey acquisition by a primary Applanix Position and Orientation System for Marine Vessels (POS/MV) and a secondary (Trimble DSM 132) navigation device acquired for quality control purposes. A Trimble Pro Beacon or CSI Wireless MBX-3S receivers were used to receive DGPS corrections from the U.S. Coast Guard (USCG) beacon at Annapolis,

Maryland (301 kHz) or from the secondary beacon at Driver, Virginia (289 kHz). Some DGPS outages from the primary beacon occurred during survey operations. The system was set up to automatically switch to the secondary beacon when the primary signal was lost.

To improve horizontal and vertical positioning, Applanix POS-Pac-MMS software (version 5.2.3317.24501) was implemented during post processing to produced a Smoothed Best Estimate Trajectory (SBET) using an Inertially Aided Kinematic Ambiguity Resolution (IAKAR) navigation solution relative to NAD83 (CORS96, Epoch 2002). The Applanix POS-Pac-MMS Smart Base or Single Base processing methods were used to produce the SBET during the course of the project. To implement the Smart Base method, seven existing Continuously Operating Reference Stations (CORS) were strategically selected to encompass the survey area. To improve the Smart Base network and to use as potential Single Base solutions, two additional temporary GPS base stations were established using the Online Positioning Users Service (OPUS) provided by The National Geodetic Survey (NGS). The temporary stations were designated AIRD and EWELL and were strategically located near the project site in order to meet the 20-kilometer maximum baseline length for Single Base processing method and to augment the Smart Base network in the event that the existing CORS sites failed.

Base Station AIRD was located in Airedale, Maryland near the northwest corner of the project area and EWELL was located in Ewell, Maryland on Smith Island near the southeast corner of the project site. The temporary base stations were established using Trimble Net-R5 GPS dual frequency (L1/L2) receivers with Trimble Zephyr Geodetic GPS antennas. Each station was selected to provide a clear satellite visibility with the GPS antennas installed on a rigid steel pole securely attached to a structure. Table 1 lists the GPS base station equipment used on the project.

Table 1. GPS Base Station Equipment

GPS Base Station Equipment					
Item/ Manufacturer	**Model**	**P/N**	**S/N**	**Antenna Type**	**Firmware Version**
Receiver					
Trimble	NetR5	62800-10	4750K11594		4.14
Trimble	NetR5	62800-10	4750K11589		4.03
Antenna					
Trimble	Zephyr-Geodetic	41249-00	12338039	TRM41249.00	
Trimble	Zephyr-Geodetic	41249-00	12237025	TRM41249.00	

The coordinates were derived at each site from the GPS receiver logging one second epochs for a 24-hour static occupation. The data files recorded at each site were submitted to NGS for an OPUS derived position. The solutions derived from OPUS were processed using a rapid GPS ephemeris and all solutions were in accordance with the passing criteria for the solution statistics established in the National Oceanic and Atmospheric Administration (NOAA) publication *User's Guide for GPS Observations at Tide and Water Level Station Benchmarks (March 2009).* The coordinates for each site were derived at the Antenna Reference Point (ARP) of the Trimble Zephyr Geodetic Antennas. The coordinates derived from the OPUS solutions and used for the project are referenced to NAD83 (CORS96, Epoch 2002) as shown in Figure 1 and Tables 2 and 4. Table 3 shows the primary and control stations used for each survey.

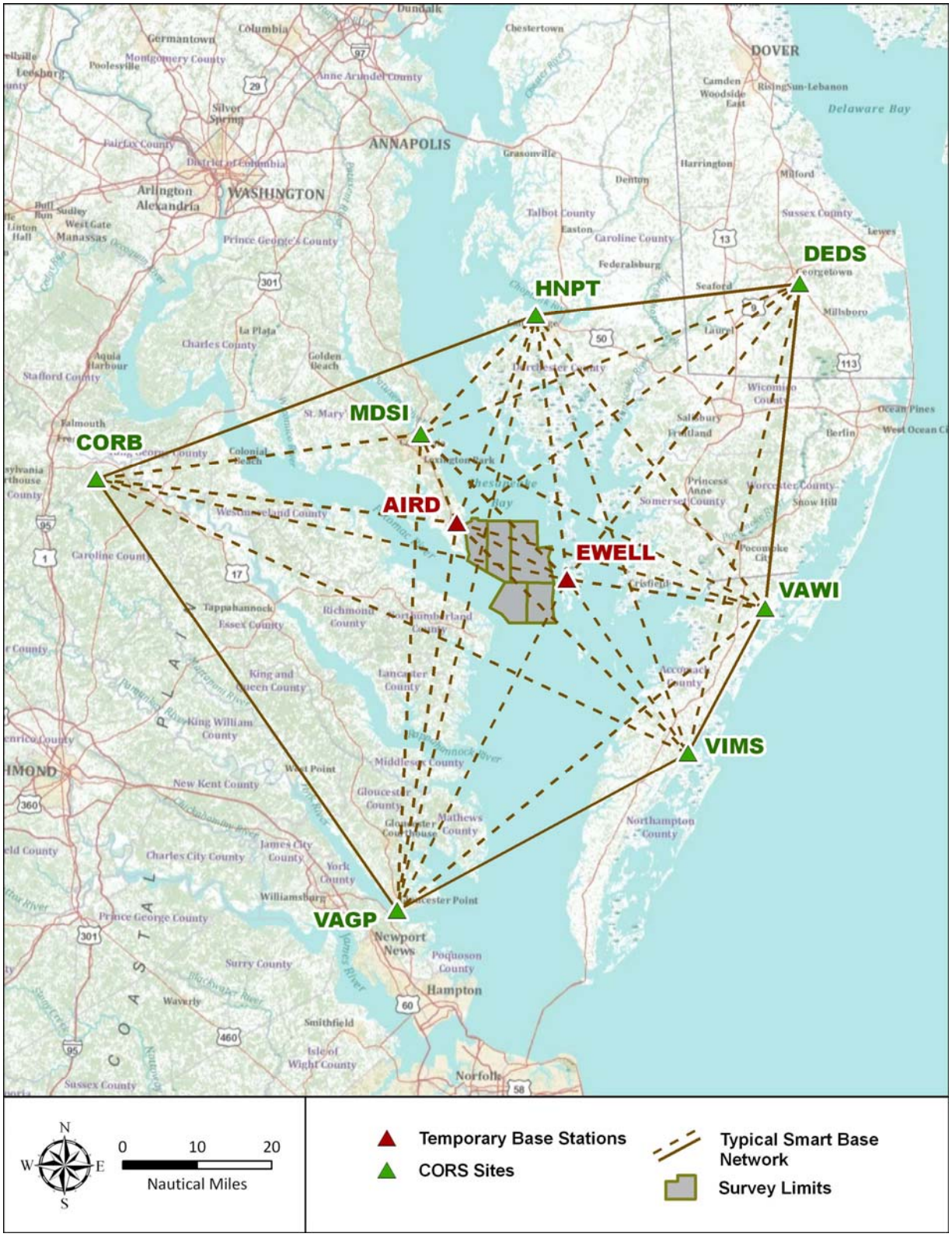


Figure 1. CORS and Temporary Base Stations used for OPR-E349-KR-10

Table 2. Antenna Reference Point (ARP) Station Coordinates

Coordinates NAD83 (CORS96, Epoch 2002) ARP (24 Hour OPUS Solution)			
Temporary Station	**Latitude**	**Longitude**	**Ellipsoid Height (m)**
AIRD	38-07-10.22946 N	76-20-53.79559 W	-22.567
EWELL	37-59-46.25232 N	76-01-59.09814 W	-31.911

Table 1. Stations Used as Primary and Control during Base Processing for Each Survey

Base Processing Primary and Control Stations		
Survey	**Control**	**Primary**
H12238	MSDI, AIRD	MDSI, AIRD
H12239	MSDI, AIRD	MDSI, VAWI, HNTP, AIRD
H12240	MDSI, AIRD	MDSI, AIRD, VAWI
H12241	MDSI, EWELL, AIRD	MDSI, EWELL, AIRD
H12242	MDSI, EWELL, AIRD	MDSI, EWELL, AIRD

GPS base stations are documented in Appendix IV *GPS Base Stations* and include: GPS base station position summary; a GPS base station network map; a map of temporary base station locations; temporary base station observation logs, site sketch, sky plot, OPUS solution report, 24-hour site verification and weekly base station check; and CORS station NGS data sheets.

Control and primary stations were selected based on proximity to the survey area. If stations exhibited bad positional accuracy or estimates and/or failed validation due to high Root Mean Square (RMS) values from high Positional Dilution of Precision (PDOP) or satellite constellations, data from these stations were disabled and the primary network was reexamined. There were times when network processing provided erroneous SBET solutions which were typically noted by high RMS values or unstable height solutions. These sessions were reprocessed using the ‘single base’ option. To keep single base solution lengths less than 20 kilometers, the base station located closest to the survey area was used to improve accuracies.

To track each vessel SBET solution, vessel data was given a two letter identifier where TH indicated the R/V *Theory* and CH indicated the R/V *Chinook*. Navigation and attitude data were post-processed using Applanix POSPac MMS software version 5.2.3317.24501 Service Pack 1, which produced an IAKAR navigation solution relative to NAD83 (CORS96, Epoch 2002). The bulk of the SBET solutions were post-processed using the Applanix SmartBase (ASB) base

station option. The exception is Julian day numbers (DNs) 208_TH, 210_TH, 218_CH, 229_TH, 237_CH, 238_CH, 260_TH, 296_TH, 307_TH, and 317_TH, which were post-processed using the Single Base Station option due to an erroneous new work solution,. The reference station network used during Smart Base processing relied on ARP coordinates from DEA installed temporary base stations and NGS CORS stations. OPUS derived DEA temporary base station positions are listed in Table 2. The published NGS coordinates of the sites used during processing are listed in Table 4.

Table 4. CORS Base Stations Used During Smart Base Processing

CORS Base Stations	Coordinates NAD83(CORS96, Epoch 2002) ARP		
	Latitude	Longitude	Ellipsoid Height (m)
VIMS	37-36-30.04548 N	75-41-13.20712 W	-27.739
MDSI	38-19-08.07256 N	76-27-13.95583 W	-16.774
HNPT	38-35-19.71067 N	76-07-49.33296 W	-26.645
VAGP	37-14-55.00860 N	76-29-57.73125 W	-19.809
VAWI	37-56-03.49983 N	75-28-15.94949 W	-22.315
CORB	38-12-07.82819 N	77-22-24.57106 W	37.252
DEDS	38-39-52.29188 N	75-22-38.75868 W	-12.428

The real-time sensor data logged during acquisition was overwritten with a post-processed IAKAR solution. The HIPS Load Attitude and Navigation tool was used to load position, heading, height and attitude data from an SBET file created by Applanix POSPac. Post-processed uncertainty estimates for position, height, attitude, and heading were applied using the HIPS Load Error Tool and used during the calculation of total propagated error (TPE).

A1. Differential Corrections

Real-time primary positioning for this survey was achieved with a POS/MV combined inertial and DGPS using differential corrections obtained from the USCG Maritime DGPS Service. CSI-Wireless MBX-3S receivers acquired corrections from the USCG beacons located in Driver, Virginia (289 kHz) or Annapolis, Maryland (301 kHz) which provided differential corrections to both the primary and secondary positioning systems on each vessel.

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.

Multibeam real-time navigation was overwritten with post processed kinematic navigation during data processing.

A2. Positioning System Confidence Checks

The real-time positioning system aboard both survey vessels for this task order was an Applanix POS/MV-320 (Version 5.01) supplied with differential correctors from USCG beacons in Annapolis, Maryland and Driver, Virginia. The final positioning solution was derived from the POSPac SBET solution and was applied in Caris HIPS. For real-time quality control, a secondary DGPS positioning system (Trimble DSM132) was monitored in Hypack software.

A weekly comparison between positions from the primary DGPS and the secondary DGPS positioning systems of each research vessel was documented while the vessel was stationary in port. After accounting for antenna offsets the greatest computed difference between the two positions was 0.80 meters for the *R/V Theory* and 0.61 meters for the *R/V Chinook*, which are well within the NOS specification of hydrographic positioning.

The final positioning solution was derived from the POSPac SBET solution and was applied in Caris HIPS. As an additional confidence check, the POSPac NAVDIFF function was used to compare the post-processed SBET solution to the real-time differential navigation solution for all daily post-processing sessions. No blunders or systematic errors were discovered during this review process. This process also served to validate GPS base station positions.

B. VERTICAL CONTROL

The chart datum for this project is Mean Lower Low Water (MLLW) for depths and Mean High Water (MHW) for heights. All soundings are referenced to MLLW. All data (tidal, position, attitude, sonar, survey logs, etc.) were time tagged using Coordinated Universal Time (UTC).

Sounding reduction to MLLW was achieved by collecting GPS data on the survey vessel that would accurately determine the height relative to the NAD83 ellipsoid. The NAD83 ellipsoidal heights were then adjusted to MLLW using a composite separation model constructed using VDatum.

The estimated uncertainty of the ellipsoid to MLLW separation model was computed from the values published on the VDatum website. This estimate is the cumulative uncertainty of the source data and transformation uncertainties required to convert a NAD83 ellipsoid height to MLLW using VDatum. The published Maximum Cumulative Uncertainty (MCU) value for the Chesapeake Bay region file (Version 01) was computed using a transformation from ITRF to MLLW. The MCU is based on the maximum of the tidal datum uncertainties, which in the Chesapeake Bay region are the MLLW and mean higher high water (MHHW) datums, with an uncertainty of 3.1 centimeters. The resulting published MCU is 10.2 centimeters, which is inclusive of the uncertainty in the transformation between ITRF and NAD83. Removing the ITRF to NAD83 transformation uncertainty yields an MCU of 10.0 centimeters. This value was applied to the data as a tidal zoning error during the computation of Total Propagated Uncertainty (TPU).

Table 5 lists the source and transformation uncertainty values used to compute the total model uncertainty for the Chesapeake Bay region file.

Table 5. Estimated VDatum Model Uncertainty

Maryland - Virginia - Chesapeake Bay (Version 01)	
Transformation Uncertainty	1-Sigma (cm)
NAD83 to NAVD88	5.0
NAVD88 to LMSL	5.6
LMSL to MLLW	3.1
Total Transformation Uncertainty	*8.12*
Source Uncertainty	
NAD83	2.0
NAVD88	5.0
LMSL	1.6
MLLW	1.6
Total Source Uncertainty	*5.84*
MODEL Uncertainty	10.0

B1. Tide and Water Level Corrections

For OPR-E349-KR-10 absolute vertical positioning was used to overcome the limitations of discrete zoning, static draft and dynamic draft. The processing methodology discussed in the Horizontal Control component of this report was also used to determine accurate heights using dual-frequency GPS and IAKAR solutions to bridge the measurement gap between the heave and the water level gauge by use of ellipsoid heights. The effects of dynamic draft and changes in static draft can also be mitigated as the GPS is a fixed distance from the sonar acoustic center and vertical effects of these parameters are directly measured with GPS and inertial observations.

The basic components that make up the vertical measurement in hydrographic surveys relative to the ellipsoid are illustrated in Figure 2. This illustration shows the relationship of the GPS antenna to the water line, the separation model between the ellipsoid and chart datum, the chart datum, the reference ellipsoid and the seafloor. Actual measurements for each vessel may be found in *OPR-E349-KR-10 Data Acquisition and Processing Report.*

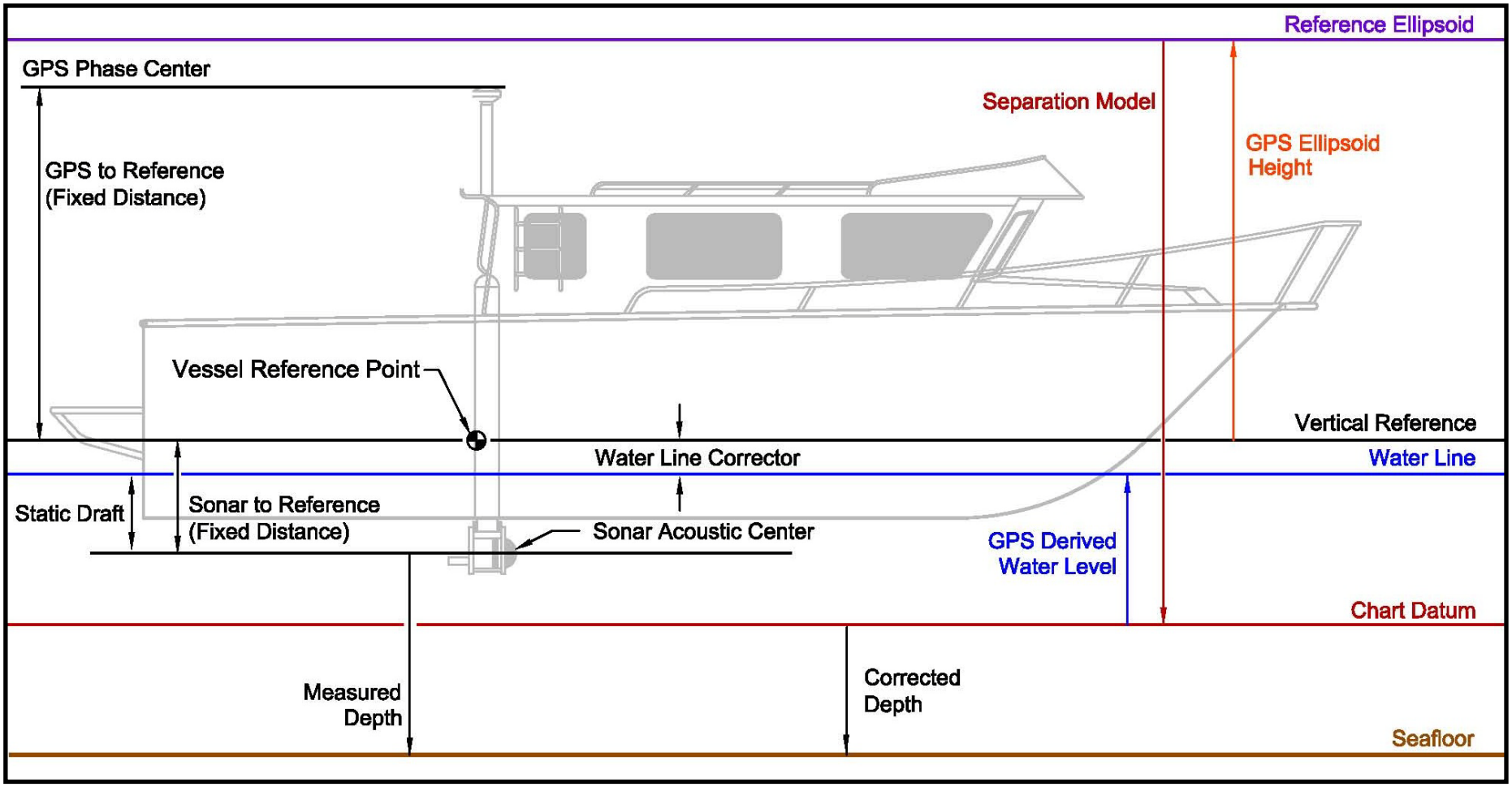


Figure 2. Vertical Components of Hydrographic Surveying Relative to the Ellipsoid

The real-time sensor data logged during acquisition was overwritten with a post-processed IAKAR solution. The HIPS Load Attitude and Navigation tool was used to load position, heading, height and attitude data from a SBET file created by Applanix POSPac software using methods described in the Horizontal Control section of this report. Post-processed uncertainty estimates for position, height, attitude, and heading were applied using the HIPS Load Error Tool and used during the calculation of TPU.

For all surveys, the NAD83 ellipsoid to MLLW separation model file, *Potomac.bin*, was used to reduce ellipsoid height measurements to MLLW. The model file, which has been included with each survey's digital deliverables, was generated by DEA specifically for this project. When the model file was used in the tide reduction process in CARIS HIPS for surveys H12238, H12239, and H12240 it was inadvertently misspelled. A query of the GPS Tide Datum in HIPS will show the file *Potamic.bin*.

Data processing followed the typical Caris HIPS CUBE (Combined Uncertainty Bathymetric Estimator) workflow with integration of SBET data through the HIPS load Attitude and Navigation tool. GPS water levels from the POSPac SBET solutions were computed using the HIPS Compute GPS Tide dialogue. During this step the NAD83 to MLLW model file was selected as well as options necessary to apply HIPS water line offsets and to remove heave and dynamic draft from the GPS signal. During the HIPS Merge process GPS Tides were applied and the waterline, heave, and dynamic draft correctors applied during the GPS tide computation were backed out. With all correctors applied, depths were reduced to MLLW.

B2. NWLON Stations and VDatum Validation

The active National Water Level Observation Network (NWLON) station at Lewisetta, Virginia (863-5750) is the reference station for this project. The Lewisetta NWLON station has 19 years of observation over the full 1983-2001 Tidal Epoch which is presently the National Tidal Datum Epoch (NTDE) used for nautical charting. As such, the station serves as the control station for tide by tide datum computations for subordinate gauging sites for this project and is the reference station for tidal zoning provided by Center for Operational Oceanographic Products and Services (CO-OPS) for project OPR-E349-KR-10. Further, the primary tidal bench mark is part of an NGS leveling network for which North American Vertical Datum of 1988 (NAVD88) elevations are published and is a cornerstone for the development of NOAA's VDatum separation model for the project area. To ensure that this station is operating within expected accuracies, and to evaluate VDatum validation methods, this site was selected for a battery of observations made by DEA field crews. Data collected at the Lewisetta site is idealized for tidal zoning (i.e. no zone correctors need to be applied to direct gauge observations) and less favorable to GPS observations (i.e. 18 kilometers from the nearest GPS reference station).

As part of the GPS water level quality assurance procedures, a one-hour vessel float observation was acquired adjacent to the Lewisetta tide station. GPS data acquired during the vessel float observation was logged and processed using the combined separation model generated from VDatum which incorporates MLLW to Local Mean Sea level (LMSL), LMSL to NAVD88, and the GEOID09 model for NAVD88 to NAD83 ellipsoid heights. The resulting water elevations on MLLW were then compared to the verified NWLON station values logged at the same time by

CO-OPS. The vessel measurements were averaged over 3-minutes using the same interval as the NWLON gauge for direct comparison.

The mean float observation was 4.7 centimeters below CO-OPS observed water levels at Lewisetta (Table 6). Checks of the GPS phase center height confirmed correct values were being used and GPS derived water elevations were valid.

Table 6. Lewisetta, VA (863-5750) GPS to NWLON Water Levels Comparison

Lewisetta, VA (863-5750), August 31, 2010			
Time (UTC)	GPS Waterlevel (VDATUM MLLW m)	Gauge Water Level (CO-OPS MLLW m)	Difference (m)
21:24	0.479	0.523	-0.044
21:30	0.478	0.529	-0.057
21:36	0.494	0.535	-0.041
21:42	0.488	0.540	-0.052
21:48	0.487	0.544	-0.057
21:54	0.484	0.549	-0.065
22:00	0.505	0.553	-0.048
22:06	0.506	0.557	-0.051
22:12	0.516	0.561	-0.045
22:18	0.545	0.564	-0.019
		Mean	-0.047
		Standard Deviation	0.012

To confirm water levels posted by CO-OPS matched published tidal bench marks, manual water level observations (staff shots) were made to validate the gauge performance relative to the bench marks. This was accomplished by leveling from a tidal bench mark to the water surface at the even six-minute interval for one hour. To ensure the stability of the mark, it was included in a 3rd order level loop with two other marks, including the primary bench mark. A summary of the staff shot results is presented in Table 7, while the complete forms and level abstracts are included in Appendix A *NWLON Staff Shots and Levels.* Figure 4 shows the combined staff shot and vessel float plot.

Table 7 also indicates the mean staff observation was 1.2 centimeters below CO-OPS observed water levels at Lewisetta. This observation documents that the NWLON site was reporting water levels 1.2 centimeters higher than the published tidal bench marks that reference tidal datum at the site and reduces the observed difference from the GPS float observation from 4.7 centimeters to 3.5 centimeters.

Table 7. Lewisetta, VA (863-5750) Staff Shots to NWLON Water Levels Comparison

Lewisetta, VA (863-5750), August 31, 2010 (CO-OPS MLLW)			
Time (UTC)	Manual Water Level (m)	Gauge Water level (m)	Difference (m)
21:24	0.515	0.523	-0.008
21:30	0.521	0.529	-0.008
21:36	0.522	0.535	-0.013
21:42	0.527	0.54	-0.013
21:48	0.532	0.544	-0.012
21:54	0.537	0.549	-0.012
22:00	0.542	0.553	-0.011
22:06	0.542	0.557	-0.015
22:12	0.546	0.561	-0.015
22:18	0.552	0.564	-0.012
		Mean	-0.012
		Standard Deviation	0.002

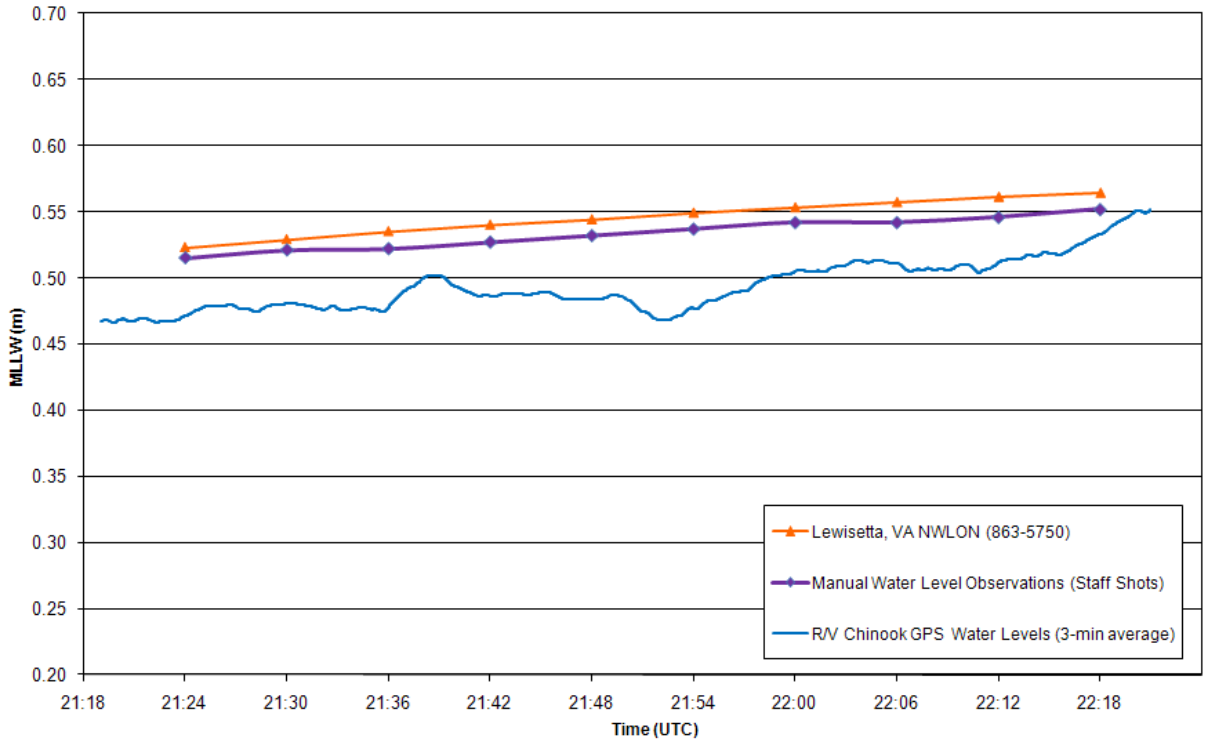


Figure 3. Lewisetta Water Level Observation Comparison on August 31, 2010

To evaluate the difference between NGS level runs and the GEOID09 separation model from the NAD83 ellipsoid, static GPS observations on the primary tidal bench mark R 462 (PID GV0156) were collected. The four hour GPS observation data were processed using OPUS after precise ephemeris files were available to be consistent with other project control comparisons. The derived NAVD88 orthometric height was compared to the NGS published NAVD88 elevation derived from First Order Class I level runs (Table 8.). Complete field notes and OPUS results are included in Appendix V *NWLON Verification Results.* The GPS data was collected to meet the guidelines established in the *User's Guide for GPS Observations at Tide and Water Level Station Benchmarks (March 2009).* Data was submitted to OPUS after the precise ephemeris files were available.

Table 8. Published NAVD88 Elevations Compared to GPS Survey Results

CO-OPS Site	Benchmark	NGS Adjusted NAVD88 Height (m)	GPS Derived NAVD88 GEOID09 (m)
Lewisetta (863-5750)	R 462	1.169	1.154

CO-OPS MLLW and NGS NAVD88 published data for the primary bench mark R 462 at Lewisetta show some disagreement when converted to the same datum planes using the VDatum GEOID09 model (Table 8 and Figure 5). At Lewisetta, the difference between the NGS published (derived from adjusted First Order Class 1 level observations) NAVD88 orthometric height and the GPS derived height using GEOID09 is 1.5 centimeters. Using the VDatum model to obtain MLLW increases the difference between the CO-OPS MLLW datum and the derived VDatum MLLW to 2.2 centimeters (Table 9). Based on these observations one can infer relative model accuracies of 1.5 centimeters in the GEOID09 model and 0.7 centimeters accuracy in the combined MLLW to LMSL and LMSL to NAVD88 models at Lewisetta.

Table 9. Datum Plane Comparison

Lewisetta (863-5750) Benchmark R 462 (PBM)	
Reference Datum	**Meters**
MLLW (CO-OPS)	1.420
MLLW (VDatum GEOID09)	1.398
VDatum Difference to MLLW	**-0.022**
NAVD88 (NGS Adjusted)	1.169
NAVD88 (GEOID09)	1.154
VDatum GEOID09 Difference to NAVD88	**-0.015**
NAD83 (CORS96, 2002 Epoch)	-33.734

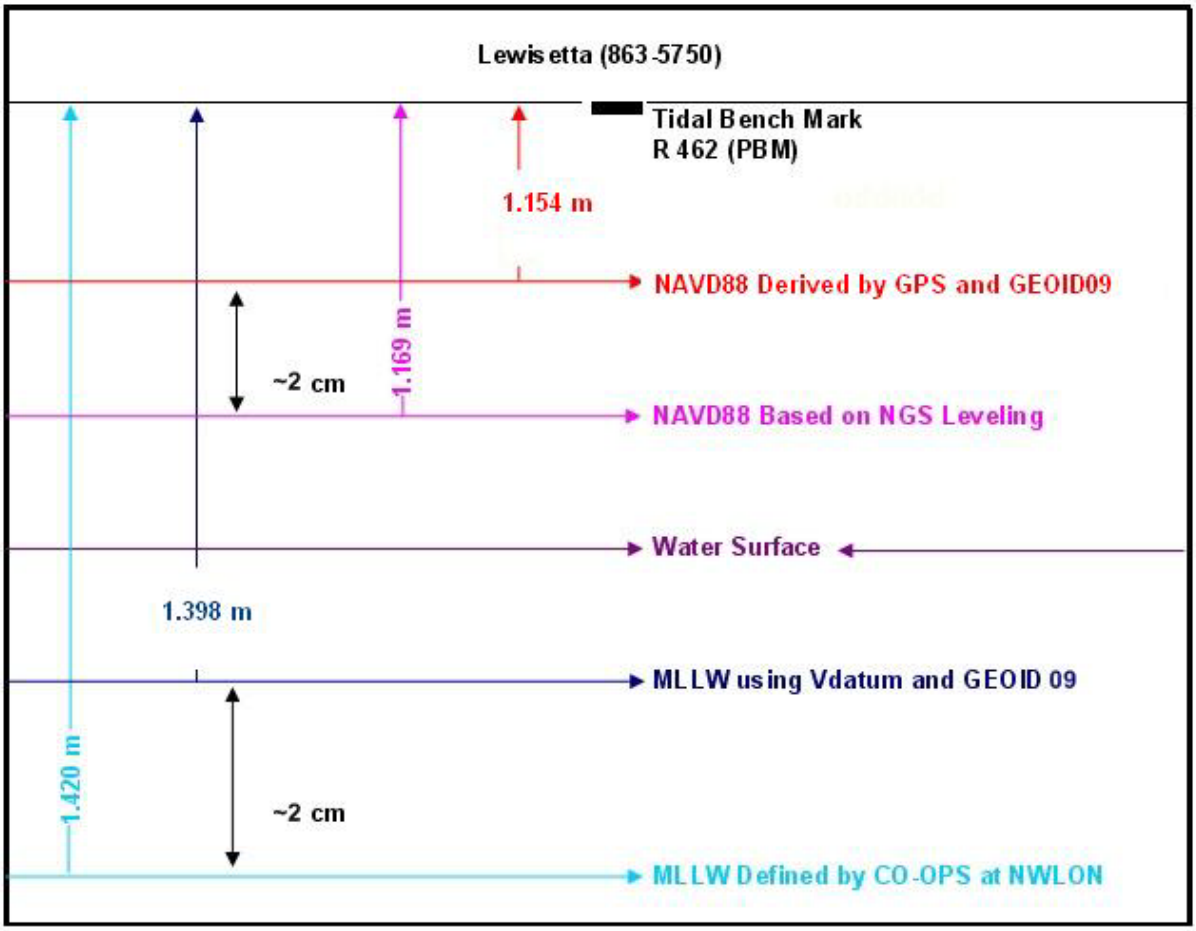


Figure 4. Lewisetta Datum Comparison

The mean vessel GPS observations corrected to the waterline were 4.7 centimeters below the NWLON station readings (Table 6) and 3.5 centimeters after correcting NWLON readings to tidal bench marks. The direction of the error is consistent with the GEOID09 separation model as shown in the datum comparison in Figure 5. The differences observed are mostly likely a combination of the expected uncertainty in the GPS measurements and the GEOID model accuracy with a relatively minor uncertainty of 0.7 centimeters in the combined models of MLLW to Local Means Sea Level (LMSL) and LMSL to NAVD88 at Lewisetta. VDatum uses the GEOID09 model to determine NAVD88 orthometric heights rather than the published NAVD88 elevations from level runs. Use of GPS observations and GEOID models for obtaining orthometric heights is widely accepted in the survey community and differences are within expected tolerances of both GEOID models and GPS observations. From these cumulative results, water level observations determined by the NWLON station at Lewisetta as well as methods used to determine GPS water levels aboard the survey platform are within expected uncertainties and are valid for comparison purposes.

The Tide and Water Level Data and Predicted Tidal Zoning requirements in the *Project Letter Instructions* specified that the operating NWLON station at Lewisetta, VA (863-5750) provide datum control for the tertiary station Ewell, Smith Island, MD (857-1117).

B3. Subordinate Tide Station and VDatum Validation

As specified in the OPR-E349-KR-10 *Statement of Work*, a tertiary station was established at Ewell, Smith Island, MD (857-1117) which provided water level correctors for the project as well as information on tidal datums, zoning refinement and harmonic constituents for tide predictions. The station was last occupied in 1997. DEA worked jointly with John Oswald and Associates, Inc. (JOA) to install DEA's Aquatrak acoustic primary gauge with a redundant water level sensor to collect data for datum determination and possible sounding reduction. Complete details of the installation were submitted to CO-OPS in the Installation Report dated July 28, 2010. A summary of gauge equipment is listed in Table 10. The station was operated from July 1, 2010 (DN 182) to November 14, 2010 (DN318). The station Closeout Report was submitted to CO-OPS on December 16, 2010.

Table 10. Ewell, Smith Island, Maryland Installation Sensors

Gauges	Sensor	Serial Number	Data Logger	Radio
Gauge # 1	Aquatrak 3000 in 4" stilling well	1654-3880	Sutron Xlite 9210B DCP	GOES
Gauge # 2	DAA H3611i Radar Gauge	2105	Steven's DL3000 Replaced with Sutron Xlite on DN191 due to malfunction	Steven's GHT GOES

The gauge systems were powered by 12 Volt batteries supplied with 1 Amp AC trickle chargers with 40 Watt solar panels for recharging. Separate GPS modules provided time syncing for each gauge. At the time of establishment, a vitrified staff was installed for water level observations.

Four (4) of five associated benchmarks were recovered and one benchmark was established. 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 sensor leveling points were measured 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*. GPS observations were submitted to NGS for processing and publication through the OPUS. Table 11 summarizes the primary benchmark OPUS solution.

Table 11. Static GPS Survey of Primary Bench Mark

Station	Bench Mark	NAVD88 Elevation	NAD83 Geographic Coordinates	
			Latitude	Longitude
Ewell, Smith Island, MD	857 1117 TIDAL 2	0.565 m	37-59-45.81671 N	76-01-58.89598 W

Detailed information pertaining to bench mark descriptions, opening and closing levels runs, staff-to-gauge observations, and datum determination are included in the station reports submitted to CO-OPS by DEA.

To compare the results to the published historic datum and VDatum values, the elevation of the primary bench mark was used (857 1117 TIDAL 2). The result from the project datum computation is 3.1 centimeters lower than the published CO-OPS datum from 1997 that was based on 3 months of data. The historic datum planes were computed using the Solomons Island, MD (857-7330) gauge as the control station.

To compare the VDatum model to the project datum computed from observed water levels, the ellipsoid height of the primary bench mark determined by static GPS observations during the installation was input to the VDatum software and the MLLW elevation was computed. It was found that the VDatum determined MLLW elevation was 9.2 centimeters below the MLLW datum computed from the observed water levels for this project (Table 12).

Table 12. Ewell, Smith Island MLLW Datum Plane Comparison

Ewell, Smith Is. MD (857-1117)	
Bench Mark	8571117 TIDAL 2 (PBM)
MLLW (Project Datum from Observations)	0.983 m
MLLW (CO-OPS Published)	0.952 m
Difference from CO-OPS	**-0.031 m**
MLLW (VDatum GEOID09)	0.891 m
Difference from VDatum	**-0.092 m**
NAD83 (CORS96, 2002 Epoch)	-35.345 m

To compare the gauge results with GPS water levels, vessel float observations were acquired adjacent to the tertiary gauge at Ewell during maintenance visits. GPS data acquired during the vessel float observations were logged and processed using the combined separation model generated from the VDatum model and GEOID09. The resulting water elevations on MLLW were then compared to the tertiary gauge measured values on MLLW. The vessel measurements were averaged using the same interval as the gauge. The average difference between the two methodologies was 7.9 centimeters with a standard deviation of 1.4 centimeters (Table 13).

Table 13. Ewell, Smith Island MD (857-1117) GPS to Tertiary Water Levels Comparison

Ewell, Smith Island, MD (857-1117), September 2, 2010			
Time (UTC)	GPS Water Level (VDATUM MLLW m)	Gauge Water Level (MLLW m)	Difference (m)
12:48	0.554	0.625	-0.071
12:54	0.546	0.619	-0.073
13:00	0.533	0.61	-0.077
13:06	0.540	0.601	-0.061
13:12	0.487	0.594	-0.107
13:18	0.491	0.581	-0.090
13:24	0.502	0.574	-0.072
13:30	0.481	0.567	-0.086
		Mean	-0.079
		Standard Deviation	0.014

The direction of the difference is consistent with the differences observed by static GPS at the primary bench mark. These observations suggest that the MLLW datum determined using the VDatum model is approximately 9 centimeters higher than the MLLW datum computed from water level observations. It should be noted that the gauging site at Ewell is in a narrow waterway inside Smith Island.

The mean float observation was 7.9 centimeters below observed water levels at Ewell (Table 14). Checks of the GPS phase center height confirmed correct values were being used and GPS derived water elevations were valid. A summary of all float results at Ewell are included in Table 14, with detailed results included in Appendix VI *Tertiary Gauge Results*.

Table 14. Summary of Vessel Float Results

Vessel	Day	Duration	Mean Float Difference [vessel minus gauge] (m)	Weather
Chinook	245	00:42	-0.079	Sea state = 0 foot waves Wind Speed = calm
Theory	252	01:06	-0.047	Sea state = 3 foot waves Wind Speed = 15 knots

B4. Short Term VDatum Validation Stations

B4.a Radar Gauge at Green Light 1

Figure 5. Radar Gauge and GPS

With approval for installation from the USCG, DEA worked jointly with JOA to install a Design Analysis and Associates, Inc. (DAA) Waterlog H3611 radar gauge. The system consists of an H3611i radar level sensor and an H522+ data collection platform with integrated Geostationary Operations Environmental Satellite (GOES) radio and GPS for signal timing. The entire system is very compact and is powered by a 12 volt sealed lead acid battery charged with a 20W solar panel.

The water level station was established on the platform of navigation aid Green Light "1" marking the western approach to Ewell on Smith Island, Maryland on the east side of the Chesapeake Bay (Table 15). The radar gauge and GPS mounting system are shown in Figure 5. The gauge was configured to log data on even six-minute intervals, with water levels averaged for 181 seconds. To link the station datum to the ellipsoid, a static GPS tie was completed.

The gauge was assigned an arbitrary station number for tracking during this project: 857-0004. This number was not assigned by CO-OPS, and has no meaning outside of the scope of this project.

The gauge was originally installed on July 7, 2010. Shortly after installation, the gauge suffered a hardware fault that lead to the failure of the solar controller. The solar controller regulates the power from the solar panel to charge the battery powering the station. As a result, the battery and components in the GOES transmission system became inoperable. The gauge continued to log data during the day, while the solar panel could generate enough current to run the radar sensor and data collection platform (DCP). However, when the sun dropped the gauge shut down. This problem was repaired on August 7, 2010 and the system was restarted.

Table 15. Radar Gauge Installation Location

Gauge	Latitude	Longitude	Start Date (UTC)	End Date (UTC)
Green 1 (857-0004)	38-00-00.3 N	076-03-22.3 W	08-07-2010 16:00	11-16-2010 13:07

As a part of the GPS water level quality assurance procedures, staff shots were conducted from a measure down point to the water surface and concurrent GPS observations were collected on the survey vessel. The radar gauge's distance measurements are not affected by atmospheric changes or water density variations. As such, site visits were minimal during the occupation.

Table 16 lists the observations and statistics and Figure 6 is a graph of the observations from August 23, 2010.

Table 16. Tabular Results of Green Light 1 Radar Manual Measurements

Green Light 1 Radar Gauge (857-0004), August 23, 2010			
Time (UTC)	Gauge Water Level (STND m)	Measure Down (STND m)	Difference (m)
18:54	-35.719	-35.691	-0.028
19:00	-35.703	-35.701	-0.002
19:06	-35.711	-35.701	-0.010
19:12	-35.730	-35.751	0.021
19:18	-35.738	-35.761	0.023
19:24	-35.735	-35.761	0.026
19:30	-35.75	-35.771	0.021
19:36	-35.761	-35.801	0.040
19:42	-35.789	-35.811	0.022
19:48	-35.800	-35.811	0.011
19:54	-35.794	-35.821	0.027
20:00	-35.813	-35.831	0.018
		Mean	0.014
		Standard Deviation	0.019

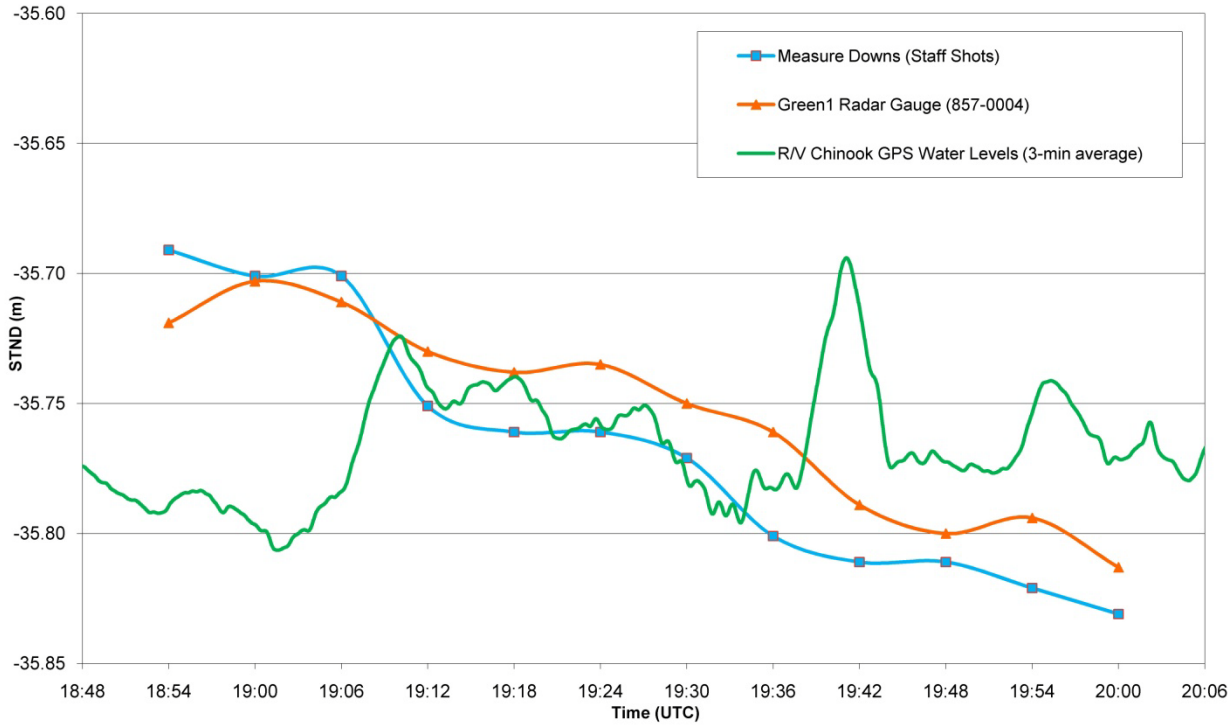


Figure 6. Green Light 1 Radar Gauge and Manual Measurements on August 23, 2010

To compare the gauge results with GPS water levels, a one-hour vessel float observation was acquired adjacent to the radar gauge. GPS data acquired during the vessel float observation was logged and processed using the combined separation model generated from the VDatum model using GEOID09 and compared using the same interval as the radar gauge. The resulting GPS derived water elevations relative to MLLW were then compared to the radar gauge measured values based on the computed datum and using VDatum to convert radar observed water levels relative to NAD83 ellipsoid heights to MLLW (Figure 7). Statistics comparing the vessel GPS water level measurements and data from Green Light 1 radar gauge (857-0004) and the tertiary station Ewell, Smith Island, MD (857-1117) using the MLLW datum are presented in Table 17. Green Light 1 and Ewell, Smith Island gauges fall within the same tide zone (NCB8) which allows direct comparison of water levels without applying zone correctors.

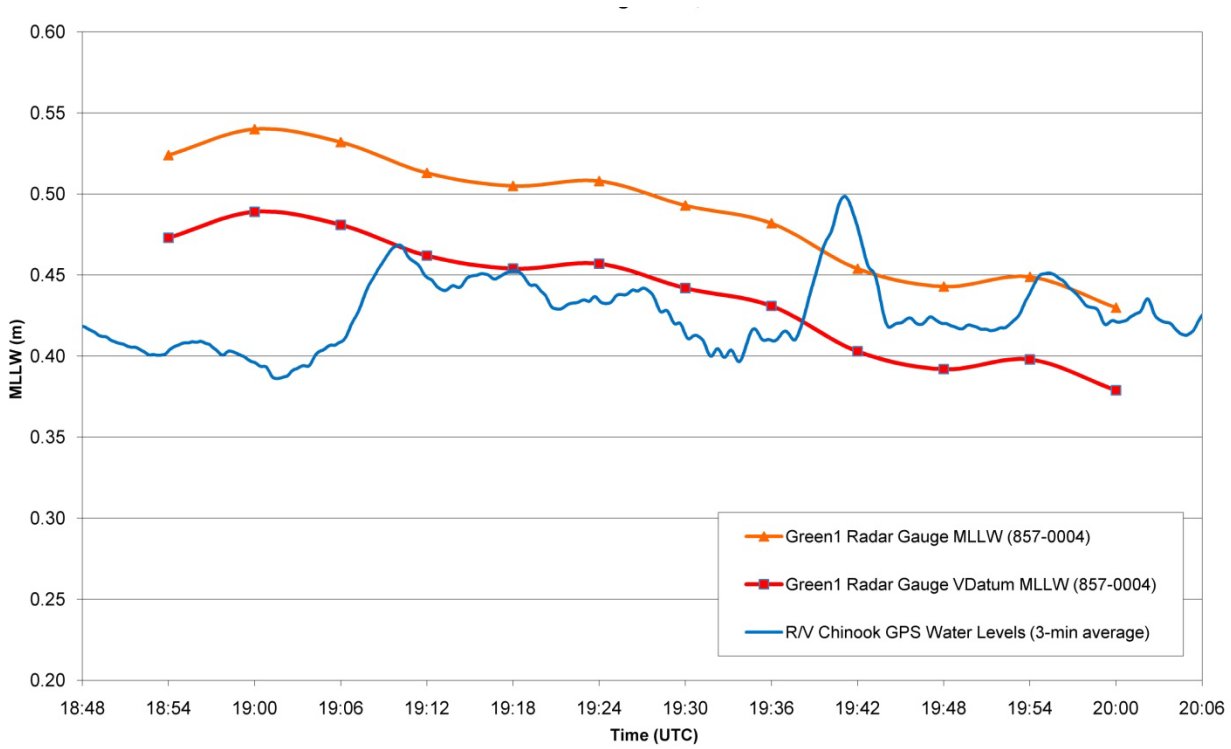


Figure 7. Green Light 1 Radar Gauge Data and Vessel Float Observations

Table 17. Tabular Results of Green Light 1 and Vessel Float Observations

Green Light 1 Radar Gauge (857-0004), August 23, 2010					
Time (UTC)	Vessel GPS Water Level (m)	Radar Water level (m)	Ewell Gauge (m)	Difference to Vessel (m)	Difference to Gauge (m)
18:54	0.409	0.524	0.621	0.115	-0.097
19:00	0.386	0.540	0.613	0.154	-0.073
19:06	0.434	0.532	0.604	0.098	-0.072
19:12	0.442	0.513	0.593	0.071	-0.080
19:18	0.444	0.505	0.584	0.061	-0.079
19:24	0.438	0.508	0.570	0.070	-0.062
19:30	0.404	0.493	0.564	0.089	-0.071
19:36	0.410	0.482	0.555	0.072	-0.073
19:42	0.439	0.454	0.542	0.015	-0.088
19:48	0.418	0.443	0.533	0.025	-0.090
19:54	0.451	0.449	0.524	-0.002	-0.075
20:00	0.427	0.430	0.513	0.003	-0.083
		Mean		0.064	-0.079
		Standard Deviation		0.047	0.010

Additional vessel floats were performed over the course of the project. Results from these checks are summarized in Table 18 with detailed results included in Appendix VII *Radar Gauge Results.*

Table 18. Summary of Vessel Float Results

Vessel	Day	Duration	Radar minus Vessel (m)	Radar minus Ewell (m)	Weather
Chinook	235	1:06	0.064	-0.079	Sea state = 1-2 foot waves Wind Speed = 5-10 knots
Theory	272	2:10	0.031	-0.042	Sea state = 1 foot waves Wind Speed = 10-12 knots
Theory	307	1:13	0.021	-0.064	Sea state = 1 foot waves Wind Speed = 10-15 knots
Theory	318	2:00	0.040	-0.020	Sea state = <1 foot waves Wind Speed = 5 knots

Static GPS data was collected at the sensor to tie the gauge zero to the ellipsoid. This put the station datum (STND) on NAD83 (CORS96, Epoch 2002). Three valid occupations were collected, results shown in Table 19. The final coordinates were computed using a weighted average where the 3 solutions were weighted by their peak-to-peak uncertainties.

Table 19. 857-0004 Radar Gauge at Green Light 1 GPS Observations

857-0004 Radar Gauge Preliminary Station Datum NAD83(CORS96, Epoch 2002)			
Date	Session Length (hours)	Ellipsoid Height (m)	Height Uncertainty (m)
7/15/2010	5:717	-31.979	0.038
9/29/2010	7:117	-31.986	0.061
11/14/2010	8:083	-31.963	0.026
Weighted Mean	-	-31.970	0.042

Results from the OPUS solutions, weighted position computation, manual measure downs, vessel floats and datum computations can be found in Appendix VII *Radar Gauge Results*.

By using this method for STND, the water levels measured by the radar gauge were measured relative to NAD83 ellipsoid heights. The VDatum model was applied to convert the measured readings on STND (NAD83 ellipsoid heights) to the MLLW datum plane.

Datums were computed using the Modified Range Ratio Method. From Table 20, the mean difference between the final MLLW datum and the application of VDatum to the radar observations is 5.1 centimeters. This is consistent and in the same direction as the mean differences between the vessel observed water levels using the VDatum MLLW datum plane, and the gauge observed water level using the final MLLW datum listed in Tables 17 and 18. Results and plots from the datum computations can also be found in Appendix VII *Radar Gauge Results*.

Table 20. Radar Gauge MLLW Datum Plane Comparison

Green Light 1 Radar Gauge (857-0004)	
Datum	STND (NAD83)
MLLW (CO-OPS Published)	N/A
MLLW (Final)	-36.243 m
MLLW (VDatum /GEOID09)	-36.192 m
Difference	**-0.051**

B4.b GPS Tide Buoy

Tidal datum planes were also computed at discrete locations using an AXYS Technologies Inc. Hydro Level Mini GPS Buoy provided by the Naval Oceanographic Office (NAVO). The first deployment was as close to the Lewisetta NWLON gauge as possible, while still maintaining a safe distance from navigation channels, clear view of the GPS constellation and sufficient water depth. The final deployment area selected was approximately 800 meters east of the Lewisetta gauge which is not ideal for direct comparison to the NWLON gauge. The second deployment area selected was situated to the northeast of the survey area and approximately 2300 meters west of Holland Island. The third deployment area was approximately 3800 meters south-southeast of the charted Bombing Area (Hannibal Target) located in the H12242 survey area. Care was taken in the planning of the deployment sites along with consultation with the USCG to ensure sites were selected well outside of any areas of heavy vessel traffic while also providing a good distribution for VDatum model validation. The United States Navy was also consulted on site selection for deployment 3 due to the proximity to the Bombing Area.

Each deployment was assigned an arbitrary station number for tracking purposes during this project. This number was not assigned by CO-OPS, and has no meaning outside of the scope of this project. Table 21 lists the deployment location, dates of operation and duration of deployment.

Table 21. GPS Tide Buoy Deployment Locations and Durations

Deployment	Latitude (N)	Longitude (W)	Start Date (UTC)	End Date (UTC)	Duration (Days)
1 (857-0005)	37/59/39.20	76/27/15.00	07/06/2010 19:50	08/06/2010 21:00	31
2 (857-0006)	38/07/40.49	76/06/56.44	08/08/2010 17:47	09/11/2010 21:50	34
3 (857-0007)	38/00/25.71	76/08/18.01	09/14/2010 13:41	10/18/2010 21:54	34

Raw GPS observables were processed in NovAtel's GrafNav version 8.30 software using Post Processed Kinematic (PPK) techniques. The post-processed navigation solution was then imported into Caris HIPS version 7 for application of tilt data. Resulting water surface elevations were smoothed with a 3rd order Butterworth filter in MATLAB and prepared for datum determinations. Detailed discussion of acquisition and processing methodology can be found in *OPR-E349-KR-10 Central Chesapeake Bay, VA Interim VDatum Report*.

During each deployment and recovery operation with the buoy, GPS data was collected on the survey vessels in the vicinity. Theses floats were designed to serve as a method to verify the accuracy of the post-processed buoy data similar to a staff reading at a conventional tide gauge. Representative results for these floats are displayed in Table 22 and Figure 8.

Table 22. July 6, 2010 Deployment 1 GPS Buoy to GPS Vessel Float and Lewisetta, VA (863-5750) NWLON Water Level Comparison

July 6, 2010 (MLLW)					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water level (m)	Lewisetta Gauge (m)	Difference to Vessel (m)	Difference to Gauge (m)
20:00	0.079	0.145	0.16	0.066	-0.015
20:06	0.105	0.086	0.162	-0.019	-0.076
20:12	0.109	0.086	0.167	-0.022	-0.081
20:18	0.108	0.112	0.172	0.004	-0.060
20:24	0.116	0.095	0.178	-0.021	-0.083
20:30	0.126	0.106	0.184	-0.020	-0.078
20:36	0.146	0.145	0.191	0.000	-0.046
20:42	0.118	0.190	0.198	0.073	-0.008
20:48	0.154	0.204	0.206	0.050	-0.002
20:54	0.142	0.149	0.214	0.008	-0.065
		Mean		0.012	-0.051
		Standard Deviation		0.037	0.032

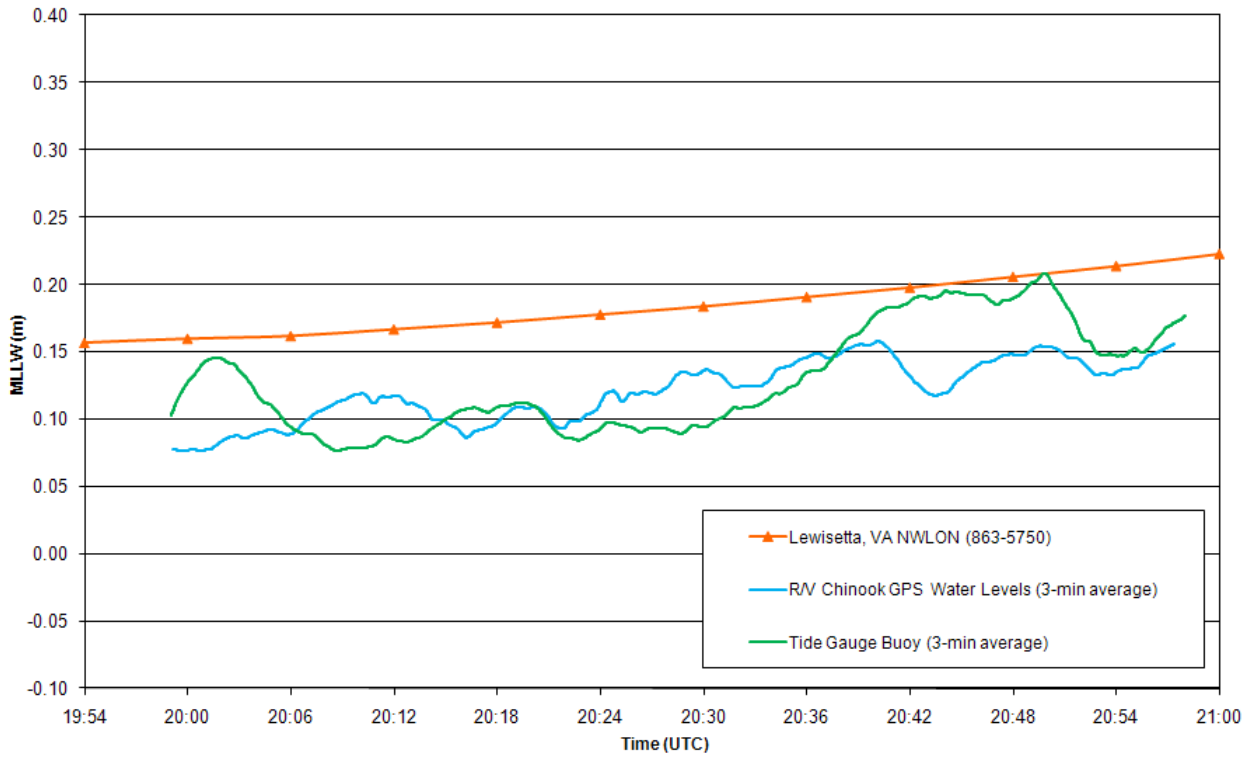


Figure 8. Comparison of Values from the GPS buoy, R/V Chinook Tide Float and Lewisetta Gauge on July 6, 2010

Table 23 summarizes the results of all vessel floats and the sea state at the time of collection. More detailed results are included in Appendix VIII *GPS Buoy Datum Results.*

Table 23. Vessel Float Results

Vessel	Day	Duration	Buoy minus Vessel	Buoy minus Lewisetta*	Buoy Site	Weather
Chinook	187	1:01	0.012	-0.055	1	Sea State = 0 foot waves Wind Speed = 0 knots
Theory	204	1:17	0.039	-0.044	1	Sea State = 0 foot waves Wind Speed = 0 knots
Theory	218	1:23	-0.080	-0.008	1	Sea State = 1 foot waves Wind Speed = 10 knots
Theory	220	1:18	0.041	-0.178	2	Sea State = 0 foot waves Wind Speed = 0 knots
Theory	244	1:13	-0.048	-0.154	2	Sea State = 0 foot waves Wind Speed = 0 knots
Theory	254	1:03	-0.029	-0.190	2	Sea State = 1 foot waves Wind Speed = 5 knots
Theory	257	1:18	-0.051	-0.115	3	Sea State = 2-3 foot waves Wind Speed = 12-15 knots
Theory	272	1:16	-0.017	-0.060	3	Sea State = 1 foot waves Wind Speed = 10-12 knots
Theory	272	0:22	0.023	-0.086	3	Sea State = 1 foot waves Wind Speed = 10-12 knots
Theory	291	1:00	-0.005	-0.071	3	Sea State = 1 foot waves Wind Speed = 5 knots

Buoy Site 1 within 8635750 primary zone (range x0.00, average time 0 min)
Buoy Site 2 within 8635750 zone NCB18 (range x1.21, average time -6 min)
Buoy Site 3 within 8635750 zone NCB9 (range x1.05, average time -30 min)

Datum planes were computed using the ellipsoid height of the water surface, leading to a station datum on NAD83 (CORS96 Epoch 2002).

Note that the results from the first two floats at Buoy #1 (Tables 22 and 23, and Figure 8) show an apparent bias of approximately 4 to 5 centimeters, with the GPS results lower than the gauge readings for both the buoy and the vessel. This is attributable to the difference in the GEOID09 model from the gauge to the buoy location. The buoy was situated as close to the gauge as feasible due to navigation concerns, but was still approximately 800 meters east. The GEOID

model difference of -3.8 centimeters (shown in Table 24 and Figure 9) is coincident in direction and magnitude to the differences between the GPS derived water levels and the gauge derived water levels.

Table 24. GEOID09 Model Separation Values

Location	Latitude	Longitude	NAD83, CORS96 Epoch 2002 -> NAVD88 Separation (m)
Lewisetta, VA NWLON (863-5750)	37/59/43.6 N	76/27/52.8 W	34.885
Deployment 1 (857-0005)	37/59/39.2 N	76/27/15.0 W	34.923
		Difference	-0.038

Figure 9. GEOID09 Model Separation Values in the Vicinity of Deployment 1

The final float observation conducted on August 6, 2010 (DN218) shows a larger height difference when compared to the verified gauge readings than the other floats. Both the buoy and the vessel GPS determined height values deviate from the gauge readings by 10-20 centimeters in some cases. This is most likely caused by an atmospheric event during the time period. Atmospheric effects can be problematic when processing over long baselines. Although the dual frequency single and smart base solutions attempt to correct for variations, any large disturbances in the troposphere or ionosphere cause degradation in positioning accuracy. Local tropospheric disturbances could be caused by such events as thunderstorms while ionospheric variations can be the result of solar activity.

Datums were computed using the TBYT method of simultaneous comparisons using the Lewisetta gauge as the control station.

For Deployment 1 the values for the Lewisetta datum planes (Table 25) were adjusted to the station datum of the GPS buoy (NAD83, CORS96, Epoch 2002) by using the published NAVD88 elevation of STND at Lewisetta. STND at Lewisetta is 1.707 m below NAVD88 (CO-OPS published value). The GEOID09 separation between NAVD88 and the reference ellipsoid at the primary bench mark (R 462) at Lewisetta is -34.888 m. Therefore, the conversion from Lewisetta STND to NAD83, CORS96, Epoch 2002 is -36.595 m.

Table 25. GPS Buoy Deployment 1 (857-0005) Datum Plane Comparison

	GPS Buoy Deployment 1 Datum Planes (m)	Lewisetta, VA Published Datum Planes (m)	Difference (m)
MHHW	-34.765	-34.682	-0.083
MHW	-34.806	-34.725	-0.081
DTL	-35.001	-34.912	-0.089
MTL	-35.004	-34.915	-0.089
MSL	-35.000	-34.910	-0.090
MLW	-35.203	-35.105	-0.098
MLLW	-35.238	-35.141	-0.097
GT	0.473	0.458	0.015
MN	0.397	0.379	0.018
DHQ	0.041	0.043	-0.002
DLQ	0.035	0.036	-0.001

When compared to the VDatum results, the MLLW datum of the Lewisetta station was adjusted by the difference introduced by the GEOID09 model due to the location of the buoy and the NWLON station (Table 23). The preliminary datum computed at the GPS buoy deployment 1 location was 6.4 centimeters below the adjusted Lewisetta MLLW datum plane and 7.1 centimeters below the VDatum model value (Table 26).

Table 26. GPS Buoy Deployment 1 MLLW Datum Plane Comparison

GPS Buoy Deployment 1 (857-0005)	
Datum	**STND (NAD83)**
MLLW (CO-OPS Published at Lewisetta adjusted for GEOID09 difference to buoy location)	-35.174 m
MLLW (TBYT)	-35.238 m
MLLW (VDatum GEOID09)	-35.167 m

Table 27 shows the comparison between the computed MLLW datum using each deployment site's measurements and the VDatum model results for that position. Complete datum plane results can be found in Appendix VIII *GPS Buoy Datum Results*.

Table 27. Computed Datums at Tide Gauge Buoy vs. VDatum Comparison

		MLLW	Difference
Deployment 1 (857-0005)	TBYT	-35.238 m	
	VDatum GEOID09	-35.167 m	-0.071 m
Deployment 2 (857-0006)	TBYT	-36.016 m	
	VDatum GEOID09	-35.943 m	-0.073 m
Deployment 3 (857-0007)	TBYT	-36.142 m	
	VDatum GEOID09	-36.079 m	-0.063 m

Note 1: Datum separation values computed using version 2.2.5 with Maryland - Virginia - Chesapeake Bay, Version 01 area file

Cumulative uncertainty estimates were computed for each of the GPS buoy datum results by using the square root of the sum of the squares of all of the source uncertainties (ellipsoid, measurement, and series length). All of the buoy datum uncertainties fall within the error bounds of the VDatum profile. These values are presented in Table 28 and Figure 10.

Table 28. Uncertainty Estimates for Tide Gauge Buoy Datums

Uncertainty Source	8570005 GPS Buoy Site 1 (m)	8570006 GPS Buoy Site 2 (m)	8570007 GPS Buoy Site 3 (m)
Ellipsoid	0.020	0.020	0.020
Measurement	0.056	0.055	0.053
Data series length	0.042	0.042	0.040
Total	0.073	0.072	0.069

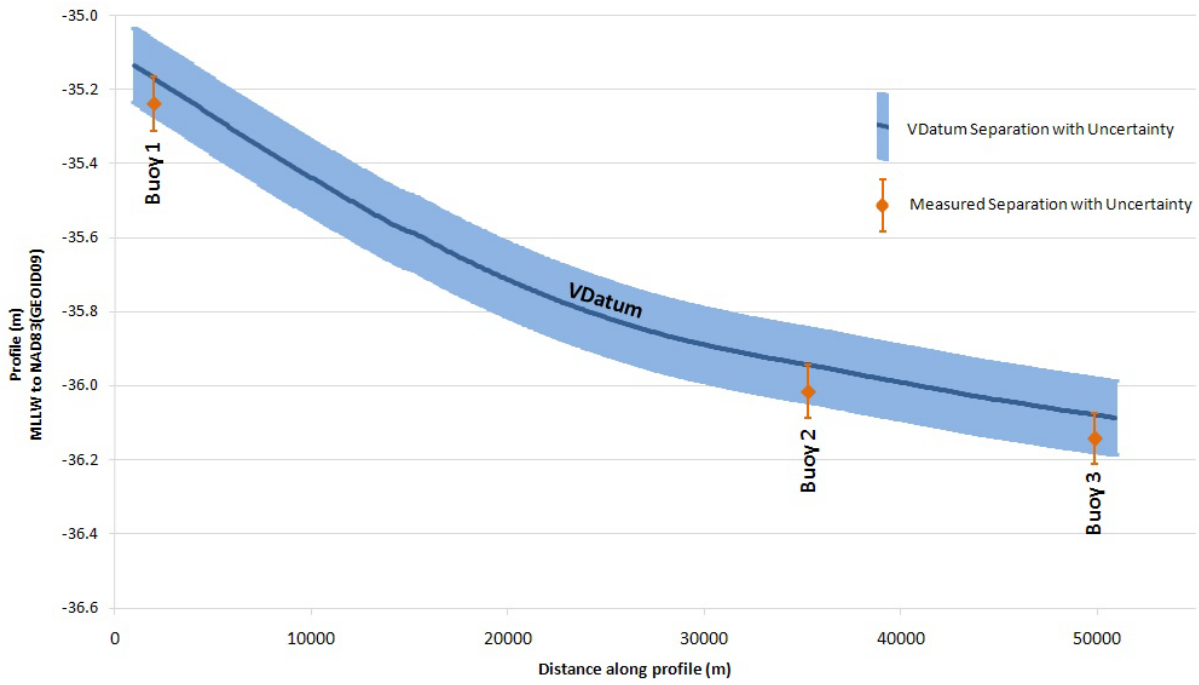


Figure 10. Comparison of VDatum and Observed MLLW at Buoy Locations

Figure 11 summarizes MLLW determinations from all 2010 measurement sites relative to VDatum using GEOID09.

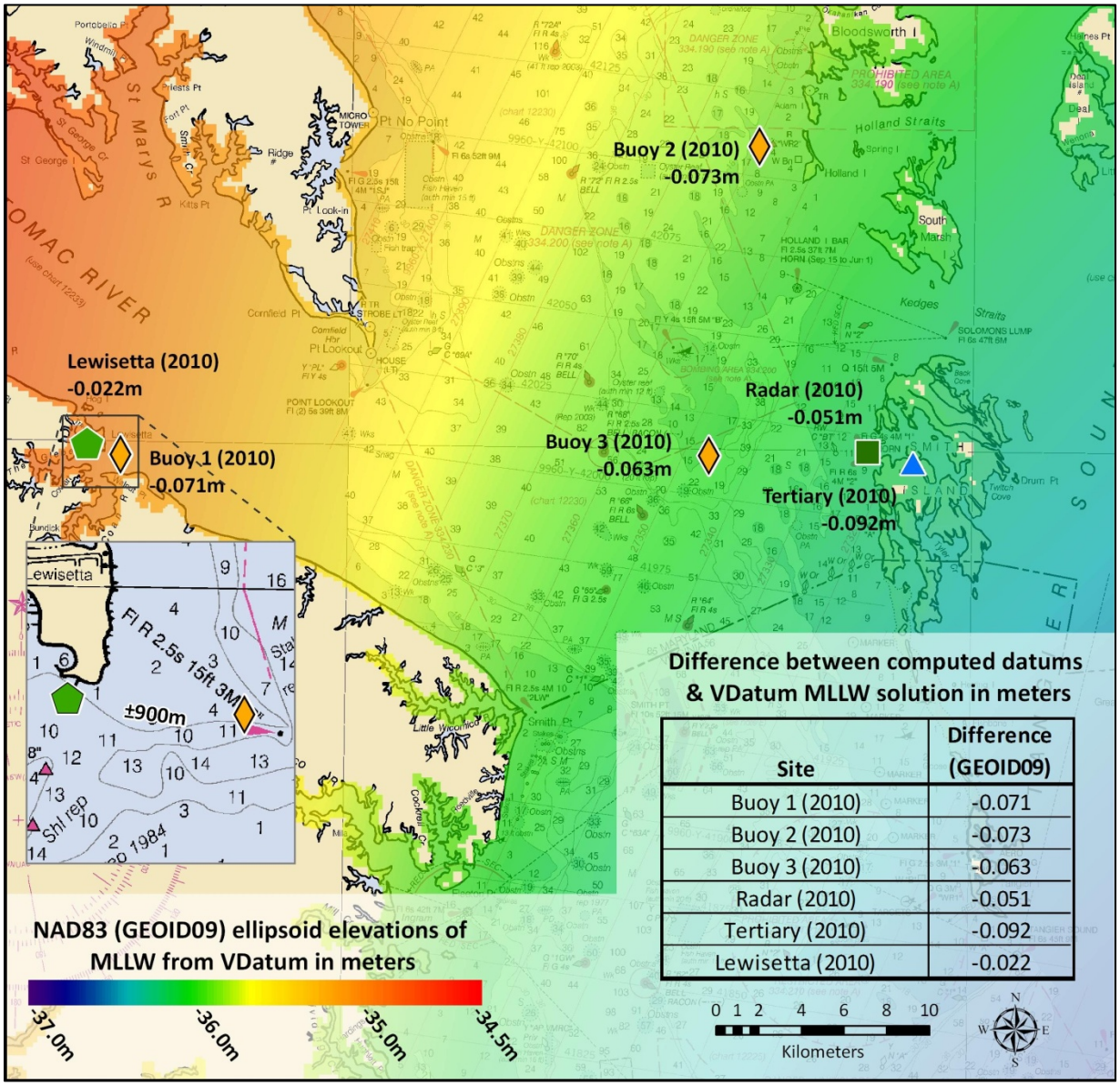


Figure 11. Comparison of VDatum and Observed MLLW Determinations

C. LETTER OF APPROVAL

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

DAVID EVANS AND ASSOCIATES INC.

LETTER OF APPROVAL

OPR-E349-KR-10
HORIZONTAL AND VERTICAL CONTROL REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-E349-KR-10 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-10 Statement of Work*, dated April, 2010 as modified by Task Order Number 5.

Digitally signed by Jon Dasler
DN: cn=Jon Dasler, email=jld@deainc.com, o=David Evans and Associates, Inc., c=US
Date: 2011.05.26 14:43:09 -07'00'

Jonathan L. Dasler, PE (OR), PLS (OR, CA)
ACSM/THSOA Certified Hydrographer
Chief of Party

Digitally signed by Jason Creech
DN: cn=Jason Creech, email=jasc@deainc.com, o=David Evans and Associates, Inc., c=US
Date: 2011.05.26 14:44:59 -07'00'

Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
November 2010

APPENDIX I
TIDES AND WATER LEVEL REQUIREMENT

ERS / VDATUM / TIDE BUOY VALIDATION DELIVERABLES FOR OPR-E349-KR-10

Note: All VDatum-related activities for this project shall use the following component versions, unless otherwise agreed to.

VDatum Version: 2.3
Geoid: 2009
VDatum Area: Chesapeake Bay
VDatum Area Version: 1

1 Interim Deliverables

NOAA requires interim deliverables from the ERS / VDatum / Tide Buoy validation effort associated with this project. DEA will provide preliminary data and analysis for this component of the project based on the first 30 days of field work. These preliminary results will be delivered no more than 60 days after initiation of field work. These deliverables will support NOAA's decision on final deliverables for the project (ERS/VDatum or traditional tides), as well as serve as a potential model for future pre-survey ERS/VDatum application assessments.

Preliminary VDatum / Tide Buoy / ERS validation results to include:

- Recommended vertical transformation technique based on results to date (VDatum or Tidal package)
- Discussion of GPS water level buoy and radar water level gauge methods, including MLLW datum computation.
- Comparison of 30 days of water level observations from tide buoy and Lewisetta NWLON gauge.
    - Tide buoy to be deployed adjacent to gauge.
    - Gauge elevation and data to be checked with GPS methods and staff observations.
    - 30-day datum for tide buoy to be computed and compared with accepted datum at NWLON station.
    - Direct comparison of 6 minute averages between NWLON and buoy data.
- Initial 30 days of raw data, MLLW datum computation, and 30 day datum separation (computed MLLW to VDatum MLLW) analysis and results for:
    - Radar water level gauge (no datum computation required)
    - Tertiary acoustic gauge (Ewell)
    - GPS water level buoy (first occupation at Lewisetta NWLON site)
- Bathymetric data from test lines in CARIS HIPS format, reduced to MLLW with both VDatum and traditional zoning package provided by CO-OPS.
    - Test lines to be proposed by DEA and approved by NOAA. Test lines will provide adequate spatial diversity across the survey area, but not to the extent of full crosslines required for the project.
    - Test lines will transect the project area following approximate path of the greatest slope in the geoid.
    - Additional test lines will be planned through areas of largest tide zoning range and phase correctors

    - Test lines to be run during periods of minimum influence from non-tidal factors (e.g., weather)
    - Test lines may be dual purposed as crosslines if they adhere to crossline orientation and data quality requirements.
- VDatum- and Zoning-reduced crossline data to be compared by surface-differencing, with analysis, discussion, and explanaiton of resutls.

Upon review of interim deliverables, HSD will determine the final vertical transformation technique to be used to create the final deliverables within 30 days.

2 Final Deliverables

Deliverables below to be submitted with project data.

2.1 Reports

Horizontal and Vertical Control Report (HVCR) describing horizontal and vertical positioning techniques employed in final deliverables, as well as water level buoy and radar gauge data acquisition, processing, and quality control, Information on the VDatum and ERS techniques which does not fit into the existing HVCR structure shall be included as an appendix. This report shall include:

- GPS-to-water line offsets/calculation for tide buoy
- Ellipsoid to sensor offsets/calculation for radar gauge
- MLLW datum computation methods for both water level buoy and radar gauge
- 6-minute heights/water level computation methods for both water level buoy and radar gauge
- Discussion of water level measurement uncertainties

2.2 GPS and Datum Transformation Data

- Applanix POSPac project data and processing files (rover, base, orbits & clocks) for all survey platform hydrography, and the resulting SBET (.000), RMS (smrmsg*.out), and processing log files
- Applanix POSPac project data and processing files (bases, orbits & clocks, OPUS solutions) for all static GPS-positioning of local reference station(s)
- A copy of the VDatum transformation/separation grid of ellipsoid height to MLLW

2.3 GPS Water Level Buoy Data & Related

- Buoy "raw" dual-frequency GPS data in RINEX format + any "raw" tilt time series data. Include metadata for the GPS antenna type/model number.
- All relevant KGPS base station "raw" dual-frequency GPS data in RINEX format. Include metadata for the GPS antenna type/model number and known vertical and horizontal benchmarking.
- Processed GPS water level buoy 6-minute height time series files in "pressure sensor or generic data" format (XXX.BWL) per the HSD Specifications & Deliverables (see below).

        - For each buoy deployment, one file of the ellipsoid-referenced water level time series. Include metadata to indicate the precise vertical datum; e.g., NAD83 (NSRS2009/CORS96/HARN).
        - For each buoy deployment, one file of the MLLW-referenced water level time series. Include metadata to indicate the value and calculation of the ellipsoid-to-MLLW offset.

2.4 Ewell Radar Gauge Data

- Processed radar water level gauge 6-minute height time series files in "pressure sensor or generic data" format (XXX.BWL) per the HSD Specifications & Deliverables (see below).
    - One file of the ellipsoid-referenced water level time series. Include metadata to indicate the precise vertical datum; e.g., NAD83 (NSRS2009/CORS96/HARN).
    - One file of MLLW-referenced water level time series. Include metadata to indicate the value and calculation of the ellipsoid-to-MLLW offset.

APPENDIX II
CORRESPONDENCE

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Coast Survey
Silver Spring, Maryland 20910-3282

26 October 2010

MEMORANDUM FOR: Jonathan L. Dasler, PE (OR), PLS (OR, CA)
David Evans and Associates, Inc.
2100 SW River Parkway
Portland, OR 97201

FROM: Jeffrey Ferguson
Chief, Hydrographic Surveys Division (HSD)

Jeffrey Ferguson
I am approving this document
2010.10.27 10:49:23 -04'00'

SUBJECT: Vertical Datum Transformation Technique,
OPR-E349-KR-10, Central Chesapeake Bay, MD

Hydrographic surveys H12238. H12239, H12240, H12241, and H12242, OPR-E349-KR-10, Central Chesapeake Bay, MD are approved for vertical reduction to chart datum, Mean Lower Low Water (MLLW), using the NOAA published Vertical Datum Transformation (VDatum) toolset (http://vdatum.noaa.gov). However, this approval does not remove the requirement to submit all water level data for subordinate gauges as required by the Statement of Work and Chapter 4 of the NOS Hydrographic Surveys Specifications and Deliverables.

Approval of VDatum, in lieu of the NOAA Center for Operational Oceanographic Products and Services (CO-OPS) discrete zoning package as per the Statement of Work, is based on review of David Evans and Associates (DEA) recommendations in their Interim VDatum Report (see OPRE349KR10 Interim VDatum Report – Sept 2010 Rev.pdf) and results from an internal review of current and previous year data indicating agreement within acceptable limits. Consult HSD, if computation of datums at the Ewell subordinate gauge site upon completion of the project significantly changes the final discrete zoning schema or comparison values to that of data reduced via VDatum.

Internal *CARIS* Ping-Vessel-Day-Line (PVDL) or "ping-to-ping" quality control comparison of DEA data acquired in 2010 across the OPR-E345-KR-10 survey area indicate MLLW referenced data reduced via discrete tide zones agree within 5.0 cm ± 4.4 cm, 1σ, to MLLW referenced data reduced via VDatum (see NOAA_Interim_VDatum_QC_Report.pdf). The 5.0 cm "ping-to-ping" findings are consistent with DEA's analysis results computed using an alternate method of differencing *CARIS* swath-angle derived one meter surfaces of MLLW referenced data via discrete zones against VDatum reduced data (see Table 26: OPRE349KR10 Interim VDatum Report – Sept 2010 Rev.pdf). A positive 5.0 cm difference indicates that VDatum derived depths are slightly deeper than discrete tide zone derived depths.

The results of the DEA's analysis show that ellipsoidally referenced survey (ERS) techniques with VDatum used as the vertical datum reducer to MLLW in this area indicate a better internal consistency of the survey data, and produces final sounding values that meet or exceed horizontal and vertical specifications for hydrographic surveys.

Reports and documents referenced in this memorandum may be made available upon request and will be archived with the survey data.

APPENDIX III
FINAL TIDE NOTE

H12238

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: November 16, 2010

HYDROGRAPHIC BRANCH: Atlantic

HYDROGRAPHIC PROJECT: OPR-E349-KR-10

HYDROGRAPHIC SHEET: H12238

LOCALITY Central Chesapeake Bay, Maryland and Virginia

SUB-LOCALITY: 4nm NE of Smith Point

TIME PERIOD:	July	4-17, 20
	August	6
	October	7-8
	November	4, 12

TIDE STATIONS USED: 8635750, Lewisetta, VA
Lat. 37° 59.7' N, Lon. 76° 27.8' W

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

HEIGHT OF MEAN HIGH WATER (863-5750) ABOVE PLANE OF REFERENCE: 0.416 meters [1]

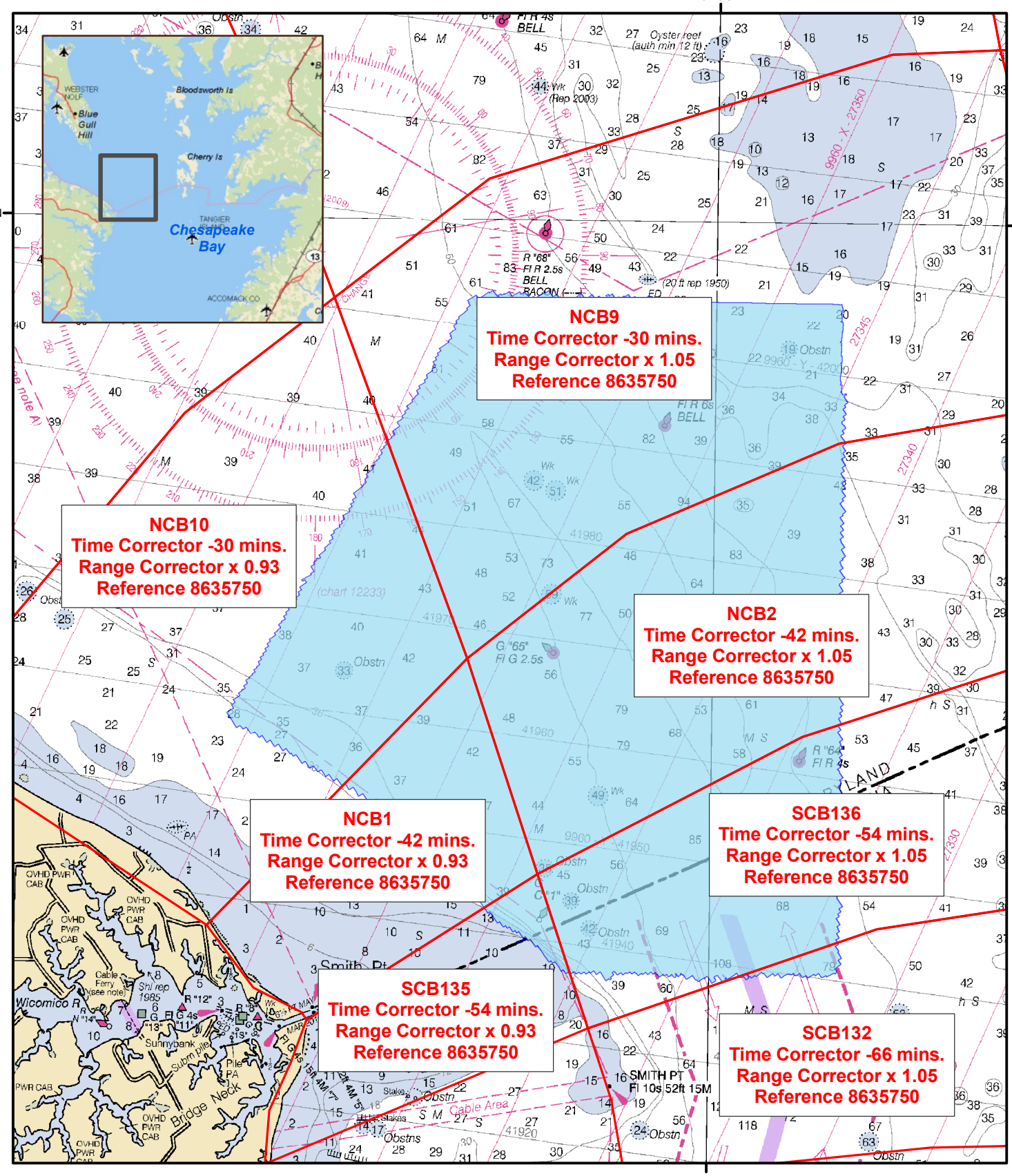
[1] MLLW 1.454m Mean Lower-Low Water
MHW 1.870m Mean High Water

http://tidesandcurrents.noaa.gov/data_menu.shtml?unit=0&format=Apply+Change&stn=8635750+Lewisetta%2C+VA&type=Datums

FINAL TIDE ZONING
H12238
OPR-E349-KR-10

Zone	Time Corrector (Mins)	Range Ratio	Reference Station
NCB1	-42	0.93	8635750
NCB10	-30	0.93	8635750
NCB2	-42	1.05	8635750
NCB9	-30	1.05	8635750
SCB132	-66	1.05	8635750
SCB135	-54	0.93	8635750
SCB136	-54	1.05	8635750

NOTE: These values are provided for information only. Final sounding reduction used Global Positioning System (GPS) water levels acquired directly at the survey vessel. Zoning and verified water level files were provided by CO-OPS.



N
W E
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0 0.4 0.8
Nautical Miles

H12238
Final Tide Zoning
Reference Only

H12238
OPR-E349-KR-10
Central Chesapeake Bay, MD and VA
David Evans and Associates, Inc.
Jon Dasler, Lead Hydrographer
Chart 12230

H12239

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: November 16, 2010

HYDROGRAPHIC BRANCH: Atlantic

HYDROGRAPHIC PROJECT: OPR-E349-KR-10

HYDROGRAPHIC SHEET: H12239

LOCALITY Central Chesapeake Bay, Maryland and Virginia

SUB-LOCALITY: 5nm East of Point Look-in

TIME PERIOD:

July	3,6,16-18,20-26, 28
August	6-7,9-10
October	13, 18

TIDE STATIONS USED: 8635750, Lewisetta, VA
Lat. 37° 59.7' N, Lon. 76° 27.8' W

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

HEIGHT OF MEAN HIGH WATER (863-5750) ABOVE PLANE OF REFERENCE: 0.416 meters [1]

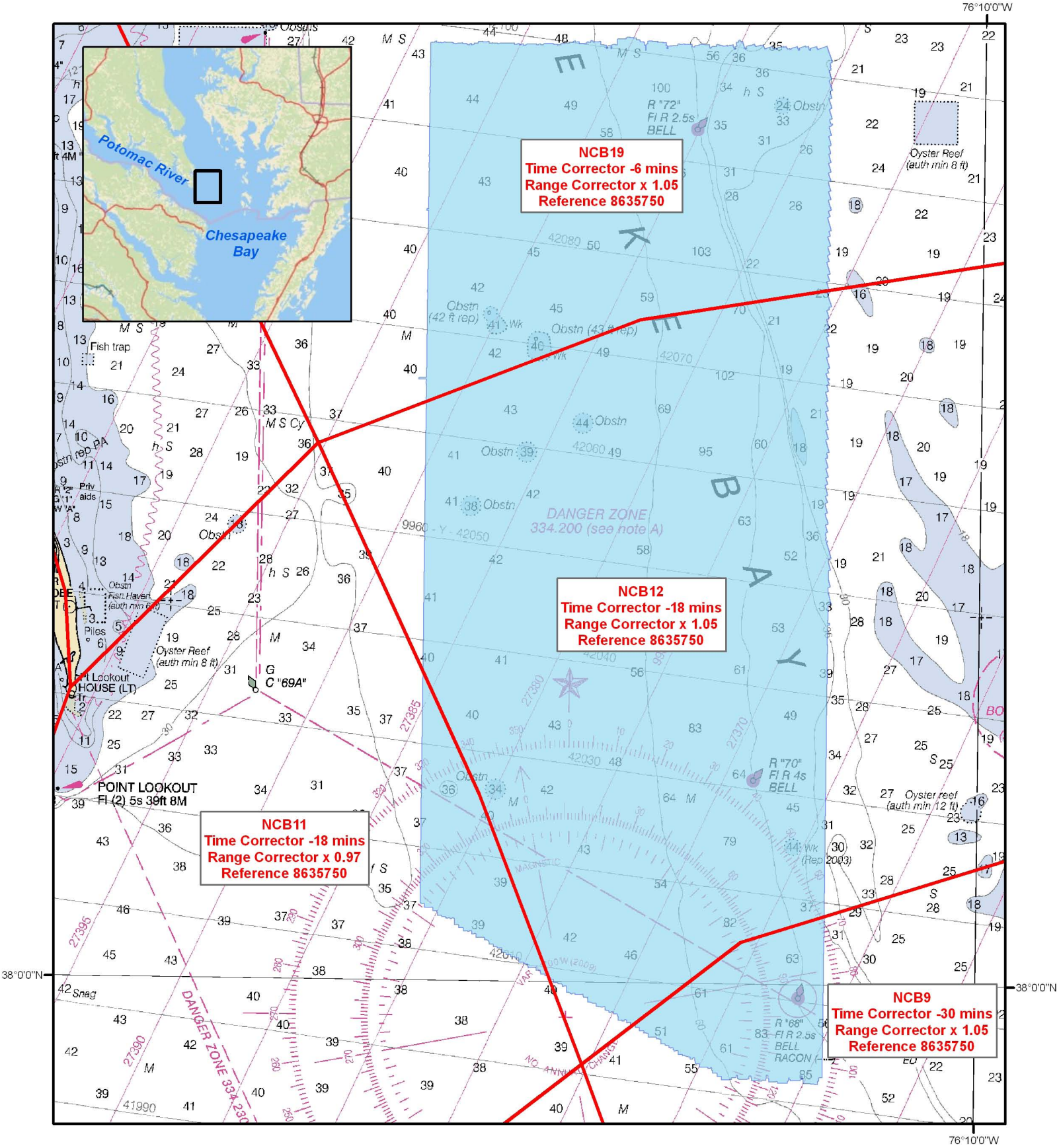
[1] MLLW 1.454m Mean Lower-Low Water
MHW 1.870m Mean High Water

http://tidesandcurrents.noaa.gov/data_menu.shtml?unit=0&format=Apply+Change&stn=8635750+Lewisetta%2C+VA&type=Datums

FINAL TIDE ZONING
H12239
OPR-E349-KR-10

Zone	Time Corrector (Mins)	Range Ratio	Reference Station
NCB09	-30	1.05	**8635750**
NCB11	-18	0.97	**8635750**
NCB12	-18	1.05	**8635750**
NCB19	-6	1.05	**8635750**

NOTE: These values are provided for information only. Final sounding reduction used Global Positioning System (GPS) water levels acquired directly at the survey vessel. Zoning and verified water level files were provided by CO-OPS.



