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

HORIZONTAL & VERTICAL CONTROL REPORT

Type of Survey:	Navigable Area
Project Number:	OPR-B300-KR-20
Time Frame:	July - December 2020

LOCALITY

State(s):	Connecticut New York
General Locality:	New York and Connecticut
Sub-locality:	Western Long Island Sound

2020

CHIEF OF PARTY

John R. Bean

LIBRARY & ARCHIVES

Date:

TABLE OF CONTENTS

A. TIME BASIS ..... - 1 -

B. VERTICAL CONTROL ..... - 1 -

B.1 ERS Tide Source Data ..... - 1 -

B.2 VDatum Separation Model (SEP) ..... - 1 -

B.3 ERS Tide Smoothing ..... - 3 -

B.4 Final Application of ERS Tides ..... - 4 -

B.5 GNSS Base Station "OSNR" ..... - 4 -

C. HORIZONTAL CONTROL ..... - 8 -

C.1 Horizontal Datum ..... - 8 -

C.2 Horizontal Control ..... - 8 -

D. APPROVAL SHEET ..... - 20 -

A. TIME BASIS

Coordinated Universal Time (UTC) was used to annotate the tide records and all other data obtained for this project.

B. VERTICAL CONTROL

All soundings are referenced to Mean Lower Low Water (MLLW) using Ellipsoidally Referenced Survey (ERS) methods per the Project Instructions. All baring features are reported in Mean High Water (MHW).

B.1 ERS Tide Source Data

Inertially Aided Post Processed Kinematic (IAPPK) ellipsoid heights were computed using POSPac MMS, Applanix SmartBase (ASB) processing. The ellipsoid heights in the resulting Smoothed Best Estimate Trajectory (SBET) data were used as the basis for the development of ERS Tide.

ASB processing was organized into POSPac projects by vessel and day. Figure 1 illustrates the location of CORS stations (including OSI's locally installed base station OSNR) which contributed to ASB processing. The total number of stations occasionally varied from one POSPac project to the next (i.e. vessel-day) based on CORS data availability and solution quality. The inset table on Figure 1 shows the POSPac IAPPK project count for each station. The final coordinates of OSNR were determined using OPUS.

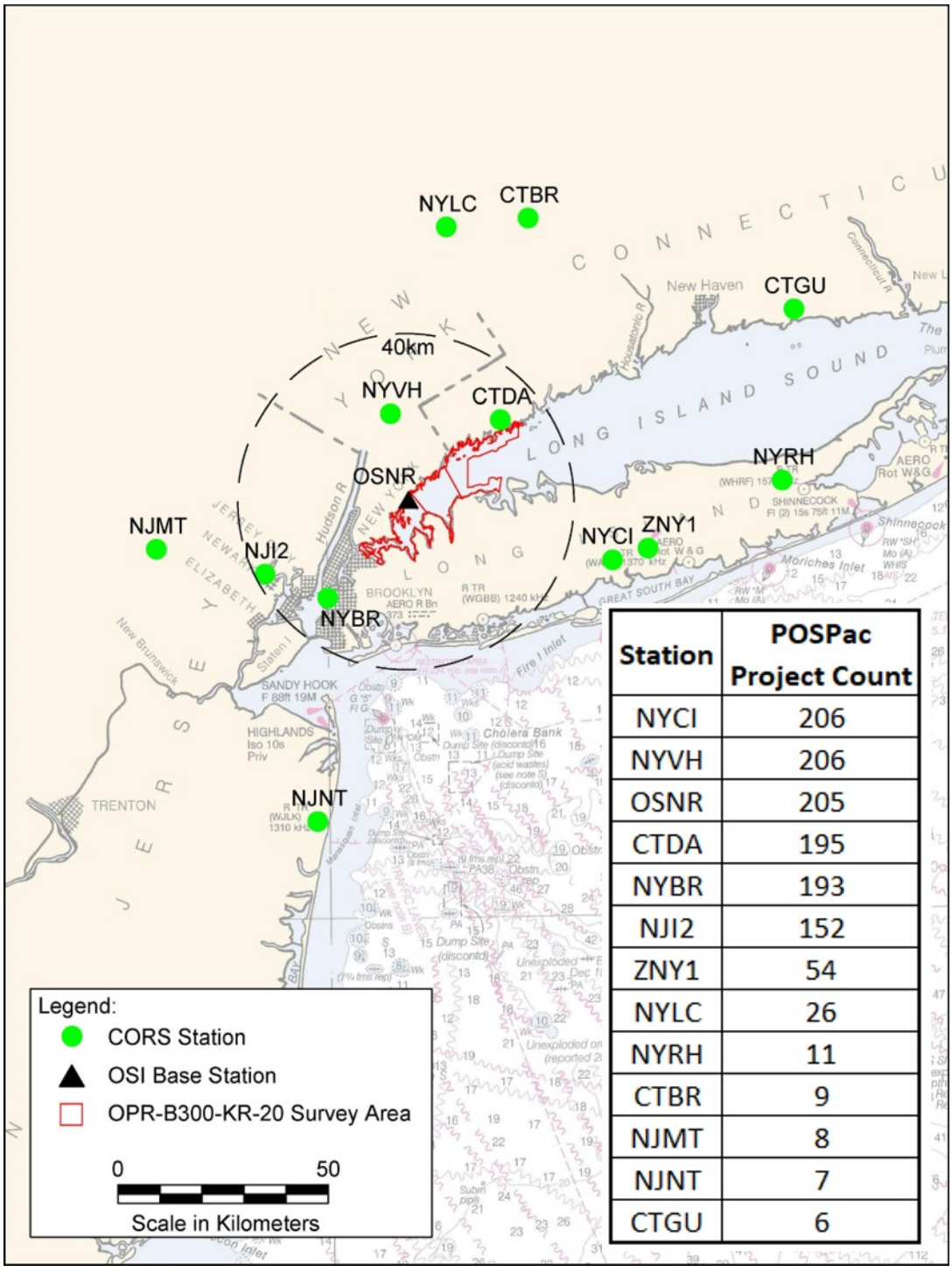
SBET altitude corrected for heave, dynamic draft, and static draft were reviewed graphically in MATLAB and compared to the local NOAA tide gauge water levels. When apparent invalid altitude was present in the daily SBET, additional CORS stations were added to the ASB network. For the few remaining daily SBETs that contained invalid altitude data, NOAA's POSPacAutoQC application was used to interpolate through and replace the invalid data.

