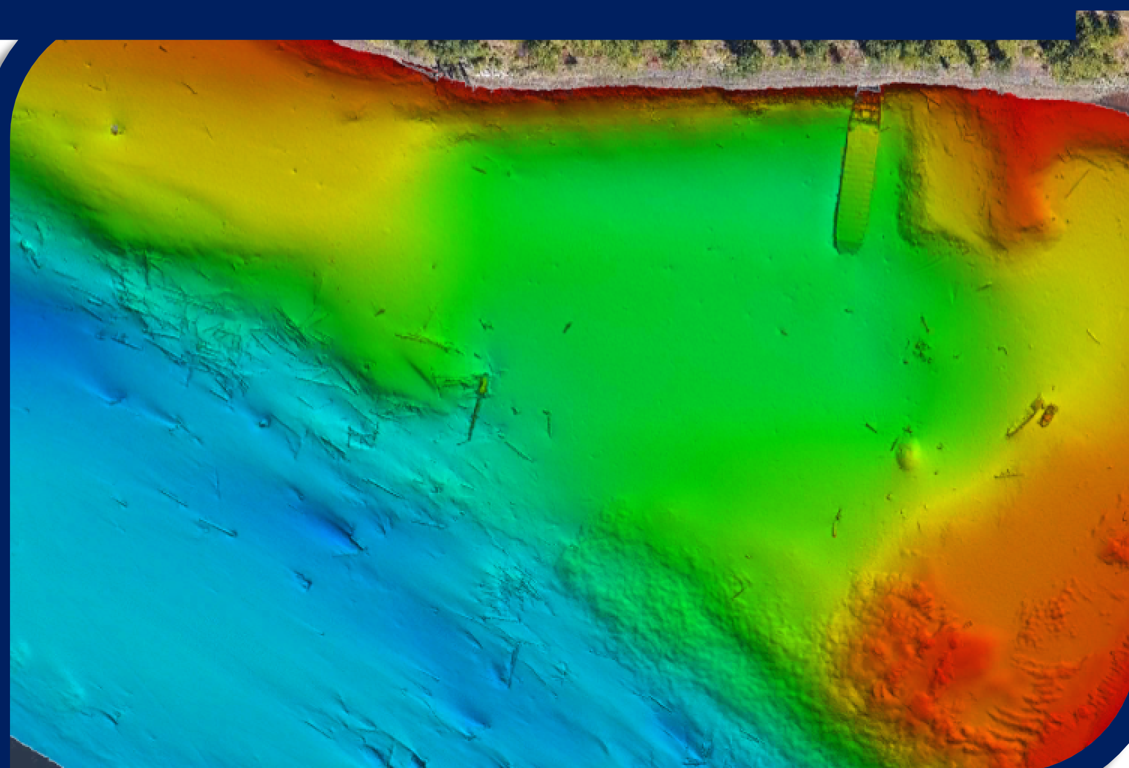
# WILLAMETTE COVE HYDROGRAPHIC SURVEY

## 2020 Field Survey Memorandum



February 2020

**Prepared for:**

GSI Water Solutions, Inc.

**Prepared by:**

solmar hydro

Marine Engineering & Surveying

# WILLAMETTE COVE HYDROGRAPHIC SURVEY

## 2020 FIELD SURVEY MEMORANDUM

**FEBRUARY 2020**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# ABBREVIATIONS

| | |
|---|---|
| DEM | Digital Elevation Model |
| GAMS | GPS Azimuth Measurement Subsystem |
| GNSS | Global Navigation Satellite System |
| MBES | Multi-beam Echosounder |
| NAD83/2011 | North American Datum of 1983 (2011 Adjustment) |
| NAVD88 | National Vertical Datum of 1988 |
| NOAA | National Oceanographic and Atmospheric Administration |
| NOS | National Ocean Service |
| NSPS | National Society of Professional Surveyors |
| OTF | On the Fly |
| PDI | Preliminary Design Investigation |
| RD | Remedial Design |
| RTK | Real-time Kinematic |
| QA | Quality Assurance |
| QC | Quality Control |
| SBES | Single-beam Echosounder |
| SHI | Solmar Hydro, Inc. |
| UHF | Ultra-high Frequency |
| WGS84 | World Geodetic System 1984 |

## 1.0 INTRODUCTION

Solmar Hydro, Inc. (SHI) recently completed a high-resolution hydrographic survey within the Portland Harbor at the Willamette Cove Project Area. The survey was completed February 10, 2020 for the Performing Parties on behalf of GSI Water Solutions, Inc. The survey was designed to support the Preliminary Design Investigation (PDI) and Remedial Design (RD) activities being undertaken as a part of the Willamette Cove Environmental Cleanup, and included simultaneous bathymetric and acoustic backscatter intensity measurements.

Willamette Cove is a shallow bay between, approximately, river mile (RM) 6 and RM 7 on the east side of the Willamette River (see Figure 1). The project objectives were to measure present-day riverbed elevations in sufficiently-high resolution to identify existing bottom debris, hazards, and other features in preparation for future remedial sampling and/or action. In addition, acoustic backscatter (ABS) intensity (i.e., “snippets”) data were concurrently collected to support bottom characterization evaluations.

The survey was generally conducted in accordance with the procedures and guidelines specified in the USACE Hydrographic Surveying Manual EM 1110-2-1003 (2013). The survey exceeded the specifications - of the USACE as well as the International Hydrographic Organization (IHO) Standards for Hydrographic Surveys (S-44, 5th Edition, 2008).

The sections below comprise a narrative of the survey procedures including a discussion of the survey setup, equipment used, data collection methods followed, data quality control and assurance (QC/QA) measures applied, and post-processing techniques. Additional supporting information such as copies of daily and safety meeting reports are included as appendices.

