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

HORIZONTAL AND VERTICAL CONTROL REPORT

Type of Survey	**Hydrographic**
Project	**OPR-J348-KR-11**
Contract No	**DG133C08CQ0006**
Task Order No	**T0006**
Time Frame	**July 2011 - March 2012**

LOCALITY

State	**Mississippi**
General Locality	**Approaches to Mississippi Sound**

2012

CHIEF OF PARTY

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

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DATE ____________________

NOAA FORM 77-28 (11-72)

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

HYDROGRAPHIC TITLE SHEET

REGISTRY No
H12353
H12354
H12355
H12356

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: Mississippi

General Locality: Approaches to Mississippi Sound

Sub-Locality: SE of Ship Island Harbor to SE of Horn Island

Scale: 1:20,000

Date of Survey: July 12, 2011 to March 13, 2012

Instructions dated: June 22, 2011

Project No.: OPR-J348-KR-11

Vessel: R/V Westerly 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, EdgeTech 4200-HFL, Odom CV-100

Graphic record scaled by: N/A

Graphic record checked by: N/A

Automated Plot: N/A

Verification by:

Soundings in: Meters at MLLW

REMARKS: NAD 83, UTM Zone 16, Meters, 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
CO-OPS - Center for Operational Oceanographic Products and Services
CUBE - Combined Uncertainty Bathymetric Estimator
DAA - Design Analysis and Associates, Inc.
DEA - David Evans and Associates, Inc.
DGPS - Differential Global Positioning System
DN - Julian Day Number
ERS - Ellipsoidally-Referenced Survey
GOES - Geostationary Operations Environmental Satellite
GPS - Global Positioning System
HIPS - Hydrographic Information Processing System
HSD - Hydrographic Surveys Division
HSSD - Hydrographic Surveys Specifications and Deliverables
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
MHW - Mean High Water
MLLW - Mean Lower Low Water
NAD 83 (CORS96) (Epoch 2002.00) - North American Datum of 1983 CORS96 realization, 2002 Epoch
NAVD88 - North American Vertical Datum of 1988
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
POS/MV - Position and Orientation System for Marine Vessels
SBET - Smoothed Best Estimate of Trajectory
TBYT - Tide by Tide
TPE - Total Propagated Error
TPU - Total Propagated Uncertainty
USCG - U.S. Coast Guard
UTC - Coordinated Universal Time
UTM - Universal Transverse Mercator

OPR-J348-KR-11
Horizontal and Vertical Control Report
Approaches to Mississippi Sound, Mississippi
July 2011 – March 2012
R/V *Westerly* 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 H12353, H12354, H12355, and H12356 located in the Approaches to Mississippi Sound, Mississippi. These contract surveys were performed by David Evans and Associates, Inc. (DEA) under project *OPR-J348-KR-11 Approaches to Mississippi Sound, Mississippi* as specified in the *Statement of Work* (June 23, 2011) and *Hydrographic Survey Project Instructions* (June 22, 2011). All survey methods meet or exceed requirements as defined in the National Ocean Service (NOS) *Hydrographic Surveys Specifications and Deliverables* (HSSD) (April 2011). On December 13, 2011, DEA was directed to use Ellipsoidally-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 November 1, 2011) for the ERS/VDatum Validation components of OPR-J348-KR-11 specified in the *Hydrographic Survey Project Instructions* (June 2011). A copy of this memo is included in *OPR-J348-KR-11 Project Correspondence*.

Parts of the OPR-J348-KR-11 survey area fell within the Gulf Islands National Seashore. Scientific Research and Collecting Permit GUIS-2011-SCI-0055 was issued by the National Park Service (NPS) on July 5, 2011 which permitted bathymetric data collection and bottom sampling in the waters managed by the NPS. The permit also allowed for tide gauge installation on Ship Island and Global Positioning System (GPS) base station installation on Ship and Horn Islands. A copy of the Scientific Research and Collecting Permit is included in *OPR-J348-KR-11 Project Correspondence*.

This Horizontal and Vertical Control Report outlines the methodology for collecting and applying GPS water level correctors and the results obtained during project OPR-J348-KR-11.