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0 0.5 1
Nautical Miles

H12239
Final Tide Zoning
Reference Only

H12239
OPR-E349-KR-10
Central Chesapeake Bay, MD and VA
David Evans and Associates, Inc.
Jon Dasler, Lead Hydrographer
Chart 12230

H12240

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: November 16, 2010

HYDROGRAPHIC BRANCH: Atlantic

HYDROGRAPHIC PROJECT: OPR-E349-KR-10

HYDROGRAPHIC SHEET: H12240

LOCALITY Central Chesapeake Bay, Maryland and Virginia

SUB-LOCALITY: East of Point Look-in

TIME PERIOD:		
	July	3, 18, 25-31
	August	1, 3, 5-6, 9-10,17
	September	23
	October	19-20, 23
	November	3-4,13,15

TIDE STATIONS USED: 8635750, Lewisetta, VA
Lat. 37° 59.7' N, Lon. 76° 27.8' W

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

HEIGHT OF MEAN HIGH WATER (863-5750) ABOVE PLANE OF REFERENCE: 0.416 meters [1]

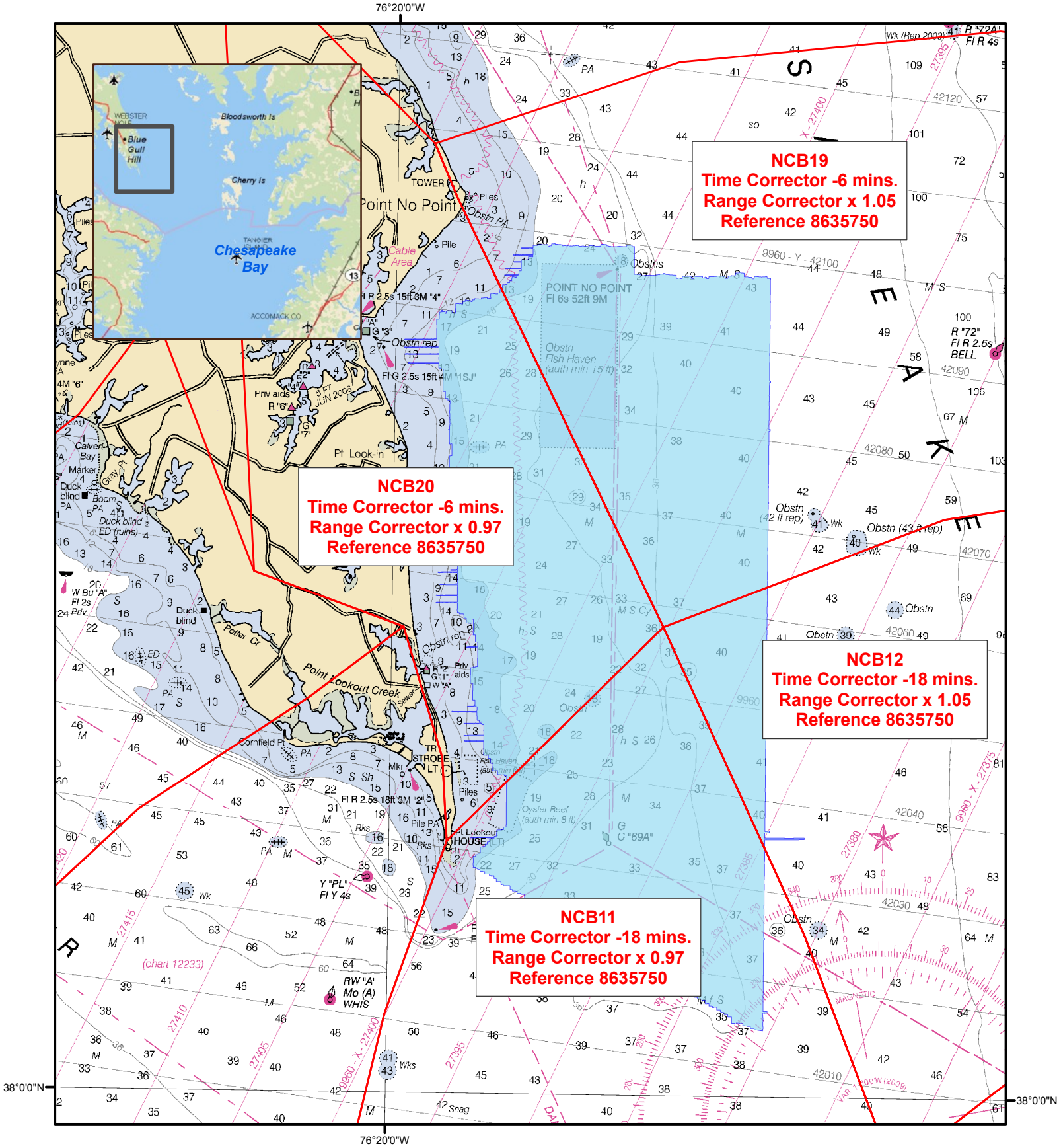
[1] MLLW 1.454m Mean Lower-Low Water
MHW 1.870m Mean High Water

http://tidesandcurrents.noaa.gov/data_menu.shtml?unit=0&format=Apply+Change&stn=8635750+Lewisetta%2C+VA&type=Datums

FINAL TIDE ZONING
H12240
OPR-E349-KR-10

Zone	Time Corrector (Mins)	Range Ratio	Reference Station
NCB11	-18	0.97	8635750
NCB12	-18	1.05	8635750
NCB19	-6	1.05	8635750
NCB20	-6	0.97	8635750

NOTE: These values are provided for information only. Final sounding reduction used Global Positioning System (GPS) water levels acquired directly at the survey vessel. Zoning and verified water level files were provided by CO-OPS.



N W E S 0 0.4 0.8 Nautical Miles	**H12240** **Final Tide Zoning** ***Reference Only***	**H12240** **OPR-E349-KR-10** **Central Chesapeake Bay, MD and VA** **David Evans and Associates, Inc.** **Jon Dasler, Lead Hydrographer** **Chart 12230**

H12241

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: November 16, 2010

HYDROGRAPHIC BRANCH: Atlantic

HYDROGRAPHIC PROJECT: OPR-E349-KR-10

HYDROGRAPHIC SHEET: H12241

LOCALITY Central Chesapeake Bay, Maryland and Virginia

SUB-LOCALITY: 3nm SW of Smith Island

TIME PERIOD:	July	4, 6
	August	10-11,14-15,17-21, 23, 25-27,
	October	13, 23, 28
	November	3, 13

TIDE STATIONS USED: 8635750, Lewisetta, VA
Lat. 37° 59.7' N, Lon. 76° 27.8' W

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

HEIGHT OF MEAN HIGH WATER (863-5750) ABOVE PLANE OF REFERENCE: 0.416 meters [1]

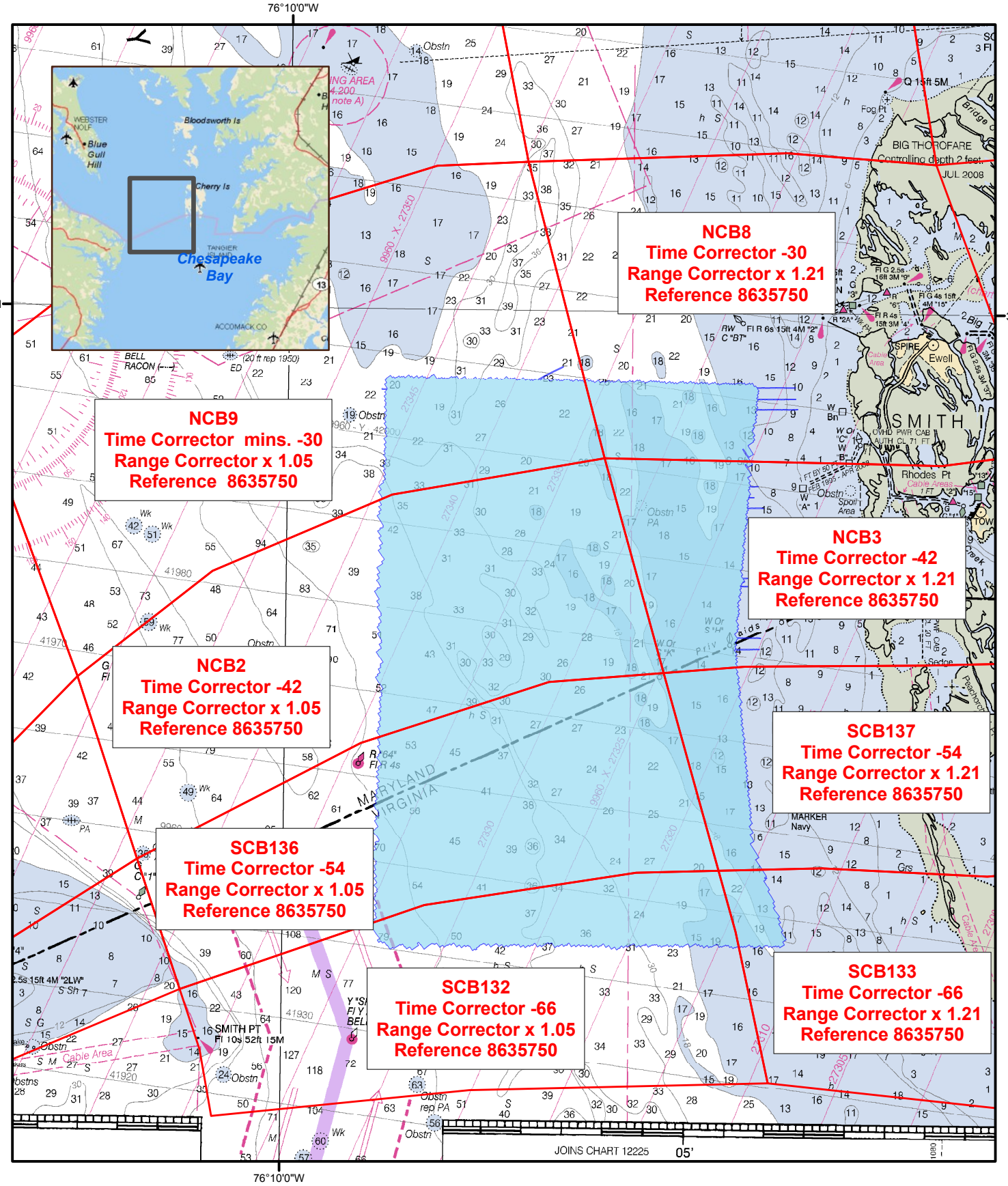
[1] MLLW 1.454m Mean Lower-Low Water
MHW 1.870m Mean High Water

http://tidesandcurrents.noaa.gov/data_menu.shtml?unit=0&format=Apply+Change&stn=8635750+Lewisetta%2C+VA&type=Datums

FINAL TIDE ZONING
H12241
OPR-E349-KR-10

Zone	Time Corrector (Mins)	Range Ratio	Reference Station
NCB8	-30	1.21	8635750
NCB9	-30	1.05	8635750
NCB2	-42	1.05	8635750
NCB3	-42	1.21	8635750
SCB136	-54	1.05	8635750
SCB137	-54	1.21	8635750
SCB132	-66	1.05	8635750
SCB133	-66	1.21	8635750

NOTE: These values are provided for information only. Final sounding reduction used Global Positioning System (GPS) water levels acquired directly at the survey vessel. Zoning and verified water level files were provided by CO-OPS.



N
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0 0.45 0.9
Nautical Miles

H12241
Final Tide Zoning
Reference Only

H12241
OPR-E349-KR-10
Central Chesapeake Bay, MD and VA
David Evans and Associates, Inc.
Jon Dasler, Lead Hydrographer
Chart 12230

H12242

FINAL TIDE NOTE and FINAL TIDE ZONING CHART

DATE: November 16, 2010

HYDROGRAPHIC BRANCH: Atlantic

HYDROGRAPHIC PROJECT: OPR-E349-KR-10

HYDROGRAPHIC SHEET: H12242

LOCALITY Central Chesapeake Bay, Maryland and Virginia

SUB-LOCALITY: West of Kedges Straits

TIME PERIOD:

July	3, 6-7
August	11, 25-31
September	1, 5-7, 11-13,15-17,19, 21, 23-24, 27
October	2, 6, 9-13, 17-18, 28, 30
November	1-4, 12,13

TIDE STATIONS USED: 8635750, Lewisetta, VA
Lat. 37° 59.7' N, Lon. 76° 27.8' W

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

HEIGHT OF MEAN HIGH WATER (863-5750) ABOVE PLANE OF REFERENCE: 0.416 meters [1]

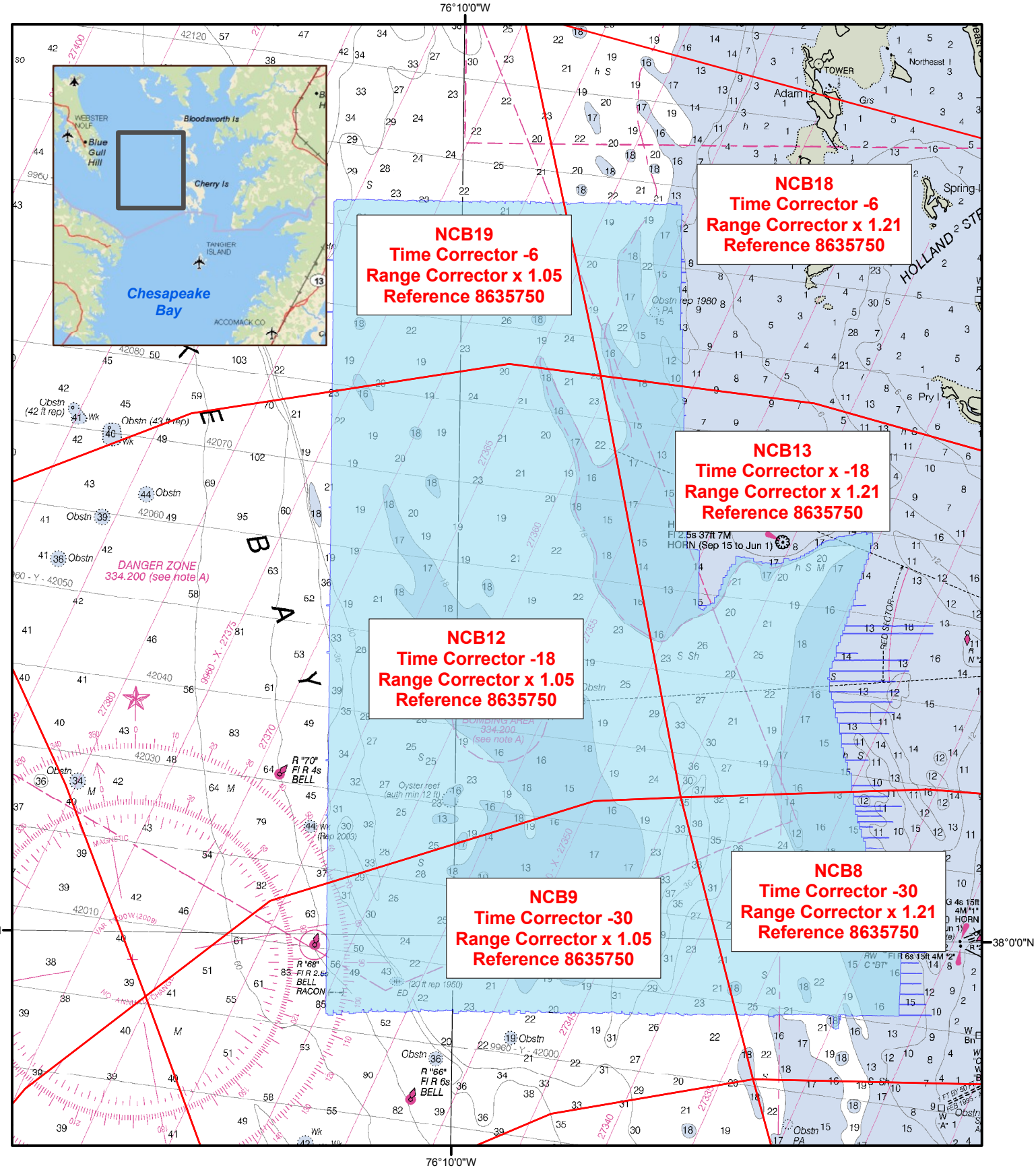
[1] MLLW 1.454m Mean Lower-Low Water
MHW 1.870m Mean High Water

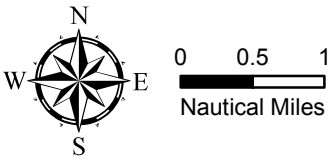
http://tidesandcurrents.noaa.gov/data_menu.shtml?unit=0&format=Apply+Change&stn=8635750+Lewisetta%2C+VA&type=Datums

FINAL TIDE ZONING
H12242
OPR-E349-KR-10

Zone	Time Corrector (Mins)	Range Ratio	Reference Station
NCB8	-30	1.21	8635750
NCB9	-30	1.05	8635750
NCB13	-18	1.21	8635750
NCB12	-18	1.05	8635750
NCB18	-6	1.21	8635750
NCB19	-6	1.05	8635750

NOTE: These values are provided for information only. Final sounding reduction used Global Positioning System (GPS) water levels acquired directly at the survey vessel. Zoning and verified water level files were provided by CO-OPS.





H12242

Final Tide Zoning

Reference Only

H12242
OPR-E349-KR-10
Central Chesapeake Bay, MD and VA
David Evans and Associates, Inc.
Jon Dasler, Lead Hydrographer
Chart 12230

NOTE

Soundings were reduced to chart datum using GPS water levels acquired directly at the vessel. Tidal zoning information provided by CO-OPS is included for information only.

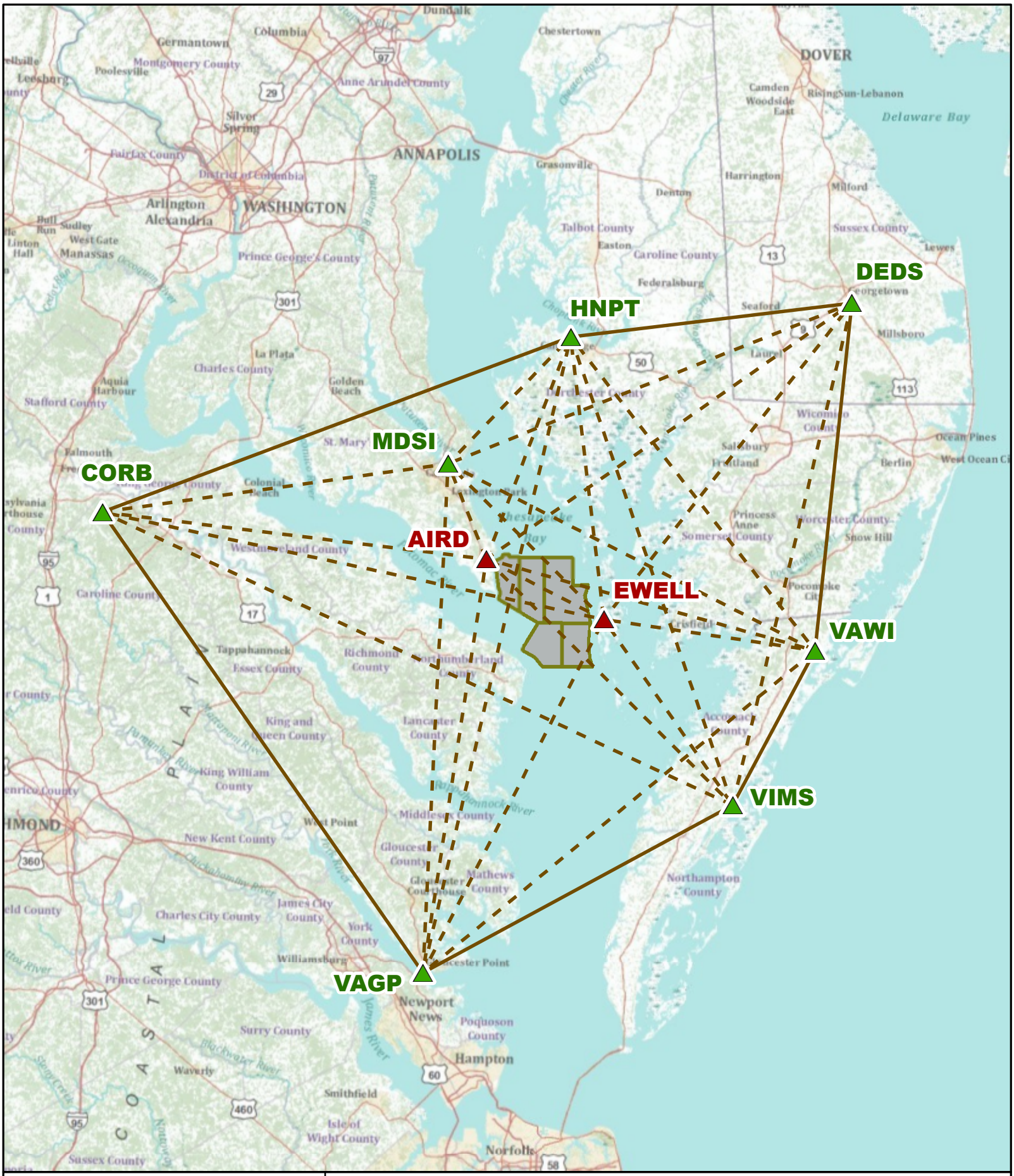
APPENDIX IV
GPS BASE STATIONS

David Evans and Associates, Inc.
2801 SE Columbia Way, Suite 130
Vancouver, WA 98661
Phone: 360-314-3200
Fax: 360-314-3250

GPS Base Station Summary

Temporary Base Stations	Coordinates NAD83 (CORS96, Epoch 2002) D.M.S.		NAD83 Ellipsoid Heights (m)
	Latitude	Longitude	
AIRD	38-07-10.22946 N	76-20-53.79559 W	-22.567
EWELL	37-59-46.25232 N	76-01-59.09814 W	-31.911

CORS Base Stations	Coordinates NAD83 (CORS96, Epoch 2002) D.M.S.		NAD83 Ellipsoid Heights (m)
	Latitude	Longitude	
CORB	38-12-07.82819 N	77-22-24.57106 W	37.252
DEDS	38-39-52.29188 N	75-22-38.75868 W	-12.428
HNPT	38-35-19.71067 N	76-07-49.33296 W	-26.645
MDSI	38-19-08.07256 N	76-27-13.95583 W	-16.774
VAGP	37-14-55.00860 N	76-29-57.73125 W	-19.809
VAWI	37-56-03.49983 N	75-28-15.94949 W	-22.315
VIMS	37-36-30.04548 N	75-41-13.20712 W	-27.739



N
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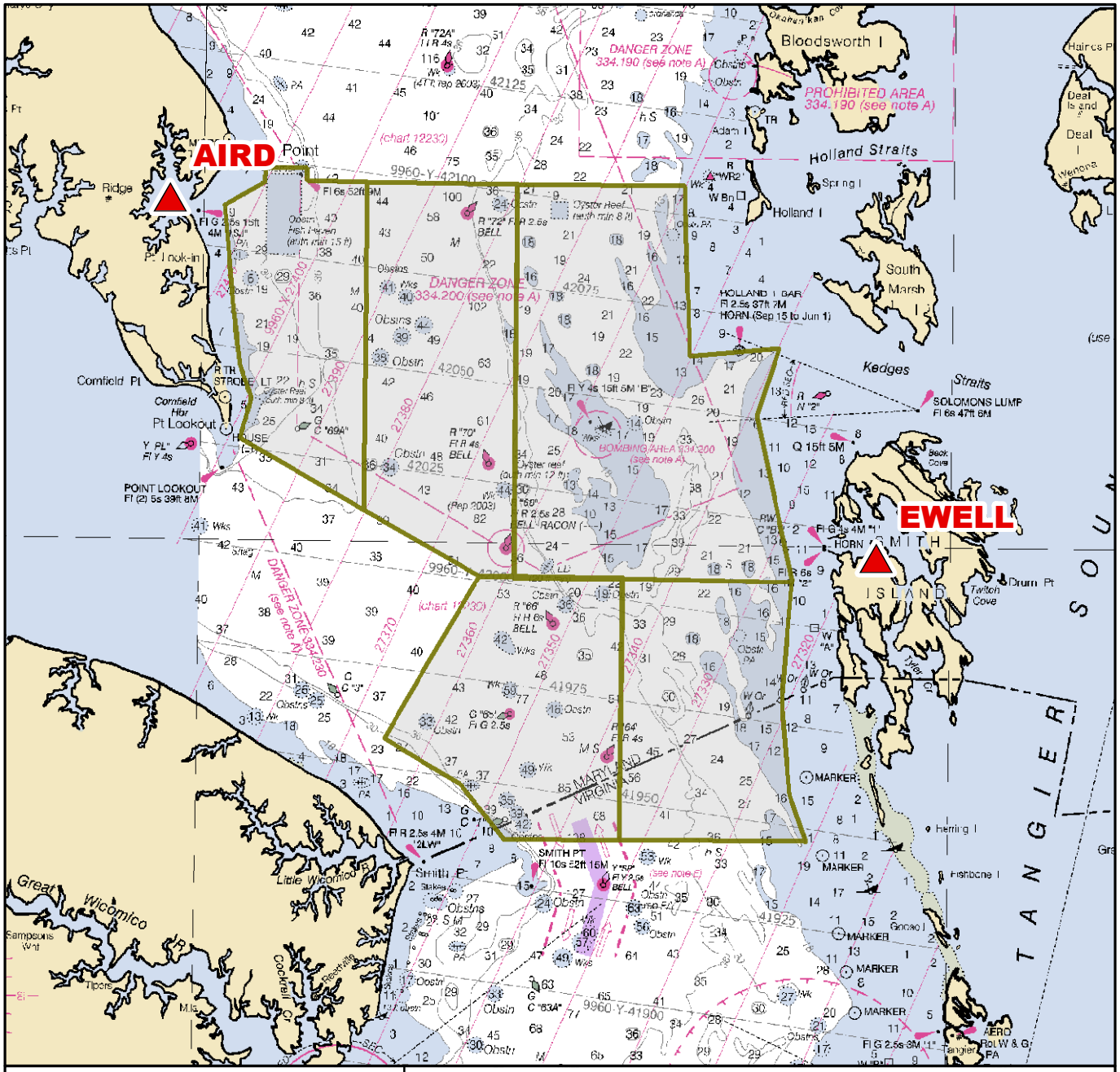
0 10 20
Nautical Miles

OPR-E349-KR-10 GPS Base Stations

- Temporary Base Stations
- CORS Sites
- Typical Smart Base Network
- Survey Limits



N
W E
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0 2 4
Nautical Miles

Temporary GPS Base Stations

OPR-E349-KR-10 Survey Limits

NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable:__ FBN__ CBN__ PAC__ SAC __BM) AIRD		Station PID, if any: N/A	Date (UTC): 07/01/2010
General Location: RIDGE, MD	Airport ID, if any: N/A	Station 4-Character ID: N/A	Day of Year: 182
Project Name: NOAA0000-0015	Project Number: GPS-	Station Serial # (SSN): N/A	Session ID:(A,B,C etc) A

NAD83 Latitude ° ' "	NAD83 Longitude ° ' "	NAD83 Ellipsoidal Height meters	Agency Full Name: DEA INC.
Observation Session Times (UTC): Sched. Start _____ Stop _____ Actual Start 00:07 Stop CONT.	Epoch Interval= 1 Seconds Elevation Mask = 10 Degrees	NAVD88 Orthometric Ht. meters GEOID99 Geoid Height meters	Operator Full Name: MIKE HILL Phone #: (360) 314-3200 e-mail address: mhi@deainc.com

Receiver Brand & Model:
TRIMBLE NET R5
P/N: NETR-5 62800-10
S/N: 4750K11594
Firmware Version: 4.14
☐ CamCorder Battery, ☒ 12V DC, ☒ 110V AC, ☒ Other (SOLAR)

Antenna Code*, Brand & Model:
TRIMBLE ZEPHYR GEODETIC
P/N: 41249-00
S/N: 12338038
Cable Length, meters: 30m RG213
Vehicle is Parked _____ meters ____(direction) from antenna.

Antenna plumb before session?	(Y / N)	Circle Yes or No -If no, explain
Antenna plumb after session?	(Y / N)	
Antenna oriented to true North?	(Y / N)	
Weather observed at antenna ht.	(Y / N)	
Antenna ground plane used?	(Y / N)	
Antenna radome used?	(Y / N)	If yes, describe. Use Vis. form
Eccentric occupation (>0.5 mm)?	(Y / N)	
Any obstructions above 10°?	(Y / N)	
Radio interference source nearby	(Y / N)	

Tripod or Antenna Mount: Check one:
☐ Fixed-Leg Tripod, ☐ Collapsible-leg tripod ☒ Fixed Mount
Brand & Model:
P/N: N/A FIXED MOUNT
S/N:
Last Adjustment date:

Psychrometer (if used) Brand & Model:
P/N: N/A
S/N:
Last Calibration or check Date:

** ANTENNA HEIGHT **

	Before Session Begins: Meters	Before Session Begins: Feet	After Session Ends: Meters	After Session Ends: Feet
A= Datum point to Top of Tripod (Tripod Height)	0.000	0.00		
B=Additional offset to ARP if any (Tribrach/Spacer)	0.000	0.00		
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)	0.000	0.00		

Meters = Feet x (0.3048)
Height Entered Into Receiver = _____ meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model:
S/N: N/A

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before									
Middle									
After									

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

START OF LONG TERM INSTALLATION AT BLUE CREW HOUSE IN RIDGE, MD FOR HYDRO SURVEY BASE STATION WEATHER NOT OBSERVED LONG TERM OCCUPATION

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s): 1594 <ddd> 0.t01
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ☐ Attached ☐ Submitted earlier
Visibility Obstruction Form: ☒ Attached ☐ Submitted earlier
Photographs of Station: ☒ Attached ☐ Submitted earlier
Pencil Rubbing of Mark: ☐ Attached

LOG CHECKED BY:

Table of Weather Codes	CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
	0	did not occur	Good, over 15 miles	Normal, 32° F- 80° F	Clear, below 20%	Calm, under 5mph (8km/h)
	1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
	2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)

Examples: 00000 = No problem, good visibility, normal temp, clear, calm wind 12121 = Problems, poor visibility, hot, overcast, moderate wind

Station Location Sketch and Visibility Diagram

Location / Airport Name and ID 49946 AIREDELE RD, RIDGE, MD

Project NOAA 0000-0015

Station Designation AIRD

PID N/A

Date 07/01/10

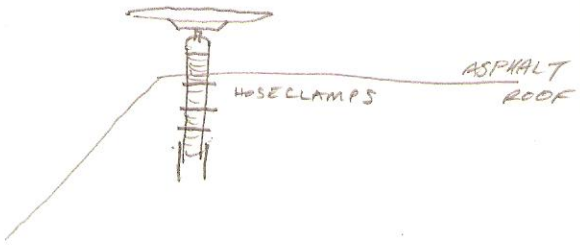
Circle all applicable: PACS SACS BM FBN CBN OTHER GPS BASE

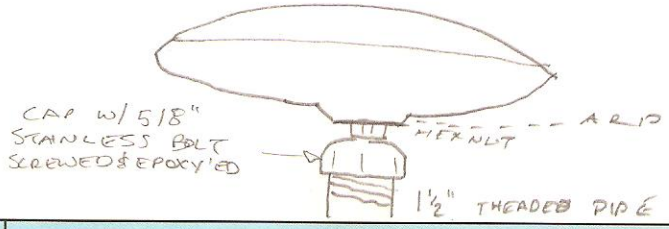
Observer & Organization BKHO. DEA INC.

Station Location Sketch

ARP IS TOP OF 5/8" HEX NUT SECURED TO 1½" PIPE HOSECLAMPED TO EXISTING SATELLITE DISH MOUNT (DISH) REMOVED

ANTENNA NOT ORIENTED TO TRUE NORTH.

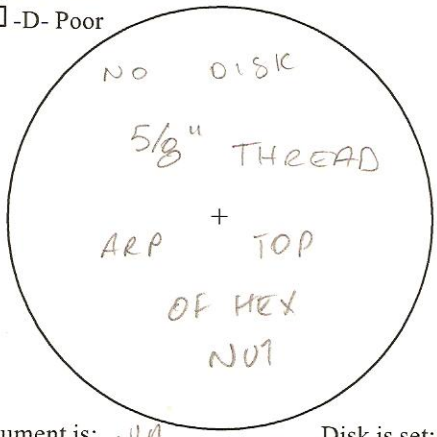




Sketch of Disk

Monument Stability Quality: ☒ Photos Available

- ☐ -A- Most stable
- ☐ -B- Excellent
- ☒ -C- Good
- ☐ -D- Poor



Monument is: N/A

- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☐ Projecting ___ cm

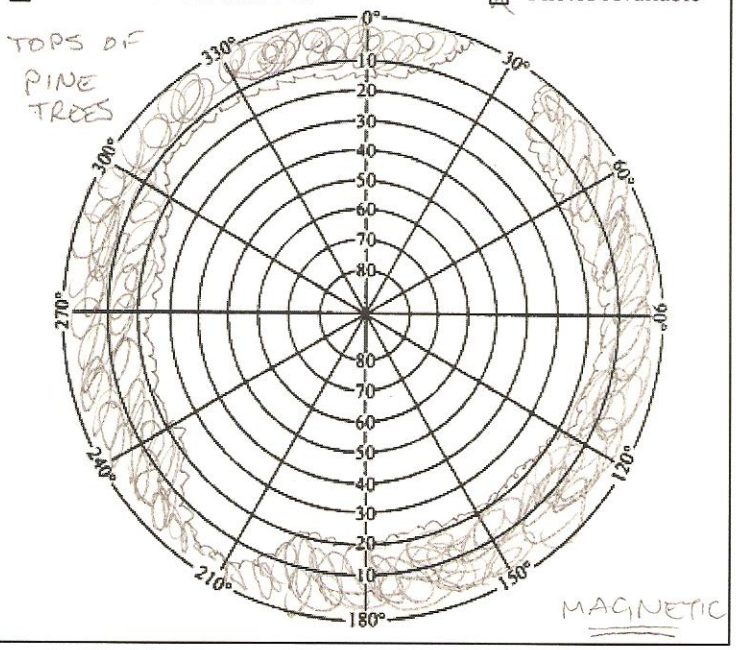
Disk is set: N/A

- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

☐ No Obstructions above 10°

☒ Photos Available



From: opus [opus@NGS.NOAA.GOV]
Sent: Monday, July 12, 2010 6:47 AM
To: Jason Creech
Subject: OPUS solution : 15941840.10o 000038827 **"AIRD" GPS BASE STATION**

```
 FILE: 15941840.10o 000038827

 1008   NOTE:  Antenna offsets supplied by the user were zero.  Coordinates
 1008   returned will be for the antenna reference point (ARP).
 1008
                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

      USER: jasc@deainc.com                         DATE: July 12, 2010
RINEX FILE: 15941840.10o                            TIME: 13:47:09 UTC


  SOFTWARE: page5  0909.08 master40.pl 081023      START: 2010/07/03  00:00:00
 EPHEMERIS: igr15906.eph [rapid]                    STOP: 2010/07/03  23:59:00
  NAV FILE: brdc1840.10n                       OBS USED: 53382 / 57604   :  93%
  ANT NAME: TRM41249.00     NONE             # FIXED AMB:   192 /   211   :  91%
ARP HEIGHT: 0.0                              OVERALL RMS: 0.014(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2010.5027)

         X:      1185816.907(m)   0.021(m)           1185816.161(m)   0.021(m)
         Y:     -4882290.857(m)   0.015(m)          -4882289.397(m)   0.015(m)
         Z:      3915874.572(m)   0.029(m)           3915874.453(m)   0.029(m)

       LAT:   38  7 10.22946      0.024(m)        38  7 10.25836      0.024(m)
     E LON:  283 39  6.20441      0.022(m)       283 39  6.18879      0.022(m)
     W LON:   76 20 53.79559      0.022(m)        76 20 53.81121      0.022(m)
    EL HGT:          -22.567(m)   0.020(m)               -23.895(m)   0.020(m)
 ORTHO HGT:           12.557(m)   0.020(m) [NAVD88 (Computed using GEOID09)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 18)         SPC (1900 MD  )
Northing (Y) [meters]     4219933.324           50471.841
Easting (X)  [meters]      381814.659          457151.044
Convergence  [degrees]    -0.83239250           0.40904388
Point Scale                0.99977203           1.00003630
Combined Factor            0.99977557           1.00003984

US NATIONAL GRID DESIGNATOR: 18SUH8181419933(NAD 83)



                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DL3474 LOYM LOYOLA M CORS ARP              N381838.119 W0763757.974   32720.0
AI3494 HNPT HORN POINT ENVIRO CORS ARP     N383519.710 W0760749.332   55466.2
DL3889 LOYW LOYOLA LOYW CORS ARP           N373140.995 W0755052.663   79055.0

                 NEAREST NGS PUBLISHED CONTROL POINT
HV9786      SMC 006                        N380705.982 W0762042.293     309.1

This position and the above vector components were computed without any knowledge
by the National Geodetic Survey regarding the equipment or field operating
procedures used.
```

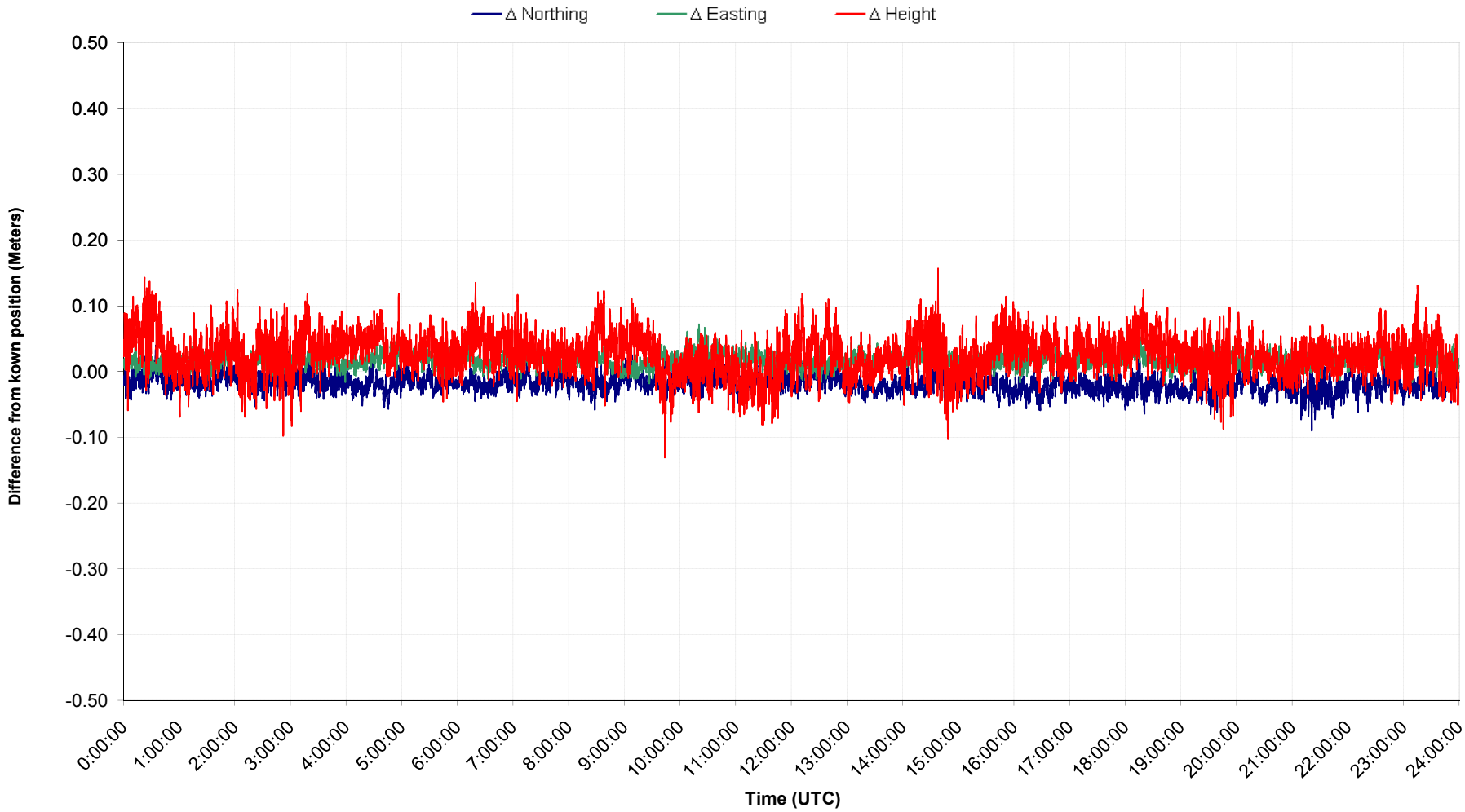
David Evans and Associates, Inc.
2801 SE Columbia Way, Suite 130
Vancouver, WA 98661
Phone: 360-314-3200
Fax: 360-314-3250

"AIRD"
GPS Base Station Site Verification
24 Hour PPK Solution Relative to Base Station Position

Date 11/4/2010
Locality Central Chesapeake Bay
Project OPR-N349-KR-10
Version GrafNav Version 8.30.1123
Datum NAD-83 UTM Zone 18 North, Meters

Base Station held for PPK processing MDSI (DN308) - precise

Station Latitude 38 07 10.22946 N
Station Longitude 76 20 53.79559 W
Station Ellipsoid Height -22.567
Receiver Trimble NetR5
Antenna Type TRM41249.00



OPR-E349-KR-10
WEEKLY BASE STATION CHECKS
"AIRD"

David Evans and Associates, Inc.
2801 SE Columbia Way, Ste 130
Vancouver, WA 98661
Phone: 360-314-3200
Fax: 360-314-3250

Reference Frame NAD83 (CORS96) Epoch 2002.00
Latitude 38° 07' 10.22946" (N)
Longitude 76° 20' 53.79559" (W)
Ellipsoid Height (m) -22.567

Datum NAD-83 UTM Zone 18 North, Meters
Northing (Y) 4219933.324
Easting (X) 381814.659
Derived from 24hr OPUS with rapid orbit 15891840.10o

INFORMATION			Base Station: AIRD OPUS Positon			Quality Check						Comments
Week of	DN	RINEX File	Northing	Easting	Ellipsoid Height	Northing Measured Seperation	Northing 95% CI	Easting Measured Seperation	Easting 95% CI	Ellipsoid Height Measured Seperation	Ellipsoid Height 95% CI	
7/4/2010	186	15891860.10o	4219933.324	381814.660	-22.567	0.000	PASS	0.001	PASS	0.000	PASS	precise
07/11/2010	192	15891920.10o	4219933.330	381814.659	-22.569	0.006	PASS	0.000	PASS	-0.002	PASS	rapid
07/18/2010	199	15941990.10o	4219933.317	381814.664	-22.564	-0.007	PASS	0.005	PASS	0.003	PASS	rapid
07/25/2010	206	15942060.10o	4219933.310	381814.665	-22.575	-0.014	PASS	0.006	PASS	-0.008	PASS	rapid
08/01/2010	213	15942130.10o	4219933.320	381814.663	-22.569	-0.004	PASS	0.004	PASS	-0.002	PASS	precise
08/08/2010	220	15942200.10o	4219933.319	381814.664	-22.560	-0.005	PASS	0.005	PASS	0.007	PASS	rapid
08/15/2010	227	15942270.10o	4219933.311	381814.662	-22.580	-0.013	PASS	0.003	PASS	-0.013	PASS	rapid
08/22/2010	234	15942340.10o	4219933.324	381814.655	-22.564	0.000	PASS	-0.004	PASS	0.003	PASS	rapid
08/29/2010	241	15942410.10o	4219933.315	381814.664	-22.562	-0.009	PASS	0.005	PASS	0.005	PASS	precise
09/05/2010	248	15942480.10o	4219933.317	381814.664	-22.564	-0.007	PASS	0.005	PASS	0.003	PASS	rapid
09/12/2010	255	15942550.10o	4219933.315	381814.666	-22.562	-0.009	PASS	0.007	PASS	0.005	PASS	rapid
09/19/2010	262	15942620.10o	4219933.315	381814.663	-22.564	-0.009	PASS	0.004	PASS	0.003	PASS	rapid
09/26/2010	269	15942690.10o	4219933.326	381814.657	-22.589	0.002	PASS	-0.002	PASS	-0.022	PASS	rapid
10/05/2010	278	15942780.10o	4219933.322	381814.663	-22.555	-0.002	PASS	0.004	PASS	0.012	PASS	rapid
10/10/2010	283	15942830.10o	4219933.324	381814.664	-22.569	0.000	PASS	0.005	PASS	-0.002	PASS	rapid
10/17/2010	290	15942900.10o	4219933.323	381814.654	-22.568	-0.001	PASS	-0.005	PASS	-0.001	PASS	rapid
10/24/2010	297	15942970.10o	4219933.316	381814.665	-22.553	-0.008	PASS	0.006	PASS	0.014	PASS	rapid
10/31/2010	304	15943040.10o	4219933.321	381814.665	-22.537	-0.003	PASS	0.006	PASS	0.030	PASS	rapid
11/07/2010	311	15943110.10o	4219933.325	381814.665	-22.542	0.001	PASS	0.006	PASS	0.025	PASS	rapid
11/15/2010	319	15943190.10o	4219933.310	381814.682	-22.562	-0.014	PASS	0.023	PASS	0.005	PASS	rapid (24 hr splice of 2 files,4 sec. data gap)
					Average	-0.005		0.004		0.003		
					Std Deviation	0.006		0.006		0.012		

Established Position Peak to Peak Values		95% Confidence
Northing	0.024	0.047
Easting	0.022	0.043
Ellipsoid Height	0.020	0.039

NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable:__ FBN__ CBN__ PAC__ SAC __BM) EWELL		Station PID, if any: N/A	Date (UTC): 07/01/2010
General Location: SMITH ISLAND, MD	Airport ID, if any: N/A	Station 4-Character ID: N/A	Day of Year: 182
Project Name: NOAA 0000-0015	Project Number: GPS-	Station Serial # (SSN): N/A	Session ID:(A,B,C etc) A

NAD83 Latitude ° ' "	NAD83 Longitude ° ' "	NAD83 Ellipsoidal Height meters	Agency Full Name: DEA INC.
Observation Session Times (UTC): Sched. Start _____ Stop _____ Actual Start _____ Stop _____	Epoch Interval= 1 Seconds Elevation Mask = _____ Degrees	NAVD88 Orthometric Ht. meters GEOID99 Geoid Height meters	Operator Full Name: BEN HOCKER Phone #: (360) 314-3200 e-mail address: bxho@deainc.com

Receiver Brand & Model: TRIMBLE NET R5 (VIRGO)
P/N:
S/N: 4750K11589
Firmware Version: 4.03
☐ CamCorder Battery, ☒ 12V DC, ☒ 110V AC, ☒ Other SOCAR

Antenna Code*, Brand & Model: TRIMBLE ZEPHYR GEODETIC
P/N: 41249-00
S/N: 12237025
Cable Length, meters: 15m
Vehicle is Parked _____ meters ____(direction) from antenna.

		Circle Yes or No -If no, explain
Antenna plumb before session?	(Y / N)	
Antenna plumb after session?	(Y / N)	
Antenna oriented to true North?	(Y / N)	
Weather observed at antenna ht.	(Y / N)	
Antenna ground plane used?	(Y / N)	"
Antenna radome used?	(Y / N)	If yes, describe. Use Vis. form
Eccentric occupation (>0.5 mm)?	(Y / N)	
Any obstructions above 10°?	(Y / N)	
Radio interference source nearby	(Y / N)	

Tripod or Antenna Mount: Check one:
☐ Fixed-Leg Tripod, ☐ Collapsible-leg tripod ☒ Fixed Mount
Brand & Model: N/A - FIXED MOUNT
P/N:
S/N:
Last Adjustment date:

Psychrometer (if used) Brand & Model:
P/N: N/A
S/N:
Last Calibration or check Date:

**** ANTENNA HEIGHT ****

	Before Session Begins: Meters	Before Session Begins: Feet	After Session Ends: Meters	After Session Ends: Feet
A= Datum point to Top of Tripod (Tripod Height)	0.000	0.00		
B= Additional offset to ARP if any (Tribrach/Spacer)	0.000	0.00		
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)	0.000	0.00		

Meters = Feet x (0.3048)
Height Entered Into Receiver = 0.000 meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model:
S/N: N/A

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before									
Middle									
After									

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:
START OF LONG TERM INSTALLATION AT EWELL, MD LOCATED ON SMITH ISLAND FOR HYDRO SURVEY BASE STATION. WEATHER NOT OBSERVED. LONG TERM OCCUPATION

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s): <4CHAR SN><3 CHAR JD><SESS ID>A .T01
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description:	☒ Attached	☐ Submitted earlier
Visibility Obstruction Form:	☒ Attached	☐ Submitted earlier
Photographs of Station:	☒ Attached	☐ Submitted earlier
Pencil Rubbing of Mark:	☐ Attached	

LOG CHECKED BY:

Table of Weather Codes

CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	did not occur	Good, over 15 miles	Normal, 32° F- 80° F	Clear, below 20%	Calm, under 5mph (8km/h)
1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)

Examples: 00000 = No problem, good visibility, normal temp, clear, calm wind 12121 = Problems, poor visibility, hot, overcast, moderate wind

Station Location Sketch and Visibility Diagram

Location / Airport Name and ID: EWELL, SMITH ISLAND, MD

Project: NOAA 0000 0015

Station Designation: EWELL

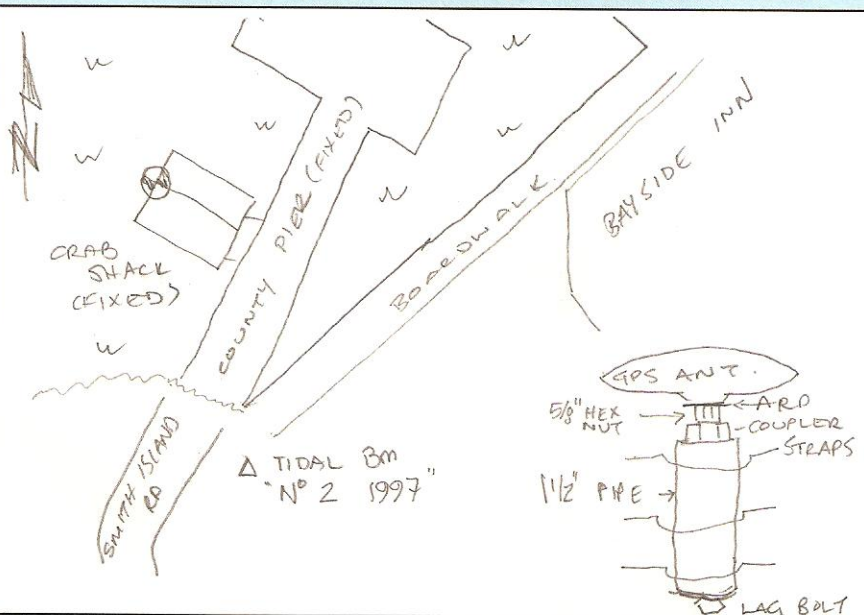
PID: N/A

Date: 07/01/10

Circle all applicable: PACS SACS BM FBN CBN OTHER GPS BASE

Observer & Organization: BCHO, DEA INC.

Station Location Sketch

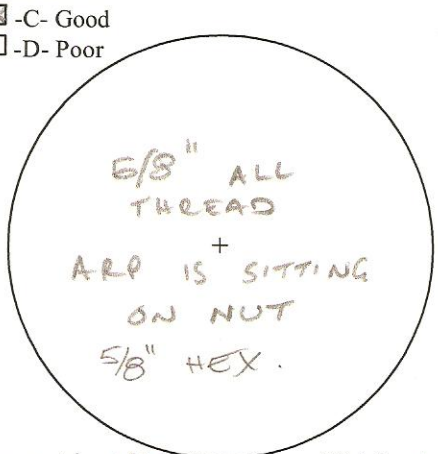


STATION IS MOUNTED TO THE NW PEAK OF THE ASPHALT ROOF OF CRAB SHACK AT EWELL ~~COUNTY~~ PIER SUPPORTED BY TREATED 2×6" SHEETED W/ TREATED PLYWOOD. 5/8" THREAD ON 1½" PIPE BANDED TO PLYWOOD AND SUPPORTED ON LAG BOLT. ARP ON 5/8" HEX NUT TOP.

Sketch of Disk

Monument Stability Quality: ☒ Photos Available

- ☐ -A- Most stable
- ☐ -B- Excellent
- ☒ -C- Good
- ☐ -D- Poor



Monument is: N/A

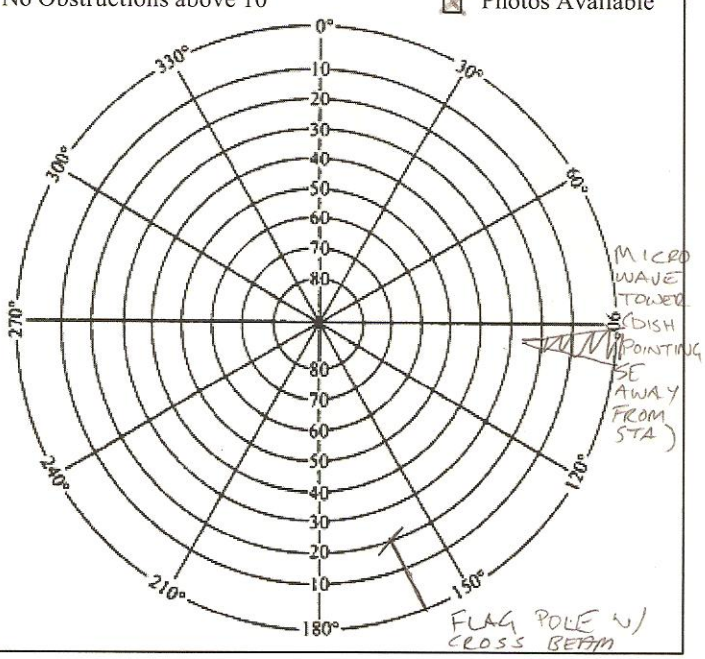
- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☐ Projecting ___ cm

Disk is set: N/A

- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

☐ No Obstructions above 10° ☒ Photos Available



From: opus [opus@NGS.NOAA.GOV]
Sent: Thursday, July 15, 2010 12:30 PM
To: Jason Creech
Subject: OPUS solution : 15891850A.10o 000042059 **"EWELL" GPS BASE STATION**

```
 FILE: 15891850A.10o 000042059

 1008   NOTE:  Antenna offsets supplied by the user were zero.  Coordinates
 1008   returned will be for the antenna reference point (ARP).
 1008
                              NGS OPUS SOLUTION REPORT
                              ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

      USER: jasc@deainc.com                         DATE: July 15, 2010
RINEX FILE: 15891850.10o                            TIME: 19:30:03 UTC


  SOFTWARE: page5  0909.08 master10.pl 081023      START: 2010/07/04  00:00:00
 EPHEMERIS: igr15910.eph [rapid]                    STOP: 2010/07/04  23:59:00
  NAV FILE: brdc1850.10n                       OBS USED: 59142 / 61735   :  96%
  ANT NAME: TRM41249.00     NONE             # FIXED AMB:   210 /   236   :  89%
ARP HEIGHT: 0.0                              OVERALL RMS: 0.013(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2010.5055)

         X:      1214692.120(m)   0.010(m)           1214691.374(m)   0.010(m)
         Y:     -4883875.645(m)   0.022(m)          -4883874.182(m)   0.022(m)
         Z:      3905090.298(m)   0.024(m)           3905090.179(m)   0.024(m)

       LAT:   37 59 46.25232      0.007(m)        37 59 46.28122      0.007(m)
     E LON:  283 58  0.90186      0.005(m)       283 58  0.88666      0.005(m)
     W LON:   76  1 59.09814      0.005(m)        76  1 59.11334      0.005(m)
    EL HGT:          -31.911(m)   0.032(m)               -33.245(m)   0.032(m)
 ORTHO HGT:            3.999(m)   0.032(m) [NAVD88 (Computed using GEOID09)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 18)         SPC (1900 MD  )
Northing (Y) [meters]     4205894.769           37027.955
Easting (X)  [meters]      409292.184          484935.199
Convergence  [degrees]    -0.63601837          0.60687023
Point Scale                0.99970134          1.00006673
Combined Factor            0.99970634          1.00007174

US NATIONAL GRID DESIGNATOR: 18SVH0929205894(NAD 83)



                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DL3474 LOYM LOYOLA M CORS ARP              N381838.119 W0763757.974   63092.4
DL3889 LOYW LOYOLA LOYW CORS ARP           N373140.995 W0755052.663   54458.3
DI2269 VAWI WALLOPS ISLAND CORS ARP        N375603.499 W0752815.949   49858.7

                 NEAREST NGS PUBLISHED CONTROL POINT
GV3611      EWELL ME CHURCH SPIRE          N375942.648 W0760200.015     113.6

This position and the above vector components were computed without any knowledge
by the National Geodetic Survey regarding the equipment or field operating
procedures used.
```

David Evans and Associates, Inc.
2801 SE Columbia Way, Suite 130
Vancouver, WA 98661
Phone: 360-314-3200
Fax: 360-314-3250

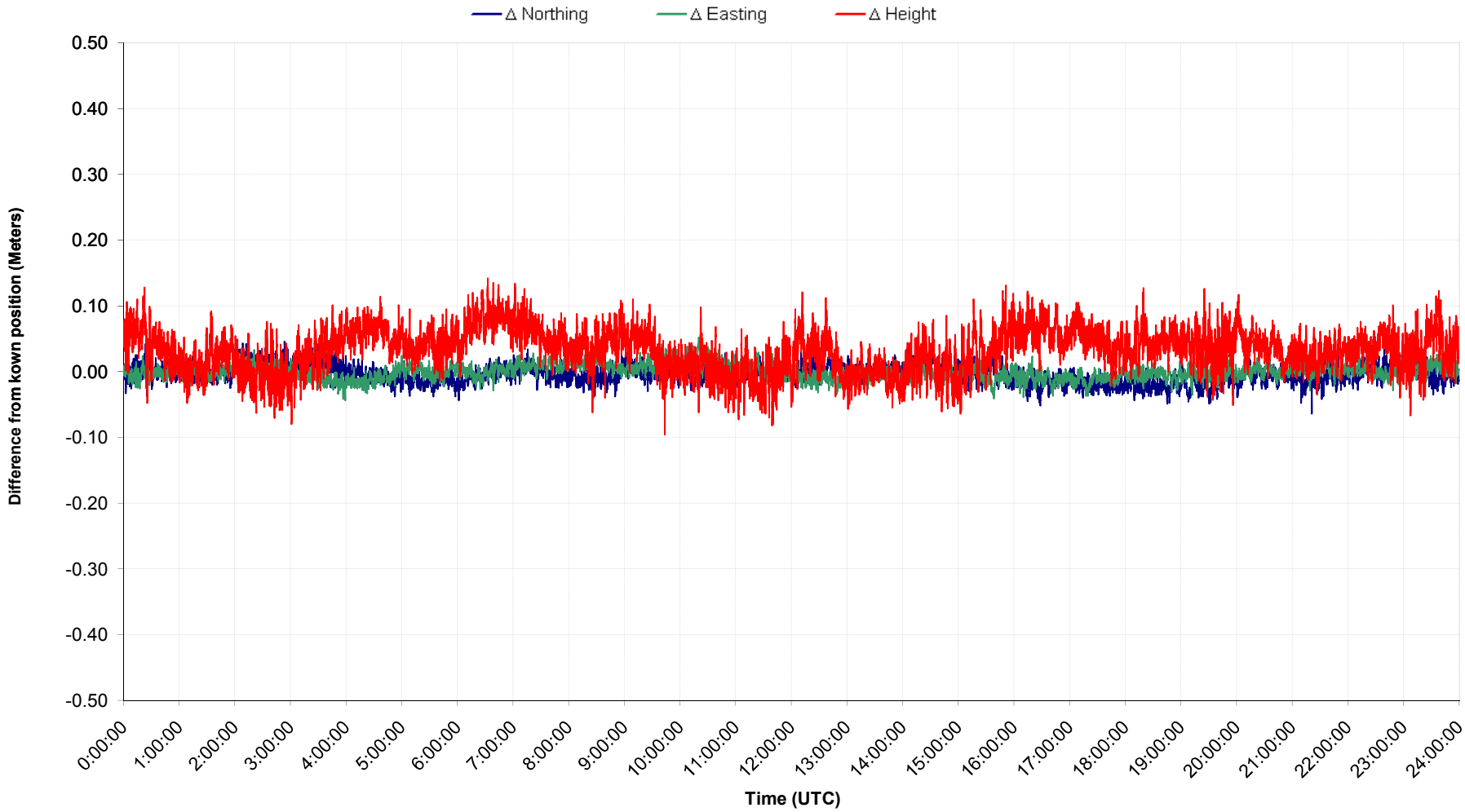
"EWELL"
GPS Base Station Site Verification

24 Hour PPK Solution Relative to Base Station Position

Date 11/4/2010
Locality Central Chesapeake Bay
Project OPR-N349-KR-10
Version GrafNav Version 8.30.1123
Datum NAD-83 UTM Zone 18 North, Meters

Base Station held for PPK processing "MDSI" (DN308) - CORS

Station Latitude 37 59 46.25232 N
Station Longitude 76 01 59.09814 W
Station Ellipsoid Height -31.911
Receiver Trimble NetR5
Antenna Type TRM41249.00



David Evans and Associates, Inc.
2801 SE Columbia Way, Suite 130
Vancouver, WA 98661
Phone: 360-314-3200
Fax: 360-314-3250

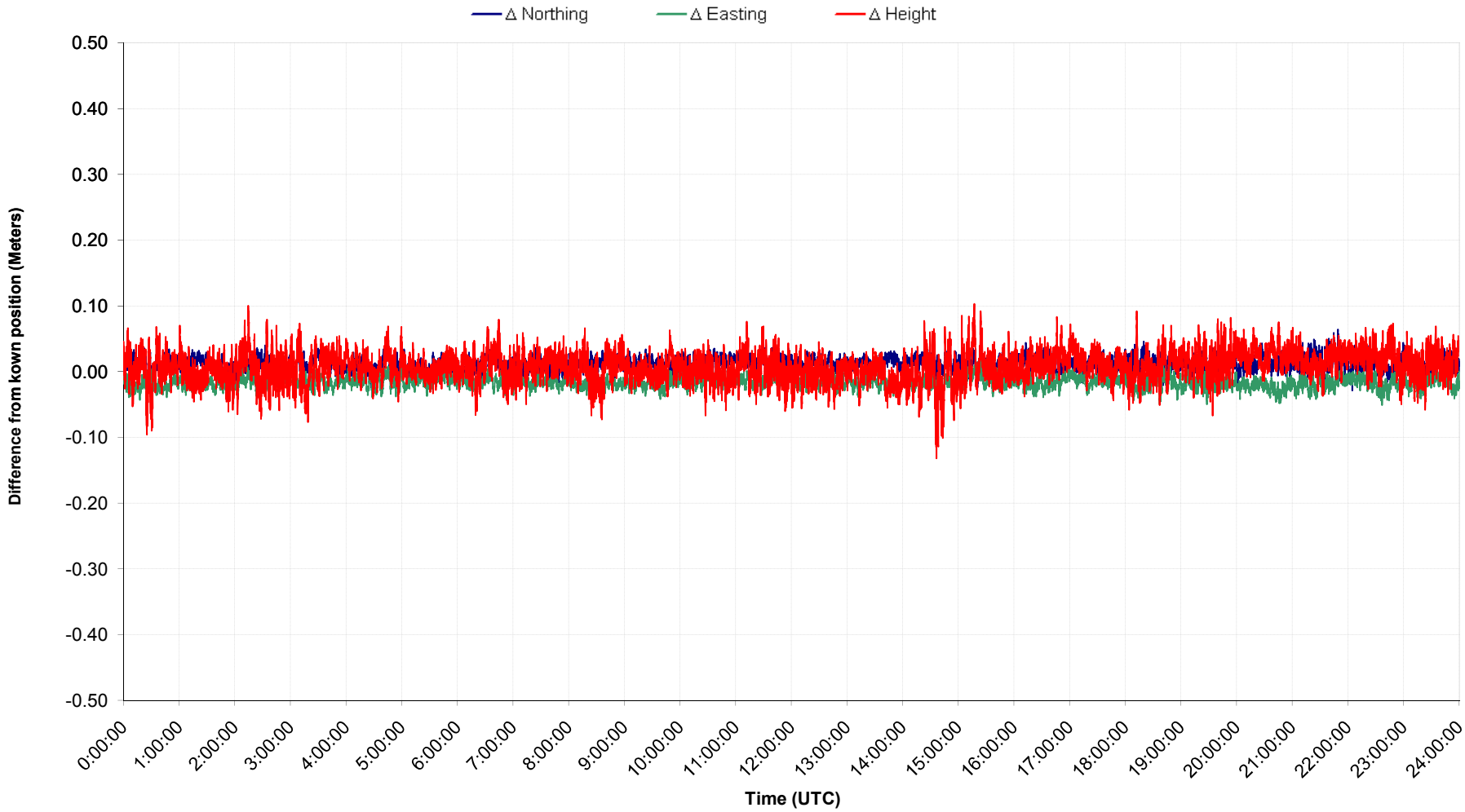
"EWELL"
GPS Base Station Site Verification

24 Hour PPK Solution Relative to Base Station Position

Date 11/4/2010
Locality Central Chesapeake Bay
Project OPR-N349-KR-10
Version GrafNav Version 8.30.1123
Datum NAD-83 UTM Zone 18 North, Meters

Base Station held for PPK processing "AIRD" (DN308) - precise

Station Latitude 37 59 46.25232 N
Station Longitude 76 01 59.09814 W
Station Ellipsoid Height -31.911
Receiver Trimble NetR5
Antenna Type TRM41249.00



OPR-E349-KR-10
WEEKLY BASE STATION CHECKS
"EWELL"

David Evans and Associates, Inc.
2801 SE Columbia Way, Ste 130
Vancouver, WA 98661
Phone: 360-314-3200
Fax: 360-314-3250

Reference Frame NAD83 (CORS96) Epoch 2002.00
Latitude 37° 59' 46.25232" (N)
Longitude 76° 01' 59.09814" (W)
Ellipsoid Height (m) -31.911

Datum NAD-83 UTM Zone 18 North, Meters
Northing (Y) 4205894.769
Easting (X) 409292.184
Derived from 24hr OPUS with rapid orbit 15941840.10o

INFORMATION			Base Station: EWELL OPUS Positon			Quality Check						Comments
Week of	DN	RINEX File	Northing	Easting	Ellipsoid Height	Northing Measured Seperation	Northing 95% CI	Easting Measured Seperation	Easting 95% CI	Ellipsoid Height Measured Seperation	Ellipsoid Height 95% CI	
7/4/2010	186	15891860.10o	4205894.769	409292.183	-31.920	0.000	PASS	-0.001	PASS	-0.009	PASS	precise
07/11/2010	192	15891920.10o	4205894.773	409292.175	-31.911	0.004	PASS	-0.009	PASS	0.000	PASS	rapid
07/18/2010	199	15891990.10o	4205894.770	409292.185	-31.915	0.001	PASS	0.001	PASS	-0.004	PASS	rapid
07/25/2010	206	15892060.10o	4205894.770	409292.185	-31.921	0.001	PASS	0.001	PASS	-0.010	PASS	rapid
08/01/2010	213	15892130.10o	4205894.769	409292.181	-31.929	0.000	PASS	-0.003	PASS	-0.018	PASS	rapid
08/08/2010	220	15892200.10o	4205894.768	409292.187	-31.907	-0.001	PASS	0.003	PASS	0.004	PASS	rapid
08/15/2010	227	15892270.10o	4205894.770	409292.183	-31.917	0.001	PASS	-0.001	PASS	-0.006	PASS	rapid
08/22/2010	234	15892340.10o	4205894.767	409292.187	-31.906	-0.002	PASS	0.003	PASS	0.005	PASS	rapid
08/29/2010	241	15892410.10o	4205894.769	409292.185	-31.909	0.000	PASS	0.001	PASS	0.002	PASS	precise
09/05/2010	248	15892480.10o	4205894.770	409292.185	-31.911	0.001	PASS	0.001	PASS	0.000	PASS	rapid
09/12/2010	255	15892550.10o	4205894.769	409292.184	-31.913	0.000	PASS	0.000	PASS	-0.002	PASS	rapid
09/19/2010	262	15892620.10o	4205894.767	409292.186	-31.912	-0.002	PASS	0.002	PASS	-0.001	PASS	rapid
09/26/2010	269	15892690.10o	4205894.771	409292.177	-31.917	0.002	PASS	-0.007	PASS	-0.006	PASS	rapid
10/05/2010	278	15892780.10o	4205894.772	409292.181	-31.907	0.003	PASS	-0.003	PASS	0.004	PASS	rapid
10/10/2010	283	15892830.10o	4205894.770	409292.184	-31.908	0.001	PASS	0.000	PASS	0.003	PASS	rapid
10/17/2010	290	15892900.10o	4205894.769	409292.185	-31.909	0.000	PASS	0.001	PASS	0.002	PASS	rapid
10/24/2010	297	15892970.10o	4205894.771	409292.184	-31.896	0.002	PASS	0.000	PASS	0.015	PASS	rapid
10/31/2010	304	15893040.10o	4205894.768	409292.185	-31.899	-0.001	PASS	0.001	PASS	0.012	PASS	rapid
11/07/2010	311	15893110A.10o	4205894.771	409292.184	-31.894	0.002	PASS	0.000	PASS	0.017	PASS	rapid
11/14/2010	318	15893180A.10o	4205894.771	409292.183	-31.896	0.002	PASS	-0.001	PASS	0.015	PASS	rapid
11/15/2010	319	15893190A.10o	4205894.771	409292.182	-31.893	0.002	PASS	-0.002	PASS	0.018	PASS	rapid (24hr splice of 2 files,5sec data gap)
				Average		0.001		-0.001		0.002		
				Standard Deviation		0.002		0.003		0.009		

Established Peak-to-Peak		95% Confidence
Northing	0.007	0.014
Easting	0.005	0.010
Ellipsoid Height	0.032	0.063

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = JANUARY 18, 2011
 AJ2122 ***********************************************************************
 AJ2122  CORS         -  This is a GPS Continuously Operating Reference Station.
 AJ2122  DESIGNATION -  CORBIN CORS ARP
 AJ2122  CORS_ID      -  CORB
 AJ2122  PID          -  AJ2122
 AJ2122  STATE/COUNTY-  VA/CAROLINE
 AJ2122  USGS QUAD    -
 AJ2122
 AJ2122                        *CURRENT SURVEY CONTROL
 AJ2122  ___________________________________________________________________
 AJ2122* NAD 83(CORS)-  38 12 07.82819(N)    077 22 24.57106(W)     ADJUSTED
 AJ2122* NAVD 88     -              **(meters)            **(feet)
 AJ2122  ___________________________________________________________________
 AJ2122  EPOCH DATE  -        2002.00
 AJ2122  X           -   1,097,041.982 (meters)                     COMP
 AJ2122  Y           -  -4,897,239.901 (meters)                     COMP
 AJ2122  Z           -   3,923,126.377 (meters)                     COMP
 AJ2122  ELLIP HEIGHT-          37.252 (meters)          (03/??/02) ADJUSTED
 AJ2122  GEOID HEIGHT-         -32.54  (meters)                     GEOID09
 AJ2122  HORZ ORDER  -  SPECIAL (CORS)
 AJ2122  ELLP ORDER  -  SPECIAL (CORS)
 AJ2122
 AJ2122.ITRF positions are available for this station.
 AJ2122.The coordinates were established by GPS observations
 AJ2122.and adjusted by the National Geodetic Survey in March 2002.
 AJ2122.The coordinates are valid at the epoch date displayed above.
 AJ2122.The epoch date for horizontal control is a decimal equivalence
 AJ2122.of Year/Month/Day.
 AJ2122
 AJ2122
 AJ2122.The PID for the CORS L1 Phase Center is AJ2123.
 AJ2122
 AJ2122.The XYZ, and position/ellipsoidal ht. are equivalent.
 AJ2122
 AJ2122.The ellipsoidal height was determined by GPS observations
 AJ2122.and is referenced to NAD 83.
 AJ2122
 AJ2122.The geoid height was determined by GEOID09.
 AJ2122
 AJ2122;                    North         East     Units Scale Factor Converg.
 AJ2122;SPC VA N     - 2,060,045.533 3,598,666.726   MT  0.99997449   +0 42 11.1
 AJ2122;SPC VA N     - 6,758,666.05 11,806,625.75   sFT  0.99997449   +0 42 11.1
 AJ2122
 AJ2122!             -  Elev Factor  x  Scale Factor =   Combined Factor
 AJ2122!SPC VA N     -   0.99999415  x   0.99997449  =   0.99996864
 AJ2122
 AJ2122                          SUPERSEDED SURVEY CONTROL
 AJ2122
 AJ2122  NAD 83(CORS)-  38 12 07.82820(N)    077 22 24.57106(W) AD(1997.00) c
 AJ2122  ELLIP H (03/??/01)   37.251  (m)                      GP(1997.00) c c
 AJ2122
 AJ2122.Superseded values are not recommended for survey control.
 AJ2122.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 AJ2122.See file dsdata.txt to determine how the superseded data were derived.
 AJ2122
 AJ2122_U.S. NATIONAL GRID SPATIAL ADDRESS: 18STH9217330910(NAD 83)
 AJ2122_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 AJ2122
```

```
AJ2122                          STATION DESCRIPTION
AJ2122
AJ2122'DESCRIBED BY NATIONAL GEODETIC SURVEY 2002
AJ2122'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
AJ2122'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
AJ2122'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
AJ2122'   FTP CORS.NGS.NOAA.GOV: CORS/COORD  AND  CORS/STATION_LOG
AJ2122'   HTTP://WWW.NGS.NOAA.GOV/CORS.
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = JANUARY 18, 2011
 DJ8939 ***********************************************************************
 DJ8939  CORS         -  This is a GPS Continuously Operating Reference Station.
 DJ8939  DESIGNATION -  DELDOT SOUTH CORS ARP
 DJ8939  CORS_ID      -  DEDS
 DJ8939  PID          -  DJ8939
 DJ8939  STATE/COUNTY-  DE/SUSSEX
 DJ8939  USGS QUAD    -  GEORGETOWN (1992)
 DJ8939
 DJ8939                        *CURRENT SURVEY CONTROL
 DJ8939  ___________________________________________________________________
 DJ8939* NAD 83(CORS)-  38 39 52.29188(N)    075 22 38.75868(W)     ADJUSTED
 DJ8939* NAVD 88     -              **(meters)            **(feet)
 DJ8939  ___________________________________________________________________
 DJ8939  EPOCH DATE  -        2002.00
 DJ8939  X           -   1,258,887.228 (meters)                     COMP
 DJ8939  Y           -  -4,825,150.621 (meters)                     COMP
 DJ8939  Z           -   3,963,298.506 (meters)                     COMP
 DJ8939  ELLIP HEIGHT-         -12.428 (meters)          (01/??/08) ADJUSTED
 DJ8939  GEOID HEIGHT-         -35.62  (meters)                     GEOID09
 DJ8939  HORZ ORDER  -  SPECIAL (CORS)
 DJ8939  ELLP ORDER  -  SPECIAL (CORS)
 DJ8939
 DJ8939.ITRF positions are available for this station.
 DJ8939.The coordinates were established by GPS observations
 DJ8939.and adjusted by the National Geodetic Survey in January 2008.
 DJ8939.The coordinates are valid at the epoch date displayed above.
 DJ8939.The epoch date for horizontal control is a decimal equivalence
 DJ8939.of Year/Month/Day.
 DJ8939
 DJ8939
 DJ8939.The PID for the CORS L1 Phase Center is DK5489.
 DJ8939
 DJ8939.The XYZ, and position/ellipsoidal ht. are equivalent.
 DJ8939
 DJ8939.The ellipsoidal height was determined by GPS observations
 DJ8939.and is referenced to NAD 83.
 DJ8939
 DJ8939.The geoid height was determined by GEOID09.
 DJ8939
 DJ8939;                    North         East     Units Scale Factor Converg.
 DJ8939;SPC DE       -    73,764.540   203,414.648   MT  0.99999514   +0 01 28.2
 DJ8939;SPC DE       -   242,009.16    667,369.56   sFT  0.99999514   +0 01 28.2
 DJ8939
 DJ8939!             -  Elev Factor  x  Scale Factor =   Combined Factor
 DJ8939!SPC DE       -   1.00000195  x   0.99999514  =   0.99999709
 DJ8939
 DJ8939                          SUPERSEDED SURVEY CONTROL
 DJ8939
 DJ8939.No superseded survey control is available for this station.
 DJ8939
 DJ8939_U.S. NATIONAL GRID SPATIAL ADDRESS: 18SVH6716379617(NAD 83)
 DJ8939_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 DJ8939
 DJ8939                          STATION DESCRIPTION
 DJ8939
 DJ8939'DESCRIBED BY NATIONAL GEODETIC SURVEY 2008
 DJ8939'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
 DJ8939'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
```

```
DJ8939'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DJ8939'   FTP CORS.NGS.NOAA.GOV: CORS/COORD  AND  CORS/STATION_LOG
DJ8939'   HTTP://WWW.NGS.NOAA.GOV/CORS.
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = JANUARY 18, 2011
 AI3494 ***********************************************************************
 AI3494  CORS         -  This is a GPS Continuously Operating Reference Station.
 AI3494  DESIGNATION -  HORN POINT ENVIRO CORS ARP
 AI3494  CORS_ID      -  HNPT
 AI3494  PID          -  AI3494
 AI3494  STATE/COUNTY-  MD/DORCHESTER
 AI3494  USGS QUAD    -  CHURCH CREEK (1982)
 AI3494
 AI3494                        *CURRENT SURVEY CONTROL
 AI3494  ______________________________________________________________________
 AI3494* NAD 83(CORS)-  38 35 19.71067(N)    076 07 49.33296(W)     ADJUSTED
 AI3494* NAVD 88     -              **(meters)            **(feet)
 AI3494  ______________________________________________________________________
 AI3494  EPOCH DATE  -        2002.00
 AI3494  X           -   1,196,627.004 (meters)                     COMP
 AI3494  Y           -  -4,846,359.975 (meters)                     COMP
 AI3494  Z           -   3,956,723.241 (meters)                     COMP
 AI3494  ELLIP HEIGHT-         -26.645 (meters)          (03/??/02) ADJUSTED
 AI3494  GEOID HEIGHT-         -34.88  (meters)                     GEOID09
 AI3494  HORZ ORDER  -  SPECIAL (CORS)
 AI3494  ELLP ORDER  -  SPECIAL (CORS)
 AI3494
 AI3494.ITRF positions are available for this station.
 AI3494.The coordinates were established by GPS observations
 AI3494.and adjusted by the National Geodetic Survey in March 2002.
 AI3494.The coordinates are valid at the epoch date displayed above.
 AI3494.The epoch date for horizontal control is a decimal equivalence
 AI3494.of Year/Month/Day.
 AI3494
 AI3494
 AI3494.The PID for the CORS L1 Phase Center is DI8696.
 AI3494
 AI3494.The XYZ, and position/ellipsoidal ht. are equivalent.
 AI3494
 AI3494.The ellipsoidal height was determined by GPS observations
 AI3494.and is referenced to NAD 83.
 AI3494
 AI3494.The geoid height was determined by GEOID09.
 AI3494
 AI3494;                    North         East     Units Scale Factor Converg.
 AI3494;SPC MD       -   102,722.214   475,762.970   MT  0.99996232   +0 32 44.9
 AI3494;SPC MD       -   337,014.46  1,560,899.01   sFT  0.99996232   +0 32 44.9
 AI3494
 AI3494!             -  Elev Factor  x  Scale Factor =   Combined Factor
 AI3494!SPC MD       -   1.00000418  x   0.99996232  =   0.99996650
 AI3494
 AI3494                          SUPERSEDED SURVEY CONTROL
 AI3494
 AI3494  NAD 83(CORS)-  38 35 19.71008(N)    076 07 49.33310(W) AD(1997.00) c
 AI3494  ELLIP H (01/??/00)  -26.640  (m)                       GP(1997.00) c c
 AI3494
 AI3494.Superseded values are not recommended for survey control.
 AI3494.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 AI3494.See file dsdata.txt to determine how the superseded data were derived.
 AI3494
 AI3494_U.S. NATIONAL GRID SPATIAL ADDRESS: 18SVH0155371753(NAD 83)
 AI3494_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 AI3494
```

```
AI3494                          STATION DESCRIPTION
AI3494
AI3494'DESCRIBED BY NATIONAL GEODETIC SURVEY 2002
AI3494'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
AI3494'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
AI3494'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
AI3494'   FTP CORS.NGS.NOAA.GOV: CORS/COORD  AND  CORS/STATION_LOG
AI3494'   HTTP://WWW.NGS.NOAA.GOV/CORS.
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = JANUARY 18, 2011
 DJ3041 ***********************************************************************
 DJ3041  CORS         -  This is a GPS Continuously Operating Reference Station.
 DJ3041  DESIGNATION -  MD SOLOMONS ISLAN CORS ARP
 DJ3041  CORS_ID      -  MDSI
 DJ3041  PID          -  DJ3041
 DJ3041  STATE/COUNTY-  MD/CALVERT
 DJ3041  USGS QUAD    -  SOLOMONS ISLAND (1987)
 DJ3041
 DJ3041                        *CURRENT SURVEY CONTROL
 DJ3041  ___________________________________________________________________
 DJ3041* NAD 83(CORS)-  38 19 08.07256(N)    076 27 13.95583(W)     ADJUSTED
 DJ3041* NAVD 88     -              **(meters)            **(feet)
 DJ3041  ___________________________________________________________________
 DJ3041  EPOCH DATE  -        2002.00
 DJ3041  X           -   1,173,610.188 (meters)                     COMP
 DJ3041  Y           -  -4,871,160.059 (meters)                     COMP
 DJ3041  Z           -   3,933,267.362 (meters)                     COMP
 DJ3041  ELLIP HEIGHT-         -16.774 (meters)          (09/??/07) ADJUSTED
 DJ3041  GEOID HEIGHT-         -34.40  (meters)                     GEOID09
 DJ3041  HORZ ORDER  -  SPECIAL (CORS)
 DJ3041  ELLP ORDER  -  SPECIAL (CORS)
 DJ3041
 DJ3041.ITRF positions are available for this station.
 DJ3041.The coordinates were established by GPS observations
 DJ3041.and adjusted by the National Geodetic Survey in September 2007.
 DJ3041.The coordinates are valid at the epoch date displayed above.
 DJ3041.The epoch date for horizontal control is a decimal equivalence
 DJ3041.of Year/Month/Day.
 DJ3041
 DJ3041
 DJ3041.The PID for the CORS L1 Phase Center is DJ3042.
 DJ3041
 DJ3041.The XYZ, and position/ellipsoidal ht. are equivalent.
 DJ3041
 DJ3041.The ellipsoidal height was determined by GPS observations
 DJ3041.and is referenced to NAD 83.
 DJ3041
 DJ3041.The geoid height was determined by GEOID09.
 DJ3041
 DJ3041;                    North         East     Units Scale Factor Converg.
 DJ3041;SPC MD       -    72,544.655   447,758.453   MT  0.99999676   +0 20 34.0
 DJ3041;SPC MD       -   238,006.92  1,469,020.86   sFT  0.99999676   +0 20 34.0
 DJ3041
 DJ3041!             -  Elev Factor  x  Scale Factor =   Combined Factor
 DJ3041!SPC MD       -   1.00000263  x   0.99999676  =   0.99999939
 DJ3041
 DJ3041                          SUPERSEDED SURVEY CONTROL
 DJ3041
 DJ3041.No superseded survey control is available for this station.
 DJ3041
 DJ3041_U.S. NATIONAL GRID SPATIAL ADDRESS: 18SUH7290542199(NAD 83)
 DJ3041_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 DJ3041
 DJ3041                          STATION DESCRIPTION
 DJ3041
 DJ3041'DESCRIBED BY NATIONAL GEODETIC SURVEY 2007
 DJ3041'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
 DJ3041'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
```

```
DJ3041'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DJ3041'   FTP CORS.NGS.NOAA.GOV: CORS/COORD  AND  CORS/STATION_LOG
DJ3041'   HTTP://WWW.NGS.NOAA.GOV/CORS.