B.2 VDatum Separation Model (SEP)

A VDatum Separation Model (SEP) was provided by NOAA with the original project files and described in the Project Instructions (Table 1).

Table 1
VDATUM Model

VDATUM Version	Geoid	Area	Area Version	Separation Uncertainty
3.9	2012	NYNJhbr22_8301	1	9.45 centimeters



Station	POSPac Project Count
NYCI	206
NYVH	206
OSNR	205
CTDA	195
NYBR	193
NJI2	152
ZNY1	54
NYLC	26
NYRH	11
CTBR	9
NJMT	8
NJNT	7
CTGU	6

Figure 1. Local CORS network and "OSNR" in relation to the project site.

B.3 ERS Tide Smoothing

ASB derived ERS tides were smoothed prior to inclusion in the data reduction process.

I. ERS MLLW Tide Smoothing Steps:

1) Create and export final SBETs
2) Smooth SBETs using MATLAB
    - Convert SBET altitude to an isolated NAVD88 tide by removing the following components of the SBET altitude:
        - Static draft based on time
        - Dynamic draft based on speed
        - Delayed heave based on time
        - SEP based on position
    - Smooth NAVD88 tide with a 4th order Butterworth low-pass filter
    - Export smoothed SBETs after re-applying the above components
3) Import smoothed SBETs in CARIS HIPS
4) Run CARIS HIPS "Compute GPS Tides" with the NOAA-provided SEP to create MLLW tide correctors.

II. ERS Smoothed Tide Curve QA/QC:

Graphical analysis was the primary QA/QC tool used during the development phase of the ERS smoothing routine described above. MATLAB graphs were generated for all conversion and correction steps to identify erroneous source data or MATLAB program code.

III. Choice of Smoothing Parameters:

Combined SBETs were smoothed with a 4th order Butterworth low-pass filter using MATLAB's "filtfilt" function, which runs the filter in forward and reverse, resulting in a zero-lag solution.

When choosing the smoothing method to apply, OSI considered several approaches: those used by OSI on prior NOAA contract surveys (see OPR-K354-KR-18, OPR-K379-KR-19, and OPR-K354-KR-19), those used by JOA Surveys (on behalf of OSI for a prior NOAA contract survey), and new approaches developed by OSI data analysts.

To determine the best smoothing parameter settings, the final SBETs were smoothed, converted to ERS tides and applied to the soundings using each of the following smoothing methods:

- 1, 5, and 10-minute averages
- 0.33, 0.5, 1, 2, 3, 4, 5, and 6-hour low pass filters

Statistical comparisons were made of crossline and mainscheme difference data generated by CARIS HIPS. Standard deviation surfaces at intersections were reviewed, and the smoothed ERS tide was compared to local NOAA tide gauges and evaluated for trends and general agreement.

As a result of this iterative comparative analysis, a 4th order Butterworth low pass filter with a 20 minute cutoff frequency was chosen to smooth ERS tides.

B.4 Final Application of ERS Tides

For the final application of ERS tides, the final tide-smoothed SBET ellipsoid record was imported to CARIS. The CARIS "Compute GPS Tides" function was used in conjunction with the NOAA-provided SEP (buff_newVdatum2_Merge_Diss_100m_NAD83-MLLW_geoid12b.csar and buff_newVdatum2_Merge_Diss_100m_NAD83-MHW_geoid12b.csar) to apply MLLW tide correctors to the soundings and MHW heights to baring features.

Qualitative and quantitative crossline analysis as well as junction analysis indicated that the final ERS correctors applied to reduce soundings and heights to MLLW and MHW, respectively, were adequate for the purpose. The results of crossline and junction analysis are presented in the Descriptive Report (DR) for each survey.