A. HORIZONTAL CONTROL

The horizontal datum for this project is the North American Datum of 1983 CORS96, realization 2002 Epoch (NAD83 (CORS96) (Epoch 2002.00)). Position data consists of both geographic coordinates and projected coordinates. Projected coordinates are in meters using the Universal Transverse Mercator (UTM) Zone 16 projection. All horizontal positioning for soundings followed the *OPR-J348-KR-11 Statement of Work (June 2011)* and the NOS *Hydrographic Surveys Specifications and Deliverables (April 2011*).

A1. Differential Correctors

A 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-320 Version 4) and a secondary Trimble DSM132 DGPS receiver for quality control purposes. A CSI Wireless MBX-3S receiver was used to receive DGPS corrections for the Position and Orientation System for Marine Vessels (POS/MV), from the U.S. Coast Guard (USCG) beacon at English Turn, Louisiana (293 kHz). The DSM132 received DGPS corrections from USCG beacon at Eglin, Florida (295 kHz).

A2. POSPAC Application

To improve horizontal and vertical positioning, Applanix POS-Pac-MMS software (version 5.4.4183.20673) was implemented during post processing to produced a Smoothed Best Estimate of Trajectory (SBET) using an Inertially Aided Kinematic Ambiguity Resolution (IAKAR) navigation solution relative to NAD83 (CORS96) (Epoch 2002.00). The Applanix POS-Pac-MMS Single Base processing method was used to produce the SBET during the course of the project. Data from existing CORS sites could not be used in a multi-base solution in POSPac MMS due to the geometry of the network. The distances between the existing stations forming the southern baseline (needed to capture the offshore sides of the project area) exceeded the maximum length of 100 km specified in Section 9.1.1.1 of the NOS HSSD dated April 2011.

In order to differentiate SBET solutions by survey vessel, processed POSPac data filenames were appended with a two letter identifier where “WE” indicated the R/V *Westerly* and “CH” indicated the R/V *Chinook*. The real-time sensor data logged during acquisition was overwritten with a post-processed IAKAR solution. The Hydrographic Information Processing System (HIPS) Load Attitude and Navigation tool was used to load position, heading, height, and attitude data from an SBET file. 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).

A3. Base Stations

To implement the Single Base method, two temporary GPS base stations were established using the Online Positioning User Service (OPUS) operated by The National Geodetic Survey (NGS). The temporary stations were designated SHIP and HORN and were strategically located near the project site in order to meet the 20-kilometer maximum baseline length for Single Base processing method. The base station HORN was located along the east side of the project area while SHIP was located on the west at the tertiary tide station (Figure 1).