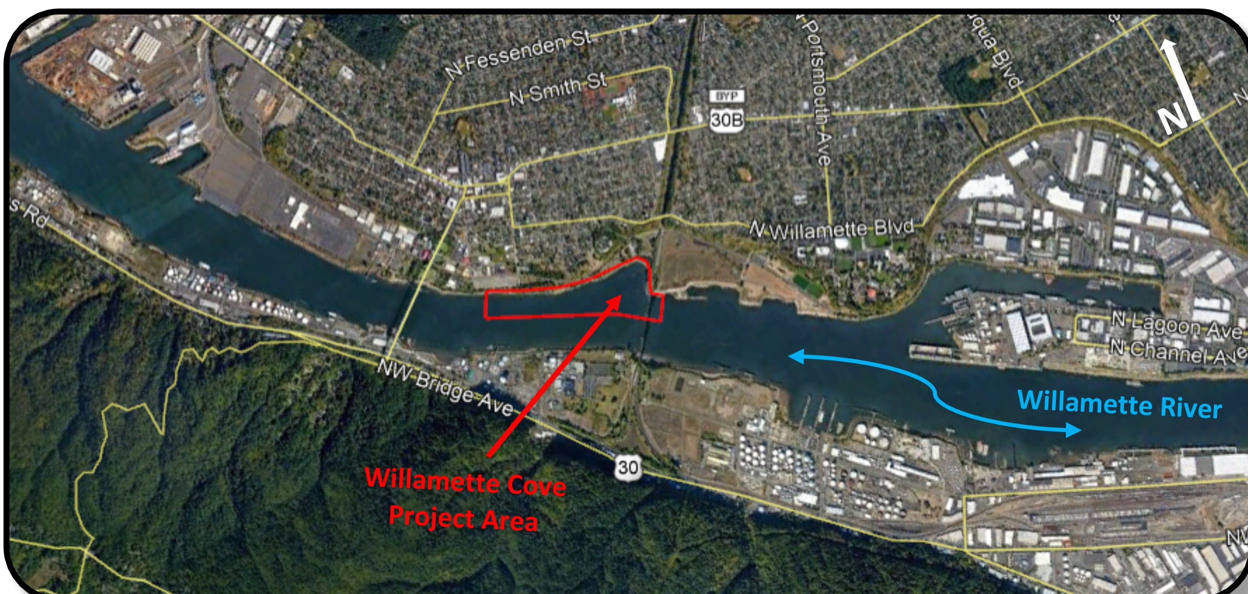



**Figure 1. Hydrographic survey extent map (red outline).**

## 2.0 SYSTEM SETUP AND PROJECT CONTROL

### SURVEY VESSEL AND CREW

SHI used our 24-ft aluminum hydrographic survey vessel for this project (Figure 2). The survey crew comprised a National Society of Professional Surveyors (NSPS) Certified Hydrographer, an Oregon Registered Professional Engineer, and a U.S. Coast Guard licensed vessel captain.

The project team members and their roles on this project were as follows:

- Jason Magalen, C.H., P.E. – Project Manager and Lead Hydrographic Surveyor[1,3]
- Matt Stein – Survey Technician and Survey Vessel Captain[2]

*1 – NSPS Certified Hydrographer; 2 – USCG Licensed Vessel Captain; 3 – Registered Professional Engineer (OR, WA, CA, GU)*


**Figure 2. SHI's shallow water 24' survey vessel with multi-beam sonar in water (on side pole mount)**

### DATA ACQUISITION SYSTEM

The bathymetric survey was completed on February 10, 2020. The sonar system comprised an R2Sonic 2024 wideband ultra-high frequency (UHF) MBES simultaneously collecting ABS snippets data. The R2Sonic 2024 improves over other MBES systems with its individual beam widths of 0.45º by 0.9º when operated at 450 kHz. This translates into finer resolution final data products than MBES systems with larger beam widths.

ABS intensity is an inherent property of the riverbed material(s) that describes how strongly a unit area of substrate scatters acoustic energy back toward an acoustic source. The ABS data help identify characteristics of the bed by comparing the strength of the return echo to the strength of the outgoing pulse. Collection of ABS intensity data in this manner allows a large spatial scale dataset to be generated rapidly and cost-effectively via remote sensing methods. The results provide an indication of bed material and debris type, density, and surface hardness. In order to confirm remote sensing classification of the surficial materials, however, it is always necessary to validate (ground truth) acoustic backscatter results via direct sampling or observation methods.

During surveying, the horizontal and vertical positions and orientations were measured with an Applanix POS/MV Wavemaster II positioning and orientation system. The POS/MV is a real-time kinematic (RTK) global navigation satellite system (GNSS)-augmented navigation system that provides accurate, real-time position, heading, and attitude measurements for the survey vessel. The system provides inertially-derived positions allowing for data collection to continue in situations where GPS-compromised environments are encountered.

While acquiring data, a Trimble R7 RTK-GNSS system was used to transmit positioning corrections from land-based survey control to the survey vessel. Raw GNSS observations were recorded at both the GNSS base station and on board the vessel (e.g., Applanix POSPAC raw, inertial, and GNSS data) to apply post-processed kinematic (PPK) positioning to the dataset. PPK reduces 3D positioning errors, and improves 3D positioning accuracies, in comparison to RTK 3D positioning.

Vertical reference elevations during surveying were collected with RTK GNSS on-the-fly (OTF) ambiguity resolution by the POS/MV. The Geoid 2012B model was used in the data acquisition and processing software packages, HYPACK and CARIS, for OTF conversion from the World Geodetic System 1984 (WGS84) ellipsoid to North American Vertical Datum of 1988 (NAVD88) orthometric heights. The benefits of using OTF RTK techniques at the point of measurement eliminated several potentially significant vertical error components such as errors introduced from vessel settlement and squat or errors introduced from other static and dynamic draft changes.

Xylem Coastal Oceanographics Hypack Hysweep 2019 was the primary sonar data acquisition system. The system provided precise time-tagging of the sensor data and real-time data displays for coverage and quality control. Teledyne CARIS HIPS was subsequently utilized to QC and post-process the all MBES data.