B.5 GNSS Base Station "OSNR"

To supplement IAPPK SBET processing, OSI installed a temporary GNSS base station on a structure roof at Imperial Yacht Club in New Rochelle, NY (Figure 2). The installed station was designated "OSNR" (Ocean Surveys New Rochelle) and consisted of a Trimble NetR9 GNSS receiver equipped with a Zephyr 3 Geodetic antenna (Model: TRM115000.00 None). OSNR also supplied real-time CMR+ RTK correctors to each survey vessel via a cellular based NTRIP stream. Real-time correctors provided precise horizontal positioning and allowed for real-time water level monitoring.

Figure 2. Ortho imagery and setup images of OSI's user-installed base station "OSNR" on top of a building at the Imperial Yacht Club in New Rochelle, NY.

The configuration of the NetR9 was based on UNAVCO standard configuration settings for this device. The NetR9 was configured to record GNSS observables continuously throughout the period of the survey and parse data observables into daily files for each 24-hour period. Data were delivered to OSI's home office processing center via regular automated FTP and e-mail "pushes." Pushes were transmitted over a network connection that was established on site for this purpose. Data were also saved to the receiver's internal storage as a backup.

During a routine "nav check" on DN280 (10/06/2020), the crew on *R/V Ready II* noticed unusually large horizontal/vertical deltas when using OSNR RTK correctors. When an alternate source of correctors was used (CT ACORN's GUP NTRIP stream) the position deltas were within expected tolerances.

After inquiring with the Imperial Yacht Club, it was revealed that an electrician conducting maintenance work had removed the base station antenna unannounced, and then remounted the antenna in a new position less than 0.5 m away (Figure 4).

Figure 4. OSNR's original antenna position (left) from 07/25/2020 (DN207) to 10/02/2020 (DN276), and OSNR's antenna position following the position shift that occurred on DN 276 (right). The antenna remained in the shifted position through the end of the project.

Based on an inspection of the raw observables files, OSI determined that the shift in antenna position occurred sometime between 14:56 and 15:12 UTC on DN276. The new installation was stable, secure and unlikely to interfere with any future maintenance, so OSI decided to leave the antenna in its new position. New OPUS solutions were collected following the base station antenna shift and the new X,Y,Z values were updated in the base receiver to reflect the new position for RTK corrector output. Survey data collected after DN276 was processed with the new base coordinates. Survey data collected on DN276 was processed using the local CORS network while excluding OSNR.

The HSSD requires that "*The reference position of non-CORS antenna installations shall be verified at least once per week while the site is utilized for survey operations."* OSI submitted all

individual days of dual frequency GNSS observables (Rinex files) from OSNR to the NGS' Online Positioning Users Service (OPUS). Data files were organized into two groups: those from before the antenna shift and those after. Data were submitted with an ARP height of 0. OSI used OPUS Projects (https://www.ngs.noaa.gov/OPUS-Projects/OpusProjects.shtml) for OPUS solution management, quality control, and to compute the final network-adjusted coordinates which were then incorporated into ASB processing (Table 2). Processing steps and parameter selection were in accordance with the NGS-provided OPUS Projects Managers Training (required in order to obtain access to OPUS projects).

Table 2
OPUS Projects Network Adjusted Positions of OSNR

Time period	Latitude (NAD83-2011)	Longitude (NAD83-2011)	Ellipsoid Height (GRS80)
DN 207-275	40 53 34.425 N	073 46 39.503 W	-19.974m
DN 277-349	40 53 34.431 N	073 46 39.499 W	-20.092m

Figure 3 shows a summary of the residuals for each of the daily OPUS solutions, and the improved residuals obtained with OPUS Projects session processing. The residuals are relative to the final network adjusted position computed by OPUS Projects using all of the solutions. The error bars on each point indicate the 1-sigma peak-to-peak root mean square (RMS) error estimate of the 3-D position components, namely east, north, and ellipsoid height. The offset in the apparent mean position of the daily residuals and the final network-adjusted position is due to plate velocities as handled in OPUS Projects for the time span of the project. All processing was done in ITRF 2014; however, final network-adjusted coordinates are also provided by OPUS Projects in NAD 83 (2011) @ 2010.00 (i.e. Table 2).