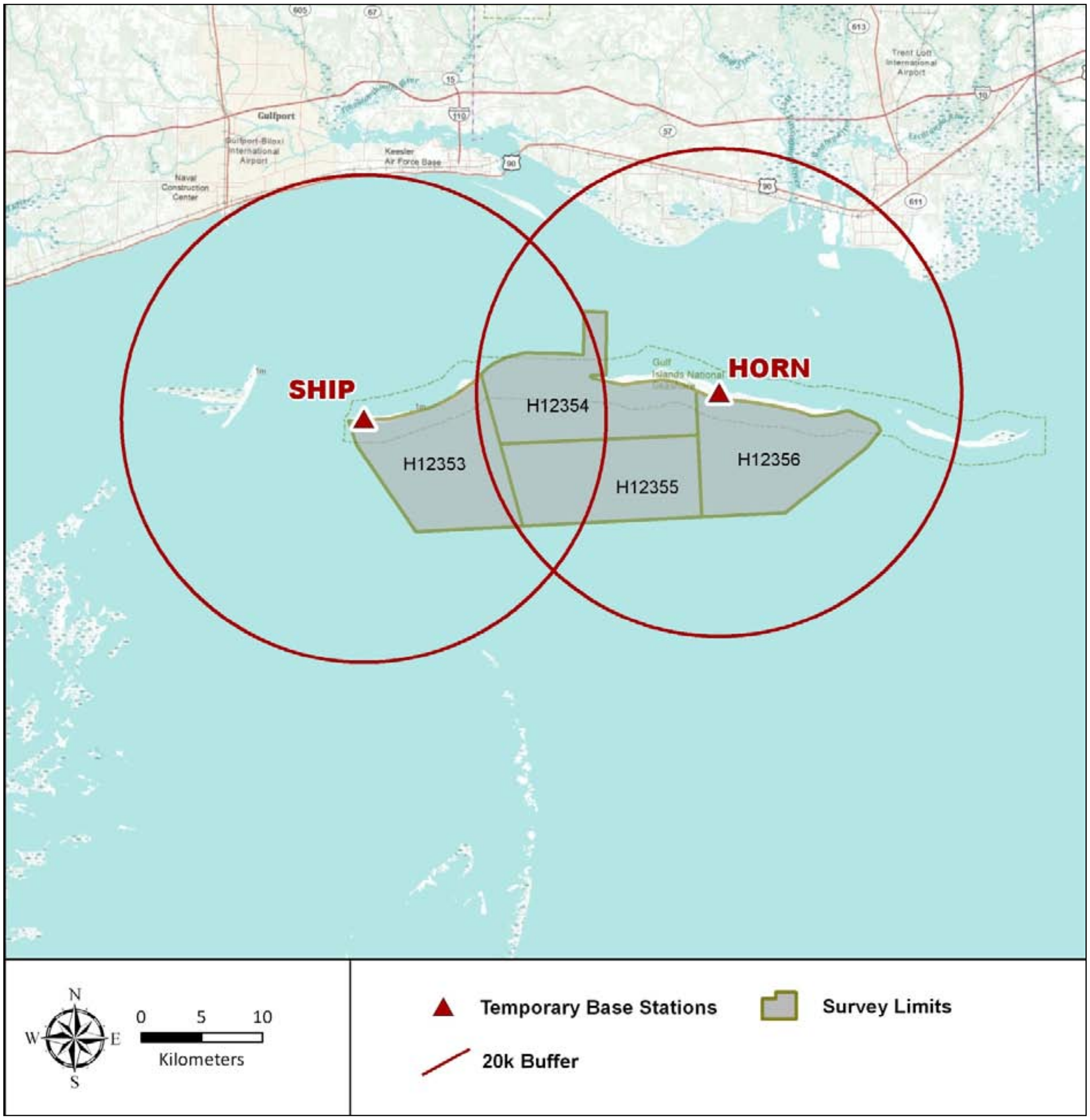

Figure 1. Temporary base stations, SHIP and HORN, used for OPR-J348-KR-11

Each temporary GPS base station consisted of a Trimble Net-R5 GPS dual frequency (L1/L2) receiver with Trimble Zephyr Geodetic GPS antenna. The station location was selected to provide clear satellite visibility with the GPS antennas installed on a rigid steel pole securely attached to a stable 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 were stored in Trimble T01 format and segmented into 24-hour files that were automatically uploaded to the DEA FTP site daily. The network connection was provided by a cellular modem with a directional antenna to increase signal strength. Files were manually downloaded from the FTP site and quality controlled daily. Table 1 lists the GPS equipment used during the project.

Table 1. GPS Base Station Equipment

GPS Base Station Equipment					
Item/ Manufacturer	**Model**	**P/N**	**S/N**	**Firmware Version**	**Location**
Receiver					
Trimble	NetR5	62800-10	4750K11594	4.19	SHIP
Trimble	NetR5	62800-10	4750K11589	4.19	HORN
Antenna					
Trimble	Zephyr-Geodetic	41249-00	12338039	N/A	SHIP
Trimble	Zephyr-Geodetic	41249-00	60201334	N/A	HORN

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 OPUS, operated by 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 National Oceanic Atmospheric Administration (NOAA) publication *User's Guide for GPS Observations (December 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 at the temporary base stations are shown in Table 2, referenced to NAD83 (CORS96) (Epoch 2002.00).

Table 2. Antenna Reference Point (ARP) Station Coordinates

Coordinates NAD83 (CORS96) (Epoch 2002.00) ARP (24 Hour OPUS Solution)			
Temporary Station	**Latitude**	**Longitude**	**Ellipsoid Height (m)**
SHIP	30° 12' 50.79097" N	088° 58' 17.34520" W	-21.222
HORN	30° 14' 17.35884" N	088° 40' 01.67123" W	-21.122[1]

[1] Adjusted height using OPUS 10-day average. A 0.027-meter shift in the vertical position of the Horn Island base station was applied to the bathymetric data as a static offset during the computation of GPS Tide in Caris HIPS.

GPS base stations are documented in Appendix III *GPS Base Stations* and include: GPS base station position summary; 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.