*** retrieval complete.
Elapsed Time = 00:00:00
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = JANUARY 18, 2011
 DJ5202 ***********************************************************************
 DJ5202  CORS         -  This is a GPS Continuously Operating Reference Station.
 DJ5202  DESIGNATION -  VA GLOUCESTER PT CORS ARP
 DJ5202  CORS_ID      -  VAGP
 DJ5202  PID          -  DJ5202
 DJ5202  STATE/COUNTY-  VA/GLOUCESTER
 DJ5202  USGS QUAD    -  POQUOSON WEST (1983)
 DJ5202
 DJ5202                        *CURRENT SURVEY CONTROL
 DJ5202  ___________________________________________________________________
 DJ5202* NAD 83(CORS)-  37 14 55.00860(N)    076 29 57.73125(W)     ADJUSTED
 DJ5202* NAVD 88     -              **(meters)            **(feet)
 DJ5202  ___________________________________________________________________
 DJ5202  EPOCH DATE  -        2002.00
 DJ5202  X           -   1,186,732.985 (meters)                     COMP
 DJ5202  Y           -  -4,942,859.121 (meters)                     COMP
 DJ5202  Z           -   3,839,380.324 (meters)                     COMP
 DJ5202  ELLIP HEIGHT-         -19.809 (meters)          (11/??/07) ADJUSTED
 DJ5202  GEOID HEIGHT-         -35.76  (meters)                     GEOID09
 DJ5202  HORZ ORDER  -  SPECIAL (CORS)
 DJ5202  ELLP ORDER  -  SPECIAL (CORS)
 DJ5202
 DJ5202.ITRF positions are available for this station.
 DJ5202.The coordinates were established by GPS observations
 DJ5202.and adjusted by the National Geodetic Survey in November 2007.
 DJ5202.The coordinates are valid at the epoch date displayed above.
 DJ5202.The epoch date for horizontal control is a decimal equivalence
 DJ5202.of Year/Month/Day.
 DJ5202
 DJ5202
 DJ5202.The PID for the CORS L1 Phase Center is DJ5203.
 DJ5202
 DJ5202.The XYZ, and position/ellipsoidal ht. are equivalent.
 DJ5202
 DJ5202.The ellipsoidal height was determined by GPS observations
 DJ5202.and is referenced to NAD 83.
 DJ5202
 DJ5202.The geoid height was determined by GEOID09.
 DJ5202
 DJ5202;                    North         East     Units Scale Factor Converg.
 DJ5202;SPC VA S     - 1,103,453.318 3,677,475.378   MT  0.99994754   +1 12 51.2
 DJ5202;SPC VA S     - 3,620,246.43 12,065,183.80   sFT  0.99994754   +1 12 51.2
 DJ5202
 DJ5202!             -  Elev Factor  x  Scale Factor =   Combined Factor
 DJ5202!SPC VA S     -   1.00000311  x   0.99994754  =   0.99995065
 DJ5202
 DJ5202                          SUPERSEDED SURVEY CONTROL
 DJ5202
 DJ5202.No superseded survey control is available for this station.
 DJ5202
 DJ5202_U.S. NATIONAL GRID SPATIAL ADDRESS: 18SUG6702323505(NAD 83)
 DJ5202_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 DJ5202
 DJ5202                          STATION DESCRIPTION
 DJ5202
 DJ5202'DESCRIBED BY NATIONAL GEODETIC SURVEY 2007
 DJ5202'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
 DJ5202'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
```

```
DJ5202'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DJ5202'   FTP CORS.NGS.NOAA.GOV: CORS/COORD  AND  CORS/STATION_LOG
DJ5202'   HTTP://WWW.NGS.NOAA.GOV/CORS.
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = JANUARY 18, 2011
 DI2269 ***********************************************************************
 DI2269  CORS         -  This is a GPS Continuously Operating Reference Station.
 DI2269  DESIGNATION -  WALLOPS ISLAND CORS ARP
 DI2269  CORS_ID      -  VAWI
 DI2269  PID          -  DI2269
 DI2269  STATE/COUNTY-  VA/ACCOMACK
 DI2269  USGS QUAD    -  CHINCOTEAGUE WEST (1989)
 DI2269
 DI2269                        *CURRENT SURVEY CONTROL
 DI2269  ___________________________________________________________________
 DI2269* NAD 83(CORS)-  37 56 03.49983(N)    075 28 15.94949(W)     ADJUSTED
 DI2269* NAVD 88     -              **(meters)            **(feet)
 DI2269  ___________________________________________________________________
 DI2269  EPOCH DATE  -        2002.00
 DI2269  X           -   1,263,598.246 (meters)                     COMP
 DI2269  Y           -  -4,875,823.836 (meters)                     COMP
 DI2269  Z           -   3,899,681.648 (meters)                     COMP
 DI2269  ELLIP HEIGHT-         -22.315 (meters)          (11/??/06) ADJUSTED
 DI2269  GEOID HEIGHT-         -36.49  (meters)                     GEOID09
 DI2269  HORZ ORDER  -  SPECIAL (CORS)
 DI2269  ELLP ORDER  -  SPECIAL (CORS)
 DI2269
 DI2269.ITRF positions are available for this station.
 DI2269.The coordinates were established by GPS observations
 DI2269.and adjusted by the National Geodetic Survey in November 2006.
 DI2269.The coordinates are valid at the epoch date displayed above.
 DI2269.The epoch date for horizontal control is a decimal equivalence
 DI2269.of Year/Month/Day.
 DI2269
 DI2269
 DI2269.The PID for the CORS L1 Phase Center is DI2270.
 DI2269
 DI2269.The XYZ, and position/ellipsoidal ht. are equivalent.
 DI2269
 DI2269.The ellipsoidal height was determined by GPS observations
 DI2269.and is referenced to NAD 83.
 DI2269
 DI2269.The geoid height was determined by GEOID09.
 DI2269
 DI2269;                    North         East     Units Scale Factor Converg.
 DI2269;SPC VA S     - 1,181,944.926 3,766,225.935   MT  0.99999425   +1 50 17.9
 DI2269;SPC VA S     - 3,877,764.31 12,356,359.59   sFT  0.99999425   +1 50 17.9
 DI2269
 DI2269!             -  Elev Factor  x  Scale Factor =   Combined Factor
 DI2269!SPC VA S     -   1.00000350  x   0.99999425  =   0.99999775
 DI2269
 DI2269                          SUPERSEDED SURVEY CONTROL
 DI2269
 DI2269.No superseded survey control is available for this station.
 DI2269
 DI2269_U.S. NATIONAL GRID SPATIAL ADDRESS: 18SVG5860198630(NAD 83)
 DI2269_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
 DI2269
 DI2269                          STATION DESCRIPTION
 DI2269
 DI2269'DESCRIBED BY NATIONAL GEODETIC SURVEY 2006
 DI2269'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
 DI2269'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
```

```
DI2269'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
DI2269'   FTP CORS.NGS.NOAA.GOV: CORS/COORD  AND  CORS/STATION_LOG
DI2269'   HTTP://WWW.NGS.NOAA.GOV/CORS.
```

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
DATABASE =  ,PROGRAM = datasheet, VERSION = 7.85
1        National Geodetic Survey,   Retrieval Date = JANUARY 18, 2011
 AI3289 ***********************************************************************
 AI3289  CORS         -  This is a GPS Continuously Operating Reference Station.
 AI3289  DESIGNATION -  VIRGINIA INSTITUT CORS ARP
 AI3289  CORS_ID      -  VIMS
 AI3289  PID          -  AI3289
 AI3289  STATE/COUNTY-  VA/ACCOMACK
 AI3289  USGS QUAD    -  WACHAPREAGUE (1974)
 AI3289
 AI3289                        *CURRENT SURVEY CONTROL
 AI3289  ______________________________________________________________________
 AI3289* NAD 83(CORS)-  37 36 30.04548(N)    075 41 13.20712(W)     ADJUSTED
 AI3289* NAVD 88     -              **(meters)            **(feet)
 AI3289  ______________________________________________________________________
 AI3289  EPOCH DATE  -        2002.00
 AI3289  X           -   1,250,693.276 (meters)                     COMP
 AI3289  Y           -  -4,902,018.667 (meters)                     COMP
 AI3289  Z           -   3,871,080.404 (meters)                     COMP
 AI3289  ELLIP HEIGHT-         -27.739 (meters)          (03/??/02) ADJUSTED
 AI3289  GEOID HEIGHT-         -36.66  (meters)                     GEOID09
 AI3289  HORZ ORDER  -  SPECIAL (CORS)
 AI3289  ELLP ORDER  -  SPECIAL (CORS)
 AI3289
 AI3289.ITRF positions are available for this station.
 AI3289.The coordinates were established by GPS observations
 AI3289.and adjusted by the National Geodetic Survey in March 2002.
 AI3289.The coordinates are valid at the epoch date displayed above.
 AI3289.The epoch date for horizontal control is a decimal equivalence
 AI3289.of Year/Month/Day.
 AI3289
 AI3289
 AI3289.The PID for the CORS L1 Phase Center is AI3290.
 AI3289
 AI3289.The XYZ, and position/ellipsoidal ht. are equivalent.
 AI3289
 AI3289.The ellipsoidal height was determined by GPS observations
 AI3289.and is referenced to NAD 83.
 AI3289
 AI3289.The geoid height was determined by GEOID09.
 AI3289
 AI3289;                    North         East     Units Scale Factor Converg.
 AI3289;SPC VA S     - 1,145,195.887 3,748,332.627   MT  0.99995421   +1 42 26.2
 AI3289;SPC VA S     - 3,757,196.84 12,297,654.63   sFT  0.99995421   +1 42 26.2
 AI3289
 AI3289!             -  Elev Factor  x  Scale Factor =   Combined Factor
 AI3289!SPC VA S     -   1.00000435  x   0.99995421  =   0.99995856
 AI3289
 AI3289                          SUPERSEDED SURVEY CONTROL
 AI3289
 AI3289  NAD 83(CORS)-  37 36 30.04563(N)    075 41 13.20742(W) AD(1997.00) c
 AI3289  ELLIP H (07/??/00)  -27.738  (m)                       GP(1997.00) c c
 AI3289  NAD 83(CORS)-  37 36 30.04497(N)    075 41 13.20766(W) AD(1997.00) c
 AI3289  ELLIP H (01/??/00)  -27.624  (m)                       GP(1997.00) c c
 AI3289
 AI3289.Superseded values are not recommended for survey control.
 AI3289.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
 AI3289.See file dsdata.txt to determine how the superseded data were derived.
 AI3289
 AI3289_U.S. NATIONAL GRID SPATIAL ADDRESS: 18SVG3936362583(NAD 83)
```

```
AI3289_MARKER: STATION IS THE ANTENNA REFERENCE POINT OF THE GPS ANTENNA
AI3289
AI3289                          STATION DESCRIPTION
AI3289
AI3289'DESCRIBED BY NATIONAL GEODETIC SURVEY 2002
AI3289'STATION IS A GPS CORS.  LATEST INFORMATION INCLUDING POSITIONS AND
AI3289'VELOCITIES ARE AVAILABLE IN THE COORDINATE AND LOG FILES ACCESSIBLE
AI3289'BY ANONYMOUS FTP OR THE WORLDWIDE WEB.
AI3289'   FTP CORS.NGS.NOAA.GOV: CORS/COORD  AND  CORS/STATION_LOG
AI3289'   HTTP://WWW.NGS.NOAA.GOV/CORS.

*** retrieval complete.
Elapsed Time = 00:00:00
```

APPENDIX V
NWLON VERIFICATION RESULTS

Abstract of Leveling

Lewisetta, VA - Verification Levels
863-5750

Recovered tidal bench marks:	3	R 462 1971, 863 5750 TIDAL 5, Q 462
Established tidal bench marks:	0	
Primary bench mark:		**R 462**

Date	8/31/2010
Level/SN	Wild NA 540706
Observer	Tobin Guthrie
Rod person	Eliot Dasler
C Factor (mm/m)	0.025

Level Abstract

(all values in meters)

BM Name			Diff. of Elevation (DE)				MLLW Datum	NTDE 1983-2001
From	To	Distance	Forward	Reverse	Closure	Mean DE	Elevation	Benchmark
							1.4200	**R 462**
R 462	863 5750 TIDAL 5	73.6	0.0480	-0.0473	0.0007	0.0477	1.4677	863 5750 TIDAL 5
R 462	Q 462	70.8	-0.2000	0.2003	0.0003	-0.2002	1.2199	Q 462

Compiled by: Tobin Guthrie 9/7/10 *date*

Verified by: Ben Hocker 9/7/10 *date*

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NOAA 0000-0015

OPR-E349-KR-10
CENTRAL CHESAPEAKE BAY

2

TLG
JLD

90° +/-

PEG TEST

8/30/2010

BALLANCED

STA	+	HI	-	EL
A				1000.0 mm
	T 1087			
	M 0887			
	B 0688			
	AVE 0887.3			
		1887.3		
(MID)				
B			T 1795	
			M 1595	
			B 1395	
			AVE 1595	
				0292.3

Level SN# 540706

Rod SN# T41998

UNBALLANCED

STA	+	HI	-	EL
A				1000.0
	T 1047			
	M 1036			
	B 1025			
	AVE 1036			
		2036		
(NEAR "A")				
B			2138	
			1745	
			1354	
			1745.7	
				0290.3

CLOSURE 0.02551 mm/M

4 T TLG

ELD LEWISETTA LEVELS 8/31/2010

STA	+	HI	-	ELEV	
R462 1971				1420	Rec MLLW
	T) 1807				
	M) 1621				
	B) ~~1507~~ 1434				
	AVE 1620 67				
		3040 67			
			T) 1754		
			M) 1573		
			B) 1391		
			AVE 1572 67		
No. 5				1468	MEAS
				1474	Rec
	T) 1643			0014	DIFF'N
	M) 1461				
	B) 1280				
	AVE 1461 3				
		2929 3			
			T) 1694		
			M) 1509		
			B) 1323		
			AVE 1508 67		
				1420 63	MEAS
				1420	Rec
				0000 63	Closure

LEVEL SN# 540706

Rod SN# T4998

STA	+	HI	-	ELEV	
R462 1971				1420	Rec MLLW
	T) 1660				
	M) 1472				
	B) 1284				
	AVE 1472				
		2892			
			T) 1838		
			M) 1672		
			B) 1506		
			AVE 1672		
~~R462~~				1220	meas
				1216 ~~1289~~	Rec
				0004 ~~0064~~	DIFF'N
	T) 1804				
	M) 1638				
	B) 1471				
	AVE 1637 67				
		2857 67			
			T) 1625		
			M) 1437		
			B) 1250		
			AVE 1437 3		
				1420 37	
				0000 37	Closure

6 TLG
ELD

GPS STATIC OBSERVATION 8/31/2010

TC R462 1971

Found BRASS DISK STAMPED "R462 1971" in hole 0.3 M Below GRADE w/ ORANGE NOAA CARSONITE Witness Post

HI: 2.000 m. Fixed HT TRIPOD
0.08546 m FROM ANTENNA BASE TO Ph.C.

START: ~~1851~~ 1902 UTC / ~~2:51~~ 3:02 pm EDT
END: 2305 UTC / 7:05 pm EDT

ANTENNA: Zephyr Geodetic SN# 1441003 78
Receiver: Trimble R7 SN# 4915K34863
CONTROLLER: Trimble TSC2 SN# 55ARC51260

File Name: 48632433

TTLG
ELD

LEWISETTA Levels

STA	+	HI	-	ELEV
No. 5				1468 MEAS
	T) 1573			
	M) 1458			
	B) 1343			
	AVE 1458			
		2926		
			T ~~1458~~ 1527	
			M 1429	
			B 1330	
			AVE 1428 67	
TP 1 ~~No 2~~				1497 3
	T 1579			
	M 1482			
	B 1385			
	AVE 1482			
		2979 3		
			T 1860	
			M 1758	
			B 1656	
			AVE 1758	
Q462 ~~No 3~~				1221 3

STA	+	HI	-	ELEV
Q462 ~~No 3~~				1221 3
	T 1909			
	M 1807			
	B 1705			
	AVE 1807			
		3028 3		
			T 1628	
			M 1531	
			B 1434	
			AVE 1531	
TP 2				1497 3
	T 1584			
	M 1483			
	B 1382			
	AVE 1483			
		2980 3		
			T 1624	
			M 1512	
			B 1401	
			AVE 1512 3	
No 5				1468 MEAS
				closure 0000 MM

NOAA FORM 78-29
(12-75)

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

PRECISE LEVELING

THREE - WIRE

FORWARD RUN (See reverse for BACKWARD RUN)

TIDE STATION: LEWISETTA

NUMBER:

SHEET 11 OF 14

FROM B.M.: PEG TEST

TO B.M.: BALANCE

WEATHER: CLEAR 90° +/-

TIME:

DATE: 8/30/2010

ORDER, CLASS

BACKSIGHTS						FORESIGHTS				
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	REMARKS
										BS "A"
	1087					1795				FS "B"
	0987		200			1595		200		
	0688	0887½	199	399		1395	1595	200	400	
	2662					4785				

FORWARD Run....	-0.708 M
BACKWARD RUN....	-0.709 M
DIFFERENCE.....	0.001 M
DISTANCE.....	79.9 M

SUPERCEDES NOAA FORM 75-29, 11-72 EDITION WHICH IS OBSOLETE.

BACKWARD RUN (See front side for *FORWARD RUN* and other information)

WEATHER: CLEAR 90° +/-

TIME:

DATE: 8/30/2010

BACKSIGHTS						FORESIGHTS				REMARKS
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	DEG TEST
										UNBALANCED
										BS = "A"
	1047					2138				FS = "B"
	1036		11			1745		393		
	1025	1036	11	22		1354	1745 47	392	784	
	3108					5237				

NOAA FORM 75-29. 12 - 75

NOAA FORM 76-29
(12-75)

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

PRECISE LEVELING

THREE - WIRE

FORWARD RUN (See reverse for BACKWARD RUN)

TIDE STATION: LEWISETTA

NUMBER:

SHEET: 12 OF 14

FROM B.M.: R462

TO B.M.: No. 5

WEATHER: Sunny 90° +/-

TIME:

DATE: 8/31/2010

_____ ORDER, CLASS _____

BACKSIGHTS						FORESIGHTS				
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	REMARKS
										BS = R462
	1807					1754				FS = No. 5
	1621		186			1573		181		
	1434	1620 67	187	373		1391	1572 67	182	363	PARTY CHIEF: T. GUTHRIE
	4862					4718				OBSERVER: T. GUTHRIE
										Rodman: E. DASLER
										INSTRUMENT: (WILD NA SN# 540706
										Rod SN# T4998

FORWARD Run....	0.048 m
BACKWARD RUN....	-0.048 m
DIFFERENCE.....	Ø m
DISTANCE.....	73.6 m

SUPERCEDES NOAA FORM 75-29, 11-72 EDITION WHICH IS OBSOLETE.

BACKWARD RUN (See front side for *FORWARD RUN* and other information)

WEATHER

TIME

DATE 8/31/2010

BACKSIGHTS						FORESIGHTS				REMARKS
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	
										BS = No. 5
	1643					1694				FS = R 462
	1461		182			1509		185		
	1280	1461 3	181	363		1323	1508 67	186	371	
	4384					4526				

NOAA FORM 75-29. 12 - 75

NOAA FORM 75-29
(12-75)

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

PRECISE LEVELING

THREE - WIRE

FORWARD RUN (See reverse for BACKWARD RUN)

TIDE STATION: LEWISETTA

NUMBER:

SHEET 13 OF 14

FROM B.M.: R 462

TO B.M.: Q 462

WEATHER: SUNNY 90° +/-

TIME:

DATE: 8/31/2010

_____ ORDER, CLASS _____

BACKSIGHTS						FORESIGHTS				
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	REMARKS
										BS = R 462
	1660					1838				FS = Q 462
	1472		188			1672		166		
	1284	1472	188	376		1506	1672	166	332	
	4416					5016				

FORWARD Run....	- 0.200 m
BACKWARD RUN....	+0.201 m
DIFFERENCE.....	0.001 m
DISTANCE.....	70.8 m

SUPERCEDES NOAA FORM 75-29, 11-72 EDITION WHICH IS OBSOLETE.

BACKWARD RUN (See front side for *FORWARD RUN* and other information)						WEATHER				TIME	DATE 8/31/2010
BACKSIGHTS						FORESIGHTS				REMARKS	
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS		
										BS = Q462	
	1804					1625				FS = R462	
	1638		166			1437		188			
	1471	1637^{67}	167	333		1250	1437^{3}	187	375		
	4913					4312					

NOAA FORM 75-29, 12 - 75

NOAA FORM 75-29
(12-75)

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

PRECISE LEVELING

THREE - WIRE

FORWARD RUN (See reverse for BACKWARD RUN)

TIDE STATION: LEWISETTA

NUMBER:

SHEET 14 OF 14

FROM B.M.: No. 5

TO B.M.: Q 462

WEATHER: SUNNY 90°+/-

TIME:

DATE: 8/31/2010

_____ ORDER, CLASS _____

BACKSIGHTS						FORESIGHTS				
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	REMARKS
										BS = No. 5
	1573					1527				FS = TP 1
	1458		115			1429		98		
	1343	1458	115	230		1330	1428.67	99	197	
	4374					4286				
	1579					1860				BS = TP 1
	1482		97			1758		102		FS = Q462
	1385	1482	97	194		1656	1758	102	204	
	4446					5274				

FORWARD Run....	-0.247 m
BACKWARD RUN....	+0.247 m
DIFFERENCE.....	Ø
DISTANCE.....	82.5 m

SUPERCEDES NOAA FORM 75-29, 11-72 EDITION, WHICH IS OBSOLETE.

BACKWARD RUN (See front side for *FORWARD RUN* and other information)						WEATHER				TIME	DATE 8/31/2010
BACKSIGHTS						FORESIGHTS				REMARKS	
No. of Station	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS	ROD TEMP	THREAD READING	MEAN	THREAD INTERVAL	SUM OF INTERVALS		
										BS = Q 462	
	1909					1628				FS = TP 2	
	1807		102			1531		97			
	1705	1807	102	204		1434	1531	97	194		
	5421					4593					
	1584					1624				BS = TP 2	
	1483		101			1512		112		FS = No. 5	
	1382	1483	101	202		1401	1512 3	111	223		
	4449					4537					

NOAA FORM 75-29. 12 - 75

TIDE STATION SITE: 8635750 Lewisetta, Potomaca River, Virginia

GMT Date: DN 243

Sheet 1 / 1

Local Date: August 31, 2010 S M (T) W TH F SA

Wave Height: Ø meters

Staff Shot Instructions:
Record UTC time and Rod Cut at a six min. interval 00:06, 00:12, 00:18, 00:24, 00:30, 00:36, 00:42, 00:48, 00:54 etc. Use a handheld GPS for time, it's important to read rod at the same time the gauge is taking a measurement. Rod cut is water level on staff in the water, to the centimeter. Rod Read is read with the level - instrument at the same time as the Rod Cut, to the millimeter, basicly a front sight. Single Wire leveling.

Bench Mark = No. 5

Bench Mark Elev. = 1.2210

Backsight = 1493

HI = 2714

Foresight = 1493

Bench Mark Elev. = 0.000

Closure = Ø 0.000

Water Elevation = HI - Rod Read + Rod Cut
UTC = Eastern +4 hours

	UTC Time	Rod Read	Rod Cut	MLLW Water Elevation	MLLW Stage Reading Gauge 1	Stage Reading Gauge 2	Water Elev Minus Stage Read Gauge 1	Water Elev Minus Stage Read Gauge 2
1	21:24	2827	0375	0262		1493 BS ✓		
2	21:30	2826	0380	0268		1493 BS ✓		
3	21:36	2825	0380	0269		1493 BS ✓		
4	21:42	2825	0385	0274		1493 BS ✓		
5	21:48	2825	0390	0279		1493 BS ✓		
6	21:54	2825	0395	0284		1493 BS ✓		
7	22:00	2825	0400	0289		1493 BS ✓		
8	22:06	2825	0400	0289		1493 BS ✓		
9	22:12	2826	0405	0293		1493 BS ✓		
10	22:18	2825	0410	0299		1493 BS ✓		
11								
12								
13								
14								
15								
						Average:		
						Standard Deviation:		

Comments:

NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable: __ FBN __ CBN __ PAC __ SAC ✓ BM) R 462 1971		Station PID, if any: GV0156	Date (UTC): DN243
General Location: LEWISETTA	Airport ID, if any:	Station 4-Character ID: R462	Day of Year: 8/31/2010
Project Name: NOAA CENTRAL CHESAPEAKE BAY	Project Number: NOAA00000015 GPS-	Station Serial # (SSN):	Session ID:(A,B,C etc)

NAD83 Latitude	NAD83 Longitude	NAD83 Ellipsoidal Height	Agency Full Name: DAVID EVANS & ASSOC.
° ' "	° ' "	meters	Operator Full Name: TOBIN GUTHRIE ELIOT DASLER
Observation Session Times (UTC): Sched. Start _____ Stop _____ 1902 UTC 2305 UTC	Epoch Interval= 1 Seconds	NAVD88 Orthometric Ht. meters	Phone #: (360) 314-3200
Actual Start 1502 EDT Stop 1905 EDT	Elevation Mask = _____ Degrees	GEOID99 Geoid Height meters	e-mail address: TLGRDEA@INC.COM

Receiver Brand & Model: TRIMBLE R7
P/N:
S/N: 4915 K 34863
Firmware Version:
☐ CamCorder Battery, ☐ 12V DC, ☐ 110V AC, ☐ Other

Antenna Code*, Brand & Model: ZEPHYR Geodetic
P/N:
S/N: 144100378
Cable Length, meters:
Vehicle is Parked _____ meters _____(direction) from antenna.

Antenna plumb before session?	(Y/N)	Circle Yes or No -If no, explain
Antenna plumb after session?	(Y/N)	
Antenna oriented to true North?	(Y/N)	
Weather observed at antenna ht.	(Y/N)	
Antenna ground plane used?	(Y/N)	
Antenna radome used?	(Y/N)	If yes, describe. Use Vis. form
Eccentric occupation (>0.5 mm)?	(Y/N)	
Any obstructions above 10°?	(Y/N)	
Radio interference source nearby	(Y/N)	

Tripod or Antenna Mount: Check one:
☒ Fixed-Leg Tripod, ☐ Collapsible-leg tripod ☐ Fixed Mount
Brand & Model:
P/N:
S/N:
Last Adjustment date:

Psychrometer (if used) Brand & Model:
P/N:
S/N:
Last Calibration or check Date:

** ANTENNA HEIGHT **

	Before Session Begins: Meters	Feet	After Session Ends: Meters	Feet
A= Datum point to Top of Tripod (Tripod Height)	2.000 m		2.000 m	
B= Additional offset to ARP if any (Tribrach/Spacer)	/		/	
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)	2.08546 m		2.08546 m	

Meters = Feet x (0.3048)
Height Entered Into Receiver = 2.000 meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model:
S/N:

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before	00100	1902							
Middle	00100	2200							
After	00100	2305							

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

FOUND BRASS DISK STAMPED "R 462 1971" IN hole 0.3 m BELOW GRADE w/ ORANGE NOAA CARSONITE WITNESS POST.

R 462
1971

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s):
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ☐ Attached ☐ Submitted earlier
Visibility Obstruction Form: ☐ Attached ☐ Submitted earlier
Photographs of Station: ☐ Attached ☐ Submitted earlier
Pencil Rubbing of Mark: ☐ Attached

LOG CHECKED BY:

Table of Weather Codes

CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	did not occur	Good, over 15 miles	Normal, 32° F- 80°F	Clear, below 20%	Calm, under 5mph (8km/h)
1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)

Examples: 00000 = No problem, good visibility, normal temp, clear, calm wind 12121 = Problems, poor visibility, hot, overcast, moderate wind

Station Location Sketch and Visibility Diagram

Location / Airport Name and ID LEWISETTA

Project NOAA CENTRAL CHESAPEAKE DN 2413

Station Designation R462

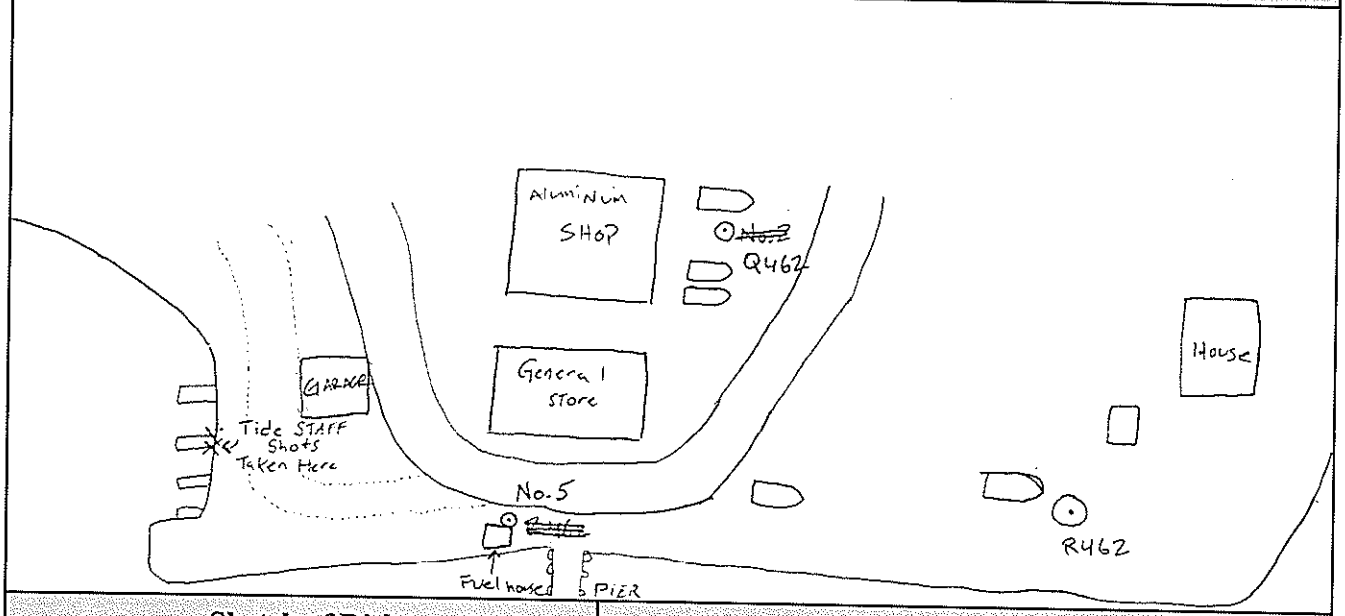
PID GV0156

Date 8/31/2010

Circle all applicable:
PACS SACS (BM) FBN CBN OTHER_____

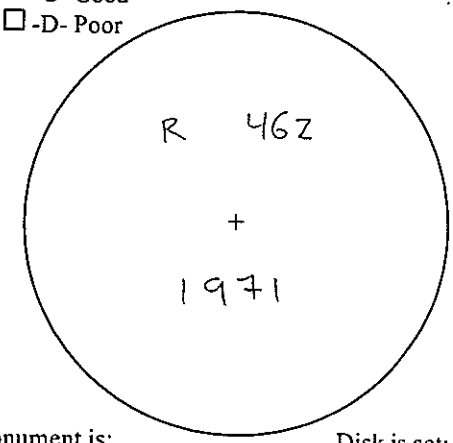
Observer & TOBIN GUTHRIE / ELIOT DASLER
Organization DAVID EVANS & ASSOCIATES

Station Location Sketch



Sketch of Disk

Monument Stability Quality: ☐ Photos Available
- ☐ -A- Most stable
- ☐ -B- Excellent
- ☐ -C- Good
- ☐ -D- Poor

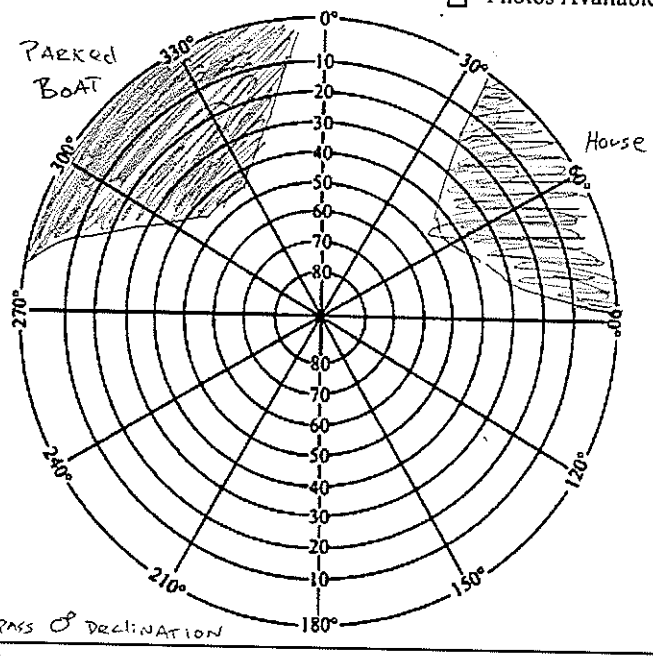


Monument is:
- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☐ Projecting ___ cm

Disk is set:
- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

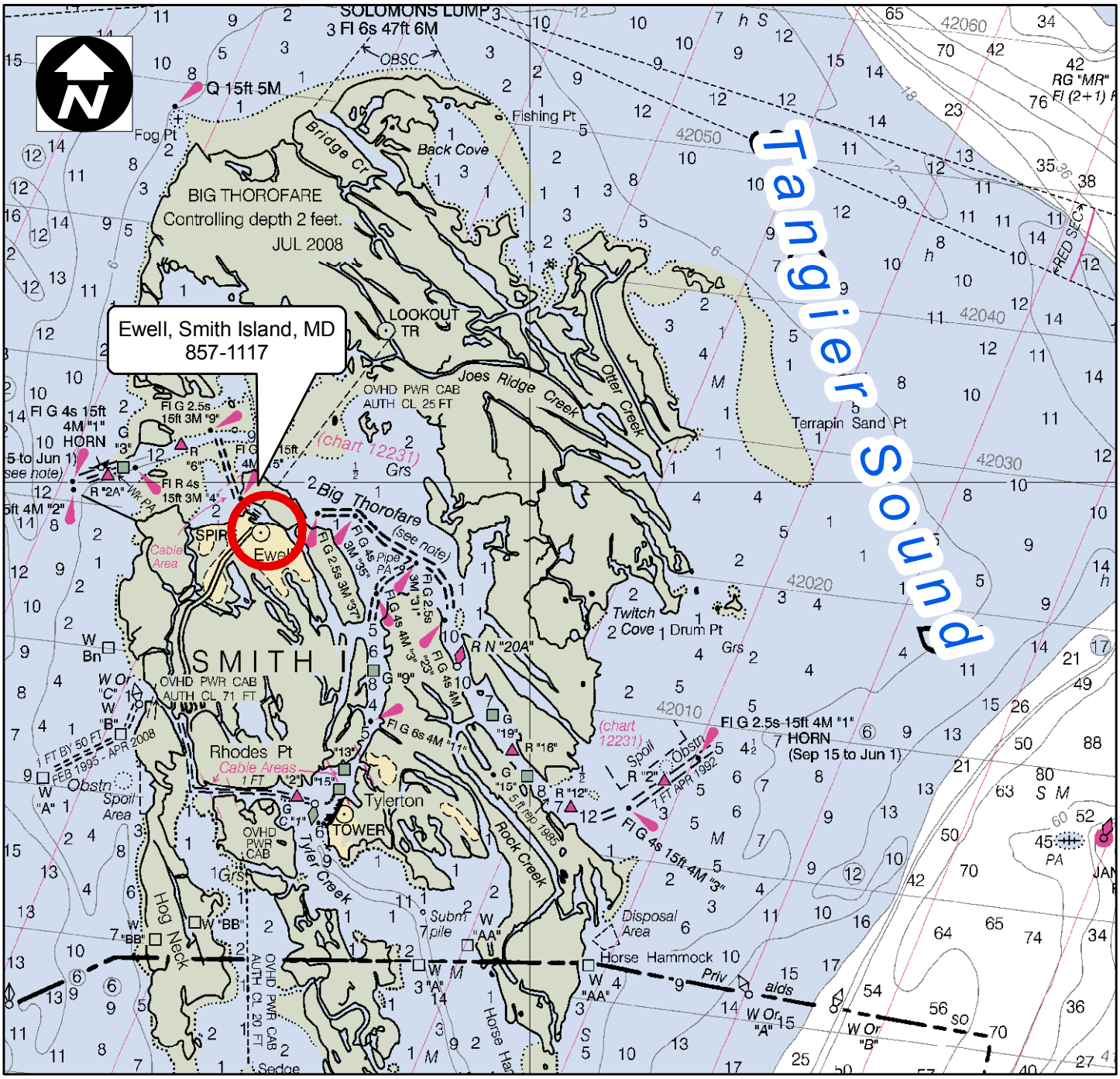
☐ No Obstructions above 10° ☐ Photos Available



```
 FILE: 48632433_Adj.10o 000082155

                            NGS OPUS SOLUTION REPORT
                            ========================

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

      USER: bxho@deainc.com                          DATE: September 20, 2010
RINEX FILE: 4863243t.10o                             TIME: 16:46:19 UTC


  SOFTWARE: page5  0909.08 master29.pl 100910      START: 2010/08/31  19:02:00
 EPHEMERIS: igs15992.eph [precise]                  STOP: 2010/08/31  23:03:30
  NAV FILE: brdc2430.10n                        OBS USED:  9112 /  9359   :  97%
  ANT NAME: TRM55971.00     NONE             # FIXED AMB:    39 /    44   :  89%
ARP HEIGHT: 2.000                             OVERALL RMS: 0.013(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2010.6654)

         X:      1177974.422(m)   0.033(m)           1177973.675(m)   0.033(m)
         Y:     -4892880.708(m)   0.086(m)          -4892879.247(m)   0.086(m)
         Z:      3905063.542(m)   0.056(m)           3905063.422(m)   0.056(m)

       LAT:   37 59 45.19730      0.019(m)        37 59 45.22609      0.019(m)
     E LON:  283 32 11.42177      0.044(m)       283 32 11.40602      0.044(m)
     W LON:   76 27 48.57823      0.044(m)        76 27 48.59398      0.044(m)
    EL HGT:          -33.734(m)   0.100(m)              -35.065(m)   0.100(m)
 ORTHO HGT:            1.154(m)   0.171(m) [NAVD88 (Computed using GEOID09)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 18)         SPC (4502 VA S)
Northing (Y) [meters]     4206369.220          1186438.470
Easting (X)  [meters]      371498.550          3678868.428
Convergence  [degrees]    -0.90105731           1.23600612
Point Scale                0.99980337           1.00000546
Combined Factor            0.99980867           1.00001076

US NATIONAL GRID DESIGNATOR: 18SUH7149806369(NAD 83)


                            BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
AI3494 HNPT HORN POINT ENVIRO CORS ARP     N383519.710 W0760749.332   71977.9
DL3889 LOYW LOYOLA LOYW CORS ARP           N373140.995 W0755052.663   75085.8
AI3289 VIMS VIRGINIA INSTITUT CORS ARP     N373630.045 W0754113.207   80786.1

                 NEAREST NGS PUBLISHED CONTROL POINT
GV0156      R 462                          N375945.    W0762748.         15.4
```

APPENDIX VI
TERTIARY GAUGE DATUM RESULTS

Ewell, Smith Island, MD (857-1117)



0 1.5 3 Miles

0 1.5 3 Kilometers

Station Number: 857-1117

Station Name: Ewell, Smith Island, MD

Latitude: 37° 59' 46.0" N

Longitude: 76° 01' 59.0" W

NOAA Chart: 12230, 64th Ed., March 2009

USGS Quad: EWELL

Chart Scale = 1:80,000

Display Scale = 1:80,000

US Dept. of Commerce/NOAA/National Ocean Service/Center for Operational Oceanographic Products and Services

TIDE STATION - PRELIMINARY SITE REPORT

(FOD Form 03/31/06) NOAA - National Ocean Service - Center for Operational Oceanographic Products and Services

STATION INFO

Station Name:	Ewell, Smith Island, Maryland		**Station Number:**	857-1117	
Lat:	37º 59' 42.00" N	Long:	76º 01' 54.00" W	Lat. / Long. By GPS ? (Y/N)	No
Facility Name	Ewell Marina			Time Meridian	75 W
GMT Offset	0 (UTC)				
Address	4063 Smith Island Rd.				
City	Ewell			State	MD
Zip	21824				

INSPECT INFO

Date/s of Visit	June 26 - July 3 2010		
Established	X	Team Leader	Nathan Wardwell
Inspected		Member	Ben Hocker
Repaired		Member	
Removed		Member	
TYPE: Full		Cursory	Emergency

Field Office Approval:	
Date	
CO-OPS Approval:	
Date	

OWNER

Owner	Terry Laird	City/State/Zip	Ewell, MD 21824
Owner Contact	Terry Laird	Work Phone	N/A
Work Fax	N/A	Address	4032 Smith Island Rd.
Home Phone	N/A	Cell Phone	410-425-5931
Address		Email	N/A
Comments	Sensors are located on the county pier and the DCP's, GOES and solar panels are located in a privately owned structure approximatly 100' along the pier.		

CONTACT

#1 Contact Name	Terry Laird	#2 Contact Name	
#1 Address	4032 Smith Island Rd.	#2 Address	
#1Home Phone	410-425-5931	#1 Work Phone	
#2 Work Phone		#2Home Phone	
City/State/Zip	Ewell, MD 21824	Email	NA
Comments			

SHELTER

Shelter type	15' x 20' Wood building on pilings				
Date Installed	7/2/2010	AC Power (Y/N)	Yes	Combo	2100
Key Location	N/A				
Comments	DCP's are housed in a shed at the base of the county pier.				

WELL/ SUMP

Purpose	Dia	Length	Material	Intake Type	Top Hat	Copper Insert	Parallel Plates	# Brackets	Sump Pumped	Valve Turns	Heater Setting	Date Installed
Aquatrak	4"	5m	PVC	N/A	CUS	Yes	No		NO	N/A	N/A	6/30/2010

Comments: Well is secured to fixed couty pier with UNISTRUT and lag bolts.

PRIMARY DCP	Date Installed	7/2/2010	Sutron Model	Xlite 9210B	RTU S/N	71184	DCP Phone	410-425-2003
	Xpert OS Ver	3.5.0.3	Battery Type	AGM	Battery AmpHr	55	Battery Date	Jun-10
	Power Supply S/N	N/A	Digital I/O S/N	N/A	PIC Ver D1	N/A	Cellular (Y/N)	No
	Modem S/N	N/A	Analog 1 I/O S/N	N/A	PIC Ver A1	N/A	Ph dwnld date	N/A
	Xpert Display S/N	N/A	Analog 2 I/O S/N	N/A	PIC Ver A2	N/A	AC (Y/N)	Yes
	IP #	162.84.42.79	Sat Phone #	N/A	Radio ID	N/A	Solar (Y/N)	Yes
	Sat Link S/N	072802	Sat Version	N/A	Sat Link Type	2		
	DCP Comments	Xlite and GOES housed in a yellow Pelican case in the gauge house. System is powered by batteries supplied with 1A AC trickle chargers and 40W solar panels.						
	Module Comments	No additional modules at this station.						
GOES	GOES ID #	907073D0	GOES Channel	145	Transmit Time	00:39:25	Transmit Inter	1:00:00
	Antenna S/N	N/A	Date Installed	Jun-10	Azimuth	178	Elev from Horz	46
	Cable Length	7.6 m (25 ft)	Cable Type	RG58	Transmit Power	7 Watts	Magnetic Var	10W
SOLAR PANELS	Xpert Panel #1	40 W	Date Installed	7/1/2010	Xpert Panel #2	N/A	Date Installed	N/A
	Xpt Dk Panel #1	40 W	Date Installed	7/1/2010	Pump Panel #1	N/A	Date Installed	N/A
	Elev from Horz	30	Cable Length	10 m (33 ft)	Pump Panel #2	N/A	Date Installed	N/A
	GOES & Solar Panel Comments	GOES antennas are secured to a piling on the SW side of the gauge house using a 2" aluminum pipe and stainless steel banding. Solar panels are mounted on the SE side of the gauge house using treated 2x6" supports.						
AQUATRAK SENSOR	Date Installed	7/1/2010	Aquatrak S/N	1654-3880	Matched Tube S/N	1052		
	Sensor Offset	-0.096	SNS	0.000	DAT	0.0000	Aquatrak Cont S/N	120224
	Comments	Note that no SNS or DAT value entered into primary DCP.						
AQUATRAK SOUNDING TUBE	Sound tube length (level pt to copper tube end)				Copper Tube Length			
	SNS from above				T1-T2 Separation	N/A		
	Aquatrak value during deck test				T1-T2 Cable Length	N/A		
	Difference (less than +/- 0.06m passes)			0.000	Sounding Tube Cleaned (Y/N)	Yes	Number of Bails	3
	Comments	Calibration done prior to gauge installation. No deck test conducted.						

PARO-SCIENTIFIC DIGIQUARTZ SENSOR	Delta Dual Orifice(m)		(Note: N1 is Primary and Lower Orifice)					
	Model		Date Installed		Model		Date Installed	
	N1 S/N		Range		T1 S/N		Range	
	Vent Value		Flow	Feed	Vent Value		Flow	Feed
	Tide Staff Installed (Y/N)		Staff Value of Orifice Zero		RS-232 Speed			
	Comments	**No ParoScientific DigiQuartz sensor at this station.**						
SHAFT ANGLE ENCODERS	***Primary SAE Type***			SAE S/N		Date Installed		
	Display		ETG		Float Dia		Tape Length	
	Initial Display		Initial ETG		ETG-Display		Reset C2 (Y/N)	
	Encoder Offset		Initial C2		ZETG C2			
	Redundant SAE Type			SAE S/N		Date Installed		
	Display		ETG		Float Dia		Tape Length	
	Initial Display		Initial ETG		ETG-Display		Reset C2 (Y/N)	
	Encoder Offset		Initial C2		ZETG C2			
	Comments	**No shaft angle encoders at this station.**						
SECONDARY DCP	Date Installed	**7/1/2010**	9210/Xpt Dk	**DL3000**	RTU S/N	**N/A**	Primary (Y/N)	**No**
	Dark OS Ver	**fldep_v_1.5**	Xprt display S/N	**N/A**	Analog I/O S/N	**N/A**	A1 PIC Ver	**N/A**
	Modem S/N	**N/A**	Power Supply S/N	**N/A**	Digital I/O S/N	**N/A**	D1 PIC Ver	**N/A**
	SatLink S/N		Sat Version	**X.K. 02/21/08**	SatLink Type	**GHT**	Power Source	**12VDC**
			Battery Date	**Jun-10**	Battery Type	**AGM**	Batt Amp-hr	**55**
	Comments	**Secondary DCP is a Steven's DL3000 with a Steven's GHT GOES transmitter.**						
	Module Comments	**No XPERT DARK at this station.**						
REDUNDANT WATER LEVEL SENSOR	Date Installed	**7/1/2010**	Sensor Manufacture	**DAA H3611i Radar Gauge**	Serial Number	**2105**		
	Sensor Slope	**N/A**	Manifold Type	**N/A**	Flow	**N/A**	Feed psi	**N/A**
	Comments	**Radar sensor is mounted near Aquatrak on separate structure constructed with 2x6" treated lumber secured to county pier.**						
PUMPS	***Paros 1***	Date Installed		Manufacturer		Serial S/N		
	Purge Rate		Battery Date					
	Paros 2	Date Installed		Manufacturer		Serial S/N		
	Purge Rate		Battery Date					
	Redundant Sensor		Date Installed		Manufacturer		Serial S/N	
	Purge Rate		Battery Date					
	Comments	**No pumps at this location.**						

NITROGEN

N2 Supplier		Phone #	
Address		Fax #	
City, State, Zip		Tank Size	
Normal hours / operation			
Comments	**No nitrogen at this station.**		

ANCILLARY SENSORS

WATER TEMP		***AIR TEMP***		***WIND***		***CONDUCTIVITY***	
Manufacturer		Manufacturer		Manufacturer		Manufacturer	
Model		Model		Model		Model	
S/N		S/N		S/N		S/N	
Date Installed		Date Installed		Date Installed		Date Installed	
Coeff 1	Coeff 2	Coeff 1	Coeff 2	Coeff 1	Coeff 2	Coeff 1	Coeff 2
Cable Length		Cable Length		Cable Length		Cable Length	
Elevation on S/D		Elevation on S/D		Elevation on S/D		Elevation on S/D	
N2 HIGH PRESSURE		***Back up WIND***		***<enter sensor type here>***		***<enter sensor type here>***	
Manufacturer		Manufacturer		Manufacturer		Manufacturer	
Model		Model		Model		Model	
S/N		S/N		S/N		S/N	
Date Installed		Date Installed		Date Installed		Date Installed	
Slope	Offset	Coeff 1 unknown	Coeff 2 unknown	Coeff 1	Coeff 2	Coeff 1	Coeff 2
Cable Length		Cable Length		Cable Length		Cable Length	
Elevation on S/D		Elevation on S/D		Elevation on S/D		Elevation on S/D	
BAROMETER		Slope	Offset	Range		Cal checked (Y/N)	
Manufacturer		Cal Corr.		Baro / SD		Baro now +/- 1mb (Y/N)	
Model		Elev Corr.		MSL / SD		Date offset entrd	
S/N		Date Installed		Baro / MSL		Time offset entrd	
Comments	**No ancillary sensors at this location.**						

LEVELS

Date of Levels	**7/1/2010**	# BMs Connected	**5**	# BMs Recovered	**4**	# BMs Established	**1**
Primary BM Designation		**8571117 TIDAL 2**		PBM Elevation above Station Datum		**1.095**	
Datum Offset (DAT) in Xpert		**0.0000**		Levels type (Optical / Barcode / Mixed)		**Optical**	
Datum Offset (DAT) from Abstract				Levels agree with history (Y/N)	**N/A**	Staff Connected (Y/N)	**Yes**
Diff (Change if > +/- 0.0060m)				Downshot Leveling Req'd (Y/N)	**No**	Orifice(s) Connected (Y/N)	**N/A**
Comments	**Note that no SNS or DAT value entered into primary DCP.**						

GPS							
GPS accomplished this AI (Y/N)	Yes	GPS Bench Mark Designation		8571117 TIDAL 2		OPUS (Y/N)	
	UTC		Hrs	Meters		Meters	
Session Number	Date Started	Time Started	Session Length	ARP Height	Percent Obs Used	Ellipsoidal Height	Ortho Height
1	7/1/2010	2:10	14.8	1.500	95.00%	-35.345	0.565
				Average of Session Heights			
Comments							

DIVE INFO				
Dive this year (Y/N)	Last Dive Date	Marine growth (Low/Med/High)	Dive Time (hrs)
Comments	No dive reqirement at this station.		

STATION HISTORY (Significant highlights from inspections)	Station operational July 1st, 2010. Station will support hydrographic operations conducted by David Evans and Associates, Inc. on Contract DG133C-08-CQ-0006, Task Order No. T0005, Project OPR-E349-KR-10, Central Chesapeake Bay, Maryland. This is a historic station- previous NOAA CO-OPS station installation was removed November 19, 1997.
STATION NOTES (Pre-visit notifications, items stored in shelter, etc)	Smith Island is difficult to access. A scheduled ferry runs from Crisfield, MD on the East side of Chesapeake Bay daily at 12:30 and 5:30pm. The ferry travels from Ewell to Crisfield daily at 7:00am and 4:30pm. There is also a cruise ship, the Twister, that run on the weekends from Reedsville, VA on the west side of Chesapeake Bay. Items stored in tide house: 8' treated 2x6", 8' treated 2x4", 9' CPVC sounding tube, CPVC glue, CPVC primer, ABS-PVC glue, power strip, spare solar controller, DSL filter, Trimble Network/USB/PWR conector, Trimble LEMO power connector, 30' 4-pole 18G wire, AC power supply for DSL modem, Aquatrak bails, top hat bolts, CVPC couplers, 5A fuses, serial null cable M/M, serial straight cable M/F, serial config cable for radar, USB cable, assorted small UNISTRUT pieces.
WORK REQUESTS (For next annual inspection)	No work requests at this time.

TIDE STATION - PRELIMINARY SITE REPORT

(FOD Form 03/31/06) NOAA - National Ocean Service - Center for Operational Oceanographic Products and Services

STATION INFO

Station Name:	Ewell, Smith Island, Maryland		**Station Number:**	857-1117	
Lat:	37º 59' 42.00" N	Long:	76º 01' 54.00" W	Lat. / Long. By GPS ? (Y/N)	No
Facility Name	Ewell Marina			Time Meridian	75 W
Address	4063 Smith Island Rd.			GMT Offset	5 hrs
City	Ewell			State	MD
Zip	21824				

INSPECT INFO

Date/s of Visit	June 26 - July 3 2010		
Established	X	Team Leader	Nathan Wardwell
Inspected		Member	Ben Hocker
Repaired		Member	
Removed		Member	
TYPE: Full		Cursory	Emergency

Field Office Approval:	
Date	
CO-OPS Approval:	
Date	

OWNER

Owner	Terry Laird	City/State/Zip	Ewell, MD 21824		
Owner Contact	Terry Laird	Work Phone	N/A	Work Fax	N/A
Address	4032 Smith Island Rd.	Home Phone	N/A	Cell Phone	410-425-5931
Address		Email	N/A		
Comments	Sensors are located on the county pier and the DCP's, GOES and solar panels are located in a privately owned structure approximatly 100' along the pier.				

CONTACT

#1 Contact Name	Terry Laird		#2 Contact Name		
#1 Address	4032 Smith Island Rd.		#2 Address		
#1Home Phone	410-425-5931	#1 Work Phone	#2 Work Phone	#2Home Phone	
City/State/Zip	Ewell, MD 21824		Email	NA	
Comments					

SHELTER

Shelter type	15' x 20' Wood building on pilings				
Date Installed	7/2/2010	AC Power (Y/N)	Yes	Combo	2100
Key Location	N/A				
Comments	DCP's are housed in a shed at the base of the county pier.				

WELL/ SUMP

Purpose	Dia	Length	Material	Intake Type	Top Hat	Copper Insert	Parallel Plates	# Brackets	Sump Pumped	Valve Turns	Heater Setting	Date Installed
Aquatrak	4"	5m	PVC	N/A	CUS	Yes	No		NO	N/A	N/A	6/30/2010

Comments: Well is secured to fixed couty pier with UNISTRUT and lag bolts.

PRIMARY DCP	Date Installed	7/2/2010	Sutron Model	Xlite 9210B	RTU S/N	71184	DCP Phone	410-425-2003
	Xpert OS Ver	3.5.0.3	Battery Type	AGM	Battery AmpHr	55	Battery Date	Jun-10
	Power Supply S/N	N/A	Digital I/O S/N	N/A	PIC Ver D1	N/A	Cellular (Y/N)	No
	Modem S/N	10FX03069222	Analog 1 I/O S/N	N/A	PIC Ver A1	N/A	Ph dwnld date	N/A
	Xpert Display S/N	N/A	Analog 2 I/O S/N	N/A	PIC Ver A2	N/A	AC (Y/N)	Yes
	IP #	162.84.42.79	Sat Phone #	N/A	Radio ID	N/A	Solar (Y/N)	Yes
	Sat Link S/N	072802	Sat Version	N/A	Sat Link Type	2		
	DCP Comments	Xlite and GOES housed in a yellow Pelican case in the gauge house. System is powered by batteries supplied with 1A AC trickle chargers and 40W solar panels.						
	Module Comments	No additional modules at this station.						
GOES	GOES ID #	907073D0	GOES Channel	145	Transmit Time	00:39:25	Transmit Inter	1:00:00
	Antenna S/N	N/A	Date Installed	Jun-10	Azimuth	178	Elev from Horz	46
	Cable Length	7.6 m (25 ft)	Cable Type	RG58	Transmit Power	7 Watts	Magnetic Var	10W
SOLAR PANELS	Xpert Panel #1	40 W	Date Installed	7/1/2010	Xpert Panel #2	N/A	Date Installed	N/A
	Xpt Dk Panel #1	40 W	Date Installed	7/1/2010	Pump Panel #1	N/A	Date Installed	N/A
	Elev from Horz	30	Cable Length	10 m (33 ft)	Pump Panel #2	N/A	Date Installed	N/A
	GOES & Solar Panel Comments	GOES antennas are secured to a piling on the SW side of the gauge house using a 2" aluminum pipe and stainless steel banding. Solar panels are mounted on the SE side of the gauge house using treated 2x6" supports.						
AQUATRAK SENSOR	Date Installed	7/1/2010	Aquatrak S/N	1654-3880	Matched Tube S/N	1052		
	Sensor Offset	-0.096	SNS	0.000	DAT	0.0000	Aquatrak Cont S/N	120224
	Comments	Note that no SNS or DAT value entered into primary DCP.						
AQUATRAK SOUNDING TUBE	Sound tube length (level pt to copper tube end)				Copper Tube Length			
	SNS from above				T1-T2 Separation	N/A		
	Aquatrak value during deck test				T1-T2 Cable Length	N/A		
	Difference (less than +/- 0.06m passes)			*0.000*	Sounding Tube Cleaned (Y/N)	Yes	Number of Bails	3
	Comments	Calibration done prior to gauge installation. No deck test conducted.						

PARO-SCIENTIFIC DIGIQUARTZ SENSOR	Delta Dual Orifice(m)		(Note: N1 is Primary and Lower Orifice)					
	Model		Date Installed		Model		Date Installed	
	N1 S/N		Range		T1 S/N		Range	
	Vent Value		Flow	Feed	Vent Value		Flow	Feed
	Tide Staff Installed (Y/N)		Staff Value of Orifice Zero		RS-232 Speed			
	Comments	**No ParoScientific DigiQuartz sensor at this station.**						
SHAFT ANGLE ENCODERS	***Primary SAE Type***			SAE S/N		Date Installed		
	Display		ETG		Float Dia		Tape Length	
	Initial Display		Initial ETG		ETG-Display		Reset C2 (Y/N)	
	Encoder Offset		Initial C2		ZETG C2			
	Redundant SAE Type			SAE S/N		Date Installed		
	Display		ETG		Float Dia		Tape Length	
	Initial Display		Initial ETG		ETG-Display		Reset C2 (Y/N)	
	Encoder Offset		Initial C2		ZETG C2			
	Comments	**No shaft angle encoders at this station.**						
SECONDARY DCP	Date Installed	**7/1/2010**	9210/Xpt Dk	**DL3000**	RTU S/N	**N/A**	Primary (Y/N)	**No**
	Dark OS Ver	**fldep_v_1.5**	Xprt display S/N	**N/A**	Analog I/O S/N	**N/A**	A1 PIC Ver	**N/A**
	Modem S/N	**N/A**	Power Supply S/N	**N/A**	Digital I/O S/N	**N/A**	D1 PIC Ver	**N/A**
	SatLink S/N		Sat Version	**X.K. 02/21/08**	SatLink Type	**GHT**	Power Source	**12VDC**
			Battery Date	**Jun-10**	Battery Type	**AGM**	Batt Amp-hr	**55**
	Comments	**Secondary DCP is a Steven's DL3000 with a Steven's GHT GOES transmitter.**						
	Module Comments	**No XPERT DARK at this station.**						
REDUNDANT WATER LEVEL SENSOR	Date Installed	**7/1/2010**	Sensor Manufacture	**DAA H3611i Radar Gauge**	Serial Number	**2105**		
	Sensor Slope	**N/A**	Manifold Type	**N/A**	Flow	**N/A**	Feed psi	**N/A**
	Comments	**Radar sensor is mounted near Aquatrak on separate structure constructed with 2x6" treated lumber secured to county pier.**						
PUMPS	***Paros 1***	Date Installed		Manufacturer		Serial S/N		
	Purge Rate		Battery Date					
	Paros 2	Date Installed		Manufacturer		Serial S/N		
	Purge Rate		Battery Date					
	Redundant Sensor		Date Installed		Manufacturer		Serial S/N	
	Purge Rate		Battery Date					
	Comments	**No pumps at this location.**						

NITROGEN

N2 Supplier		Phone #	
Address		Fax #	
City, State, Zip		Tank Size	
Normal hours / operation			
Comments	**No nitrogen at this station.**		

ANCILLARY SENSORS

WATER TEMP		***AIR TEMP***		***WIND***		***CONDUCTIVITY***	
Manufacturer		Manufacturer		Manufacturer		Manufacturer	
Model		Model		Model		Model	
S/N		S/N		S/N		S/N	
Date Installed		Date Installed		Date Installed		Date Installed	
Coeff 1	Coeff 2	Coeff 1	Coeff 2	Coeff 1	Coeff 2	Coeff 1	Coeff 2
Cable Length		Cable Length		Cable Length		Cable Length	
Elevation on S/D		Elevation on S/D		Elevation on S/D		Elevation on S/D	
N2 HIGH PRESSURE		***Back up WIND***		***<enter sensor type here>***		***<enter sensor type here>***	
Manufacturer		Manufacturer		Manufacturer		Manufacturer	
Model		Model		Model		Model	
S/N		S/N		S/N		S/N	
Date Installed		Date Installed		Date Installed		Date Installed	
Slope	Offset	Coeff 1 unknown	Coeff 2 unknown	Coeff 1	Coeff 2	Coeff 1	Coeff 2
Cable Length		Cable Length		Cable Length		Cable Length	
Elevation on S/D		Elevation on S/D		Elevation on S/D		Elevation on S/D	
BAROMETER		Slope	Offset	Range		Cal checked (Y/N)	
Manufacturer		Cal Corr.		Baro / SD		Baro now +/- 1mb (Y/N)	
Model		Elev Corr.		MSL / SD		Date offset entrd	
S/N		Date Installed		Baro / MSL		Time offset entrd	
Comments	**No ancillary sensors at this location.**						

LEVELS

Date of Levels	**7/1/2010**	# BMs Connected	**5**	# BMs Recovered	**4**	# BMs Established	**1**
Primary BM Designation		**8571117 TIDAL 2**		PBM Elevation above Station Datum		**1.095**	
Datum Offset (DAT) in Xpert		**0.0000**		Levels type (Optical / Barcode / Mixed)		**Optical**	
Datum Offset (DAT) from Abstract				Levels agree with history (Y/N)	**N/A**	Staff Connected (Y/N)	**Yes**
Diff (Change if > +/- 0.0060m)				Downshot Leveling Req'd (Y/N)	**No**	Orifice(s) Connected (Y/N)	**N/A**
Comments	**Note that no SNS or DAT value entered into primary DCP.**						

GPS							
	GPS accomplished this AI (Y/N)	Yes	GPS Bench Mark Designation		8571117 TIDAL 2		OPUS (Y/N)
		UTC		Hrs	Meters		Meters
	Session Number	Date Started	Time Started	Session Length	ARP Height	Percent Obs Used	Ellipsoidal Height	Ortho Height
	1	7/1/2010	2:10	14.8	1.500	95.00%	-35.345	0.565
					Average of Session Heights			
	Comments							

DIVE INFO				
	Dive this year (Y/N)	Last Dive Date	Marine growth (Low/Med/High)	Dive Time (hrs)
	Comments	No dive reqirement at this station.		

STATION HISTORY (Significant highlights from inspections)	Station operational July 1st, 2010. Station will support hydrographic operations conducted by David Evans and Associates, Inc. on Contract DG133C-08-CQ-0006, Task Order No. T0005, Project OPR-E349-KR-10, Central Chesapeake Bay, Maryland. This is a historic station- previous NOAA CO-OPS station installation was removed November 19, 1997.
STATION NOTES (Pre-visit notifications, items stored in shelter, etc)	Smith Island is difficult to access. A scheduled ferry runs from Crisfield, MD on the East side of Chesapeake Bay daily at 12:30 and 5:30pm. The ferry travels from Ewell to Crisfield daily at 7:00am and 4:30pm. There is also a cruise ship, the Twister, that run on the weekends from Reedsville, VA on the west side of Chesapeake Bay. Items stored in tide house: 8' treated 2x6", 8' treated 2x4", 9' CPVC sounding tube, CPVC glue, CPVC primer, ABS-PVC glue, power strip, spare solar controller, DSL filter, Trimble Network/USB/PWR conector, Trimble LEMO power connector, 30' 4-pole 18G wire, AC power supply for DSL modem, Aquatrak bails, top hat bolts, CVPC couplers, 5A fuses, serial null cable M/M, serial straight cable M/F, serial config cable for radar, USB cable, assorted small UNISTRUT pieces.
WORK REQUESTS (For next annual inspection)	No work requests at this time.

TIDE STATION - PRELIMINARY SITE REPORT

(FOD Form 03/31/06) NOAA - National Ocean Service - Center for Operational Oceanographic Products and Services

STATION INFO

Station Name:	Ewell, Smith Island, Maryland		**Station Number:**	857-1117	
Lat:	37º 59' 42.00" N	Long:	76º 01' 54.00" W	Lat. / Long. By GPS ? (Y/N)	No
Facility Name	Ewell Marina		Time Meridian	75 W	GMT Offset 4 hrs
Address	4063 Smith Island Rd.				
City	Ewell		State	MD	Zip 21824

INSPECT INFO

Date/s of Visit	11/14-11/16/2010				
Established		Team Leader	Ben Hocker		
Inspected		Member			
Repaired		Member			
Removed	X	Member			
TYPE: Full	X	Cursory		Emergency	

Field Office Approval:	
Date	
CO-OPS Approval:	
Date	

OWNER

Owner	Terry Laird	City/State/Zip	Ewell, MD 21824		
Owner Contact	Terry Laird	Work Phone	N/A	Work Fax	N/A
Address		Home Phone	N/A	Cell Phone	410-425-5931
Address	Ewell, MD	Email	N/A		
Comments	Sensors are located on the county pier and the DCP's, GOES and solar panels are located in a privately owned structure approximatly 100' along the pier.				

CONTACT

#1 Contact Name	Terry Laird		#2 Contact Name		
#1 Address	4032 Smith Island Rd.		#2 Address		
#1Home Phone	410-425-5931	#1 Work Phone	#2 Work Phone		#2Home Phone
City/State/Zip	Ewell, MD 21824		Email	NA	
Comments					

SHELTER

Shelter type	15' x 20' Wood building on pilings					
Date Installed	7/2/2010	AC Power (Y/N)	Yes	Combo	2100	Key Location N/A
Comments	DCP's were housed in a shed at the base of the county pier.					

WELL/ SUMP

Purpose	Dia	Length	Material	Intake Type	Top Hat	Copper Insert	Parallel Plates	# Brackets	Sump Pumped	Valve Turns	Heater Setting	Date Installed
Aquatrak	4"	5m	PVC	N/A	CUS	Yes	No		NO	N/A	N/A	6/30/2010

Comments: Well is secured to fixed couty pier with UNISTRUT and lag bolts.

PRIMARY DCP

Date Installed	7/2/2010	Sutron Model	Xlite 9210B	RTU S/N	71184	DCP Phone	410-425-2003
Xpert OS Ver	3.5.0.3	Battery Type	AGM	Battery AmpHr	55	Battery Date	Jun-10
Power Supply S/N	N/A	Digital I/O S/N	N/A	PIC Ver D1	N/A	Cellular (Y/N)	No
Modem S/N	10FX03069222	Analog 1 I/O S/N	N/A	PIC Ver A1	N/A	Ph dwnld date	N/A
Xpert Display S/N	N/A	Analog 2 I/O S/N	N/A	PIC Ver A2	N/A	AC (Y/N)	Yes
IP #	162.84.42.79	Sat Phone #	N/A	Radio ID	N/A	Solar (Y/N)	Yes
Sat Link S/N	072802	Sat Version	N/A	Sat Link Type	2		

DCP Comments: Xlite and GOES housed in a yellow Pelican case in the gauge house. System is powered by batteries supplied with 1A AC trickle chargers and 40W solar panels.

Module Comments: No additional modules at this station.

GOES	GOES ID #	**907073D0**	GOES Channel	**145**	Transmit Time	**00:39:25**	Transmit Inter	**1:00:00**
	Antenna S/N	**N/A**	Date Installed	**Jun-10**	Azimuth	**178**	Elev from Horz	**46**
	Cable Length	**7.6 m (25 ft)**	Cable Type	**RG58**	Transmit Power	**7 Watts**	Magnetic Var	**10W**
SOLAR PANELS	Xpert Panel #1	**40 W**	Date Installed	**7/1/2010**	Xpert Panel #2	**N/A**	Date Installed	**N/A**
	Xpt Dk Panel #1	**40 W**	Date Installed	**7/1/2010**	Pump Panel #1	**N/A**	Date Installed	**N/A**
	Elev from Horz	**30**	Cable Length	**10 m (33 ft)**	Pump Panel #2	**N/A**	Date Installed	**N/A**
	GOES & Solar Panel Comments	**GOES antennas were secured to a piling on the SW side of the gauge house using a 2" aluminum pipe and stainless steel banding. Solar panels were mounted on the SE side of the gauge house using treated 2x6" supports.**						
AQUATRAK SENSOR	Date Installed	**7/1/2010**	Aquatrak S/N	**1654-3880**	Matched Tube S/N	**1052**		
	Sensor Offset	**-0.089**	SNS	**0.000**	DAT	**0.0000**	Aquatrak Cont S/N	**120224**
	Comments	**Note that no SNS or DAT value entered into primary DCP. The Sensor Offset is the average of the offset determined from the pre and post deployment calibrations. This offset is also noted in the Benchmark History. Sensor "0" is 0.089m above the level point.**						
AQUATRAK SOUNDING TUBE	Sound tube length (level pt to copper tube end)	**4.874**	Copper Tube Length	**0.91**				
	SNS from above	***-0.089***	T1-T2 Separation	**N/A**				
	Aquatrak value during deck test	***4.978***	T1-T2 Cable Length	**N/A**				
	Difference (less than +/- 0.06m passes)	***0.015***	Sounding Tube Cleaned (Y/N)	**No**	Number of Bails	**3**		
	Comments	**11/16/2010 deck test conducted** **Note: deck test was also conducted during Aquatrak maintenance 9/9/2010**						
PARO-SCIENTIFIC DIGIQUARTZ SENSOR	Delta Dual Orifice(m)		(Note: N1 is Primary and Lower Orifice)					
	Model		Date Installed		Model		Date Installed	
	N1 S/N		Range		T1 S/N		Range	
	Vent Value		Flow	Feed	Vent Value		Flow	Feed
	Tide Staff Installed (Y/N)		Staff Value of Orifice Zero		RS-232 Speed			
	Comments	**No ParoScientific DigiQuartz sensor at this station.**						
SHAFT ANGLE ENCODERS	***Primary SAE Type***		SAE S/N		Date Installed			
	Display		ETG		Float Dia		Tape Length	
	Initial Display		Initial ETG		ETG-Display		Reset C2 (Y/N)	
	Encoder Offset		Initial C2		ZETG C2			
	Redundant SAE Type		SAE S/N		Date Installed			
	Display		ETG		Float Dia		Tape Length	
	Initial Display		Initial ETG		ETG-Display		Reset C2 (Y/N)	
	Encoder Offset		Initial C2		ZETG C2			
	Comments	**No shaft angle encoders at this station.**						
SECONDARY DCP	Date Installed	**7/10/2010**	Sutron Xlite	**1006703**	RTU S/N	**N/A**	Primary (Y/N)	**No**
	OS Ver	**3.5.0.3**	Xprt display S/N	**N/A**	Analog I/O S/N	**N/A**	A1 PIC Ver	**N/A**
	Modem S/N	**N/A**	Power Supply S/N	**N/A**	Digital I/O S/N	**N/A**	D1 PIC Ver	**N/A**
	SatLink S/N		Sat Version	**N/A**	SatLink Type	**N/A**	Power Source	**12VDC**
			Battery Date	**Jun-10**	Battery Type	**AGM**	Batt Amp-hr	**55**
	Comments	**Secondary DCP is a Steven's DL3000 with a Steven's GHT GOES transmitter. The Stevens DCP was replaced with a Sutron Xlite on 7/10/2010,**						
	Module Comments	**No XPERT DARK at this station.**						
REDUNDANT WATER LEVEL SENSOR	Date Installed	**7/1/2010**	Sensor Manufacture	**DAA H3611i Radar Gauge**	Serial Number	**2105**		
	Sensor Slope	**N/A**	Manifold Type	**N/A**	Flow	**N/A**	Feed psi	**N/A**
	Comments	**Radar sensor is mounted near Aquatrak on separate structure constructed with 2x6" treated lumber secured to county pier.**						
PUMPS	***Paros 1***	Date Installed		Manufacturer		Serial S/N		
	Purge Rate		Battery Date					
	Paros 2	Date Installed		Manufacturer		Serial S/N		
	Purge Rate		Battery Date					
	Redundant Sensor		Date Installed		Manufacturer		Serial S/N	
	Purge Rate		Battery Date					
	Comments	**No pumps at this location.**						

NITROGEN

N2 Supplier		Phone #	
Address		Fax #	
City, State, Zip		Tank Size	
Normal hours / operation			
Comments	**No nitrogen at this station.**		

ANCILLARY SENSORS

WATER TEMP		***AIR TEMP***		***WIND***		***CONDUCTIVITY***	
Manufacturer		Manufacturer		Manufacturer		Manufacturer	
Model		Model		Model		Model	
S/N		S/N		S/N		S/N	
Date Installed		Date Installed		Date Installed		Date Installed	
Coeff 1	Coeff 2	Coeff 1	Coeff 2	Coeff 1	Coeff 2	Coeff 1	Coeff 2
Cable Length		Cable Length		Cable Length		Cable Length	
Elevation on S/D		Elevation on S/D		Elevation on S/D		Elevation on S/D	
N2 HIGH PRESSURE		***Back up WIND***		***<enter sensor type here>***		***<enter sensor type here>***	
Manufacturer		Manufacturer		Manufacturer		Manufacturer	
Model		Model		Model		Model	
S/N		S/N		S/N		S/N	
Date Installed		Date Installed		Date Installed		Date Installed	
Slope	Offset	Coeff 1 unknown	Coeff 2 unknown	Coeff 1	Coeff 2	Coeff 1	Coeff 2
Cable Length		Cable Length		Cable Length		Cable Length	
Elevation on S/D		Elevation on S/D		Elevation on S/D		Elevation on S/D	
BAROMETER		Slope	Offset	Range		Cal checked (Y/N)	
Manufacturer		Cal Corr.		Baro / SD		Baro now +/- 1mb (Y/N)	
Model		Elev Corr.		MSL / SD		Date offset entrd	
S/N		Date Installed		Baro / MSL		Time offset entrd	
Comments	**No ancillary sensors at this location.**						

LEVELS

Date of Levels	**11/14/2010**	# BMs Connected	**5**	# BMs Recovered	**5**	# BMs Established	**0**
Primary BM Designation		**8571117 TIDAL 2**		PBM Elevation above Station Datum		**1.095**	
Datum Offset (DAT) in Xpert		**see notes below**		Levels type (Optical / Barcode / Mixed)		**Optical**	
Datum Offset (DAT) from Abstract		**see BM History**		Levels agree with history (Y/N)	**Yes**	Staff Connected (Y/N)	**Yes**
Diff (Change if > +/- 0.0060m)		**see BM History**		Downshot Leveling Req'd (Y/N)	**No**	Orifice(s) Connected (Y/N)	**N/A**
Comments	**Note that no SNS or DAT value entered into primary DCP.**						

GPS

GPS accomplished this AI (Y/N)	**Yes**	GPS Bench Mark Designation		**8571117 TIDAL 2**		OPUS (Y/N)	**Yes**
	UTC		Hrs	Meters		Meters	
Session Number	Date Started	Time Started	Session Length	ARP Height	Percent Obs Used	Ellipsoidal Height	Ortho Height
1	**7/1/2010**	**2:10**	**14.8**	**1.500**	**95%**	**-35.345**	**0.565**
1	**11/16/2010**	**14:27**	**4:53**	**2.000**	**94%**	**-35.315**	**0.595**
				Average of Session Heights		**-35.330**	**0.580**
Comments							

DIVE INFO

Dive this year (Y/N)		Last Dive Date		Marine growth (Low/Med/High)		Dive Time (hrs)	
Comments	**No dive reqirement at this station.**						

STATION HISTORY (Significant highlights from inspections)	**Station operational July 1st, 2010. Station will support hydrographic operations conducted by David Evans and Associates, Inc. on Contract DG133C-08-CQ-0006, Task Order No. T0005, Project OPR-E349-KR-10, Central Chesapeake Bay, Maryland. This is a historic station- previous NOAA CO-OPS station installation was removed November 19, 1997.** **7/1/2010 Installation,staff shots and leveling were performed** **7/10/2010 Maintenance, Staff shots were performed** **8/7/2010 Repair trip - the radar was repaired, staff shots were performed pre and post maintenance** **9/9/2010 Maintenance of the AquaTrak, deck test and staff shots were performed** **9/21/2010 Maintenance, staff shots and leveling were performed** **11/14-16/2010 Station was removed, staff shots and leveling were performed**
STATION NOTES (Pre-visit notifications, Items stored in shelter, etc)	**Smith Island is difficult to access. A scheduled ferry runs from Crisfield, MD on the East side of Chesapeake Bay daily at 12:30 and returns at 5:30pm. The ferry travels from Ewell to Crisfield daily at 7:00am and 4:30pm. There is also a cruise ship, the Twister, that runs on the weekends from Reedsville, VA on the west side of Chesapeake Bay.**
WORK REQUESTS (For next annual inspection)	**No work requests at this time.**

FORM POS1 *All elevations are in meters above Site Datum of Tabulation*

1983-2001 Epoch

PBM	
1.095	857 1117 TIDAL 2

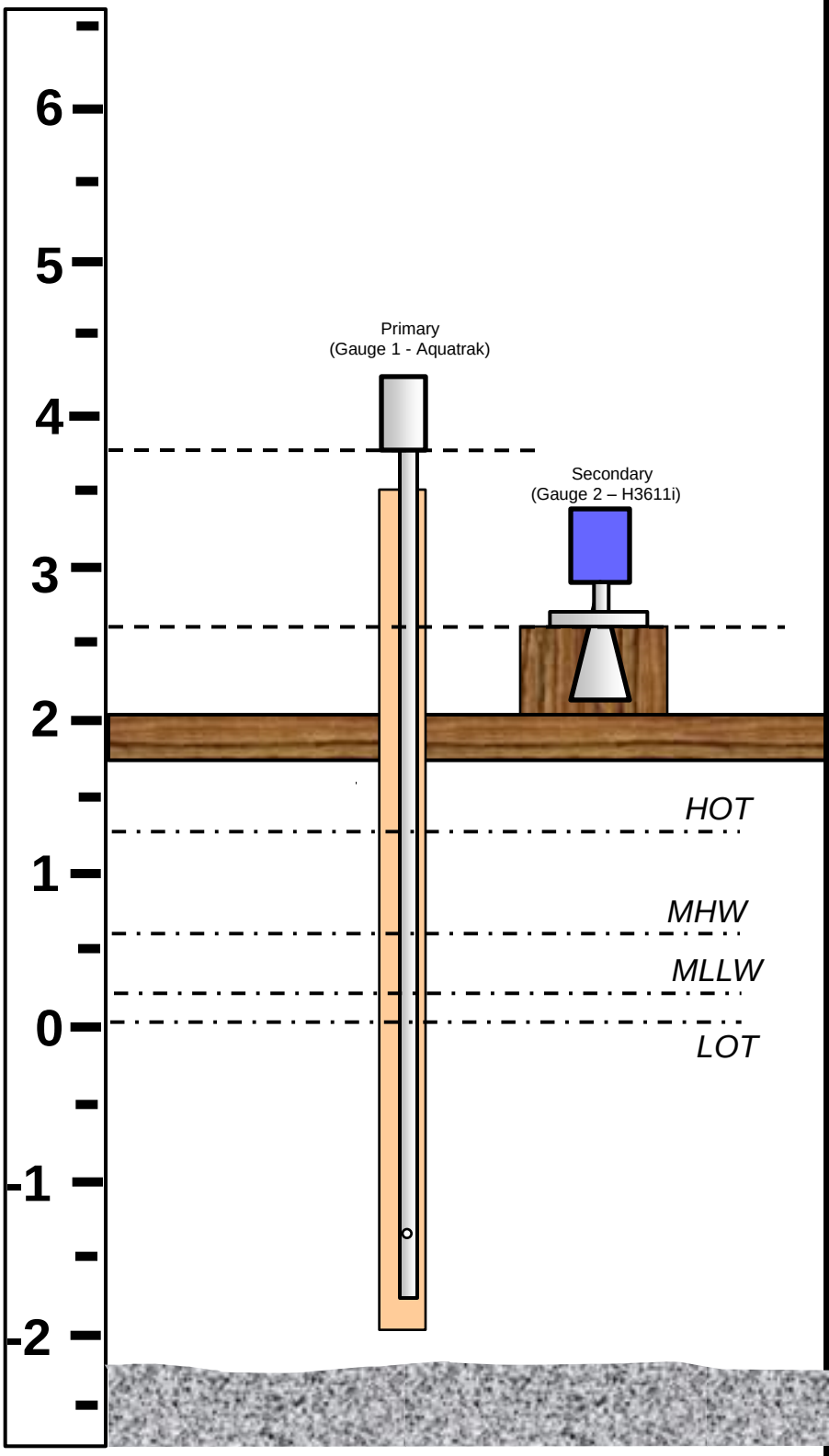
PLANES	
1.216	Highest Tide
0.623	MHW
0.112	MLLW
0.037	Lowest Tide

ORIFICES	
~2	Wharf Deck
3.884	Primary Sensor "0"
2.686	Secondary Sensor "0"
-0.010	Staff "0"

Note 1: Ewell is a historic station that was originally installed in 1997.

Note 2: The Primary Gauge has a Aquatrak sensor with a Sutron XliteB DCP.

Note 3: The Secondary Gauge has a H3611i sensor with a Sutron XliteB DCP.



Channel Bottom

JOA SURVEYS, LLC
2000 E. Dowling Rd #10
Anchorage, AK 99507
www.joasurveys.com

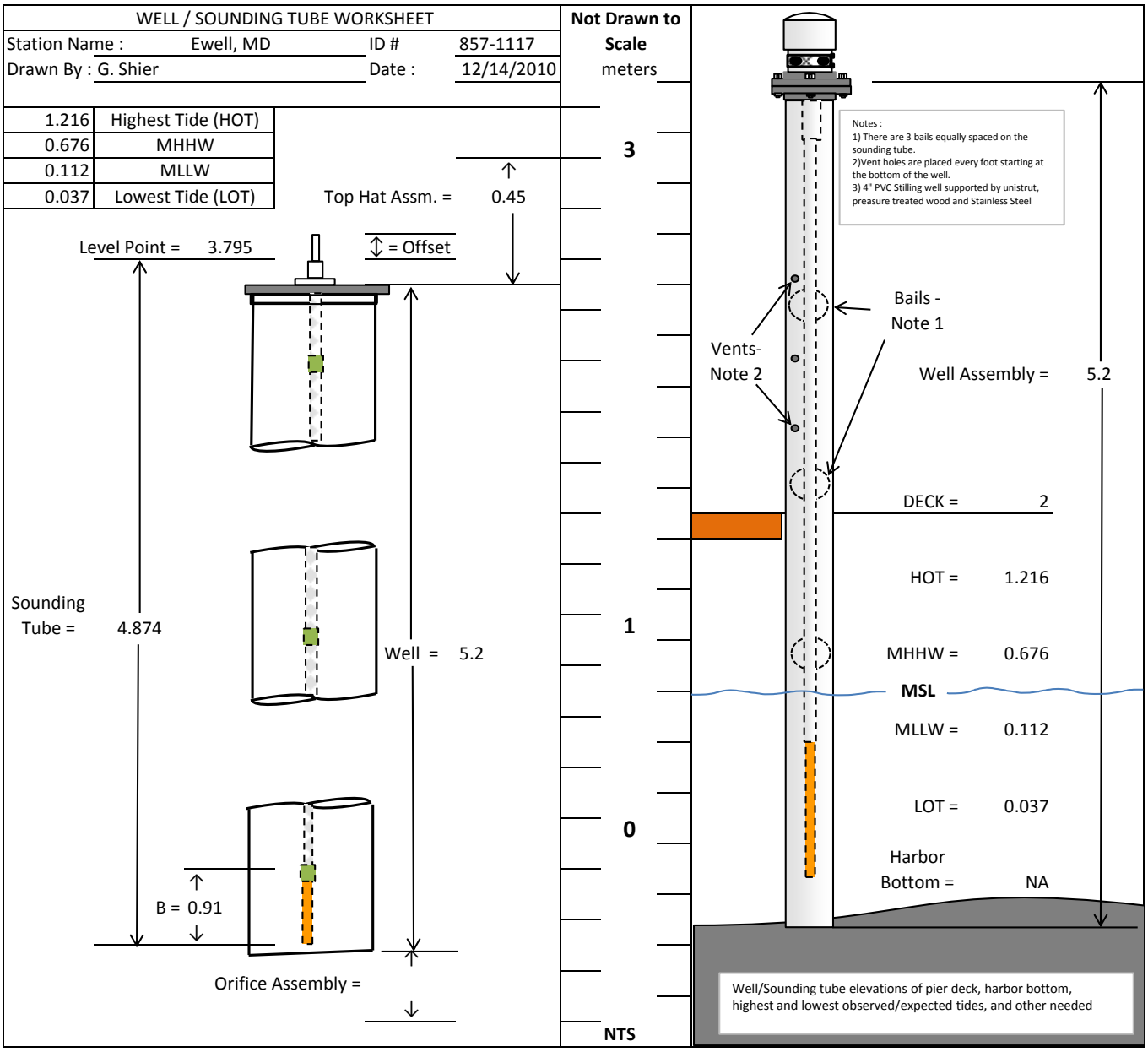
STATION	Ewell, Smith Island, MD	**REVISED** NW 12/15/10
Drawn by:	N. Wardwell	
Date:	7/25/10	

WELL / SOUNDING TUBE WORKSHEET

Station Name : Ewell, MD ID # 857-1117

Drawn By : G. Shier Date : 12/14/2010

1.216	Highest Tide (HOT)
0.676	MHHW
0.112	MLLW
0.037	Lowest Tide (LOT)



Offset Value =	0.089
Level Point =	3.795
Top Hat Assembly =	0.45
Well Length =	5.2
Sounding Tube =	4.874
Brass-copper/cpvc =	0.91
Orifice Assembly =	NA

HOT =	1.216		
MHHW =	0.676		
MLLW =	0.112		
LOT =	0.037		
Harbor Bottom =	NA		
Temp #1 =	NA	Vent #1 =	NA
Temp #2 =	NA	Vent #2 =	NA

Abstract of Conventional Leveling on Station Datum

Ewell, Smith Island, MD

857-1117

Connected bench marks: 5 8571117 TIDAL 2, 8571117 TIDAL 3, 8571117 TIDAL 4, 8571117 A
Primary bench mark: 8571117 TIDAL 2

	Initial leveling
Date	7/1-7/2/10
Level/SN	NA2/540706
Observer	N. Wardwell
Rod person	B. Hocker
C Factor (mm/m)	0.01563
JOA Field Book	FB018
Wizlevels	NewWiz

Installation Leveling

(all values in meters)

Bench Mark From	Bench Mark To	Distance	Diff. of Elevation (DE) Forward	Diff. of Elevation (DE) Reverse	Closure	Mean DE	Station Datum Elevation	Bench Mark
							1.095	**8571117 TIDAL 2**
8571117 TIDAL 2	8571117 TIDAL 5	104	0.7900	-0.7893	0.0007	0.78960	1.8846	8571117 TIDAL 5
8571117 TIDAL 5	8571117 TIDAL 4	111	-0.9027	0.9020	-0.0007	-0.90240	0.9822	8571117 TIDAL 4
8571117 TIDAL 4	8571111 A	89	0.3553	-0.3553	0.0000	0.35530	1.3375	8571111 A
Spur to 8571117 TIDAL 3								
8571117 TIDAL 2	8571117 TIDAL 3	45	-0.1730	0.1727	-0.0003	-0.17280	0.9222	8571117 TIDAL 3
Spur to Aqua-New								
8571117 TIDAL 2	TBM 1	68	1.6057	-1.6060	-0.0003	1.60580	2.7008	TBM 1
TBM 1	Aqua-New	63	1.0967	-1.0950	0.0017	1.09580	3.7966	Aqua-New
Aqua-New	Aquatrak "0"		0.0960	Note 3		0.09600	3.8926	Aquatrak "0"
Spur to Radar								
8571117 TIDAL 2	Top of Radar Mounting Plate	68	1.6003	-1.5993	0.0010	1.59980	2.6948	Top of Radar Mounting Plate
Top of Radar Mounting Plate	Radar "0"		-0.0060	Note 4		-0.00600	2.6888	Radar "0"
Spur to Staff "0"								
8571117 TIDAL 2	Staff Stop	64	-0.1933	0.1947	0.0014	-0.19400	0.9010	Staff Stop
Staff Stop	Staff "0"		-1.0000	Note 5		-1.00000	-0.0990	Staff "0"

Notes :

1) The PBM and elevation were obtained from Minilek Hailegeberel on 6/22/10 via email.
2) Three wire levels were used.
3) The Aqua-New to Aquatrak "0" distance was determiend during predeployment calibrations. This is the distance from the bottom of the metal collar to the acoustic sensor
4) The Top of Radar Mounting Plate to the Radar "0" was measured with a steel tape.
5) Staff stop is the top of a 1.000m staff.

Installation Leveling		
Abtract by:	**N. Wardwell**	**7/25/10**
Verified by:	**M. Zieserl**	**7/29/10**
		dates

Abstract of Conventional Leveling on Station Datum

Ewell, Smith Island, MD

857-1117

Connected bench marks: 3 8571117 TIDAL 2, 8571117 TIDAL 3, 8571117 A
Primary bench mark: 8571117 TIDAL 2

	Maintenance Leveling
Date	9/21/2010
Level/SN	Wild NA2, SN540706
Observer	Tom Roberts
Rod person	Erin Campbell
C Factor (mm/m)	0.02372

Maintenance Leveling (09/21/10)

(all values in meters)

Bench Mark From	Bench Mark To	Distance	Diff. of Elevation (DE) Forward	Diff. of Elevation (DE) Reverse	Diff. of Elevation (DE) Closure	Diff. of Elevation (DE) Mean DE	Station Datum Elevation	Bench Mark
							1.0950	**8571117 TIDAL 2**
8571117 TIDAL 2	8571117 A	116	0.2410	-0.2423	-0.0013	0.2416	1.3366	8571117 A
			Spur to TIDAL 3					
8571117 TIDAL 2	8571117 TIDAL 3	45	-0.1717	0.1717	0.0000	-0.1717	0.9233	8571117 TIDAL 3
			Spur to Aqua-New					
8571117 TIDAL 2	Aqua-New	45	2.7000	-2.7007	-0.0007	2.7004	3.7954	Aqua-New
Aqua-New	Aquatrak "0"	0	0.0960	Note 4		0.0960	3.8914	Aquatrak "0"
			Spur to Radar					
8571117 TIDAL 2	Top of Radar Mounting Plate	42	1.5953	-1.5963	-0.0010	1.5958	2.6908	Top of Radar Mounting Plate
Top of Radar Mounting Plate	Radar "0"	0	-0.006	Note 5		-0.0060	2.6848	Radar "0"
			Spur to Staff					
8571117 TIDAL 2	Tide Staff 1.000 m	59	-0.1970	0.1960	-0.0010	-0.1965	0.8985	Tide Staff 1.000 m
Tide Staff 1.000 m	Tide Staff 0.000 m	0	-1.000	Note 3		-1.0000	-0.1015	Tide Staff 0.000 m

Notes :

1) The PBM and elevation were obtained from Minilek Hailegeberel on 6/22/10 via email.
2) Three wire levels were used.
3) Staff stop is the top of a 1m staff.
4) Aqua-New to Aquatrak "0" offset determined from pre deployment calibrations.
5) Radar "0" is the bottom of the mounting plate. Offset from Top of Radar Mounting Plate to Radar "0" was measured with a steel tape.