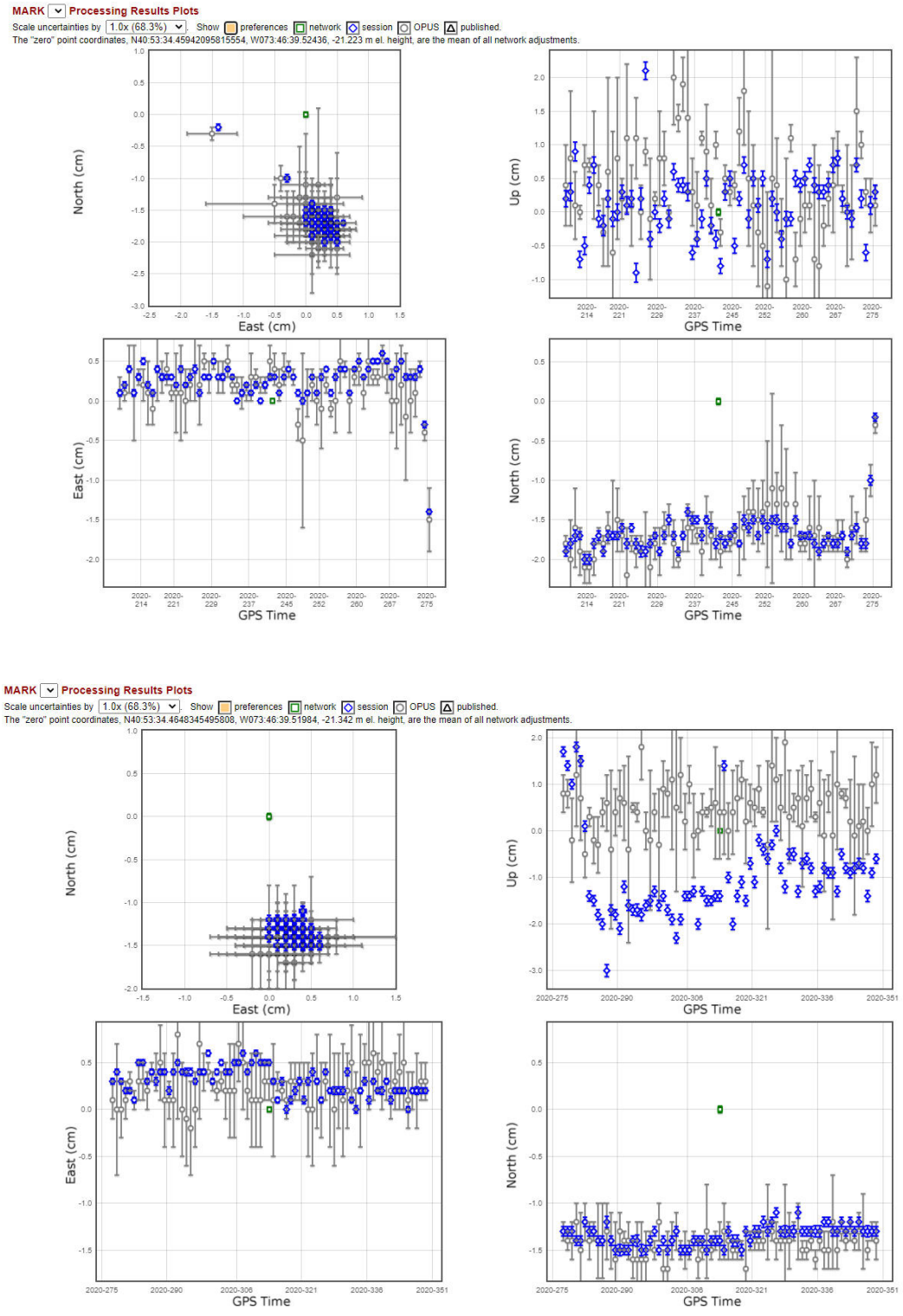


Figure 3. OPUS project coordinate residuals for both sets of GNSS observables at OSNR (before DN 276 at top, after DN 276 below). OPUS solutions are in grey, improved OPUS Project session solutions are in blue. Error bars represent 1-sigma. Residuals are relative to the final network-adjusted and velocity corrected position (green) from OPUS Projects.

Individual OSNR OPUS Project results (OPUS solutions, sessions, and final network adjustment) are included in the HVCR digital deliverables.

C. HORIZONTAL CONTROL

C.1 Horizontal Datum

The horizontal datum for this project is the North American Datum of 1983 (NAD83). Horizontal coordinates are referenced to Latitude/Longitude and Universal Transverse Mercator (UTM) Zone 18, in meters. The assigned project boundary falls entirely within UTM Zone 18.

C.2 Horizontal Control

Real-time vessel navigation was replaced during post processing with Applanix SmartBase (ASB)-derived SBET positioning and attitude. Final SBET positioning is referenced to NAD83 (2011).

During the survey, each POSMV on the *R/V Osprey, R/V Ready II,* and *R/V Able II* received real-time CMR+ RTK correctors via a cellular NTRIP stream.

Positioning system confidence checks for each vessel were accomplished at the start of survey and periodically thereafter. In practice, the distance between the vessel's reference point (RP) and the dockside horizontal control point as computed by the navigation system was compared to the tape-measured distance between the vessel RP and the horizontal control point.

Temporary navigation confidence check points were installed near each vessel's dock. "Harbor One 2020" was installed near OSI's home base of Old Saybrook, CT prior to beginning the survey. The sole purpose of this control point was to ensure that each vessel's positioning system was functioning properly before transiting to the survey site. The horizontal positions of the temporary points were established using a single OPUS observation per location, with a duration of approximately 2 hours each. Four other temporary points were established upon arrival to each vessel's respective marinas and were used for frequent positioning checks (Figure 5 - Figure 9). The X,Y coordinates for each point are presented in Table 4. OPUS reports for each installation are included in the HVCR digital deliverables.

In all cases, dockside navigation system accuracy checks demonstrated an accuracy that was substantially better than 1.0 meter.