A4. Positioning Systems Confidence Checks

Weekly OPUS solutions were obtained and compared to the initial base station position to verify the stability of the base station over the course of the project. Similar to the technique used to establish the base station coordinates, these weekly solutions were computed using a rapid GPS ephemeris. A total of 17 weekly comparisons were made between July 24, 2011 and November 13, 2011.

The very first weekly check for the HORN base station indicated a 0.026-meter vertical deviation between the weekly check position and initial HORN base position. This was well in excess of the corresponding standard deviation and suggested that either the Horn Island station had moved vertically since the initial derived position or the initial derived position was in error.

To further evaluate HORN base station stability, OPUS solutions using final ephemeris were derived for a 24-hour period prior to and another following the day used to derive the initial position. Both of these solutions deviated from the derived initial position in the same direction, with the prior day 0.042 meters higher, and the following day 0.034 meters higher. This suggested that the observed deviation was attributable to error in the estimation of the original base station position, not to a physical change in the vertical location of the base station.

To derive a more reliable estimate of the vertical position of the Horn Island base station, additional OPUS solutions using final ephemeris were derived for 10 days and averaged. The majority of the days used to compute the 10-day average did not coincide with days used for weekly checks, and included days prior to and following the day used to derive the initial position. The resulting position was 0.027 meters higher than the original base station position, with a standard deviation of 0.009 meters. Comparing the weekly check vertical positions to this new Horn Island vertical position yields an average difference of 0.001 meters, with a standard deviation of 0.005 meters. These results indicated that the rapid ephemeris OPUS solution used to compute the initial base position was in error by approximately 0.027 meters. The 0.027-meter shift in the vertical position of the Horn Island base station was applied to the bathymetric data as a static offset during the computation of GPS Tide in Caris HIPS rather than reprocessing all of the POSPac sessions using the Horn Island base station.

For the base station on Ship Island, the average vertical deviation between the weekly check position and the original reference position was 0.004 meters, with a standard deviation of 0.010 meters. Horizontal deviation was, on average, 0.004 meters or less indicating the base station was stable over the course of the project. For the base station on Horn Island with the 0.027 vertical adjustment, the average vertical deviation between the weekly check position and the original reference position was -0.001 meters, with a standard deviation of 0.005 meters. Similar to the Ship island station, the average horizontal deviation was 0.004 meters or less.

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 1.02 meters for the *R/V Westerly* and 1.20 meters for the *R/V Chinook*, which are well within the NOS specification of hydrographic positioning.

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).

Two (2) GPS base stations were installed on Ship and Horn Islands and a tertiary tide station was installed on Ship Island to provide water level support for the survey. Also monitored was the active National Water Level Observation Network (NWLON) station at Pascagoula NOAA Lab, Mississippi (874-1533).

Final sounding reduction to MLLW was achieved by collecting GPS data on the survey vessel and applying correctors from the GPS base stations that would accurately determine the sounding height relative to the NAD83 (CORS96) (Epoch 2002.00) ellipsoid. The NAD83 (CORS96) (Epoch 2002.00) ellipsoidal heights were then adjusted to MLLW using a composite separation model constructed using VDatum version 2.3.3 and the region file Eastern Louisiana to Mississippi Sound (version 02). The version 02 region file was issued after DEA notified NOAA that the version 01 region file incorporated an inaccurate NAVD88 height on the Ship Island tidal bench mark SIGNAL AZ MK. The model file used in sounding reduction, *MS_Sound.bin*, has been included with each survey's digital deliverables. Additional discussion on the generation of the model file and analysis of the VDatum transformation grids can be found in Appendix IV *Interim VDatum Report*.

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 (CORS96) (Epoch 2002.00) ellipsoid height to MLLW using VDatum. The published Maximum Cumulative Uncertainty (MCU) value for the Louisiana/Mississippi - Eastern Louisiana to Mississippi Sound region file was computed using a transformation from International Terrestrial Reference Frame (ITRF) to MLLW. The MCU is based on the maximum of the tidal datum uncertainties, which in the Mississippi Sound region is MLLW with an uncertainty of 2.9 centimeters. The resulting published MCU is 17.1 centimeters, which is inclusive of the uncertainty in the transformation between ITRF and NAD83 (CORS96) (Epoch 2002.00). Removing the ITRF to NAD83 (CORS96) (Epoch 2002.00) transformation uncertainty yields an MCU of 17.0 centimeters. This value was applied to the data as a tidal zoning error during the computation of Total Propagated Uncertainty (TPU).