#### EQUIPMENT LIST

A complete record of the equipment utilized during this effort is listed here:

- 24 foot aluminum survey vessel
- R2Sonic 2024 wideband UHF MBES with Valeport MiniSVS
- Applanix POS/MV Wavemaster II, RTK-enabled
- Trimble R7/R8 RTK GNSS systems and radios
- Xylem YSI Castaway Sound Velocity Profiler
- HYPACK 2019 (data acquisition, navigation software)
- CARIS HIPS and QPS FMGT (bathymetric and ABS intensity data post-processing software)

### CONTROL ESTABLISHMENT

The project horizontal coordinate system comprised the North American Datum of 1983 (NAD83, 2011 adjustment, EPOCH: 2010.00), projected to the State Plane Coordinate System, Oregon North Zone, and with units in international feet. The vertical datum for this survey was the North American Vertical Datum of 1988 (NAVD88) using the GEOID12B model and with units in international feet.

A Trimble R7 RTK-GNSS base station was setup on an existing, long-term stable survey control point near the project site (SHI-1). Survey control was subsequently verified via a check shot on a nearby survey control mark (SHI-2), and through direct comparison of reported vs. measured coordinate differences. Coordinates for each control mark are provided in Table 1. An image of the RTK-GNSS base station setup on SHI-1 is included in Figure 3. Coordinate differences between the reported QC check shot coordinates and those measured on 2/10/2020 are listed in Table 2. Coordinate differences were less than 0.05-ft in all three orthogonal directions, indicating very good agreement and survey control network verification.

**Table 1. Survey Control**

| Control Point ID | Description | Northing (ift) | Easting (ift) | Elevation (ift) |
|---|---|---|---|---|
| **SHI-1** | **GNSS Base Station** | 708989.948 | 7622418.484 | 34.259 |
| **SHI-2** | **GNSS QC Position Check** | 709002.210 | 7622430.894 | 34.197 |

**-Horizontal datum: NAD83/2011, OR State Plane Coordinate System, North Zone**
**-Vertical Datum: NAVD88**
**-Units: International Feet**

**Figure 3. RTK GNSS base station and radio setup at SHI-1.**

**Table 2. Differences between the reported and measured coordinates at SHI-2.**

| Point | Δ Northing (ft) | Δ Easting (ft) | Δ Elevation (NAVD88, ft) |
|---|---|---|---|
| **SHI-2** | -0.016 | -0.008 | 0.026 |

## 3.0 DATA COLLECTION AND PROCESSING

Prior to initiating the survey, SHI completed industry-standard vessel setup, mobilization, calibration, and QC checks on land and in the Columbia River. Standard checks included baseline measurement and confirmation of sensor offsets, a GAMS calibration test, an installation parameters lever arms test, an MBES sensor patch test, a vessel positioning test, and a water level verification check. QC tests and results are discussed in detail in Section 4.0 below.

MBES bathymetric data were collected within the Willamette Cove project area to attain 100% bottom coverage. The survey began offshore and proceeded shoreward in concurrence with a rising tide to ensure coverage was attained as far shoreward as possible during the highest water level. Overlapping MBES data were collected to as shallow as safely navigable (generally to water depths of 3-4 feet below the sonar).

Preliminary MBES and ABS data processing was completed in the field to verify data quality, to confirm coverage, and to identify issues of immediate concern if any arose during operations. Final processing of MBES bathymetric data was conducted in the office using CARIS HIPS V10.0 MBES editing software. Data regarding the vessel's position, attitude, water surface elevations, offsets, and sound velocity casts were applied to properly ray-trace the soundings. The MBES data were then reviewed and edited with swath and subset editors, eliminating erroneous soundings (i.e., outliers). All accepted data were then used to create a high-resolution (i.e. 1 grid point every 0.5-ft) Digital Elevation Model (DEM) of the surveyed area (see Figure 4). In the sun-illuminated figure, warmer colors (e.g., red/orange) indicate shallower water depths while cooler colors (blues) indicate deeper water depths.

R2Sonic acoustic backscatter intensity data (*.R2S files) were merged with the processed bathymetric data in CARIS HDCS so that all MBES data corrections/edits were applied to the backscatter data files as well. Backscatter data files were then processed and corrected with the QPS Fledermaus Geocoder Toolbox (FMGT). A full-site backscatter image mosaic was exported as a GeoTIFF with the same resolution as the bathymetric data for direct comparability. A site-wide illustration of the final ABS intensity mosaic is shown in Figure 5. In the figure, brighter coloring indicates higher reflected acoustic intensity (i.e., hardness) while darker coloring indicates acoustic attenuation.