Maintenance Leveling (09/21/10)		
Abstract by:	**K. Widmer**	**9/30/10**
Verified by:	**G. Shier**	**12/07/10**
		dates

Abstract of Conventional Leveling on Station Datum

Ewell, Smith Island, MD

857-1117

Connected bench marks: 5 8571117 TIDAL 2, 8571117 TIDAL 3, 8571117 TIDAL 4, 8571117 A
Primary bench mark: 8571117 TIDAL 2

	Closeout Leveling
Date	11/14/2010
Level/SN	NA2/540706
Observer	Ben Hocker
Rod person	Tom Roberts
C Factor (mm/m)	0.02097

Closeout Leveling (11/14/10)

(all values in meters)

Bench Mark From	Bench Mark To	Distance	Diff. of Elevation (DE) Forward	Reverse	Closure	Mean DE	Station Datum Elevation	Bench Mark
							1.0950	**8571117 TIDAL 2**
8571117 TIDAL 2	8571117 TIDAL 3	46	-0.1720	0.1717	-0.0003	-0.1718	0.9232	8571117 TIDAL 3
8571117 TIDAL 3	8571117 TIDAL 5	78	0.9620	-0.9627	-0.0007	0.9624	1.8856	8571117 TIDAL 5
Spur to 8571117 A and TIDAL 4								
8571117 TIDAL 2	8571117 A	114	0.2423	-0.2423	0.0000	0.2423	1.3373	8571117 A
8571117 A	8571117 TIDAL 4	89	-0.3560	0.3553	-0.0007	-0.3556	0.9817	8571117 TIDAL 4
Spur to Aqua-New								
8571117 TIDAL 2	Aqua-New	140	2.6973	-2.6983	-0.0010	2.6978	3.7928	Aqua-New
Aqua-New	Aquatrak "0"	0	0.0820	Note 4		0.0820	3.8748	Aquatrak "0"
Spur to Radar								
8571117 TIDAL 2	Top of Radar Mounting Plate	43	1.5960	-1.5967	-0.0007	1.5964	2.6914	Top of Radar Mounting Plate
Top of Radar Mounting Plate	Radar "0"	0	-0.0060	Note 5		-0.0060	2.6854	Radar "0"
Spur to Staff								
8571117 TIDAL 2	Staff Stop	58	-0.1943	0.1943	0.0000	-0.1943	0.9007	Staff Stop
Staff Stop	Staff "0"	0	-1.0000	Note 3		-1.0000	-0.0993	Staff "0"

Notes :

1) The PBM and elevation were obtained from Minilek Hailegeberel on 6/22/10 via email.
2) Three wire levels were used.
3) Staff stop is the top of a 1m staff.
4) Aqua-New to Aquatrak "0" offset determined from post deployment calibrations.
5) Radar Sensor "0" is the bottom of the mounting plate. Offset from Top of Radar Mounting Plate to Radar "0" was measured with a steel tape.

Closeout Leveling (11/14/10)		
Abstract by:	**Glen Shier**	**12/1/10**
Verified by:	**N. Wardwell**	**12/15/10**
		dates

Datum Offset Computation Worksheet

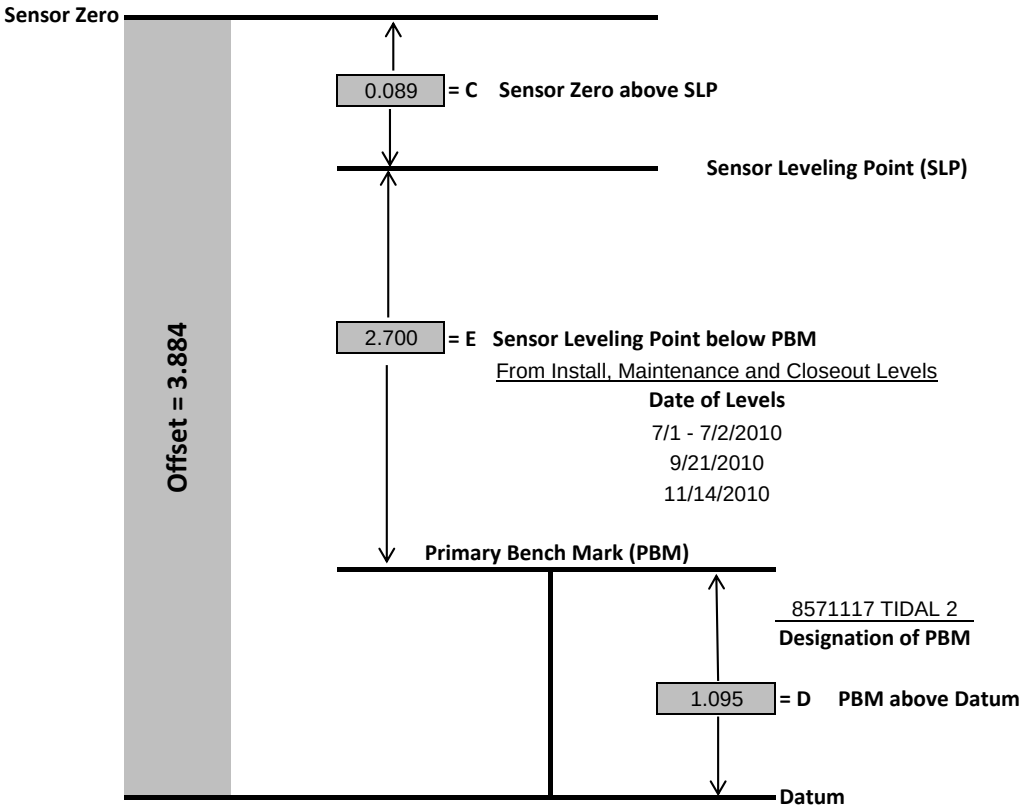
Ewell, Smith Island, MD
857-1117

all values in meters

Current as of: November 14, 2010
Type of Visit: Closeout
Sensor: The primary water level sensor is also referred to as Gauge #1, and is an Aquatrak.

Offset = D (PBM above Datum) + E (Sensor Leveling Point above PBM) + C (Sensor Zero above Sensor Leveling Point)
Offset = 1.095 + 2.700 + 0.089
Offset = 3.884

The offset is the elevation of the Primary Water Level sensor zero or orifice zero above the datum of choice.



Datum Reference: Station Datum

Summary of Staff Observations on Station Datum

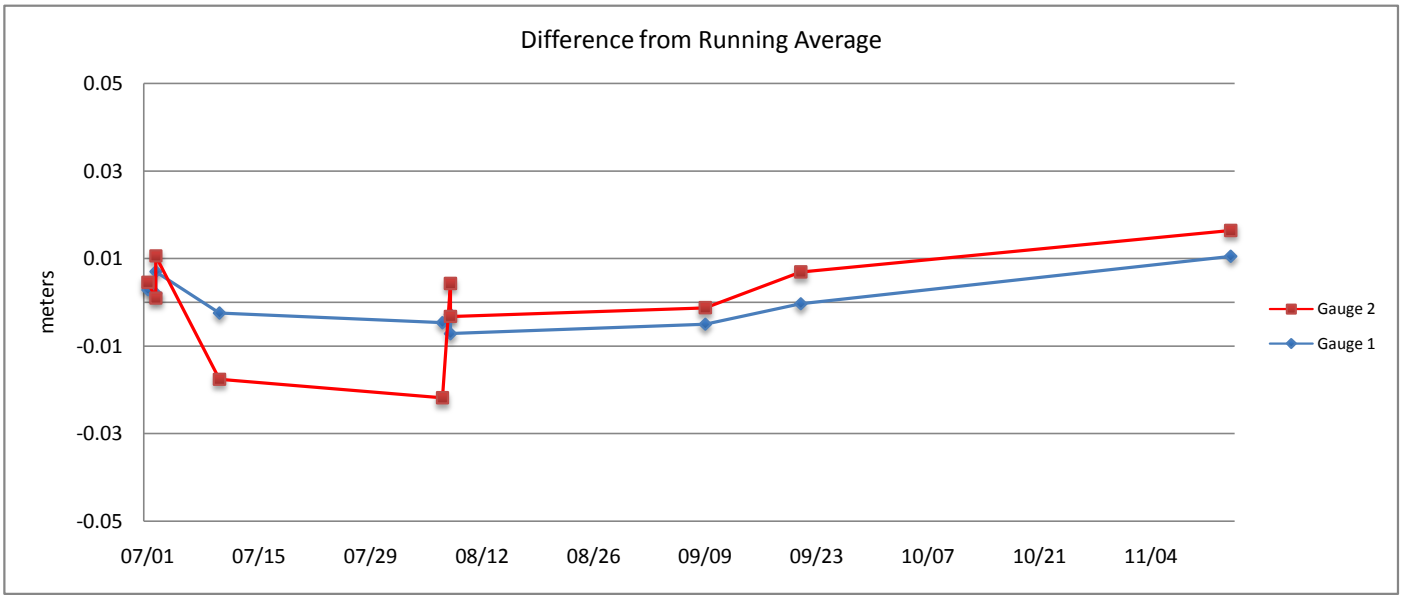
Ewell, Smith Island, MD

857-1117

all values in meters
Bold = rejected

	Gauge 1	Gauge 2
Average	**3.871**	**2.685**
St Dev	0.006	0.009
Count	10	10

Date (2010)	Gauge 1	Gauge 2	gauge 1 N	gauge 2 N	gauge 1 stdev	gauge 2 stdev
07/01	3.874	2.687	15	15	0.002	0.003
07/02	3.873	2.684	15	15	0.002	0.002
07/02	3.878	2.689	5	6	0.001	0.002
07/10	3.869	2.670	11	8	0.003	0.005
08/07	3.866	2.668	12	12	0.001	0.001
08/08	3.868	2.692	4	4	0.001	0.001
08/08	3.864	2.689	31	31	0.002	0.002
09/09	3.866	2.689	12	12	0.004	0.004
09/21	3.871	2.692	12	12	0.002	0.002
11/14	3.882	2.691	30	30	0.005	0.004



Note 1: Gauge 1 is an Aquatrak sensor. Gauge 2 is a H3611i Radar sensor.
Note 2: The average staff constants should be very close to the station datum elevations of the sensor "0" for Gauges 1 and 2.

Staff Observations on Station Datum

Ewell, Smith Island, MD
857-1117

Staff "0" = -0.100

Bold = Rejected

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
07/01/10 22:48	0.660	0.560	-3.312	-2.128	3.872	2.688	-0.002	0.001
07/01/10 22:54	0.650	0.550	-3.322	-2.136	3.872	2.686	-0.002	-0.001
07/01/10 23:00	0.645	0.545	-3.331	-2.146	3.876	2.691	0.002	0.004
07/01/10 23:06	0.630	0.530	-3.341	-2.158	3.871	2.688	-0.003	0.001
07/01/10 23:12	0.625	0.525	-3.350	-2.160	3.875	2.685	0.001	-0.002
07/01/10 23:18	0.615	0.515	-3.361	-2.176	3.876	2.691	0.002	0.004
07/01/10 23:24	0.605	0.505	-3.367	-2.178	3.872	2.683	-0.002	-0.004
07/01/10 23:30	0.595	0.495	-3.378	-2.192	3.873	2.687	-0.001	0.000
07/01/10 23:36	0.585	0.485	-3.387	-2.201	3.872	2.686	-0.002	-0.001
07/01/10 23:42	0.580	0.480	-3.397	-2.210	3.877	2.690	0.003	0.003
07/01/10 23:48	0.570	0.470	-3.407	-2.218	3.877	2.688	0.003	0.001
07/01/10 23:54	0.560	0.460	-3.416	-2.226	3.876	2.686	0.002	-0.001
07/02/10 0:00	0.550	0.450	-3.425	-2.235	3.875	2.685	0.001	-0.002
07/02/10 0:06	0.535	0.435	-3.435	-2.247	3.870	2.682	-0.004	-0.005
07/02/10 0:12	0.530	0.430	-3.444	-2.253	3.874	2.683	0.000	-0.004

Observed by: N. Wardwell
Computed by: N. Wardwell
Notes: Install obs, wave height 2-3cm

	Gauge 1	Gauge 2
Average:	3.874	2.687
St Dev:	0.002	0.003
Count:	15	15

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
07/02/10 0:18	0.520	0.420	-3.454	-2.263	3.874	2.683	0.001	-0.001
07/02/10 0:24	0.515	0.415	-3.462	-2.274	3.877	2.689	0.004	0.005
07/02/10 0:30	0.505	0.405	-3.471	-2.279	3.876	2.684	0.003	0.000
07/02/10 0:36	0.495	0.395	-3.478	-2.291	3.873	2.686	0.000	0.002
07/02/10 0:42	0.487	0.387	-3.487	-2.298	3.874	2.685	0.001	0.001
07/02/10 0:48	0.480	0.380	-3.495	-2.305	3.875	2.685	0.002	0.001
07/02/10 0:54	0.470	0.370	-3.504	-2.316	3.874	2.686	0.001	0.002
07/02/10 1:00	0.460	0.360	-3.512	-2.323	3.872	2.683	-0.001	-0.001
07/02/10 1:06	0.450	0.350	-3.519	-2.330	3.869	2.680	-0.004	-0.004
07/02/10 1:12	0.445	0.345	-3.528	-2.339	3.873	2.684	0.000	0.000
07/02/10 1:18	0.438	0.338	-3.536	-2.346	3.874	2.684	0.001	0.000
07/02/10 1:24	0.427	0.327	-3.543	-2.352	3.870	2.679	-0.003	-0.005
07/02/10 1:30	0.420	0.320	-3.551	-2.363	3.871	2.683	-0.002	-0.001
07/02/10 1:36	0.415	0.315	-3.558	-2.370	3.873	2.685	0.000	0.001
07/02/10 1:42	0.405	0.305	-3.565	-2.377	3.870	2.682	-0.003	-0.002

Observed by: N. Wardwell
Computed by: N. Wardwell
Notes: Install obs, wave height 2-3cm

	Gauge 1	Gauge 2
Average:	3.873	2.684
St Dev:	0.002	0.002
Count:	15	15

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
07/02/10 12:00	0.555	0.455		-2.231		2.686		-0.002
07/02/10 12:06	0.545	0.445	-3.434	-2.245	3.879	2.690	0.001	0.002
07/02/10 12:12			-3.445	-2.257				
07/02/10 12:18	0.523	0.423	-3.455	-2.264	3.878	2.687	0.000	-0.002
07/02/10 12:24	0.514	0.414	-3.463	-2.274	3.877	2.688	-0.001	0.000
07/02/10 12:30	0.505	0.405	-3.473	-2.286	3.878	2.691	0.000	0.002
07/02/10 12:36	0.495	0.395	-3.483	-2.294	3.878	2.689	0.000	0.001

Observed by: N. Wardwell
Computed by: N. Wardwell
Notes: Additional install obs, wave height 2-3cm

	Gauge 1	Gauge 2
Average:	3.878	2.689
St Dev:	0.001	0.002
Count:	5	6

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
07/10/10 16:00	0.935	0.835	-3.034		3.869		0.000	
07/10/10 16:06	0.935	0.835	-3.034		3.869		0.000	
07/10/10 16:12	0.932	0.832	-3.034		3.866		-0.003	
07/10/10 16:18	0.932	0.832	-3.032	-1.830	3.864	2.662	-0.005	-0.008
07/10/10 16:24	0.930	0.830	-3.038	-1.839	3.868	2.669	-0.001	-0.001
07/10/10 16:30	0.931	0.831	-3.037	-1.836	3.868	2.667	-0.001	-0.003
07/10/10 16:36	0.939	0.839	-3.031	-1.830	3.870	2.669	0.001	-0.001
07/10/10 16:42	0.926	0.826	-3.042	-1.844	3.868	2.670	-0.001	0.000
07/10/10 16:48	0.936	0.836	-3.032	-1.832	3.868	2.668	-0.001	-0.002
07/10/10 16:54	0.932	0.832	-3.043	-1.848	3.875	2.680	0.006	0.010
07/10/10 17:00	0.919	0.819	-3.050	-1.854	3.869	2.673	0.000	0.003

Observed by: N. Wardwell
Computed by: N. Wardwell
Notes: Additional install obs, wave height 2-3cm

	Gauge 1	Gauge 2
Average:	3.869	2.670
St Dev:	0.003	0.005
Count:	11	8

Staff Observations on Station Datum

Ewell, Smith Island, MD

857-1117

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
08/07/10 23:30	0.571	0.471	-3.396	-2.198	3.867	2.669	0.001	0.001
08/07/10 23:36	0.589	0.489	-3.380	-2.181	3.869	2.670	0.003	0.002
08/07/10 23:42	0.602	0.502	-3.363	-2.163	3.865	2.665	-0.001	-0.003
08/07/10 23:48	0.621	0.521	-3.346	-2.146	3.867	2.667	0.001	-0.001
08/07/10 23:54	0.638	0.538	-3.328	-2.129	3.866	2.667	0.000	-0.001
08/08/10 0:00	0.658	0.558	-3.310	-2.111	3.868	2.669	0.002	0.001
08/08/10 0:06	0.675	0.575	-3.293	-2.094	3.868	2.669	0.002	0.001
08/08/10 0:12	0.690	0.590	-3.275	-2.077	3.865	2.667	-0.001	-0.001
08/08/10 0:18	0.708	0.608	-3.258	-2.060	3.866	2.668	0.000	0.000
08/08/10 0:24	0.725	0.625	-3.239	-2.041	3.864	2.666	-0.002	-0.002
08/08/10 0:30	0.742	0.642	-3.223	-2.026	3.865	2.668	-0.001	0.000
08/08/10 0:36	0.760	0.660	-3.206	-2.008	3.866	2.668	0.000	0.000

Observed by:	C. Mayfield	Average:	3.866	2.668
Computed by:	N. Wardwell	St Dev:	0.001	0.001
Notes:	Staff obs before fixing radar mount, calm water.	Count:	12	12

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
08/08/10 1:18	0.855	0.755	-3.112	-1.937	3.868	2.693	0.000	0.001
08/08/10 1:24								
08/08/10 1:30								
08/08/10 1:36								
08/08/10 1:42								
08/08/10 1:48								
08/08/10 1:54								
08/08/10 2:00								
08/08/10 2:06								
08/08/10 2:12								
08/08/10 2:18								
08/08/10 2:24	0.958	0.858	-3.011	-1.835	3.869	2.693	0.001	0.001
08/08/10 2:30	0.964	0.864	-3.004	-1.827	3.868	2.691	0.000	-0.001
08/08/10 2:36	0.969	0.869	-2.999	-1.822	3.868	2.691	0.000	-0.001

Observed by:	C. Mayfield	Average:	3.868	2.692
Computed by:	N. Wardwell	St Dev:	0.001	0.001
Notes:	Staff obs after fixing radar mount, calm water.	Count:	4	4

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
08/08/10 7:12	0.678	0.578	-3.288	-2.112	3.866	2.690	0.002	0.001
08/08/10 7:18	0.662	0.562	-3.301	-2.125	3.863	2.687	-0.001	-0.002
08/08/10 7:24	0.650	0.550	-3.314	-2.138	3.864	2.688	0.000	-0.001
08/08/10 7:30	0.639	0.539	-3.327	-2.151	3.866	2.690	0.002	0.001
08/08/10 7:36	0.624	0.524	-3.340	-2.163	3.864	2.687	0.000	-0.002
08/08/10 7:42	0.612	0.512	-3.353	-2.177	3.865	2.689	0.001	0.000
08/08/10 7:48	0.598	0.498	-3.366	-2.189	3.864	2.687	0.000	-0.002
08/08/10 7:54	0.589	0.489	-3.378	-2.203	3.867	2.692	0.003	0.003
08/08/10 8:00	0.571	0.471	-3.390	-2.214	3.861	2.685	-0.003	-0.004
08/08/10 8:06	0.562	0.462	-3.401	-2.225	3.863	2.687	-0.001	-0.002
08/08/10 8:12	0.554	0.454	-3.411	-2.235	3.865	2.689	0.001	0.000
08/08/10 8:18	0.544	0.444	-3.422	-2.246	3.866	2.690	0.002	0.001
08/08/10 8:24	0.533	0.433	-3.431	-2.256	3.864	2.689	0.000	0.000
08/08/10 8:30	0.522	0.422	-3.441	-2.266	3.863	2.688	-0.001	-0.001
08/08/10 8:36	0.518	0.418	-3.450	-2.275	3.868	2.693	0.004	0.004
08/08/10 8:42	0.505	0.405	-3.459	-2.284	3.864	2.689	0.000	0.000
08/08/10 8:48	0.500	0.400	-3.465	-2.291	3.865	2.691	0.001	0.002
08/08/10 8:54	0.495	0.395	-3.472	-2.298	3.867	2.693	0.003	0.004
08/08/10 9:00	0.485	0.385	-3.480	-2.305	3.865	2.690	0.001	0.001
08/08/10 9:06	0.478	0.378	-3.488	-2.313	3.866	2.691	0.002	0.002
08/08/10 9:12	0.469	0.369	-3.493	-2.319	3.862	2.688	-0.002	-0.001
08/08/10 9:18	0.462	0.362	-3.499	-2.325	3.861	2.687	-0.003	-0.002
08/08/10 9:24	0.457	0.357	-3.505	-2.331	3.862	2.688	-0.002	-0.001
08/08/10 9:30	0.452	0.352	-3.510	-2.336	3.862	2.688	-0.002	-0.001
08/08/10 9:36	0.445	0.345	-3.516	-2.343	3.861	2.688	-0.003	-0.001
08/08/10 9:42	0.441	0.341	-3.520	-2.346	3.861	2.687	-0.003	-0.002
08/08/10 9:48	0.440	0.340	-3.524	-2.349	3.864	2.689	0.000	0.000
08/08/10 9:54	0.438	0.338	-3.526	-2.352	3.864	2.690	0.000	0.001
08/08/10 10:00	0.433	0.333	-3.529	-2.355	3.862	2.688	-0.002	-0.001
08/08/10 10:06	0.431	0.331	-3.531	-2.357	3.862	2.688	-0.002	-0.001
08/08/10 10:12	0.430	0.330	-3.532	-2.358	3.862	2.688	-0.002	-0.001

Observed by:	C. Mayfield	Average:	3.864	2.689
Computed by:	N. Wardwell	St Dev:	0.002	0.002
Notes:	Staff obs after fixing radar mount, calm water.	Count:	31	31

Staff Observations on Station Datum

Ewell, Smith Island, MD

857-1117

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
09/09/10 17:48	0.955	0.855	-3.016	-1.838	3.871	2.693	0.005	0.004
09/09/10 17:54	0.960	0.860	-3.009	-1.829	3.869	2.689	0.003	0.000
09/09/10 18:00	0.960	0.860	-3.010	-1.833	3.870	2.693	0.004	0.004
09/09/10 18:06	0.955	0.855	-3.010	-1.831	3.865	2.686	-0.001	-0.003
09/09/10 18:12	0.960	0.860	-3.009	-1.829	3.869	2.689	0.003	0.000
09/09/10 18:18	0.965	0.865	-3.003	-1.828	3.868	2.693	0.002	0.004
09/09/10 18:24	0.965	0.865	-3.002	-1.823	3.867	2.688	0.001	-0.001
09/09/10 18:30	0.960	0.860	-3.006	-1.830	3.866	2.690	0.000	0.001
09/09/10 18:36	0.955	0.855	-3.006	-1.828	3.861	2.683	-0.005	-0.006
09/09/10 18:42	0.950	0.850	-3.011	-1.837	3.861	2.687	-0.005	-0.002
09/09/10 18:48	0.950	0.850	-3.009	-1.831	3.859	2.681	-0.007	-0.008
09/09/10 18:54	0.955	0.855	-3.011	-1.837	3.866	2.692	0.000	0.003

Observed by:	MLHI	Average:	3.866	2.689
Computed by:	G. Shier	St Dev:	0.004	0.004
Notes:	10-15 knt wind, clear	Count:	12	12

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
09/21/10 19:00	0.810	0.710	-3.161	-1.980	3.871	2.690	0.000	-0.002
09/21/10 19:06	0.805	0.705	-3.168	-1.989	3.873	2.694	0.002	0.002
09/21/10 19:12	0.790	0.690	-3.182	-2.002	3.872	2.692	0.001	0.000
09/21/10 19:18	0.780	0.680	-3.190	-2.012	3.870	2.692	-0.001	0.000
09/21/10 19:24	0.765	0.665	-3.203	-2.023	3.868	2.688	-0.003	-0.004
09/21/10 19:30	0.760	0.660	-3.211	-2.031	3.871	2.691	0.000	-0.001
09/21/10 19:36	0.750	0.650	-3.223	-2.045	3.873	2.695	0.002	0.003
09/21/10 19:42	0.735	0.635	-3.235	-2.059	3.870	2.694	-0.001	0.002
09/21/10 19:48	0.725	0.625	-3.247	-2.069	3.872	2.694	0.001	0.002
09/21/10 19:54	0.717	0.617	-3.253	-2.074	3.870	2.691	-0.001	-0.001
09/21/10 20:00	0.701	0.601	-3.265	-2.089	3.866	2.690	-0.005	-0.002
09/21/10 20:06	0.693	0.593	-3.279	-2.102	3.872	2.695	0.001	0.003

Observed by:	KST,TWR, EAC	Average:	3.871	2.692
Computed by:	G. Shier	St Dev:	0.002	0.002
Notes:	0-5 knt wind	Count:	12	12

UTC Date and Time	Water Cut	Station Datum Water Elevation	Gauge 1 Aquatrak	Gauge 2 Radar	Staff Constant Gauge 1	Staff Constant Gauge 2	Residual Gauge 1	Residual Gauge 2
11/14/10 14:42	0.930	0.830	-3.050	-1.861	3.880	2.691	-0.002	0.000
11/14/10 14:48	0.920	0.820	-3.059	-1.871	3.879	2.691	-0.002	0.000
11/14/10 14:54	0.915	0.815	-3.067	-1.878	3.882	2.693	0.001	0.002
11/14/10 15:00	0.910	0.810	-3.076	-1.886	3.886	2.696	0.005	0.005
11/14/10 15:06	0.890	0.790	-3.086	-1.898	3.876	2.688	-0.006	-0.003
11/14/10 15:12	0.885	0.785	-3.093	-1.905	3.878	2.690	-0.003	-0.001
11/14/10 15:18	0.875	0.775	-3.102	-1.913	3.877	2.688	-0.005	-0.003
11/14/10 15:24	0.870	0.770	-3.112	-1.924	3.882	2.694	0.001	0.003
11/14/10 15:30	0.860	0.760	-3.123	-1.934	3.883	2.694	0.002	0.003
11/14/10 15:36	0.850	0.750	-3.129	-1.939	3.879	2.689	-0.002	-0.002
11/14/10 15:42	0.840	0.740	-3.139	-1.949	3.879	2.689	-0.002	-0.002
11/14/10 15:48	0.830	0.730	-3.149	-1.958	3.879	2.688	-0.002	-0.003
11/14/10 15:54	0.825	0.725	-3.154	-1.964	3.879	2.689	-0.002	-0.002
11/14/10 16:00	0.815	0.715	-3.162	-1.974	3.877	2.689	-0.005	-0.002
11/14/10 16:06	0.805	0.705	-3.170	-1.981	3.875	2.686	-0.006	-0.005
11/14/10 16:12	0.800	0.700	-3.183	-1.992	3.883	2.692	0.002	0.001
11/14/10 16:18	0.795	0.695	-3.186	-1.995	3.881	2.690	-0.001	-0.001
11/14/10 16:24	0.785	0.685	-3.197	-2.005	3.882	2.690	0.001	-0.001
11/14/10 16:30	0.780	0.680	-3.204	-2.011	3.884	2.691	0.003	0.000
11/14/10 16:36	0.775	0.675	-3.209	-2.017	3.884	2.692	0.002	0.001
11/14/10 16:42	0.765	0.665	-3.215	-2.023	3.880	2.688	-0.002	-0.003
11/14/10 16:48	0.765	0.665	-3.219	-2.027	3.884	2.692	0.002	0.001
11/14/10 16:54	0.775	0.675	-3.228	-2.035	3.903	2.710	0.022	0.019
11/14/10 17:00	0.750	0.650	-3.233	-2.041	3.883	2.691	0.002	0.000
11/14/10 17:06	0.745	0.645	-3.237	-2.044	3.882	2.689	0.001	-0.002
11/14/10 17:12	0.740	0.640	-3.244	-2.051	3.884	2.691	0.003	0.000
11/14/10 17:18	0.735	0.635	-3.248	-2.055	3.883	2.690	0.002	-0.001
11/14/10 17:24	0.730	0.630	-3.250	-2.058	3.880	2.688	-0.002	-0.003
11/14/10 17:30			-3.255	-2.063				
11/14/10 17:36	0.720	0.620	-3.258	-2.066	3.878	2.686	-0.003	-0.005
11/14/10 17:42	0.720	0.620	-3.263	-2.070	3.883	2.690	0.002	-0.001

Observed by:	ELD	Average:	3.882	2.691
Computed by:	G. Shier	St Dev:	0.005	0.004
Notes:	0 wave height	Count:	30	30

Ewell, Smith Island

TIDE STATION SITE: 8571117

UTC Date: 7/1/10

Sheet 1 / 1

Local Date: 7/1/10 S M T W (TH) F SA

Observers: N. Wardwell

Wave Height: 0.02-0.03 meters

Instructions:
Take staff readings on 6 minute intervals to coincide with the tide gauges (e.g, 00, 06, 12, 18, 24, 30, 36, 42, 48 or 54 minutes after the hour). It is OK to skip readings (e.g., read 5:06, skip 5:12, read 5:18), but do a minimum of 10 readings.

Staff "0" = meters

	UTC Time	Staff Reading	Water Elevation	Gauge Reading		Water Elevation minus Gauge Reading	
				Aquatrak - G1	H3611i - G2	Aquatrak - G1	H3611i - G2
1	22:48	0.66					
2	22:54	0.65					
3	23:00	0.645					
4	23:06	0.630					
5	23:12	0.625					
6	23:18	0.615					
7	23:24	0.605					
8	23:30	0.595					
	23:36	0.585					
10	23:42	0.580					
11	23:48	0.570					
12	23:54	0.560					
13	00:00	0.550					
14	00:06	0.535					
15	00:12	0.530					

Average: _____ _____

Standard Deviation: _____ _____

Previous Average: _____ _____

Comments: Install staff shots @ Ewell, Smith Island
This station has a Aquatrak (primary) and Radar (secondary)

Water Density Reading

Density: _____ g/cm3 @ _____ (GMT)

Density Readings are not Required Because pressure sensors are not being used @ this station.

GOES 9070730 Gauge 1

Ewel, Smith Island

TIDE STATION SITE: 8571117

UTC Date: 7/2/10

Sheet 2 / 2

Local Date: 7/1/10 S M T W TH F SA

Observers: N. Wardwell

Wave Height: 0.02-0.03 meters

Instructions:
Take staff readings on 6 minute intervals to coincide with the tide gauges (e.g, 00, 06, 12, 18, 24, 30, 36, 42, 48 or 54 minutes after the hour). It is OK to skip readings (e.g., read 5:06, skip 5:12, read 5:18), but do a minimum of 10 readings.

Staff "0" = meters

	UTC Time	Staff Reading	Water Elevation	Gauge Reading		Water Elevation minus Gauge Reading	
				Aquatrak - G1	H3611i - G2	Aquatrak - G1	H3611i - G2
1	00:18	0.520					
2	00:24	0.515					
3	00:30	0.505					
4	00:36	0.495					
5	00:42	0.487					
6	00:48	0.480					
7	00:54	0.470					
8	01:00	0.460					
	01:06	0.450					
10	01:12	0.445					
11	01:18	0.438					
12	01:24	0.427					
13	01:30	0.420					
14	01:36	0.415					
15	01:42	0.405					

Average: _____ _____

Standard Deviation: _____ _____

Previous Average: _____ _____

Comments: Install staff shots

Water Density Reading

Density: _____ g/cm3 @ _____ (GMT) NA

EWELL, SMITH ISLAND

TIDE STATION SITE: 8571117

UTC Date: 7/2/10

Sheet 1 / 1

Local Date: 7/2/10 S M T W TH (F) SA

Observers: N. Wardwell

Wave Height: 0.02 - 0.03 meters

Instructions:
Take staff readings on 6 minute intervals to coincide with the tide gauges (e.g, 00, 06, 12, 18, 24, 30, 36, 42, 48 or 54 minutes after the hour). It is OK to skip readings (e.g., read 5:06, skip 5:12, read 5:18), but do a minimum of 10 readings.

Staff "0" = meters

	UTC Time	Staff Reading	Water Elevation	Gauge Reading		Water Elevation minus Gauge Reading	
				Aquatrak - G1	H3611i - G2	Aquatrak - G1	H3611i - G2
12:00 1	~~11:54~~	0.555					
2	12:06	0.545					
3	12:12						
4	12:18	0.523					
5	12:24	0.514					
6	12:30	0.505					
7	12:36	0.495					
8							
10							
11							
12							
13							
14							
15							

Average: _____ _____

Standard Deviation: _____ _____

Previous Average: _____ _____

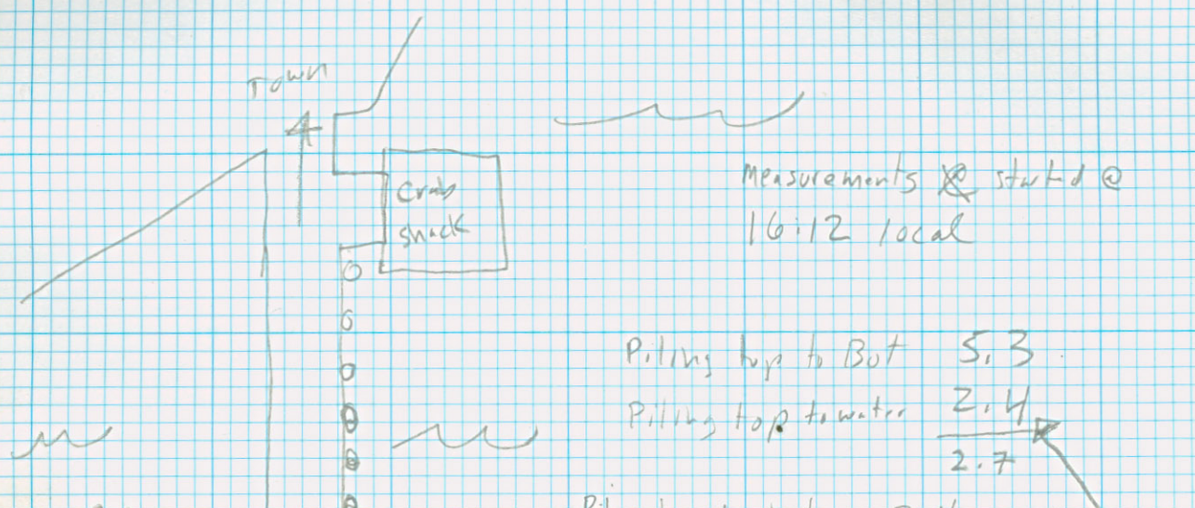
Comments: Additional staff shots to trouble shoot differences between Aquatrak and Radar Readings.

Water Density Reading

Density: _____ g/cm3 @ _____ (GMT) NA

FB 18

Smith Smith Island



Measurements ~~@~~ started @
16:12 local

Piling top to Bot 5.3
Piling top to water 2.4
2.7

Piling top to Bottom 2.4
Piling top to Water 1.0
1.4

Piling top to Bottom 4.15
Piling top to Water 2.10
2.05

~~Piling Top 3.8~~
Piling Top to Bottom 3.8
Piling Top to Water 1.65
2.15

Piling top to Bottom 3.84
Piling top to Water 1.90
1.94

Meters
Radar Piling from 2009

MHHW	0.560
MHW	0.508
MLW	0.028
MLLW	0.000
MN	0.48
GT	0.56
M.M	-0.030
Max	1.220

local 16:47

Piling #	Water	Bottom	Depth
1	1.41	2.15	0.75
2	1.7	4.81	2.40

6/29 10:38 local

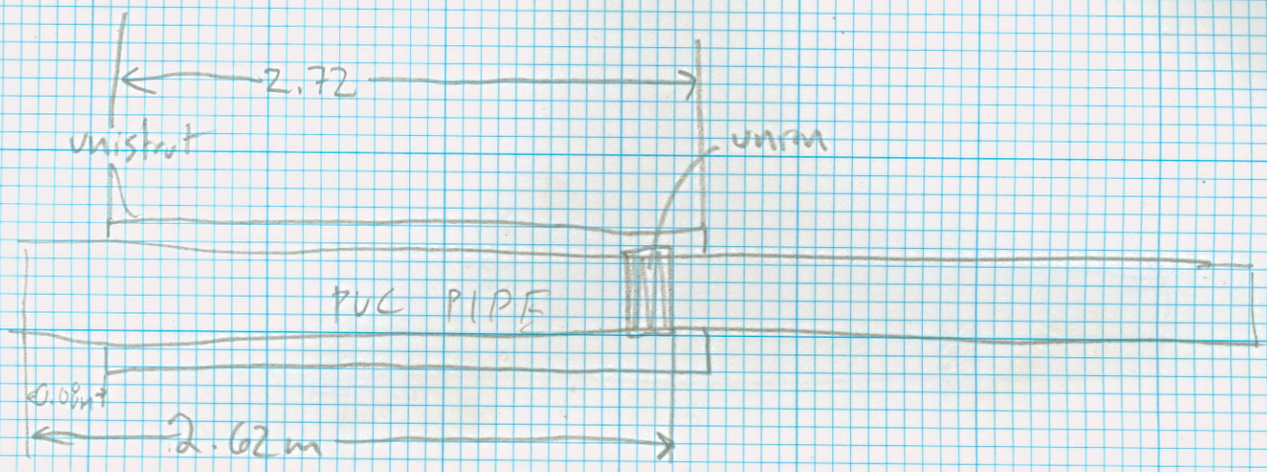
	Water Depth	
2	1.8	
3	1.7	
4	0.7	Too low

2016.06.29

SOA-171

Ewell

FBolo



Holes for water are drilled on both sides of PVC at 1' intervals starting from the Bottom of the pipe

2016.06.29

SOA-171

Ewell

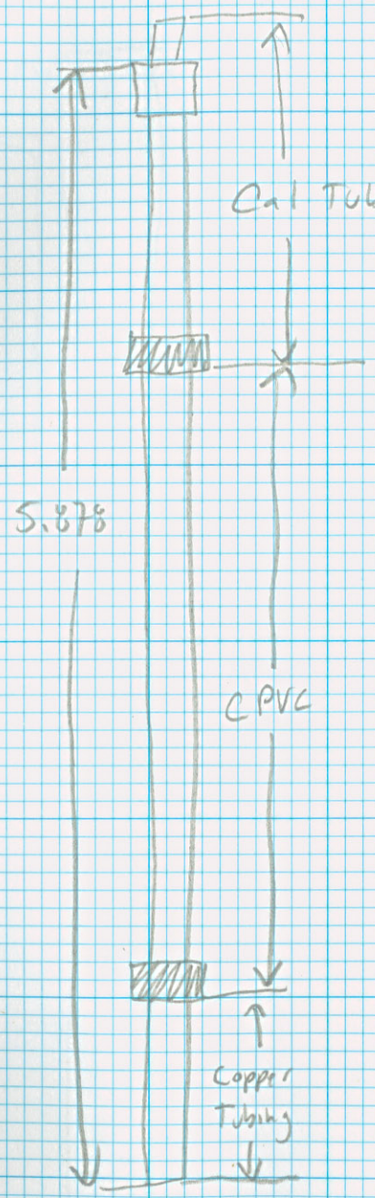
FBolo

Phone Jack is the Bottom one

JOA-171 2010.07.01

FB018

Ewell, Smith Island



JOA-171 2010.07.01

FB018

Ewell, Smith Island

Leveled Radar @ 11:08 7/1 UTC
on mount so the bullet bubble
read correctly

FB018 Ewell, ~~Island~~ Smith Island

C-Test

Level SN: 540706
Rod ~~SN~~ CRANE METRIC
Observer: Nathan Wardwell
Rodman: Ben Hocker

Unbalanced

NO 2 1997

BS	Third Interval	Mean
1787		
1760	27	1760°
1733	27	

Turtle

FS	Third Interval	Mean
2062	289	
1773	~~210~~	1773°
1484	284	

DE -0.013 m

Balanced

Turtle

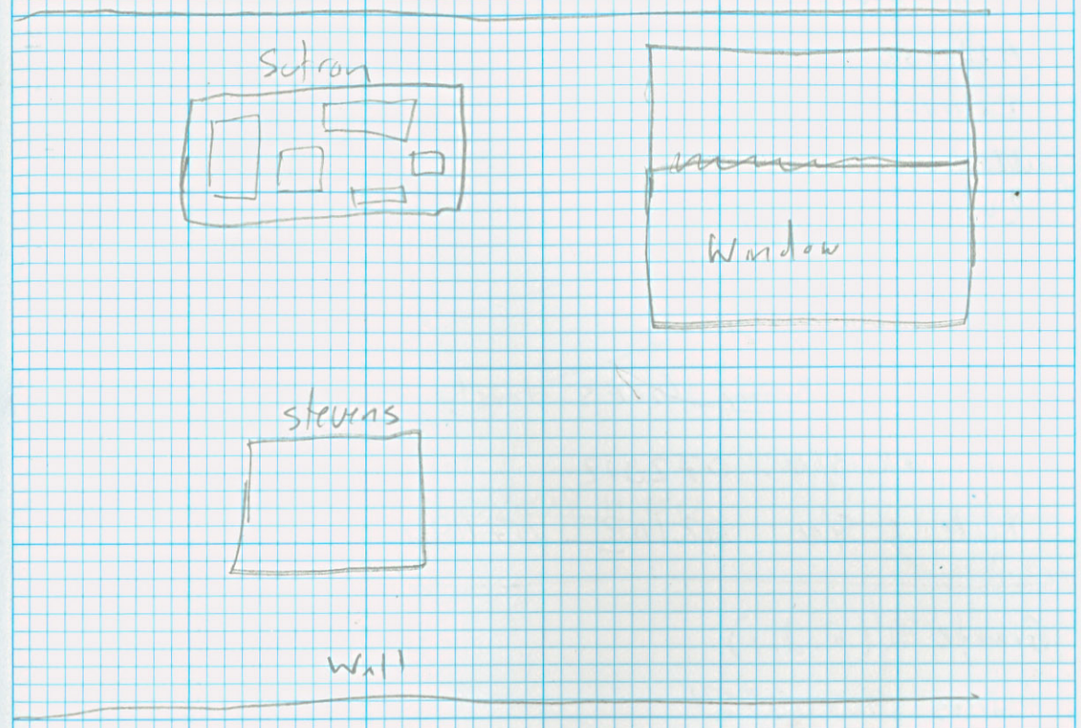
NO 2 1997

1650		
1487	163	1487°
1324	163	
	326	

1632		
1475	~~157~~	1475°
1318	157	
	314	

Unbalanced DE = -0.013 m
Balanced ~~Unbalanced~~ DE = 0.012 m
Dist = 64.0 m
mm/m = 0.0156

FB018 Ewell, Smith Island



Sutron gauge 1
- Aquatrak

Solar 40W: Model Type AP-KC40
Aquatrak head:
9210 Xlite: 071184
SATlink: 072802
Aquatrak Controller:

Stevens gauge 2
- Radar

Radar: H3611: SN 2015
Radio
DCP
Solar 40W: AP-KC40

JOA-171

FB618 Ewell, Smith Island

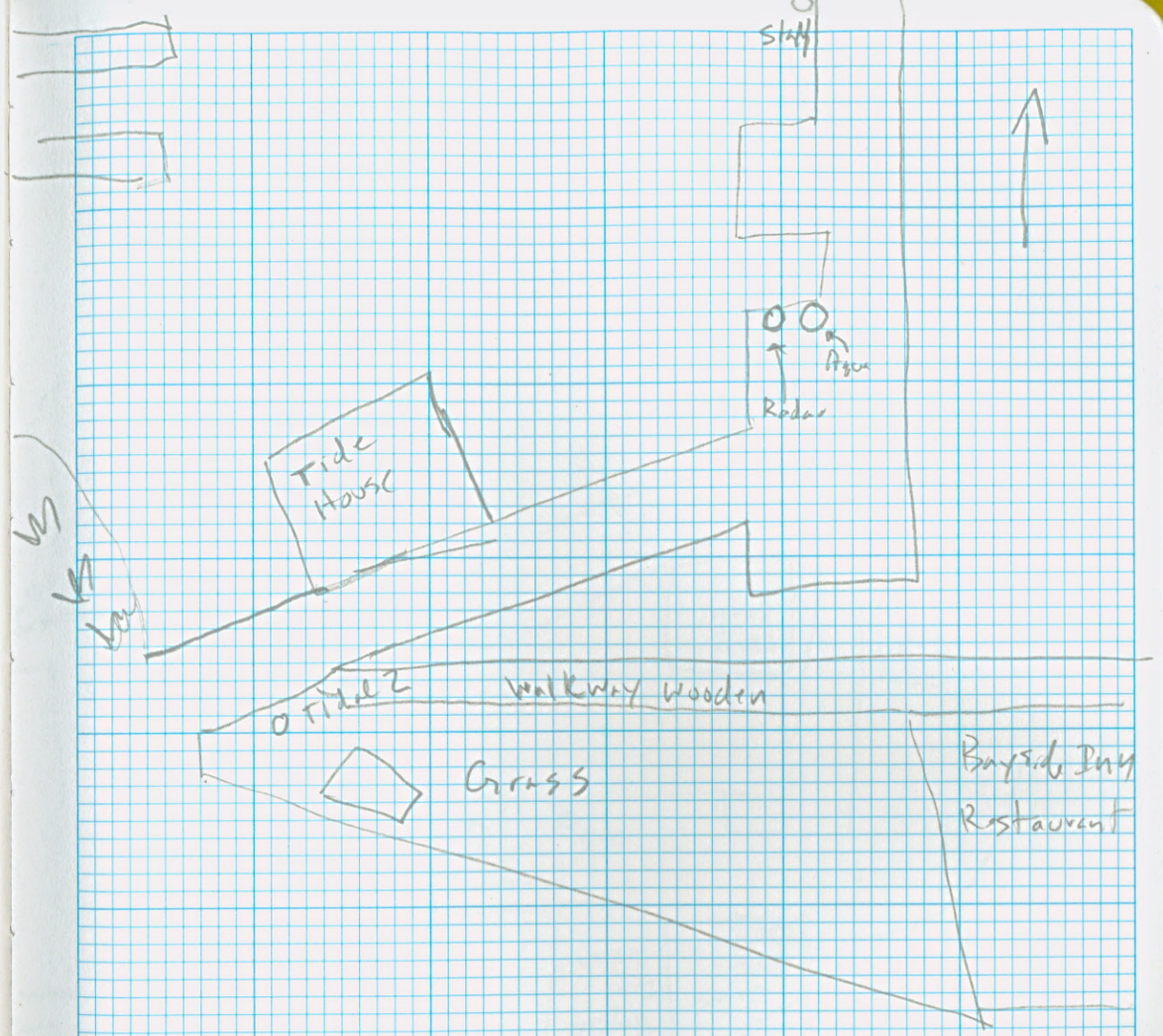
Gauge 1 (Aquatrak) GOES Parameters

Address : 90707300
Interval : 01:00:00
offset/window : 00:39:25
Channel : 145
Baud : 300 baud
Set : East
Format : Binary GOES Hourly

SATLINK S/N : 072862
Xlite S/N : ~~02108~~ 071184

Gauge 2 (Radar)
Address: 90708354
Interval: 01:00:00
offset : 00:39:35
CH : 145
~~SAT~~ : East
Format : Binary GOES Hourly

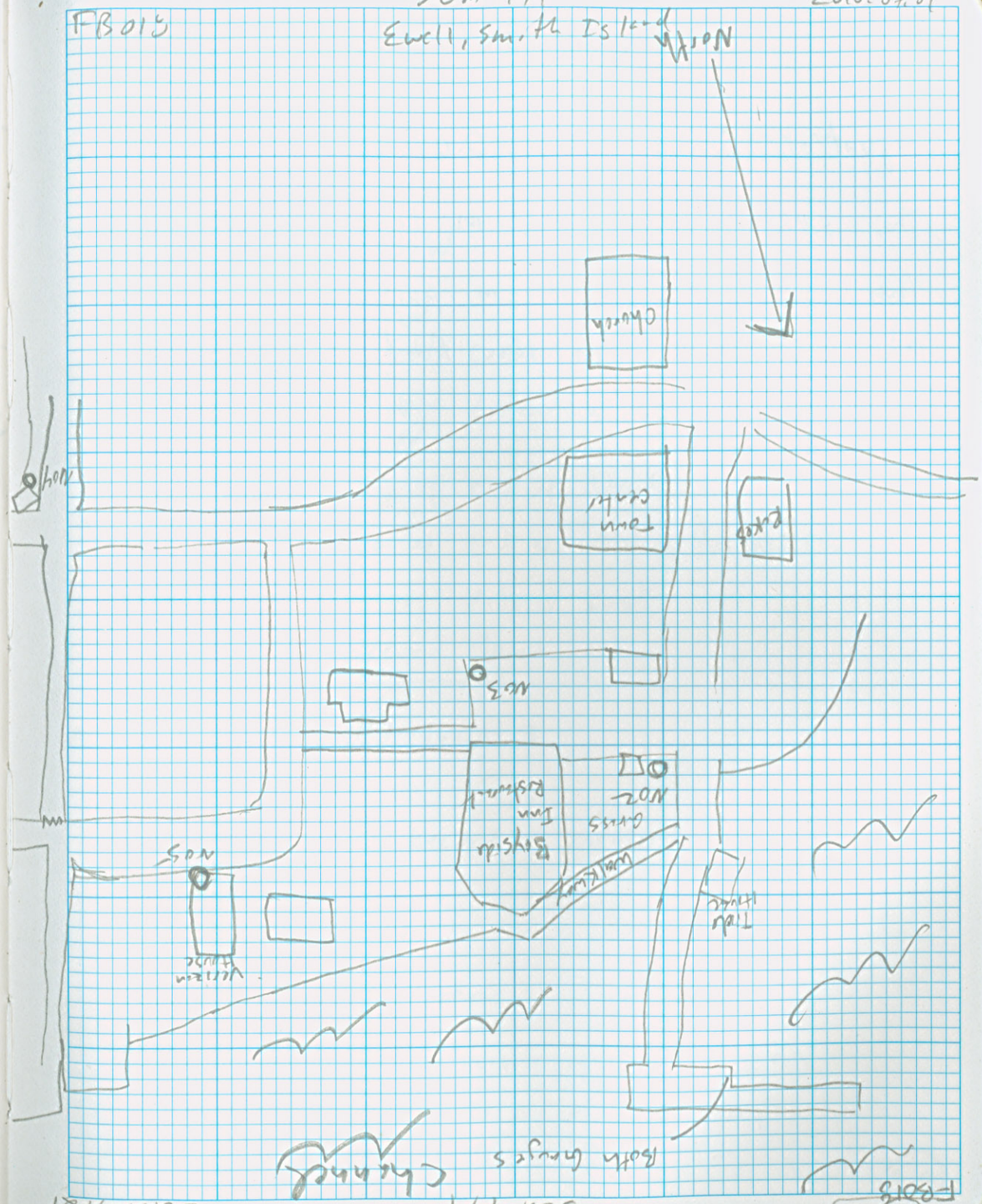
DCP: DL3000 569E718



JOA-171 2010.07.01

FB018

Ewell, Smith Island



JOA-171 2010.07.01

FB018

(49)

FB018

Ewell, Smith Island

Aquatrak SNS value = 0.096

The SNS value is <u>NOT</u> in the Sutron.

This value is applied in postprocessing and summarized in the level Abstract.

Ewell, Smith Island

Designation: 8571117 TIDAL 2

STAMPING: NO 2 1997

lat: 37-59-45.9 N

lon: 076-01-58.8 W

- 5.01m NW of ~~SW~~ W corner of refreshment stand
- 5.24m NW of ~~NW~~ N corner of refreshment
- 3.45m N70E of end of Dock
- 0.90 m S50W of end of wooden boardwalk
- 0.55m S32E of Witness post
- 20cm below ground level

Designation: 8571117 Tidal 3

Stamping: NO 3

Cannot Read Date because of corosion

lat: 37-59-44.4 N

lon: 076-01-58.4 W

- N40E of Town center
- 24.5 S70W of SE corner of Bayside Inn
- 22.2m S40E of SE corner of Gift Shop
- 4.72m N of Property corner for Bayside Inn
- 0.5 m NE of Witness post
- 11cm below Ground level

Designation: 8571117 TIDAL 5
Stamping: NO 5 1997
lat: 37-59-44.8 N
lon: 76-01-55.7 W

- 7.16m N45E of SE corner of concrete Block
- 4.26m S25E of NW corner of Verizon Building
- 2.84m N50W of SW corner of Building
- 42cm above ground level
- Center of mark is 7cm ~~of~~ from wall

Designation: 8571117 TIDAL 4
Stamping: NO 4 1997
lat: 37-59-42.1 N
lon: 076-01-56.4 W

- 12.30m N40W of Centerline of campground Road
- 16cm below ground level
- 11.35m N72E of Somers Road
- 3.52m S of SW corner of Building
- 29cm NW of ~~ele~~ Fence post directly behind SW corner of building

Designation: 8571117 A
Stamping: 1117 A 2010
lat: 37-59-42.6 N
lon: 76-01-59.9 W

- 7.12m N30E of Centerline of Caleb Jones Road
- 13.10m N20E of SW corner of Town Center Building
- 2.10m N40W of NE corner of United Methodist Church
- 42cm N40E of North wall of church

Tide House/crab shanty
lat: 37-59-46.0 N
lon: 76-01-59.0 W

Tide STAFF
lat: 37-59-47.4 N
lon: 76-01-59.0 W

Gauge 1 (Aquatrak)
lat: 37-59-47.0 N
lon: 76-01-58.2 W

Gauge 2 (Hydrolis)
lat: 37-59-47.1 N
lon: 76-01-58.3 W

JOA-171

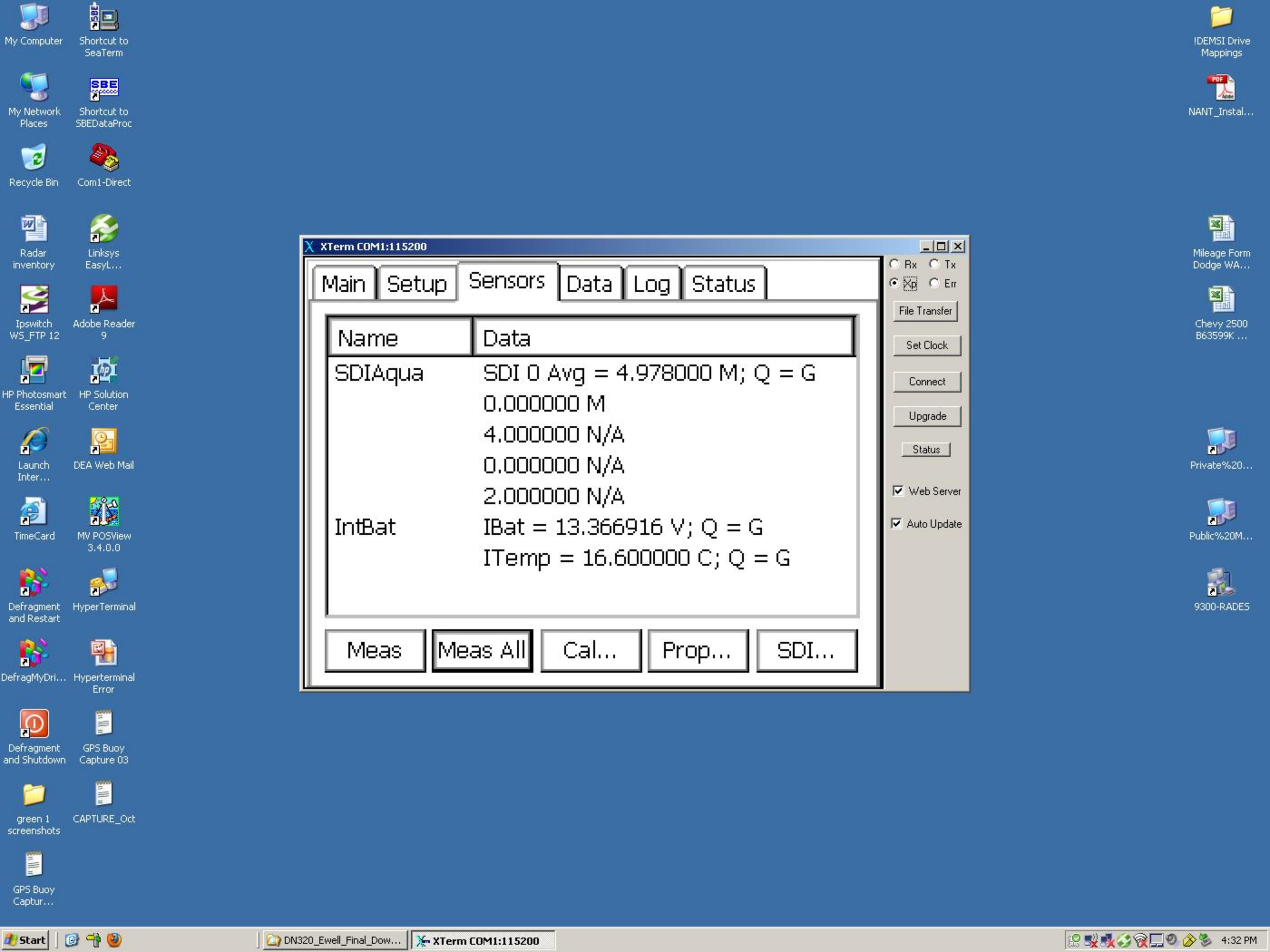
FB013

Richmond Storage

Nine pieces of Frieght in unit C130

@ Extra Attic

- 4 Totes
- 2 Tripods
- 1 Hiti
- 1 level Rod
- 1 staff shot Rod

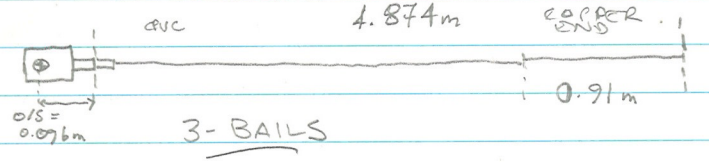

XTerm COM1:115200
Main
Setup
Sensors
Data
Log
Status
Rx
Tx
Xp
Err
File Transfer
Set Clock
Connect
Upgrade
Status
Web Server
Auto Update
Name
Data
SDIAqua
SDI 0 Avg = 4.978000 M; Q = G
0.000000 M
4.000000 N/A
0.000000 N/A
2.000000 N/A
IntBat
IBat = 13.366916 V; Q = G
ITemp = 16.600000 C; Q = G
Meas
Meas All
Cal...
Prop...
SDI...
My Computer
Shortcut to SeaTerm
My Network Places
Shortcut to SBEDataProc
Recycle Bin
Com1-Direct
Radar inventory
Linksys EasyL...
Ipswitch WS_FTP 12
Adobe Reader 9
HP Photosmart Essential
HP Solution Center
Launch Inter...
DEA Web Mail
TimeCard
MV POSView 3.4.0.0
Defragment and Restart
HyperTerminal
DefragMyDri...
Hyperterminal Error
Defragment and Shutdown
GPS Buoy Capture 03
green 1 screenshots
CAPTURE_Oct
GPS Buoy Captur...
!DEMSI Drive Mappings
NANT_Instal...
Mileage Form Dodge WA...
Chevy 2500 B63599K ...
Private%20...
Public%20M...
9300-RADES
Start
DN320_Ewell_Final_Dow...
XTerm COM1:115200
4:32 PM

BH
11/16/10

ENELL STATION DEMOBE

GAUGES SHUTDOWN 11/16/10 14:39 UTC

FINAL DECK TEST:



3- BAILS

NOTE: END OF SOUNDING TUBE HAS SOME MUD FROM SILTING IN GAUGE AREA

FINAL DECK TEST:

MEAS = ~~4.798~~m 4.978m

O/S = 0.096 m

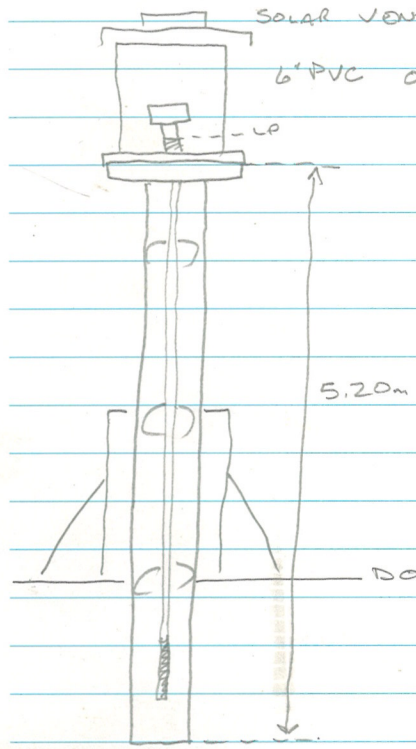
~~4.894~~m 4.882 m

TAPE = 4.874 m

Δ = ~~0.020~~m 0.008 m

BH
11/16/10

SOUNDING / STILLING TUBE



- 4" PVC STILLING WELL
- 3 BAILS EQUALLY SPACED
- COPPER END TO SOUNDING TUBE

SOUNDING/STILLING TUBE ASSEMBLY SUPPORTED BY UNI-STRUT AND PRESSURE TREATED WOOD BRACING.

"Rite in the Rain"

8571117 Dock After Removal 1.jpg

8571117 Dock After Removal 2.jpg

8571117 Dock After Removal 3.jpg

8571117 Dock After Removal 4.jpg

8571117 Dock After Removal 5.jpg

8571117 Dock After Removal 6.jpg

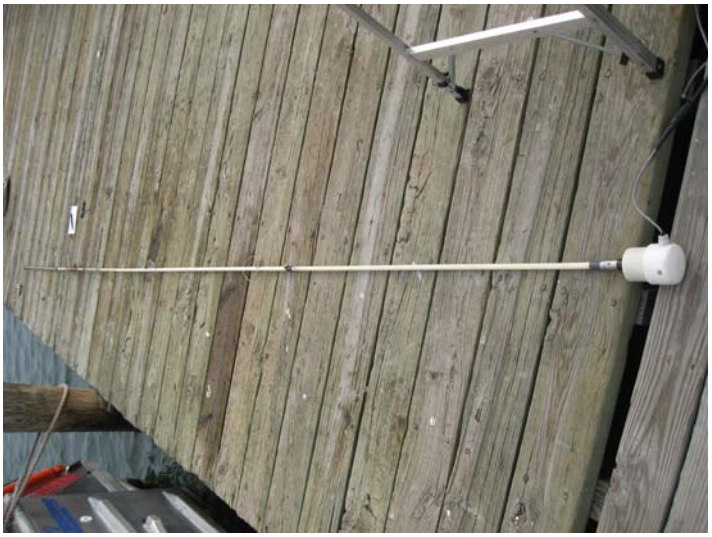
8571117 Docy After Gauge Removal 1.jpg

8571117 Docy After Gauge Removal 2.jpg

8571117 Gauge 1 Stilling Well 1.jpg

8571117 Gauge 1 Stilling Well 2.jpg

8571117 Gauge1 Sensor 1.jpg



8571117 Gauge1 Sensor 2.jpg

8571117 Gauge1 sounding tude 1.jpg

8571117 Gauge1 sounding tude 2.jpg

8571117 Tide House After Removal 1.jpg

8571117 Tide House After Removal 10.jpg

8571117 Tide House After Removal 2.jpg

8571117 Tide House After Removal 3.jpg

8571117 Tide House After Removal 4.jpg

8571117 Tide House After Removal 5.jpg

8571117 Tide House After Removal 6.jpg

8571117 Tide House After Removal 7.jpg

8571117 Tide House After Removal 8.jpg

8571117 Tide House After Removal 9.jpg

8571117-1117A2010-1-20101114.JPG

8571117-1117A2010-2-20101114.JPG

8571117-1117A2010-3SE-20101114.JPG

8571117-1117A2010-3W-20101114-2.JPG

8571117-1117A2010-3W-20101114.JPG

8571117-TIDAL 2-1-20101114.jpg

8571117-TIDAL 3-1-20101114.JPG

8571117-TIDAL 4-1-20101114.JPG

8571117-TIDAL 5-1-20101114.JPG

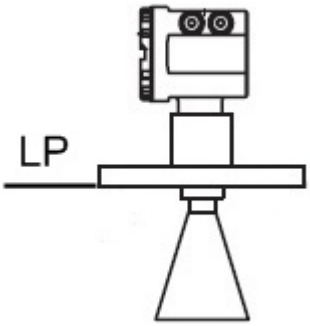
Radar Calibration Certificate

Date: June 13, 2010

Design Analysis Associates, Inc.
75 West 100 South
Logan, UT 84321
(435) 753-2212 Phone
(435) 753-7669 Fax

David Evans and Associates, Inc.
2100 SW River Parkway
Portland, OR 97201
(503) 223-6663 Phone
(503) 223-2701 Fax

Radar Gauge			
Model Number	3611i	**Serial Number**	2105
Firmware Version	3.0	**Operator**	BH



Calibration Verification			
Time (UTC)	**Reference (m)**	**Radar (m)**	**Difference (m)**
22:54:00	0.706	0.700	-0.006
23:00:00	0.840	0.837	-0.003
23:06:00	1.058	1.056	-0.002
23:12:00	1.247	1.244	-0.003
23:18:00	1.772	1.768	-0.004
23:24:00	2.218	2.214	-0.004
23:30:00	2.537	2.531	-0.006
23:42:00	0.528	0.525	-0.003
23:48:00	0.356	0.355	-0.001
Final Average Difference		**-0.004 m**	
Standard Deviation		**0.002 m**	

Aquatrak Calibration Certificate

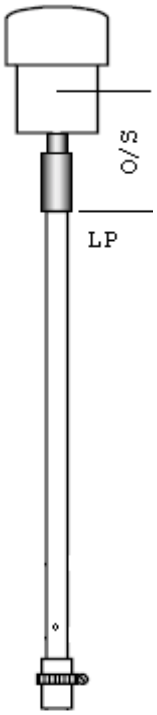
Date: June 13, 2010

Aquatrak® Corporation
1100 East 25th Street
Sanford, FL 32771
(407) 814-8680 Phone
(407) 814-9744 Fax

David Evans and Associates, Inc.
2100 SW River Parkway
Portland, OR 97201
(503) 223-6663 Phone
(503) 223-2701 Fax

Transducer			
Model Number	3000	**Calibration Tube S/N**	1052
Transducer S/N	1654-3880	**Operator**	BH

Controller			
Model Number	4110	**Serial Number**	120224
CAL Length	4 feet	**Liquid Blank Period**	100 msec
Drive Pulse Width	106 usec	**Maximum Range**	50 feet
CAL Blanking Period	60 msec	**Units**	Meters
Protocol	SDI-12	**Address**	0



Calibration			
Time (UTC)	**Reference (m)**	**Aquatrak (m)**	**Difference (m)**
20:00:00	1.750	1.848	-0.098
20:06:00	1.998	2.095	-0.097
20:12:00	2.249	2.345	-0.096
20:18:00	2.500	2.594	-0.094
20:24:00	3.000	3.090	-0.090
20:30:00	3.508	3.605	-0.097
20:36:00	1.751	1.848	-0.097
20:42:00	1.999	2.095	-0.096
20:48:00	2.249	2.345	-0.096
20:54:00	2.500	2.594	-0.094
21:00:00	3.000	3.094	-0.094
21:06:00	3.508	3.607	-0.099
Final Average Offset		**-0.096 m**	
Standard Deviation		**0.002 m**	

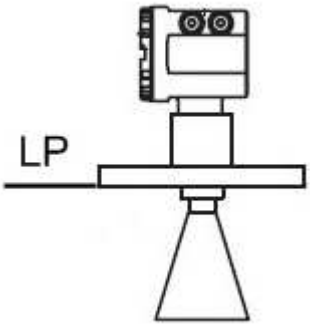
Radar Calibration Certificate

Date: December 2, 2010

Design Analysis Associates, Inc.
75 West 100 South
Logan, UT 84321
(435) 753-2212 Phone
(435) 753-7669 Fax

David Evans and Associates, Inc.
2100 SW River Parkway
Portland, OR 97201
(503) 223-6663 Phone
(503) 223-2701 Fax

Radar Gauge			
Model Number	3611i	**Serial Number**	2105
Firmware Version	3.0	**Operator**	BH



Calibration Verification			
Time (UTC)	**Reference (m)**	**Radar (m)**	**Difference (m)**
19:42:00	0.585	0.588	0.003
19:48:00	0.695	0.699	0.004
20:00:00	1.029	1.031	0.002
20:06:00	1.476	1.478	0.002
20:12:00	1.937	1.940	0.003
20:18:00	2.268	2.271	0.003
20:24:00	1.869	1.872	0.003
20:30:00	1.524	1.526	0.002
20:36:00	1.192	1.194	0.002
20:42:00	0.758	0.760	0.002
Final Average Difference		**0.003 m**	
Standard Deviation		**0.001 m**	

Aquatrak Calibration Certificate

Date: December 2, 2010

Aquatrak® Corporation
1100 East 25th Street
Sanford, FL 32771
(407) 814-8680 Phone
(407) 814-9744 Fax

David Evans and Associates, Inc.
2100 SW River Parkway
Portland, OR 97201
(503) 223-6663 Phone
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Transducer			
Model Number	3000	**Calibration Tube S/N**	1052
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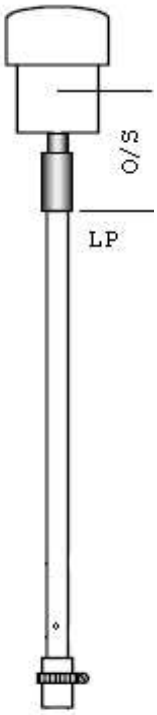
Drive Pulse Width	106 usec	**Maximum Range**	50 feet
CAL Blanking Period	60 msec	**Units**	Meters
Protocol	SDI-12	**Address**	0



Calibration			
Time (UTC)	**Reference (m)**	**Aquatrak (m)**	**Difference (m)**
18:54:00	1.748	1.829	-0.081
19:00:00	1.999	2.077	-0.078
19:18:00	2.247	2.329	-0.082
19:24:00	2.498	2.581	-0.083
19:30:00	2.997	3.081	-0.084
19:36:00	3.505	3.588	-0.083
19:42:00	3.505	3.589	-0.084
19:48:00	2.998	3.081	-0.083
19:54:00	2.498	2.581	-0.083
20:00:00	2.247	2.329	-0.082
20:12:00	1.999	2.078	-0.079
20:18:00	1.749	1.829	-0.080
Final Average Offset (O/S)		**-0.082 m**	
Standard Deviation		**0.002 m**	

Ewell, Smith Island, MD
857-1117

8571117 TIDAL 2 1.0950 m Station Datum Elevation

ELEVATIONS

Date	8571117 TIDAL 2	8571117 TIDAL 3	8571117 TIDAL 4	8571117 TIDAL 5	8571111 A	Aqua-New	Aquatrak "0"	Top of Radar Mounting Plate	Radar "0"	Staff Stop	Staff "0"	COMMENTS
7/1-7/2/10	1.0950	0.9222	0.9822	1.8846	1.3375	3.7966	3.8856	2.6948	2.6888	0.9010	-0.0990	Initial leveling
9/21/2010	1.0950	0.9233			1.3366	3.7954	3.8844	2.6908	2.6848	0.8985	-0.1015	Maintenance Leveling
11/16/2010	1.0950	0.9232	0.9817	1.8856	1.3373	3.7928	3.8818	2.6914	2.6854	0.9007	-0.0993	Closeout Leveling
	1.0950	0.9229	0.9820	1.8851	1.3371	3.7949	3.8839	2.6923	2.6863	0.9001	-0.0999	**Average**
	0.0000	0.0011	0.0005	0.0010	0.0009	0.0038	0.0038	0.0040	0.0040	0.0025	0.0025	**Maximum Difference**

Dif. Of Elev.

Date	8571117 TIDAL 2 to 8571117 TIDAL 3	8571117 TIDAL 4 to 8571117 TIDAL 5	8571117 TIDAL 2 to 8571117 A	857117 TIDAL 3 to 8571117 TIDAL 5	8571117 TIDAL 2 to 8571117 TIDAL 5	8571117 A to 8571117 TIDAL 4	8571117 TIDAL 2 to Aqua-New	Aqua-New to Aquatrak "0"	8571117 TIDAL 2 to Radar Top Plate	Radar Top Plate to Radar "0"	8571117 TIDAL 2 to Staff Stop	COMMENTS
7/1-7/2/10	-0.1728	0.9024			0.7896	-0.3553	2.7016	0.0960	1.5998	-0.0060	-0.1940	Initial leveling
9/21/2010	-0.1717		0.2416				2.7004		1.5958	-0.0060	-0.1965	Maintenance Leveling
11/16/2010	-0.1718		0.2423	0.9624		-0.3556	2.6978	0.0820	1.5964	-0.0060	-0.1943	Closeout Leveling
	-0.1721	0.9024	0.2420	0.9624	0.7896	-0.3555	2.6999	0.0890	1.5973	-0.0060	-0.1949	**Average Difference**
	0.0011	0.0000	0.0007	0.0000	0.0000	0.0003	0.0038	0.0140	0.0040	0.0000	0.0025	**Maximum Difference**

Notes:

1) Aqua-New to Aquatrak "0" offset is determined from the average of pre and post deployment calibrations. This offset is used to derive the STND elevation of the Aquatrak "0" from the Installation, Maintenance, and Closeout levels.
2) The average value for Aquatrak "0" is used to convert the Gauge 1 readings to STND.

GPS OBSERVATION LOG (15-Apr-2003)

Station Designation: (circle applicable: FBN / CBN / PAC / SAC / BM) 8571117 TIDAL 2		Station PID, if any:	Date (UTC): 7/1/10
General Location: Smith Island	Airport ID, if any:	Station 4-Character ID: ~~HOA~~ TID2	Day of Year: 182
Project Name: Chesapeake Bay Hydro	Project Number: GPS-	Station Serial # (SSN):	Session ID:(A,B,C etc) A

NAD83 Latitude	NAD83 Longitude	NAD83 Ellipsoidal Height	Agency Full Name: JOA Surveys
37° 59' 45.9"	76° 01' 58.8"	meters	Operator Full Name: Nathan Wardwell
		NAVD88 Orthometric Ht. meters	Phone #: (907)561-0136
		GEOID99 Geoid Height meters	e-mail address: nathan@joasurveys.com

Observation Session Times (UTC): Sched. Start _____ Stop _____ Actual Start 02:12 Stop 16:56

Epoch Interval= 15 Seconds; Elevation Mask = 10 Degrees

GPS Receiver: Manufacturer & Model: Topcon
P/N: D
S/N:
Firmware Version:
☐ CamCorder Battery, ☒ 12V DC, ☐ 110V AC, ☐ Other

GPS Antenna: TOPCON
Manufacturer & Model, & NGS antenna code*:
P/N: PGA_1
S/N:
Cable Length, meters:
Vehicle is Parked N/A meters ____(direction) from antenna.

		Circle Yes or No -If no, explain *
Antenna plumb before session?	(Y/N)	
Antenna plumb after session?	(Y/N)	
Antenna oriented to true North?	(Y/N)	
Weather observed at antenna ht.	(Y/N)	
Antenna ground plane used?	(Y/N)	
Antenna radome used?	(Y/N)	If yes, describe.
Eccentric occupation (>0.5 mm)?	(Y/N)	
Any obstructions above 10°?	(Y/N)	See Use Vis. form
Radio interference source nearby	(Y/N)	

Tripod or Ant. Mount: Check one: ☒ Fixed-Height Tripod, ☐ Slip-Leg Tripod, ☒ Fixed-Mount
Manufacturer & Model:
P/N:
S/N: Seco
Last Calibration date:

Tribrach: Check one: ☒ None, ☐ Wild GDF 22, ☐ Topcon, ☐ Other (describe)
Last Calibration date:

**** ANTENNA HEIGHT **** (see back of form for measurement illustration)

	Before Session Begins: measure and record both Meters	AND Feet	After Session Ends: measure and record both Meters	AND Feet
A= Datum point to Top of Tripod (Tripod Height)				
B=Additional offset to ARP if any (Tribrach/Spacer)				
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)	1.500	4.92	1.500	4.92

Note: Meters = Feet X (0.3048)
Height Entered Into Receiver = _____ meters.

Please note &/or sketch ANY unusual conditions. Be Very Explicit as to where and how Measured!

Barometer: Manufacturer & Model:
P/N:
S/N: N/A
Last Calibration or check Date:

Psychrometer: Manufacturer & Model:
S/N: N/A

Weather DATA	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar	Weather Codes *
Before									
Middle									
After									
Average of Readings									

* See back of form for codes

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

Fixed Height tripod 1.500m to ARP

There is a Verizon communications Tower ~ ESE of TIDAL 2

Note: Entries are Required in all Unshaded areas.

* Antenna code is provided by NGS coordinator in the ant_info file.

Table of Weather Codes -- for entry into Weather Data Table on front of form:

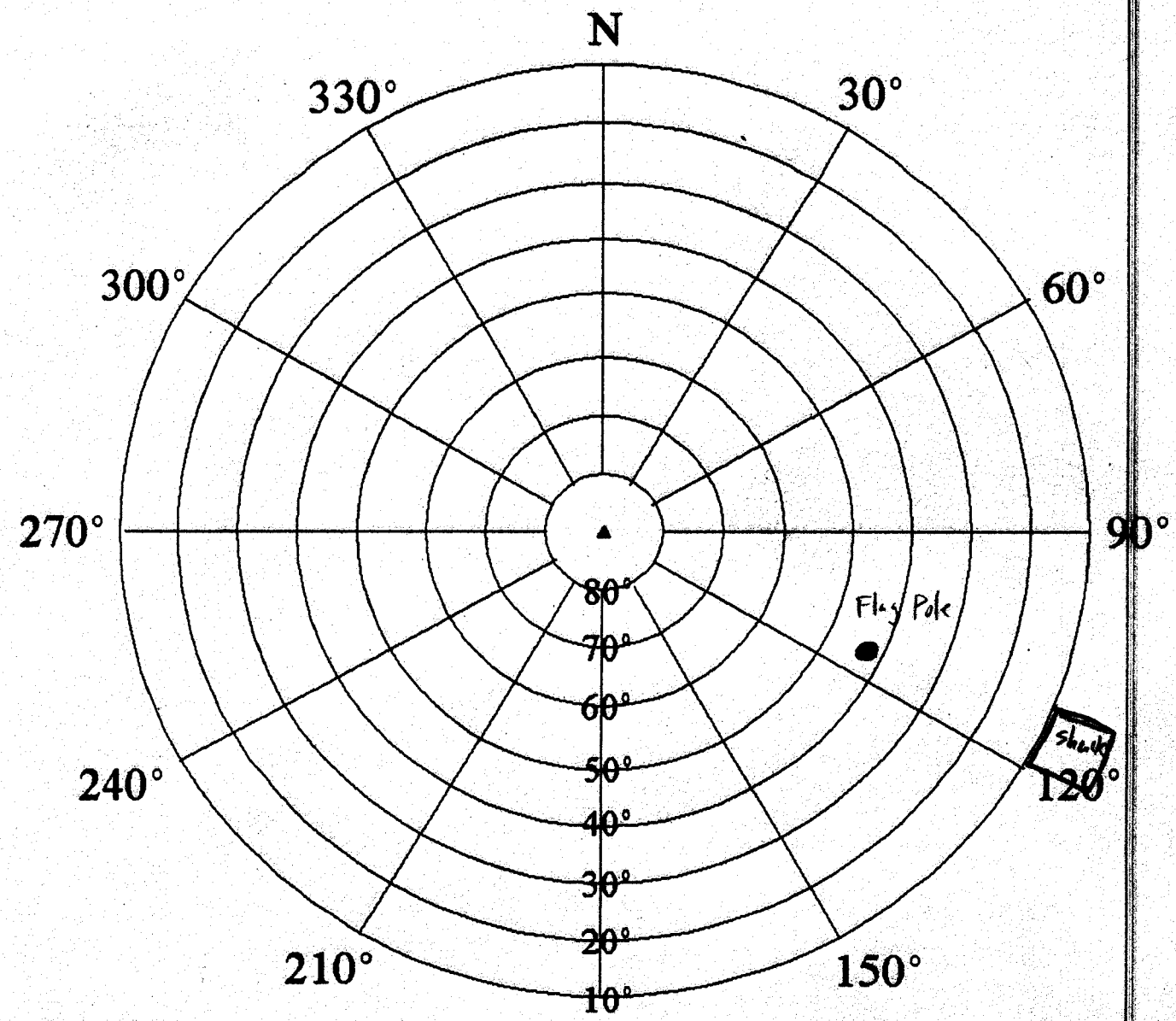
CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	NO PROBLEMS encountered	GOOD More than 15 miles	NORMAL 32° F to 80°F	CLEAR Below 20%	CALM Under 5mph (8km/h)
1	PROBLEMS encountered	FAIR 7 to 15 miles	HOT Over 80°F (27 C)	CLOUDY 20% to 70%	MODERATE 5 to 15 mph
2	-- NOT USED --	POOR Less than 7 miles	COLD Below 32° F (0 C)	OVERCAST Over 70%	STRONG over15mph (24km/h)
Examples: Code 00000 =	0 - No problems,	0 - good visibility,	0 - normal temperature,	0 - clear sky,	0 - calm wind
Code 12121 =	1 - Problems,	2 - poor visibility,	1 - hot temperature,	2 - overcast,	1 - moderate wind

Data File Name(s): TID2182a.TPS
(Standard NGS Format = abaseddds.xxx) where aaaaa=Chronister ID, ddd=Day of Year, s=Session ID, xxx=Receiver extension

Updated Station Description: ☐ Attached ☐ Submitted earlier
Visibility Obstruction Form: ☐ Attached ☐ Submitted earlier
Photographs of Station: ☐ Attached ☐ Submitted earlier
Pencil Rubbing of Mark: ☐ Attached

LOG CHECKED BY: NCW

NATIONAL GEODETIC SURVEY VISIBILITY OBSTRUCTION DIAGRAM



INSTRUCTIONS:

Identify obstructions by azimuth (magnetic) and elevation angle (above horizon) as seen from station mark. Indicate distance and direction to nearby structures and reflective surfaces (potential multipath sources).

4-char ID: TIDZ Designation: 8571117 TIDAL 2

PID: _____ Location: Sw 91, Smith Island

County: Somerset Reconnaissance By: _____

Height above mark, meters: 1.500 Agency/Company: JOA Surveys, LLC

Phone: (561) 0136 Date: 2010.07.01

Check if no obstructions above 10 degrees ☐

NATIONAL GEODETIC SURVEY STATION DESCRIPTION / RECOVERY FORM

4-char ID: TID2 Designation: 8571117 TIDAL 2

PID: _____ Alias: _____

Country: (USA /) State: MD County: Somerset

Latitude: N 37 ° 59 ' 45.9 " Longitude: W 076 ° 01 ' 58.8 " Elevation: _____ (meter / ft)

Original Description (check one):	
❒ P	Preliminary (mark has not been set yet)
❒ D	A newly set mark
☑ R	A recovered mark
Established by: (NGS / CGS / Other:)	USACE
Date:	Chief of Party (initials):

Recovery Description (check one):	
☑ F	Full description of a station *not* in the database
❒ T	Full description of a station *in* the database
❒ M	*Partial* description of a station in the database
Recovered by: (NGS / Other:)	JOA Surveys, LLC
Date: 2010-07-01	Chief of Party (initials): NCW

Monument Stability (check one):	
❒ A	Of the most reliable nature; expected to hold well
☑ B	Will probably hold position and elevation well
❒ C	May hold well, but subject to ground movement
❒ D	Of questionable or unknown reliability

Recovery Condition (check one):	
☑ G	Recovered in good condition
❒ N	Not recovered or not found
❒ P	Poor, disturbed, or mutilated
❒ X	Surface mark known destroyed

Setting Information:	
Marker Type: (Rod / Disk / Other)	Disk crimped to rod
Setting Type: (Bedrock / Concrete / Other:)	
Y / ☑ N / ?	Monument contains magnetic material?

Stamping:	NO 2 1997
Agency Inscription: (NGS / CGS / Other:)	USACE
Rod Depth: 12.8 ☑ (m/ft)	Sleeve Depth: (m/ft)
Monument is: (flush / projecting / recessed)	(cm/ft)

Special Type (check all applicable):	
❒ F	Fault monitoring site
☑ T	Tidal Station
❒ --	Control Station: (FBN / CBN / Bench mark)
❒ --	Airport Control Station: (PACS / SACS)
Y /N	Mark is suitable for GPS use?

Transportation (check one):	
❒ C	Car
❒ P	Light truck (pickup, carry-all, etc.)
❒ X	Four-Wheel Drive Vehicle
☑	Other (SnowCat, Plane, Boat; describe) ferry from Crisfield
Y /N	Pack Time (hike) to mark? (hh:mm):

See Back of Form to add Text Description

General Station Location: The station is located in Chesapeake Bay about 15 km west of Crisfield, 19 km North of Tangier Island, and 27 km NE of Reedville, VA.

(Describe general location; include airline distances to three towns or mapped features.)

Ownership: The is on prepoerty owned by the City of Ewell.

(name, address, phone of landowner)

To Reach Narrative: To reach the station from the intersection of xxxxxxxxx Crisfield, MD take a ferry west across Tangier Sound to Big Thorofare on the eastside of Smith Island, travel NW for 3.5 km to the entrance to Levering Creek, travel SW for 0.4 km to Levering Creek, bear WNW and travel 0.3 km to the Ewell Dock. The station is on the right at the end of the wooden board walk near the beginning of the pavement drive.

(Leg-by-leg distances and directions from major road intersection to mark)

Monument Description and Measurements: The station is 5.81 m NW of the W corner of a refreshment stand, 5.24 m NW of the N corner of a refreshment stand, 3.45 m NE of the end of the dock, 0.90 m SW of the end of the wooden boardwalk, 0.55 m SE of a orange carsonite witness post. The bench mark is 21 cm below ground level, crimped to an aluminum rod driven 12.8 m, and encased in a 4-inch PVC pipe and concrete kickblock.

(Add at least three measurements to permanent, identifiable, nearby objects; and a description of the monument size, shape, height, etc.)

NOTE: - Include a pencil rubbing, sketch, or photographs of mark.

Described by: N. Wardwell Phone: (907) 561-0136 e-mail: nathan@joasurveys.com

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY PENCIL RUBBING FORM

4-char ID: TID2 Day of Year ("Julian Day"): 182

Designation: 8571117 TIDAL 2 PID: _____

Stamping: NO 2 1997

Mark Type / Agency Inscription: USACE JOA Surveys, LLC

Location: Ewell, Smith Island, MD County: Somerset

Rubbing By: Nathan Wardwell Date: July 1, 2010

Agency: JOA Surveys, LLC Phone: (____) (907) 561-0136

Remarks: _____

INSTRUCTIONS:

Place the blank form (or other blank paper) over the mark and rub over the entire disk with a pencil. For rod marks, rub only the designation and date stamping from the rim of the aluminum logo cap. If it is impossible to make a rubbing of the mark, or if the rubbing appears indistinct, a sketch and/or photograph may be substituted.