Table 4
Temporary Navigation Confidence Check Points

Designation	RTK Derived Easting UTM 18N, NAD83 (meters)	RTK Derived Northing UTM 18N, NAD83 (meters)	Locale	For Survey Vessel
Harbor One 2020	721994.19	4573420.07	Old Saybrook, CT	All Boats
Grass Island	615740.50	4541334.45	Greenwich, CT	*R/V Osprey*
World's Fair	596894.73	4512791.15	Flushing, NY	*R/V Osprey*
GC20	614163.65	4523695.53	Glen Cove, NY	*R/V Ready II*
Klondike 2020	602644.86	4527295.14	New Rochelle, NY	*R/V Able II & R/V Osprey*

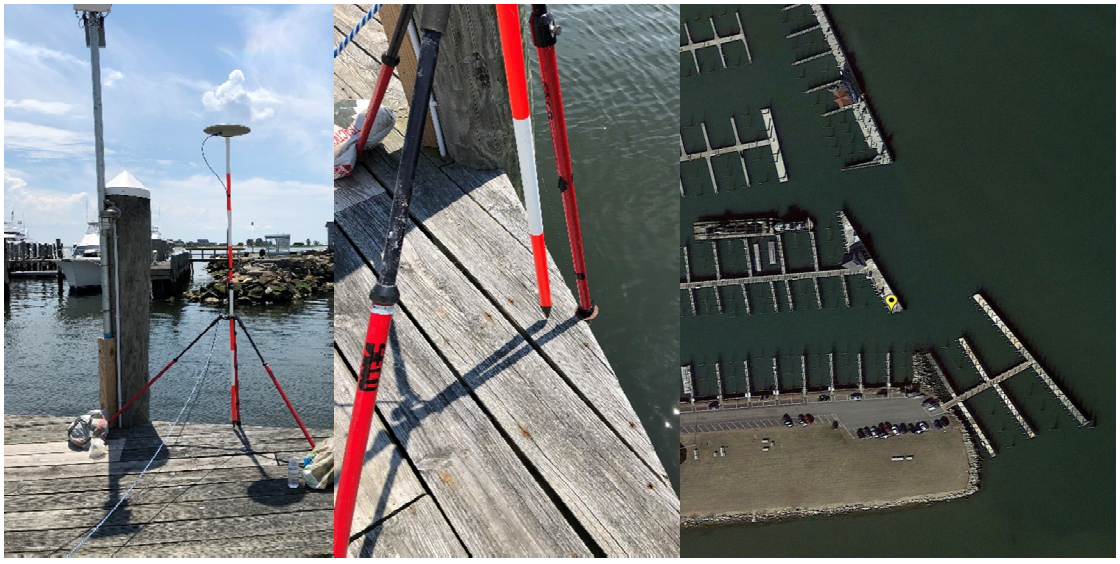


Figure 5. "Harbor One 2020" is a PK Nail in a dock at Harbor One Marina in Old Saybrook, CT.

Figure 6. "Grass Island" sits on the top surface of a square rail support foot at Grass Island Marina in Greenwich, CT.

Figure 7. "World's Fair" is a green flagged deck screw in at World's Fair Marina in Flushing, NY.

Figure 8. "GC20" is a pink flagged PK Nail in a dock at Glen Cove Marina in Glen Cove, NY.

Figure 9. "KLONDIKE 2020" is a square-headed deck screw with stainless washer next to a piling at the New Rochelle Town Dock. This point was used by *R/V Able II* and *R/V Osprey*.

Navigation system confidence checks for each vessel are included here in Tables 5, 6 and 7.

Table 5
***R/V Osprey* Tabulation of Navigation System Confidence Checks**

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
7/23/2020 (DN205)	13:02	Harbor One 2020	OSNR CMR+ RTK	721996.12	4573418.31	2.61	2.52	0.09
7/23/2020 (DN205)	13:06	Harbor One 2020	OSNR CMR+ RTK	721994.01	4573418.01	2.07	2.01	0.06
7/23/2020 (DN205)	13:09	Harbor One 2020	OSNR CMR+ RTK	721993.86	4573418.06	2.03	2.04	0.01
7/26/2020 (DN208)	10:14	Harbor One 2020	OSNR CMR+ RTK	721996.14	4573418.49	2.51	2.42	0.09
7/26/2020 (DN208)	10:18	Harbor One 2020	OSNR CMR+ RTK	721997.53	4573418.49	3.70	3.66	0.04
8/24/2020 (DN237)	21:42	Grass Island	OSNR CMR+ RTK	615738.80	4541334.68	1.71	1.65	0.06
8/25/2020 (DN238)	21:23	Grass Island	OSNR CMR+ RTK	615739.30	4541333.25	1.70	1.67	0.03
8/26/2020 (DN239)	20:53	Grass Island	OSNR CMR+ RTK	615739.30	4541333.16	1.76	1.73	0.03
8/27/2020 (DN240)	14:53	Grass Island	OSNR CMR+ RTK	615738.41	4541334.67	2.10	2.09	0.01
8/29/2020 (DN242)	13:36	Grass Island	OSNR CMR+ RTK	615738.72	4541334.59	1.78	1.78	0.00
9/2/2020 (DN246)	15:34	Grass Island	OSNR CMR+ RTK	615738.82	4541334.34	1.68	1.70	0.02
9/4/2020 (DN248)	16:37	Grass Island	OSNR CMR+ RTK	615739.01	4541333.74	1.65	1.63	0.02
9/8/2020 (DN252)	21:26	Grass Island	OSNR CMR+ RTK	615738.60	4541335.00	1.97	1.97	0.00
9/9/2020 (DN253)	21:16	Grass Island	OSNR CMR+ RTK	615738.59	4541334.93	1.97	1.96	0.01