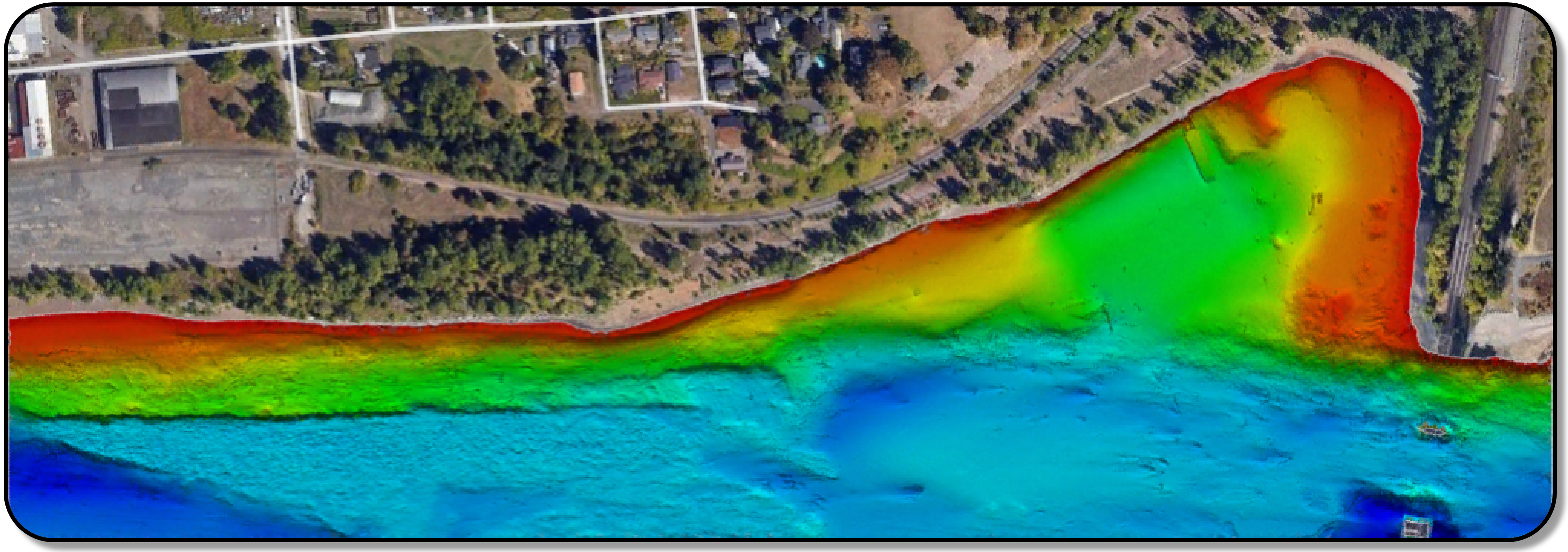


Figure 4. Site-wide final DEM from the February 10, 2020 survey.


Figure 5. Site-wide final ABS intensity mosaic from the February 10, 2020 survey.

## 4.0 QUALITY CONTROL AND ASSURANCE

To ensure the data collected met survey accuracy requirements, QA/QC procedures as stated in the USACE EM 1110-2-1003 and the IHO S-44 (2008) were followed. The QA/QC measures implemented include system confidence checks prior to and during the hydrographic survey operations. These include survey documentation, static draft checks, settlement and squat compensation, bar checks, patch tests, performance tests, and sound velocity profiles in the water column.

### VESSEL SENSOR OFFSET MEASUREMENTS

Reference positions of each MBES system sensor on the SHI vessel were previously surveyed with a total station to millimetric precision by a registered professional land surveyor. This level of accuracy and precision is required in order to achieve and exceed the targeted accuracies. Sensor offsets on this vessel have not been altered since the total station survey, but have been periodically verified through laser measurements. A copy of the SHI 24' survey vessel sensor offset survey results is included in Appendix I.

### STATIC DRAFT CHECK

Vessel draft may vary temporally depending upon characteristics such as e.g., the number or location of survey personnel onboard or amount of vessel fuel remaining. Proper measurement and inclusion of draft is important to verify water level (i.e., tide) data are being measured accurately throughout the survey and to confirm bar check measurements. Prior to initiation of the survey, the vessel draft was verified by observation and measurement of the water level within a draft tube installed in the hull of the survey vessel. The vessel draft during this survey was 0.68 feet.

### SENSOR ALIGNMENT VERIFICATION

A *GPS Azimuth Measurement Subsystem (GAMS) calibration* is used to aid the POS/MV in determining precise heading, a feature which is imperative to yield high-order accuracy survey results for MBES surveys. Calibration is necessary after system installation or when adjustments are made to sensors. A GAMS calibration comprises operating the vessel in variable turning motions at variable speeds and alternating forward and astern thrust. SHI completed a GAMS calibration prior to the start of the Willamette Cove survey which indicated that the attitude and heading accuracies of the system were less than 0.05º.

A POS/MV *installation calibration* verifies that the offsets between the IMU and the GNSS antennae are accurate. This additional calibration checks for proper entry of offsets within the POS/MV software, errors in which cannot be easily corrected during post-processing. SHI completed the installation calibration prior to starting the survey which indicated that the total station-surveyed offsets were in excellent agreement (within 0.01-0.02 m) with the calibration-derived offsets.

Additionally, a MBES/IMU calibration (i.e., "patch") test was performed prior to initiating the survey. The MBES patch test determines the 3D angular offsets between the MBES sonar reference frame and that of the POS/MV IMU. A patch test calibration is critical to obtaining high-resolution and high-accuracy sonar data. The patch test results are listed in Table 3.

Table 3. MBES calibration ("patch") test results.

| Parameter | Value | Parameter | Value |
|---|---|---|---|
| **Roll** | 0.79º | **Yaw** | 0.23º |
| **Pitch** | -0.55º | **Latency** | 0.0 sec |

### WATER SURFACE ELEVATION COMPARISON

A Trimble R8-3 RTK-GNSS rover was used to obtain a water surface elevation measurement near the survey location (at the Cathedral Park boat ramp) and compare to the water level being reported by the Hypack survey acquisition system. This is a QA test to verify that the sonar system real-time water level elevations agree with those measured with an RTK-GNSS rover. Results of the comparison are listed in Table 4 where the typical elevation differences of less than 0.1-ft shows very good agreement.

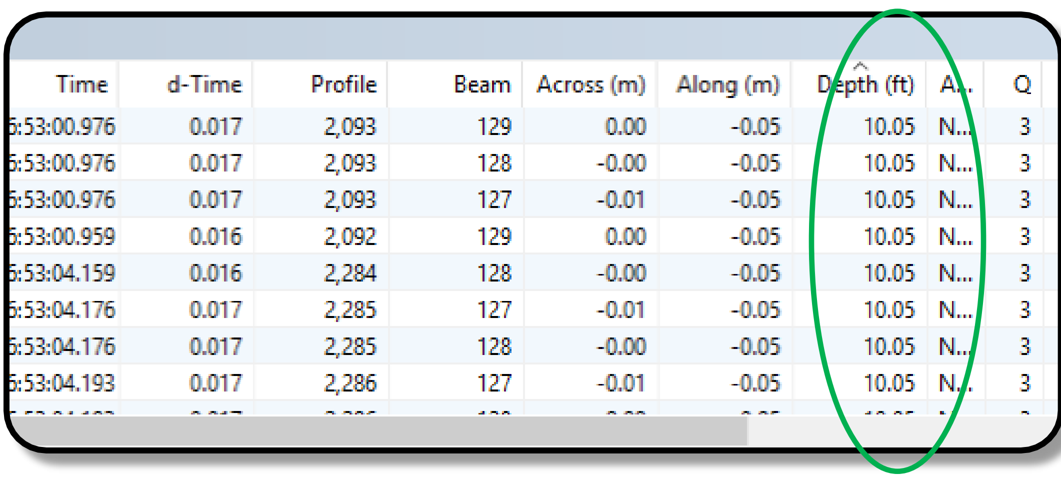
Table 4. Water surface elevation measurement comparison.