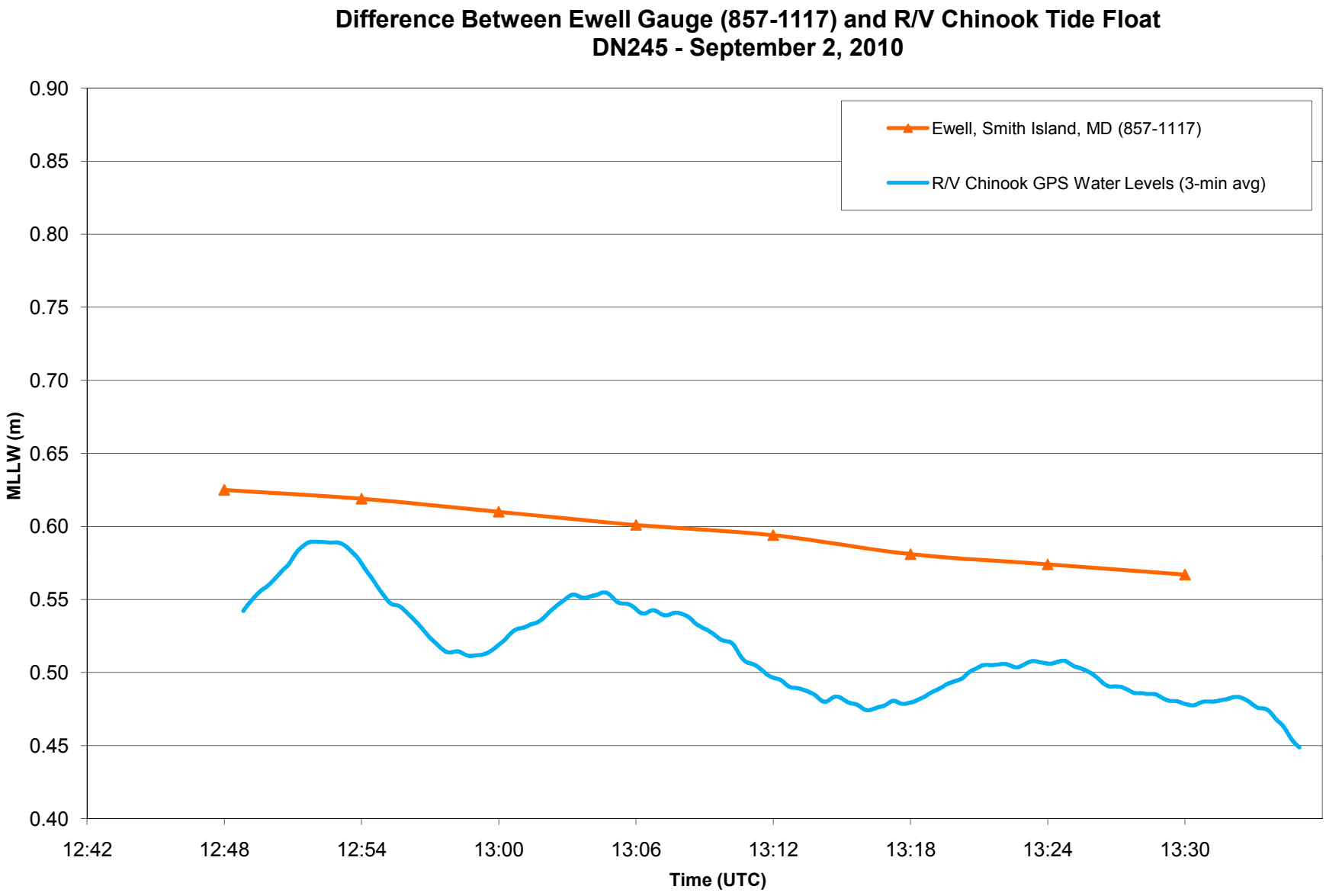
8571117 TIDAL 2, 1, 01JUL10

FILE: TID2182a.tps 000047777

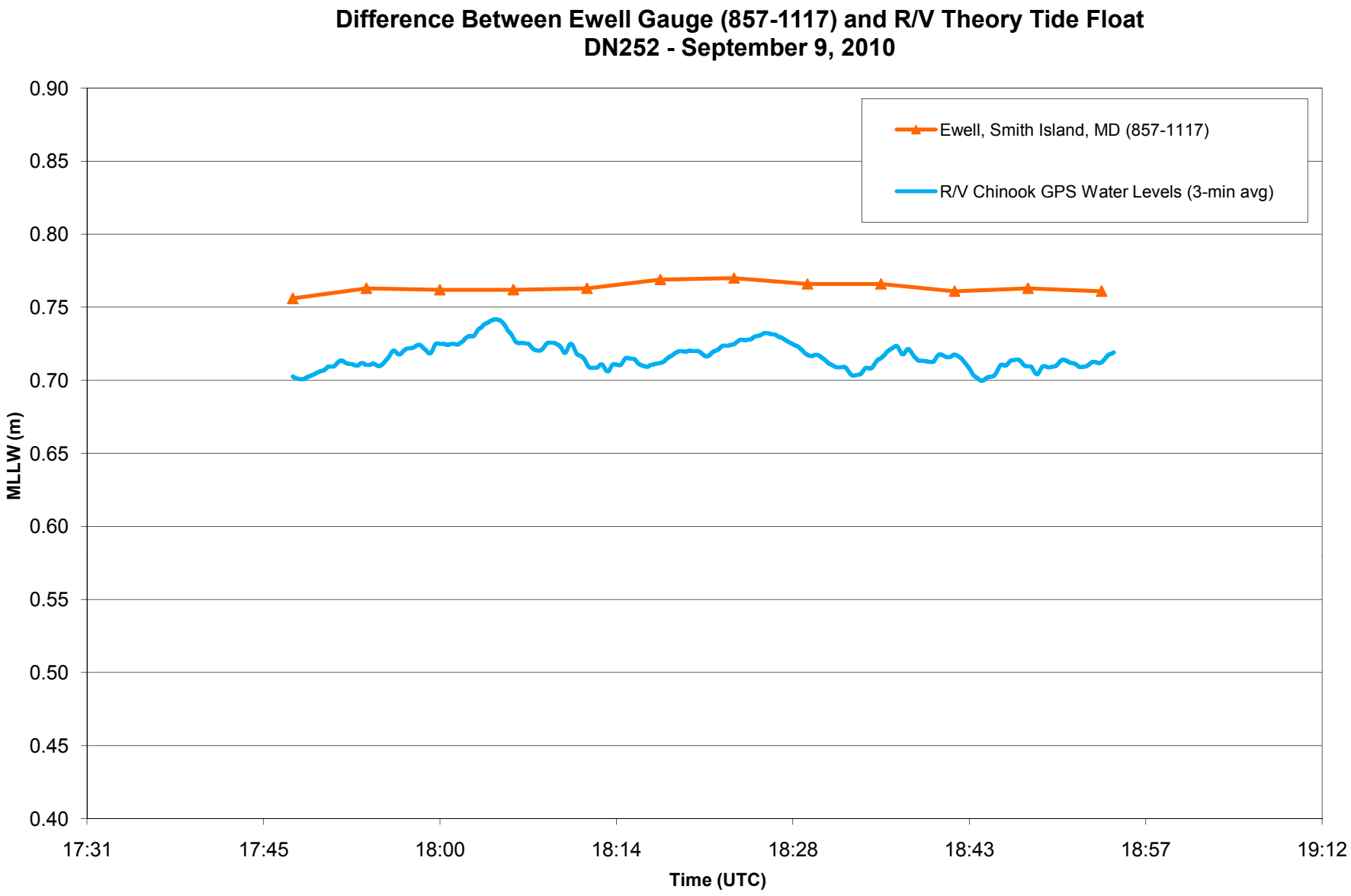
NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

```
      USER: nathan@joasurveys.com                    DATE: July 23, 2010
RINEX FILE: tid2182c.10o                             TIME: 18:05:04 UTC


  SOFTWARE: page5  0909.08 master29.pl 081023      START: 2010/07/01  02:10:00
 EPHEMERIS: igs15904.eph [precise]                  STOP: 2010/07/01  16:56:00
  NAV FILE: brdc1820.10n                        OBS USED: 36350 / 38352   :  95%
  ANT NAME: TPSPG_A1        NONE             # FIXED AMB:   133 /   150   :  89%
ARP HEIGHT: 1.500                             OVERALL RMS: 0.016(m)


 REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000)            ITRF00 (EPOCH:2010.4970)

         X:      1214698.249(m)   0.014(m)           1214697.504(m)   0.014(m)
         Y:     -4883879.852(m)   0.018(m)          -4883878.389(m)   0.018(m)
         Z:      3905077.600(m)   0.015(m)           3905077.481(m)   0.015(m)

       LAT:   37 59 45.81671      0.005(m)        37 59 45.84561      0.005(m)
     E LON:  283 58  1.10402      0.013(m)       283 58  1.08886      0.013(m)
     W LON:   76  1 58.89598      0.013(m)        76  1 58.91114      0.013(m)
    EL HGT:          -35.345(m)   0.025(m)               -36.679(m)   0.025(m)
 ORTHO HGT:            0.565(m)   0.025(m) [NAVD88 (Computed using GEOID09)]

                        UTM COORDINATES    STATE PLANE COORDINATES
                         UTM (Zone 18)         SPC (1900 MD  )
Northing (Y) [meters]     4205881.288           37014.576
Easting (X)  [meters]      409296.965          484940.274
Convergence  [degrees]    -0.63598208          0.60690547
Point Scale                0.99970133          1.00006676
Combined Factor            0.99970687          1.00007231

US NATIONAL GRID DESIGNATOR: 18SVH0929605881(NAD 83)


                              BASE STATIONS USED
PID       DESIGNATION                        LATITUDE    LONGITUDE DISTANCE(m)
DL3474 LOYM LOYOLA M CORS ARP              N381838.119 W0763757.974   63103.9
DL3889 LOYW LOYOLA LOYW CORS ARP           N373140.995 W0755052.663   54443.9
DI2269 VAWI WALLOPS ISLAND CORS ARP        N375603.499 W0752815.949   49852.0

                 NEAREST NGS PUBLISHED CONTROL POINT
GV3611      EWELL ME CHURCH SPIRE          N375942.648 W0760200.015     101.7
```


Difference Between Ewell Gauge (857-1117) and R/V Chinook Tide Float
DN245 - September 2, 2010
Ewell, Smith Island, MD (857-1117)
R/V Chinook GPS Water Levels (3-min avg)
MLLW (m)
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
12:42
12:48
12:54
13:00
13:06
13:12
13:18
13:24
13:30
Time (UTC)

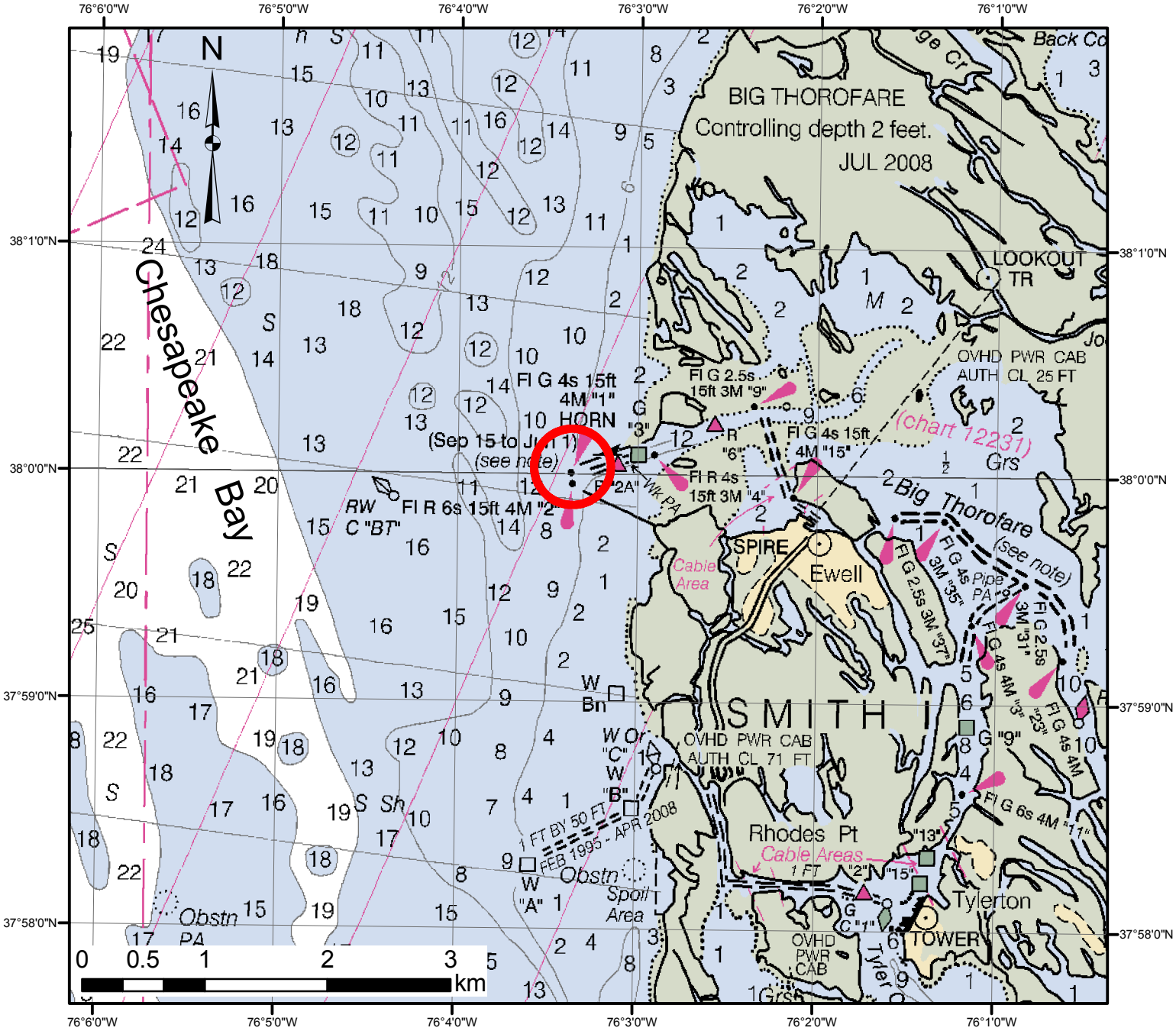
Difference Between Observed Water Levels at Ewell Tertiary Gauge and R/V Chinook Tide Float DN 245 - September 2, 2010			
Time (UTC)	Vessel GPS Water Level (m)	Ewell Gauge Level (m)	Difference to Vessel (m)
12:48	0.554	0.625	-0.071
12:54	0.546	0.619	-0.073
13:00	0.533	0.610	-0.077
13:06	0.540	0.601	-0.061
13:12	0.487	0.594	-0.107
13:18	0.491	0.581	-0.090
13:24	0.502	0.574	-0.072
13:30	0.481	0.567	-0.086
		Mean	-0.079
		Standard Deviation	0.014


Difference Between Ewell Gauge (857-1117) and R/V Theory Tide Float
DN252 - September 9, 2010
Ewell, Smith Island, MD (857-1117)
R/V Chinook GPS Water Levels (3-min avg)
MLLW (m)
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
17:31
17:45
18:00
18:14
18:28
18:43
18:57
19:12
Time (UTC)

Difference Between Observed Water Levels at Ewell Tertiary Gauge and R/V Theory Tide Float DN 252 - September 9, 2010			
Time (UTC)	Vessel GPS Water Level (m)	Ewell Gauge Level (m)	Difference to Gauge (m)
17:48	0.706	0.756	-0.050
17:54	0.715	0.763	-0.048
18:00	0.729	0.762	-0.033
18:06	0.727	0.762	-0.035
18:12	0.712	0.763	-0.051
18:18	0.716	0.769	-0.053
18:24	0.728	0.77	-0.042
18:30	0.713	0.766	-0.053
18:36	0.715	0.766	-0.051
18:42	0.710	0.761	-0.051
18:48	0.712	0.763	-0.051
18:54	0.715	0.761	-0.046
		Mean	-0.047
		Standard Deviation	0.007

APPENDIX VII
RADAR GAUGE DATUM RESULTS

Radar Gauge in Chesapeake Bay



Radar Gauge Installation in Chesapeake Bay

A Design Analysis Associates H3611i radar gauge was installed on USCG piling Green 1.
The location of the piling is outlined by the red circle in the map above.
The radar gauge data was tied to the NAD83 reference ellipsoid via static GPS techniques and NGS OPUS processing. All data was used to evaluate NOAA's Vertical Datum Transformation Tool (VDatum).

Data Source

Overview Map: NOAA chart 12230-1

Map Projection

Universal Transverse Mercator
NAD83 Zone 18N

Location of Radar Gauge

Lat: 38° 00' 00.3" N
Long: 76° 03' 22.3" W

Site Report

8570004 USCG Piling Green 1

Site Visit	Purpose of Visit	Installation	Team Leader	Nathan Wardwell	Date of Visit	8/5/09- 8/6/09
Tertiary Station	Installation	July 15, 2010	Removal	Nov. 16, 2010	Number of Days	124
Project	OCS				JOA WO#:	171
Position (NAD83)	Latitude (N)	38° 00' 0.3"	Longitude (W)	76° 03' 22.3"	Time Meridian	0° (UTC)
Local Values	Gravity (milligals)	979966 +/- 2	GOES Angles	Elev 46°/ Az 178°	Magnetic Declination	11° 11' W / 0° 0' W/year

Contractor	Prime	Tide Consultant
	David Evans & Assoc 2100 SW River Parkway Portland, OR 97201 (503) 223-6663 ATTN: Ben Hocker	JOA Surveys, LLC 2000 E. Dowling Rd, Suite 10 Anchorage, AK 99507 (907) 561-0136 phone ATTN: Nathan Wardwell

Owner

United States Coast Guard
Coast Guard Support Center
4000 Coast Guard Blvd.
Portsmouth, VA 23703-2199 (757) 483-8700

Location

To reach the radar gauge from the city dock in Crisfield, proceed by ferry west to Smith Island and Ewell at the north end of the island, then proceed by charter boat to the west harbor entrance to Ewell. The radar gauge is mounted on the USCG green 1 piling near the end of the entrance breakwaters .

Tide House

The radar gauge electronics are housed in 2 yellow pelican cases. The pelican case is mounted on the same two 10' deep sections of unistrut that support the radar sensor. A 20 watt solar panel is mounted on the western end of the piling, and the GPS antenna is mounted to near the handrail to the east the pelican cases. A GOES antenna is mounted above the ladder that is used to access the platform and is mounted to a 2x4 on the western side of the platform near the solar panel. A 5/8" section of all thread is mounted to the base plate of the radar sensor.

Primary DCP

Installed	July 15, 2010	**Removed**	Nov. 16, 2010		
Radar Sensor	H3611i	Serial No.	1618	Level Point to Sensor "0"	0.000
		Averaging Interval	181 sec	Slope Constant in Gauge	n/a
Data Logger	Xpert	Serial No.	070610	Firmware	2.8.0.3
GOES Radio	Satlink	Serial No.	070711	GPS timing	Yes
GOES Address	907181AE	Channel	141	Format	Binary (9 byte)
Interval	1 hour	Offset	0:30:15	Transmit Window	10 seconds
Power	One battery with a 20 watt solar panel with solar controller.				
Radar Mount	The radar was mounted with a custom fabricated plastic baseboard bolted to sections of unistrut, and these sections of unistrut are attached to small I-beams on the platform. The radar extends out over the NE corner of the platform. An aluminum plate is mounted to the base of the metal radar plate. This aluminum plate is used to support the 5/8" all thread for GPS observations. On top of this plate is the metal base plate for the radar. The bottom of the metal radar base plate is the sensor "0". All measurements should be referenced to this point.				
Comments					

Secondary DCP

Installed		**Removed**			
Pressure Sensor		Serial No.		Vent Value (m)	
		Averaging Interval		Slope Constant in Gauge	
Data Logger		Firmware			
Pump		Serial No.			
GOES Radio		Serial No.		GPS timing	
GOES Address		Channel		Format	
Interval		Offset		Transmit Window	
Power					
Orifice					
Comments	No secondary sensor was installed				

Tide Staff

One tide staff is mounted 3.061 meters below the bottom of the metal radar base plate.

Tidal Bench Marks

Primary	Recovered	Established	Comments
			Data was tied to ellipsoid, no benchmarks were installed

Leveling

Date	Order	Type	Bench Marks Connected
NAVD88 Level Tie			
Comments	Stability of sensor was monitored using three methods 1) static GPS techniques 2) kinematic GPS techniques (Boat Float) 3) Measure downs. The NAD83(CORS96) reference ellipsoid (EPOCH 2002.000) was used as station datum.		

GPS & OPUS

Bench Mark	Date	Session Length	Latitude (N)	Longitude (W)	Ellipsoid Height (m)
Radar Sensor "0"	7/15/2010	5.717	38-00-00.3	76-03-22.3	-31.979
Radar Sensor "0"	9/29/2010	7.117	38-00-00.3	76-03-22.3	-31.986
Radar Sensor "0"	11/14/2010	8.083	38-00-00.3	76-03-22.3	-31.963
NAVD88 GPS Tie	NA				
Comments	Lat, lon, and height are realized in the NAD83(CORS96) reference frame (epoch: 2002.0000) using OPUS.				

Station History

7/15/10: B.Hocker installed the radar gauge
7/20/2010: download trip made, gauge not running
7/22/10: maintenance trip made, gauge still not running
8/7/10: maintenance trip completed, gauge running
8/25/10: download trip completed with staff shots and measure downs
9/06/10: GPS observation made
9/25/10: download trip made with GPS observation and measure downs
11/16/10: gauge removed with GPS observations and measure downs completed

H3611i Radar Sensor Offset Test

Serial No.: 1618 (Radar Gauge) **Tested by:** N. Wardwell
Date of test: 6/25/2010

Steel Tape Distance	H3611i Radar Distance		Tape - H3611i
2.600	**2.600**		0.000
1.640	**1.637**		0.003
1.331	**1.337**		-0.006
		Average =	**-0.001**
		Standard Deviation =	**0.005**

Method: The radar gauge was checked for system acceptance at the JOA warehouse at about 20° C air temperature. The radar sensor was mounted securely at several different heights, away from obstructions. Radar head was leveled with the self contained bull's eye bubble on top of the radar housing. Radar measurements were taken and recorded every second. The radar measured for at least 10 minutes at each height interval. The radar level point is the top of the 6 mm aluminum plate mounted to the bottom of the Radar mounting plate.

H3611i Radar Sensor Offset Test

Serial No.: 1618 (Radar Gauge) **Tested by:** C. Mayfield
Date of test: 12/7/2010

Steel Tape Distance	H3611i Radar Distance	Standard Deviation
1.197	1.198	-0.0010
1.506	1.506	0.0000
2.123	2.123	0.0000
2.217	2.217	0.0000
2.981	2.981	0.0000
	Average =	**-0.0002**
	Standard Deviation =	**0.0004**

Method: The radar gauge was checked for system acceptance at the JOA warehouse at about 20 C air temperature. The radar sensor was mounted securely at several different heights above a painted concrete floor, away from any obstructions. Radar head was leveled with the self contained bull's-eye bubble on tip of radar housing. Radar measurements were taken every second, the DCP also logged a three minute average of the one second measurements every six minutes. Radar was left at each height for several hours and the distance from the bottom of the radar gauge mounting plate to the floor surface was measured with a steel tape multiple times at each height. the radar level point is the top of the 6mm aluminum mounting plate.

Summary of Measure Down and Radar Measurement Differences

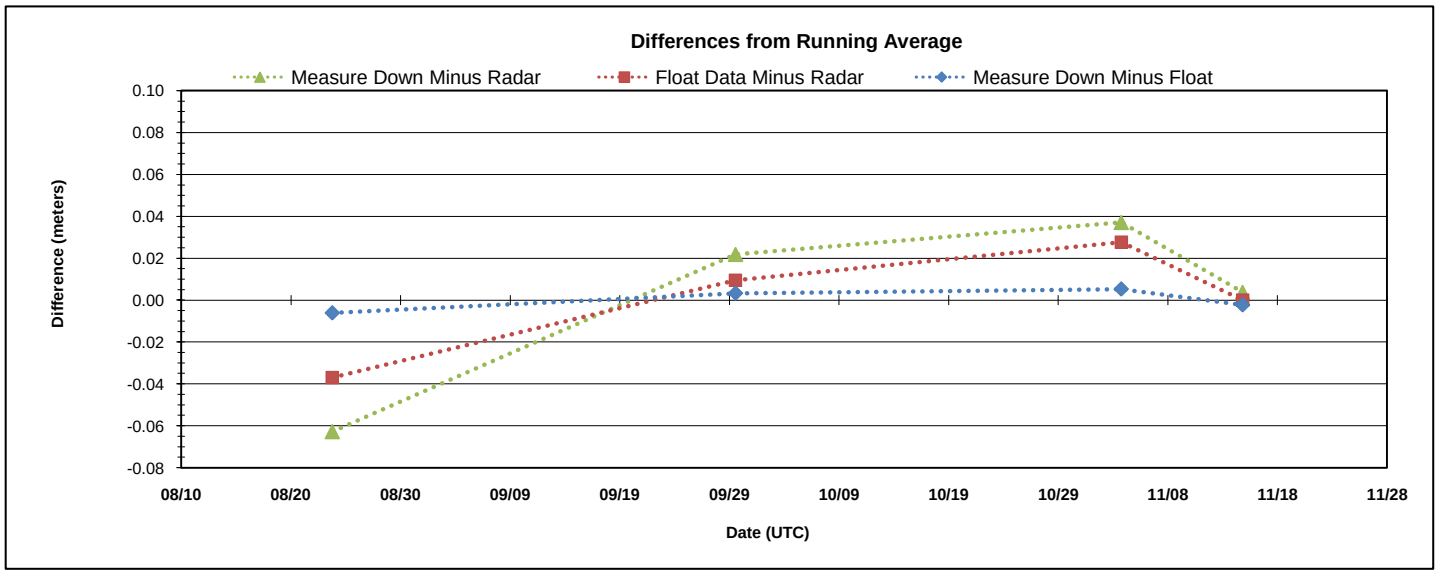
USCG PILING Green 1

857-0004

all values in meters
Bold = rejected

	Measure Down Minus Radar	Float Data Minus Radar	Measure Down Minus Float
Average	**-0.066**	**-31.959**	**31.896**
St Dev	0.044	0.027	0.005
Count	4	4	4

Date (2010)	Measure Down Minus Radar	Float Data Minus Radar	Measure Down Minus Float		N			Stdev	
08/23	**-0.128**	-31.996	31.890	9	6	5	0.012	0.014	0.013
09/29	-0.044	-31.950	31.900	6	6	5	0.012	0.008	0.011
11/03	-0.029	-31.932	31.902	12	6	5	0.009	0.018	0.014
11/14	-0.062	-31.959	31.894	11	11	10	0.007	0.009	0.009



Note 1: The Float Data are NAD83(COR96) water level data obtained using a hydro survey vessel and processed in POSPac with MultiBase PPK.

Note 2: The average difference between the Radar Data and the Measure Downs should very close in value to the measured elevation difference between the Radar Sensor "0" and the measure down point as shown on the Sensor Elevation drawing.

All elevations are in meters above Site Datum of Tabulation

Site Datum is NAD_83(CORS96)(EPOCH:2002.0000)

	Station Name: USCG Piling Green 1
	Station Number: 8570004
-31.970	**Radar Sensor "0"**
PLANES	
-35.192	**Highest Tide**
-35.720	**MHHW**
-36.243	**MLLW**
-36.354	**Lowest Tide**
Other	
-32.036	**Measure Down Point**

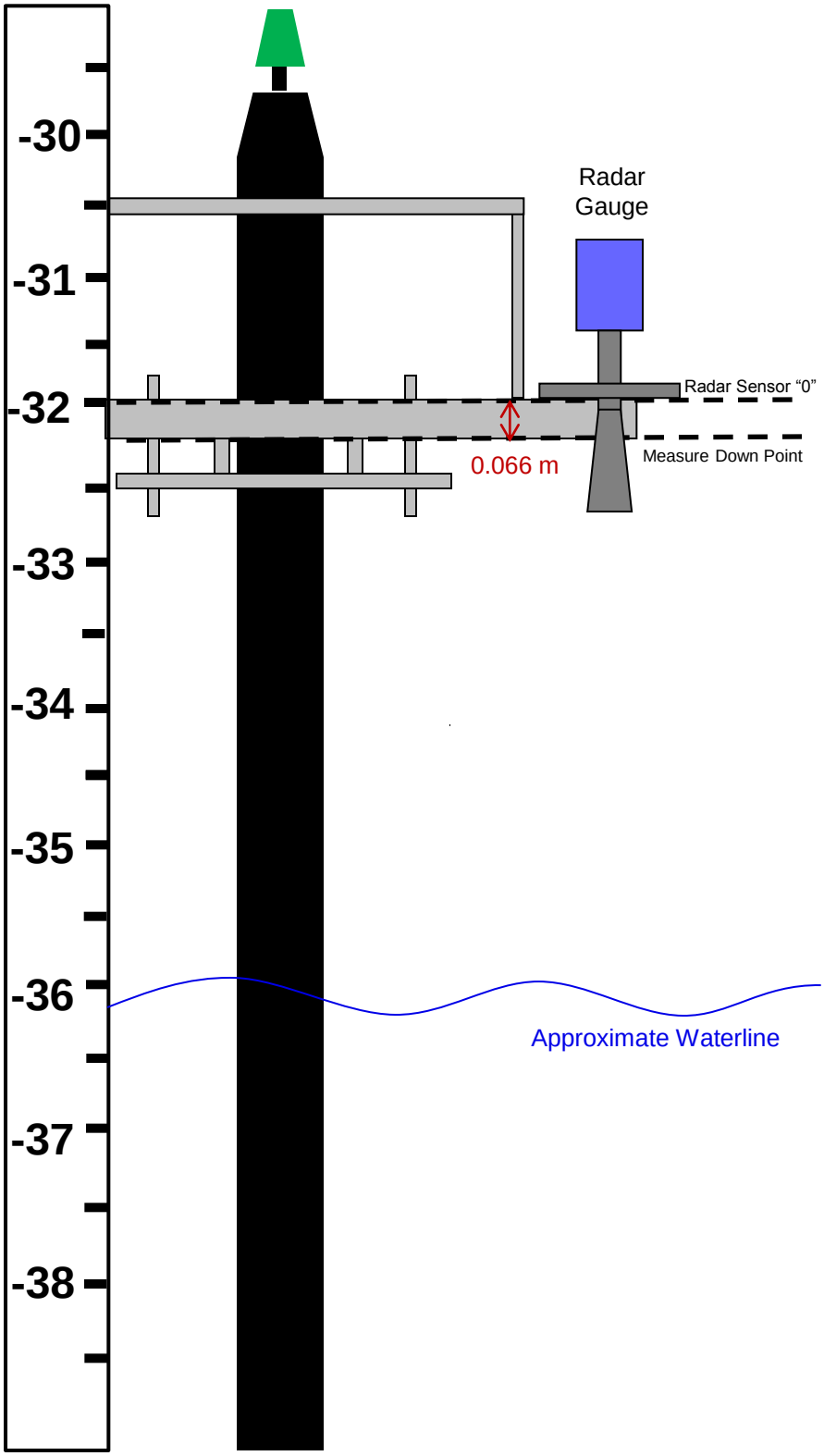
Notes:

The Radar Sensor "0" elevation was determined from 3 GPS sessions between 7/15/2010 and 11/14/2010 with each session being a minimum of 5 hours long.

The Radar Sensor was a DAA model H3611i with a Sutron Xpert data logger.

The offsets shown were determined by measurement using a steel tape.

The Measure Down Point is a reference point for manual water level measurements which were used to QC the radar data.



JOA SURVEYS, LLC
2000 E. Dowling Rd #10
Anchorage, AK 99507
www.joasurveys.com

		REVISED
STATION	8570004 USCG Piling Green 1	
Drawn by:	K. Widmer	
Date:	12/13/2010	

Measure Downs, Boat Float, and Radar Observation Comparisons

USCG PILING Green 1
857-0004

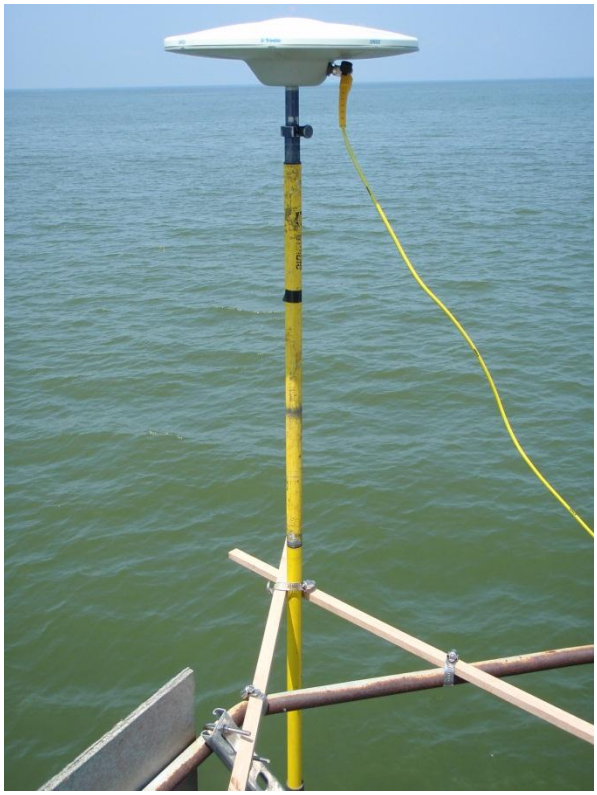
Bold = Rejected
measurements with residuals larger than 3cm are rejected

UTC Date and Time	Measure Down	Float data	Radar data	Measure Down Minus Radar	Float Minus Radar	Measure Down Minus Float	Residuals Measure Down	Residuals Float Data	Residuals Minus Float
08/23/10 18:54	-3.860	-35.784	-3.749	-0.111	-32.035	31.924	0.017	**-0.039**	**0.034**
08/23/10 19:00	-3.860	-35.806	-3.733	-0.127	-32.073	31.946	0.001	**-0.077**	**0.056**
08/23/10 19:06	-3.860	-35.759	-3.741	-0.119	-32.018	31.899	0.009	-0.022	0.009
08/23/10 19:12	-3.850	-35.751	-3.760	-0.090	-31.991	31.901	**0.038**	0.005	0.011
08/23/10 19:18	-3.850	-35.749	-3.768	-0.082	-31.981	31.899	**0.046**	0.015	0.009
08/23/10 19:24	-3.880	-35.754	-3.765	-0.115	-31.989	31.874	0.013	0.007	-0.016
08/23/10 19:30	-3.910	-35.788	-3.780	-0.130	-32.008	31.878	-0.002	-0.012	-0.012
08/23/10 19:36	-3.950	-35.782	-3.791	-0.159	-31.991	31.832	**-0.031**	0.005	**-0.058**
08/23/10 19:42	-3.950	-35.753	-3.819	-0.131	-31.934	31.803	-0.003	**0.062**	**-0.087**
08/23/10 19:48	-3.960	-35.775	-3.830	-0.130	-31.945	31.815	-0.002	**0.051**	**-0.075**
08/23/10 19:54	-3.970	-35.742	-3.824	-0.146	-31.918	31.772	-0.018	**0.078**	**-0.118**
08/23/10 20:00	-3.990	-35.766	-3.843	-0.147	-31.923	31.776	-0.019	**0.073**	**-0.114**
Observed by:	SWA		Avg	-0.128	-31.996	31.890			
Computed by:	N.Wardwell		St dev	0.012	0.014	0.013			
Notes:	approx 1' seas		Count	9	6	5			

UTC Date and Time	Measure Down (m)	Float data (m)	Radar data	Measure Down Minus Radar	Float Minus Radar	Measure Down Minus Float	Residuals Measure Down	Residuals Float Data	Residuals Minus Float
09/29/10 13:42	-4.078	-36.017	-4.052	-0.026	-31.965	31.939	0.018	-0.015	**0.039**
09/29/10 13:48	-4.098	-36.016	-4.066	-0.032	-31.950	31.918	0.012	0.000	0.018
09/29/10 13:54	-4.128	-36.025	-4.072	-0.056	-31.953	31.897	-0.012	-0.003	-0.003
09/29/10 14:00	-4.128	-36.026	-4.079	-0.049	-31.947	31.898	-0.005	0.003	-0.002
09/29/10 14:06	-4.128	-36.015	-4.072	-0.056	-31.943	31.887	-0.012	0.007	-0.013
09/29/10 14:12	-4.116	-36.014	-4.072	-0.044	-31.942	31.898	0.000	0.008	-0.002
Observed by:	TWR,MKHL,AMBI		Avg	-0.044	-31.950	31.900			
Computed by:	K.Widmer		St dev	0.012	0.008	0.011			
Notes:	1-1.5' seas		Count	6	6	5			

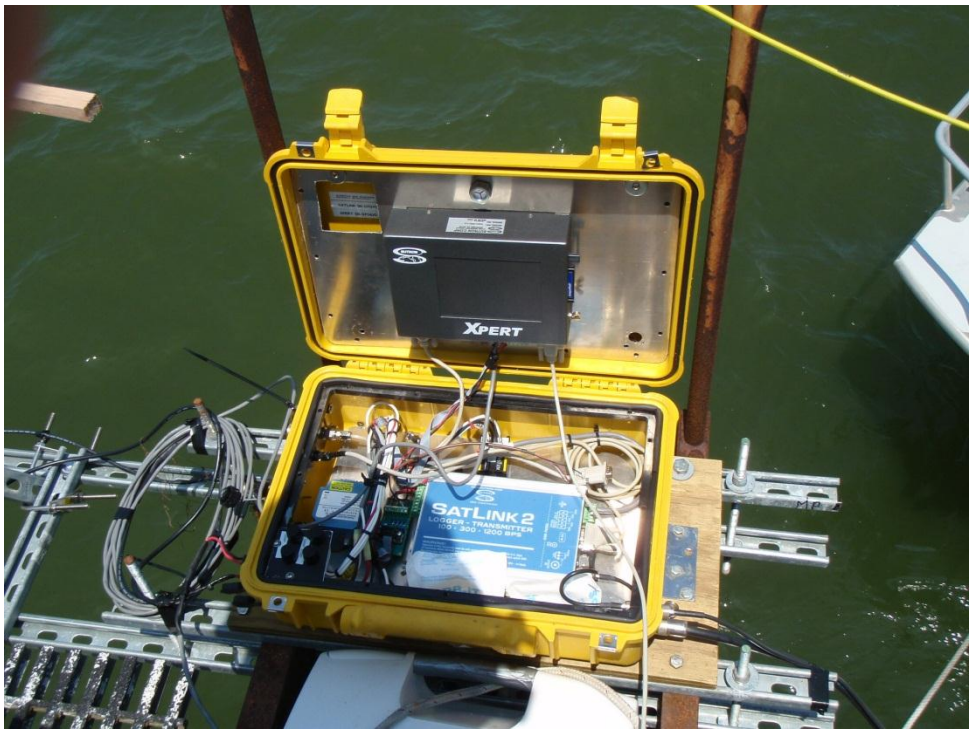
UTC Date and Time	Measure Down (m)	Float data (m)	Radar data	Measure Down Minus Radar	Float Minus Radar	Measure Down Minus Float	Residuals Measure Down	Residuals Float Data	Residuals Minus Float
11/03/10 18:06	-3.926		-3.882	-0.044			-0.015		
11/03/10 18:12	-3.928	-35.788	-3.892	-0.036	-31.896	31.860	-0.007	**0.036**	**-0.042**
11/03/10 18:18	-3.942	-35.797	-3.905	-0.037	-31.892	31.855	-0.008	**0.040**	**-0.047**
11/03/10 18:24	-3.948	-35.914	-3.909	-0.039	-32.005	31.966	-0.010	**-0.073**	**0.064**
11/03/10 18:30	-3.954	-35.846	-3.923	-0.031	-31.923	31.892	-0.002	0.009	-0.010
11/03/10 18:36	-3.962	-35.862	-3.935	-0.027	-31.927	31.900	0.002	0.005	-0.002
11/03/10 18:42	-3.966	-35.892	-3.944	-0.022	-31.948	31.926	0.007	-0.016	0.024
11/03/10 18:48	-3.974	-35.915	-3.955	-0.019	-31.960	31.941	0.010	-0.028	**0.039**
11/03/10 18:54	-3.988	-35.879	-3.964	-0.024	-31.915	31.891	0.005	0.017	-0.011
11/03/10 19:00	-3.992	-35.955	-3.973	-0.019	-31.982	31.963	0.010	**-0.050**	**0.061**
11/03/10 19:06	-4.002	-35.901	-3.983	-0.019	-31.918	31.899	0.010	0.014	-0.003
11/03/10 19:12	-4.014	-35.962	-3.988	-0.026	-31.974	31.948	0.003	**-0.042**	**0.046**
Observed by:	TWR, EAC		Avg	-0.029	-31.932	31.902			
Computed by:	K.Widmer		St dev	0.009	0.018	0.014			
Notes:	less than 1' seas		Count	12	6	5			

UTC Date and Time	Measure Down (m)	Float data (m)	Radar data	Measure Down Minus Radar	Float Minus Radar	Measure Down Minus Float	Residuals Measure Down	Residuals Float Data	Residuals Minus Float
11/14/10 19:42	-3.780	-35.713	-3.738	-0.042	-31.975	31.933	0.020	-0.016	**0.039**
11/14/10 19:48	-3.784	-35.686	-3.726	-0.058	-31.960	31.902	0.004	-0.001	0.008
11/14/10 19:54	-3.790	-35.683	-3.721	-0.069	-31.962	31.893	-0.007	-0.003	-0.001
11/14/10 20:00	-3.788	-35.678	-3.718	-0.070	-31.960	31.890	-0.008	-0.001	-0.004
11/14/10 20:06	-3.774	-35.675	-3.713	-0.061	-31.962	31.901	0.001	-0.003	0.007
11/14/10 20:12	-3.768	-35.668	-3.704	-0.064	-31.964	31.900	-0.002	-0.005	0.006
11/14/10 20:18	-3.758	-35.663	-3.696	-0.062	-31.967	31.905	0.000	-0.008	0.011
11/14/10 20:24	-3.751	-35.643	-3.687	-0.064	-31.956	31.892	-0.002	0.003	-0.002
11/14/10 20:30	-3.743	-35.625	-3.679	-0.064	-31.946	31.882	-0.002	0.013	-0.012
11/14/10 20:36	-3.738	-35.615	-3.672	-0.066	-31.943	31.877	-0.004	0.016	-0.017
11/14/10 20:42	-3.728	-35.626	-3.667	-0.061	-31.959	31.898	0.001	0.000	0.004
Observed by:	BH		Avg	-0.062	-31.959	31.894			
Computed by:	K.Widmer		St dev	0.007	0.009	0.009			
Notes:	Closeout readings		Count	11	11	10			



GPS mounted on platform

Mounting braces for GPS antenna

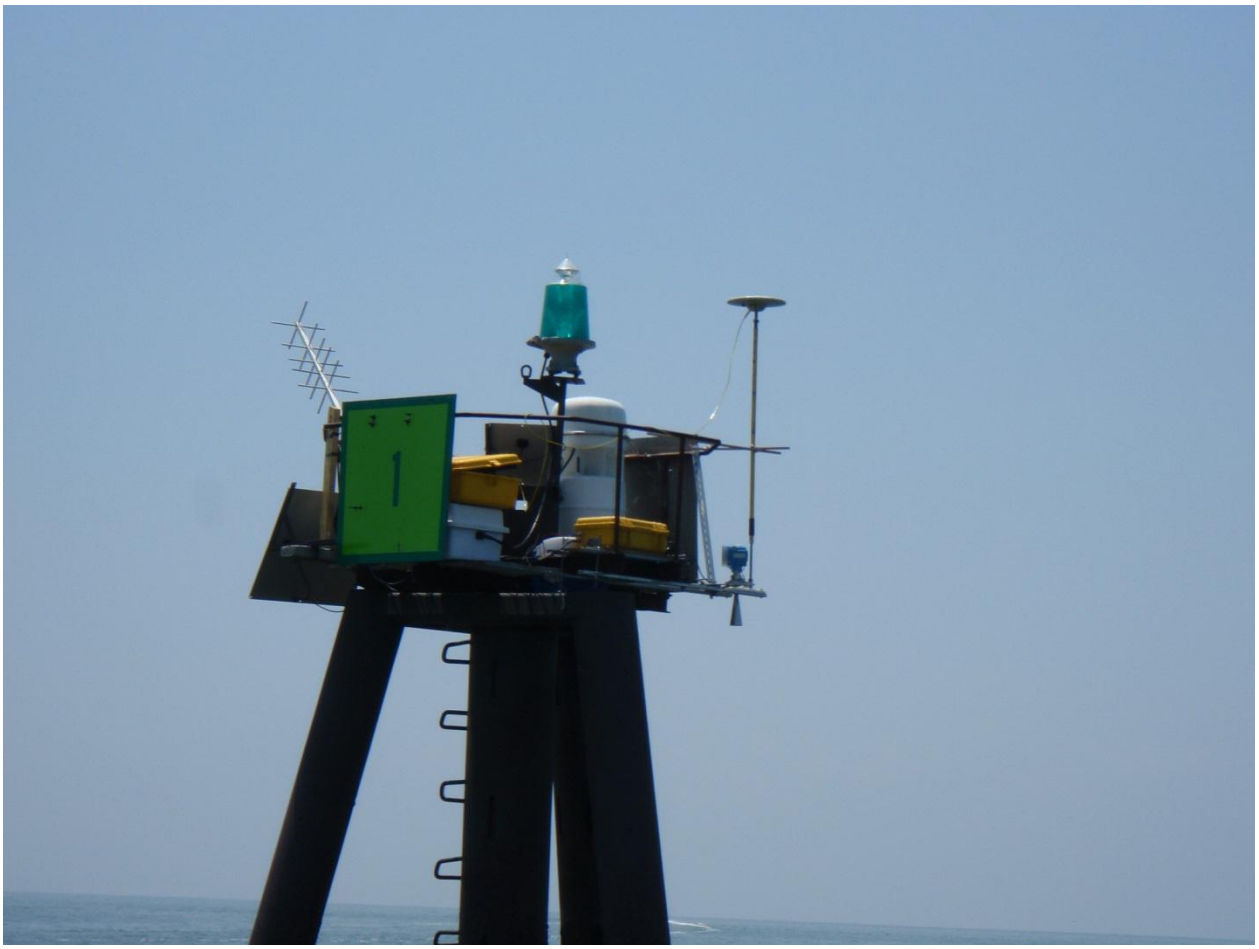


Pelican box housing radar gauge equipment

Above picture: GPS pelican case

Radar gauge mounted with all thread for GPS attached

Additional all thread added with supporting braces



View of radar gauge mounted

DN 196 GPS DATA LOGGING
TWR, ELD, EAK

GPS REC: ~~S~~ TRIMBLE SPS 851 GNSS
GPS ANT: TRIMBLE ~~SPS~~ ZEPHYR GEOD MOD 2 GNSS

GPS OBSERVATION "GREEN 2 RADAR GAGE"

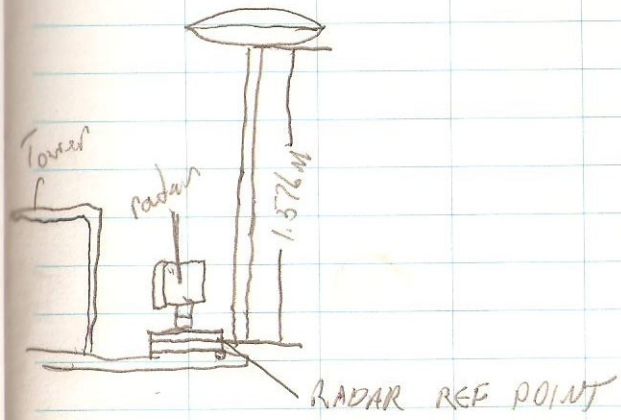
LAT 38° 0' 0.39123 N
LONG 76° 3' 22.31268 W
ELL HT -29.803 m.
MU: 1.576 m. ARP to RADAR PLAT →
✓ MU: 5.17 ft calc. 1.575 m.

DATA LOGGING @ ~~15 sec~~ 15 sec INTERVAL
AND 5 MIN INTERVAL FOR DOY TWO

FILE NAME: 5351960.T01
UTC START: ~~0352~~ 1614:16
UTC STOP: 1800 ~ ETZ

TM

- NEED NGS OBSERVATION FORM DONE



AUG 23 2010 JD 235

MESURE DOWNS / STAFF SHOTS & ANTENNA REPLACMENT

MESURE DOWNS SWA STAFF/ROD SHOTS : JPSA

TIME	ROD (m)	MD (m)
2354	4.54	3.86
0000	4.53	3.86
0006	4.53	3.86
0012	4.48	3.85
0016	4.47	3.85
0024	4.47	3.88
0030	4.46	3.91
0036	4.43	3.95
0042	4.42	3.95
0048	4.42	3.96
0054	4.41	3.97
0100	4.40	3.99

WX LIGHT WIND AT START STEADAIY INCRECED TO ~10KNTS ~~→~~ OUT OF NW

SEAS <1 ft AT START INCRECED TO 1 ft by END

WEATHER

DN 272 9/29/10

T. ROBERTS, M. HILL, A. BITTINGER

EQUIP: TRIMBLE SPS NET R7

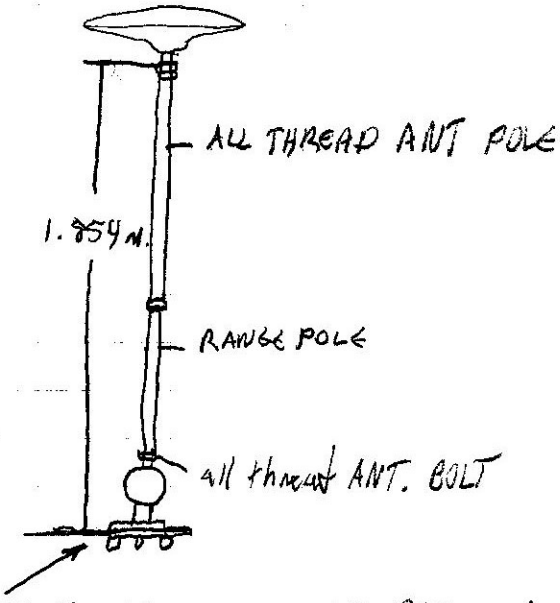
- ANT: TRIMBLE ZEPHYR GEOD. MOD-2

JOB: "LEWISETTA DN 243"

- GPS OBSERVATION "GREEN 1"
  FROM MP OF RADAR TIDE GAGE NEAR SMITH ISLAND

- LOGGING 1 SEC DATA (1 HZ)
  FILE NAME: 48632720.T01
  START 1:02:23 UTC

POS: AUTONOMOUS
MU: 1.854 m.
VMU: 1.854 m.



- MU FROM THE TOP OF THE BOTTOM ALUMINUM MOUNTING PLATE

DN 272

UTC TIME	MD READING	STAFF READING	WIND
~ 1336			
- 1342	4.078	2.45	10+ Kts.
- 1348	4.098	2.40	10+ Kts."
- 1354	4.128	2.40	10 kts.
- 1400	~~4.112~~ 4.128	2.40	10 kts.
- 1406	4.128	2.30	
- 1412	4.116	2.40	

- ALL READINGS IN METERS

- NOTE POOR CONDITIONS
  WIND 5-10 Kts.
  WAVES 1-1.5 ft.

TWR, MKHL, AMBI

TIDE STATION SITE: GREEN1 857-0004

GMT Date: ~ 272

Sheet 1 1 1

Local Date: 9/29/10 S M T W TH F SA

Observers(s) MKHI, AMBI, TWR

Wave Height: ~~1.5~~ .5 meters

Water Elevation = Elevation of Staff "0" + Staff Reading

Staff "0" = -0.099 meters

Record measuremetns on the 6 minute interval (0:06, 0:12, 0:18, 0:24, 0:30, 0:36, 0:42, 0:48, 0:54, 1:00, etc. Not 0:16, 0:22, etc.)

Calculate the "Water Minus Stage" average (this is the "staff constant") for each gauge. It should match previous staff constants within 3cm MD/SR

	GMT Time	Staff Reading	Water Elevation	Stage Reading Gauge 1	Stage Reading Gauge 2	Water Minus Stage Gauge 1	Water Minus Stage Gauge 2	Difference from Avg. Gauge 1	Difference from Avg. Gauge 2
1	1342	4.078 / 2.45							
2	1348	4.098 / 2.40							
3	1354	4.128 / 2.40							
4	1400	4.128 / 2.30							
6	1406	4.128 / 2.30							
6	1412	4.116 / 2.40							
7									
8									
9									
10									
11									
12									
13									
14									
15									

Average of Staff Constants = _____

Previous Average = _____

Comments: _____

NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable: __ FBN __ CBN __ PAC __ SAC __ BM) GREEN 1		Station PID, if any:	Date (UTC): 272
General Location: NEAR SMITH ISL. MD.	Airport ID, if any:	Station 4-Character ID:	Day of Year: 9/29/10
Project Name: NOAA00000015	Project Number: GPS-	Station Serial # (SSN):	Session ID:(A,B,C etc)

NAD83 Latitude: AUTONOMOUS	NAD83 Longitude: POSITION	NAD83 Ellipsoidal Height meters	Agency Full Name: DAVID EVANS AND ASSOCIATES
Observation Session Times (UTC): Sched. Start 102:23 Stop ____ Actual Start 102:23 Stop ____	Epoch Interval= 1 Seconds Elevation Mask = 10 Degrees	NAVD88 Orthometric Ht. meters GEOID99 Geoid Height meters	Operator Full Name: THOMAS W. ROBERTS Phone #: (541) 357-9182 e-mail address: TWR@DEA.NET.COM

Receiver Brand & Model: TRIMBLE R7 GNSS P/N: 60163 S/N: 4915K34863 Firmware Version: ☐ CamCorder Battery, ☒ 12V DC, ☐ 110V AC, ☐ Other	Antenna Code*, Brand & Model: TRIMBLE, ZEPHYR GEOD MOD-2 GNSS P/N: 57971-00-12K S/N: 1441003378 Cable Length, meters: 10 m. Vehicle is Parked ____ meters ____(direction) from antenna.	Antenna plumb before session? (Y / N) Circle Antenna plumb after session? (Y / N) Yes or No Antenna oriented to true North? (Y / N) -If no, Weather observed at antenna ht. (Y / N) explain Antenna ground plane used? (Y / N) " Antenna radome used? (Y / N) If yes, Eccentric occupation (>0.5 mm)? (Y / N) describe. Any obstructions above 10°? (Y / N) Use Radio interference source nearby (Y / N) Vis. form

Tripod or Antenna Mount: Check one: ☐ Fixed-Leg Tripod, ☐ Collapsible-leg tripod ☒ Fixed Mount Brand & Model: 36111 RADAR TIDE GAGE P/N: 36111 S/N: 2105 Last Adjustment date:	** ANTENNA HEIGHT **	Before Session Begins: Meters	Feet	After Session Ends: Meters	Feet
	A= Datum point to Top of Tripod (Tripod Height)	1.854			
	B= Additional offset to ARP if any (Tribrach/Spacer)	Ø			
Psychrometer (if used) Brand & Model: P/N: N/A S/N: Last Calibration or check Date:	H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)	1.854			

Meters = Feet x (0.3048)
Height Entered Into Receiver = 1.854 meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model: N/A
S/N:

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before	0,1,0,2,1								
Middle	0,1,0,2,1								
After	0,1,0,2,1								

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:
FABRICATED MOUNT, ON RADAR GAGE - 5/8 THREADED BOLT WITH STOP NUT AND MEASURED DOWN TO LP/REF POINT

- MEASURED FROM TOP OF BOTTOM ALUMINUM PLATE ON RADAR GAGE

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s): 48632720.T01
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ☒ Attached ☐ Submitted earlier
Visibility Obstruction Form: ☒ Attached ☐ Submitted earlier
Photographs of Station: ☒ Attached ☐ Submitted earlier
Pencil Rubbing of Mark: ☐ Attached

LOG CHECKED BY:

Table of Weather Codes	CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
	0	did not occur	Good, over 15 miles	Normal, 32° F- 80° F	Clear, below 20%	Calm, under 5mph (8km/h)
	1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
	2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)
Examples:	00000 = No problem, good visibility, normal temp, clear, calm wind			12121 = Problems, poor visibility, hot, overcast, moderate wind		

Station Location Sketch and Visibility Diagram

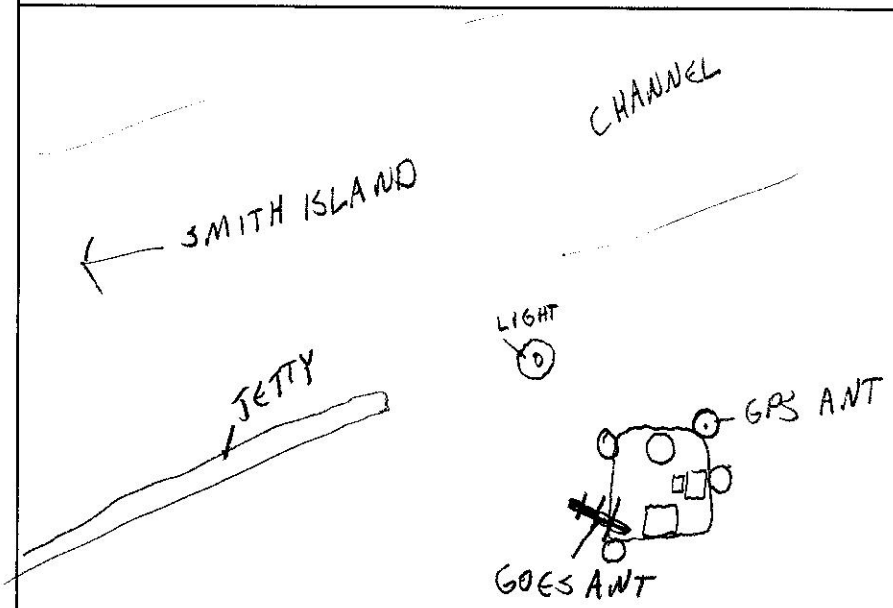
Location / Airport Name and ID: NAV LIGHT NEAR SMITH ISL, MD. Project: NOAA 00000015

Station Designation: GREEN 1 857-0004 PID: _____ Date: 9/29/10

Circle all applicable: PACS SACS BM FBN CBN OTHER_____

Observer & Organization: T. ROBERTS, DAVID EVANS AND ASSOCIATES

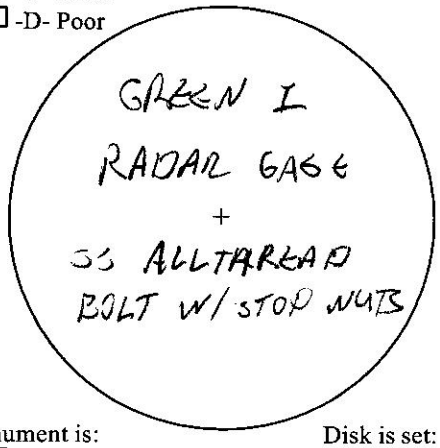
Station Location Sketch



Sketch of Disk

Monument Stability Quality: ☒ Photos Available

- ☐ -A- Most stable
- ☐ -B- Excellent
- ☒ -C- Good
- ☐ -D- Poor

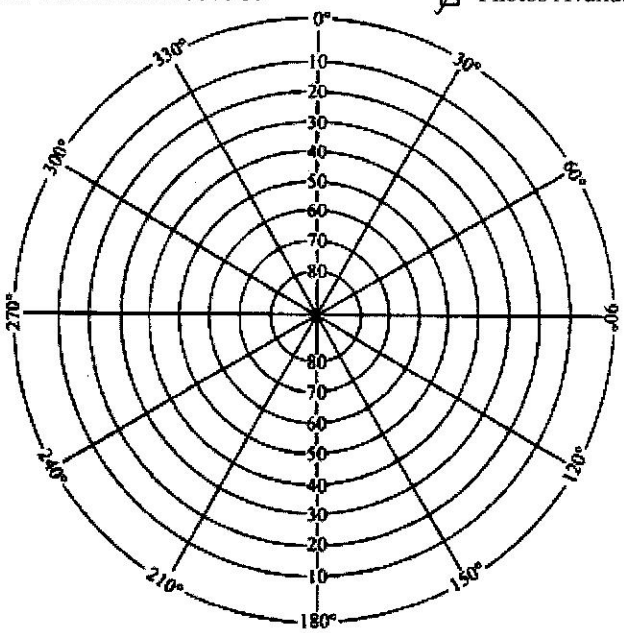


Monument is:
- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☒ Projecting ___ cm

Disk is set:
- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

☒ No Obstructions above 10° ☒ Photos Available



WEATHER, OVERCAST

NOV 3, 2010 JD 307 WIND - 5-15 kts →

TWR - M.D. , EAC - STAFF SHOTS

857-2004 GREEN I

1406	3.926	~~.475~~
1412	3.928	.475
1418	3.942	.460
1424	3.948	.452
1430	3.954	.448
1436	3.962	.440
1442	3.966	.432
1448	3.974	.415
1454	3.988	.393
1500	3.992	.381
1506	4.003	.378

TIME (GTZ)	M.D. (METERS)	STAFF SHOTS (METERS)
1512	4.014	.365

- CONDITIONS REMAINED THE SAME
WIND - SW 5-15 kts, SEAS <1 ft.

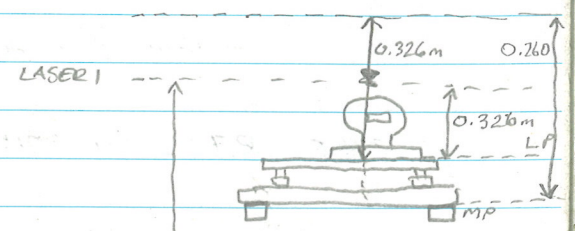
TWR, EAC

WIND OUT OF SW, SEAS <2 ft

11/16/10
BH

RADAR GAUGE TEAR-DOWN

POINT ELEVATIONS 07:45 LOCAL.



LP → MP = 0.066m

0.260 − 0.326 = 0.066m

(Δ−0.017m FROM INSTALL)

0.275m

LP → ROD ∅ = 8.261m

5.200 + 3.112 + 0.275 − 0.326 = 8.261m

(Δ+0.013m FROM INSTALL)

3.112m

STAFF
5.200m

GAUGE SHUT DOWN @ 11/16/10

"Rite in the Rain"

TIDE STATION SITE: GREEN 1

GMT Date: 11/14/10

Local Date: 11/14/10 (S) M T W TH F SA

Wave Height: < 10 m meters

Sheet 1 / 1

TWR, BVHO

ELD

Record measuremetns on the 6 minute interval
(0:06. 0:12. 0:18. 0:24. 0:30. 0:36. 0:42. 0:48. 0:54. 1:00. etc. Not 0:16. 0:22. etc.)

Water Elevation = Measure Down Reading - Rail Cut

Rail Cut = 5.000 (ASSUMED) meters

STAFF *DIFFICULT TO READ*

	GMT Time	Measure Down Reading	Rail Cut	Water Elevation	Stage Reading Gauge 1	Water Minus Stage Gauge 1	Difference from Avg. Gauge 1
1	19:42 ~~08~~	3.780m	5.000	1.22	4.55 m ~~4.50~~ m	3.33 ~~0.770~~	
2	19:48	3.784m		1.216	4.54m	3.324 ~~0.756~~	
3	19:54	3.790m		1.210	4.54m	3.333 ~~0.750~~	
4	20:00	3.788m		1.212	4.55m	3.338 ~~0.762~~	
5	20:06	3.774m		1.226	4.56	3.334 ~~0.~~	
6	20:12	3.768m		1.232	4.56	3.328	
7	20:18	3.758m		1.242	4.57	3.328	
8	20:24	3.751m		1.249	4.58	3.331	
9	20:30	3.743m		1.257	4.59	3.333	
10	20:36	3.738m		1.262	4.60	3.338	
11	20:42	3.728		1.272	4.61	3.338	
12							
13							
14							
15							

Average

*ASSUMED RAIL CUT FOR FIELD QC ONLY!

Comments:

72'3/16

NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable:__ FBN__ CBN__ PAC__ SAC __BM) GREEN 1 RADAR LP		Station PID, if any: N/A	Date (UTC): 11/14/2010
General Location: E SIDE CHESAPEAKE BAY @ SMITH ISLAND	Airport ID, if any:	Station 4-Character ID: N/A	Day of Year: 218
Project Name: OPR-E349-KR-10 T0005	Project Number: GPS-	Station Serial # (SSN): N/A	Session ID:(A,B,C etc) A

NAD83 Latitude ° ' "	NAD83 Longitude ° ' "	NAD83 Ellipsoidal Height meters	Agency Full Name: DAVID EVANS & ASS
Observation Session Times (UTC): Sched. Start 1240 Stop 2040	Epoch Interval= 1 Seconds	NAVD88 Orthometric Ht. meters	Operator Full Name: BEN HOCKER
Actual Start _____ Stop _____	Elevation Mask = 10 Degrees	GEOID99 Geoid Height meters	Phone #: (360)314-3200
			e-mail address: bxhoedeainc.com

Receiver Brand & Model: TRIMBLE R7 GNSS
P/N:
S/N: 4915K34863
Firmware Version:
☐ CamCorder Battery, ☒ 12V DC, ☐ 110V AC, ☐ Other

Antenna Code*, Brand & Model: TRIMBLE ZEPHYR GEODETIC MODEL 2
P/N: 57971-00
S/N: 1441003378
Cable Length, meters: 15m
Vehicle is Parked _____ meters ____(direction) from antenna.

Antenna plumb before session?	(Y / N)	Circle Yes or No -If no, explain "
Antenna plumb after session?	(Y / N)	
Antenna oriented to true North?	(Y / N)	
Weather observed at antenna ht.	(Y / N)	
Antenna ground plane used?	(Y / N)	
Antenna radome used?	(Y / N)	If yes, describe. Use Vis. form
Eccentric occupation (>0.5 mm)?	(Y / N)	
Any obstructions above 10°?	(Y / N)	
Radio interference source nearby	(Y / N)	

Tripod or Antenna Mount: Check one:
☐ Fixed-Leg Tripod, ☐ Collapsible-leg tripod ☐ Fixed Mount
Brand & Model: THREADED ROD TO LP
P/N:
S/N:
Last Adjustment date:

Psychrometer (if used) Brand & Model: KESTREL 4000
P/N:
S/N: 533750
Last Calibration or check Date: UNKNOWN.

** ANTENNA HEIGHT **

	Before Session Begins: Meters	Feet	After Session Ends: Meters	Feet
A= Datum point to Top of Tripod (Tripod Height)	1.849		1.851	
B= Additional offset to ARP if any (Tribrach/Spacer)	0.000		0.000	
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)	1.849		1.851	

Meters = Feet x (0.3048)
Height Entered Into Receiver = 1.850 meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model: KESTREL 4000
S/N: 533750

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before	00000	1240	55.3		49.8		68.8	30.07	
Middle									
After	00000	2040	65.0		55.2		65.4	29.99	

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s):
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ☐ Attached ☐ Submitted earlier
Visibility Obstruction Form: ☐ Attached ☐ Submitted earlier
Photographs of Station: ☐ Attached ☐ Submitted earlier
Pencil Rubbing of Mark: ☐ Attached

LOG CHECKED BY:

Table of Weather Codes	CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
	0	did not occur	Good, over 15 miles	Normal, 32° F- 80° F	Clear, below 20%	Calm, under 5mph (8km/h)
	1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
	2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)

Examples: 00000 = No problem, good visibility, normal temp, clear, calm wind 12121 = Problems, poor visibility, hot, overcast, moderate wind

Station Location Sketch and Visibility Diagram

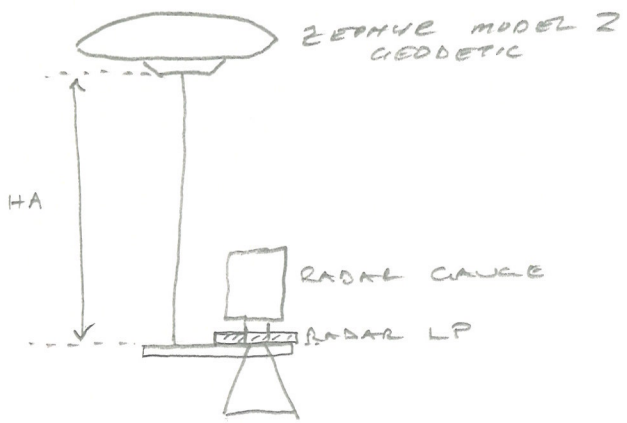
Location / Airport Name and ID: E SIDE CHESAPEAKE BAY @ SMITH ISL. Project: OPR-E349-KR-10

Station Designation: GREEN 1 RADAR LP PID: N/A Date: 11/14/10

Circle all applicable: PACS SACS BM FBN CBN OTHER GAUGE

Observer & Organization: BKHO DEA INC.

Station Location Sketch

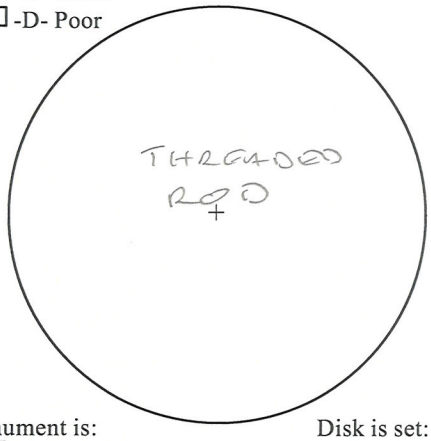


STATION IS LOCATED ON 'GREEN 1' CHANNEL MARKER AT WEST ENTRANCE TO EWELL ON SMITH ISLAND IN CHESAPEAKE BAY, MD.

Sketch of Disk

Monument Stability Quality: ☒ Photos Available

- ☐ -A- Most stable
- ☐ -B- Excellent N/A
- ☐ -C- Good
- ☐ -D- Poor

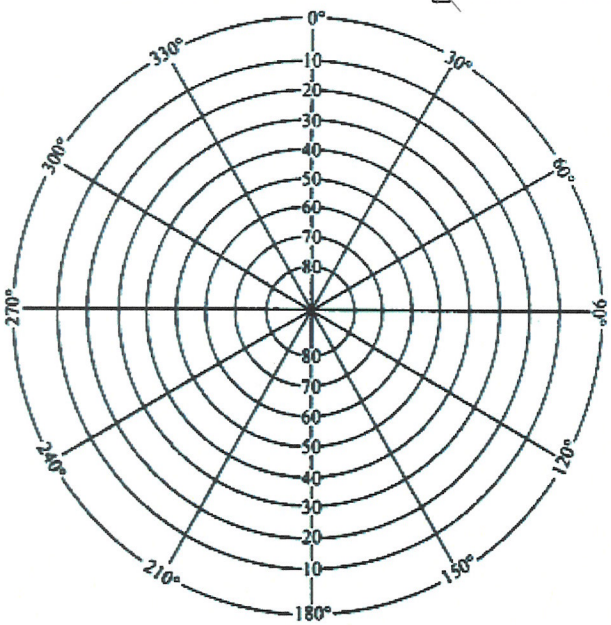


Monument is:
- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☐ Projecting ___ cm

Disk is set:
- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

☒ No Obstructions above 10° ☒ Photos Available



FILE: 53511961.10o 000076823

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

USER: nathan@joasurveys.com DATE: September 10, 2010
RINEX FILE: 5351196q.10o TIME: 23:45:51 UTC

SOFTWARE: page5 0909.08 master40.pl 100910 START: 2010/07/15 16:14:00
EPHEMERIS: igs15924.eph [precise] STOP: 2010/07/15 21:57:00
NAV FILE: brdc1960.10n OBS USED: 13479 / 14272 : 94%
ANT NAME: TRM55971.00 NONE # FIXED AMB: 54 / 61 : 89%
ARP HEIGHT: 1.576 OVERALL RMS: 0.017(m)

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000) ITRF00 (EPOCH:2010.5364)

X:	1212656.653(m)	0.057(m)	1212655.907(m)	0.057(m)
Y:	-4884105.833(m)	0.027(m)	-4884104.370(m)	0.027(m)
Z:	3905432.584(m)	0.044(m)	3905432.465(m)	0.044(m)

LAT:	38 0 0.34178	0.027(m)	38 0 0.37068	0.027(m)
E LON:	283 56 37.66274	0.058(m)	283 56 37.64751	0.058(m)
W LON:	76 3 22.33726	0.058(m)	76 3 22.35249	0.058(m)
EL HGT:	-31.979(m)	0.038(m)	-33.313(m)	0.038(m)
ORTHO HGT:	3.900(m)	0.066(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 18)	STATE PLANE COORDINATES SPC (1900 MD)
Northing (Y) [meters]	4206351.814	37441.116
Easting (X) [meters]	407266.877	482899.718
Convergence [degrees]	-0.65031230	0.59235808
Point Scale	0.99970591	1.00006569
Combined Factor	0.99971093	1.00007071

US NATIONAL GRID DESIGNATOR: 18SVH0726606351(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL3474	LOYM LOYOLA M CORS ARP	N381838.119	W0763757.974	61167.4
AI3494	HNPT HORN POINT ENVIRO CORS ARP	N383519.710	W0760749.332	65669.1
AI3289	VIMS VIRGINIA INSTITUT CORS ARP	N373630.045	W0754113.207	54293.0

NEAREST NGS PUBLISHED CONTROL POINT

HV6491	BIG THOROFARE RIVER W LIGHT 1	N380000.538	W0760320.914	35.2

BASE STATION INFORMATION

```
STATION NAME: loym  a    2 (LOYOLA M; Leonardtown, Maryland  USA)
 MONUMENT: NO DOMES NUMBER
XYZ   1158531.2965  -4875373.7554   3932556.7647  MON @ 1997.0000 (M)
XYZ       -0.0145       -0.0012        0.0016  VEL (M/YR)
NEU        0.0000        0.0000        0.0000  MON TO ARP (M)
NEU        0.0012        0.0008        0.0847  ARP TO L1 PHASE CENTER (M)
NEU       -0.0002        0.0009        0.0740  ARP TO L2 PHASE CENTER (M)
XYZ       -0.1963       -0.0162        0.0217  VEL TIMES 13.5357 YRS
XYZ        0.0000        0.0000        0.0000  MON TO ARP
XYZ        0.0160       -0.0638        0.0534  ARP TO L1 PHASE CENTER
XYZ   1158531.1162  -4875373.8354   3932556.8398  L1 PHS CEN @ 2010.5364
XYZ       -0.0000       -0.0000       -0.0000  + XYZ ADJUSTMENTS
XYZ   1158531.1162  -4875373.8354   3932556.8398  NEW L1 PHS CEN @ 2010.5364
XYZ   1158531.1002  -4875373.7717   3932556.7863  NEW ARP @ 2010.5364
XYZ   1158531.1002  -4875373.7717   3932556.7863  NEW MON @ 2010.5364
LLH  38 18 38.14835  283 22  2.00942      4.8877  NEW L1 PHS CEN @ 2010.5364
LLH  38 18 38.14831  283 22  2.00939      4.8030  NEW ARP @ 2010.5364
LLH  38 18 38.14831  283 22  2.00939      4.8030  NEW MON @ 2010.5364

STATION NAME: hnpt  a    4 (Cambridge, USA; Horn Point Environmental Lab)
 MONUMENT: 49913S001
XYZ   1196626.4656  -4846358.5068   3956723.0984  MON @ 1997.0000 (M)
XYZ       -0.0172       -0.0004        0.0027  VEL (M/YR)
NEU        0.0000        0.0000        0.0000  MON TO ARP (M)
NEU        0.0012        0.0008        0.0847  ARP TO L1 PHASE CENTER (M)
NEU       -0.0002        0.0009        0.0740  ARP TO L2 PHASE CENTER (M)
XYZ       -0.2332       -0.0049        0.0372  VEL TIMES 13.5357 YRS
XYZ        0.0000        0.0000        0.0000  MON TO ARP
```

```
XYZ        0.0165        -0.0634         0.0538  ARP TO L1 PHASE CENTER
XYZ   1196626.2489  -4846358.5750   3956723.1894  L1 PHS CEN @ 2010.5364
XYZ       -0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ   1196626.2489  -4846358.5750   3956723.1894  NEW L1 PHS CEN @ 2010.5364
XYZ   1196626.2324  -4846358.5116   3956723.1356  NEW ARP @ 2010.5364
XYZ   1196626.2324  -4846358.5116   3956723.1356  NEW MON @ 2010.5364
LLH  38 35 19.74051  283 52 10.65062    -27.8807  NEW L1 PHS CEN @ 2010.5364
LLH  38 35 19.74047  283 52 10.65059    -27.9654  NEW ARP @ 2010.5364
LLH  38 35 19.74047  283 52 10.65059    -27.9654  NEW MON @ 2010.5364

STATION NAME: vims  a    2 (Virginia Institute of Ma; Wachapreague, Virginia)
        WARNING: ORIGINALLY "AOAD/M_TA_NGS   SNOW"
XYZ   1250692.7258  -4902017.1820   3871080.2574  MON @ 1997.0000 (M)
XYZ       -0.0147        -0.0011         0.0017  VEL (M/YR)
NEU        0.0000         0.0000         0.0000  MON TO ARP (M)
NEU       -0.0000         0.0000         0.1100  ARP TO L1 PHASE CENTER (M)
NEU       -0.0000         0.0000         0.1280  ARP TO L2 PHASE CENTER (M)
XYZ       -0.1990        -0.0149         0.0230  VEL TIMES 13.5357 YRS
XYZ        0.0000         0.0000         0.0000  MON TO ARP
XYZ        0.0215        -0.0844         0.0671  ARP TO L1 PHASE CENTER
XYZ   1250692.5484  -4902017.2813   3871080.3475  L1 PHS CEN @ 2010.5364
XYZ       -0.0000         0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ   1250692.5484  -4902017.2813   3871080.3476  NEW L1 PHS CEN @ 2010.5364
XYZ   1250692.5268  -4902017.1969   3871080.2804  NEW ARP @ 2010.5364
XYZ   1250692.5268  -4902017.1969   3871080.2804  NEW MON @ 2010.5364
LLH  37 36 30.07418  284 18 46.77812    -28.9790  NEW L1 PHS CEN @ 2010.5364
LLH  37 36 30.07418  284 18 46.77812    -29.0890  NEW ARP @ 2010.5364
LLH  37 36 30.07418  284 18 46.77812    -29.0890  NEW MON @ 2010.5364

                REMOTE STATION INFORMATION

STATION NAME: 5351       1
 MONUMENT: NO DOMES NUMBER
XYZ   1212656.0713  -4884105.4446   3905433.3041  MON @ 2010.5361 (M)
NEU       -0.0016        -0.0007         1.5760  MON TO ARP (M)
NEU        0.0016         0.0007         0.0850  ARP TO L1 PHASE CENTER (M)
NEU        0.0008         0.0012         0.0701  ARP TO L2 PHASE CENTER (M)
XYZ        0.2988        -1.2064         0.9690  MON TO ARP
XYZ        0.0166        -0.0639         0.0536  ARP TO L1 PHASE CENTER
XYZ   1212656.3867  -4884106.7149   3905434.3267  L1 PHS CEN @ 2010.5364

BASELINE NAME:   loym  5351
XYZ       -0.1278         1.0850        -0.8617  + XYZ ADJUSTMENTS
```

```
XYZ   1212656.2589  -4884105.6299   3905433.4650  NEW L1 PHS CEN @ 2010.5364
XYZ   1212656.2423  -4884105.5660   3905433.4114  NEW ARP @ 2010.5364
XYZ   1212655.9435  -4884104.3596   3905432.4424  NEW MON @ 2010.5364
LLH  38  0  0.37013  283 56 37.64907    -31.6668  NEW L1 PHS CEN @ 2010.5364
LLH  38  0  0.37008  283 56 37.64904    -31.7518  NEW ARP @ 2010.5364
LLH  38  0  0.37013  283 56 37.64907    -33.3278  NEW MON @ 2010.5364

BASELINE NAME:   hnpt  5351
XYZ       -0.1852        1.0822       -0.8389  + XYZ ADJUSTMENTS
XYZ   1212656.2015  -4884105.6328   3905433.4878  NEW L1 PHS CEN @ 2010.5364
XYZ   1212656.1849  -4884105.5689   3905433.4342  NEW ARP @ 2010.5364
XYZ   1212655.8861  -4884104.3624   3905432.4652  NEW MON @ 2010.5364
LLH  38  0  0.37093  283 56 37.64676    -31.6615  NEW L1 PHS CEN @ 2010.5364
LLH  38  0  0.37088  283 56 37.64673    -31.7465  NEW ARP @ 2010.5364
LLH  38  0  0.37093  283 56 37.64676    -33.3225  NEW MON @ 2010.5364

BASELINE NAME:   vims  5351
XYZ       -0.1806        1.0580       -0.8175  + XYZ ADJUSTMENTS
XYZ   1212656.2061  -4884105.6569   3905433.5092  NEW L1 PHS CEN @ 2010.5364
XYZ   1212656.1895  -4884105.5930   3905433.4557  NEW ARP @ 2010.5364
XYZ   1212655.8907  -4884104.3866   3905432.4866  NEW MON @ 2010.5364
LLH  38  0  0.37099  283 56 37.64670    -31.6290  NEW L1 PHS CEN @ 2010.5364
LLH  38  0  0.37094  283 56 37.64667    -31.7140  NEW ARP @ 2010.5364
LLH  38  0  0.37099  283 56 37.64670    -33.2900  NEW MON @ 2010.5364

                        G-FILES

Axx2010 715  10 715
B2010 7151614  10 7152156 1 page5 v0909.08IGS     226 1 2 27NGS   2010 910IFDDFX
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C00090001 -541248433   29   87305879   29  271243439   29 X1960A5351X1960ALOYM
D  1  2 -1491993  1  3 -4784231  2  3 -7148853

Axx2010 715  10 715
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Iant_info.003        NGS   20100823
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D  1  2 -7560061  1  3   152835  2  3 -2359500

Axx2010 715  10 715
B2010 7151614  10 7152156 1 page5 v0909.08IGS     226 1 2 27NGS   2010 910IFDDFX
Iant_info.003        NGS   20100823
C00090003  380366362   53 -179128103   37 -343522062   66 X1960A5351X1960AVIMS
```

D 1 2 -5545390 1 3 -8004122 2 3 67032

POST-FIT RMS BY SATELLITE VS. BASELINE

```
        OVERALL     03     06     07     08     11     13     14     16
loym-5351|  0.020  0.020  0.020  0.029  0.014  0.017  0.021  0.026  0.018
            17     19     20     23     24     28     29     30     31
loym-5351|    ...  0.016  0.027  0.022  0.023  0.018  0.025    ...  0.015
            32
loym-5351|  0.021

        OVERALL     03     06     07     08     11     13     14     16
hnpt-5351|  0.012  0.012  0.011  0.017  0.010  0.012  0.011  0.017  0.013
            17     19     20     23     24     28     29     30     31
hnpt-5351|    ...  0.010  0.014  0.011  0.015  0.012  0.014    ...  0.012
            32
hnpt-5351|  0.014

        OVERALL     03     06     07     08     11     13     14     16
vims-5351|  0.016  0.014  0.017  0.019  0.013  0.013  0.018  0.018    ...
            17     19     20     23     24     28     29     30     31
vims-5351|    ...  0.015  0.013  0.015  0.016  0.014  0.019    ...  0.018
            32
vims-5351|  0.014
```

OBS BY SATELLITE VS. BASELINE

```
        OVERALL     03     06     07     08     11     13     14     16
loym-5351|   4807    598    591    112    182    184    499    112     74
            17     19     20     23     24     28     29     30     31
loym-5351|    ...    476    259    578    291    139    139    ...    326
            32
loym-5351|    247
        OVERALL     03     06     07     08     11     13     14     16
hnpt-5351|   4848    595    608    184    205    168    495    113     82
            17     19     20     23     24     28     29     30     31
hnpt-5351|    ...    463    254    586    293     96    144    ...    321
            32
hnpt-5351|    241
        OVERALL     03     06     07     08     11     13     14     16
vims-5351|   3824    554    490    109    160    137    443     69    ...
            17     19     20     23     24     28     29     30     31
vims-5351|    ...    428    167    519    148     65     89    ...    283
```

32
vims-5351| 163

Covariance Matrix for the xyz OPUS Position (meters2).

0.0000082200	-0.0000002919	-0.0000007111
-0.0000002919	0.0000057133	-0.0000001499
-0.0000007111	-0.0000001499	0.0000124378

Covariance Matrix for the enu OPUS Position (meters2).

0.0000079379	-0.0000010914	0.0000002217
-0.0000010914	0.0000100413	0.0000031139
0.0000002217	0.0000031139	0.0000083919

Horizontal network accuracy = 0.00735 meters.
Vertical network accuracy = 0.00568 meters.

Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96)(EPOCH:2002.0000).

	Xa(m)	Ya(m)	Za(m)	
LOYM	1158531.84701	-4875375.22808	3932556.90442	2002.00
HNPT	1196627.00367	-4846359.97458	3956723.24088	2002.00
VIMS	1250693.27562	-4902018.66696	3871080.40363	2002.00

Position of reference station monument in NAD_83(CORS96)(EPOCH:2002.0000).

	Xr(m)	Yr(m)	Zr(m)	
LOYM	1158531.84701	-4875375.22808	3932556.90442	2002.00
HNPT	1196627.00367	-4846359.97458	3956723.24088	2002.00
VIMS	1250693.27562	-4902018.66696	3871080.40363	2002.00

Velocity of reference station monument in NAD_83(CORS96)(EPOCH:2002.0000).

	Vx (m/yr)	Vy (m/yr)	Vz (m/yr)
LOYM	0.00160	0.00050	-0.00130
HNPT	-0.00100	0.00140	-0.00040
VIMS	0.00120	0.00070	-0.00160

Vectors from unknown station monument to reference station monument
in NAD_83(CORS96)(EPOCH:2002.0000).