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
9/10/2020 (DN254)	20:45	Grass Island	OSNR CMR+ RTK	615738.59	4541335.00	1.98	1.97	0.01
9/11/2020 (DN255)	21:36	Grass Island	OSNR CMR+ RTK	615738.66	4541335.76	2.25	2.23	0.02
9/18/2020 (DN262)	14:10	Grass Island	OSNR CMR+ RTK	615738.56	4541335.51	2.21	2.19	0.02
9/21/2020 (DN265)	18:53	Grass Island	OSNR CMR+ RTK	615738.64	4541334.67	1.87	1.84	0.03
9/23/2020 (DN267)	18:37	Grass Island	OSNR CMR+ RTK	615738.67	4541336.08	2.45	2.44	0.01
9/24/2020 (DN268)	21:18	Grass Island	OSNR CMR+ RTK	615738.53	4541335.72	2.34	2.35	0.01
9/25/2020 (DN269)	20:17	Grass Island	OSNR CMR+ RTK	615738.57	4541337.85	3.90	3.87	0.03
9/29/2020 (DN273)	15:32	KLON DIKE-2020	OSNR CMR+ RTK	602646.20	4527296.39	1.83	1.81	0.02
10/3/2020 (DN277)	19:51	KLON DIKE-2020	OSNR CMR+ RTK	602645.46	4527297.00	2.07	2.06	0.01
10/11/2020 (DN285)	20:42	World's Fair	OSNR CMR+ RTK	596893.20	4512789.50	2.25	2.23	0.02
10/15/2020 (DN289)	16:53	World's Fair	OSNR CMR+ RTK	596892.70	4512790.06	2.30	2.28	0.02
10/19/2020 (DN293)	20:22	World's Fair	OSNR CMR+ RTK	596893.14	4512789.57	2.24	2.22	0.02
10/20/2020 (DN294)	20:20	World's Fair	OSNR CMR+ RTK	596893.24	4512789.57	2.17	2.16	0.01
10/22/2020 (DN296)	22:04	KLON DIKE-2020	OSNR CMR+ RTK	602645.66	4527296.82	1.86	1.84	0.02

Table 6
***R/V Ready II* Tabulation of Navigation System Confidence Checks**

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
7/30/2020 (DN212)	13:40	Harbor One 2020	OSNR CMR+ RTK	721996.41	4573418.42	2.77	2.71	0.06
8/23/2020 (DN236)	21:42	GC20	OSNR CMR+ RTK	614160.79	4523701.06	6.22	6.22	0.00
8/25/2020 (DN238)	9:52	GC20	OSNR CMR+ RTK	614160.82	4523701.08	6.23	6.32	0.09
8/26/2020 (DN239)	9:48	GC20	OSNR CMR+ RTK	614160.80	4523701.11	6.26	6.26	0.00
8/27/2020 (DN240)	10:02	GC20	OSNR CMR+ RTK	614160.78	4523701.15	6.31	6.25	0.06
8/28/2020 (DN241)	10:12	GC20	OSNR CMR+ RTK	614160.87	4523701.12	6.24	6.28	0.04
8/29/2020 (DN242)	10:20	GC20	OSNR CMR+ RTK	614160.76	4523701.24	6.40	6.33	0.07
8/30/2020 (DN243)	11:23	GC20	OSNR CMR+ RTK	614160.87	4523701.09	6.22	6.19	0.03
8/31/2020 (DN244)	10:26	GC20	OSNR CMR+ RTK	614160.79	4523701.12	6.28	6.24	0.04
9/1/2020 (DN245)	10:00	GC20	OSNR CMR+ RTK	614160.80	4523701.05	6.21	6.23	0.02
9/2/2020 (DN246)	10:53	GC20	OSNR CMR+ RTK	614160.91	4523701.05	6.16	6.23	0.07
9/3/2020 (DN247)	10:53	GC20	OSNR CMR+ RTK	614160.85	4523701.02	6.16	6.15	0.01
9/4/2020 (DN248)	11:11	GC20	OSNR CMR+ RTK	614160.94	4523700.98	6.09	6.13	0.04
9/10/2020 (DN254)	11:03	GC20	OSNR CMR+ RTK	614159.25	4523691.56	5.92	5.95	0.03
9/11/2020 (DN255)	10:56	GC20	OSNR CMR+ RTK	614160.71	4523701.16	6.35	6.30	0.05