Table 3 lists the source and transformation uncertainty values used to compute the total model uncertainty for the Mississippi Sound region file.

Table 3. Estimated VDatum Model Uncertainty

Louisiana/Mississippi – Eastern Louisiana to Mississippi Sound	
Transformation Uncertainty at 1-Sigma (cm)	
ITRF to NAD83 (CORS96) (Epoch 2002.00)	N/A
NAD83 (CORS96) (Epoch 2002.00) to NAVD88	5.0
NAVD88 to LMSL	14.8
LMSL to MLLW	2.9
Total Transformation Uncertainty	*15.9*
Source Uncertainty at 1-Sigma (cm)	
NAD83 (CORS96) (Epoch 2002.00)	2.0
NAVD88	5.0
LMSL	1.9
MLLW	1.9
Total Source Uncertainty	*6.0*
MODEL Uncertainty	**17.0**

B1. Tide and Water Level Corrections

For OPR-J348-KR-11 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 were also 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-J348-KR-11 Data Acquisition and Processing Report.*

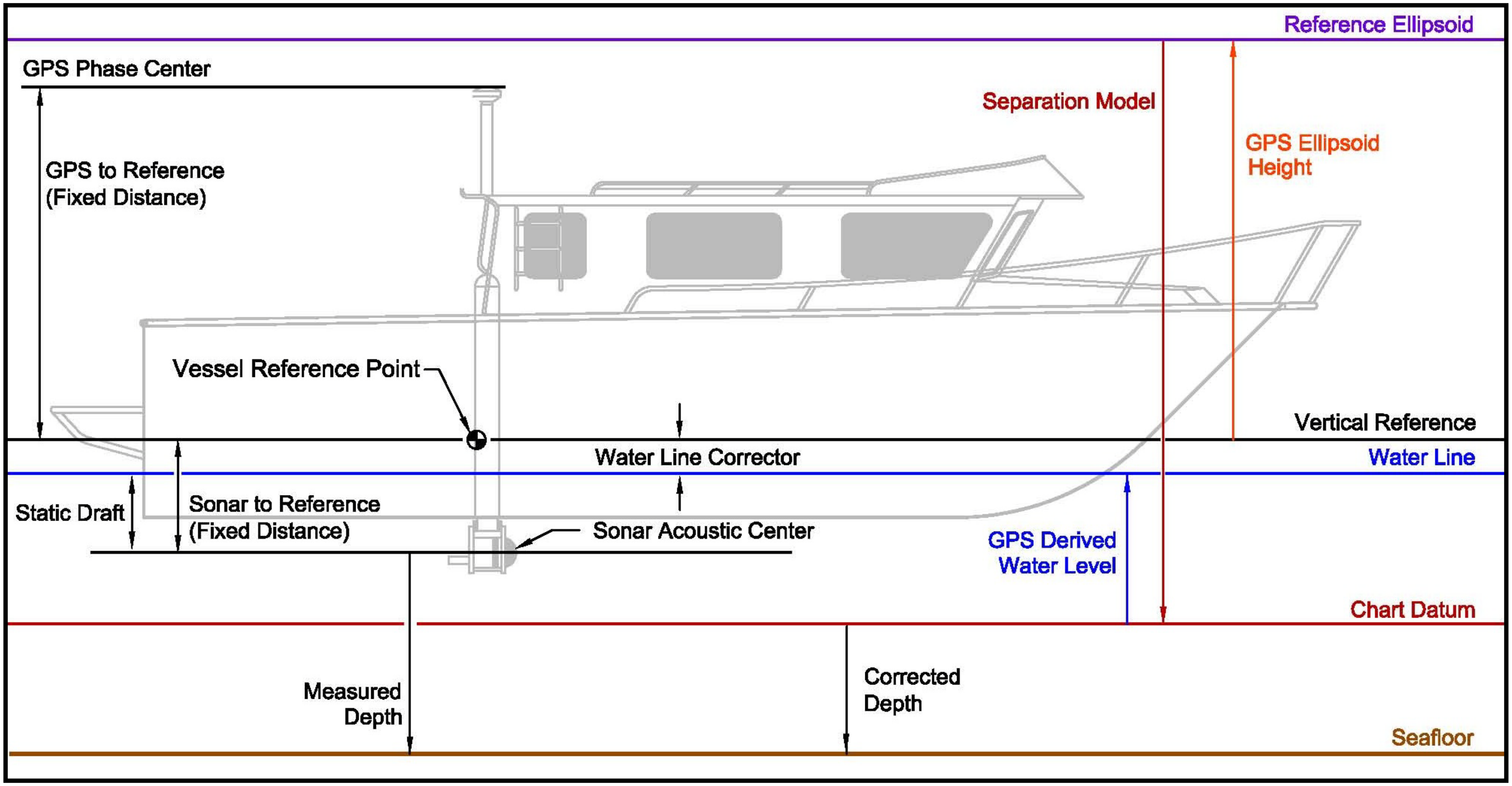

Figure 2. Vertical components of hydrographic surveying relative to the ellipsoid.

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 (CORS96) (Epoch 2002.00) ellipsoid to MLLW separation model file, *MS_Sound.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.

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 (CORS96) (Epoch 2002.00) 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 Station

The active NWLON station at Pascagoula NOAA Lab, Mississippi (874-1533) (Figure 3) is the reference station for this project. The Pascagoula 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 (TBYT) datum computations for the subordinate gauging site at Ship Island 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-J348-KR-11.

B3. Subordinate Tide Station

As specified in the OPR-J348-KR-11 *Statement of Work*, a tertiary tide station was established at the historic CO-OPS site at Ship Island, Mississippi Sound, MS (874-4756) (Figure 3). DEA incorporated this station in the permit acquired from the National Park Service and worked jointly with John Oswald and Associates, Inc. (JOA) to install two bubbler gauges to collect data for datum determination and possible sounding reduction. The primary gauge was based on a ParoScientific 6000-30G pressure sensor while the backup gauge was a Design Analysis and Associates, Inc. (DAA) H-350XL.