| Date | RTK-GNSS Elevation (ft)* | Hypack Real-time Water Level (ft) | Water Level Differences (ft) |
|---|---|---|---|
| **2020-02-10** | 8.40 | 8.41 | -0.01 |
| **2020-02-10** | 9.51 | 9.57 | -0.06 |

***vertical datum is NAVD88**

### STATIC BAR CHECK

To check that the draft setting for the MBES was accurate a bar check was completed during which a flat plate was lowered below the sonar at a known depth. This procedure checks for proper vertical measurement of instrument offsets and verifies that no systematic bias (i.e., index) or offset measurements (e.g., draft) requires additional consideration. It compares the measured depths from the sonar system to known depths of the flat plate in water depths where sound speed can be ignored.



| Time | d-Time | Profile | Beam | Across (m) | Along (m) | Depth (ft) | A... | Q |
|---|---|---|---|---|---|---|---|---|
| 5:53:00.976 | 0.017 | 2,093 | 129 | 0.00 | -0.05 | 10.05 | N... | 3 |
| 5:53:00.976 | 0.017 | 2,093 | 128 | -0.00 | -0.05 | 10.05 | N... | 3 |
| 5:53:00.976 | 0.017 | 2,093 | 127 | -0.01 | -0.05 | 10.05 | N... | 3 |
| 5:53:00.959 | 0.016 | 2,092 | 129 | 0.00 | -0.05 | 10.05 | N... | 3 |
| 5:53:04.159 | 0.016 | 2,284 | 128 | -0.00 | -0.05 | 10.05 | N... | 3 |
| 5:53:04.176 | 0.017 | 2,285 | 127 | -0.01 | -0.05 | 10.05 | N... | 3 |
| 5:53:04.176 | 0.017 | 2,285 | 128 | -0.00 | -0.05 | 10.05 | N... | 3 |
| 5:53:04.193 | 0.017 | 2,286 | 127 | -0.01 | -0.05 | 10.05 | N... | 3 |

Figure 6. MBES bar check results for 10' bar depth. Bar depth = 10.0 feet; Measured depth = 10.05 feet.

A sonar system bar check of 10.0 feet was completed with the MBES system prior to initiating the Willamette Cove survey. Example results of the MBES bar check test are illustrated in Figure 6 where a few of the representative nadir beams (beams 127-129) are shown measuring a water depth very near

10.0 feet. Bar check data files were logged during the test for thorough evaluation of the bar check data during post-processing. No systematic bias was identified in the MBES system.

### Sound Speed Corrections

A Valeport MiniSVS sound velocity profiler was located at the MBES transducer head to compensate for real time sound velocity changes at the surface and to aid in beam steering during data collection. Real-time sound velocity measurements at the sonar head are imperative for flat array sonars such as the R2Sonic 2024.

For deeper depths, it becomes important to account for water column profile sound velocity because of the potential for varying sound speeds and resultant MBES outer beam refraction effects. SVP water column data were collected at regular intervals during surveying activities to capture any temporal and spatial variation in sound velocity. Figure 7 presents a plot of the sound velocity profiles collected on 2/10/2020 and 2/11/2020 (in UTC dates and times). Very little change in sound speed was detected through the water column when measured in different locations and at different times (overall range of 1438 to 1439 m/s).