	Xr-X= DX(m)	Yr-Y= DY(m)	Zr-Z= DZ(m)	
LOYM	-54124.80599	8730.60492	27124.32042	2002.00

HNPT	-16029.64933	37745.85842	51290.65688	2002.00
VIMS	38036.62262	-17912.83396	-34352.18037	2002.00

STATE PLANE COORDINATES - U.S. Survey Foot
SPC (1900 MD)

Northing (Y) [feet]	122838.062
Easting (X) [feet]	1584313.490
Convergence [degrees]	0.59235808
Point Scale	1.00006569
Combined Factor	1.00007071

** Orthometric Heights Above Future Geopotential Datum.

Prototype orthometric heights are now being made available as a precursor to the completion of GRAV-D and the replacement of NAVD 88 with a new geopotential reference system. The following height reflects the current best estimate of the true orthometric height, based on the existing gravimetric geoid model. This height is subject to change as data and modeling for the gravimetric geoid change throughout the lifetime of the GRAV-D project, or as new realizations of the ITRF are adopted. However, at the completion of GRAV-D, these heights will supersede the NAVD 88 heights

APPROX ORTHO HGT: 3.563 (m) [PROTOTYPE (Computed using USGG2009,GRS80,ITRF2000)]

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

FILE: 48632720.10o 000000602

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

USER: kimra@joasurveys.com DATE: December 09, 2010
RINEX FILE: 4863272n.10o TIME: 19:05:49 UTC

SOFTWARE: page5 1009.28 master50.pl 120210 START: 2010/09/29 13:02:00
EPHEMERIS: igs16033.eph [precise] STOP: 2010/09/29 20:09:00
NAV FILE: brdc2720.10n OBS USED: 16849 / 17769 : 95%
ANT NAME: TRM55971.00 NONE # FIXED AMB: 63 / 68 : 93%
ARP HEIGHT: 1.854 OVERALL RMS: 0.013(m)

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000) ITRF00 (EPOCH:2010.7444)

X:	1212656.657(m)	0.018(m)	1212655.908(m)	0.018(m)
Y:	-4884105.860(m)	0.047(m)	-4884104.397(m)	0.047(m)
Z:	3905432.568(m)	0.043(m)	3905432.450(m)	0.043(m)

LAT:	38 0 0.34083	0.012(m)	38 0 0.36977	0.012(m)
E LON:	283 56 37.66263	0.019(m)	283 56 37.64729	0.019(m)
W LON:	76 3 22.33737	0.019(m)	76 3 22.35271	0.019(m)
EL HGT:	-31.968(m)	0.061(m)	-33.301(m)	0.061(m)
ORTHO HGT:	3.911(m)	0.104(m) [NAVD88 (Computed using GEOID09)]		

	UTM COORDINATES UTM (Zone 18)	STATE PLANE COORDINATES SPC (1900 MD)
Northing (Y) [meters]	4206351.785	37441.087
Easting (X) [meters]	407266.874	482899.715
Convergence [degrees]	-0.65031231	0.59235807
Point Scale	0.99970591	1.00006569
Combined Factor	0.99971093	1.00007071

US NATIONAL GRID DESIGNATOR: 18SVH0726606351(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL3474	LOYM LOYOLA M CORS ARP	N381838.119	W0763757.974	61167.4
AI3494	HNPT HORN POINT ENVIRO CORS ARP	N383519.710	W0760749.332	65669.1
AI3289	VIMS VIRGINIA INSTITUT CORS ARP	N373630.045	W0754113.207	54293.0

NEAREST NGS PUBLISHED CONTROL POINT

HV6491	BIG THOROFARE RIVER W LIGHT 1	N380000.538	W0760320.914	35.2

BASE STATION INFORMATION

```
STATION NAME: loym  a    2 (LOYOLA M; Leonardtown, Maryland  USA)
MONUMENT: NO DOMES NUMBER
XYZ   1158531.2965  -4875373.7554   3932556.7647  MON @ 1997.0000 (M)
XYZ       -0.0145       -0.0012         0.0016  VEL (M/YR)
NEU        0.0000        0.0000         0.0000  MON TO ARP (M)
NEU        0.0012        0.0008         0.0847  ARP TO L1 PHASE CENTER (M)
NEU       -0.0002        0.0009         0.0740  ARP TO L2 PHASE CENTER (M)
XYZ       -0.1993       -0.0165         0.0220  VEL TIMES 13.7435 YRS
XYZ        0.0000        0.0000         0.0000  MON TO ARP
XYZ        0.0160       -0.0638         0.0534  ARP TO L1 PHASE CENTER
XYZ   1158531.1132  -4875373.8356   3932556.8401  L1 PHS CEN @ 2010.7444
XYZ        0.0001        0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ   1158531.1132  -4875373.8356   3932556.8402  NEW L1 PHS CEN @ 2010.7444
XYZ   1158531.0973  -4875373.7719   3932556.7867  NEW ARP @ 2010.7444
XYZ   1158531.0973  -4875373.7719   3932556.7867  NEW MON @ 2010.7444
LLH  38 18 38.14837  283 22  2.00931      4.8876  NEW L1 PHS CEN @ 2010.7444
LLH  38 18 38.14833  283 22  2.00927      4.8029  NEW ARP @ 2010.7444
LLH  38 18 38.14833  283 22  2.00927      4.8029  NEW MON @ 2010.7444

STATION NAME: hnpt  a    4 (Cambridge, USA; Horn Point Environmental Lab)
MONUMENT: 49913S001
XYZ   1196626.4656  -4846358.5068   3956723.0984  MON @ 1997.0000 (M)
XYZ       -0.0172       -0.0004         0.0027  VEL (M/YR)
NEU        0.0000        0.0000         0.0000  MON TO ARP (M)
NEU        0.0012        0.0008         0.0847  ARP TO L1 PHASE CENTER (M)
NEU       -0.0002        0.0009         0.0740  ARP TO L2 PHASE CENTER (M)
XYZ       -0.2368       -0.0049         0.0378  VEL TIMES 13.7435 YRS
XYZ        0.0000        0.0000         0.0000  MON TO ARP
```

```
XYZ        0.0165        -0.0634         0.0538  ARP TO L1 PHASE CENTER
XYZ   1196626.2453  -4846358.5751   3956723.1899  L1 PHS CEN @ 2010.7444
XYZ        0.0000         0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ   1196626.2453  -4846358.5751   3956723.1899  NEW L1 PHS CEN @ 2010.7444
XYZ   1196626.2288  -4846358.5117   3956723.1362  NEW ARP @ 2010.7444
XYZ   1196626.2288  -4846358.5117   3956723.1362  NEW MON @ 2010.7444
LLH  38 35 19.74054  283 52 10.65048    -27.8810  NEW L1 PHS CEN @ 2010.7444
LLH  38 35 19.74050  283 52 10.65045    -27.9657  NEW ARP @ 2010.7444
LLH  38 35 19.74050  283 52 10.65045    -27.9657  NEW MON @ 2010.7444

STATION NAME: vims  a    2 (Virginia Institute of Ma; Wachapreague, Virginia)
        WARNING: ORIGINALLY "AOAD/M_TA_NGS   SNOW"
XYZ   1250692.7258  -4902017.1820   3871080.2574  MON @ 1997.0000 (M)
XYZ       -0.0147        -0.0011         0.0017  VEL (M/YR)
NEU        0.0000         0.0000         0.0000  MON TO ARP (M)
NEU       -0.0000         0.0000         0.1100  ARP TO L1 PHASE CENTER (M)
NEU       -0.0000         0.0000         0.1280  ARP TO L2 PHASE CENTER (M)
XYZ       -0.2020        -0.0151         0.0234  VEL TIMES 13.7434 YRS
XYZ        0.0000         0.0000         0.0000  MON TO ARP
XYZ        0.0215        -0.0844         0.0671  ARP TO L1 PHASE CENTER
XYZ   1250692.5453  -4902017.2816   3871080.3479  L1 PHS CEN @ 2010.7443
XYZ       -0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ   1250692.5453  -4902017.2816   3871080.3479  NEW L1 PHS CEN @ 2010.7443
XYZ   1250692.5238  -4902017.1971   3871080.2808  NEW ARP @ 2010.7443
XYZ   1250692.5238  -4902017.1971   3871080.2808  NEW MON @ 2010.7443
LLH  37 36 30.07419  284 18 46.77799    -28.9792  NEW L1 PHS CEN @ 2010.7443
LLH  37 36 30.07419  284 18 46.77799    -29.0892  NEW ARP @ 2010.7443
LLH  37 36 30.07419  284 18 46.77799    -29.0892  NEW MON @ 2010.7443

                REMOTE STATION INFORMATION

STATION NAME: 4863       1
MONUMENT: NO DOMES NUMBER
XYZ   1212656.1571  -4884105.7485   3905433.6085  MON @ 2010.7440 (M)
NEU       -0.0016        -0.0007         1.8362  MON TO ARP (M)
NEU        0.0016         0.0007         0.0850  ARP TO L1 PHASE CENTER (M)
NEU        0.0008         0.0012         0.0701  ARP TO L2 PHASE CENTER (M)
XYZ        0.3482        -1.4054         1.1292  MON TO ARP
XYZ        0.0166        -0.0639         0.0536  ARP TO L1 PHASE CENTER
XYZ   1212656.5219  -4884107.2178   3905434.7913  L1 PHS CEN @ 2010.7444

BASELINE NAME:   loym  4863
XYZ       -0.2410         1.3694        -1.1787  + XYZ ADJUSTMENTS
```

```
XYZ   1212656.2810  -4884105.8484   3905433.6126  NEW L1 PHS CEN @ 2010.7444
XYZ   1212656.2644  -4884105.7845   3905433.5590  NEW ARP @ 2010.7444
XYZ   1212655.9161  -4884104.3791   3905432.4298  NEW MON @ 2010.7444
LLH  38  0  0.36956  283 56 37.64779    -31.4047  NEW L1 PHS CEN @ 2010.7444
LLH  38  0  0.36951  283 56 37.64776    -31.4897  NEW ARP @ 2010.7444
LLH  38  0  0.36956  283 56 37.64779    -33.3259  NEW MON @ 2010.7444

BASELINE NAME:   hnpt  4863
XYZ       -0.2590        1.3631       -1.1625  + XYZ ADJUSTMENTS
XYZ   1212656.2630  -4884105.8547   3905433.6288  NEW L1 PHS CEN @ 2010.7444
XYZ   1212656.2464  -4884105.7908   3905433.5752  NEW ARP @ 2010.7444
XYZ   1212655.8981  -4884104.3854   3905432.4460  NEW MON @ 2010.7444
LLH  38  0  0.36994  283 56 37.64701    -31.3933  NEW L1 PHS CEN @ 2010.7444
LLH  38  0  0.36989  283 56 37.64698    -31.4783  NEW ARP @ 2010.7444
LLH  38  0  0.36994  283 56 37.64701    -33.3145  NEW MON @ 2010.7444

BASELINE NAME:   vims  4863
XYZ       -0.2474        1.3229       -1.1355  + XYZ ADJUSTMENTS
XYZ   1212656.2745  -4884105.8949   3905433.6558  NEW L1 PHS CEN @ 2010.7443
XYZ   1212656.2579  -4884105.8311   3905433.6023  NEW ARP @ 2010.7443
XYZ   1212655.9097  -4884104.4256   3905432.4730  NEW MON @ 2010.7443
LLH  38  0  0.36980  283 56 37.64707    -31.3437  NEW L1 PHS CEN @ 2010.7443
LLH  38  0  0.36974  283 56 37.64704    -31.4287  NEW ARP @ 2010.7443
LLH  38  0  0.36980  283 56 37.64707    -33.2649  NEW MON @ 2010.7443

                    G-FILES

Axx2010 929  10 929
B2010 92913 1  10 92920 9 1 page5 v1009.28IGS     226 1 2 27NGS   201012 9IFDDFX
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D  1  2 -2546204  1  3 -3470164  2  3 -7274213

Axx2010 929  10 929
B2010 92913 1  10 92920 9 1 page5 v1009.28IGS     226 1 2 27NGS   201012 9IFDDFX
Iant_info.003        NGS   20101019
C00090002 -160296693    6  377458737   16  512906902   17 X2720A4863X2720AHNPT
D  1  2 -8102701  1  3   -44497  2  3 -1294690

Axx2010 929  10 929
B2010 92913 1  10 92920 9 1 page5 v1009.28IGS     226 1 2 27NGS   201012 9IFDDFX
Iant_info.003        NGS   20101019
C00090003  380366140   27 -179127715   24 -343521923   36 X2720A4863X2720AVIMS
```

D 1 2 -4586454 1 3 -6584522 2 3 -2646984

POST-FIT RMS BY SATELLITE VS. BASELINE

```
        OVERALL     02     03     04     06     07     08     09     11
loym-4863|  0.013    ...  0.019  0.018  0.008  0.011  0.013  0.026  0.012
           13     16     17     19     20     23     24     26     27
loym-4863|  0.010  0.010  0.010  0.011  0.015  0.014  0.015  0.022  0.021
           28     31     32
loym-4863|  0.026  0.019  0.021

        OVERALL     02     03     04     06     07     08     09     11
hnpt-4863|  0.012    ...  0.015  0.017  0.009  0.010  0.011  0.028  0.009
           13     16     17     19     20     23     24     26     27
hnpt-4863|  0.011  0.010  0.009  0.010  0.012  0.011  0.014  0.019  0.023
           28     31     32
hnpt-4863|  0.017  0.017  0.021

        OVERALL     02     03     04     06     07     08     09     11
vims-4863|  0.013    ...    ...  0.021  0.013  0.012  0.013    ...  0.011
           13     16     17     19     20     23     24     26     27
vims-4863|  0.013  0.013  0.011  0.012  0.016  0.012  0.014    ...  0.016
           28     31     32
vims-4863|  0.014  0.019  0.026
```

OBS BY SATELLITE VS. BASELINE

```
        OVERALL     02     03     04     06     07     08     09     11
loym-4863|   5882    ...     62    165    356    636    602     34    563
           13     16     17     19     20     23     24     26     27
loym-4863|    437    282    411    632    249    345    462     94    120
           28     31     32
loym-4863|     93    103    236
        OVERALL     02     03     04     06     07     08     09     11
hnpt-4863|   6039    ...     84    162    423    657    580     20    560
           13     16     17     19     20     23     24     26     27
hnpt-4863|    434    310    414    661    251    338    473    134    144
           28     31     32
hnpt-4863|     80    103    211
        OVERALL     02     03     04     06     07     08     09     11
vims-4863|   4928    ...    ...     84    372    610    506    ...    554
           13     16     17     19     20     23     24     26     27
vims-4863|    408    264    345    627    165    306    377    ...     38
```

```
          28     31     32
vims-4863|     34    102    136
```

Covariance Matrix for the xyz OPUS Position (meters^2).

```
 0.0000021356    -0.0000000960    -0.0000001585
-0.0000000960     0.0000024178    -0.0000000974
-0.0000001585    -0.0000000974     0.0000040222
```

Covariance Matrix for the enu OPUS Position (meters^2).

```
 0.0000021070    -0.0000001517    -0.0000000938
-0.0000001517     0.0000033752     0.0000007773
-0.0000000938     0.0000007773     0.0000030933
```

Horizontal network accuracy = 0.00408 meters.
Vertical network accuracy = 0.00345 meters.

Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96)(EPOCH:2002.0000).

	Xa(m)	Ya(m)	Za(m)	
LOYM	1158531.84701	-4875375.22808	3932556.90442	2002.00
HNPT	1196627.00367	-4846359.97458	3956723.24088	2002.00
VIMS	1250693.27562	-4902018.66696	3871080.40363	2002.00

Position of reference station monument in NAD_83(CORS96)(EPOCH:2002.0000).

	Xr(m)	Yr(m)	Zr(m)	
LOYM	1158531.84701	-4875375.22808	3932556.90442	2002.00
HNPT	1196627.00367	-4846359.97458	3956723.24088	2002.00
VIMS	1250693.27562	-4902018.66696	3871080.40363	2002.00

Velocity of reference station monument in NAD_83(CORS96)(EPOCH:2002.0000).

	Vx (m/yr)	Vy (m/yr)	Vz (m/yr)
LOYM	0.00160	0.00050	-0.00130
HNPT	-0.00100	0.00140	-0.00040
VIMS	0.00120	0.00070	-0.00160

Vectors from unknown station monument to reference station monument
in NAD_83(CORS96)(EPOCH:2002.0000).

	Xr-X= DX(m)	Yr-Y= DY(m)	Zr-Z= DZ(m)	
LOYM	-54124.80999	8730.63192	27124.33642	2002.00

HNPT	-16029.65333	37745.88542	51290.67288	2002.00
VIMS	38036.61862	-17912.80696	-34352.16437	2002.00

STATE PLANE COORDINATES - U.S. Survey Foot
SPC (1900 MD)

Northing (Y) [feet]	122837.966
Easting (X) [feet]	1584313.482
Convergence [degrees]	0.59235807
Point Scale	1.00006569
Combined Factor	1.00007071

** Orthometric Heights Above Future Geopotential Datum.

Prototype orthometric heights are now being made available as a precursor to the completion of GRAV-D and the replacement of NAVD 88 with a new geopotential reference system. The following height reflects the current best estimate of the true orthometric height, based on the existing gravimetric geoid model. This height is subject to change as data and modeling for the gravimetric geoid change throughout the lifetime of the GRAV-D project, or as new realizations of the ITRF are adopted. However, at the completion of GRAV-D, these heights will supersede the NAVD 88 heights

APPROX ORTHO HGT: 3.575 (m) [PROTOTYPE (Computed using USGG2009,GRS80,ITRF2000)]

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

FILE: 48633180_15sec.10o 000000133

NGS OPUS SOLUTION REPORT
==========

All computed coordinate accuracies are listed as peak-to-peak values.
For additional information: http://www.ngs.noaa.gov/OPUS/about.html#accuracy

USER: kimra@joasurveys.com DATE: December 09, 2010
RINEX FILE: 4863318m.10o TIME: 02:42:32 UTC

SOFTWARE: page5 1009.28 master23.pl 120210 START: 2010/11/14 12:40:00
EPHEMERIS: igs16100.eph [precise] STOP: 2010/11/14 20:45:00
NAV FILE: brdc3180.10n OBS USED: 19307 / 20240 : 95%
ANT NAME: TRM55971.00 NONE # FIXED AMB: 88 / 95 : 93%
ARP HEIGHT: 1.850 OVERALL RMS: 0.012(m)

REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000) ITRF00 (EPOCH:2010.8704)

X:	1212656.655(m)	0.042(m)	1212655.904(m)	0.042(m)
Y:	-4884105.863(m)	0.033(m)	-4884104.400(m)	0.033(m)
Z:	3905432.572(m)	0.019(m)	3905432.454(m)	0.019(m)

LAT:	38 0 0.34088	0.041(m)	38 0 0.36983	0.041(m)
E LON:	283 56 37.66252	0.033(m)	283 56 37.64710	0.033(m)
W LON:	76 3 22.33748	0.033(m)	76 3 22.35290	0.033(m)
EL HGT:	-31.963(m)	0.026(m)	-33.297(m)	0.026(m)
ORTHO HGT:	3.916(m)	0.047(m)	[NAVD88 (Computed using GEOID09)]	

	UTM COORDINATES UTM (Zone 18)	STATE PLANE COORDINATES SPC (1900 MD)
Northing (Y) [meters]	4206351.787	37441.088
Easting (X) [meters]	407266.871	482899.713
Convergence [degrees]	-0.65031233	0.59235805
Point Scale	0.99970591	1.00006569
Combined Factor	0.99971093	1.00007071

US NATIONAL GRID DESIGNATOR: 18SVH0726606351(NAD 83)

BASE STATIONS USED

PID	DESIGNATION	LATITUDE	LONGITUDE	DISTANCE(m)
DL3474	LOYM LOYOLA M CORS ARP	N381838.119	W0763757.974	61167.4
AI3494	HNPT HORN POINT ENVIRO CORS ARP	N383519.710	W0760749.332	65669.1
AI3289	VIMS VIRGINIA INSTITUT CORS ARP	N373630.045	W0754113.207	54292.9

NEAREST NGS PUBLISHED CONTROL POINT

HV6491	BIG THOROFARE RIVER W LIGHT 1	N380000.538	W0760320.914	35.2

BASE STATION INFORMATION

```
STATION NAME: loym  a    2 (LOYOLA M; Leonardtown, Maryland  USA)
MONUMENT: NO DOMES NUMBER
XYZ   1158531.2965  -4875373.7554   3932556.7647  MON @ 1997.0000 (M)
XYZ       -0.0145       -0.0012         0.0016  VEL (M/YR)
NEU        0.0000        0.0000         0.0000  MON TO ARP (M)
NEU        0.0012        0.0008         0.0847  ARP TO L1 PHASE CENTER (M)
NEU       -0.0002        0.0009         0.0740  ARP TO L2 PHASE CENTER (M)
XYZ       -0.2011       -0.0166         0.0222  VEL TIMES 13.8694 YRS
XYZ        0.0000        0.0000         0.0000  MON TO ARP
XYZ        0.0160       -0.0638         0.0534  ARP TO L1 PHASE CENTER
XYZ   1158531.1114  -4875373.8358   3932556.8403  L1 PHS CEN @ 2010.8704
XYZ       -0.0000        0.0000         0.0000  + XYZ ADJUSTMENTS
XYZ   1158531.1113  -4875373.8358   3932556.8404  NEW L1 PHS CEN @ 2010.8704
XYZ   1158531.0954  -4875373.7720   3932556.7869  NEW ARP @ 2010.8704
XYZ   1158531.0954  -4875373.7720   3932556.7869  NEW MON @ 2010.8704
LLH  38 18 38.14838  283 22  2.00923      4.8875  NEW L1 PHS CEN @ 2010.8704
LLH  38 18 38.14834  283 22  2.00920      4.8028  NEW ARP @ 2010.8704
LLH  38 18 38.14834  283 22  2.00920      4.8028  NEW MON @ 2010.8704

STATION NAME: hnpt  a    4 (Cambridge, USA; Horn Point Environmental Lab)
MONUMENT: 49913S001
XYZ   1196626.4656  -4846358.5068   3956723.0984  MON @ 1997.0000 (M)
XYZ       -0.0172       -0.0004         0.0027  VEL (M/YR)
NEU        0.0000        0.0000         0.0000  MON TO ARP (M)
NEU        0.0012        0.0008         0.0847  ARP TO L1 PHASE CENTER (M)
NEU       -0.0002        0.0009         0.0740  ARP TO L2 PHASE CENTER (M)
XYZ       -0.2390       -0.0050         0.0381  VEL TIMES 13.8694 YRS
XYZ        0.0000        0.0000         0.0000  MON TO ARP
```

```
XYZ        0.0165        -0.0634         0.0538  ARP TO L1 PHASE CENTER
XYZ   1196626.2431  -4846358.5751   3956723.1903  L1 PHS CEN @ 2010.8704
XYZ       -0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ   1196626.2431  -4846358.5751   3956723.1903  NEW L1 PHS CEN @ 2010.8704
XYZ   1196626.2267  -4846358.5118   3956723.1365  NEW ARP @ 2010.8704
XYZ   1196626.2267  -4846358.5118   3956723.1365  NEW MON @ 2010.8704
LLH  38 35 19.74056  283 52 10.65039    -27.8811  NEW L1 PHS CEN @ 2010.8704
LLH  38 35 19.74052  283 52 10.65036    -27.9658  NEW ARP @ 2010.8704
LLH  38 35 19.74052  283 52 10.65036    -27.9658  NEW MON @ 2010.8704

STATION NAME: vims  a    2 (Virginia Institute of Ma; Wachapreague, Virginia)
        WARNING: ORIGINALLY "AOAD/M_TA_NGS   SNOW"
XYZ   1250692.7258  -4902017.1820   3871080.2574  MON @ 1997.0000 (M)
XYZ       -0.0147        -0.0011         0.0017  VEL (M/YR)
NEU        0.0000         0.0000         0.0000  MON TO ARP (M)
NEU       -0.0000         0.0000         0.1100  ARP TO L1 PHASE CENTER (M)
NEU       -0.0000         0.0000         0.1280  ARP TO L2 PHASE CENTER (M)
XYZ       -0.2039        -0.0153         0.0236  VEL TIMES 13.8694 YRS
XYZ        0.0000         0.0000         0.0000  MON TO ARP
XYZ        0.0215        -0.0844         0.0671  ARP TO L1 PHASE CENTER
XYZ   1250692.5435  -4902017.2817   3871080.3481  L1 PHS CEN @ 2010.8704
XYZ        0.0000        -0.0000        -0.0000  + XYZ ADJUSTMENTS
XYZ   1250692.5435  -4902017.2817   3871080.3481  NEW L1 PHS CEN @ 2010.8704
XYZ   1250692.5219  -4902017.1973   3871080.2810  NEW ARP @ 2010.8704
XYZ   1250692.5219  -4902017.1973   3871080.2810  NEW MON @ 2010.8704
LLH  37 36 30.07420  284 18 46.77792    -28.9793  NEW L1 PHS CEN @ 2010.8704
LLH  37 36 30.07420  284 18 46.77792    -29.0893  NEW ARP @ 2010.8704
LLH  37 36 30.07420  284 18 46.77792    -29.0893  NEW MON @ 2010.8704

                REMOTE STATION INFORMATION

STATION NAME: 4863       1
MONUMENT: NO DOMES NUMBER
XYZ   1212656.2005  -4884105.6142   3905433.6400  MON @ 2010.8699 (M)
NEU       -0.0016        -0.0007         1.8322  MON TO ARP (M)
NEU        0.0016         0.0007         0.0850  ARP TO L1 PHASE CENTER (M)
NEU        0.0008         0.0012         0.0701  ARP TO L2 PHASE CENTER (M)
XYZ        0.3475        -1.4024         1.1268  MON TO ARP
XYZ        0.0166        -0.0639         0.0536  ARP TO L1 PHASE CENTER
XYZ   1212656.5646  -4884107.0805   3905434.8203  L1 PHS CEN @ 2010.8704

BASELINE NAME:   loym  4863
XYZ       -0.2903         1.2238        -1.1923  + XYZ ADJUSTMENTS
```

```
XYZ   1212656.2742  -4884105.8566   3905433.6281  NEW L1 PHS CEN @ 2010.8704
XYZ   1212656.2576  -4884105.7928   3905433.5745  NEW ARP @ 2010.8704
XYZ   1212655.9102  -4884104.3904   3905432.4477  NEW MON @ 2010.8704
LLH  38  0  0.36983  283 56 37.64744    -31.3901  NEW L1 PHS CEN @ 2010.8704
LLH  38  0  0.36978  283 56 37.64741    -31.4751  NEW ARP @ 2010.8704
LLH  38  0  0.36983  283 56 37.64744    -33.3073  NEW MON @ 2010.8704

BASELINE NAME:   hnpt  4863
XYZ       -0.3199        1.2264       -1.1730  + XYZ ADJUSTMENTS
XYZ   1212656.2447  -4884105.8541   3905433.6474  NEW L1 PHS CEN @ 2010.8704
XYZ   1212656.2281  -4884105.7902   3905433.5938  NEW ARP @ 2010.8704
XYZ   1212655.8806  -4884104.3878   3905432.4670  NEW MON @ 2010.8704
LLH  38  0  0.37051  283 56 37.64629    -31.3858  NEW L1 PHS CEN @ 2010.8704
LLH  38  0  0.37046  283 56 37.64626    -31.4708  NEW ARP @ 2010.8704
LLH  38  0  0.37051  283 56 37.64629    -33.3030  NEW MON @ 2010.8704

BASELINE NAME:   vims  4863
XYZ       -0.2779        1.1931       -1.1915  + XYZ ADJUSTMENTS
XYZ   1212656.2867  -4884105.8874   3905433.6288  NEW L1 PHS CEN @ 2010.8704
XYZ   1212656.2701  -4884105.8235   3905433.5752  NEW ARP @ 2010.8704
XYZ   1212655.9226  -4884104.4211   3905432.4485  NEW MON @ 2010.8704
LLH  38  0  0.36919  283 56 37.64763    -31.3638  NEW L1 PHS CEN @ 2010.8704
LLH  38  0  0.36914  283 56 37.64760    -31.4488  NEW ARP @ 2010.8704
LLH  38  0  0.36919  283 56 37.64763    -33.2810  NEW MON @ 2010.8704

                    G-FILES

Axx20101114  101114
B201011141240  1011142045 1 page5 v1009.28IGS     226 1 2 27NGS   201012 8IFDDFX
Iant_info.003        NGS   20101019
C00090001 -541248148   13   87306184   12  271243392   11 X3180A4863X3180ALOYM
D  1  2 -3976040  1  3 -3526354  2  3 -5932734

Axx20101114  101114
B201011141240  1011142045 1 page5 v1009.28IGS     226 1 2 27NGS   201012 8IFDDFX
Iant_info.003        NGS   20101019
C00090002 -160296540    5  377458761   14  512906695   15 X3180A4863X3180AHNPT
D  1  2 -7748059  1  3 -1911731  2  3   176524

Axx20101114  101114
B201011141240  1011142045 1 page5 v1009.28IGS     226 1 2 27NGS   201012 8IFDDFX
Iant_info.003        NGS   20101019
C00090003  380365993   23 -179127761   21 -343521675   25 X3180A4863X3180AVIMS
```

D 1 2 -6702242 1 3 -6585611 2 3 -274559

POST-FIT RMS BY SATELLITE VS. BASELINE

```
        OVERALL     02     03     04     05     06     07     08     09
loym-4863|  0.012  0.009  0.015  0.017  0.009  0.020  0.010  0.022  0.015
           10     11     12     13     17     19     20     23     24
loym-4863|  0.008  0.010  0.011  0.021  0.008  0.013  0.012  0.023  0.011
           25     26     27     28     29     32
loym-4863|  0.018  0.019  0.015  0.011    ...  0.018

        OVERALL     02     03     04     05     06     07     08     09
hnpt-4863|  0.011  0.010  0.012  0.008  0.010  0.014  0.008  0.015  0.018
           10     11     12     13     17     19     20     23     24
hnpt-4863|  0.008  0.009  0.011  0.013  0.010  0.009  0.013  0.020  0.008
           25     26     27     28     29     32
hnpt-4863|  0.013  0.023  0.015  0.009    ...  0.014

        OVERALL     02     03     04     05     06     07     08     09
vims-4863|  0.013  0.012  0.016  0.014  0.012  0.021  0.011  0.011  0.018
           10     11     12     13     17     19     20     23     24
vims-4863|  0.011  0.016  0.012  0.016  0.010  0.013  0.012    ...  0.013
           25     26     27     28     29     32
vims-4863|    ...  0.019  0.021  0.012    ...  0.018
```

OBS BY SATELLITE VS. BASELINE

```
        OVERALL     02     03     04     05     06     07     08     09
loym-4863|   6778    448    110     73    217     54    387     69    232
           10     11     12     13     17     19     20     23     24
loym-4863|    372    530    321    306    823    312    415    109    421
           25     26     27     28     29     32
loym-4863|    155    116    306    727    ...    275
        OVERALL     02     03     04     05     06     07     08     09
hnpt-4863|   6979    348    154    592    207     88    378     63    207
           10     11     12     13     17     19     20     23     24
hnpt-4863|    350    575    332    328    401    310    442    165    429
           25     26     27     28     29     32
hnpt-4863|    140    133    292    730    ...    315
        OVERALL     02     03     04     05     06     07     08     09
vims-4863|   5550    399    120     42    211     56    381    465     56
           10     11     12     13     17     19     20     23     24
vims-4863|    351     31    314    214    770    298    329    ...    395
```

```
            25     26     27     28     29     32
vims-4863|    ...     30    213    677    ...    198
```

Covariance Matrix for the xyz OPUS Position (meters^2).

```
 0.0000016067    -0.0000000978    -0.0000000985
-0.0000000978     0.0000017356    -0.0000000198
-0.0000000985    -0.0000000198     0.0000021578
```

Covariance Matrix for the enu OPUS Position (meters^2).

```
 0.0000015684    -0.0000001138    -0.0000000171
-0.0000001138     0.0000020179     0.0000001848
-0.0000000171     0.0000001848     0.0000019137
```

Horizontal network accuracy = 0.00328 meters.
Vertical network accuracy = 0.00271 meters.

Derivation of NAD 83 vector components

Position of reference station ARP in NAD_83(CORS96)(EPOCH:2002.0000).

	Xa(m)	Ya(m)	Za(m)	
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VIMS	1250693.27562	-4902018.66696	3871080.40363	2002.00

Position of reference station monument in NAD_83(CORS96)(EPOCH:2002.0000).

	Xr(m)	Yr(m)	Zr(m)	
LOYM	1158531.84701	-4875375.22808	3932556.90442	2002.00
HNPT	1196627.00367	-4846359.97458	3956723.24088	2002.00
VIMS	1250693.27562	-4902018.66696	3871080.40363	2002.00

Velocity of reference station monument in NAD_83(CORS96)(EPOCH:2002.0000).

	Vx (m/yr)	Vy (m/yr)	Vz (m/yr)
LOYM	0.00160	0.00050	-0.00130
HNPT	-0.00100	0.00140	-0.00040
VIMS	0.00120	0.00070	-0.00160

Vectors from unknown station monument to reference station monument
in NAD_83(CORS96)(EPOCH:2002.0000).

	Xr-X= DX(m)	Yr-Y= DY(m)	Zr-Z= DZ(m)	
LOYM	-54124.80799	8730.63492	27124.33242	2002.00

HNPT	-16029.65133	37745.88842	51290.66888	2002.00
VIMS	38036.62062	-17912.80396	-34352.16837	2002.00

STATE PLANE COORDINATES - U.S. Survey Foot
SPC (1900 MD)

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Combined Factor	1.00007071

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Prototype orthometric heights are now being made available as a precursor to the completion of GRAV-D and the replacement of NAVD 88 with a new geopotential reference system. The following height reflects the current best estimate of the true orthometric height, based on the existing gravimetric geoid model. This height is subject to change as data and modeling for the gravimetric geoid change throughout the lifetime of the GRAV-D project, or as new realizations of the ITRF are adopted. However, at the completion of GRAV-D, these heights will supersede the NAVD 88 heights

APPROX ORTHO HGT: 3.579 (m) [PROTOTYPE (Computed using USGG2009,GRS80,ITRF2000)]

This position and the above vector components were computed without any knowledge by the National Geodetic Survey regarding the equipment or field operating procedures used.

NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable:__ FBN__ CBN__ PAC__ SAC __BM) GREEN-1 RADAR GAUGE		Station PID, if any: N/A	Date (UTC): 15-Jul-10
General Location: Smith Island, VA	Airport ID, if any:	Station 4-Character ID: N/A	Day of Year: 196
Project Name: NOAA0000-0015	Project Number: GPS-	Station Serial # (SSN): N/A	Session ID:(A,B,C etc)

NAD83 Latitude	NAD83 Longitude	NAD83 Ellipsoidal Height	Agency Full Name:
038°00'00.3"	076°03'22.3"	-32.0 meters	David Evans & Assoc.
Observation Session Times (UTC): Sched. Start _____ Stop _____	Epoch Interval= 15 Seconds	NAVD88 Orthometric Ht. 3.9 meters	Operator Full Name: Tom Roberts
Actual Start 16:14 Stop 21:57	Elevation Mask = 10 Degrees	GEOID99 Geoid Height meters	Phone #: ( ) (360) 314-3200
			e-mail address: trw@deainc.com

Receiver Brand & Model: Trimble SPS-881 GNSS
P/N:
S/N: sn:5004k65351
Firmware Version: 4.14
❒ CamCorder Battery, ❒ 12V DC, ❒ 110V AC, ❒ Other

Antenna Code*, Brand & Model: Trimble Zephyr Geodetic Model-2
P/N:
S/N:
Cable Length, meters: 10
Vehicle is Parked _____ meters ____(direction) from antenna.

Antenna plumb before session?	(✓ / N)	Circle
Antenna plumb after session?	(✓ / N)	Yes or No
Antenna oriented to true North?	(✓ / N)	-If no,
Weather observed at antenna ht.	(✓ / N)	explain
Antenna ground plane used?	(✓ / N)	"
Antenna radome used?	(Y / ✓)	If yes,
Eccentric occupation (>0.5 mm)?	(Y / ✓)	describe.
Any obstructions above 10°?	(Y / ✓)	Use
Radio interference source nearby	(✓ / N)	Vis. form

Tripod or Antenna Mount: Check one:
❒ Fixed-Leg Tripod, ❒ Collapsible-leg tripod ❒ Fixed Mount
Brand & Model: n/a fixed mount pole
P/N:
S/N: n/a
Last Adjustment date:

Psychrometer (if used) Brand & Model:
P/N:
S/N:
Last Calibration or check Date:

** ANTENNA HEIGHT **	Before Session Begins: Meters	Before Session Begins: Feet	After Session Ends: Meters	After Session Ends: Feet
A= Datum point to Top of Tripod (Tripod Height)	1.576	5.170	1.576	5.170
B=Additional offset to ARP if any (Tribrach/Spacer)	0.000	0.000	0.000	0.000
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)				

Meters = Feet x (0.3048)
Height Entered Into Receiver = 1.576 meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model: n/a
S/N:

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before									
Middle									
After									

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s): 35311960.t01
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ❒ Attached ❒ Submitted earlier
Visibility Obstruction Form: ❒ Attached ❒ Submitted earlier
Photographs of Station: ❒ Attached ❒ Submitted earlier
Pencil Rubbing of Mark: ❒ Attached

LOG CHECKED BY:

Table of Weather Codes

CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	did not occur	Good, over 15 miles	Normal, 32° F- 80° F	Clear, below 20%	Calm, under 5mph (8km/h)
1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)

Examples: 00000 = No problem, good visibility, normal temp, clear, calm wind 12121 = Problems, poor visibility, hot, overcast, moderate wind

Station Location Sketch and Visibility Diagram

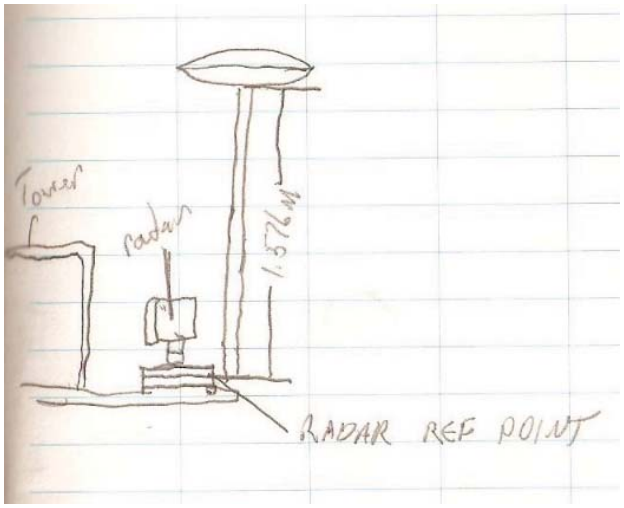
Location / Airport Name and ID: Navigation Aid Green-1, Smith Island, VA Project: NOAA0000-0015

Station Designation: Green-1 Radar Gauge PID: _____ Date: 2010-07-15

Circle all applicable:
PACS SACS BM FBN CBN OTHER Gauge

Observer & Organization: TRW, David Evans & Accos.

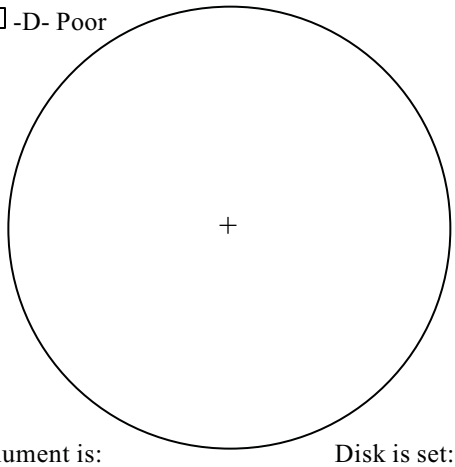
Station Location Sketch



Sketch of Disk

Monument Stability Quality:
- ☐ -A- Most stable
- ☐ -B- Excellent
- ☐ -C- Good
- ☐ -D- Poor

☑ Photos Available



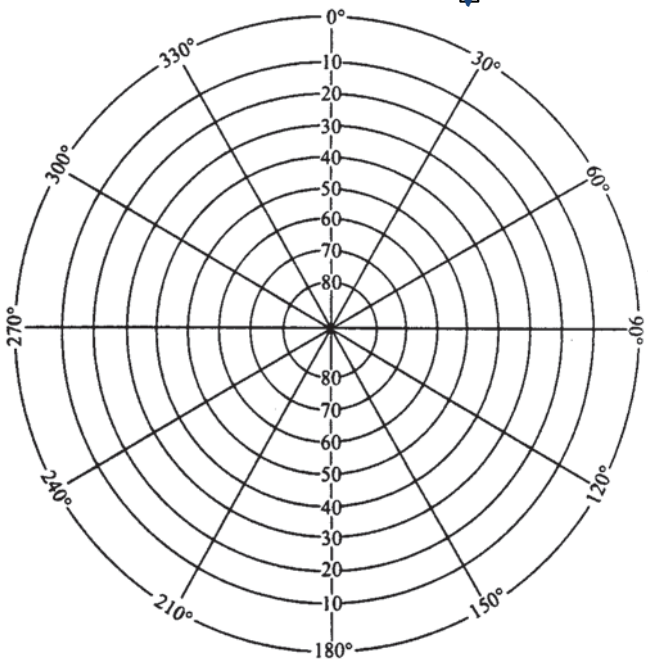
Monument is:
- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☐ Projecting ___ cm

Disk is set:
- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

☑ No Obstructions above 10°

☑ Photos Available



NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable:__ FBN__ CBN__ PAC__ SAC __BM) GREEN-1 RADAR GAUGE		Station PID, if any: N/A	Date (UTC): 29-Sep-10
General Location: Smith Island, VA	Airport ID, if any:	Station 4-Character ID: N/A	Day of Year: 272
Project Name: NOAA0000-0015	Project Number: GPS-	Station Serial # (SSN): N/A	Session ID:(A,B,C etc)

NAD83 Latitude	NAD83 Longitude	NAD83 Ellipsoidal Height	Agency Full Name:
038°00'00.3"	076°03'22.3"	-32.0 meters	David Evans & Assoc.
Observation Session Times (UTC): Sched. Start _____ Stop _____	Epoch Interval= 1 Seconds	NAVD88 Orthometric Ht. 3.9 meters	Operator Full Name: Tom Roberts
Actual Start 13:02 Stop 20:09	Elevation Mask = 10 Degrees	GEOID99 Geoid Height meters	Phone #: ( ) (360) 314-3200
			e-mail address: trw@deainc.com

Receiver Brand & Model: Trimble R7 GNSS
P/N:
S/N: SN:4915k34863
Firmware Version: 4.12
❒ CamCorder Battery, ❒ 12V DC, ❒ 110V AC, ❒ Other

Antenna Code*, Brand & Model: Trimble Zephyr Geodetic Model-2
P/N:
S/N:
Cable Length, meters: 10
Vehicle is Parked _____ meters ____(direction) from antenna.

Antenna plumb before session?	(Y / N)	Circle
Antenna plumb after session?	(Y / N)	Yes or No
Antenna oriented to true North?	(Y / N)	-If no,
Weather observed at antenna ht.	(Y / N)	explain
Antenna ground plane used?	(Y / N)	"
Antenna radome used?	(Y / N)	If yes,
Eccentric occupation (>0.5 mm)?	(Y / N)	describe.
Any obstructions above 10°?	(Y / N)	Use
Radio interference source nearby	(Y / N)	Vis. form

Tripod or Antenna Mount: Check one:
❒ Fixed-Leg Tripod, ❒ Collapsible-leg tripod ❒ Fixed Mount
Brand & Model: n/a fixed mount pole
P/N:
S/N: n/a
Last Adjustment date:

Psychrometer (if used) Brand & Model:
P/N:
S/N:
Last Calibration or check Date:

** ANTENNA HEIGHT **	Before Session Begins: Meters	Before Session Begins: Feet	After Session Ends: Meters	After Session Ends: Feet
A= Datum point to Top of Tripod (Tripod Height)	1.854	6.080	1.854	6.080
B=Additional offset to ARP if any (Tribrach/Spacer)	0.000	0.000	0.000	0.000
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)				

Meters = Feet x (0.3048)
Height Entered Into Receiver = 1.854 meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model: n/a
S/N:

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before									
Middle									
After									

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s): 4863720.T01
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ❒ Attached ❒ Submitted earlier
Visibility Obstruction Form: ❒ Attached ❒ Submitted earlier
Photographs of Station: ❒ Attached ❒ Submitted earlier
Pencil Rubbing of Mark: ❒ Attached

LOG CHECKED BY:

Table of Weather Codes	CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
	0	did not occur	Good, over 15 miles	Normal, 32° F- 80° F	Clear, below 20%	Calm, under 5mph (8km/h)
	1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
	2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)
Examples:	00000 = No problem, good visibility, normal temp, clear, calm wind				12121 = Problems, poor visibility, hot, overcast, moderate wind	

Station Location Sketch and Visibility Diagram

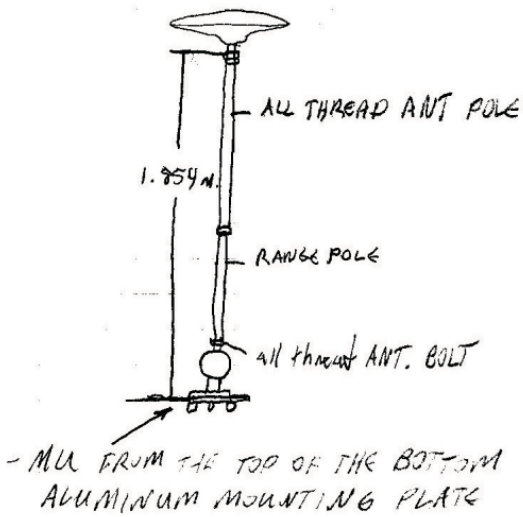
Location / Airport Name and ID: Navigation Aid Green-1, Smith Island, VA Project: NOAA0000-0015

Station Designation: Green-1 Radar Gauge PID: _____ Date: 2010-09-29

Circle all applicable:
PACS SACS BM FBN CBN OTHER Gauge

Observer & Organization: TRW, David Evans & Accos.

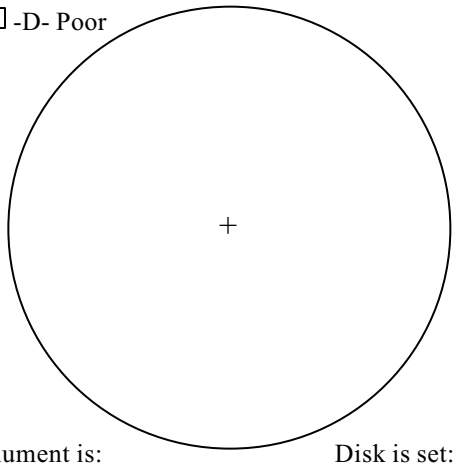
Station Location Sketch



Sketch of Disk

Monument Stability Quality:
- ☐ -A- Most stable
- ☐ -B- Excellent
- ☐ -C- Good
- ☐ -D- Poor

☑ Photos Available



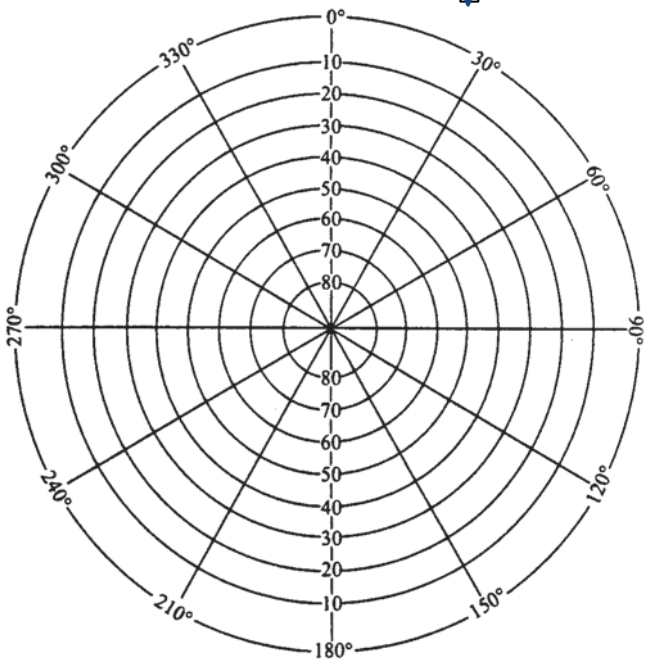
Monument is:
- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☐ Projecting ___ cm

Disk is set:
- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

☑ No Obstructions above 10°

☑ Photos Available



72'3/16

NOTE: This form intended for field use. Unsolicited data submitted to NGS must be converted to bluebook format.

GPS STATION OBSERVATION LOG
April 16, 2003

Station Designation: (check applicable:__ FBN__ CBN__ PAC__ SAC __BM) GREEN 1 RADAR LP		Station PID, if any: N/A	Date (UTC): 11/14/2010
General Location: E SIDE CHESAPEAKE BAY @ SMITH ISLAND	Airport ID, if any:	Station 4-Character ID: N/A	Day of Year: 218
Project Name: OPR-E349-KR-10 T0005	Project Number: GPS-	Station Serial # (SSN): N/A	Session ID:(A,B,C etc) A

NAD83 Latitude ° ' "	NAD83 Longitude ° ' "	NAD83 Ellipsoidal Height meters	Agency Full Name: DAVID EVANS & ASS
Observation Session Times (UTC): Sched. Start 1240 Stop 2040	Epoch Interval= 1 Seconds	NAVD88 Orthometric Ht. meters	Operator Full Name: BEN HOCKER
Actual Start _____ Stop _____	Elevation Mask = 10 Degrees	GEOID99 Geoid Height meters	Phone #: (360)314-3200
			e-mail address: bxhoedeainc.com

Receiver Brand & Model: TRIMBLE R7 GNSS
P/N:
S/N: 4915K34863
Firmware Version:
☐ CamCorder Battery, ☒ 12V DC, ☐ 110V AC, ☐ Other

Antenna Code*, Brand & Model: TRIMBLE ZEPHYR GEODETIC MODEL 2
P/N: 57971-00
S/N: 1441003378
Cable Length, meters: 15m
Vehicle is Parked _____ meters ____(direction) from antenna.

Antenna plumb before session?	(Y / N)	Circle Yes or No -If no, explain "
Antenna plumb after session?	(Y / N)	
Antenna oriented to true North?	(Y / N)	
Weather observed at antenna ht.	(Y / N)	
Antenna ground plane used?	(Y / N)	
Antenna radome used?	(Y / N)	If yes, describe. Use Vis. form
Eccentric occupation (>0.5 mm)?	(Y / N)	
Any obstructions above 10°?	(Y / N)	
Radio interference source nearby	(Y / N)	

Tripod or Antenna Mount: Check one:
☐ Fixed-Leg Tripod, ☐ Collapsible-leg tripod ☐ Fixed Mount
Brand & Model: THREADED ROD TO LP
P/N:
S/N:
Last Adjustment date:

Psychrometer (if used) Brand & Model: KESTREL 4000
P/N:
S/N: 533750
Last Calibration or check Date: UNKNOWN.

** ANTENNA HEIGHT **

	Before Session Begins: Meters	Feet	After Session Ends: Meters	Feet
A= Datum point to Top of Tripod (Tripod Height)	1.849		1.851	
B= Additional offset to ARP if any (Tribrach/Spacer)	0.000		0.000	
H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)	1.849		1.851	

Meters = Feet x (0.3048)
Height Entered Into Receiver = 1.850 meters.
Note &/or sketch **ANY** unusual conditions. Be **Very Explicit** as to where and how Measured!

Barometer (if used) Brand & Model: KESTREL 4000
S/N: 533750

Weather Data	Weather Codes	Time (UTC)	Dry-Bulb Temp Fahrenheit	Dry-Bulb Temp Celsius	WetBulb Temp Fahrenheit	WetBulb Temp Celsius	Rel. % Humidity	Atm. Pressure inches Hg	Atm. Pressure millibar
Before	00000	1240	55.3		49.8		68.8	30.07	
Middle									
After	00000	2040	65.0		55.2		65.4	29.99	

Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc:

Weather codes are required. Weather data are optional but encouraged. *Antenna code comes from ant_info file furnished by project coordinator.

Data File Name(s):
(Standard NGS Format = aaaaddds.xxx)
where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension

Updated Station Description: ☐ Attached ☐ Submitted earlier
Visibility Obstruction Form: ☐ Attached ☐ Submitted earlier
Photographs of Station: ☐ Attached ☐ Submitted earlier
Pencil Rubbing of Mark: ☐ Attached

LOG CHECKED BY:

Table of Weather Codes	CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
	0	did not occur	Good, over 15 miles	Normal, 32° F- 80° F	Clear, below 20%	Calm, under 5mph (8km/h)
	1	did occur	Fair, 7-15 miles	Hot, over 80°F (27 C)	Cloudy, 20% to 70%	Moderate, 5 to 15 mph
	2	- not used -	Poor, under 7 miles	Cold, below 32° F (0 C)	Overcast, over 70%	Strong, over15 mph (24km/h)

Examples: 00000 = No problem, good visibility, normal temp, clear, calm wind 12121 = Problems, poor visibility, hot, overcast, moderate wind

Station Location Sketch and Visibility Diagram

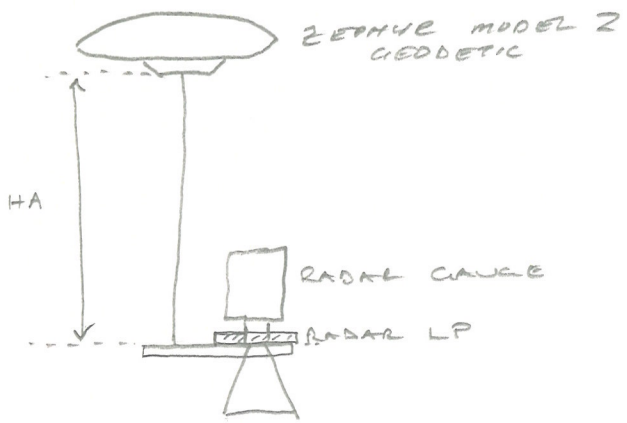
Location / Airport Name and ID: E SIDE CHESAPEAKE BAY @ SMITH ISL. Project: OPR-E349-KR-10

Station Designation: GREEN 1 RADAR LP PID: N/A Date: 11/14/10

Circle all applicable: PACS SACS BM FBN CBN OTHER GAUGE

Observer & Organization: BKHO DEA INC.

Station Location Sketch

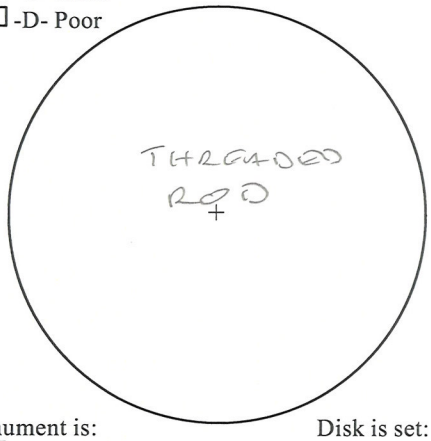


STATION IS LOCATED ON 'GREEN 1' CHANNEL MARKER AT WEST ENTRANCE TO EWELL ON SMITH ISLAND IN CHESAPEAKE BAY, MD.

Sketch of Disk

Monument Stability Quality: ☒ Photos Available

- ☐ -A- Most stable
- ☐ -B- Excellent N/A
- ☐ -C- Good
- ☐ -D- Poor

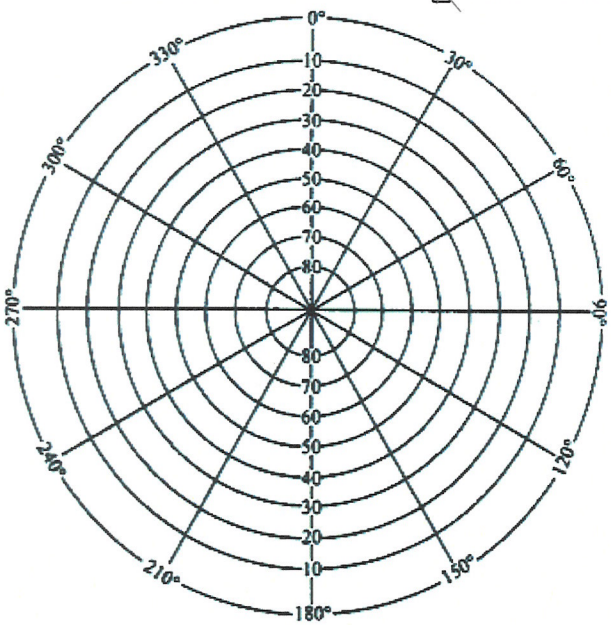


Monument is:
- ☐ Recessed ___ cm
- ☐ Flush with ground surface
- ☐ Projecting ___ cm

Disk is set:
- ☐ in bedrock.
- ☐ in concrete.
- ☐ in structure.

Visibility Diagram

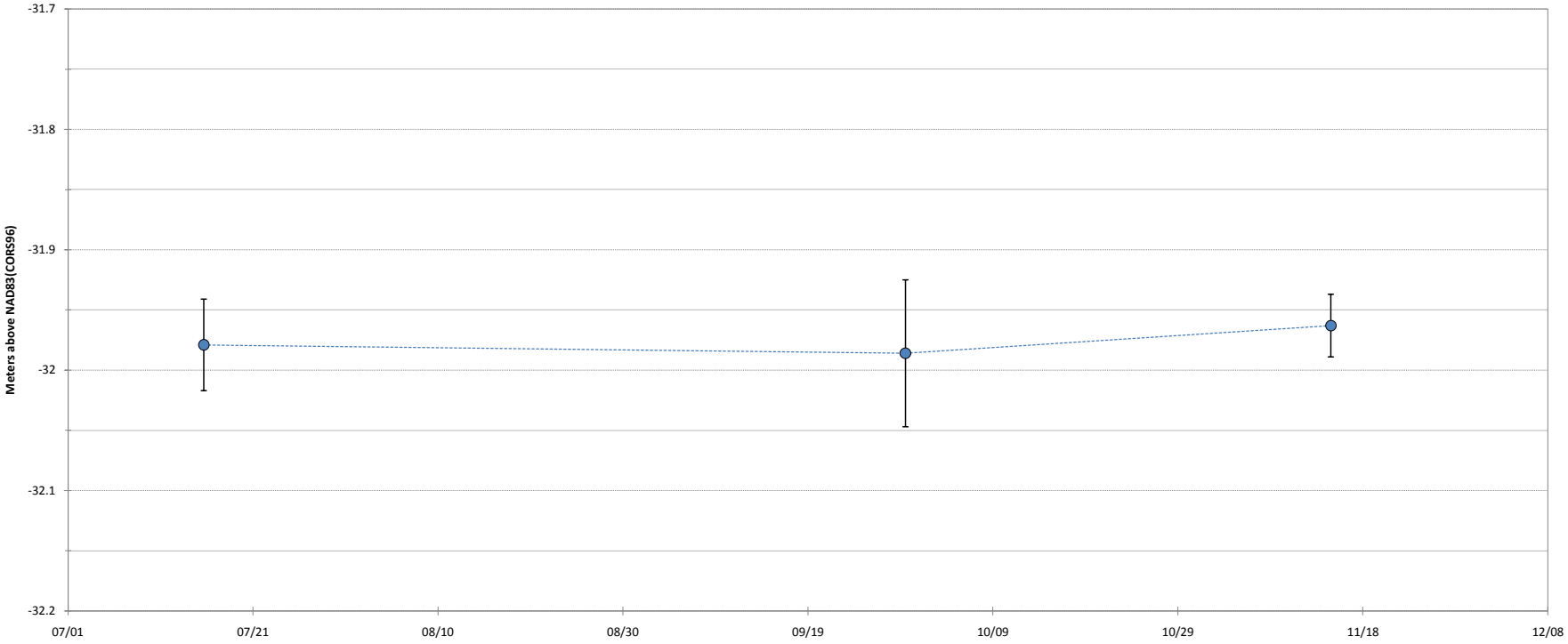
☒ No Obstructions above 10° ☒ Photos Available



8570004 USCG Piling Green 1
Radar Height History

				NAD_83(CORS96)(EPOCH:2002.0000)								ITRF00								
		hours	*meters*							*meters*								*meters*		
Start Time	**End Time**	**Session Length**	**Antenna Ht**	**Longitude**			**Latitude**			**Ellipsoid Ht**	**Ht uncertainty**	**Longitude**			**Latitude**			**Ellipsoid Ht**	**Ht uncertainty**	**EPOCH**
07/15/2010 16:14	07/15/2010 21:57	5.717	1.576	76	3	22.33726	38	0	0.34178	-31.979	0.038	76	3	22.35249	38	0	0.37068	-33.313	0.038	2010.5364
09/29/2010 13:02	09/29/2010 20:09	7.117	1.854	76	3	22.33735	38	0	0.34084	-31.986	0.061	76	3	22.3527	38	0	0.36978	-33.319	0.061	2010.7443
11/14/2010 12:40	11/14/2010 20:45	8.083	1.85	76	3	22.33748	38	0	0.34088	-31.963	0.026	76	3	22.3529	38	0	0.36983	-33.297	0.026	2010.8704

Radar OPUS Solution History

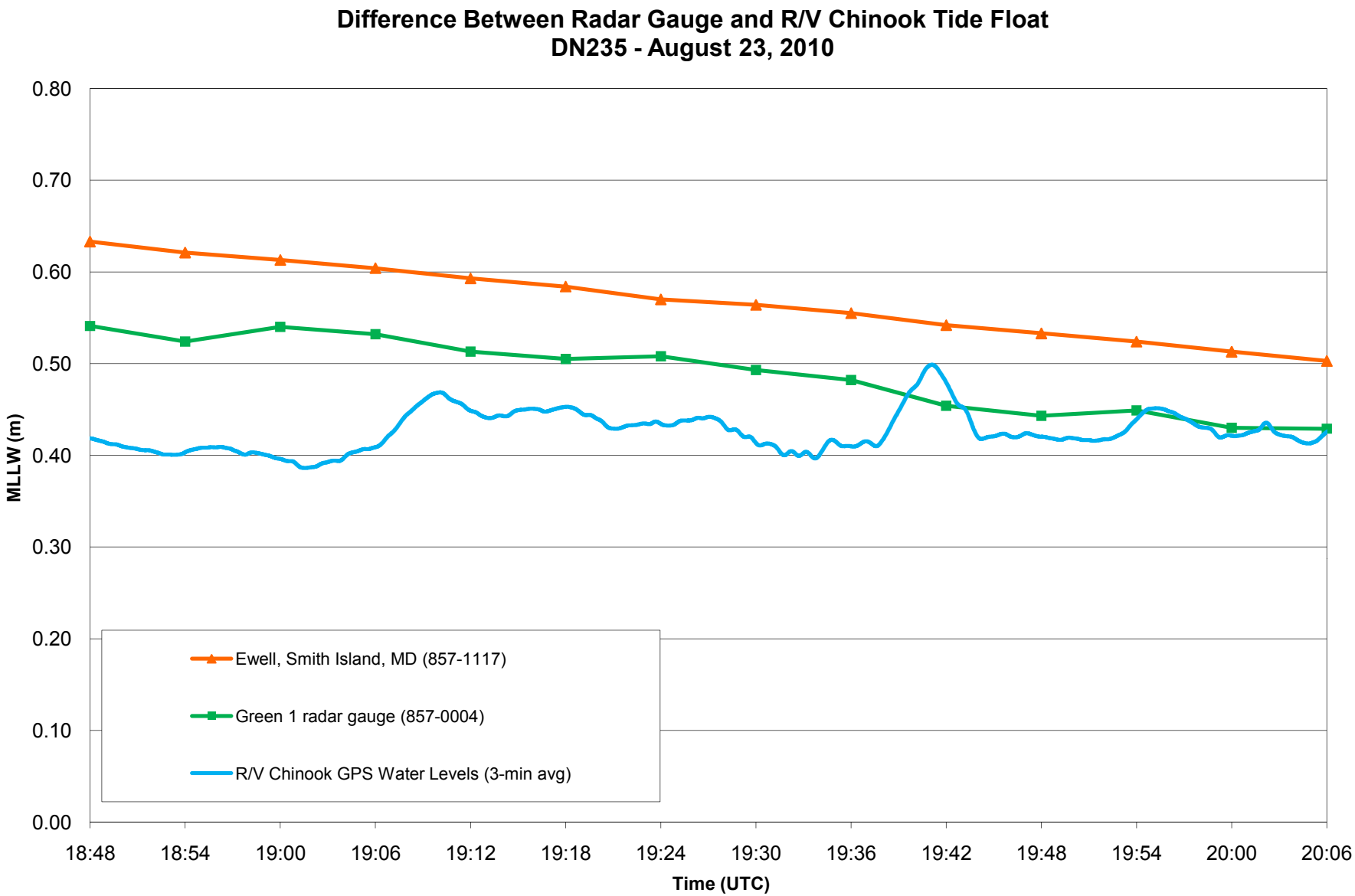


Final Coordinates of the Radar and Statistics for OPUS Solution

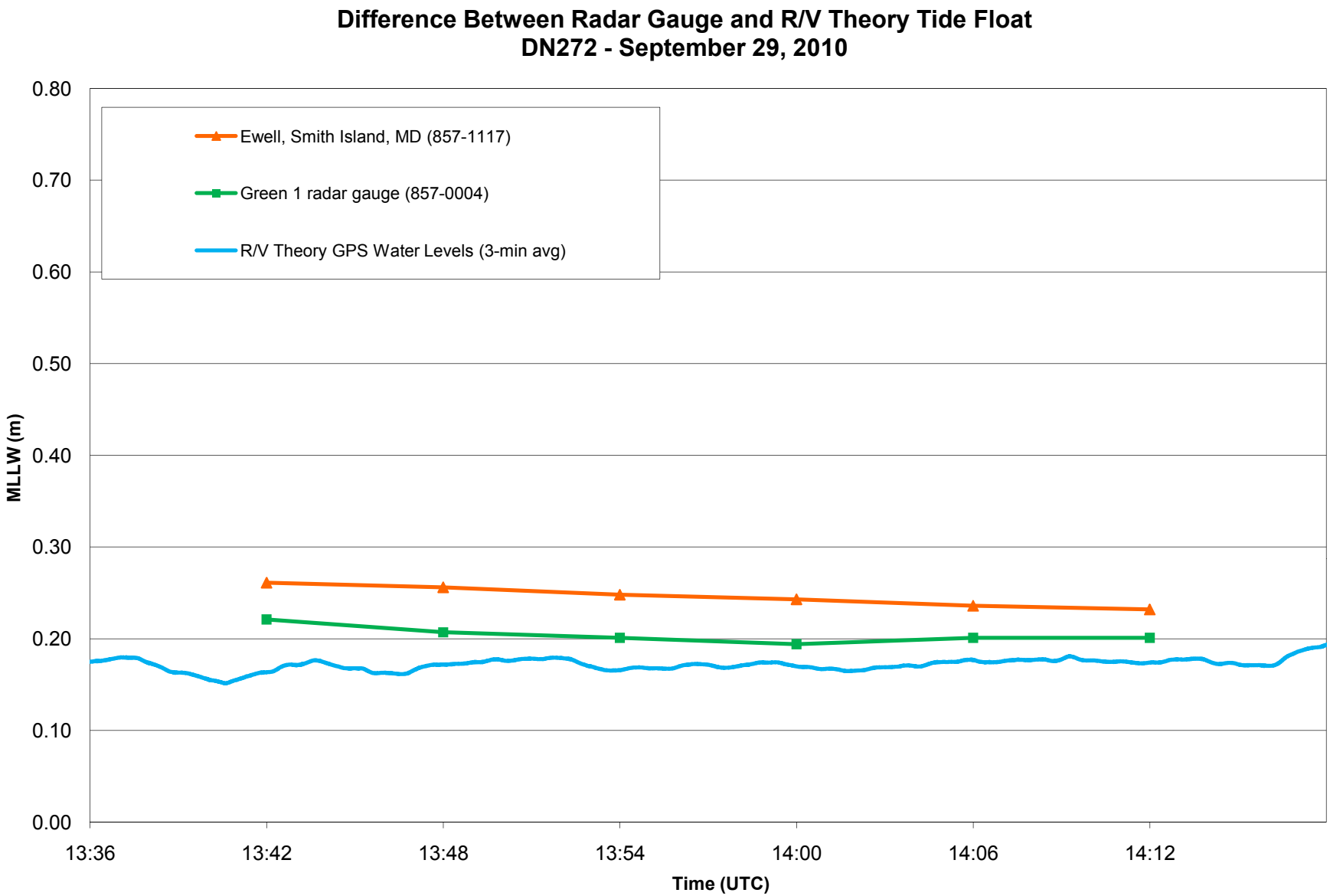
			NAD_83(CORS96)(EPOCH:2002.0000)								ITRF00							
	hours	*meters*							*meters*								*meters*	
	Session Length	**Antenna Ht**	**Longitude**			**Latitude**			**Ellipsoid Ht**	**Ht uncertainty**	**Longitude**			**Latitude**			**Ellipsoid Ht**	**Ht uncertainty**
Mean	6.972	1.760	76	3	22.337	38	0	0.341	-31.970	0.042	76	3	22.353	38	0	0.370	-33.304	0.042
								1-Sigma	0.012	0.018						**1-Sigma**	0.011	0.018

Notes:

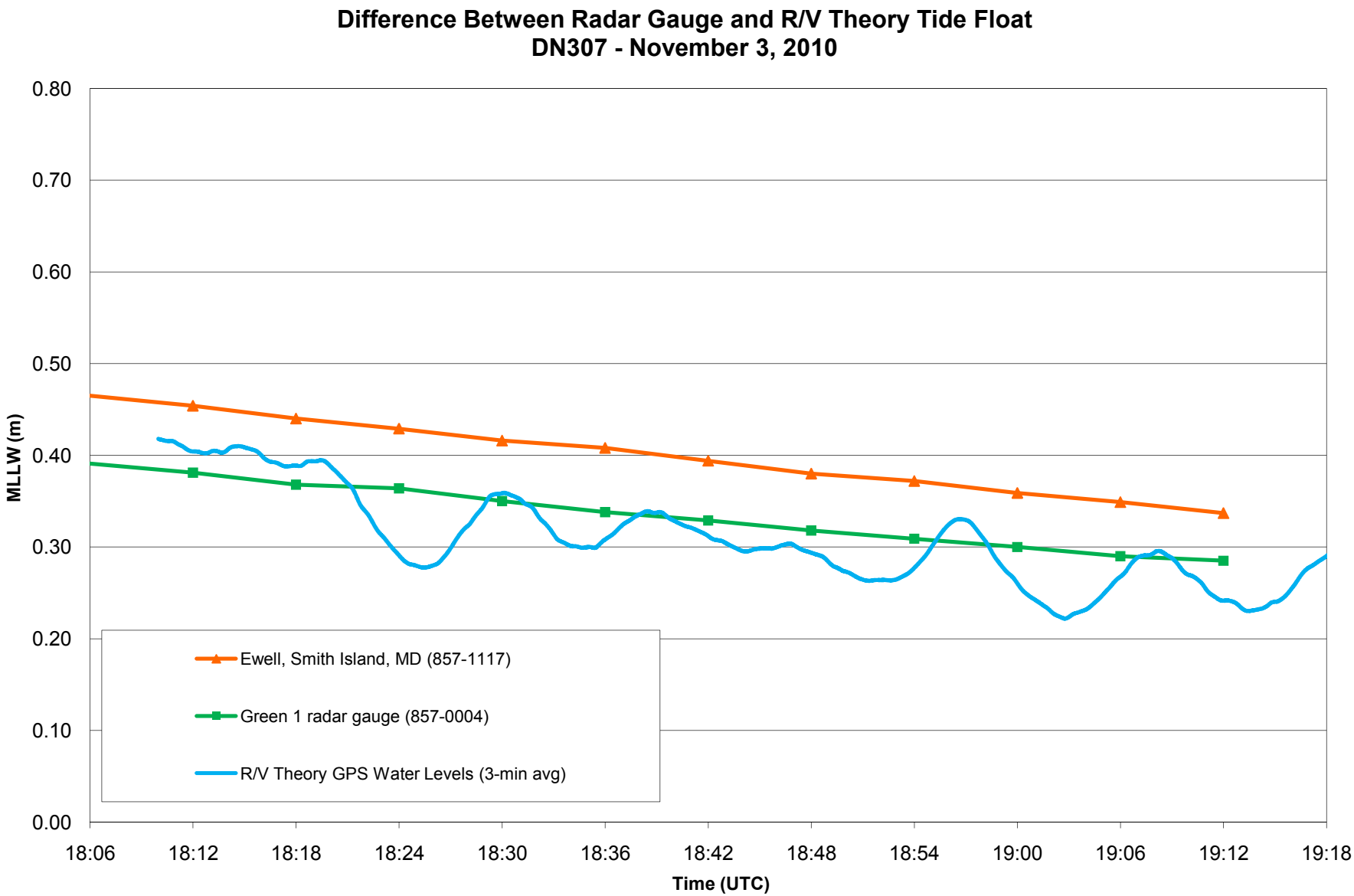
1) The final NAD83(CORS96) and IRTF00 ellipsoid height of the radar is a weighted average. The OPUS solutions are weighted by the inverse of the square of the solutions' peak-to-peak uncertainty
2) The final NAD83(CORS96) ellipsoid height is used to transfer the radar measurements to the reference ellipsoid.
3) The vertical bars in the above plot are +/- the vertical peak-to-peak uncertainty.


Difference Between Radar Gauge and R/V Chinook Tide Float
DN235 - August 23, 2010
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
MLLW (m)
18:48
18:54
19:00
19:06
19:12
19:18
19:24
19:30
19:36
19:42
19:48
19:54
20:00
20:06
Time (UTC)
Ewell, Smith Island, MD (857-1117)
Green 1 radar gauge (857-0004)
R/V Chinook GPS Water Levels (3-min avg)

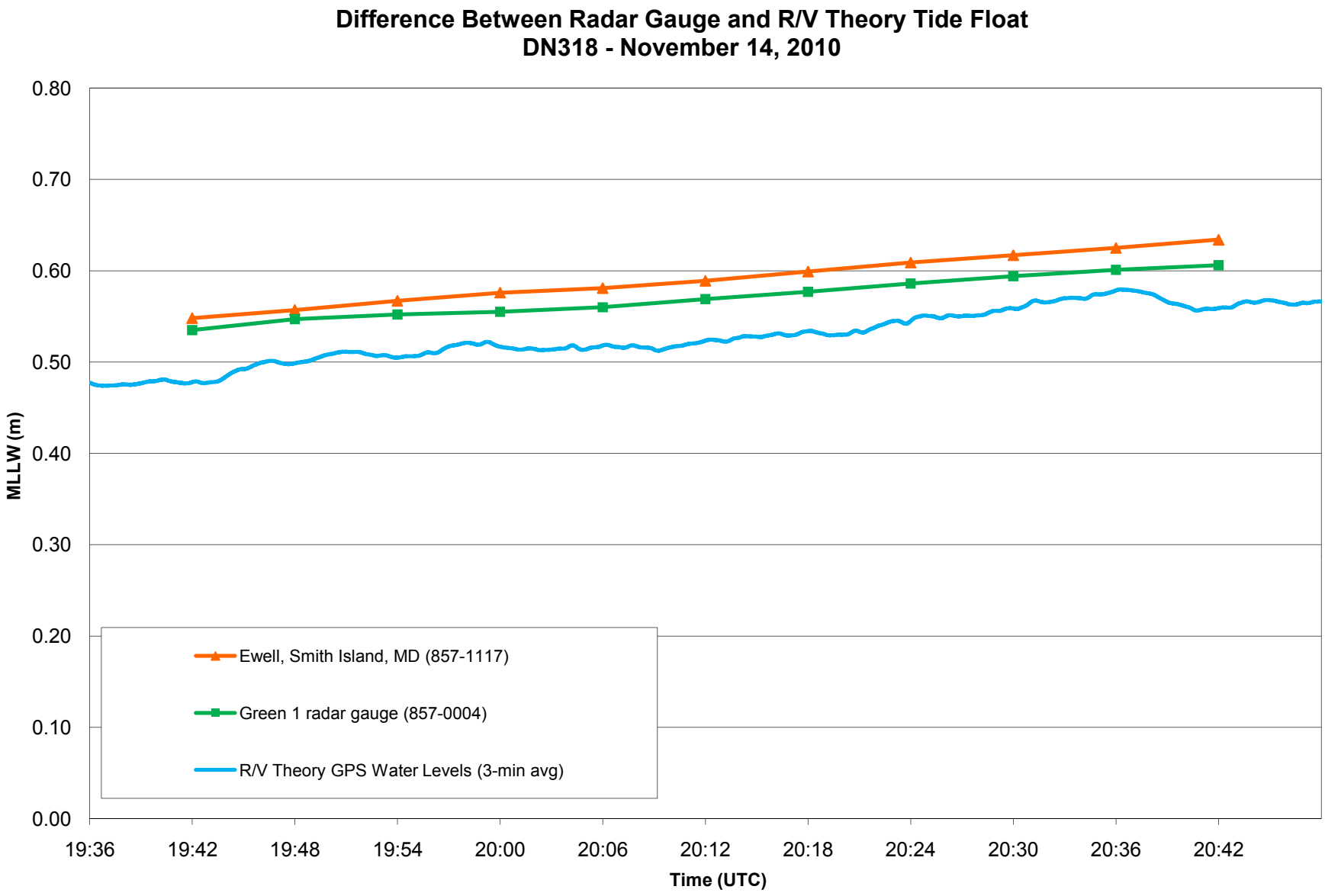
Difference Between Observed Water Levels at Green "1" Radar Gauge and R/V Chinook Tide Float and Ewell Tide Gauge DN235 - August 23, 2010					
Time (UTC)	Vessel GPS Water Level (m)	Observed Water Level (m)	Ewell Gauge Level (m)	Difference to Vessel (m)	Difference to Ewell (m)
18:54	0.409	0.524	0.621	0.115	-0.097
19:00	0.386	0.540	0.613	0.154	-0.073
19:06	0.434	0.532	0.604	0.098	-0.072
19:12	0.442	0.513	0.593	0.071	-0.080
19:18	0.444	0.505	0.584	0.061	-0.079
19:24	0.438	0.508	0.570	0.070	-0.062
19:30	0.404	0.493	0.564	0.089	-0.071
19:36	0.410	0.482	0.555	0.072	-0.073
19:42	0.439	0.454	0.542	0.015	-0.088
19:48	0.418	0.443	0.533	0.025	-0.090
19:54	0.451	0.449	0.524	-0.002	-0.075
20:00	0.427	0.430	0.513	0.003	-0.083
		Mean		0.064	-0.079
		Standard Deviation		0.047	0.010


Difference Between Radar Gauge and R/V Theory Tide Float
DN272 - September 29, 2010
Ewell, Smith Island, MD (857-1117)
Green 1 radar gauge (857-0004)
R/V Theory GPS Water Levels (3-min avg)
MLLW (m)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
13:36
13:42
13:48
13:54
14:00
14:06
14:12
Time (UTC)

Difference Between Observed Water Levels at Green "1" Radar Gauge and R/V Theory Tide Float and Ewell Tide Gauge DN272 - September 29, 2010					
Time (UTC)	Vessel GPS Water Level (m)	Observed Water Level (m)	Ewell Gauge Water Level (m)	Difference to Vessel (m)	Difference to Ewell (m)
13:42	0.175	0.221	0.261	0.046	-0.040
13:48	0.176	0.207	0.256	0.031	-0.049
13:54	0.167	0.201	0.248	0.034	-0.047
14:00	0.166	0.194	0.243	0.028	-0.049
14:06	0.177	0.201	0.236	0.024	-0.035
14:12	0.178	0.201	0.232	0.023	-0.031
		Mean		0.031	-0.042
		Standard Deviation		0.008	0.008


Difference Between Radar Gauge and R/V Theory Tide Float
DN307 - November 3, 2010
MLLW (m)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
18:06
18:12
18:18
18:24
18:30
18:36
18:42
18:48
18:54
19:00
19:06
19:12
19:18
Time (UTC)
Ewell, Smith Island, MD (857-1117)
Green 1 radar gauge (857-0004)
R/V Theory GPS Water Levels (3-min avg)

Difference Between Observed Water Levels at Green "1" Radar Gauge and R/V Theory Tide Float and Ewell Tide Gauge DN307 - November 3, 2010					
Time (UTC)	Vessel GPS Water Level (m)	Observed Water Level (m)	Ewell Gauge Level (m)	Difference to Vessel (m)	Difference to Ewell (m)
18:12	0.404	0.381	0.454	-0.023	-0.073
18:18	0.395	0.368	0.440	-0.027	-0.072
18:24	0.278	0.364	0.429	0.086	-0.065
18:30	0.346	0.350	0.416	0.004	-0.066
18:36	0.330	0.338	0.408	0.008	-0.070
18:42	0.300	0.329	0.394	0.029	-0.065
18:48	0.277	0.318	0.380	0.041	-0.062
18:54	0.313	0.309	0.372	-0.004	-0.063
19:00	0.237	0.300	0.359	0.063	-0.059
19:06	0.291	0.290	0.349	-0.001	-0.059
19:12	0.230	0.285	0.337	0.055	-0.052
		Mean		0.021	-0.064
		Standard Deviation		0.037	0.006


Difference Between Radar Gauge and R/V Theory Tide Float
DN318 - November 14, 2010
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
MLLW (m)
19:36
19:42
19:48
19:54
20:00
20:06
20:12
20:18
20:24
20:30
20:36
20:42
Time (UTC)
Ewell, Smith Island, MD (857-1117)
Green 1 radar gauge (857-0004)
R/V Theory GPS Water Levels (3-min avg)

Difference Between Observed Water Levels at Green "1" Radar Gauge and R/V Theory Tide Float and Ewell Tide Gauge DN318 - November 14, 2010					
Time (UTC)	Vessel GPS Water Level (m)	Observed Water Level (m)	Ewell Gauge Level (m)	Difference to Vessel (m)	Difference to Ewell (m)
19:42	0.479	0.535	0.548	0.056	-0.013
19:48	0.506	0.547	0.557	0.041	-0.010
19:54	0.509	0.552	0.567	0.043	-0.015
20:00	0.514	0.555	0.576	0.041	-0.021
20:06	0.517	0.560	0.581	0.043	-0.021
20:12	0.524	0.569	0.589	0.045	-0.020
20:18	0.529	0.577	0.599	0.048	-0.022
20:24	0.549	0.586	0.609	0.037	-0.023
20:30	0.567	0.594	0.617	0.027	-0.023
20:36	0.577	0.601	0.625	0.024	-0.024
20:42	0.566	0.606	0.634	0.040	-0.028
		Mean		0.040	-0.020
		Standard Deviation		0.009	0.005

APPENDIX VIII
GPS BUOY DATUM RESULTS

2010 Chesapeake Bay VDatum Validation - Comparison of Computed Datums and VDatum

2009 Sites

8630000 USCG Piling 1N (Radar)

	values in meters				differences in cm		
	Radar	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-36.264	-36.184	-36.190	-36.201	-8.0	-7.4	-6.4
MHW	-36.312	-36.227	-36.233	-36.244	-8.4	-7.8	-6.8
MSL	-36.548	-36.461	-36.468	-36.478	-8.7	-8.1	-7.0
DTL	-36.549	-36.460	-36.466	-36.476	-9.0	-8.3	-7.3
MTL	-36.556	-36.466	-36.472	-36.482	-9.1	-8.5	-7.4
MLW	-36.801	-36.704	-36.710	-36.721	-9.7	-9.1	-8.1
MLLW	-36.834	-36.736	-36.742	-36.752	-9.9	-9.3	-8.2

8630001 GPS Buoy Site 1

	values in meters				differences in cm		
	GPS Buoy 1	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-35.722	-35.670	-35.694	-35.715	-5.2	-2.8	-0.8
MHW	-35.759	-35.705	-35.729	-35.749	-5.4	-3.0	-1.0
MSL	-35.921	-35.876	-35.900	-35.920	-4.6	-2.2	-0.1
DTL	-35.921	-35.878	-35.902	-35.923	-4.3	-1.9	0.1
MTL	-35.916	-35.880	-35.904	-35.924	-3.6	-1.2	0.8
MLW	-36.097	-36.055	-36.079	-36.100	-4.2	-1.8	0.3
MLLW	-36.120	-36.086	-36.110	-36.131	-3.4	-1.0	1.0

8630002 GPS Buoy Site 2

	values in meters				differences in cm		
	GPS Buoy 2	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-35.897	-35.845	-35.852	-35.870	-5.2	-4.5	-2.7
MHW	-35.939	-35.884	-35.891	-35.910	-5.5	-4.8	-3.0
MSL	-36.141	-36.089	-36.096	-36.115	-5.1	-4.4	-2.6
DTL	-36.139	-36.089	-36.097	-36.115	-4.9	-4.2	-2.4
MTL	-36.145	-36.093	-36.100	-36.118	-5.2	-4.4	-2.6
MLW	-36.350	-36.302	-36.309	-36.327	-4.8	-4.1	-2.3
MLLW	-36.380	-36.334	-36.341	-36.359	-4.6	-3.9	-2.1

8630003 GPS Buoy Site 3

	values in meters				differences in cm		
	GPS Buoy 3	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-36.077	-36.097	-36.097	-36.123	2.0	2.0	4.7
MHW	-36.113	-36.139	-36.139	-36.165	2.6	2.6	5.3
MSL	-36.385	-36.386	-36.387	-36.413	0.2	0.2	2.8
DTL	-36.372	-36.383	-36.383	-36.409	1.1	1.1	3.8
MTL	-36.386	-36.388	-36.388	-36.415	0.3	0.3	2.9
MLW	-36.659	-36.638	-36.638	-36.664	-2.1	-2.1	0.6
MLLW	-36.667	-36.669	-36.669	-36.696	0.2	0.3	2.9

2010 Sites

8570004 USCG Piling Green 1 (Radar)

	values in meters				differences in cm		
	Radar	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-35.720	-35.673	-35.682	-35.688	-4.7	-3.8	-3.2
MHW	-35.771	-35.713	-35.722	-35.729	-5.8	-4.9	-4.3
MSL	-35.975	-35.925	-35.935	-35.941	-5.0	-4.0	-3.4
DTL	-35.981	-35.925	-35.934	-35.940	-5.6	-4.7	-4.1
MTL	-35.985	-35.928	-35.938	-35.944	-5.7	-4.7	-4.1
MLW	-36.199	-36.144	-36.153	-36.159	-5.5	-4.6	-4.0
MLLW	-36.243	-36.177	-36.186	-36.192	-6.6	-5.7	-5.1

8571117 Ewell, Smith Island (Tertiary)

	values in meters				differences in cm		
	Ewell	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-35.764	-35.692	-35.700	-35.709	-7.2	-6.4	-5.5
MHW	-35.817	-35.737	-35.745	-35.754	-8.0	-7.2	-6.3
MSL	-36.041	-35.957	-35.965	-35.974	-8.4	-7.6	-6.7
DTL	-36.046	-35.956	-35.963	-35.972	-9.0	-8.3	-7.4
MTL	-36.049	-35.961	-35.969	-35.978	-8.8	-8.0	-7.1
MLW	-36.281	-36.184	-36.192	-36.201	-9.7	-8.9	-8.0
MLLW	-36.328	-36.219	-36.227	-36.236	-10.9	-10.1	-9.2

8570005 GPS Buoy Site 1

	values in meters				differences in cm		
	GPS Buoy 1	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-34.765	-34.654	-34.693	-34.717	-11.1	-7.2	-4.8
MHW	-34.806	-34.691	-34.730	-34.753	-11.5	-7.6	-5.3
MSL	-35.000	-34.876	-34.915	-34.939	-12.4	-8.5	-6.1
DTL	-35.001	-34.879	-34.918	-34.942	-12.2	-8.3	-5.9
MTL	-35.004	-34.881	-34.920	-34.943	-12.3	-8.4	-6.1
MLW	-35.203	-35.071	-35.109	-35.133	-13.3	-9.4	-7.0
MLLW	-35.238	-35.105	-35.143	-35.167	-13.3	-9.5	-7.1

8570006 GPS Buoy Site 2

	values in meters				differences in cm		
	GPS Buoy 2	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-35.498	-35.413	-35.429	-35.437	-8.5	-6.9	-6.1
MHW	-35.547	-35.456	-35.472	-35.480	-9.1	-7.5	-6.7
MSL	-35.756	-35.665	-35.681	-35.689	-9.1	-7.5	-6.7
DTL	-35.757	-35.666	-35.682	-35.690	-9.1	-7.5	-6.7
MTL	-35.759	-35.668	-35.685	-35.693	-9.1	-7.4	-6.6
MLW	-35.971	-35.881	-35.897	-35.905	-9.0	-7.4	-6.6
MLLW	-36.016	-35.919	-35.935	-35.943	-9.7	-8.1	-7.3

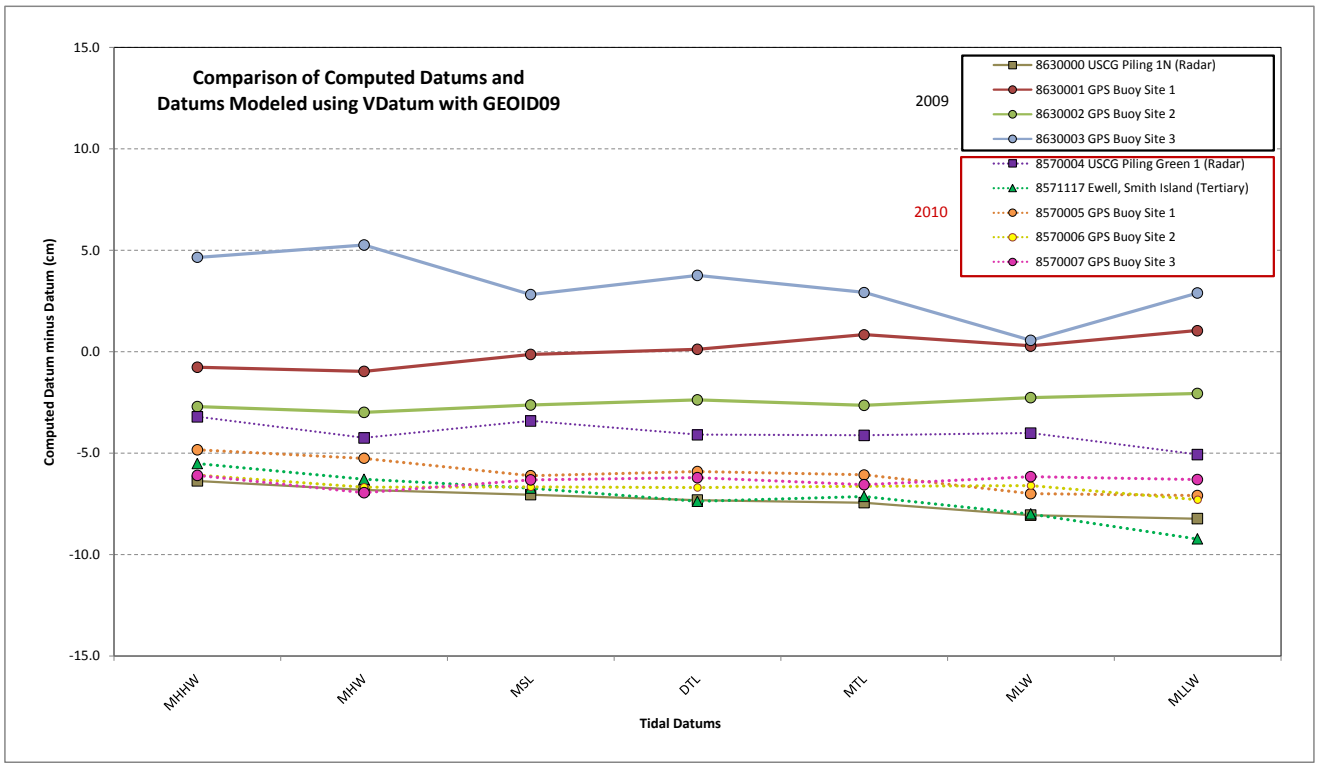
8570007 GPS Buoy Site 3

	values in meters				differences in cm		
	GPS Buoy 3	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09	VDatum GEOID99	VDatum GEOID03	VDatum GEOID09
MHHW	-35.664	-35.579	-35.592	-35.603	-8.6	-7.2	-6.1
MHW	-35.712	-35.618	-35.632	-35.643	-9.4	-8.0	-7.0
MSL	-35.903	-35.815	-35.829	-35.840	-8.8	-7.4	-6.3
DTL	-35.903	-35.817	-35.830	-35.841	-8.7	-7.3	-6.2
MTL	-35.909	-35.819	-35.833	-35.843	-9.0	-7.6	-6.6
MLW	-36.106	-36.020	-36.034	-36.044	-8.6	-7.2	-6.2
MLLW	-36.142	-36.054	-36.068	-36.079	-8.8	-7.4	-6.3

SUMMARY

	differences in cm				
	Average	1-Sigma	Range	Count	
GPS Buoy Sites	-3.0	3.8	12.6	6	42
Radar Sites	-5.7	1.8	5.0	2	14
Tertiary Sites	-7.2	1.2	3.7	1	7
2009 Sites	-1.6	4.0	13.5	4	28
2010 Sites	-6.1	1.3	6.0	5	35
Total	-4.1	3.6	14.5	9	63

2010 Chesapeake Bay VDatum Validation - Comparison of Computed Datums and VDatum



Notes

1) 2009 data are represented by solid lines.
2) 2010 data are represented by dashed lines
3) GPS buoy data are represented by circles.
4) Radar data are represented by squares
5) Tertiary tide station data are represented by triangles.
6) 2009 data were not tilt corrected.
7) 2010 data were tilt corrected.