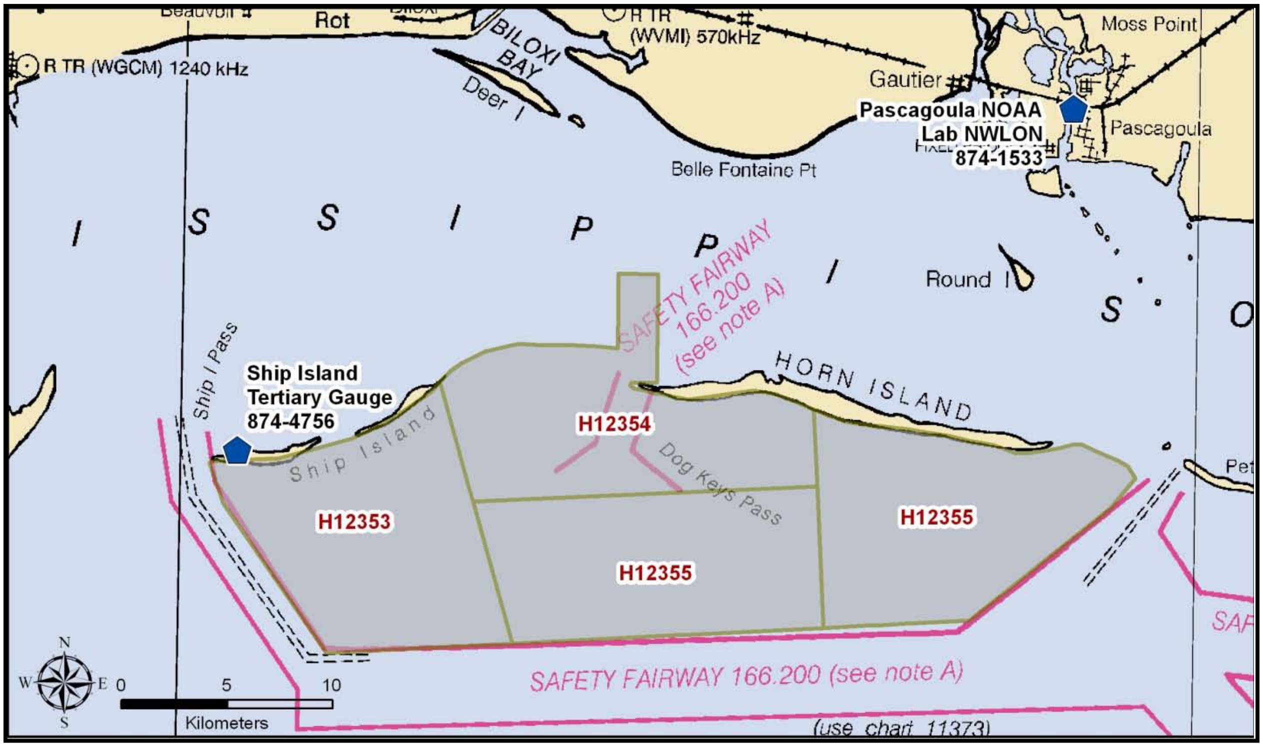

Figure 3. NWLON and subordinate tide gauge sites for OPR-J348-KR-11

Complete details of the installation, which was established to CO-OPS specifications as required by the Tides and Water Levels component of the project instructions, were submitted to CO-OPS in the Installation Report dated September 1, 2011. Due to access restrictions from the National Park Service which limited the ability to recover existing bench marks or install new benchmarks CO-OPS granted a waiver to allow use of three bench marks instead of the five required by the HSSD. A copy of this waiver is included in *OPR-J348-KR-11 Project Correspondence*. A summary of gauge equipment and serial numbers is listed in Table 4. The station was operated from July 15, 2011 (DN 196) to December 1, 2011 (DN 335). The station Closeout Report was submitted to CO-OPS on December 22, 2011.

Table 4. Ship Island, Mississippi Sound, Mississippi Installation Sensors

Gauge	Sensor	Pump	Data Logger	GOES Radio
Primary	ParoScientific 6000-30G S/N:100336	DAA H355 S/N: 5593	Sutron Xpert Dark S/N: 70610	Sutron SatLink 2 S/N: 70711
Secondary	DAA H-350XL S/N: 003541	DAA H355 S/N:1803	DAA H-350XL S/N: 003541	DAA H222 S/N: 1001

The gauge systems were powered by 12-Volt batteries with 20-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.

To compare the gauge results with GPS water levels, a one hour vessel float observation was acquired adjacent to the tertiary gauge at Ship Island 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, which were also adjusted to MLLW using a preliminary datum computed from the