Port of Hood River

Hood River Bridge Geophysical Survey

SUMMARY REPORT

APRIL 2021

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Port of Hood River

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ACRONYMS AND ABBREVIATIONS

CORS	Continuously Operating Reference Stations
DEA	David Evans and Associates, Inc.
GNSS	Global Navigation Satellite System
HIPS	Hydrographic Information Processing System
Hz	Hertz
ITRF14	International Terrestrial Reference Frame 2014
kHz	Kilohertz
NAD83(2011)	North American Datum of 1983, National Adj. 2011, Epoch 2010.00
NGS	National Geodetic Survey
NOAA	National Oceanic and Atmospheric Administration
nT	nanoTesla (unit of magnetic measurement, equivalent to one gamma)
OSMB	Oregon State Marine Board
POHR	Port of Hood River
POS/MV	Position and Orientation System for Marine Vessels
PPK	Post-Processed Kinematic
RTK	Real-Time Kinematic
SBET	Smoothed Best Estimate of Trajectory
SPCS	State Plane Coordinate System
SSP	Sound Speed Profile
UNAVCO	University NAVSTAR Consortium
WAAS	Wide Area Augmentation System
WGS84	World Geodetic System 1984, based on ITRF14
WSDOT	Washington State Department of Transportation
WSRN	Washington State Reference Network

1.0 INTRODUCTION

David Evans and Associates, Inc. (DEA), Marine Services Division, conducted a geophysical survey on the Columbia River near Hood River, Oregon, from March 8 to March 11, 2021. The survey was conducted in support of archeological investigations around the northern end of the potential new bridge site, being planned just west of the existing bridge. A variety of marine geophysical survey instruments were utilized to try to assess the existence of targets or anomalies, which may possibly represent cultural artifacts. This report summarizes the survey operation and presents the results of the various remote-sensing instruments used, including multibeam bathymetric sonar, side scan sonar, sub-bottom profiler and marine magnetometer.

2.0 DATUMS AND PROJECT CONTROL

The survey was conducted using Real-Time Kinematic Global Navigation Satellite System (RTK-GNSS) positioning with corrections provided by the Washington State Reference Network (WSRN), based on North American Datum of 1983 with the 2011 realization (NAD83(2011)). The horizontal projection used was Washington State Plane, South Zone, with units in U.S. survey feet. The vertical datum is North American Vertical Datum of 1988 (NAVD88) using Geoid 2012b.

2.1 Positioning Accuracy Verification

Several checks were made in the field to confirm the accuracy of the navigation setup being utilized for the project and the RTK-GNSS corrections obtained from the Washington State Reference Network (WSRN). Initial checks were made to an existing Washington State Department of Transportation (WSDOT) monument, GP20141-24, in White Salmon, Washington, using the WSRN correctors and a portable Trimble SPS-985 RTK-GNSS rover system to occupy the monument; the monument is situated along a very busy road, where it was not possible to position the survey vessel. The check-in difference on GP20141-24 were 0.03 feet in northing, 0.02 feet in easting, and 0.02 feet in elevation. After verifying that the WSRN setup was correct, an existing monument at the top of the Port of Hood River (POHR) boat ramp, Oregon State Marine Board (OSMB) 1401-01, was occupied with the same portable RTK-GNSS rover system using a three-minute occupation to establish a check-in point for the survey vessel. The survey vessel was then maneuvered to occupy the OSMB 1401-01 monument with the survey vessel's RTK-GNSS system and geodetic settings in the Hypack acquisition software. (See Table 1 for survey control used.) The survey vessel's navigation and positioning system was checked at the OSMB 1401-01 monument as established with RTK-GNSS corrections from the WSRN each day prior to launching the vessel. The purpose of the checks was to verify system geodetic parameters settings and positional accuracy of the survey vessel acquisition software. The average difference values from record positions for horizontal were 0.04 feet and the average difference for vertical was 0.07 feet.

Table 1: Survey Control Used

Survey Control Monuments Used				
	NAD83(2011) Washington South Zone		NAVD-88	
Monument	Northing (U.S. ft.)	Easting (U.S. ft.)	Elevation (U.S. ft.)	Description
WSDOT “GP20141-24”	144088.59	1390961.12	461.34	Standard WSDOT brass cap stamped “GP20141-24” coordinates and elevation provided by WSDOT data sheet
OSBM “1401-01”	139874.18	1384408.77	90.38	3” brass cap stamped “OSMB, 1401-10, 1996” coordinates and elevation established with 3-minute RTK-GNSS occupation from WSRN RTK-GNSS corrections

3.0 HYDROGRAPHIC SURVEY METHODOLOGY

3.1 Survey Vessel and Instrumentation

The vessel used for this survey was the *River Hawk*, DEA’s 19-foot custom-built survey vessel with a 105-HP jet drive outboard configured for working in rivers and near structures (Figure 1). The primary equipment on the vessel included an Applanix POS/MV-320 version 5 (Positioning and Orientation System for Marine Vessels) combined inertial and RTK GNSS, Trimble SPS-851 RTK-GNSS system, a Teledyne T50P multibeam sonar, an EdgeTech 4200 dual-frequency (300 kHz Low, 600 kHz High) side scan sonar, an Edgetech 3200/512i chirp sub-bottom profiler and a Marine Magnetic SeaSpy magnetometer.