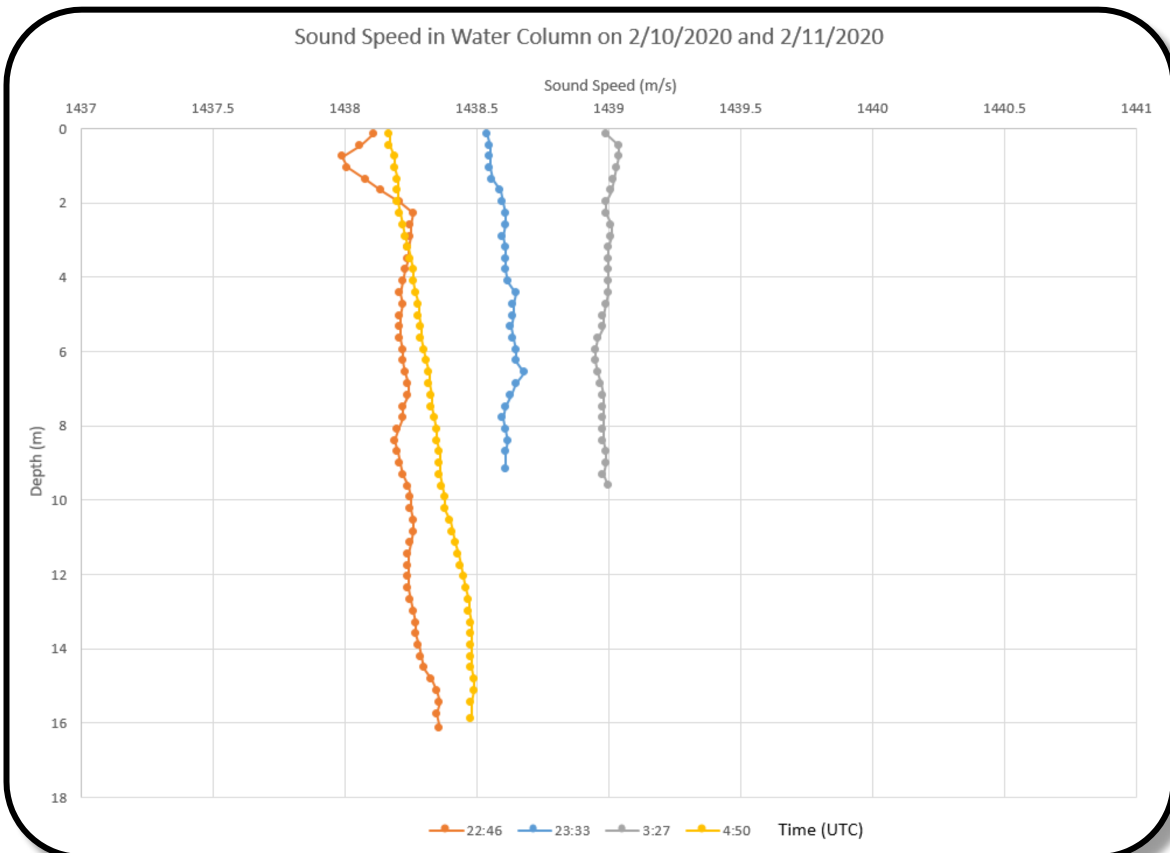



**Figure 7. SVP from 2/10/2020 at different UTC times (see legend).**

### Performance Tests

A system performance test was completed prior to initiating the survey at Willamette Cove to affirm MBES system accuracy. A reference surface, a survey completed over a relatively flat bottom area comprising several orthogonal survey lines in an overlapping grid pattern, was completed. During reference surface data collection, the MBES data are masked such that data are only collected to 45º to each side of nadir, in the angular range where the most accurate data are measured. The reference surface is used in the following QA/QC tests.

MBES performance tests are statistical verifications of the sonar system accuracy and are essential in order to demonstrate data quality. Two performance tests are commonly executed during MBES surveys: 1) a SBES-MBES comparison test, and 2) a MBES beam angle test.

#### *SBES-MBES Comparison Test*

SBES transducers operate pointing in a vertically down orientation. Because of this, SBES measurements (and nadir [center of swath] MBES measurements) are generally considered to be the most accurate soundings as they are not subjected to the refraction and ray-tracing errors that decrease accuracies in outer angle beams of swath systems.

During an SBES-MBES comparison test several SBES measurement transects are collected across the MBES reference surface, which was previously developed with MBES data from +/- 45º around nadir. Therefore, good agreement between the SBES and MBES reference surface depths indicates that the MBES system is performing well.


**Figure 8. SBES and MBES data comparison at reference surface.**

An SBES-MBES performance test was conducted prior to initiating the Willamette Cove survey. It was completed with a 200 kHz SBES transducer and the 450 kHz MBES sonar. An example of the SBES depths compared to the MBES depths is illustrated in Figure 8 where the differences shown are considered good agreement.

In addition, statistical analysis between the SBES and MBES data also indicates good agreement (see Figure 9). The mean difference between the data is less than 0.1 meter (0.09 m), with a standard deviation of 0.03 m and 95% of differences within 0.06 meters.

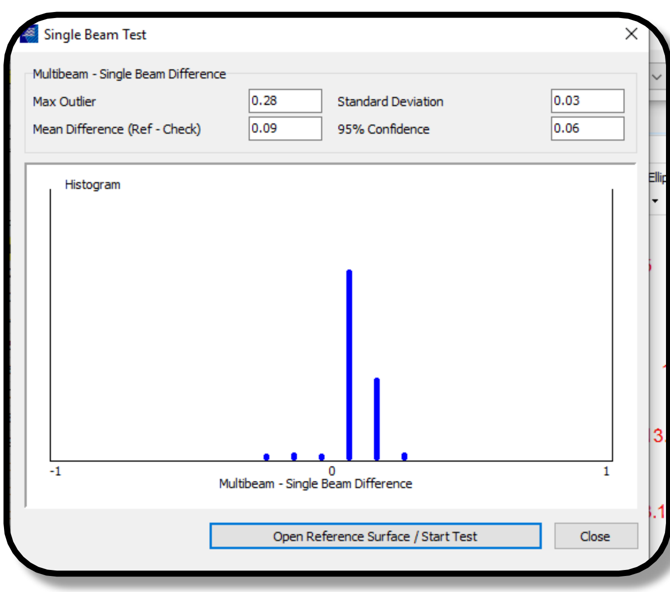



**Figure 9. Statistical results of SBES-MBES comparison performance test.**

*MBES BEAM ANGLE TEST*

As soundings are measured at outer angles (i.e., further away from nadir), the accuracy of the depth estimate decreases. This is due to several factors including refraction of the acoustic signal, sound speed variations, and decreases in reflected acoustic intensity. Consequently, an MBES beam angle test is completed to determine the largest swath angle that can be used to measure the bathymetry while still remaining within accuracy specifications.