2010 Chesapeake Bay VDatum Validation

meters above STND

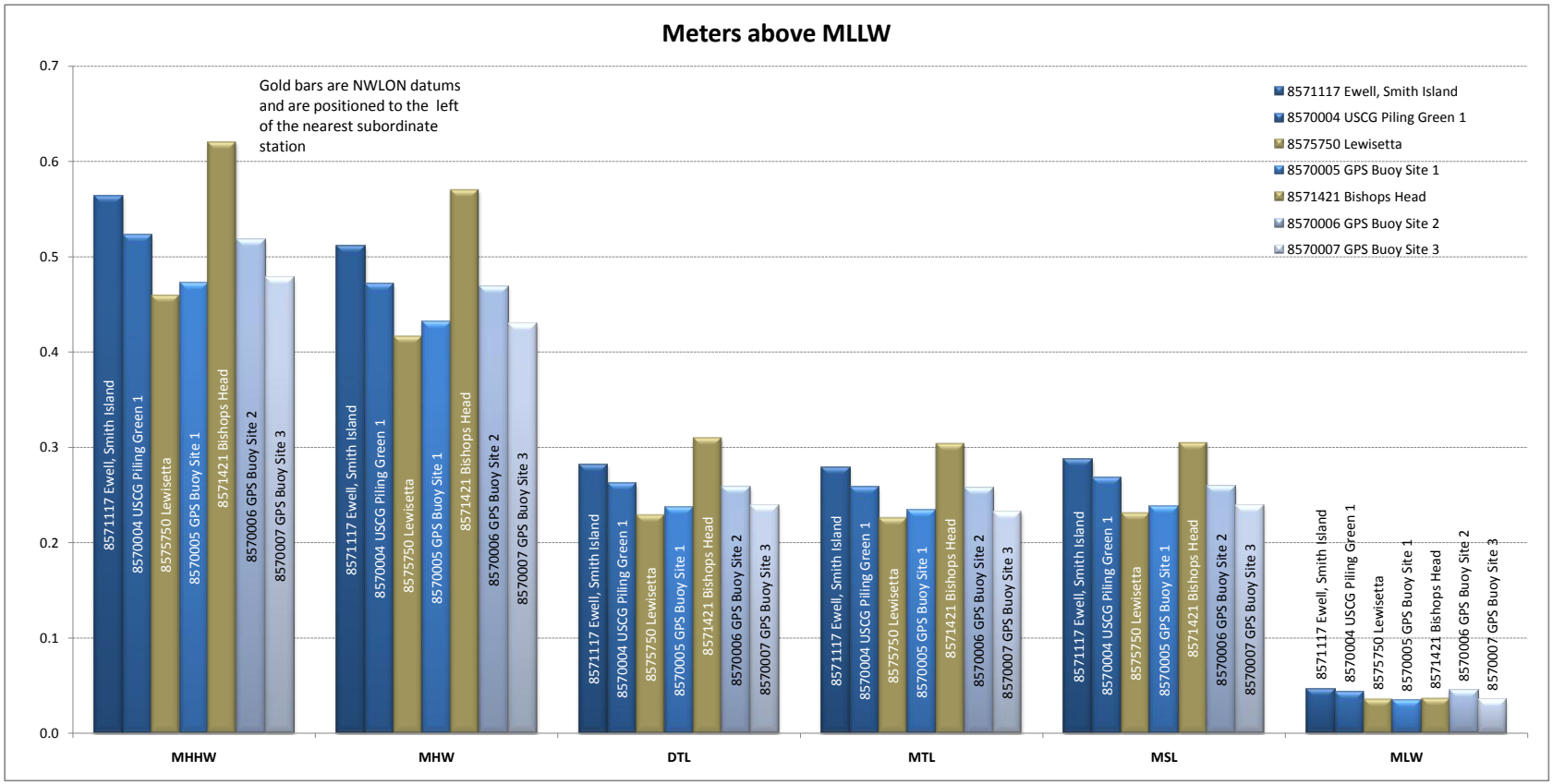
Station		Method	MHHW	MHW	DTL	MTL	MSL	MLW	MLLW	GT	Mn	DHQ	DLQ	HWI	LWI	Start Date	End Date	N Highs	N Lows
8571117	Ewell, Smith Island	MM	0.676	0.623	0.394	0.391	0.399	0.159	0.112	0.563	0.464	0.053	0.046	5.51		'01-Jul-2010 02:12'	'15-Nov-2010 14:06'	266	266
8570004	USCG Piling Green 1	MM	-35.720	-35.771	-35.981	-35.985	-35.975	-36.199	-36.243	0.523	0.428	0.051	0.044			'08-Aug-2010 00:00'	'16-Nov-2010 13:00'	194	194
8570005	GPS Buoy Site 1	TBYT	-34.765	-34.806	-35.001	-35.004	-35.000	-35.203	-35.238	0.473	0.397	0.041	0.035	6.07	0.13	'06-Jul-2010 21:00'	'06-Aug-2010 19:00'	60	59
8570006	GPS Buoy Site 2	TBYT	-35.498	-35.547	-35.757	-35.759	-35.756	-35.971	-36.016	0.518	0.424	0.049	0.045	5.81	-0.05	'08-Aug-2010 17:48'	'11-Sep-2010 21:24'	66	66
8570007	GPS Buoy Site 3	TBYT	-35.664	-35.712	-35.903	-35.909	-35.903	-36.106	-36.142	0.478	0.394	0.048	0.036	5.48	-0.52	14-Sep-2010 13:48'	'18-Oct-2010 21:42'	66	67

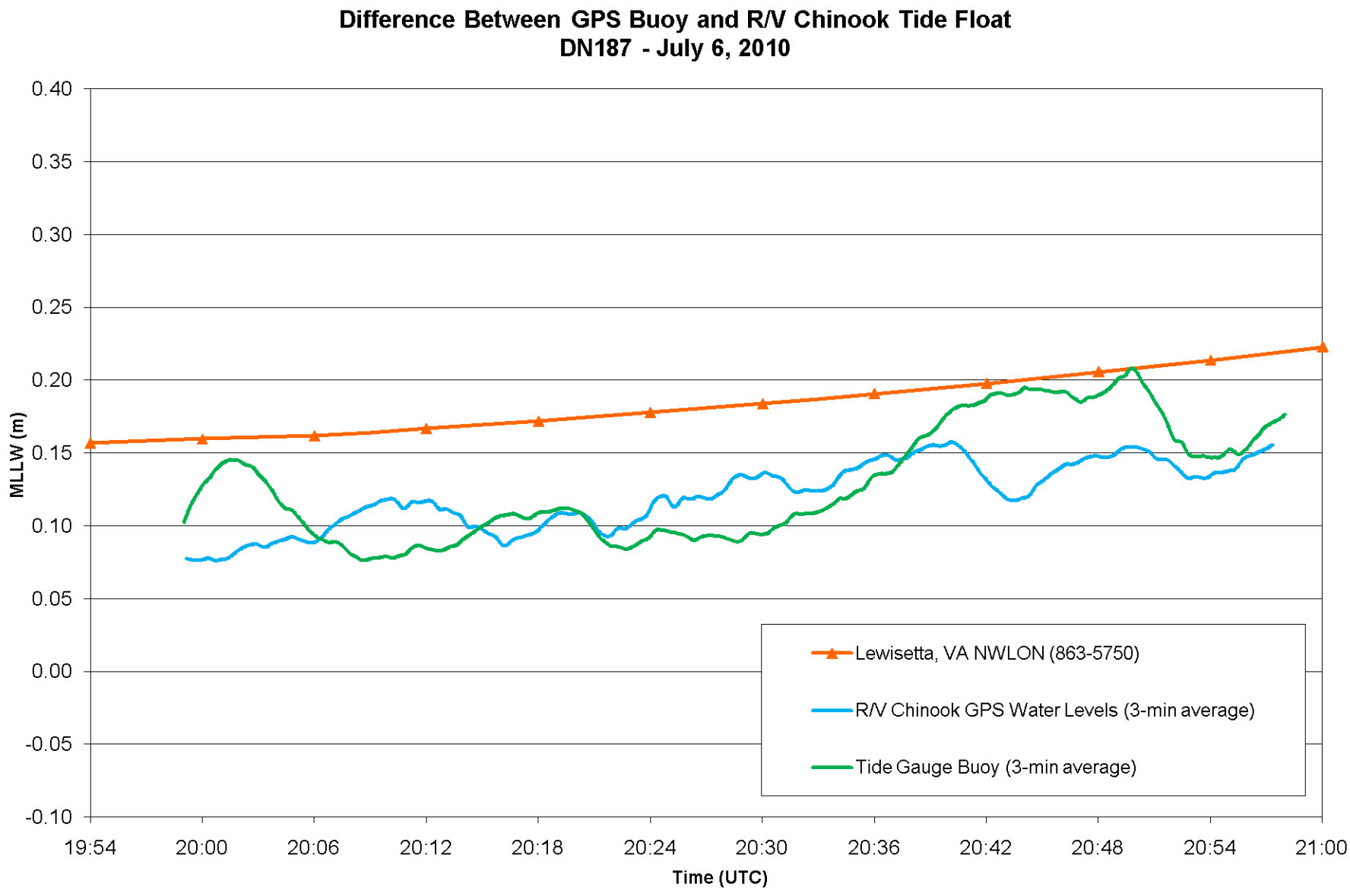
meters above MLLW

Station		Method	MHHW	MHW	DTL	MTL	MSL	MLW	MLLW	GT	Mn	DHQ	DLQ	HWI	LWI	Start Date	End Date	N Highs	N Lows
8571117	Ewell, Smith Island	MM	0.564	0.511	0.282	0.279	0.287	0.047	0.000	0.563	0.464	0.053	0.046	5.51		'01-Jul-2010 02:12'	'15-Nov-2010 14:06'	266	266
8570004	USCG Piling Green 1	TBYT	0.523	0.472	0.262	0.258	0.268	0.044	0.000	0.523	0.428	0.051	0.044			'08-Aug-2010 00:00'	'16-Nov-2010 13:00'	194	194
8570005	GPS Buoy Site 1	TBYT	0.473	0.432	0.237	0.234	0.238	0.035	0.000	0.473	0.397	0.041	0.035	6.07	0.13	'06-Jul-2010 21:00'	'06-Aug-2010 19:00'	60	59
8570006	GPS Buoy Site 2	TBYT	0.518	0.469	0.259	0.257	0.260	0.045	0.000	0.518	0.424	0.049	0.045	5.81	-0.05	'08-Aug-2010 17:48'	'11-Sep-2010 21:24'	66	66
8570007	GPS Buoy Site 3	TBYT	0.478	0.430	0.239	0.233	0.239	0.036	0.000	0.478	0.394	0.048	0.036	5.48	-0.52	14-Sep-2010 13:48'	'18-Oct-2010 21:42'	66	67

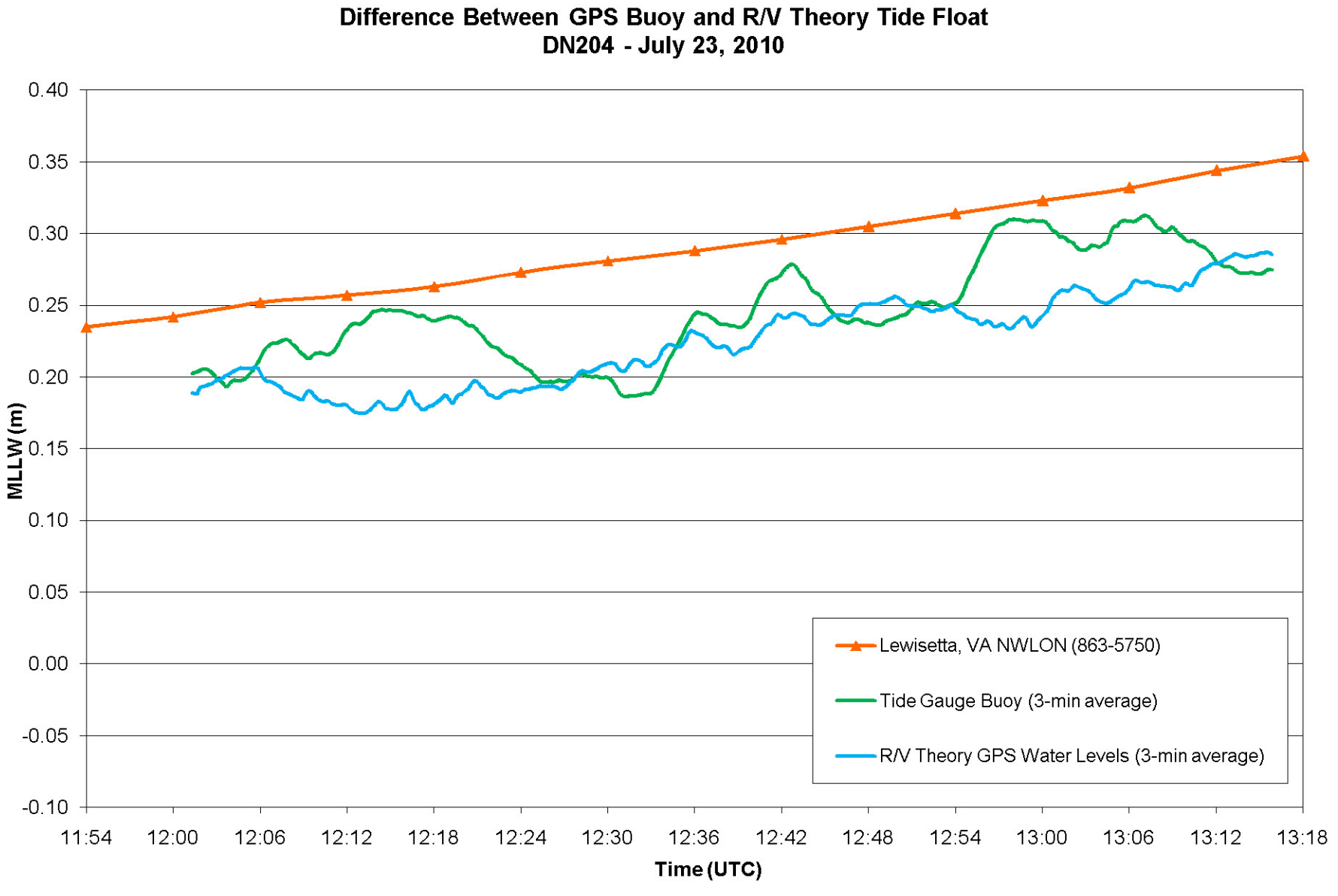
meters above NAD83(CORS96 EPOCH 2003.000)

Station		Method	MHHW	MHW	DTL	MTL	MSL	MLW	MLLW	GT	Mn	DHQ	DLQ	HWI	LWI	Start Date	End Date	N Highs	N Lows
8571117	Ewell, Smith Island	MM	-35.764	-35.817	-36.046	-36.049	-36.041	-36.281	-36.328	0.563	0.464	0.053	0.046	5.51		'01-Jul-2010 02:12'	'15-Nov-2010 14:06'	266	266
8570004	USCG Piling Green 1	TBYT	-35.720	-35.771	-35.981	-35.985	-35.975	-36.199	-36.243	0.523	0.428	0.051	0.044			'08-Aug-2010 00:00'	'16-Nov-2010 13:00'	194	194
8570005	GPS Buoy Site 1	TBYT	-34.765	-34.806	-35.001	-35.004	-35.000	-35.203	-35.238	0.473	0.397	0.041	0.035	6.07	0.13	'06-Jul-2010 21:00'	'06-Aug-2010 19:00'	60	59
8570006	GPS Buoy Site 2	TBYT	-35.498	-35.547	-35.757	-35.759	-35.756	-35.971	-36.016	0.518	0.424	0.049	0.045	5.81	-0.05	'08-Aug-2010 17:48'	'11-Sep-2010 21:24'	66	66
8570007	GPS Buoy Site 3	TBYT	-35.664	-35.712	-35.903	-35.909	-35.903	-36.106	-36.142	0.478	0.394	0.048	0.036	5.48	-0.52	14-Sep-2010 13:48'	'18-Oct-2010 21:42'	66	67

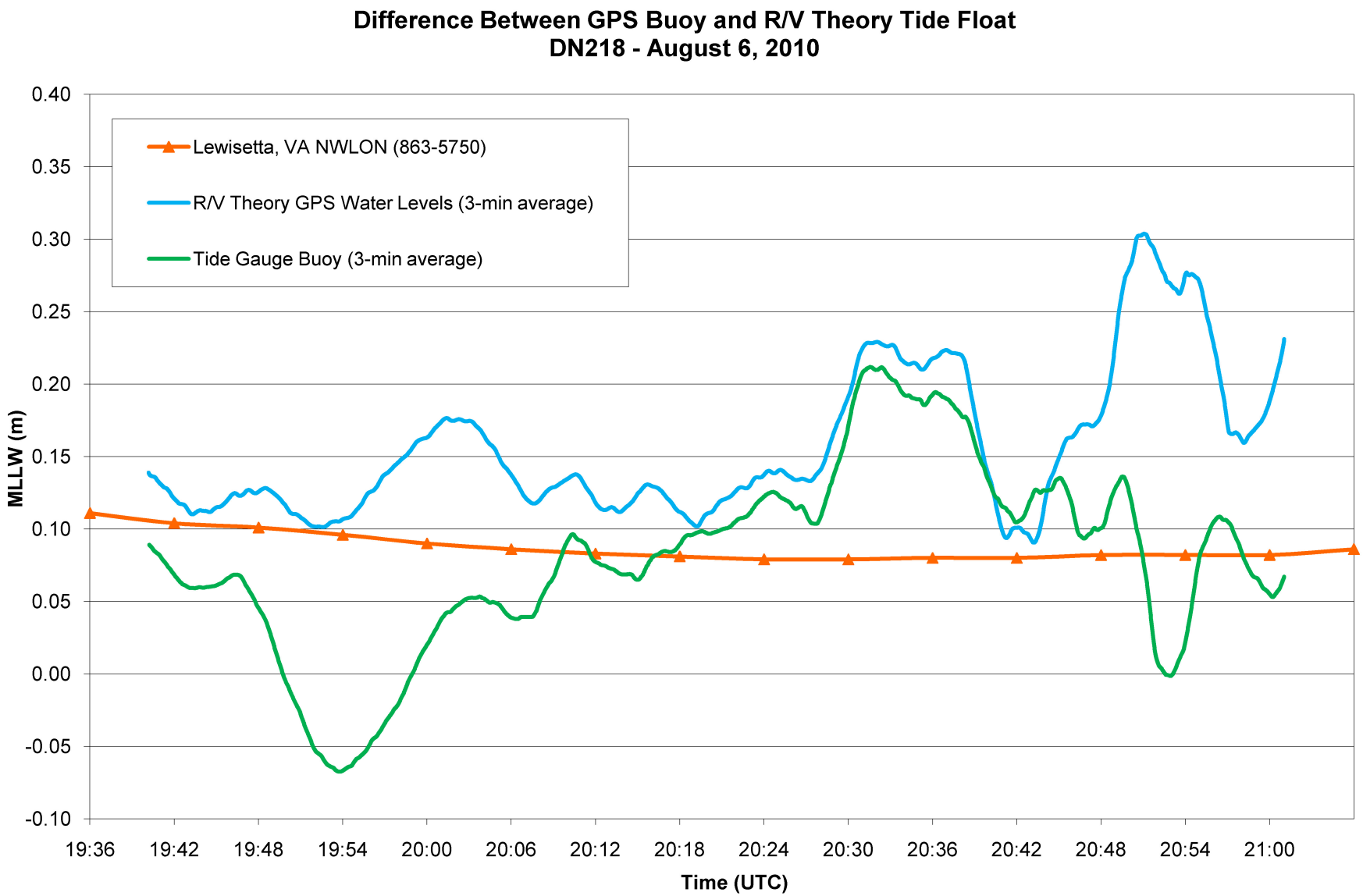



Difference Between GPS Buoy and R/V Chinook Tide Float
DN187 - July 6, 2010
MLLW (m)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
19:54
20:00
20:06
20:12
20:18
20:24
20:30
20:36
20:42
20:48
20:54
21:00
Time (UTC)
Lewisetta, VA NWLON (863-5750)
R/V Chinook GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

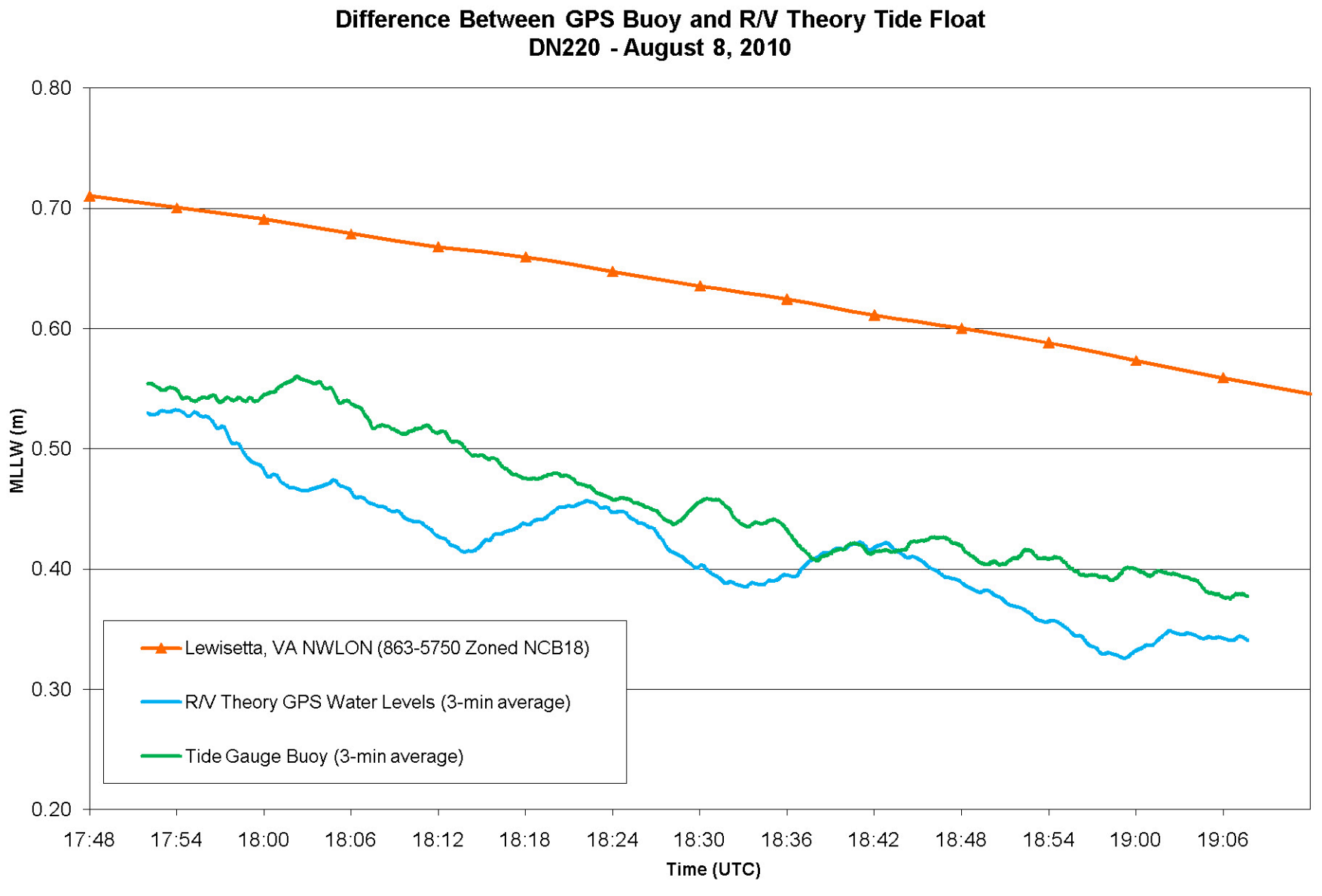
Difference Between GPS Buoy and R/V Chinook Tide Float DN187 - July 6, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Lewisetta Gauge (m)	Difference to Vessel (m)	Difference to Gauge (m)
20:00	0.079	0.145	0.160	0.066	-0.015
20:06	0.105	0.086	0.162	-0.019	-0.076
20:12	0.109	0.086	0.167	-0.022	-0.081
20:18	0.108	0.112	0.172	0.004	-0.060
20:24	0.116	0.095	0.178	-0.021	-0.083
20:30	0.126	0.106	0.184	-0.020	-0.078
20:36	0.146	0.145	0.191	0.000	-0.046
20:42	0.118	0.190	0.198	0.073	-0.008
20:48	0.154	0.204	0.206	0.050	-0.002
20:54	0.142	0.149	0.214	0.008	-0.065
		Mean		0.012	-0.051
		Standard deviation		0.037	0.032


Difference Between GPS Buoy and R/V Theory Tide Float
DN204 - July 23, 2010
MLLW (m)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
11:54
12:00
12:06
12:12
12:18
12:24
12:30
12:36
12:42
12:48
12:54
13:00
13:06
13:12
13:18
Time (UTC)
Lewisetta, VA NWLON (863-5750)
Tide Gauge Buoy (3-min average)
R/V Theory GPS Water Levels (3-min average)

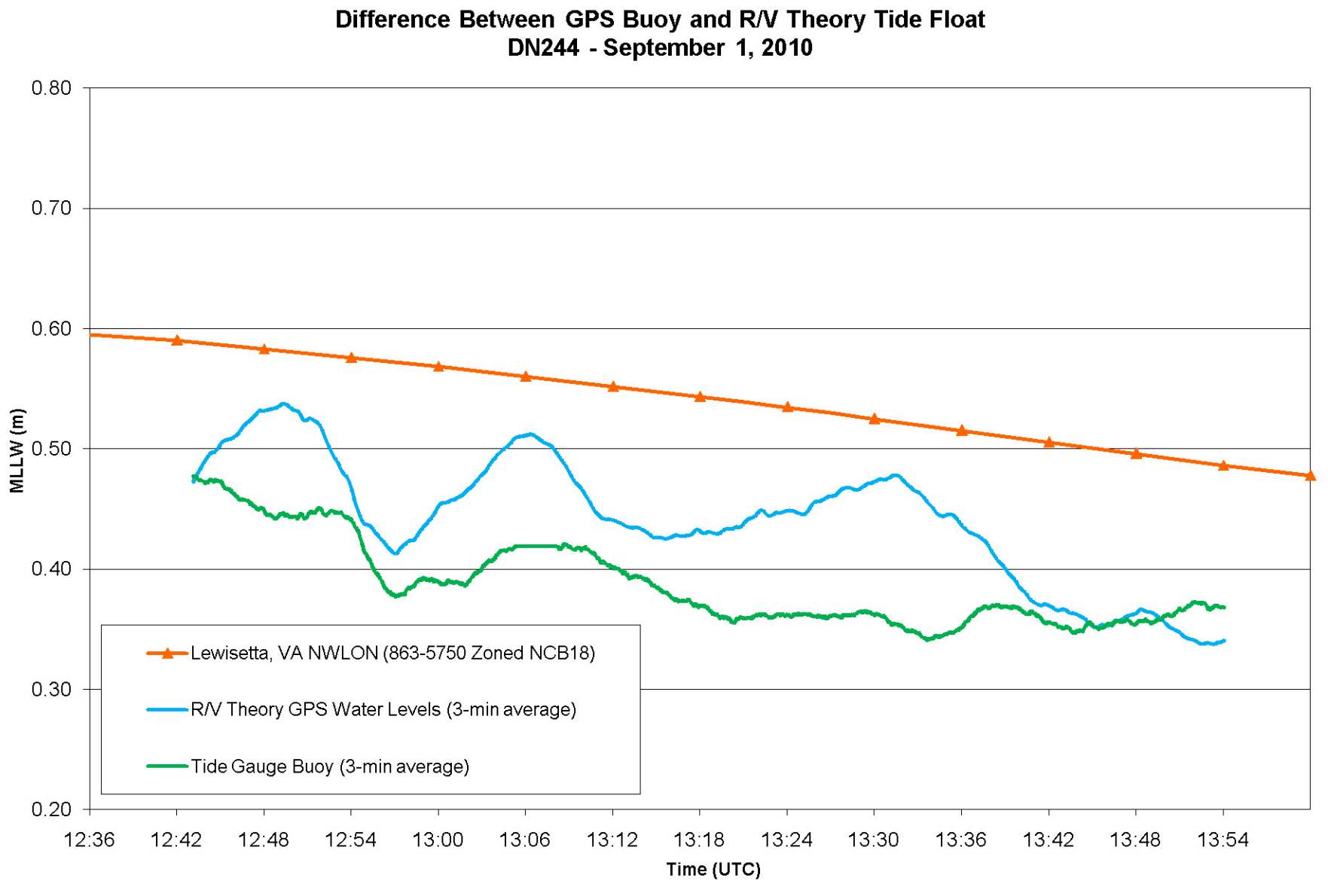
Difference Between GPS Buoy and R/V Theory Tide Float DN204 - July 23, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Lewisetta Gauge (m)	Difference to Vessel (m)	Difference to Gauge (m)
12:00	0.189	0.203	0.242	0.015	-0.039
12:06	0.192	0.225	0.252	0.034	-0.027
12:12	0.177	0.242	0.257	0.066	-0.015
12:18	0.185	0.242	0.263	0.056	-0.021
12:24	0.194	0.197	0.273	0.003	-0.076
12:30	0.209	0.187	0.281	-0.022	-0.094
12:36	0.221	0.237	0.288	0.016	-0.051
12:42	0.242	0.265	0.296	0.023	-0.031
12:48	0.255	0.241	0.305	-0.014	-0.064
12:54	0.239	0.288	0.314	0.049	-0.026
13:00	0.261	0.295	0.323	0.034	-0.028
13:06	0.266	0.306	0.332	0.040	-0.026
13:12	0.286	0.272	0.344	-0.013	-0.072
		Mean		0.022	-0.044
		Standard Deviation		0.028	0.025


Difference Between GPS Buoy and R/V Theory Tide Float
DN218 - August 6, 2010
Lewisetta, VA NWLON (863-5750)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)
MLLW (m)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
19:36
19:42
19:48
19:54
20:00
20:06
20:12
20:18
20:24
20:30
20:36
20:42
20:48
20:54
21:00
Time (UTC)

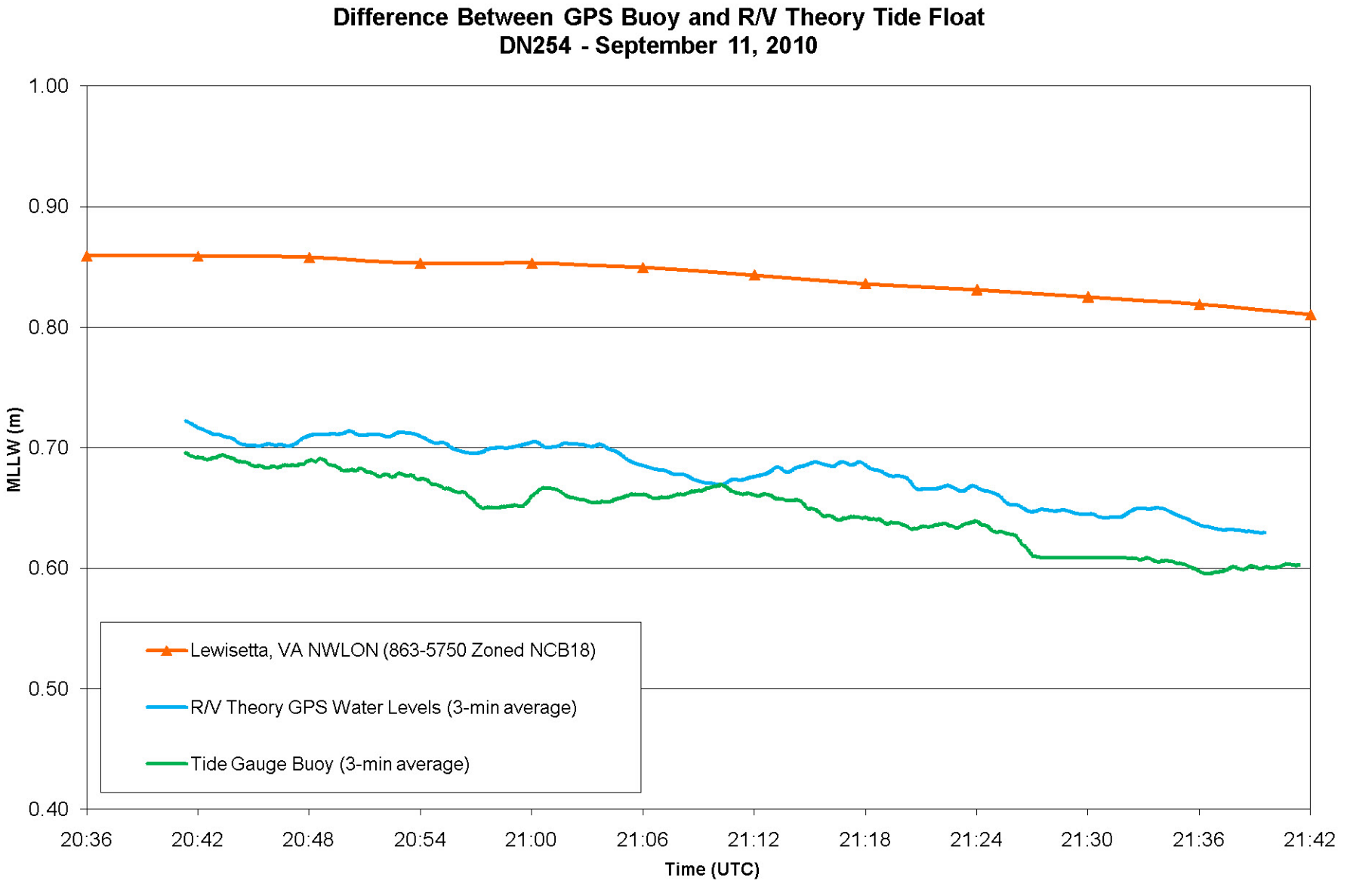
Difference Between GPS Buoy and R/V Theory Tide Float DN218 - August 6, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Lewisetta Gauge (m)	Difference to Vessel (m)	Vessel to Gauge (m)
19:42	0.114	0.062	0.104	-0.052	-0.042
19:48	0.115	-0.011	0.101	-0.126	-0.112
19:54	0.125	-0.045	0.096	-0.170	-0.141
20:00	0.175	0.047	0.090	-0.128	-0.043
20:06	0.125	0.070	0.086	-0.056	-0.016
20:12	0.117	0.082	0.083	-0.035	-0.001
20:18	0.110	0.119	0.081	0.009	0.038
20:24	0.137	0.205	0.079	0.068	0.126
20:30	0.223	0.182	0.079	-0.041	0.103
20:36	0.204	0.121	0.080	-0.083	0.041
20:42	0.126	0.111	0.080	-0.015	0.031
20:48	0.279	0.086	0.082	-0.193	0.004
20:54	0.223	0.067	0.082	-0.156	-0.015
		Mean		-0.075	-0.002
		Standard Deviation		0.076	0.075


Difference Between GPS Buoy and R/V Theory Tide Float
DN220 - August 8, 2010
0.80
0.70
0.60
0.50
0.40
0.30
0.20
MLLW (m)
17:48
17:54
18:00
18:06
18:12
18:18
18:24
18:30
18:36
18:42
18:48
18:54
19:00
19:06
Time (UTC)
Lewisetta, VA NWLON (863-5750 Zoned NCB18)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

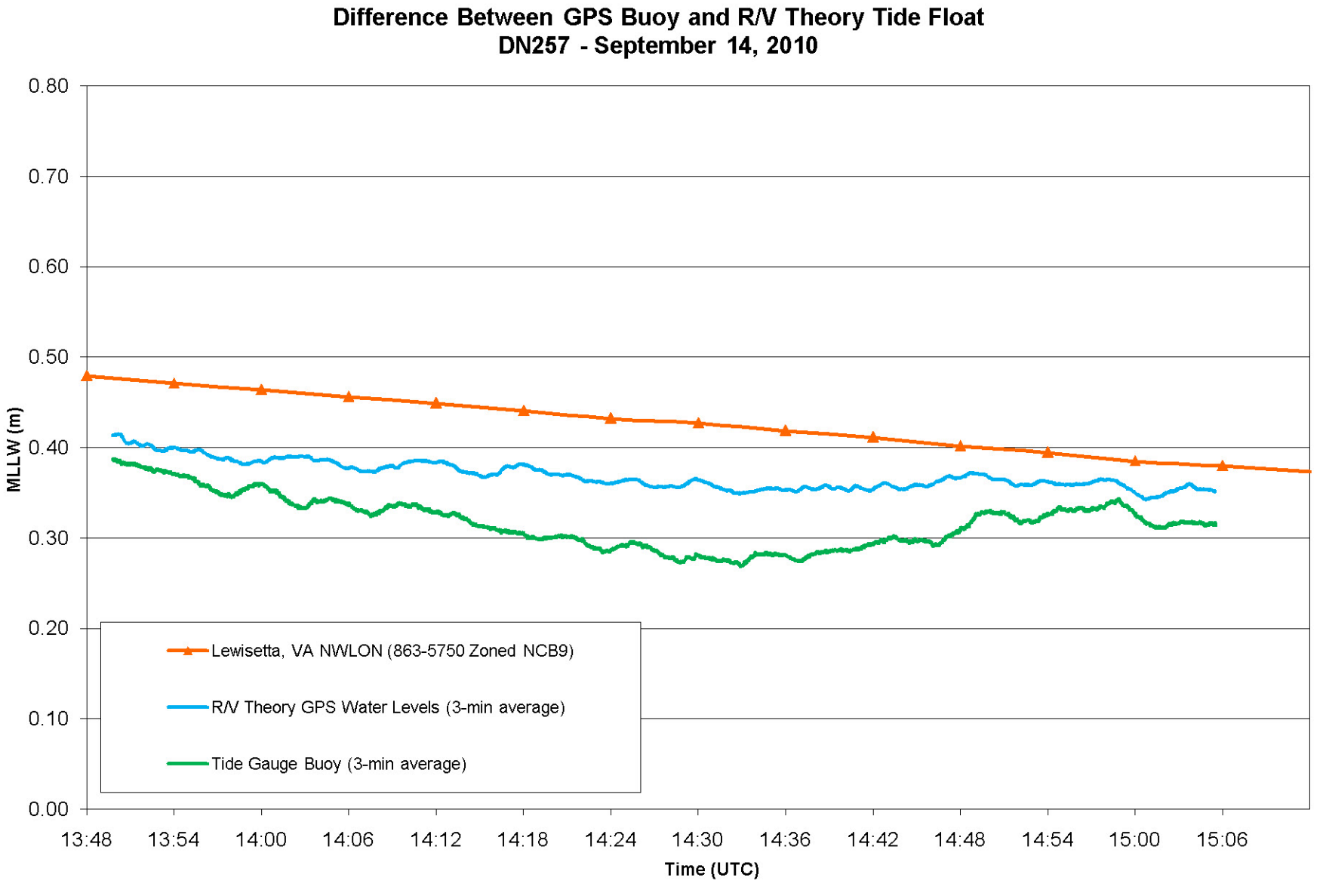
Difference Between GPS Buoy and R/V Theory Tide Float DN220 - August 8, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Zoned Water Level (m)	Difference to Vessel (m)	Difference to Zoned (m)
17:54	0.529	0.542	0.701	0.013	-0.159
18:00	0.470	0.555	0.691	0.085	-0.136
18:06	0.454	0.517	0.679	0.063	-0.161
18:12	0.416	0.505	0.668	0.089	-0.163
18:18	0.444	0.479	0.659	0.035	-0.181
18:24	0.441	0.455	0.647	0.014	-0.192
18:30	0.391	0.456	0.635	0.065	-0.180
18:36	0.406	0.412	0.624	0.005	-0.213
18:42	0.415	0.415	0.611	0.000	-0.196
18:48	0.382	0.405	0.600	0.023	-0.195
18:54	0.348	0.400	0.588	0.052	-0.188
19:00	0.341	0.399	0.574	0.057	-0.175
19:06	0.342	0.378	0.559	0.036	-0.181
		Mean		0.041	-0.178
		Standard Deviation		0.030	0.020


Difference Between GPS Buoy and R/V Theory Tide Float
DN244 - September 1, 2010
MLLW (m)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
12:36
12:42
12:48
12:54
13:00
13:06
13:12
13:18
13:24
13:30
13:36
13:42
13:48
13:54
Time (UTC)
Lewisetta, VA NWLON (863-5750 Zoned NCB18)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

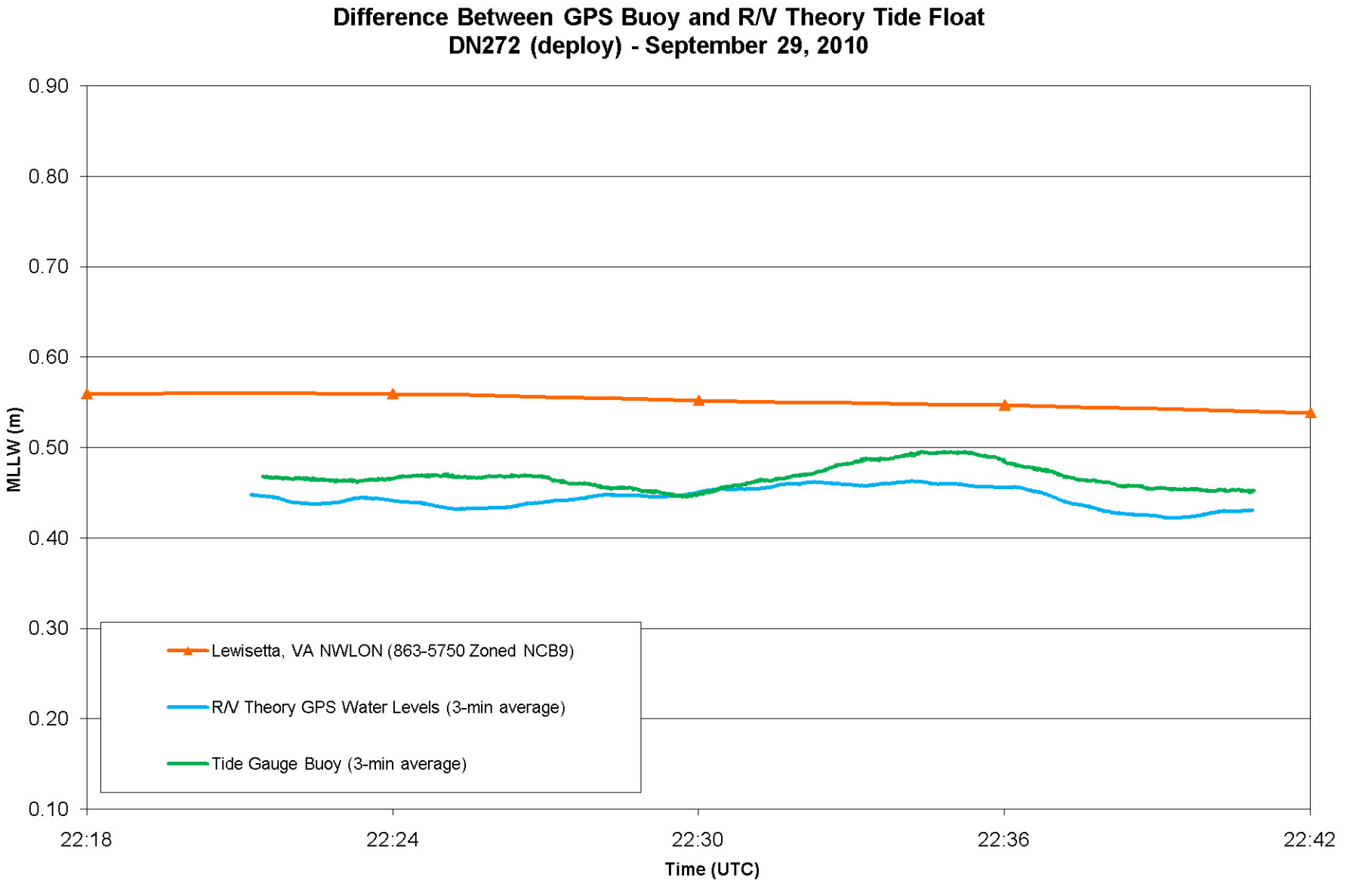
Difference Between GPS Buoy and R/V Theory Tide Float DN244 - September 1, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Zoned Water Level (m)	Difference to Vessel (m)	Difference to Zoned (m)
12:42	0.481	0.473	0.590	-0.008	-0.117
12:48	0.537	0.446	0.583	-0.091	-0.137
12:54	0.433	0.401	0.576	-0.032	-0.175
13:00	0.461	0.388	0.569	-0.073	-0.181
13:06	0.504	---	0.560	---	---
13:12	0.434	0.394	0.552	-0.040	-0.158
13:18	0.431	0.361	0.543	-0.071	-0.183
13:24	0.450	0.363	0.535	-0.087	-0.172
13:30	0.478	0.354	0.525	-0.123	-0.171
13:36	0.424	0.369	0.515	-0.056	-0.147
13:42	0.363	0.349	0.506	-0.014	-0.157
13:48	0.361	0.359	0.496	-0.001	-0.137
13:54	0.343	0.368	0.486	0.025	-0.119
		Mean		-0.048	-0.154
		Standard deviation		0.043	0.023


Difference Between GPS Buoy and R/V Theory Tide Float
DN254 - September 11, 2010
1.00
0.90
0.80
0.70
0.60
0.50
0.40
MLLW (m)
20:36
20:42
20:48
20:54
21:00
21:06
21:12
21:18
21:24
21:30
21:36
21:42
Time (UTC)
Lewisetta, VA NWLON (863-5750 Zoned NCB18)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

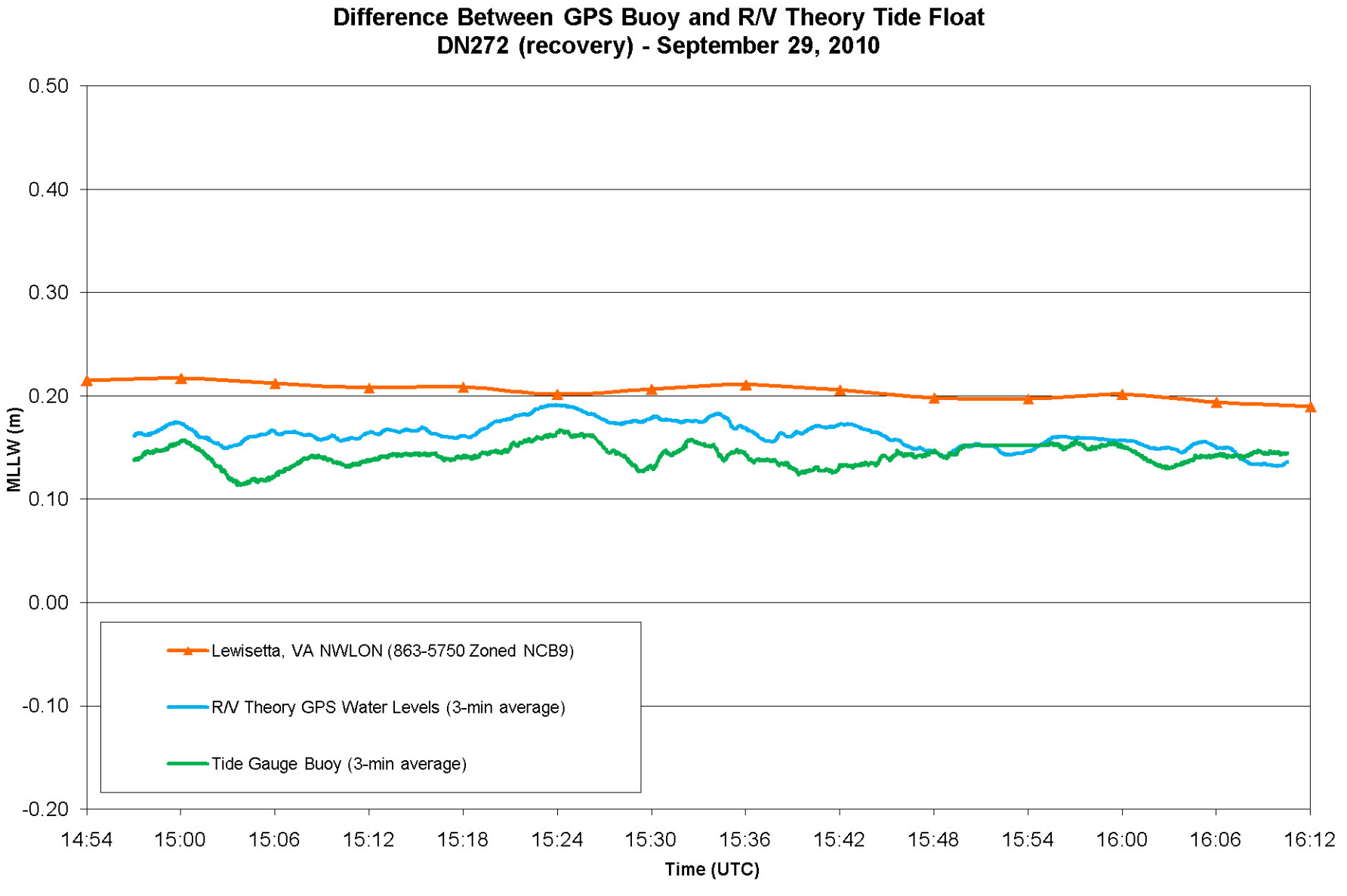
Difference Between GPS Buoy and R/V Theory Tide Float DN254 - September 11, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Zoned Water Level (m)	Difference to Vessel (m)	Difference to Zoned (m)
20:42	0.709	0.693	0.859	-0.016	-0.166
20:48	0.711	0.684	0.858	-0.027	-0.174
20:54	0.702	0.666	0.853	-0.036	-0.187
21:00	0.702	0.664	0.853	-0.038	-0.189
21:06	0.679	0.659	0.849	-0.020	-0.190
21:12	0.682	0.658	0.843	-0.024	-0.185
21:18	0.676	0.638	0.836	-0.039	-0.198
21:24	0.656	0.630	0.831	-0.026	-0.202
21:30	0.642	---	0.825	---	---
21:36	0.632	0.599	0.819	-0.033	-0.220
		Mean		-0.029	-0.190
		Standard deviation		0.008	0.016


Difference Between GPS Buoy and R/V Theory Tide Float
DN257 - September 14, 2010
MLLW (m)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
13:48
13:54
14:00
14:06
14:12
14:18
14:24
14:30
14:36
14:42
14:48
14:54
15:00
15:06
Time (UTC)
Lewisetta, VA NWLON (863-5750 Zoned NCB9)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

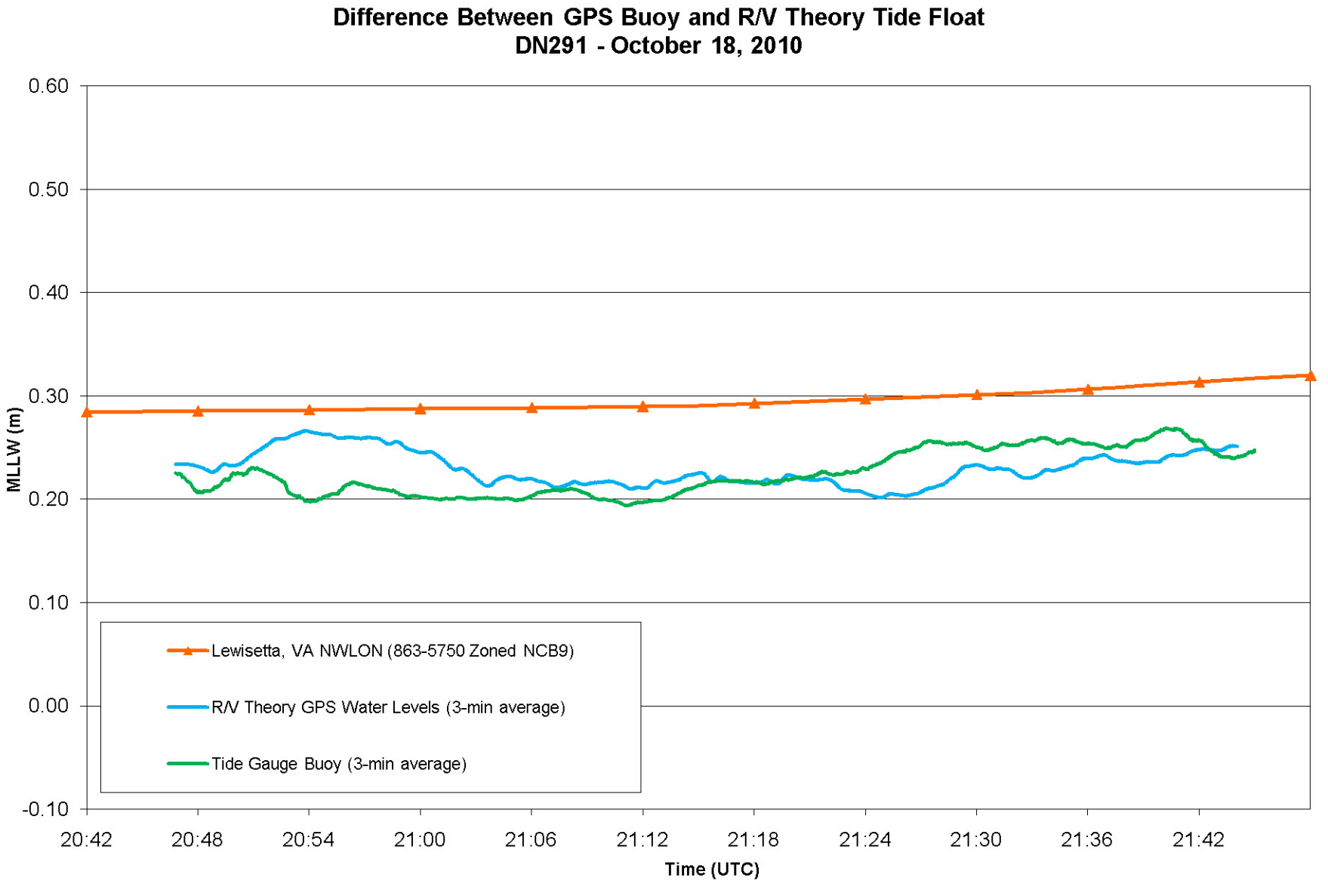
Difference Between GPS Buoy and R/V Theory Tide Float DN257 - September 14, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Zoned Water Level (m)	Difference to Vessel (m)	Difference to Zoned (m)
13:48	0.412	0.390	0.480	-0.022	-0.090
13:54	0.397	0.363	0.471	-0.034	-0.108
14:00	0.389	0.344	0.464	-0.044	-0.120
14:06	0.374	0.324	0.457	-0.050	-0.132
14:12	0.376	0.325	0.449	-0.051	-0.125
14:18	0.373	0.300	0.441	-0.073	-0.141
14:24	0.365	0.295	0.433	-0.070	-0.138
14:30	0.355	0.276	0.427	-0.080	-0.152
14:36	0.356	0.279	0.419	-0.077	-0.140
14:42	0.356	0.302	0.412	-0.054	-0.110
14:48	0.371	0.328	0.402	-0.043	-0.074
14:54	0.360	0.331	0.395	-0.029	-0.064
15:00	0.346	0.312	0.385	-0.033	-0.073
		Mean		-0.051	-0.113
		Standard Deviation		0.019	0.029


Difference Between GPS Buoy and R/V Theory Tide Float
DN272 (deploy) - September 29, 2010
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
MLLW (m)
22:18
22:24
22:30
22:36
22:42
Time (UTC)
Lewisetta, VA NWLON (863-5750 Zoned NCB9)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

Difference Between GPS Buoy and R/V Theory Tide Float DN 272 Deployment - September 29, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Zoned Water Level (m)	Difference to Vessel (m)	Difference to Zoned (m)
22:24	0.433	0.467	0.560	0.034	-0.093
22:30	0.458	0.465	0.552	0.007	-0.087
22:36	0.437	0.465	0.547	0.029	-0.082
		Mean		0.023	-0.087
		Standard Deviation		0.014	0.005


Difference Between GPS Buoy and R/V Theory Tide Float
DN272 (recovery) - September 29, 2010
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
MLLW (m)
14:54
15:00
15:06
15:12
15:18
15:24
15:30
15:36
15:42
15:48
15:54
16:00
16:06
16:12
Time (UTC)
Lewisetta, VA NWLON (863-5750 Zoned NCB9)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

Difference Between GPS Buoy and R/V Theory Tide Float DN272 Recovery - September 29, 2010					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water Level (m)	Zoned Water Level (m)	Difference to Vessel (m)	Difference to Zoned (m)
15:00	0.160	0.143	0.217	-0.017	-0.074
15:06	0.164	0.136	0.212	-0.028	-0.076
15:12	0.167	0.145	0.208	-0.022	-0.063
15:18	0.170	0.147	0.209	-0.023	-0.062
15:24	0.186	0.167	0.202	-0.019	-0.034
15:30	0.176	0.151	0.207	-0.025	-0.055
15:36	0.157	0.141	0.211	-0.016	-0.070
15:42	0.168	0.133	0.206	-0.035	-0.073
15:48	0.150	0.150	0.198	0.000	-0.048
15:54	0.160	0.148	0.197	-0.011	-0.049
16:00	0.151	0.140	0.202	-0.012	-0.062
16:06	0.141	0.141	0.194	0.001	-0.053
		Mean		-0.017	-0.060
		Standard Deviation		0.011	0.013

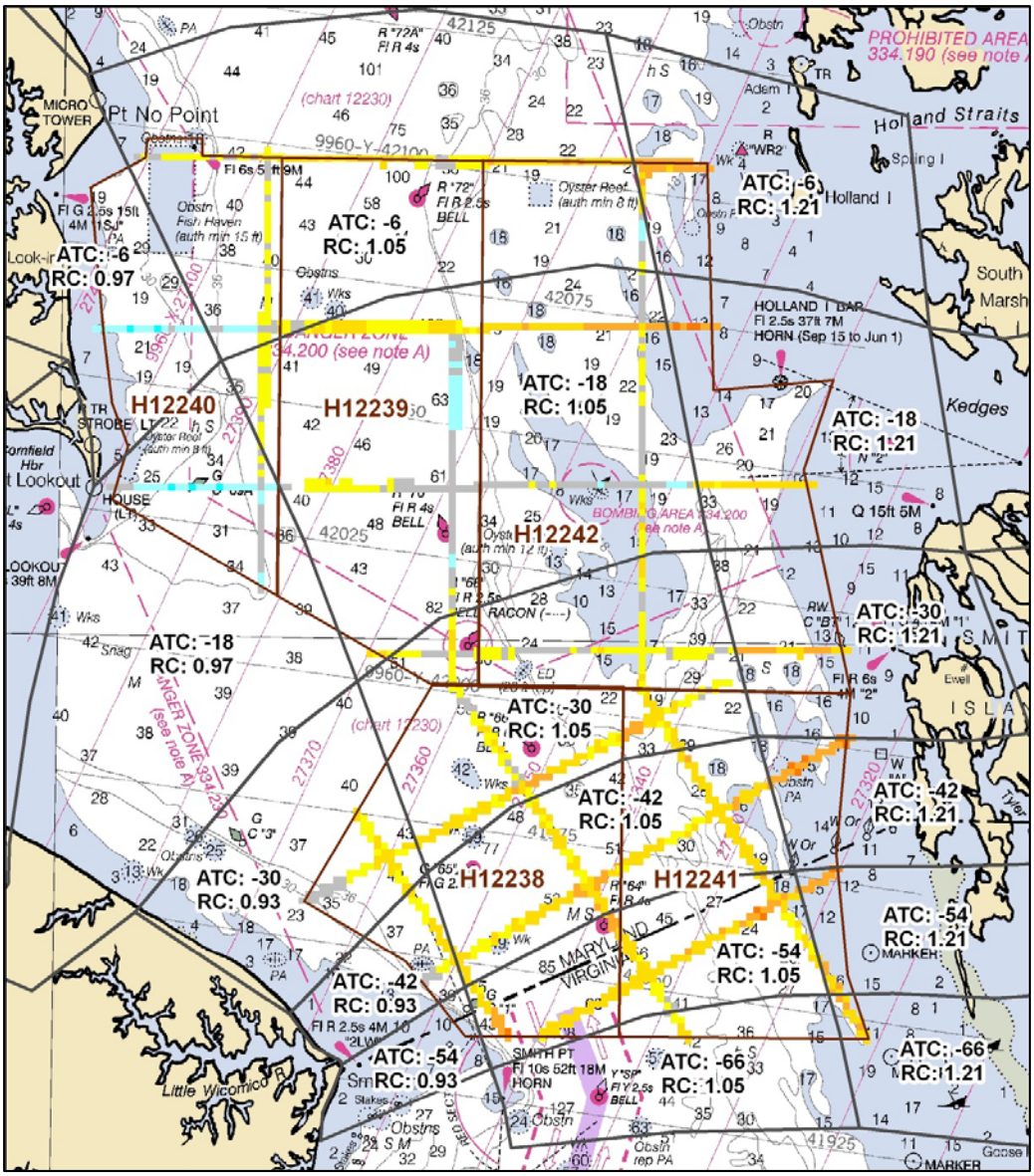

Difference Between GPS Buoy and R/V Theory Tide Float
DN291 - October 18, 2010
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
MLLW (m)
20:42
20:48
20:54
21:00
21:06
21:12
21:18
21:24
21:30
21:36
21:42
Time (UTC)
Lewisetta, VA NWLON (863-5750 Zoned NCB9)
R/V Theory GPS Water Levels (3-min average)
Tide Gauge Buoy (3-min average)

Difference Between GPS Buoy and R/V Theory Tide Float DN291 - October 18, 2010					
Time (UTC)	Vessel GPS Water Levels (m)	GPS Buoy Water Level (m)	Zoned Water Level (m)	Difference to Vessel (m)	Difference to Zoned (m)
20:48	0.234	0.220	0.286	-0.014	-0.066
20:54	0.260	0.206	0.287	-0.054	-0.081
21:00	0.233	0.201	0.288	-0.033	-0.087
21:06	0.212	0.209	0.289	-0.003	-0.080
21:12	0.217	0.202	0.290	-0.015	-0.088
21:18	0.219	0.218	0.293	-0.001	-0.075
21:24	0.205	0.244	0.297	0.038	-0.053
21:30	0.229	0.254	0.301	0.025	-0.047
21:36	0.238	0.253	0.307	0.015	-0.054
21:42	0.250	0.239	0.314	-0.011	-0.075
		Mean		-0.005	-0.071
		Standard Deviation		0.027	0.015

APPENDIX IX
OPR-E349-KR-10 CENTRAL CHESAPEAKE BAY, VA
INTERIM VDATUM REPORT, SEPTEMBER 2010

OPR-E349-KR-10 Central Chesapeake Bay, VA
Interim VDatum Report

September 2010



Prepared For:

US Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service

Prepared By:

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Portland, OR 97201
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OPR-E349-KR-10 Central Chesapeake Bay, VA
Interim VDatum Report

September 2010

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-E349-KR-10 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 for an interim deliverable as per the OPR-E349-KR-10 *Statement of Work* (July 2010).

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Tides and Water Levels Specialist

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Acronyms and Abbreviations

ARP	Antenna Reference Point
ASCII	American Standard Code for Information Interchange
CF	Compact Flash
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Station
CUBE	Combined Uncertainty and Bathymetry Estimator
DAA	Design Analysis and Associates
DCP	Data Collection Platform
DEA	David Evans and Associates, Inc.
DN	Day Number
ERS	Ellipsoidal Referenced Survey
GNSS	Global Navigation Satellite System
GOES	Geostationary Operation Environmental Satellite
GPS	Global Positioning System
GT	Great Diurnal Range
HIPS	Hydrographic Information Processing System
HVF	HIPS Vessel Files
IAKAR	Inertially Aided Kinematic Ambiguity Resolution
JOA	John Oswald and Associates
LMSL	Local Mean Sea Level
MLLW	Mean Lower Low Water
MN	Mean Range
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NAVO	Naval Oceanographic Office
NGS	National Geodetic Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NTDE	National Tidal Datum Epoch
NWLON	National Water Level Observation Network
OPUS	Online Positioning User Service
PPK	Post-Processed Kinematic
R/V	Research Vessel
RMS	Root Mean Square
SBD	Short Burst Data
SBET	Smoothed Best Estimate Trajectory
STND	Station Datum
TBYT	Tide-by-Tide
TPVU	Total Propagated Vertical Uncertainty
USCG	United States Coast Guard
UTC	Universal Time Coordinated
VDATUM	Vertical Datum
ZDF	Zone Definition File

1.0 Executive Summary

This document is an interim report describing preliminary methods and results of an ongoing VDatum analysis component of project OPR-E349-KR-10. The project, which is being performed by David Evans and Associates, Inc. (DEA), is located on the Central Chesapeake Bay, Maryland and Virginia and encompasses hydrographic surveys H12238, H12239, H12240, H12241 and H12242. DEA was contracted to perform an analysis of the reliability of Mean Lower Low Water (MLLW) estimates from the current Chesapeake Bay VDatum release and the ability to use those estimates to compute a North American Datum of 1983 (NAD83) ellipsoid to MLLW separation model for use with Global Positioning System (GPS) water levels. A copy of the list of deliverables included in the OPR-E349-KR-10 Project Instructions can be found in Appendix F. This interim report and supporting data will be used by NOAA to support a decision on whether to use ERS (Ellipsoidal Referenced Survey) methods in lieu of traditional tides for final water level correctors for the OPR-E349-KR-10 surveys. Final validation deliverables will be included with the project data and reports.

Validation of measurement methods was performed using a battery of observations at the National Water Level Observation Network (NWLON) station at Lewisetta, Virginia. The findings noted that the Center for Operational Oceanographic Products and Services (CO-OPS) posted water levels at Lewisetta were 1 centimeter higher than manual observations relative to tidal bench marks. Based on the evaluation of GPS observations, National Geodetic Survey (NGS) North American Vertical Datum of 1988 (NAVD88) published elevations, and CO-OPS MLLW published elevations on the primary bench mark at Lewisetta, one can infer relative model accuracies for this site at 1.5 centimeters in the GEOID09 model (GEOID09 yields NAVD88 values 1.5 centimeters lower than NGS published adjusted elevations) and 0.7 centimeters accuracy (VDatum model yields MLLW values lower than CO-OPS published values) for the combined MLLW to Local Mean Sea Level (LMSL) and LMSL to North American Vertical Datum of 1988 (NAVD88) models. The VDatum model provides values 1.5 centimeters lower than published values for NAVD88 orthometric heights and 2.2 centimeters lower than published values for MLLW. Combining these findings (CO-OPS posted elevations 1 centimeter high and VDatum model computing values 2.2 centimeters low) one would expect GPS water levels to be 3.2 centimeters lower when compared to CO-OPS posted water levels at Lewisetta. A vessel float observation using GPS near the Lewisetta site logged mean MLLW values 4.7 centimeters lower than CO-OPS posted MLLW values. This is within 1.5 centimeters from the expected difference of 3.2 centimeters and within the uncertainty of dynamic GPS observations. From this one can conclude that use of GPS vessel float observations are a valid method for correlating relative accuracies in the VDatum model and relative gauge performance. Vessel float observations were used throughout the project for VDatum validation and to correlate vessel determined water levels to tertiary gauge, radar gauge and GPS tide buoy water levels.

Based on preliminary and historic tidal datum computations at Ewell on Smith Island, Maryland, MLLW determined using GPS and VDatum is approximately 10 centimeters below the measured MLLW based on preliminary datum computations. At the radar gauge operating at Green Light 1 at the western approach to Smith Island, VDatum MLLW values are approximately 8 centimeters below the measured MLLW based on preliminary datum computations. Vessel float observations

at Ewell and Green Light 1 agreed relatively well with these findings (8.5 centimeters at Ewell and 8.3 centimeters at Green Light 1).

It was noted during processing of GPS height data that there is more variance (jitter) in GPS positioning than experienced in prior years when working to the immediate south. The survey area for project OPR-E349-KR-10 falls within the 17 nautical mile radius for the GPS testing and jamming exercises at the Naval Air Station Patuxent River as reported by the United States Coast Guard Navigation Center. In addition, 2010 experienced higher space weather events than 2009. Space weather can have a direct impact on GPS positioning. The jitter in GPS positioning was also detected at GPS base stations and CORS sites over a large area which suggests upper atmosphere signal interference typical of space weather events.

The results of the test line analysis show no significant difference between crossline ties with mainscheme data when using either GPS or traditional tidal correctors. The use of GPS water levels does offer a general improvement in the agreement of the VDatum test line crossings. It should be noted that these test lines were run under near optimum conditions for using traditional tidal zoning (calm seas, light winds, relatively low tide ranges, etc.). One would expect comparable results when using GPS methods as sea and weather patterns degrade while the traditional tidal zoning would not perform nearly as well. Past experience working in the vicinity of the OPR-E349-KR-10 survey area has shown that there is an issue with high range ratio correctors on the eastern side of the Chesapeake Bay. As water levels increase, larger errors in zoned tides are observed. Further, the application of zoned tides does not adequately correct multibeam data for large kinematic waves, wind driven water level changes and other small scale transient water levels typical to the survey area. Last, ERS eliminates errors resulting from vessel loading and inadequate compensation for vessel squat by using speed over ground lookup tables. For this project, the implementation of ERS will result in the application of slightly lower water levels that more accurately reflect dynamic water levels in the survey area. The resultant soundings will be slightly deeper than soundings corrected through the application of zoned tides.

Based on the analysis performed to date DEA recommends moving forward with ERS deliverables for this project.

2.0 Lewisetta NWLON Verification

The active NWLON station at Lewisetta, Virginia (863-5750) is the reference station for this project. The Lewisetta NWLON station has 19 years of observation over the full 1983-2001 Tidal Epoch which is presently the National Tidal Datum Epoch (NTDE) used for nautical charting. As such, the station serves as the control station for tide by tide datum computations for subordinate gauging sites for this project and is the reference station for tidal zoning provided by CO-OPS for project OPR-E349-KR-10. Further, the primary tidal bench mark is part of a NGS leveling network for which North American Vertical Datum of 1988 (NAVD88) elevations are published and is a cornerstone for the development of NOAA's VDatum separation model for the project area. To ensure that this station is operating within expected accuracies, and to evaluate VDatum verification methods, this site was selected for a battery of observations made

by DEA field crews. Data collected at the Lewisetta site is idealized for tidal zoning (i.e. no zone correctors need to be applied to direct gauge observations) and less favorable to GPS observations (i.e. 18 kilometers from the nearest GPS reference station).

2.1 Vessel Float Observations

As part of the GPS water level quality assurance procedures, a one-hour vessel float observation was acquired adjacent to the tide station. GPS data acquired during the vessel float observation was logged and processed using the combined separation model generated from VDatum which incorporates MLLW to Local Mean Sea level (LMSL), LMSL to NAVD88, and the GEOID09 model for NAVD88 to NAD83 ellipsoid heights. The resulting water elevations on MLLW were then compared to the verified NWLON station values logged at the same time by CO-OPS. The vessel measurements were averaged over 3-minutes using the same interval as the NWLON gauge for direct comparison.

Table 1: Lewisetta, VA (863-5750) GPS to NWLON Water Levels Comparison

Lewisetta, VA (863-5750), August 31, 2010			
Time (UTC)	GPS Water Level (VDATUM MLLW m)	Gauge Water Level (CO-OPS MLLW m)	Difference (m)
21:24	0.479	0.523	-0.044
21:30	0.478	0.529	-0.051
21:36	0.494	0.535	-0.041
21:42	0.488	0.540	-0.052
21:48	0.487	0.544	-0.057
21:54	0.484	0.549	-0.065
22:00	0.505	0.553	-0.048
22:06	0.506	0.557	-0.051
22:12	0.516	0.561	-0.045
22:18	0.545	0.564	-0.019
		Mean	-0.047
		Standard Deviation	0.012

The mean float observation was 4.7 centimeters below CO-OPS observed water levels at Lewisetta (Table 1). Checks of the GPS phase center height confirmed correct values were being used and GPS derived water elevations were valid.

2.2 Validation of Lewisetta Posted Water Levels

To confirm water levels posted by CO-OPS matched published tidal bench marks, manual water level observations (staff shots) were made to validate the gauge performance relative to the bench marks. This was accomplished by leveling from a tidal bench mark to the water surface at the even six-minute interval for one hour. To ensure the stability of the mark, it was included in a 3rd order level loop with two other marks, including the primary bench mark. A summary of the

staff shot results is presented in Table 2, while the complete forms and level abstracts are included in *Appendix A. NWLON Staff Shots and Levels.* Figure 1 shows the combined staff shot and vessel float plot.

Table 2: Lewisetta, VA (863-5750) Staff Shots to NWLON Water Levels Comparison

Lewisetta, VA (863-5750), August 31, 2010 (CO-OPS MLLW)			
Time (UTC)	Manual Water Level (m)	Gauge Water level (m)	Difference (m)
21:24	0.515	0.523	-0.008
21:30	0.521	0.529	-0.008
21:36	0.522	0.535	-0.013
21:42	0.527	0.54	-0.013
21:48	0.532	0.544	-0.012
21:54	0.537	0.549	-0.012
22:00	0.542	0.553	-0.011
22:06	0.542	0.557	-0.015
22:12	0.546	0.561	-0.015
22:18	0.552	0.564	-0.012
		Mean	-0.012
		Standard Deviation	0.002

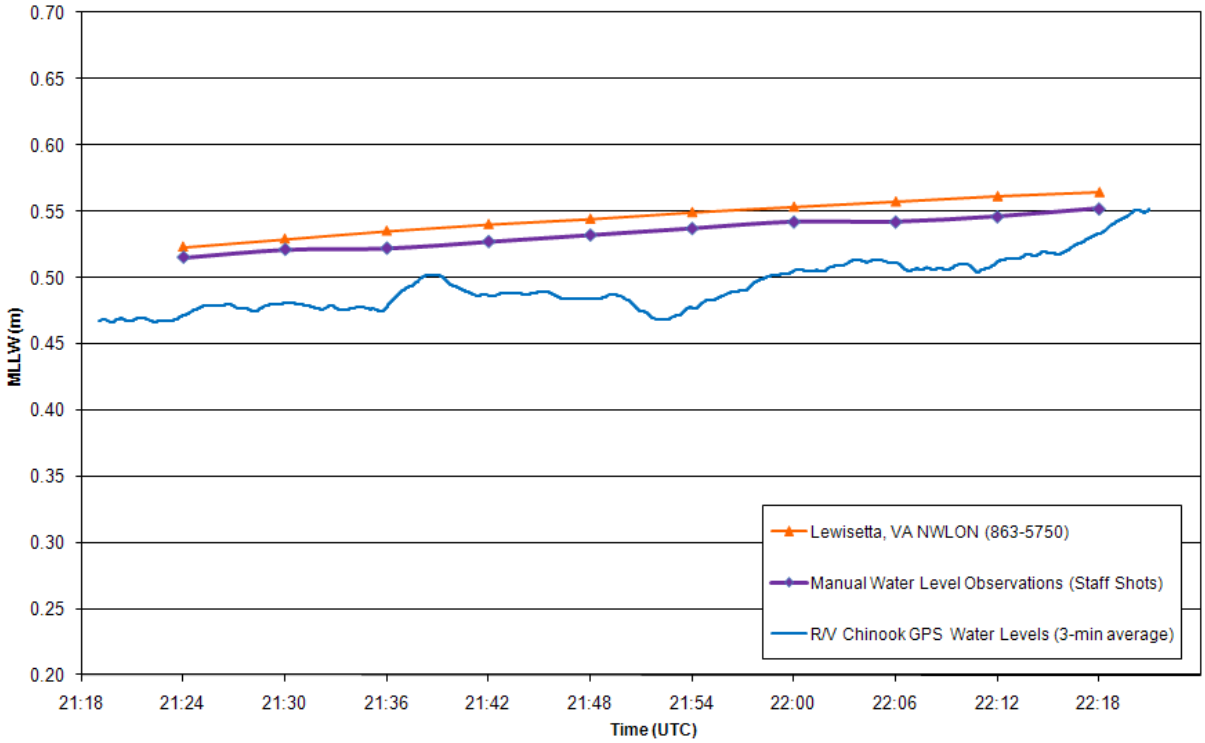

Figure 1: Lewisetta Water Level Observation Comparison on August 31, 2010

2.3 Comparison of GPS Observations using GEOID09 to NGS Level Runs

To evaluate the difference between NGS level runs and the GEOID09 separation model from the North American Datum of 1983 (NAD83) ellipsoid, static GPS observations on the primary tidal bench mark R 462 (PID GV0156) were collected. The four hour GPS observation data were processed using OPUS after precise ephemeris files were available to be consistent with other project control comparisons. The derived NAVD88 orthometric height was compared to the National Geodetic Service (NGS) published NAVD88 elevation derived from First Order Class I level runs (Table 3.). Complete field notes and OPUS results are included in *Appendix B. Lewisetta GPS Observations.*

Table 3: Published NAVD88 elevations compared to GPS survey results

R462 at Lewisetta, VA (863-5750)		
NGS Adjusted NAVD88 Height (m)	GPS Derived NAVD88 GEOID09 (m)	OPUS RMS Value (m)
1.169	1.154	0.013

CO-OPS MLLW and NGS NAVD88 published data for the primary bench mark R 462 at Lewisetta show some disagreement when converted to the same datum planes using the VDatum GEOID09 model (Table 3 and Figure 2). At Lewisetta, the difference between the NGS published (derived from adjusted First Order Class 1 level observations) NAVD88 orthometric height and the GPS derived height using GEOID09 is 1.5 centimeters. Using the VDatum model to obtain MLLW increases the difference between the CO-OPS MLLW datum and the derived VDatum MLLW to 2.2 centimeters (Table 4). Based on these observations one can infer relative model accuracies of 1.5 centimeters in the GEOID09 model and 0.7 centimeters accuracy in the combined MLLW to LMSL and LMSL to NAVD88 models at Lewisetta.

Table 4: Lewisetta Datum Planes

Lewisetta, VA (863-5750)	
Bench Mark	R 462 (PBM)
MLLW (VDatum GEOID09)	1.398 m
MLLW (CO-OPS)	1.420 m
VDatum Difference to MLLW	-0.022 m
NAVD88 (GEOID09)	1.154 m
NAVD88 (NGS Adjusted)	1.169 m
VDatum GEOID09 Difference to NAVD88	-0.015 m
NAD83 (CORS96, 2002 Epoch)	-33.734 m

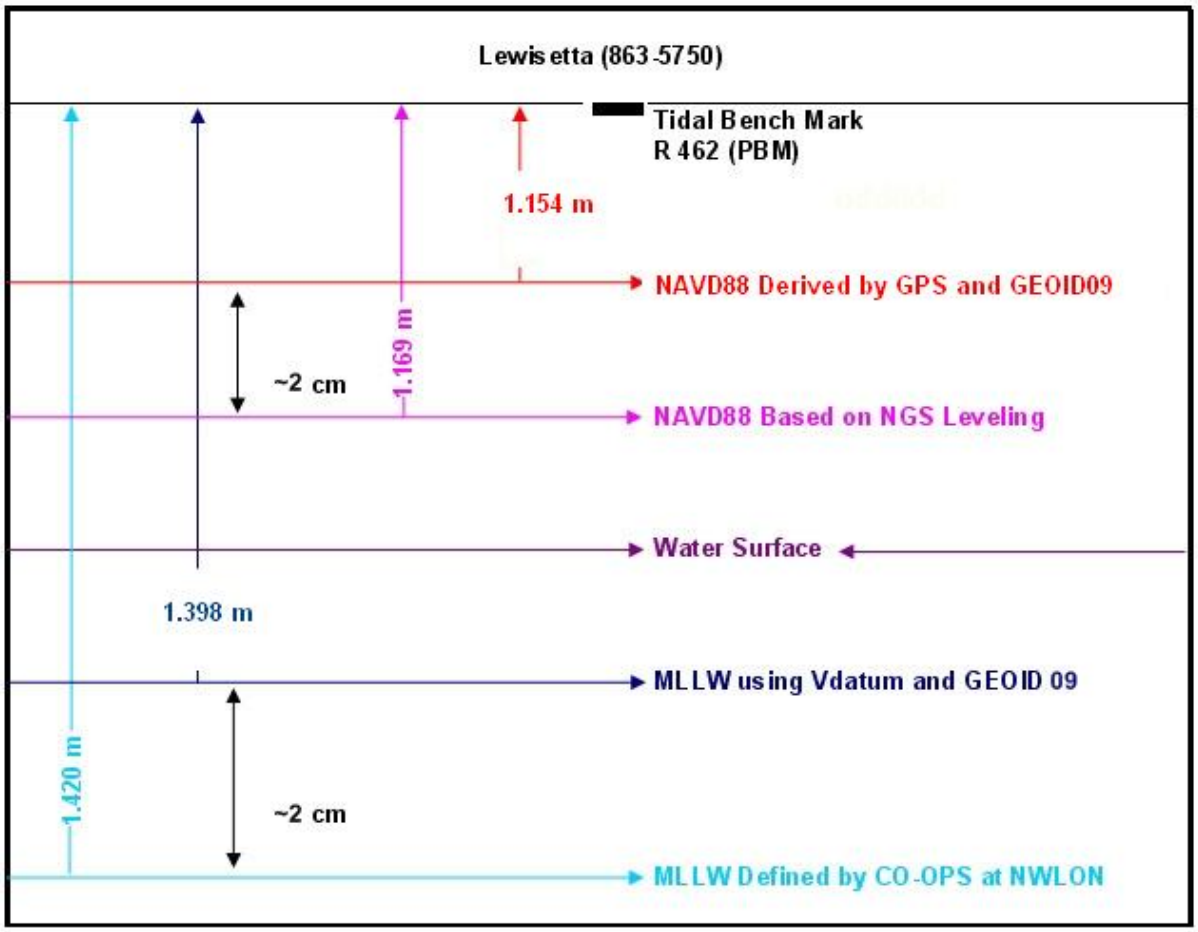

Figure 2: Lewisetta Datum Comparison

2.4 Findings at Lewisetta

The mean vessel GPS observations corrected to the waterline were 4.7 centimeters below the NWLON station readings (Table 1). The direction of the error is consistent with the GEOID09 separation model as shown in the datum comparison in Figure 2. The differences observed are mostly likely a combination of the expected uncertainty in the GPS measurements and the GEOID model accuracy with a relatively minor uncertainty of 0.7 centimeters in the combined models of MLLW to Local Means Sea Level (LMSL) and LMSL to NAVD88 at Lewisetta. VDatum uses the GEOID09 model to determine NAVD88 orthometric heights rather than the published NAVD88 elevations from level runs. Use of GPS observations and GEOID models for obtaining orthometric heights is widely accepted in the survey community and differences are within expected tolerances of both GEOID models and GPS observations. From these cumulative results, water level observations determined by the NWLON station at Lewisetta as well as methods used to determine GPS water levels aboard the survey platform are within expected uncertainties and are valid for comparison purposes.

3.0 GPS Base Stations

Data from existing Continually Operating Reference Station (CORS) sites were used to post-process GPS and inertial data collected on the survey vessels by the Applanix POS/MV. To strengthen the existing CORS GPS base station network, two temporary GPS base stations were established by DEA. These stations are in close proximity and span the survey area thereby providing the ability to process in both single-base and multi-base configurations. The two base stations, designated AIRD and EWELL, were strategically located near the project site in order to meet the 20-kilometer maximum baseline length for single base post-processed kinematic (PPK) mode using Applanix POSPac MMS software. Base station AIRD was located along the west side of the project area and EWELL was located on the east at the tertiary tide station on Smith Island (Figure 3).

The temporary base stations consist of Trimble Net-R5 GPS dual frequency (L1/L2) receivers with Trimble Zephyr Geodetic GPS antennas. Each station was selected to provide a clear satellite visibility with the GPS antennas installed on a rigid steel pole securely attached to a structure. The receivers were configured to log raw GPS observables at 1 Hz. Data logged included: L1 phase, C/A code, L2 phase, P(Y) code and L2C (CM+CL). Internally logged data was stored in Trimble T01 format and segmented into 24-hour files that were manually downloaded and quality controlled daily. Table 5 lists the GPS equipment used on the project.

Table 5: GPS Base Station Equipment

GPS Base Station Equipment					
Item/ Manufacturer	Model	P/N	S/N	Firmware Version	Location
Receiver					
Trimble	NetR5	62800-10	4750K11594	4.14	AIRD
Trimble	NetR5	62800-10	4750K11589	4.03	EWELL
Antenna					
Trimble	Zephyr-Geodetic	41249-00	12338039	N/A	AIRD
Trimble	Zephyr-Geodetic	41249-00	12237025	N/A	EWELL

The coordinates were derived at each site from the GPS receiver logging one second epochs for a 24-hour static occupation. The data files recorded at each site were submitted to the Online Positioning User Service (OPUS), operated by the NGS. The solutions derived from OPUS were processed using a rapid GPS ephemeris and later checked against a precise orbit. This was done to expedite processing and meet the interim deliverables deadline. All solutions were in accordance with the passing criteria for the solution statistics established in the NOAA publication *User's Guide for GPS Observations (March 2007).* The coordinates for each site were derived at the Antenna Reference Point (ARP) of the Trimble Zephyr Geodetic Antennas. The coordinates derived from the OPUS solutions at the temporary base stations are shown in Table 6 referenced to NAD83 (CORS96, Epoch 2002).

Table 6: Antenna Reference Point (ARP) Station Coordinates

Coordinates NAD83(CORS96, Epoch 2002) ARP (24 Hour OPUS Solution)			
Temporary Station	Latitude	Longitude	Ellipsoid Height (m)
AIRD	38/07/10.22946 N	076/20/53.79559 W	-22.567
EWELL	37/59/46.25232 N	076/01/59.09814 W	-31.911

These stations as well as all existing CORS stations in the area were used in the Smart Base solution in Applanix POSPac MMS software. AIRD was used as the primary station, while MDSI was used as the control station in the network verification phase. Table 7 lists the published NGS coordinates of the CORS stations used for smart-base processing.

Table 7: CORS Base Stations Used During Smart Base Processing

CORS Base Stations	**Coordinates NAD83(CORS96, Epoch 2002) ARP**		
	Latitude	Longitude	Ellipsoid Height (m)
VIMS	37/36/30.04548 N	075/41/13.20712 W	-27.739
MDSI	38/19/08.07256 N	076/27/13.95583 W	-16.774
HNPT	38/35/19.71067 N	076/07/49.33296 W	-26.645
VAGP	37/14/55.00860 N	076/29/57.73125 W	-19.809
VAWI	37/56/03.49983 N	075/28/15.94949 W	-22.315
DEDS	38/39/52.29188 N	075/22/38.75868 W	-12.428
CORB	38/12/07.82819 N	077/22/24.57106 W	37.252

Figure 3, on the following page, shows the entire GPS base station network used for Smart-Base processing.

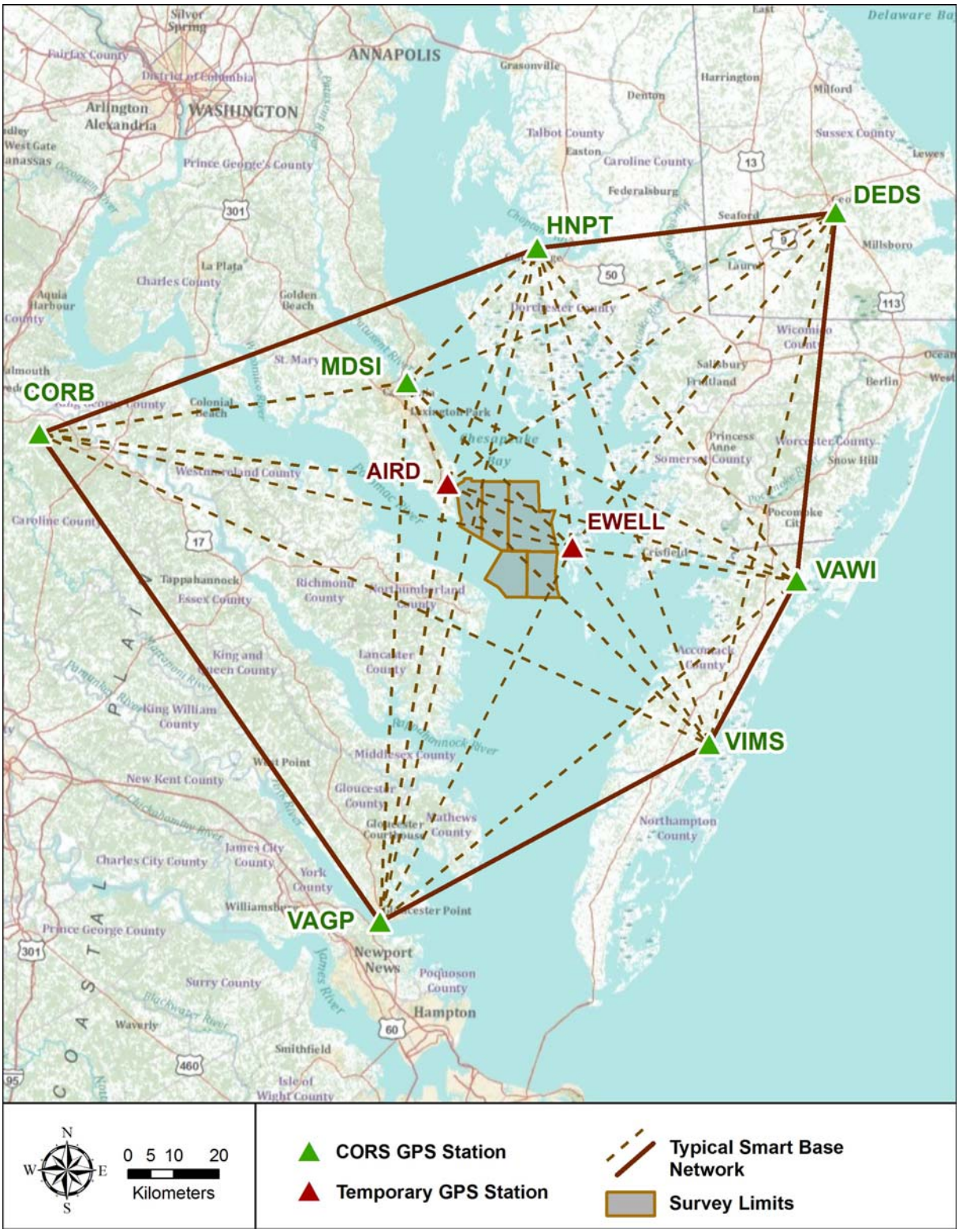

Figure 3: CORS and Temporary Base Stations used for OPR-E349-KR-10

4.0 Water Level Gauging Methods

To observe water-levels during the project, DEA used three separate gauging methods: a tertiary gauge was established at the historic CO-OPS site at Ewell, Smith Island, MD (857-1117), a radar gauge was installed on navigation aid Green 1 in open water west of Smith Island and a GPS tide buoy was deployed at three locations over the duration of the project (Figure 4). The tertiary site was established to CO-OPS specifications as required by the Tides and Water Levels component of the project instructions. The radar gauge and GPS tide buoy were used as part of the VDatum validation component of the project and to compare observations in open water relative to zoned tides.

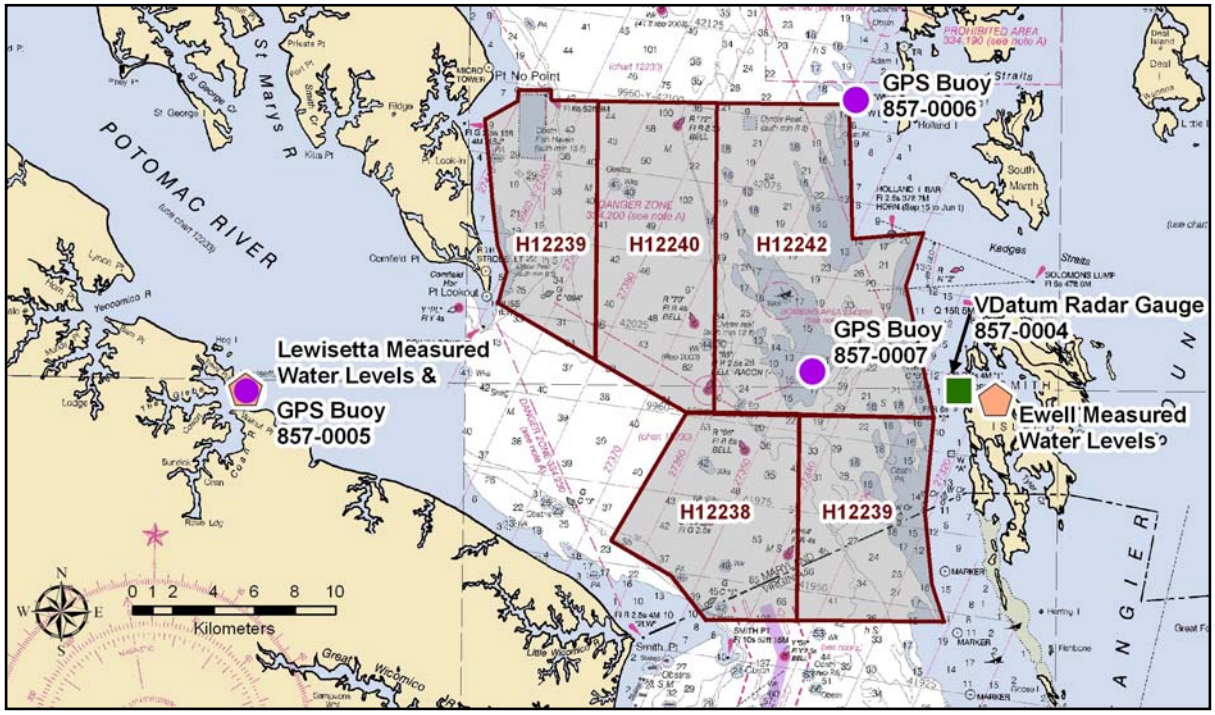

Figure 4: Water level gauging sites for OPR-E349-KR-10

This interim report covers only the first GPS buoy deployment and data collected during the first month of the project. The first deployment was situated as close as possible to the active National Water Level Observation Network (NWLON) tide gauge at Lewisetta, VA (863-5750). Datum planes were computed for Ewell and the GPS buoy deployment, but were not required for the radar gauge.