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
9/13/2020 (DN257)	10:29	GC20	OSNR CMR+ RTK	614160.88	4523700.83	5.98	6.10	0.12
9/14/2020 (DN258)	12:36	GC20	OSNR CMR+ RTK	614162.22	4523701.38	6.02	6.05	0.03
9/16/2020 (DN260)	21:39	GC20	OSNR CMR+ RTK	614162.23	4523701.55	6.18	6.22	0.04
9/17/2020 (DN261)	21:36	GC20	OSNR CMR+ RTK	614162.24	4523701.54	6.17	6.26	0.09
9/21/2020 (DN265)	22:16	GC20	OSNR CMR+ RTK	614162.32	4523701.37	5.99	6.00	0.01
9/23/2020 (DN267)	11:09	GC20	OSNR CMR+ RTK	614161.12	4523688.65	7.33	7.40	0.07
9/28/2020 (DN272)	11:09	GC20	OSNR CMR+ RTK	614162.13	4523701.63	6.29	6.31	0.02
10/3/2020 (DN277)	10:30	GC20	OSNR CMR+ RTK	614160.73	4523700.91	6.12	6.38	0.26
10/4/2020 (DN278)	10:50	GC20	OSNR CMR+ RTK	614160.64	4523701.03	6.27	6.33	0.06
10/9/2020 (DN283)	10:39	GC20	OSNR CMR+ RTK	614141.21	4523715.38	29.96	29.89	0.07
10/11/2020 (DN285)	11:27	GC20	OSNR CMR+ RTK	614162.25	4523701.45	6.08	6.14	0.06
10/14/2020 (DN288)	22:29	GC20	OSNR CMR+ RTK	614162.13	4523701.68	6.33	6.40	0.07
10/15/2020 (DN289)	11:05	GC20	OSNR CMR+ RTK	614162.15	4523701.67	6.32	6.45	0.13
10/15/2020 (DN289)	11:13	GC20	OSNR CMR+ RTK	614162.12	4523701.64	6.30	6.47	0.17
10/15/2020 (DN289)	17:47	GC20	OSNR CMR+ RTK	614141.34	4523715.29	29.80	29.77	0.03

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
10/17/2020 (DN291)	21:01	GC20	OSNR CMR+ RTK	614160.97	4523700.91	6.01	6.08	0.07
10/18/2020 (DN292)	10:51	GC20	OSNR CMR+ RTK	614160.87	4523701.11	6.23	6.22	0.01
10/19/2020 (DN293)	10:59	GC20	OSNR CMR+ RTK	614160.72	4523701.16	6.35	6.60	0.25
10/19/2020 (DN293)	11:02	GC20	OSNR CMR+ RTK	614160.71	4523701.18	6.37	6.56	0.19
10/19/2020 (DN293)	11:13	GC20	OSNR CMR+ RTK	614160.73	4523701.18	6.36	6.49	0.13
10/20/2020 (DN294)	21:31	GC20	OSNR CMR+ RTK	614160.19	4523704.56	9.67	9.65	0.02
10/21/2020 (DN295)	16:06	GC20	OSNR CMR+ RTK	614160.67	4523701.24	6.44	6.47	0.03

Table 7
***R/V Able II* Tabulation of Navigation System Confidence Checks**

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
7/21/2020 (DN203)	21:25	Harbor One 2020	OSNR CMR+ RTK	721997.44	4573418.30	3.70	3.68	0.02
7/22/2020 (DN204)	16:37	Harbor One 2020	OSNR CMR+ RTK	721995.68	4573418.41	2.23	2.23	0.00
8/24/2020 (DN237)	22:33	KLON DIKE-2020	OSNR CMR+ RTK	602644.57	4527297.41	2.29	2.24	0.05
8/24/2020 (DN237)	22:42	KLON DIKE-2020	OSNR CMR+ RTK	602644.87	4527297.33	2.19	2.18	0.01

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
8/25/2020 (DN238)	12:06	KLON DIKE-2020	OSNR CMR+ RTK	602644.85	4527297.38	2.24	2.33	0.09
8/25/2020 (DN238)	12:08	KLON DIKE-2020	OSNR CMR+ RTK	602644.88	4527297.37	2.23	2.23	0.00
8/27/2020 (DN240)	11:20	KLON DIKE-2020	OSNR CMR+ RTK	602644.68	4527297.48	2.35	2.32	0.03
8/28/2020 (DN241)	15:05	KLON DIKE-2020	OSNR CMR+ RTK	602644.79	4527297.27	2.13	2.16	0.03
9/2/2020 (DN246)	17:49	KLON DIKE-2020	OSNR CMR+ RTK	602645.20	4527297.28	2.17	2.15	0.02
9/4/2020 (DN248)	16:22	KLON DIKE-2020	OSNR CMR+ RTK	602644.73	4527297.32	2.18	2.20	0.02
9/8/2020 (DN252)	21:11	KLON DIKE-2020	OSNR CMR+ RTK	602645.40	4527297.17	2.10	2.13	0.03
9/9/2020 (DN253)	10:07	KLON DIKE-2020	OSNR CMR+ RTK	602645.12	4527297.25	2.13	2.16	0.03
9/9/2020 (DN253)	10:11	KLON DIKE-2020	OSNR CMR+ RTK	602645.09	4527297.28	2.15	2.15	0.00
9/10/2020 (DN254)	20:13	KLON DIKE-2020	OSNR CMR+ RTK	602645.25	4527297.26	2.15	2.17	0.02
9/11/2020 (DN255)	10:25	KLON DIKE-2020	OSNR CMR+ RTK	602645.05	4527297.18	2.05	2.06	0.01
9/12/2020 (DN256)	10:12	KLON DIKE-2020	OSNR CMR+ RTK	602644.86	4527297.24	2.10	2.14	0.04
9/12/2020 (DN256)	10:15	KLON DIKE-2020	OSNR CMR+ RTK	602644.89	4527297.29	2.15	2.16	0.01
9/13/2020 (DN257)	10:31	KLON DIKE-2020	OSNR CMR+ RTK	602644.94	4527297.33	2.19	2.20	0.01
9/23/2020 (DN267)	19:13	KLON DIKE-2020	OSNR CMR+ RTK	602644.55	4527297.34	2.22	2.26	0.04