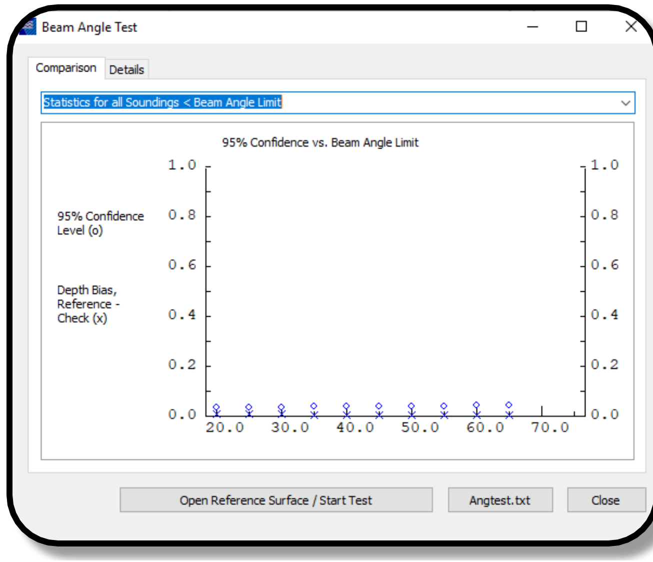



**Figure 10. MBES beam angle test results.**

Following the reference surface creation, in which swath angles are restricted to +/- 45º to each side of nadir, the swath angles are opened up to the maximum desired swath angle for the survey (e.g., 70º to each side). Two additional MBES transects of data are collected across the reference surface using the wider swath and compared to the reference surface data. The furthest angle from nadir to which the depth bias (statistical differences between the reference and check surfaces) remains below a specified threshold is the maximum angle deemed to perform with sufficient accuracy. For most applications, SHI adheres to the most recent version of the USACE Hydrographic Surveying Manual (EM 1110-2-1003) specifications which state the maximum allowable mean bias between reference and check surfaces shall be +/- 0.2 ft.

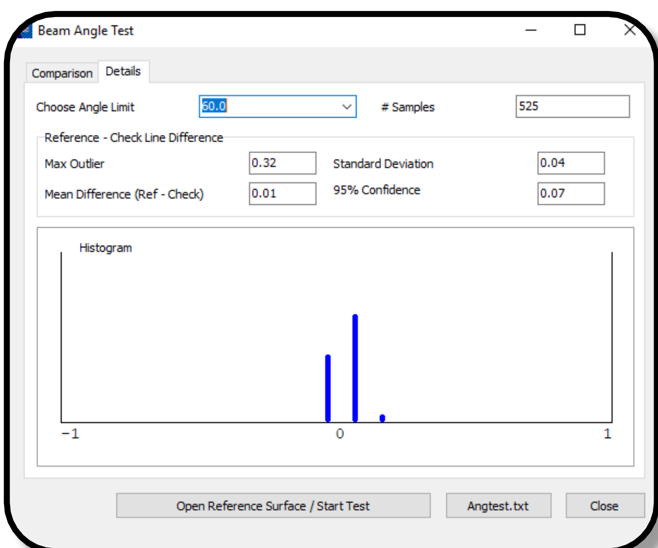



**Figure 11. Statistical results of beam angle test for 60º beam.**

The results of the beam angle test from the 2020 survey are illustrated graphically in Figure 10 where it is observed that the depth bias remains less than 0.1 meters out to a swath angle of 65º. The statistical results of this test are shown in Figure 11 where the calculated mean bias is 0.01 meters at an example angle of 60º from nadir.

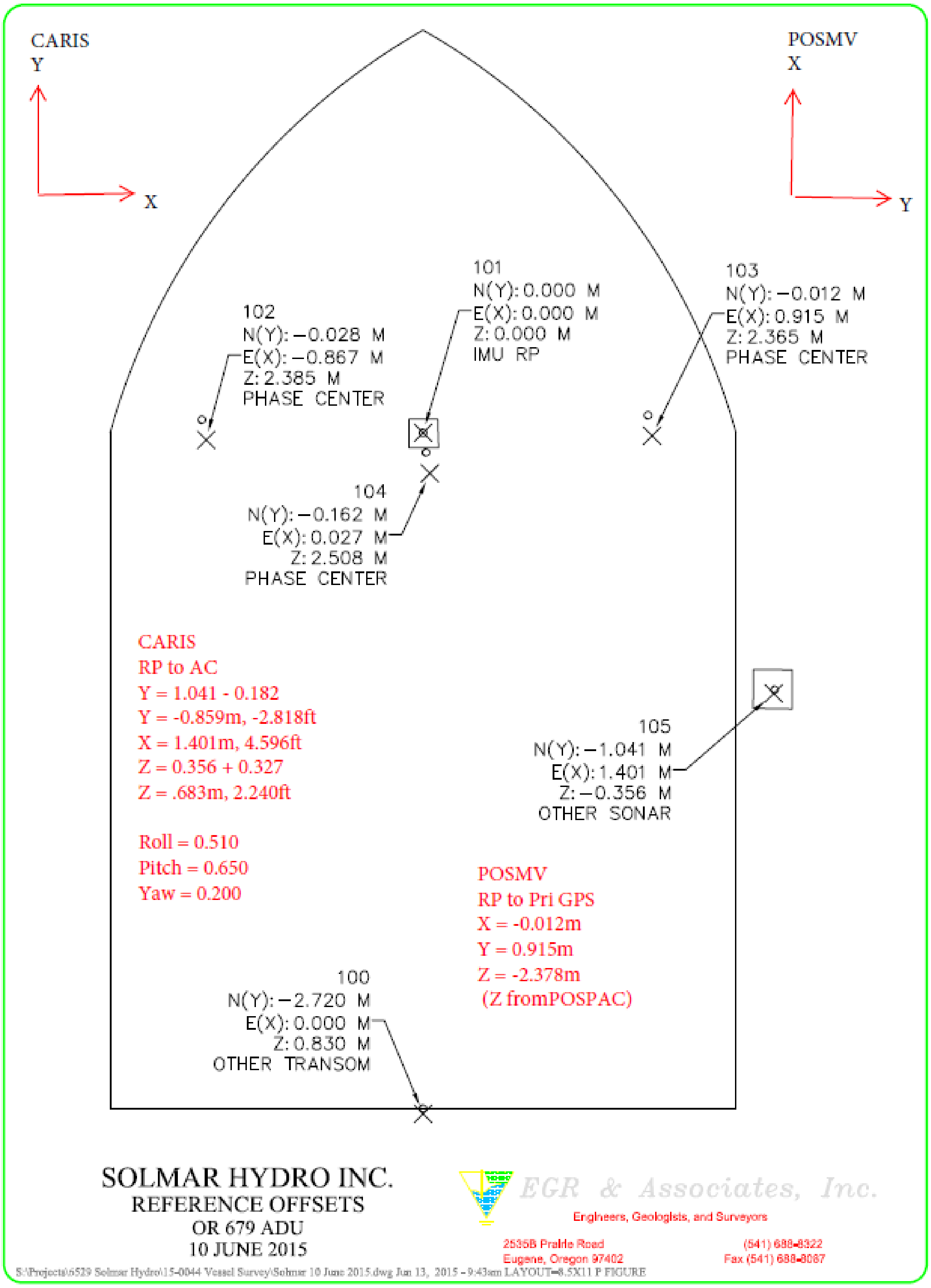
## 5.0 DELIVERABLES

Deliverables for the 2020 Willamette Cove hydrographic survey included the following:

- ASCII XYZ bathymetric text files at 0.5-ft gridded resolution (NAVD88 vertical datum)
    - **.xyz files that can be opened with any text editor (e.g., Notepad) or GIS/CAD program*
- ASCII Grid file of bathymetry at 0.5-ft gridded resolution (NAVD88 vertical datum)
    - **.asc file that can be opened with ESRI ArcGIS and other GIS software programs*
- Metadata files (NAVD88 vertical datum)
    - **.xml files that can be opened with any text editor (e.g., Notepad)*
- 0.5-ft resolution bathymetric DEM Geotiff files (sun-illuminated hillshade)
    - **.tif image files that can be opened in any image viewer (e.g., Windows Photo Viewer) or loaded in proper geographical space in any GIS/CAD program.*
    - **.tfw file (tiff world file) associated with the *.tif file of the same name; provides the geo-referencing projection information for the *.tif file*
- 0.5-ft resolution acoustic backscatter intensity mosaic Geotiff files
    - **.tif image files that can be opened in any image viewer (e.g., Windows Photo Viewer) or loaded in proper geographical space in any GIS/CAD program.*
    - **.tfw file (tiff world file) associated with the *.tif file of the same name; provides the geo-referencing projection information for the *.tif file*
- Google Earth imagery (multi-color DEM and grayscale ABS mosaic)
    - **.kmz files viewable via Google Earth*
- Bathymetric Survey Report (this document) documenting survey control, methodology, calibration procedures, data processing, quality assurance procedures, and stamped by a Registered Professional Engineer (OR and WA) and NSPS/THSOA Certified Hydrographer.

# APPENDICES

## APPENDIX I - SHI 24' SURVEY VESSEL SENSOR OFFSET SURVEY RESULTS


CARIS
Y
X
POSMV
X
Y
101
N(Y): 0.000 M
E(X): 0.000 M
Z: 0.000 M
IMU RP
102
N(Y): −0.028 M
E(X): −0.867 M
Z: 2.385 M
PHASE CENTER
103
N(Y): −0.012 M
E(X): 0.915 M
Z: 2.365 M
PHASE CENTER
104
N(Y): −0.162 M
E(X): 0.027 M
Z: 2.508 M
PHASE CENTER
CARIS
RP to AC
Y = 1.041 - 0.182
Y = -0.859m, -2.818ft
X = 1.401m, 4.596ft
Z = 0.356 + 0.327
Z = .683m, 2.240ft
Roll = 0.510
Pitch = 0.650
Yaw = 0.200
105
N(Y): −1.041 M
E(X): 1.401 M
Z: −0.356 M
OTHER SONAR
POSMV
RP to Pri GPS
X = -0.012m
Y = 0.915m
Z = -2.378m
(Z fromPOSPAC)
100
N(Y): −2.720 M
E(X): 0.000 M
Z: 0.830 M
OTHER TRANSOM
SOLMAR HYDRO INC.
REFERENCE OFFSETS
OR 679 ADU
10 JUNE 2015
EGR & Associates, Inc.
Engineers, Geologists, and Surveyors
2535B Prairie Road
Eugene, Oregon 97402
(541) 688-8322
Fax (541) 688-8087

## APPENDIX II – DAILY FIELD AND SAFETY REPORTS

# DAILY REPORT

**PROJECT INFORMATION** **DATE: 2/10/2020**

| | |
|---|---|
| Project Name | Willamette Cove Hydrographic Survey |
| Contract Number | n/a |
| Description of Operations | Multi-beam Hydrographic and Acoustic Backscatter Intensity Survey |
| Time Zone | UTC |
| Locality | Willamette River |
| Sub-Locality | Portland, OR |

**HORIZONTAL CONTROL**

| | |
|---|---|
| Positioning System | Applanix POSMV Wavemaster II |
| Antennae Type | Aero |
| GNSS Reference Station | Trimble R7 |
| Antennae Type | Zephyr Model II |
| Horizontal Datum | NAD83/11 |
| Horizontal Projection | State Plane Coordinate System, Oregon North Zone |
| Horizontal Units | International Feet |

**VERTICAL CONTROL**

| | |
|---|---|
| Primary Water Levels | RTK-GNSS, NAVD88, Geoid 2012B |
| Vertical Units | International Feet |

**INSTRUMENTATION**

| | |
|---|---|
| Primary Sensor(s) | R2 Sonic 2024 Multi-beam Echosounder |
| MRU | Applanix POSMV Wavemaster II |
| Heading | Applanix POSMV Wavemaster II |
| Sound Velocity Profiler | YSI Castaway |
| Data Acquisition System | Hypack Hysweep 2019 |

**VESSEL AND CREW**

| | |
|---|---|
| Vessel Name | SHI 24' Survey Vessel |
| Pilot | M. Stein |
| Crew | J. Magalen |

**Summary of Work Performed and Issues Encountered**

- Survey vessel setup, mobilization, calibration, and survey completion
- Safety briefing regarding potential work hazards
- Verify all sensor offsets, connections, and software setup

**Safety Subjects Discussed:**

Weather safety – working in elements with power tools, slippery work surfaces

Slips and trips on vessel

3-point contact when boarding and departing vessel

Always keep eyes up on waterway for approaching vessels

**Environmental Subjects Discussed**

Cleanup all debris/materials and place in proper receptacles.