4.1 Ewell Tertiary Gauge

A tertiary gauge was established at the historic CO-OPS site at Ewell, Smith Island, MD (857-1117). This station was last occupied by CO-OPS in 1997. DEA worked jointly with John Oswald and Associates, Inc. (JOA) to install DEA's Aquatrak acoustic primary gauge with a redundant water level sensor to collect data for datum determination and possible sounding

reduction. Complete details of the installation were submitted to CO-OPS in the Installation Report dated July 28, 2010.

4.1.a Preliminary Tidal Datum at Ewell

A preliminary datum was computed from the first set of data using the Tide-by-Tide (TBYT) method. Data from July 2 to August 31, 2010 was used, with Lewisetta, VA (863-5750) as the control station. Datum planes are presented in Table 8 while the complete computations plots of picked highs and lows are in *Appendix C. Ewell, Smith Island, MD Datum Computation Results*.

To compare the results to the published historic datum and VDatum values, the elevation of the primary bench mark was used (857 1117 TIDAL 2). The results from this preliminary datum computation are 3.9 centimeters lower than the published CO-OPS datum from 1997 that was based on 3 months of data (Table 8). The historic datum planes were computed using the Solomons Island, MD (857-7330) gauge as the control station.

Table 8: Ewell, Smith Island MD (857-1117) Preliminary Datum Planes

	Preliminary TBYT All Data (m)
MHHW	0.663
MHW	0.614
DTL	0.384
MTL	0.382
MSL	0.382
MLW	0.151
MLLW	0.104
GT	0.559
MN	0.463
DHQ	0.049
DLQ	0.047

The Computational Techniques for Tidal Datums Handbook estimates the uncertainty of a tidal datum computed from 1 month of data collected on the East Coast is 3.96 cm at 1 sigma. And a datum computed from 3 months of data has an associated uncertainty of 3.05 cm at 1 sigma. The uncertainty of a two-month datum is estimated to be 3.51 cm (the average uncertainty of the 1 and 3 month datums). Thus in general the differences between the 1997 published datum and three sets of 2010 computed datums are within the estimated uncertainties.

4.1.b Preliminary VDatum Comparison at Ewell

To compare the VDatum model to the preliminary datum, the ellipsoid height of the primary bench mark determined by static GPS observations during the installation was input to the VDatum software and the MLLW elevation was computed. It was found that the VDatum determined MLLW elevation was 10.0 centimeters below the preliminary MLLW datum computed from the observed water levels (Table 9).

Table 9: Ewell, Smith Island MLLW Datum Plane Comparison

Ewell, Smith Is. MD (857-1117)	
Bench Mark	8571117 TIDAL 2 (PBM)
MLLW (Preliminary)	0.991 m
MLLW (CO-OPS Published)	0.952 m
Difference from CO-OPS	0.039 m
MLLW (VDatum GEOID09)	0.891 m
Difference from VDatum	0.100 m
NAD83 (CORS96, 2002 Epoch)	-35.345 m

4.1.c Vessel Float Observation at Ewell

To compare the gauge results with GPS water levels, a one-hour vessel float observation was acquired adjacent to the tertiary gauge at Ewell during a maintenance visit. GPS data acquired during the vessel float observation was logged and processed using the combined separation model generated from the VDatum model and GEOID09. The resulting water elevations on MLLW were then compared to the tertiary gauge measured values also adjusted to MLLW using a preliminary datum computed at the site from the first month of data. The vessel measurements were averaged using the same interval as the gauge. The average difference between the two methodologies was 8.5 centimeters with a standard deviation of 1.4 centimeters (Table 10).

Table 10: Ewell, Smith Island MD (857-1117) GPS to Tertiary Water Levels Comparison

Ewell, Smith Island, MD (857-1117), September 2, 2010			
Time (UTC)	GPS Water Level (VDATUM MLLW m)	Gauge Water Level (Prelim MLLW m)	Difference (m)
12:48	0.554	0.631	-0.077
12:54	0.546	0.625	-0.079
13:00	0.533	0.616	-0.083
13:06	0.540	0.607	-0.067
13:12	0.487	0.600	-0.113
13:18	0.491	0.587	-0.096
13:24	0.502	0.580	-0.078
13:30	0.481	0.573	-0.092
		Mean	-0.085
		Standard Deviation	0.014

The direction of the difference is consistent with the differences observed by static GPS at the primary bench mark. These observations suggest that the VDatum model may be approximately 10 centimeters below the observed MLLW plane at Ewell. It should be noted that the gauging site at Ewell is in a narrow waterway inside Smith Island.

4.2 Radar Gauge

With approval for installation from the USCG, DEA worked jointly with JOA to install a Design Analysis and Associates, Inc. (DAA) Waterlog H3611 radar gauge. The system consists of an H3611i radar level sensor and an H522+ data collection platform with integrated Geostationary Operations Environmental Satellite (GOES) radio and GPS for signal timing. The entire system is very compact and is powered by a 12 volt sealed lead acid battery charged with a 20W solar panel.

The subordinate water level station was established on the platform of navigation aid Green Light "1" marking the western approach to Ewell on Smith Island, Maryland on the east side of the Chesapeake Bay (Table 11). The radar gauge and GPS mounting system are shown in Figure 5. The gauge was configured to log data on even six-minute intervals, with water levels averaged for 181 seconds. To link the station datum to the ellipsoid, a static GPS tie was completed.

Figure 5: Radar gauge installation

The gauge was assigned an arbitrary station number for tracking during this project: 857-0004. This number was not assigned by CO-OPS, and has no meaning outside of the scope of this project.

Table 11: Radar gauge installation location

Gauge	Latitude	Longitude	Start Date (UTC)
Green 1 (857-0004)	38/00/00.3 N	076/03/22.3 W	08/07/2010 16:00

The gauge was originally installed on July 7, 2010. Shortly after installation, the gauge suffered a hardware fault that lead to the failure of the solar controller. The solar controller regulates the power from the solar panel to charge the battery powering the station. As a result, the battery and components in the GOES transmission system became inoperable. The gauge continued to log data during the day, while the solar panel could generate enough current to run the radar sensor and data collection platform (DCP). However, when the sun dropped the gauge shut down. This problem was repaired on August 7, 2010 and the system was restarted.

4.2a Radar Gauge Comparison to Manual Measurements

The radar gauge's distance measurements are not affected by atmospheric changes or water density variations. As such, site visits were minimal during the occupation. During each visit, staff shots were conducted from a measure down point to the water surface and GPS observations were collected on the survey vessel. Figure 6 is a graph of the observations from August 23, 2010. Table 12 lists the observations and statistics.

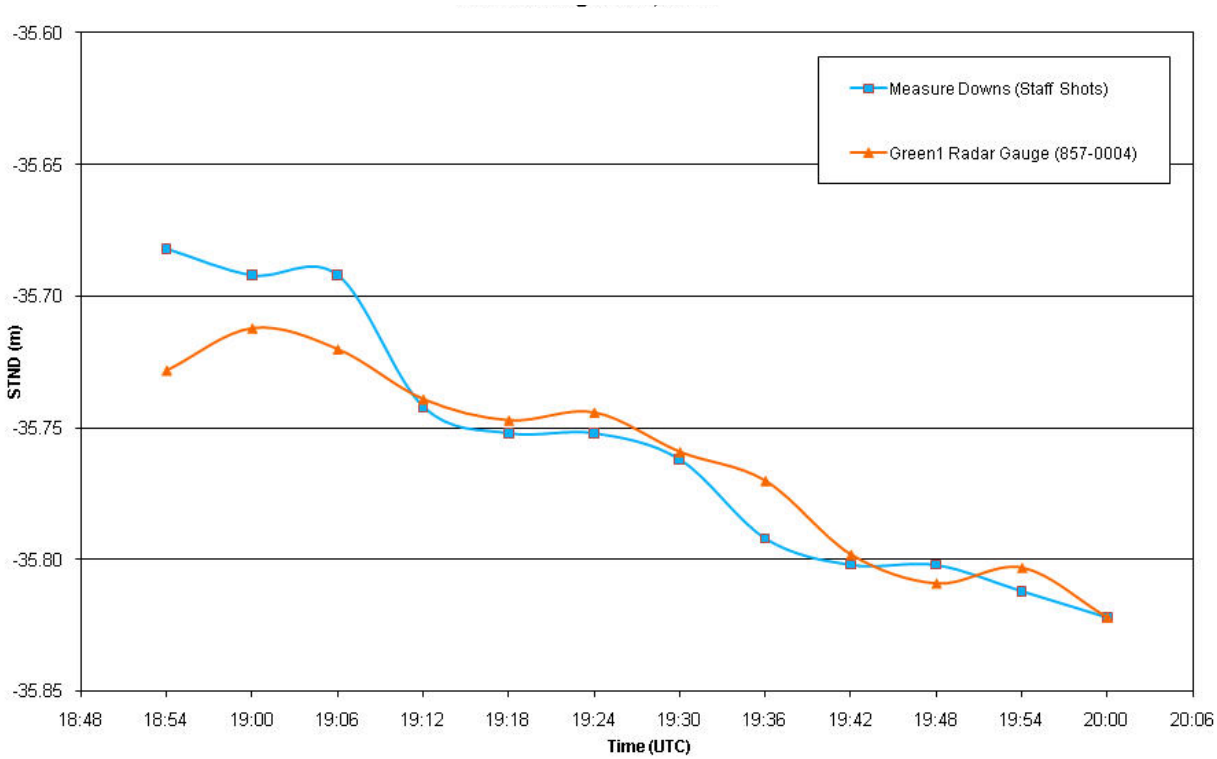

Figure 6: Green Light 1 Radar Gauge and Manual Measurements on August 23, 2010

Table 12: Tabular results of Green Light 1 Radar manual measurements

Green Light 1 Radar Gauge (857-0004), August 23, 2010			
Time (UTC)	Gauge Water Level (STND m)	Measure Down (STND m)	Difference (m)
18:54	-35.728	-35.682	-0.046
19:00	-35.712	-35.692	-0.020
19:06	-35.720	-35.692	-0.028
19:12	-35.739	-35.742	0.003
19:18	-35.747	-35.752	0.005
19:24	-35.744	-35.752	0.008
19:30	-35.759	-35.762	0.003
19:36	-35.770	-35.792	0.022
19:42	-35.798	-35.802	0.004
19:48	-35.809	-35.802	-0.007
19:54	-35.803	-35.812	0.009
20:00	-35.822	-35.822	0.000
		Mean	-0.004
		Standard Deviation	0.019

4.2.b Preliminary VDatum Comparison at the Radar Gauge

Static GPS data was collected at the sensor to tie the gauge zero to the ellipsoid. This put the station datum (STND) on NAD83 (CORS96, Epoch 2002). To date, only one valid occupation has been collected, results shown in Table 13. This is the preliminary station datum value. As further GPS sessions are conducted, a weighted average will determine the final value.

Table 13: 857-0004 Radar gauge at Green Light 1 GPS observations

857-0004 Radar Gauge Preliminary Station Datum NAD83(CORS96, Epoch 2002)			
Observation Date	Session Length (Hours)	Ellipsoid Height (m)	Height Uncertainty (m)
07/15/2010	5.72	-31.979	0.038

By using this method for STND, the water levels measured by the radar gauge were measured relative to NAD83 ellipsoid heights. The VDatum model was applied to convert the measured readings on STND (NAD83 ellipsoid heights) to the MLLW datum plane.

A datum determination at the radar gauge was not required for this interim deliverable; however a preliminary datum was computed using the TBYT method. The preliminary datum was determined from observed water levels over 16 days and was 7.9 cm above the VDatum model

value for that location (Table 14). This time period is relatively short, but the results are in the same direction and consistent with the Ewell tertiary gauge (857-1117) values.

Table 14: Radar Gauge Preliminary MLLW Datum Relative to VDatum

Green Light 1 Radar Gauge (857-0004)	
Datum	STND (NAD83)
MLLW (CO-OPS Published)	N/A
MLLW (Preliminary)	-36.271 m
MLLW (VDatum GEOID09)	-36.192 m
Difference	-0.073

4.2.c Vessel Float Observations at the Radar Gauge

To compare the gauge results with GPS water levels, a one-hour vessel float observation was acquired adjacent to the radar gauge. GPS data acquired during the vessel float observation was logged and processed using the combined separation model generated from the VDatum model using GEOID09 and compared using the same interval as the radar gauge. The resulting GPS derived water elevations relative to MLLW were then compared to the radar gauge measured values based on the computed datum and using VDatum to convert radar observed water levels relative to NAD83 ellipsoid heights to MLLW (Figure 7). Statistics comparing the vessel GPS water level measurements and data from the Green Light 1 radar gauge (857-0004) using the preliminary MLLW datum are presented in Table 15.

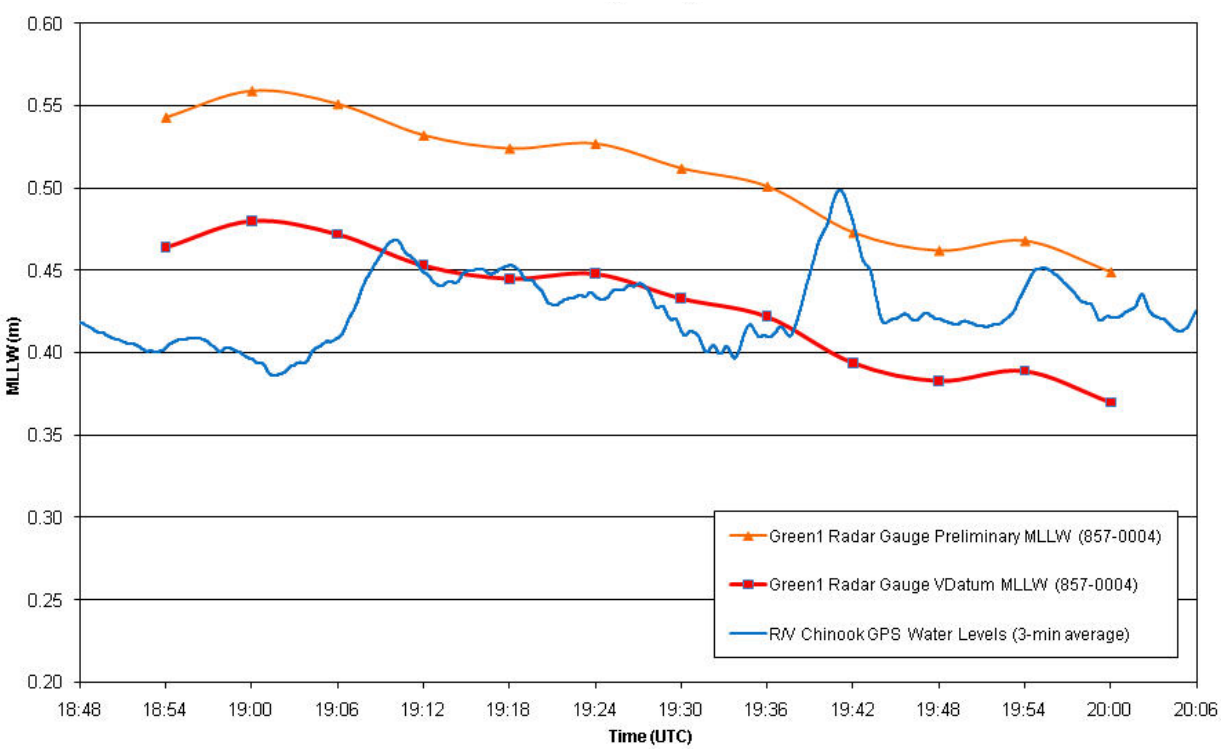

Figure 7: Green Light 1 Radar Gauge data and vessel float observations on August 23, 2010

Table 15: Tabular results of Green Light 1 and vessel float observations

Green Light 1 Radar Gauge (857-0004), August 23, 2010			
Time (UTC)	Vessel GPS Water Level (VDatum MLLW m)	Gauge Water Level (Prelim MLLW m)	Difference (m)
18:54	0.409	0.543	-0.134
19:00	0.386	0.559	-0.173
19:06	0.434	0.551	-0.117
19:12	0.442	0.532	-0.090
19:18	0.444	0.524	-0.080
19:24	0.438	0.527	-0.089
19:30	0.404	0.512	-0.108
19:36	0.410	0.501	-0.091
19:42	0.439	0.473	-0.034
19:48	0.418	0.462	-0.044
19:54	0.451	0.468	-0.017
20:00	0.427	0.449	-0.022
		Mean	-0.083
		Standard Deviation	0.047

From Table 15, the mean difference between the vessel observed water level using the VDatum MLLW datum plane and the gauge observed water level using the preliminary MLLW datum is 8.3 centimeters. This is consistent and in the same direction as the mean difference of 7.9 centimeters between the preliminary datum and the application of VDatum to the radar observations listed in Table 14. From this, one can infer that the preliminary MLLW datum determined from 16 days of radar observations is relatively accurate and that VDatum is in error by approximately 8 centimeters at the radar site and is consistent with the VDatum error observed at Ewell (Table 9).

Results from the OPUS solutions, manual measure downs, vessel float and datum computations can be found in *Appendix D. Radar Gauge Datum Results*.

4.3 GPS Tide Buoy

Tidal datum planes were also computed using an AXYS Technologies Inc. Hydro Level Mini GPS Buoy provided by the Naval Oceanographic Office (NAVO). The first deployment was as close to the Lewisetta NWLON gauge as possible, while still maintaining a safe distance from navigation channels, clear view of the GPS constellation and sufficient water depth. The deployment area selected was approximately 800 meters east of the Lewisetta gauge. Care was taken in the planning of the deployment sites along with consultation with the United States Coast Guard to ensure sites were selected well outside of any areas of heavy vessel traffic while also providing a good distribution for VDatum model validation.

For this report, only deployment 1 was evaluated. Full discussion of all buoy deployments will be discussed in the *Horizontal and Vertical Control Report* for project OPR-E349-KR-10

Deployment 1was assigned an arbitrary station number for of 857-0005 for tracking purposes during this project. This number was not assigned by CO-OPS, and has no meaning outside of the scope of this project. Table 16 lists the deployment location, dates of operation and duration of deployment.

Table 16: GPS tide buoy deployment location and duration.

Deployment	Latitude	Longitude	Start Date (UTC)	End Date (UTC)	Duration (Days)
1 (857-0005)	37/59/39.2 N	76/27/15.0 W	07/06/2010 19:50	08/06/2010 21:00	31

4.3.a GPS Buoy Components

The buoy uses the AXYS Technologies Inc. TRIAXYS Mini Buoy hull which is a 0.65-meter diameter stainless steel sphere outfitted with a mooring pad-eye and lifting handles. The buoy is sealed using a rubber gasket and 12 stainless steel bolts holding the two halves together. A rubber surround ring then protects the flange at the buoy equator that seals the two halves. The antennas, obstruction light and cable connections are protected by the lifting handle that is welded to the top of the buoy. Figure 8 shows the GPS buoy on a calm day.

Figure 7: GPS buoy

The batteries used for this unit have been upgraded from the non-rechargeable Lithium Thionyl Chloride platters to rechargeable Lithium Iron Phosphate cells. Each of the new batteries has a nominal voltage of 12 V and a manufacturer quoted capacity of 55 Amp-Hours. The three batteries are secured to the bottom of the buoy hull while the electronics are packaged above

inside a second sealed enclosure. This improved the usability and safety of the system as well as lowering deployment costs. However, early testing suggests that the new cells may not have the capacity to endure a 30-day deployment. Testing is not complete at this time the batteries could not be discharged completely. New batteries of this type need at least 5 complete charge/discharge cycles to no less than 12.3 V otherwise there is a risk of cell imbalance that could lead to failure of the pack.

This system uses a Watchman 500 data collection platform to log raw GPS observables and tilt data while compiling and sending status messages via an Iridium satellite modem. Data is logged to a 8 GB Compact Flash (CF) data card.

The GPS sensor used in this buoy is a dual frequency Trimble BD950 board that is streaming data in RT17 format (position, raw observables and ephemeris) at 5 Hz. This creates data files that are on the order of approximately 8.2 MB per hour, depending on the number of satellites tracked. Files were broken into 1-hour increments to mitigate the data loss should a file become corrupt. A NavCom model 2004T dual frequency antenna is mounted on the top of the buoy with the cable sealed in a watertight pass-through.

The tilt sensor used was a PNI TCM2.6 tilt corrected compass module. The manufacturer quoted specifications are: 0.8º heading accuracy with 0.1º resolution, 0.2º pitch and roll accuracy with a resolution of 0.1º (range of +/-50º). No confidence level was provided.

An Iridium 9601 Short Burst Data (SBD) modem was used to send buoy status messages that can be monitored remotely. This includes records such as system health, position, battery voltage, memory free-space and many other parameters. It is important to note that the raw GPS observables are not broadcast from the buoy. The only way to download the full resolution GPS and tilt data is to open the buoy and remove the memory card.

To monitor the buoy's performance, the GPS systems onboard the survey vessels were used. The vessel, acting as a mobile tide gauge, would collect data while floating in the vicinity of the buoy for at least 1-hour. This data was then processed using POSPac MMS and reduced to the waterline and compared to the final buoy water surface elevations. These vessel floats were also conducted during each deployment and recovery operation to serve as opening and closing checks. The vessel float observation used identical methods as those observed at the NWLON station at Lewisetta, the tertiary gauge established at Ewell and the radar gauge at Green 1.

The buoy has one centimeter increment draft marks painted on each the side of the hull. These marks allow for the determination of the GPS antenna height above the water surface. The waterline was recorded relative to these marks when the buoy was deployed, and during each visit to monitor the buoy. The mass of the buoy remained constant for the entire duration of the deployment, thus the water line did not change. The waterline in all cases was at the buoy vertical reference, which coincides with the flange joining the two halves of the hull.

4.3.b GPS Buoy Buffer Overflow and Data Gaps

The Watchman 500 DCP was heavily taxed by the amount of data to log. The system uses a buffer to capture streaming data while it records information to the flash card. Unfortunately, the system could not capture data quickly enough as the number of satellites increased (approximately 10). As a result, the buffer overflowed causing a loss of data. This affected both the raw GPS observables/ephemeris data as well as tilt information.

As the batteries did not have enough capacity to last for the entire duration of the deployment, a data gap of 8 hrs 34 minutes occurred on July 23, 2010 while the buoy was temporarily retrieved to charge the batteries. The second longest gap of 3 hrs 47 minutes was on August 5, 2010 due to several corrupt files. Other data gaps included: 1 gap longer than 1 hour; 24 gaps longer than 30 minutes and less than 1 hour; and 81 gaps longer than 1 minute and less than or equal to 30 minutes.

4.3.c Data Processing

Raw GPS observables were processed in NovAtel's GrafNav version 8.30 software using Post Processed Kinematic (PPK) techniques. The precise ephemeris, clock and IONEX models were also used in the solution. Data from the DEA GPS base station at AIRD was used to compute corrected antenna positions in single-base mode using the NAD83 (CORS96 Epoch 2002) datum as the reference. The baseline length was approximately 16 km.

The raw data collected on the buoy was first converted to GrafNav compatible GPB format. The 668 files (5.52 GB) logged during the first deployment were converted from Trimble Real Time format (RT17) to GPB using the GNSS Converter utility in GrafNav. These files were then merged into 64-file blocks to be processed, with each block spanning approximately 3 days (710 MB). Due to the large file sizes, and several limitations in GrafNav, the entire deployment could not be processed at once. GrafNav projects were created for each block of data and processed separately.

The raw base station data was converted from Trimble internal T01 format to RINEX using the Trimble RINEX utility then to GPB using the GrafNav converter. The daily files logged at the base station were then merged into a 3-day block that spanned same time period as the corresponding the rover data file. Since the base data was collected at 1 Hz, it was then re-sampled to match the rover data 5 Hz interval in GrafNav.

The NGS antenna model was used for both the base and rover. The offset between the ARP and the water surface constituted the effective antenna height, and lever arm to be used in the application of the tilt measurements.

Processed data from GrafNav was brought into Caris HIPS version 7 for application of the tilt data. HIPS also provided excellent data visualization tools for quality control and manual editing. An ASCII export was formatted out of GrafNav and imported to HIPS using the Generic Data Parser.

The tilt data logged by the Watchman 500 was reformatted to a structure that could be merged onto the data in Caris. The compass, pitch and roll values were aligned by time and imported into the HIPS data using the Generic Data Parser.

Once all the data had been brought in, the water surface height was computed. The buoy tilt sensor measures angular orientation in two axes: pitch and roll. Heading is measured, but not required as the direction of the combined tilt is irrelevant. To determine the effect of buoy pitch and roll on the height of the antenna relative to the water surface, a combined value of tilt was computed that is independent of direction. The angular tilt value was then applied to the lever arm of the antenna height above the water line to determine the difference in height due to buoy orientation.

Due to the buffer overflow during acquisition, there were not only GPS observables missing, but also gaps in the tilt data. These ranged from less than a second to several minutes in some cases. There were also issues with the timing of the tilt sensor data. The PNI sensor is a separate board and is not time synchronized with the Watchman 500. The Watchman 500 is synchronized with the GPS clock every hour to keep the absolute time accurate. This resulted in some drift between the tilt sensor's internal oscillator and the Watchman 500 over the course of the deployment. The combined latency between the message recovery from the buffer/decoding/storage and the time discrepancy lead to many messages falling on either side of the 1-second boundary for the logging interval. No data was lost; however, the result was that the frequency of the tilt data appeared to be 4 Hz one second, then 6 Hz the next. It could not be determined which integer second the extra reading belonged to due to the message format. As a result, the data was read-in as it was logged, creating some time periods with data that bounced between update rates. This created an additional apparent fluctuating latency in the tilt data. As the effect of the tilt data, particularly on the order of 0.1 second increments, was negligible, this was deemed acceptable.

The primary use of the tilt data is to remove the effects of large or long-term constant pitch/roll angles. As the antenna height above water will always be decreased due to tilt, resolution of this component is important if there are constantly present significant biases. Heave is a much larger contributor to the vertical displacement than the instantaneous tilt. The heave can be, in the simplest case averaged out; however any large or significant long term bias in tilt will result in an offset in the height that cannot be removed without reasonably accurate application of the angles to the lever arm. A small timing error will not adversely affect the overall result since the direction of the correction is the same, regardless of angle (lower antenna height).

Figure 9 shows a representative plot of data on a calm day with the exception of a wave event that passed through. The disturbance is apparent in both pitch and roll data as well as computed GPS height.

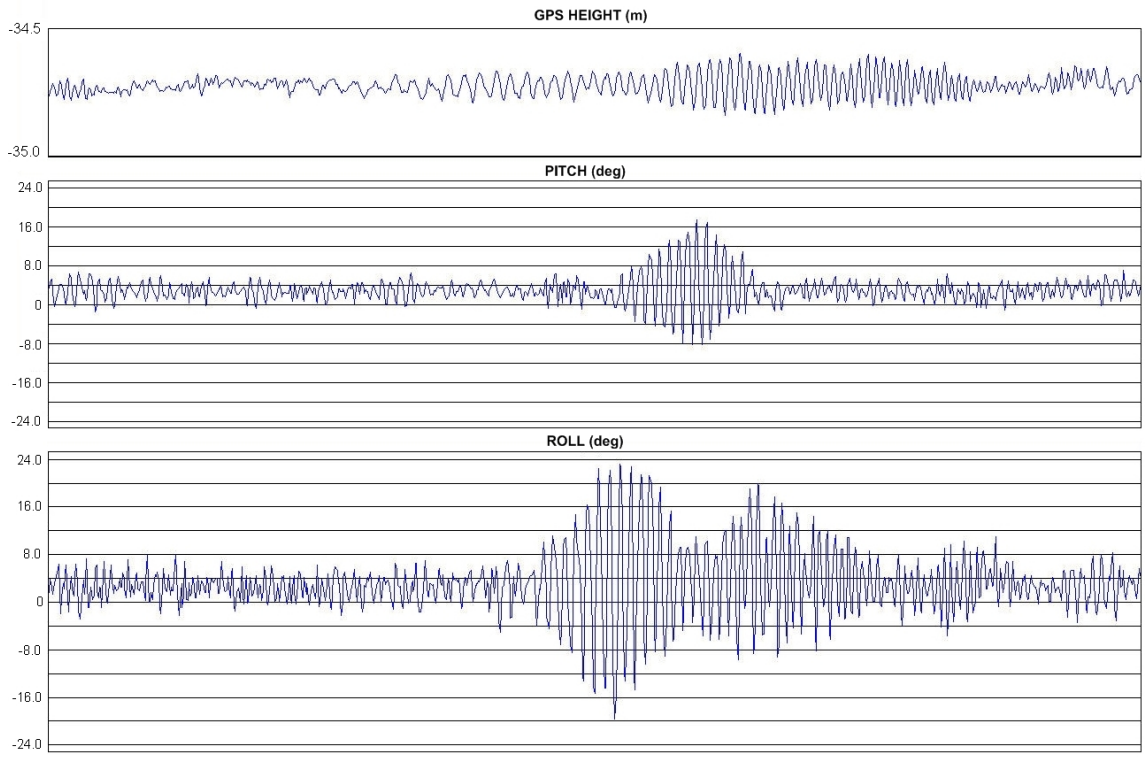

Figure 8: Plot of wave event at buoy during calm weather

Also seen in Figure 9 is a constant bias in the angular data. This is due to an apparent imbalance of the buoy- the three rectangular batteries and additional power box create a list when the buoy sits in the water that was not present with the circular battery platters used with the non-rechargeable configuration. Although the offset was negligible, the tilt sensor data worked well to correct for this. For an average of 4 degrees of roll and 3 degrees of pitch, the tilt would be approximately 5 degrees leading to a vertical correction of -0.001 m.

The standard deviation of the height solution and the GrafNav quality factor were used to determine the quality of the data: The quality factor is an indicator of a fixed integer, floating or invalid solution. These parameters were used to remove outliers from the 5 Hz time series. All solutions with a standard deviation greater than ten centimeters or a quality factor that was not a fixed integer were excluded from the processing.

The resulting solutions from GrafNav were decimated to 1 HZ to allow processing in MATLAB then filtered using a 3rd order Butterworth filter with a cut off frequency of 11 cpd. Considering the majority of the energy in a tidal signal is around the 2 cpd a cut off frequency of 11 cpd will easily retain the primary signal. The filtering was accomplished in MATLAB using the 'filtfilt' function which filtered the data in both a forward and reverse direction to minimize phase distortion. Outliers in the buoy data are the result of both noise and wave induced buoy vertical motion (heave) and were removed during the filtering process. The Butterworth filter removed a

significant amount of the higher frequencies that would have been preserved by a six-minute averaging filter.

The following two plots (Figure 10 and Figure 11) show two different days of filtered GPS Buoy data and their comparison to the verified data for the Lewisetta NWLON (shown in light blue). These two days were chosen because they show examples of "good" and "bad" data. The first plot shows data from July 12, 2010. On this day there were two gaps that were filled using the MATLAB Spline interpolation function. The primary duration of interest is from approximately 07:00 to 08:30 UTC. During this period of time there appears to be a vertical shift in the PPK solutions. This shift is not filtered out completely. In fact the sharp drop appears to create a sharp response in the filter that intensifies the inflection point at that high water. A similar although somewhat less dramatic event occurs from 18:00 to 19:00 UTC. On this occasion the result of the shift is that there are two high water inflection points with each one occurring on opposite sides of the time of the high water observed at the Lewisetta NWLON.

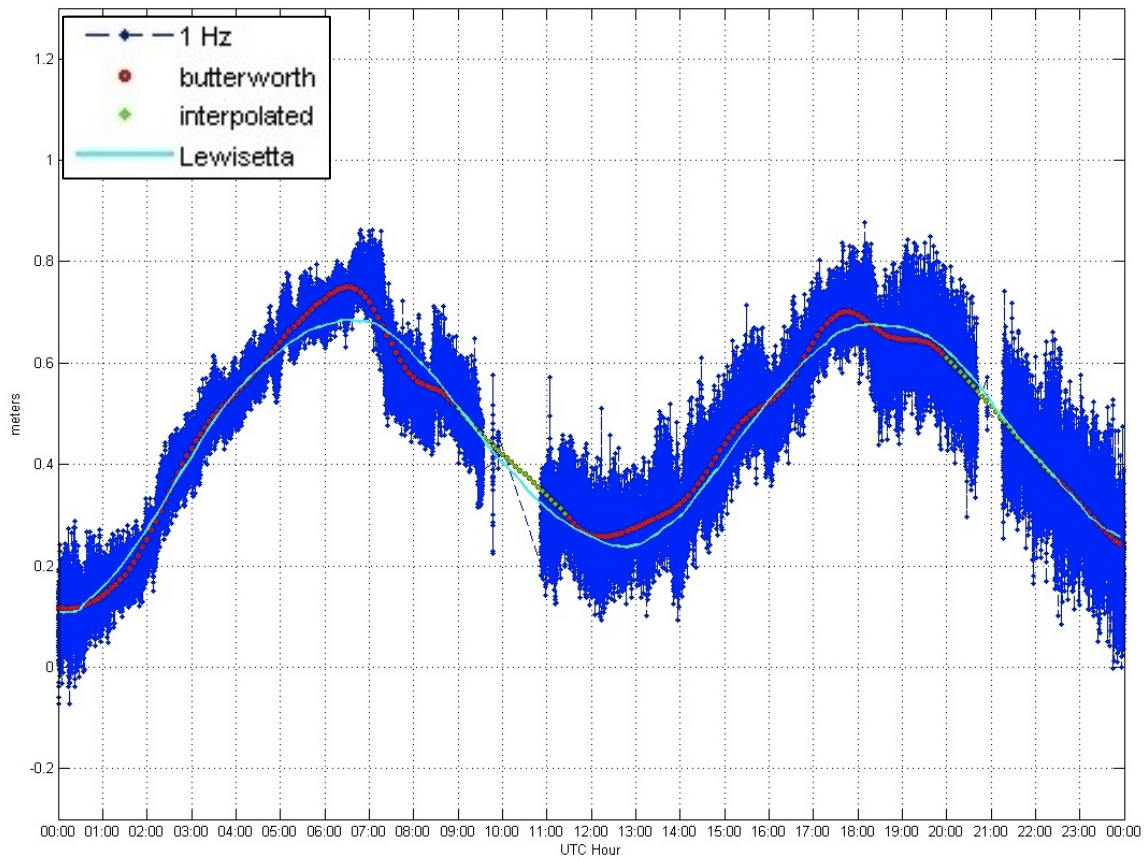

Figure 9: Comparison of unfiltered and filtered data on July 12, 2010

This may suggest that the cutoff frequency used in the filter was too high and a lower one would reduce these sharp and additional inflection points. However, the Figure 11 shows a very good example of a sharp high water inflection point observed at the Lewisetta NWLON that is also appropriately represented in the filtered PPK solutions. The specific event of interest occurs between 17:00 and 22:00 UTC on July 29, 2010. During this time PPK water levels from the

GPS buoy become more erratic and after 22:00 UTC on that day the range of the PPK solutions increases from 30 cm to 60 cm. At that time there is a distinct event in the Lewisetta water levels and they increase by 10 cm in less than an hour, which is a substantial increase considering it took close to 6 hours for the water level to increase the 50 cm from the low water to the high water earlier in the day. The interesting part is that even though the range of the PPK solutions almost doubles during that time the filter results represent the event well. Granted there are several additional inflection points in the filtered PPK solutions leading up to that time that are not in the Lewisetta data.

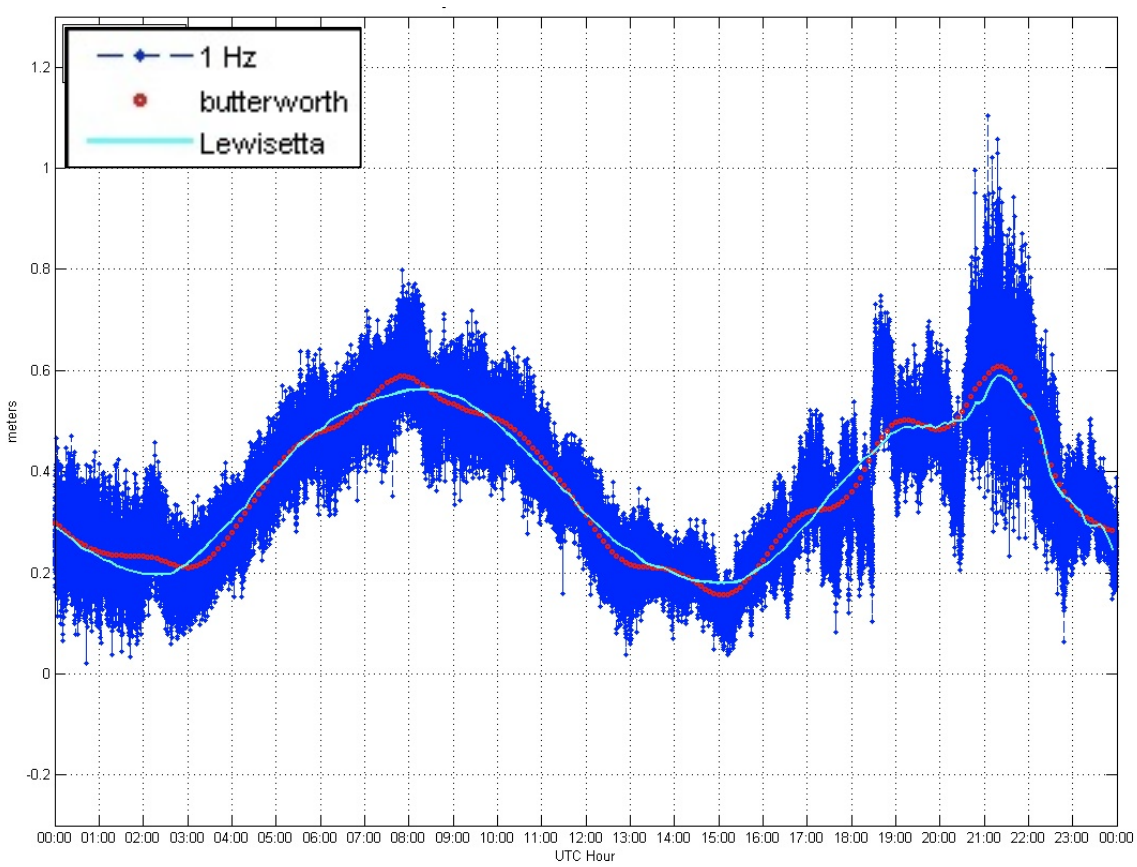

Figure 10: Comparison of unfiltered and filtered data on July 29, 2010

This consideration of inflection points is of particular interest since the tidal computations are driven by the observed high and low water levels thus increases or decreases of the height of the inflection points will affect the computed tidal range. This will then propagate through to the final datum planes as is shown by the equations below:

MLW = MTL – (0.5*Mn)
MHW = MLW + Mn
MLLW = DTL – (0.5*Gt)
MHHW = MLLW+Gt

Where Mn (Mean Range) and Gt (Great Diurnal Range) are two measures of tidal range and are required for the computation of tidal datums. Another affect, not having to do with range, is time. As was pointed out earlier in the first of these two plots there are two inflection points resulting from the filtered PPK solutions that are around the time of the observed high water at Lewisetta. If the inflection points are real then there is no problem but if they are induced by either the filter or the GPS data the actual time of the high or low water would not be accurately recorded and time offsets derived from Tide-by-Tide simultaneous comparisons would be incorrect.

The MATLAB Spline interpolation handled most all of the gaps appropriately. There were no major divergences in comparison to the Lewisetta data except for over the 8 hour gap on July 23, 2010. Figure 12 shows how the interpolation function clearly could not handle a gap that long.

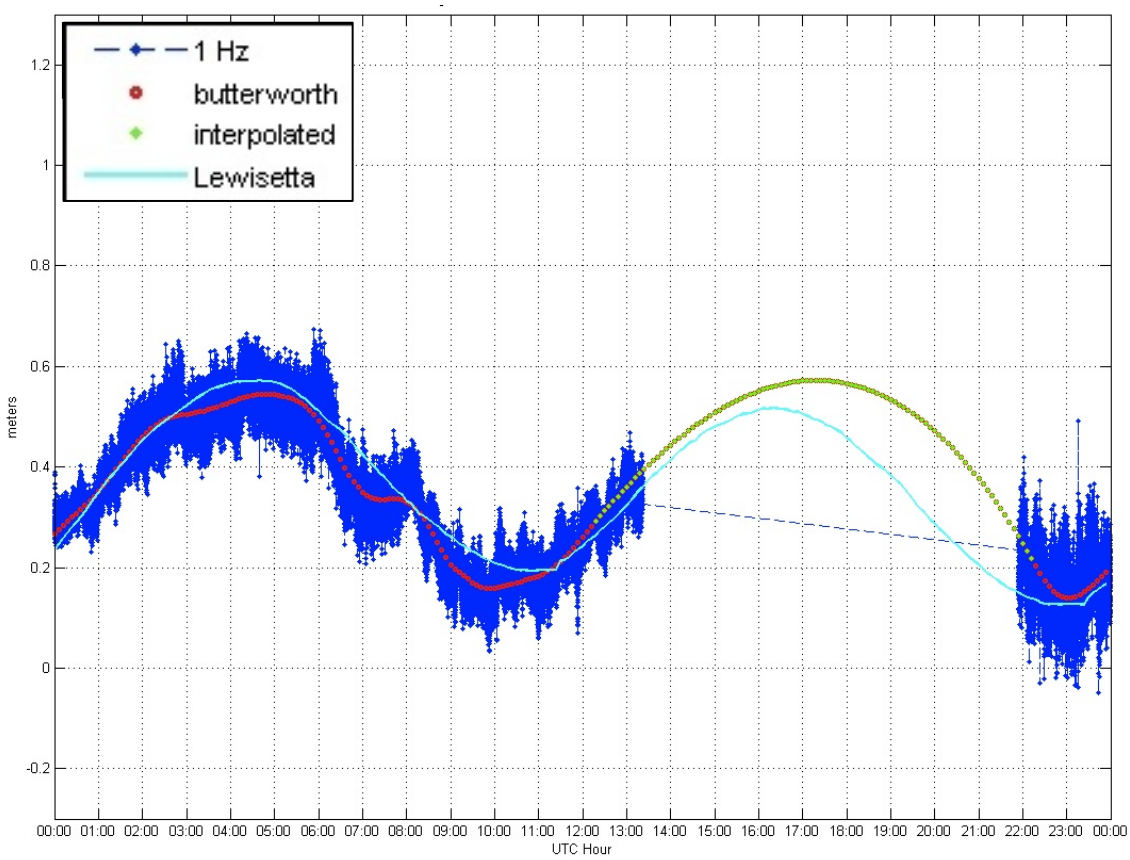

Figure 11: Comparison of 1 Hz and interpolated buoy data on July 23, 2010

4.3.d Evaluation of GPS Buoy Data to other methods

During each deployment and recovery operation with the buoy, GPS data was collected on the survey vessels in the vicinity. Theses floats were designed to serve as a method to verify the accuracy of the post-processed buoy data similar to a staff reading at a conventional tide gauge. Figures 13-15 show a graphical representation of the results while Tables 17-19 present the 6-minute data and differences.

Table 17: July 6, 2010 GPS Buoy to GPS Vessel Float and Lewisetta, VA (863-5750) NWLON Water Level Comparison

July 6, 2010 (MLLW)					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water level (m)	Lewisetta Gauge (m)	Difference to Vessel (m)	Difference to Gauge (m)
20:00	0.079	0.145	0.16	0.066	-0.015
20:06	0.105	0.086	0.162	-0.019	-0.076
20:12	0.109	0.086	0.167	-0.022	-0.081
20:18	0.108	0.112	0.172	0.004	-0.060
20:24	0.116	0.095	0.178	-0.021	-0.083
20:30	0.126	0.106	0.184	-0.020	-0.078
20:36	0.146	0.145	0.191	0.000	-0.046
20:42	0.118	0.190	0.198	0.073	-0.008
20:48	0.154	0.204	0.206	0.050	-0.002
20:54	0.142	0.149	0.214	0.008	-0.065
		Mean		0.012	-0.051
		Standard Deviation		0.037	0.032

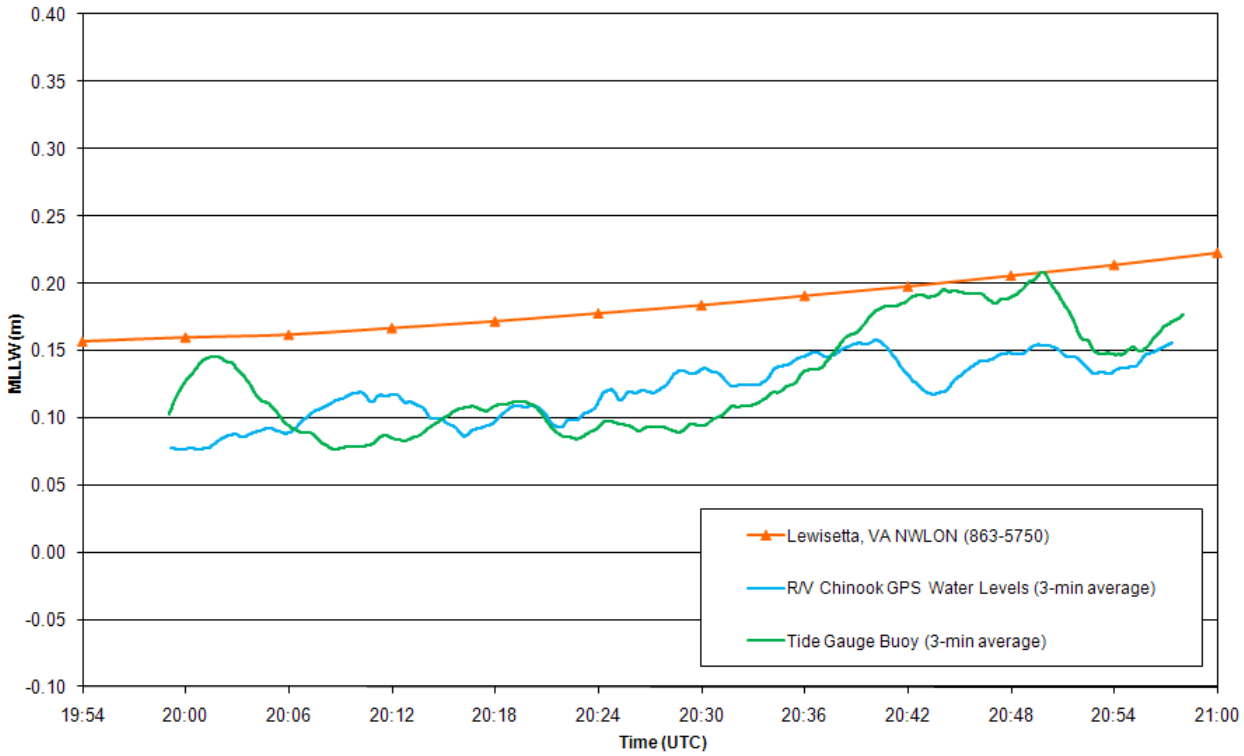

Figure 12: Comparison of values from the GPS buoy, R/V Chinook tide float and Lewisetta gauge on July 6, 2010

Table 18: July 23, 2010 GPS Buoy to GPS Vessel Float and Lewisetta, VA (863-5750) NWLON Water Level Comparison

July 23, 2010 (MLLW)					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water level (m)	Lewisetta Gauge (m)	Difference to Vessel (m)	Difference to Gauge (m)
12:00	0.189	0.203	0.242	0.015	-0.039
12:06	0.192	0.225	0.252	0.034	-0.027
12:12	0.177	0.242	0.257	0.066	-0.015
12:18	0.185	0.242	0.263	0.056	-0.021
12:24	0.194	0.197	0.273	0.003	-0.076
12:30	0.209	0.187	0.281	-0.022	-0.094
12:36	0.221	0.237	0.288	0.016	-0.051
12:42	0.242	0.265	0.296	0.023	-0.031
12:48	0.255	0.241	0.305	-0.014	-0.064
12:54	0.239	0.288	0.314	0.049	-0.026
13:00	0.261	0.295	0.323	0.034	-0.028
13:06	0.266	0.306	0.332	0.040	-0.026
13:12	0.286	0.272	0.344	-0.013	-0.072
		Mean		0.022	-0.044
		Standard Deviation		0.028	0.025

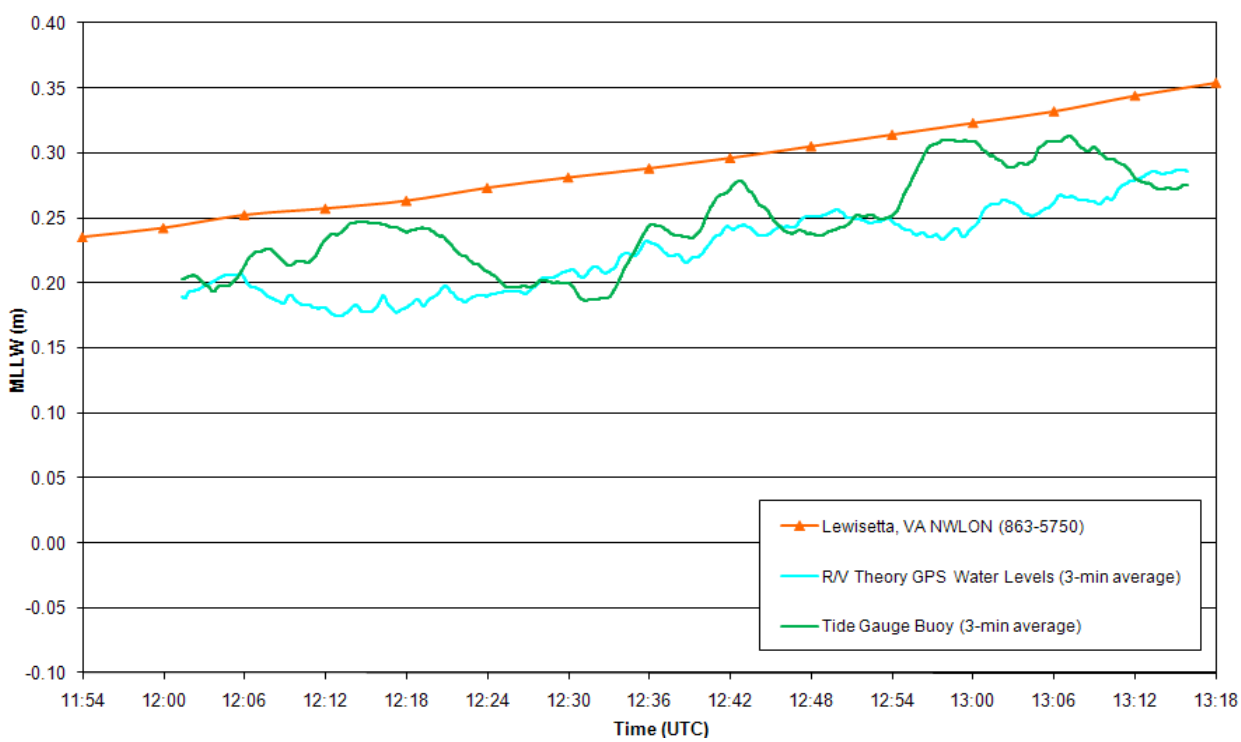

Figure 14: Comparison of values from the GPS buoy, R/V Theory tide float and Lewisetta gauge on July 23, 2010

Table 19: August 6, 2010 GPS Buoy to GPS Vessel Float and Lewisetta, VA (863-5750) NWLON Water Level Comparison

August 6, 2010 (MLLW)					
Time (UTC)	Vessel GPS Water Level (m)	GPS Buoy Water level (m)	Lewisetta Gauge (m)	Difference to Vessel (m)	Difference to Gauge (m)
19:42	0.114	0.062	0.104	-0.052	-0.042
19:48	0.115	-0.011	0.101	-0.126	-0.112
19:54	0.125	-0.045	0.096	-0.170	-0.141
20:00	0.175	0.047	0.090	-0.128	-0.043
20:06	0.125	0.070	0.086	-0.056	-0.016
20:12	0.117	0.082	0.083	-0.035	-0.001
20:18	0.110	0.119	0.081	0.009	0.038
20:24	0.137	0.205	0.079	0.068	0.126
20:30	0.223	0.182	0.079	-0.041	0.103
20:36	0.204	0.121	0.080	-0.083	0.041
20:42	0.126	0.111	0.080	-0.015	0.031
20:48	0.279	0.086	0.082	-0.193	0.004
20:54	0.223	0.067	0.082	-0.156	-0.015
		Mean		-0.075	-0.002
		Standard Deviation		0.076	0.075

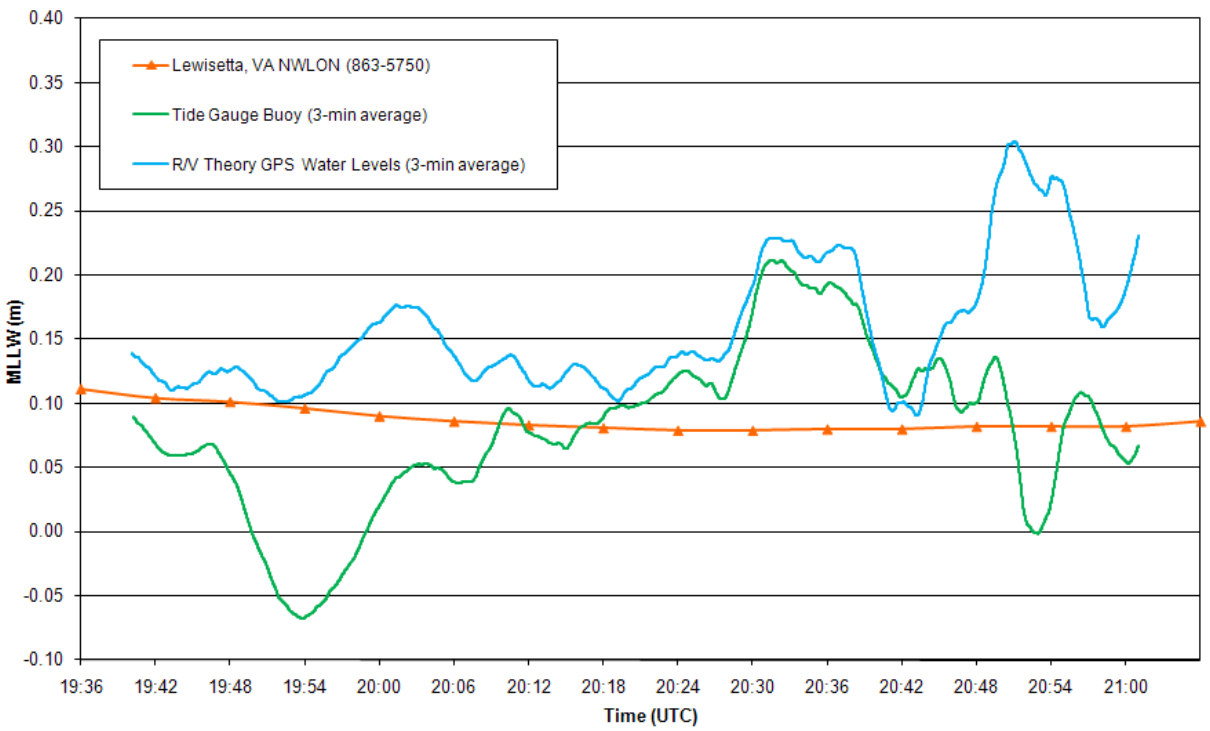

Figure 15: Comparison of values from the GPS buoy, R/V Theory tide float and Lewisetta gauge on August 6, 2010

Table 20 summarizes the results of all vessel floats and the sea state at the time of collection.

Table 20: Summary of vessel float results

Vessel	Day	Duration	Mean Buoy Difference (m)		Weather
			Vessel	Gauge	
Chinook	187	00:54	0.012	-0.051	Sea state = 0 foot waves Wind Speed = 0 knots
Theory	204	01:12	0.022	-0.044	Sea state = 0 foot waves Wind Speed = 0 knots
Theory	218	01:12	-0.075	-0.002	Sea state = 1 foot waves Wind Speed = 10 knots

Note that the results from the first two floats (Tables 17 and 18, Figures 13, and 15) show an apparent bias of approximately 4 to 5 centimeters, with the GPS results lower than the gauge readings for both the buoy and the vessel. This is attributable to the difference in the GEOID09 model from the gauge to the buoy location. The buoy was situated as close to the gauge as possible, but was still approximately 800 meters east. The GEOID model difference of -3.3 centimeters (shown in Table 21) is coincident in direction and magnitude to the differences between the GPS derived water levels and the gauge derived water levels.

Table 21: GEOID09 model separation values

Location	Latitude	Longitude	NAD83, CORS96 Epoch 2002 -> NAVD88 Separation (m)
Lewisetta, VA NWLON (863-5750)	37/59/42.0 N	76/27/48.0 W	34.890
Deployment 1 (857-0005)	37/59/39.2 N	76/27/15.0 W	34.923
		Difference	-0.033

The final float observation conducted on August 6, 2010 (DN218) shows a larger height difference when compared to the verified gauge readings than the other floats. Both the buoy and the vessel GPS determined height values deviate from the gauge readings by 10-20 centimeters in some cases. This is most likely caused by an atmospheric event during the time period. Atmospheric effects can be problematic when processing over long baselines. Although the dual frequency single and smart base solutions attempt to correct for variations, any large disturbances in the troposphere or ionosphere cause degradation in positioning accuracy. Local tropospheric disturbances could be caused by such events as thunderstorms while ionospheric variations can be the result of solar activity.

During the time of the float observation, the GPS base stations in the area also exhibited a degradation in accuracy. As a way to quantify this, the data from the AIRD station and the

closest CORS station (MDSI) was post-processed using GrafNav PPK methods (a similar engine to the POSPac processing without the inertial component). MDSI was set as the base and AIRD as the rover (1 second update rate). From Table 6, the published elevation of the AIRD ARP is -22.567 m. Figure 16 shows the plot of elevation over time at AIRD.

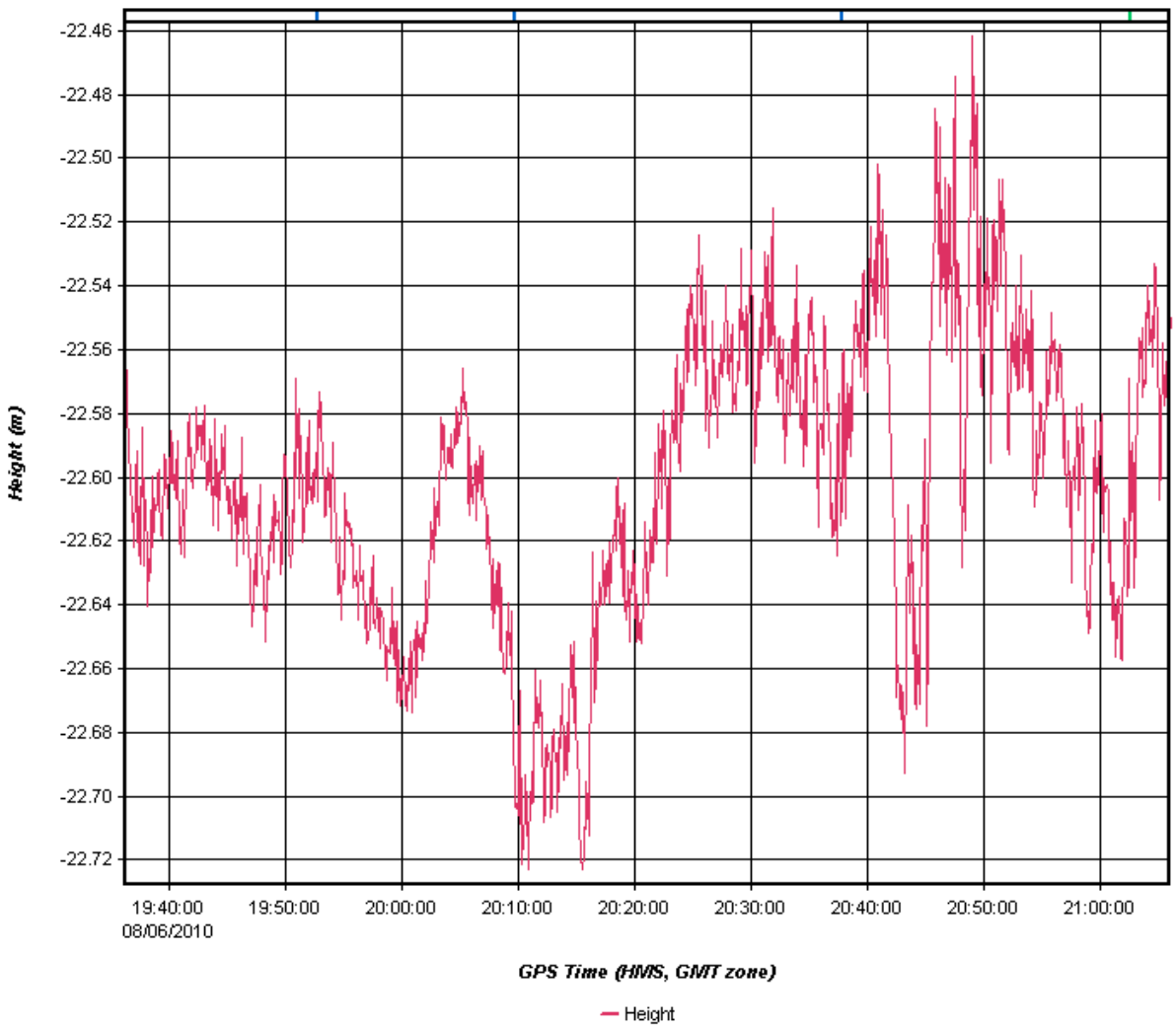

Figure 16: Data fluctuations at AIRD station

The variations in the AIRD station seen above coincide with the elevations spikes in the post-processed vessel data, particularly between 20:40 and 21:00. This likely indicates a period of poor atmospheric conditions in the area or impacts from GPS testing at Naval Air Station Patuxent River.

4.3.e Datum Computations

Datums were computed using the TBYT method of simultaneous comparisons. Results and plots from the datum computations can be found in *Appendix E. GPS Buoy Datum Results*. The Lewisetta gauge was used as the control station over the 31 days of data (Table 22). The values for the Lewisetta datum planes were adjusted to the station datum of the GPS buoy (NAD83, CORS96, Epoch 2002) by using the published NAVD88 elevation of STND at Lewisetta. STND

at Lewisetta is 1.707 m below NAVD88 (CO-OPS published value). The GEOID09 separation between NAVD88 and the reference ellipsoid at the primary bench mark (R 462) at Lewisetta is -34.888 m. Therefore, the conversion from Lewisetta STND to NAD83, CORS96, Epoch 2002 is -36.595 m.

Table 22: GPS Buoy Deployment 1 (857-0005) Preliminary Datum Plane Comparison

	GPS Buoy Deployment 1 Preliminary Datum Planes (m)	Lewisetta, VA Published Datum Planes (m)	Difference (m)
MHHW	-34.765	-34.682	-0.083
MHW	-34.806	-34.725	-0.081
DTL	-35.001	-34.912	-0.089
MTL	-35.004	-34.915	-0.089
MSL	-35.000	-34.910	-0.090
MLW	-35.203	-35.105	-0.098
MLLW	-35.238	-35.141	-0.097
GT	0.473	0.458	0.015
MN	0.397	0.379	0.018
DHQ	0.041	0.043	-0.002
DLQ	0.035	0.036	-0.001

When compared to the VDatum results, the MLLW datum of the Lewisetta station was adjusted by the difference introduced by the GEOID09 model due to the location of the buoy and the NWLON station (Table 21). The preliminary datum computed at the GPS buoy deployment 1 location was 6.4 centimeters below the adjusted Lewisetta MLLW datum plane and 7.1 centimeters below the VDatum model value (Table 23).

Table 23: GPS Buoy Deployment 1 Preliminary MLLW Datum Plane Comparison

GPS Buoy Deployment 1 (857-0005)	
Datum	STND (NAD83)
MLLW (CO-OPS Published at Lewisetta adjusted for GEOID09 difference to buoy location)	-35.174 m
MLLW (Preliminary TBYT)	-35.238 m
MLLW (VDatum GEOID09)	-35.167 m

5.0 Analysis of VDatum Test Lines

A series of VDatum test lines have been processed and reduced to MLLW using both ERS methods and traditional discrete zoning. The intent of these lines, which are required by the Project Instructions, is to provide a baseline in which to compare results of the two sounding reduction techniques. The VDatum test lines consist of a subset of preplanned mainscheme and crosslines which run perpendicular to the maximum slopes of both the geiod and the zoning range correctors.

5.1 Processing Methods

Integrated vessel attitude and Global Satellite Navigation System (GNSS) data were post-processed using the Applanix POSPac MMS SmartBase option. The SmartBase network was created from National Geodetic Survey (NGS) Continuously Operating Reference Stations (CORS) CORB, DEDS, HNPT, MDSI, VAGP, VAWI, and VIMS as well as the DEA installed sites Ewell and AIRD. After overriding the control station position and ellipsoid height with NAD83 coordinates the SmartBase Quality Check utility was run to evaluate data quality of the GPS reference stations and to perform a network adjustment of the remaining stations. If results indicated a station location outside the allotted 10-centimeter accuracy for position of the constrained network, the station was disabled. Base station positions were never adjusted when generating the SmartBase solution.

For both datasets (ERS and discrete zoning) data processing followed the typical Caris HIPS CUBE (Combined Uncertainty Bathymetric Estimator) workflow with integration of SBET data through the HIPS load Attitude and Navigation tool. Applanix POSPac MMS was used to produce an Inertially Aided Kinematic Ambiguity Resolution (IAKAR) navigation solution relative to NAD83 (CORS96, Epoch 2002) and well as real time error estimates. All available post-processed navigation, attitude, and error parameters (Navigation/Position, Gyro, Pitch, Roll, and GPS Height/Down) were applied to the ERS versions of the survey lines. All parameters except Down RMS were applied to the zoned version of the survey lines. Down RMS was excluded in order to facilitate the proper computation of total propagated vertical uncertainty (TPVU).

The file name convention of all delivered HIPS survey lines follows the Hypack CHS format which uses a thirteen character structure incorporating year, the first two letters of the survey vessel name, Julian day number, and year (e.g. 2010CH2061402). A suffix has been appended to each survey line to indicate the method of datum reduction. The suffix _SmartBase indicates that the survey line uses ERS methods with SmartBase post-processing while the suffix _Zoned indicated that the survey line uses discrete zoning with NOS verified water levels.

GPS water levels from the POSPac SBET solutions were computed for the ERS version using the HIPS Compute GPS Tide dialogue. During this step the NAD83 to MLLW model file (Potomic.bin) created by DEA was selected as well as options necessary to apply HIPS water line offsets and to remove heave and dynamic draft from the GPS signal. The bin file was created with the aid of VDatum using GEOID09 and the Chesapeake Bay are version 1. During the HIPS Merge process GPS Tides are applied and the waterline, heave, and dynamic draft correctors

applied during the GPS tide computation are backed out. With all correctors applied, depths were reduced to MLLW. Figure 17 shows the basic ERS processing workflow. This same methodology will be used for all project OPR-E349-KR-10 survey deliverables if permission is granted to use ERS methods in place of traditional discrete zoning.

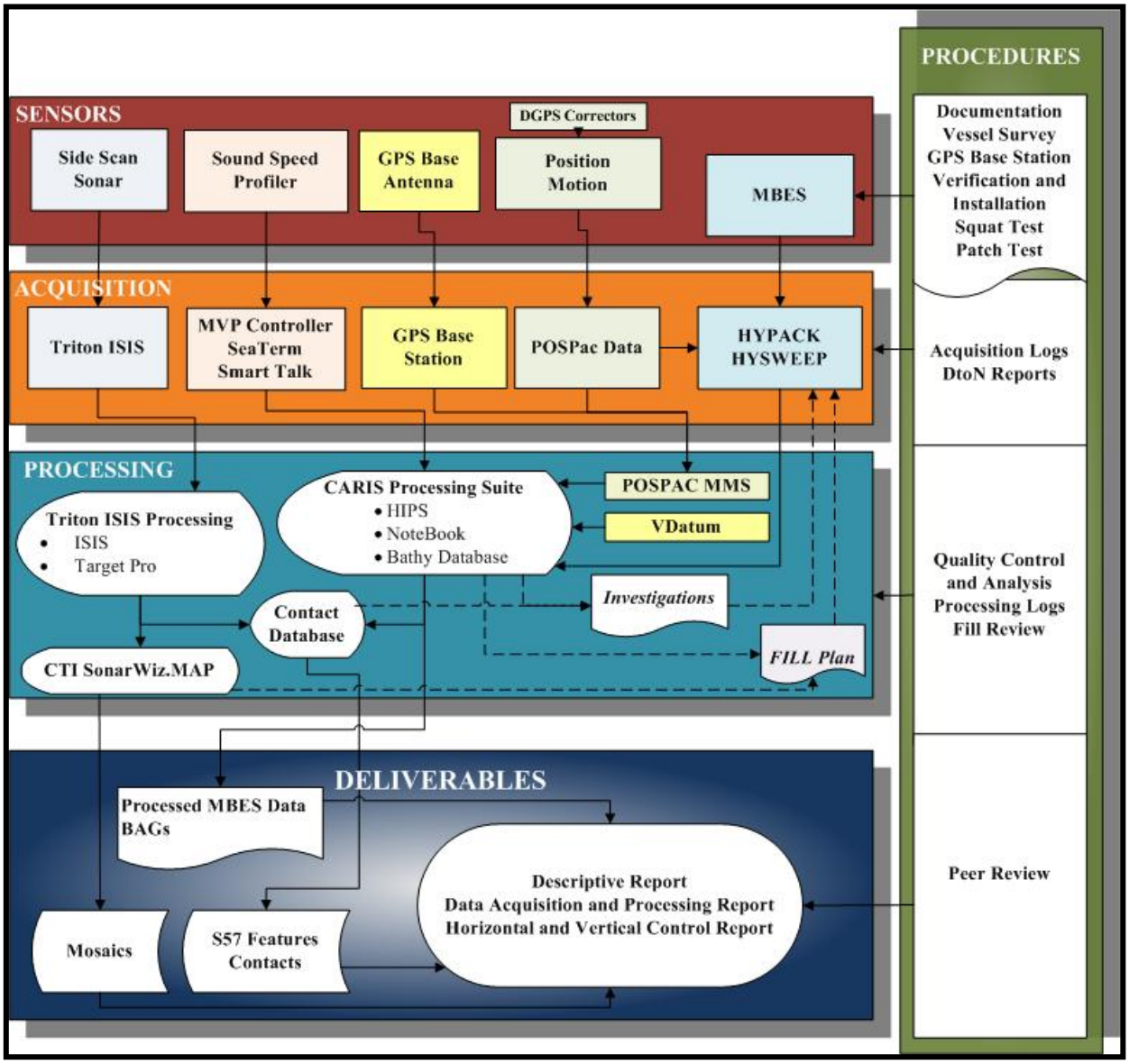

Figure 17: Workflow for GPS Water Levels

The zoned version of the survey lines followed a similar workflow. Data were reduced to MLLW using a HIPS Zone Definition File (ZDF) rather than the VDatum model file. The zoning scheme E349KR2010CORP_Rev_1s.zdf used to correct the data is a modified version of the scheme supplied with the project instructions. The modified file used a HIPS Interval value of 1 second rather than the default value of 360 seconds which was used in the file received by DEA. The interval value controls the frequency of tide zoning interpolation. The default value of 360

seconds is too infrequent to properly correct for the assigned zoning boundaries where it would be possible for the survey vessel to pass through a zone without a zoned tide corrector being applied if the vessel was not within the zone boundary for longer than 359 seconds. Using a one second interval value is also more appropriate when evaluating the performance of zoning correctors since the longer default interval has the potential to mask zoning artifacts at zone boundaries.

Table 24 lists the inputs entered into the Caris HIPS Compute Total Propagated Error (TPE) dialogue for each version of the data.

Table 24: Differences between GPS Water Levels and Zoned Tides

Parameter	ERS	Zoned
Tide Value Measured (m)	0.000	0.000
Tide Value Zoning (m)	0.100[1]	0.066[2]
Sound Speed Measured (m/s)	1.000	1.000
Surface Sound Speed (m/s)	0.500	0.500

[1] Computed from published values (http://vdatum.noaa.gov/docs/est_uncertainties.html)
[2] Supplied with OPR-E349-KR-10 Tides and Water Levels Project Instructions

5.2 Analysis Methods

Difference surfaces of the VDatum test lines were created over the project area in order to quantify the differences between the two tide correction methods.

Difference surfaces were created between one meter HIPS swath angle surfaces for each survey. HIPS swath angle surfaces were generated using the 1x1 maximum footprint setting to prevent depth interpolation beyond the boundary of each one meter node. The surface differencing analysis used swath angle surfaces in lieu of CUBE surfaces to remove the impact of uncertainty weighting on the final depth estimates of each node. Total propagated uncertainty was computed for both datasets using the appropriate a priori and real-time uncertainties to enable the comparison of both depth and uncertainly differences resulting from the two tide correction techniques. This required the use of two HIPS Vessel Files (HVF) which used the same senor offset information, but with standard deviation values specific to the water level correction technique. Loading, draft, and dynamic draft error estimates were used in the Zoned version of the vessel files while these parameters were zeroed out in the ERS version.

The difference surfaces were created in HIPS Bathy DataBASE 2.3 using the GPS water levels version of a surface as Input Surface 1 and the zoned version as Input Surface 2. The output grid was then exported to American Standard Code for Information Interchange (ASCII) to enable computation of descriptive statistics (Table 25). Positive differences indicate that the zoned tide was greater than the GPS water level.

Table 25: Differences between GPS Water Levels and Zoned Tides

Survey	Minimum (m)	Maximum (m)	Mean (m)	Median (m)	Standard Deviation (m)
H12238	-0.030	0.180	0.062	0.060	0.032
H12239	-0.100	0.100	0.025	0.030	0.030
H12240	-0.110	0.100	0.002	0.010	0.033
H12241	-0.010	0.180	0.076	0.070	0.031
H12242	-0.090	0.180	0.050	0.040	0.047

Figures 18 and 19 display difference surfaces for each of the five survey sheets overlaid on the zoning scheme and the GEOID09 model. A standard difference color map was applied to all of the surfaces in order to aid in the visual comparison of differences. Areas where the zoned tide was greater than the GPS water level are depicted in yellows and reds and areas where the zoned tide was less than the GPS water level are depicted in shades of blues. As evident in both the graphical representation of the differences and the basic descriptive statistics presented in Table 24, both the magnitude and range of the differences increase in on the eastern side of the survey area which suggests there is a strong association between the magnitude of the differences and the distance from the controlling stations at Lewisetta (863-5750). This behavior was also exhibited in past analysis performed under OPR-E349_KR-09.

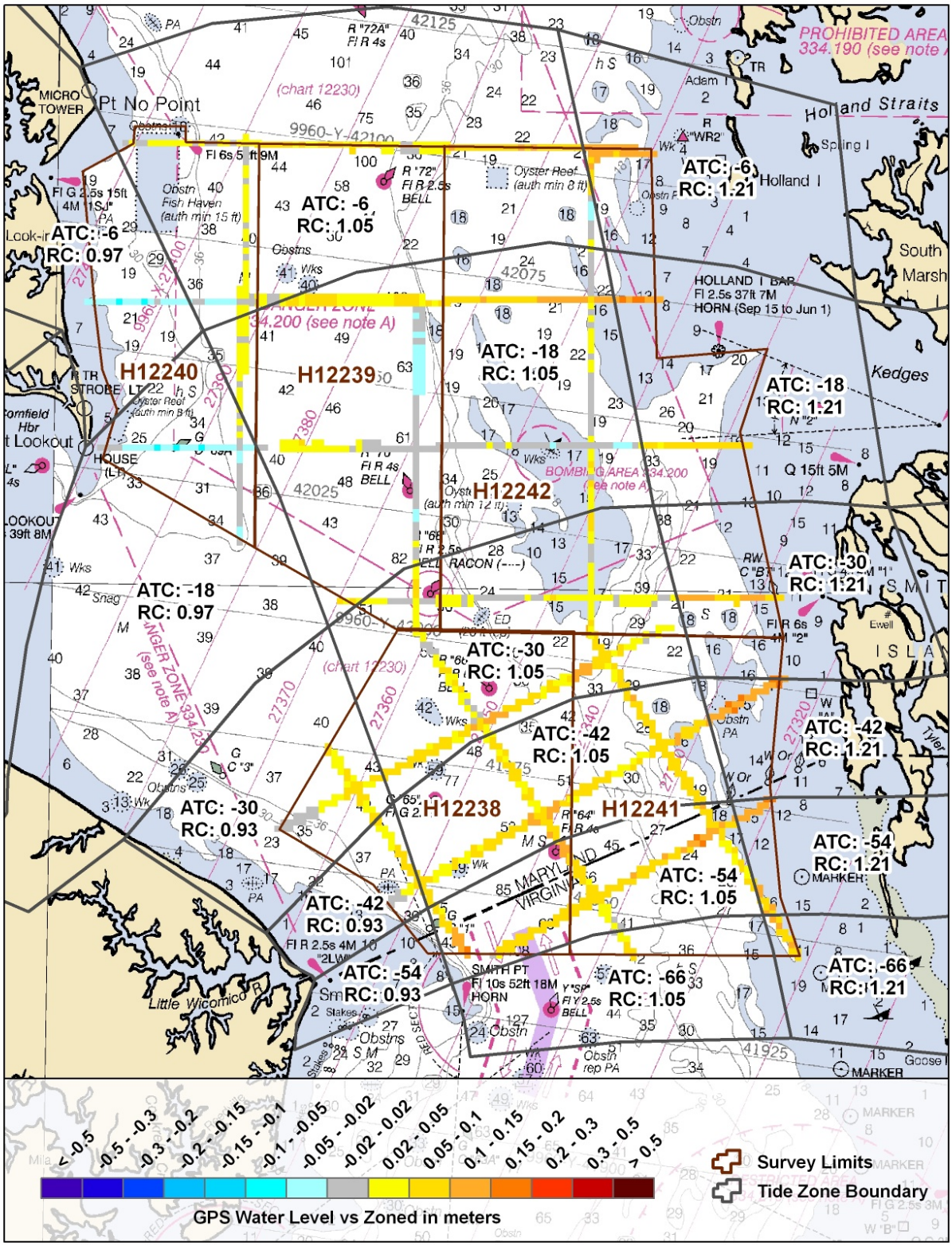

Figure 18: Difference Surface of GPS Water Levels and Zoned Tides with Zoning Scheme

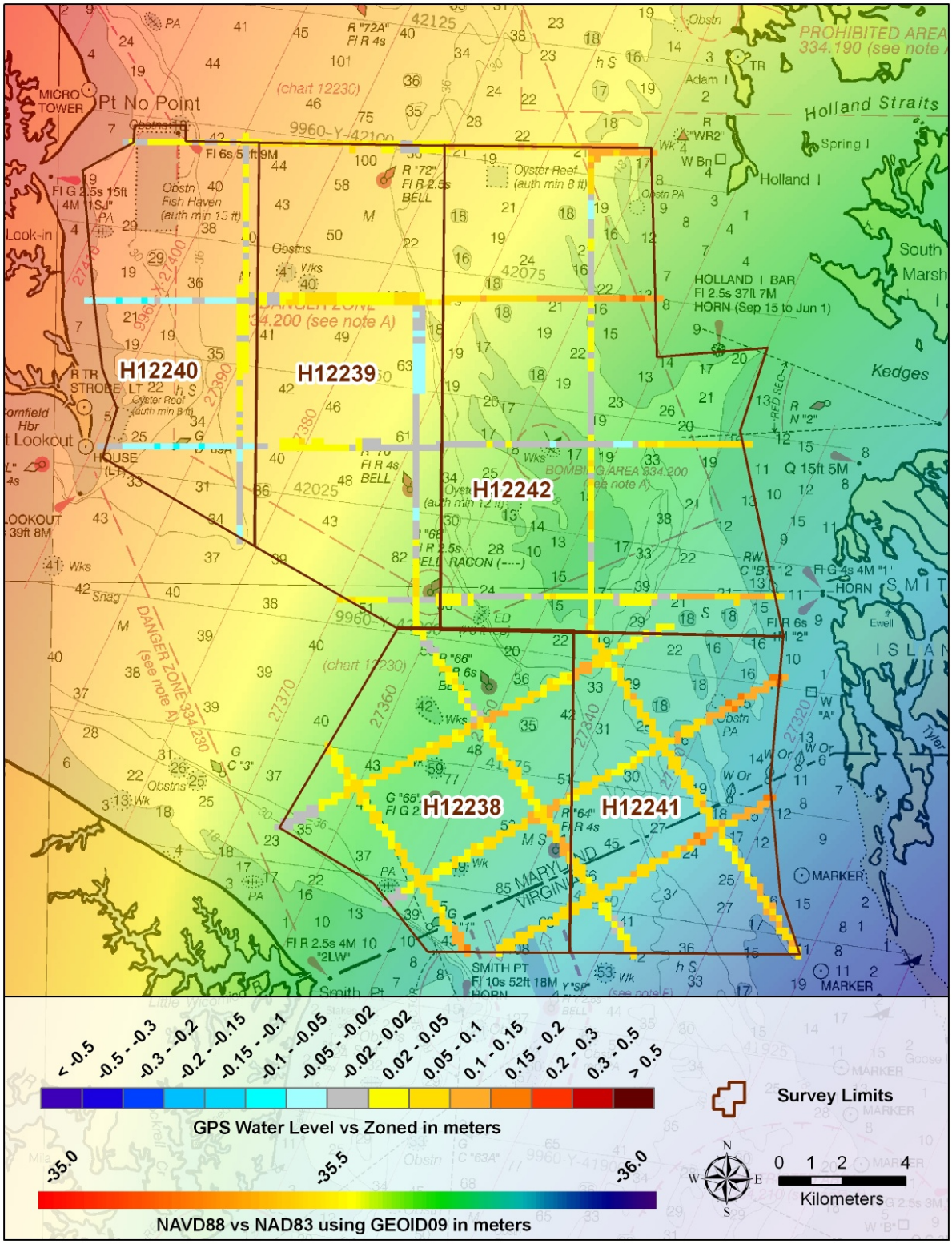

Figure 19: Difference Surface of GPS Water Levels and Zoned Tides with GEOID09

Transitions between zone boundaries are also apparent in the figures as well as in the zoned version of the survey data. A more detailed example is presented if Figure 20 which shows zoned

corrected data in green and GPS corrected data in purple. This is a common artifact caused by the coarse resolution of the range correctors of the zoning scheme. Since range correctors are used to scale the tide, the significance of these artifacts is correlated to magnitude of the tide.

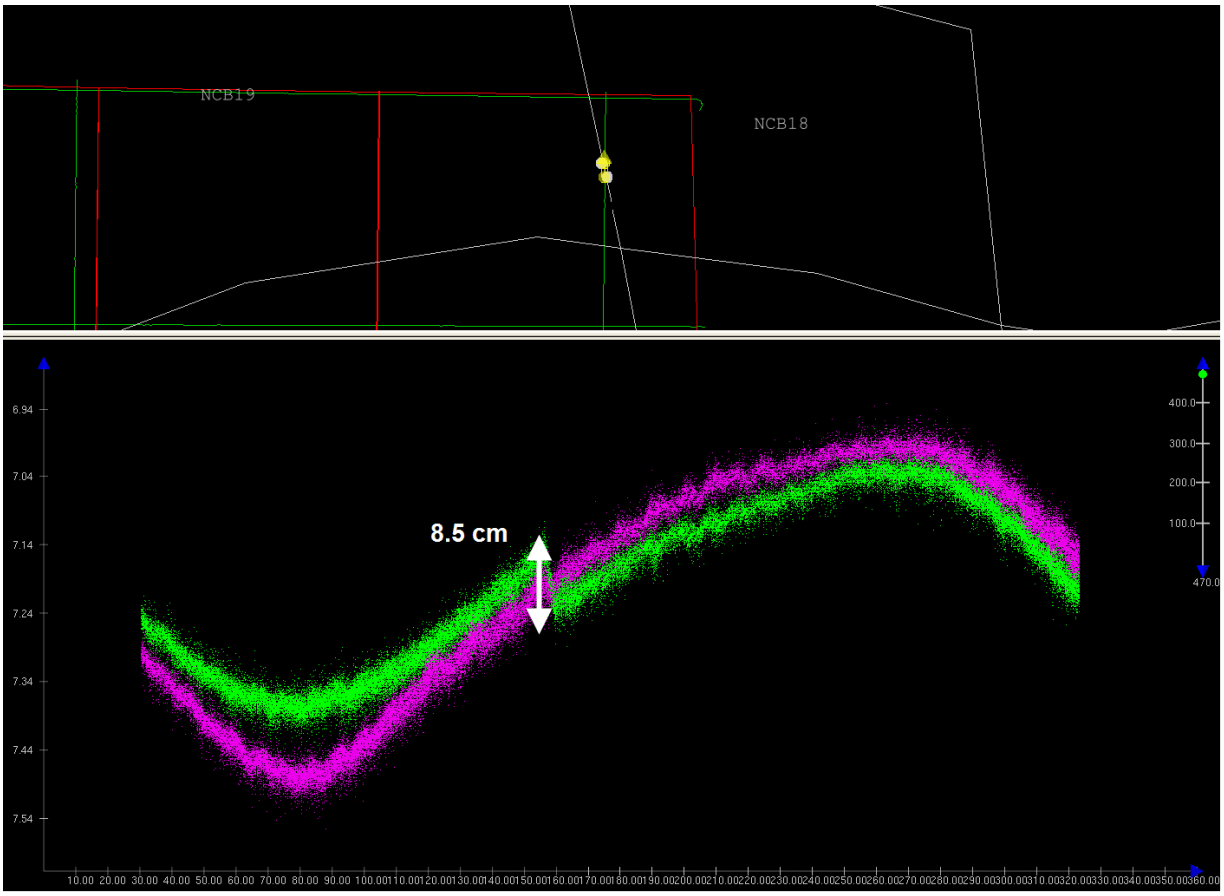

Figure 20: Example of Tide Zone Artifact at Zone Boundary were Green is Zoned Corrected Data and Purple is GPS Corrected Data.

Difference surfaces between crossings of the VDatum test lines were also created to evaluate the performance of each tide correction method. The results of this analysis are presented in Table 26.

Table 26: Differences at VDatum Test Line Crossings

	H12238		H12239		H12240	
	SmartBase	Zoned	SmartBase	Zoned	SmartBase	Zoned
Mean (m)	0.01	0.07	0.04	0.01	0.06	0.07
Median (m)	0.01	0.07	0.04	0.01	0.06	0.07
Standard Deviation (m)	0.047	0.026	0.029	0.026	0.017	0.017
Range (m)	0.4	0.32	0.22	0.26	0.13	0.13
Minimum (m)	-0.2	-0.09	-0.09	-0.12	-0.01	-0.01
Maximum (m)	0.2	0.23	0.13	0.14	0.12	0.12

	H12241		H12242	
	SmartBase	Zoned	SmartBase	Zoned
Mean (m)	0.05	0.07	-0.01	0
Median (m)	0.02	0.07	-0.04	0
Standard Deviation (m)	0.059	0.023	0.066	0.041
Range (m)	0.26	0.17	0.22	0.17
Minimum (m)	-0.08	-0.02	-0.11	-0.08
Maximum (m)	0.18	0.15	0.11	0.09

6.0 Recommendations

Based on the analysis performed to date DEA recommends moving forward with ERS deliverables for this project. The results of the test line analysis show no significant difference between crossline ties with mainscheme data when using either GPS or traditional tidal correctors. It should be noted that these test lines were run under near optimum conditions for using traditional tidal zoning (calm seas, light winds, relatively low tide ranges, etc.). One would expect comparable results when using GPS methods as sea and weather patterns degrade while the traditional tidal zoning would not perform nearly as well. Past experience working in the vicinity of the OPR-E349-KR-10 survey area has shown that there is an issue with high range ratio correctors on the eastern side of the Chesapeake Bay. As water levels increase, larger errors in zoned tides are observed. Further, the application of zoned tides does not adequately correct multibeam data for large kinematic waves, wind driven water level changes and other small scale transient water levels typical to the survey area. Last, ERS eliminates errors resulting from vessel loading and inadequate compensation for vessel squat by using speed over ground lookup tables. For this project, the implementation of ERS will result in the application of slightly lower water levels that more accurately reflect dynamic water levels in the survey area. The resultant soundings will be slightly deeper than soundings corrected through the application of zoned tides.