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
9/29/2020 (DN273)	15:18	KLON DIKE-2020	OSNR CMR+ RTK	602645.24	4527297.25	2.14	2.15	0.01
10/4/2020 (DN278)	20:30	KLON DIKE-2020	OSNR CMR+ RTK	602644.55	4527297.01	1.90	2.08	0.18
10/5/2020 (DN279)	20:24	KLON DIKE-2020	OSNR CMR+ RTK	602645.17	4527297.04	1.92	2.13	0.21
10/5/2020 (DN279)	20:26	KLON DIKE-2020	OSNR CMR+ RTK	602644.60	4527297.14	2.02	2.14	0.12
10/5/2020 (DN279)	20:28	KLON DIKE-2020	OSNR CMR+ RTK	602644.59	4527297.12	2.00	2.14	0.14
10/5/2020 (DN279)	20:33	KLON DIKE-2020	OSNR CMR+ RTK	602644.22	4527297.24	2.20	2.28	0.08
10/5/2020 (DN279)	20:37	KLON DIKE-2020	OSNR CMR+ RTK	602644.51	4527297.18	2.07	2.16	0.09
10/6/2020 (DN280)	20:03	KLON DIKE-2020	OSNR CMR+ RTK	602644.35	4527297.54	2.45	2.49	0.04
10/6/2020 (DN280)	20:08	KLON DIKE-2020	OSNR CMR+ RTK	602644.49	4527297.20	2.09	2.15	0.06
10/9/2020 (DN283)	20:01	KLON DIKE-2020	OSNR CMR+ RTK	602644.76	4527297.29	2.15	2.17	0.02
10/10/2020 (DN284)	20:25	KLON DIKE-2020	OSNR CMR+ RTK	602645.17	4527297.16	2.04	1.98	0.06
10/13/2020 (DN287)	16:04	KLON DIKE-2020	OSNR CMR+ RTK	602644.52	4527297.38	2.27	2.28	0.01
10/16/2020 (DN290)	18:56	KLON DIKE-2020	OSNR CMR+ RTK	602644.59	4527297.44	2.32	2.24	0.08
10/16/2020 (DN290)	18:58	KLON DIKE-2020	OSNR CMR+ RTK	602644.62	4527297.25	2.12	2.15	0.03
10/18/2020 (DN292)	17:11	KLON DIKE-2020	OSNR CMR+ RTK	602644.47	4527292.42	2.75	2.34	0.41

Date	Time UTC	Nav. Check-point	DGNSS Corr. Source	Observed Easting UTM 18N, NAD83 (meters)	Observed Northing UTM 18N, NAD83 (meters)	Calculated Distance RP to Nav. Checkpoint (meters)	Tape Measure RP to Nav. Checkpoint (meters)	Difference Calculated vs. Tape Measured (meters)
10/18/2020 (DN292)	17:13	KLON DIKE-2020	OSNR CMR+ RTK	602644.45	4527297.43	2.33	2.29	0.04
10/18/2020 (DN292)	17:15	KLON DIKE-2020	OSNR CMR+ RTK	602644.45	4527297.39	2.29	2.28	0.01
10/20/2020 (DN294)	16:33	KLON DIKE-2020	OSNR CMR+ RTK	602644.84	4527297.46	2.32	2.30	0.02
10/20/2020 (DN294)	16:36	KLON DIKE-2020	OSNR CMR+ RTK	602644.81	4527297.51	2.37	2.37	0.00

D. APPROVAL SHEET

This report and the accompanying data are respectfully submitted.

Field operations contributing to the accomplishment of Surveys H13384, H13385, and H13386 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 Statement of Work.

Approver Name	Approver Title	Approval Date	Signature
John R. Bean	Chief of Party	05/27/2021	John R. Bean 2021.05.27 14:56:13 -04'00'
David T. Somers	Data Processing Manager	05/27/2021	David T. Somers 2021.05.27 14:56:27 -04'00'