first month of data. The vessel measurements were averaged using the same interval as the gauge (three minutes centered on the six-minute interval). The average difference between the Ship Island Tide Gauge and GPS Water Level Observations was 2.2 centimeters with a standard deviation of 1.2 centimeters (Table 5).

Table 5. R/V *Westerly* September 6, 2011 (DN249) 6-Minute Vessel Float Time Series Gauge Comparisons Referenced to MLLW in meters.

Time (hh:mm)	Ship Island Gauge	GPS Water Levels	GPS Water Levels Minus Ship Island Gauge
19:42	0.268	0.259	-0.009
19:48	0.260	0.247	-0.013
19:54	0.258	0.256	-0.002
20:00	0.253	0.234	-0.019
20:06	0.243	0.225	-0.018
20:12	0.238	0.226	-0.012
20:18	0.238	0.217	-0.021
20:24	0.228	0.192	-0.036
20:30	0.220	0.185	-0.035
20:36	0.217	0.191	-0.026
20:42	0.205	0.167	-0.038
20:48	0.201	0.164	-0.037
		Mean	-0.022
		Std Dev	0.012

C. LETTER OF APPROVAL

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

LETTER OF APPROVAL

OPR-J348-KR-11
HORIZONTAL AND VERTICAL CONTROL REPORT

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of OPR-J348-KR-11 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-J348-KR-11 *Statement of Work* (April 2011) and *Hydrographic Survey Project Instructions* (June 2011).

Digitally signed by Jon Dasler
DN: cn=Jon Dasler, email=jld@deainc.com, o=David Evans and Associates, Inc., c=US
Date: 2012.03.27 09:07:37 -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, o=David Evans and Associates, Inc., ou, email=jasc@deainc.com, c=US
Date: 2012.03.27 09:07:17 -07'00'

Jason Creech
Lead Hydrographer

David Evans and Associates, Inc.
March 2012