Figure 1. Survey vessel *River Hawk.*

Due to the size of the various survey equipment, the survey was run in stages in order not to overload the vessel. During pre-survey planning, it was established with the Port that it may not be safe or feasible to survey the entire site due to the existence of very shallow water mud flats, designated as less than 3-feet deep on National Oceanic and Atmospheric Administration (NOAA) chart 18532, at the northern third of the site. Coordination with the Bonneville Dam operations team prior to the survey resulted in the pool elevation being raised by several feet to help facilitate surveying over the very shallow flats toward the north.

3.2 Geophysical Data Acquisition

On Tuesday, March 8, the multibeam bathymetric survey was conducted. The multibeam operation gave the crew a good overview of the work area and they were able to assess the extent to which it was feasible to conduct the survey into the extreme shallows of the site. Figure 2 shows the extent of multibeam coverage relative to the survey site outline.

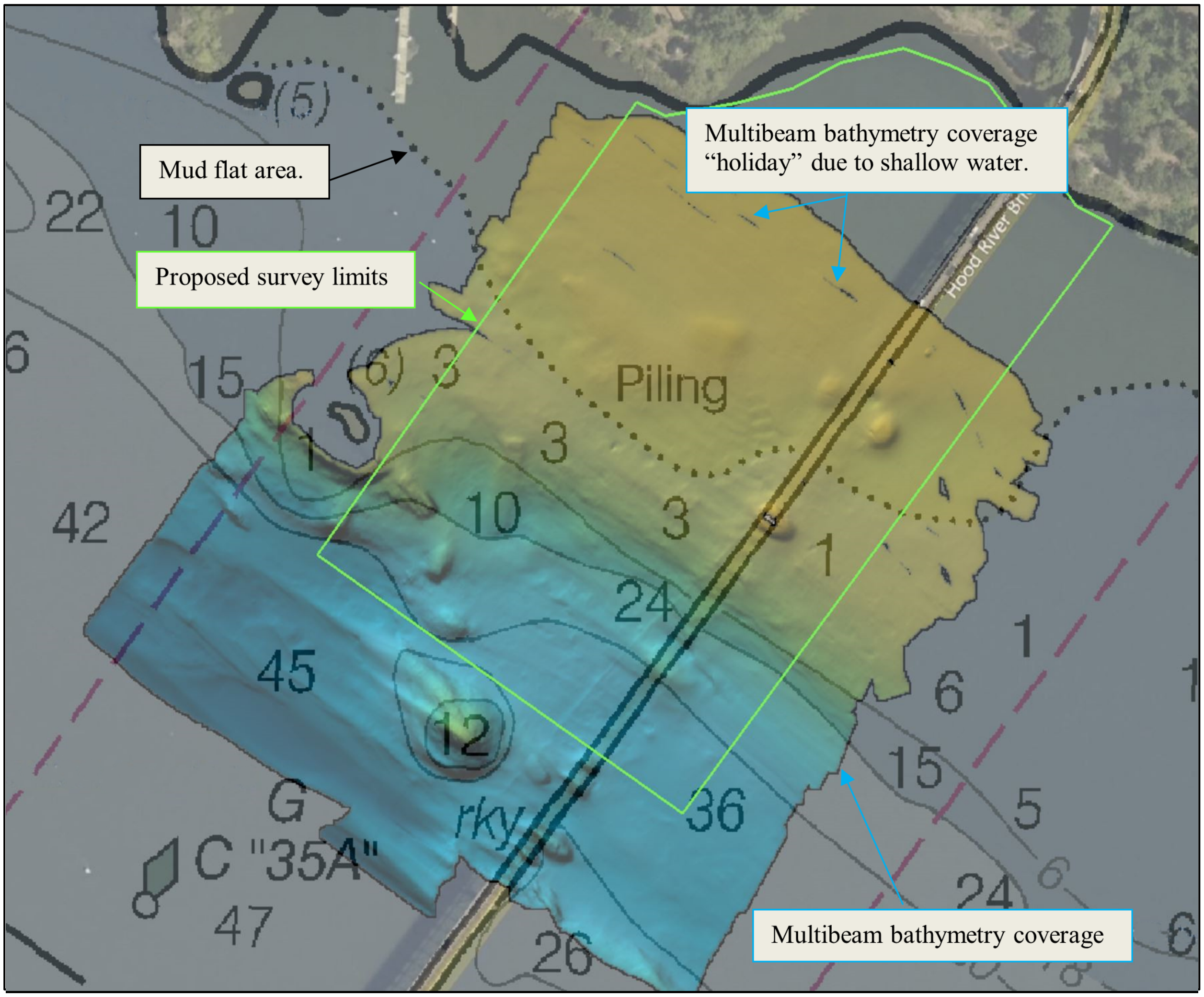


Figure 2. Multibeam bathymetric coverage relative to planned survey area. NOAA chart 18532 in background.

On Wednesday, March 10, side scan sonar operations were conducted. The sonar towfish was deployed from a davit on the starboard side of the vessel and kept at a fixed tow depth just below the surface due to the very shallow water. The system was set to operate the high-frequency channels (600 kHz) using an 82-foot (25 meter) range and the low frequency (300 kHz) at 114-foot (35 meter) range. Due to numerous clusters of piles, in addition to exposed rock outcrops and bridge piers, the survey crew had to make field adjustments so transects were placed in locations deemed safe to navigate the vessel. Figure 3 shows the various sonar transects.

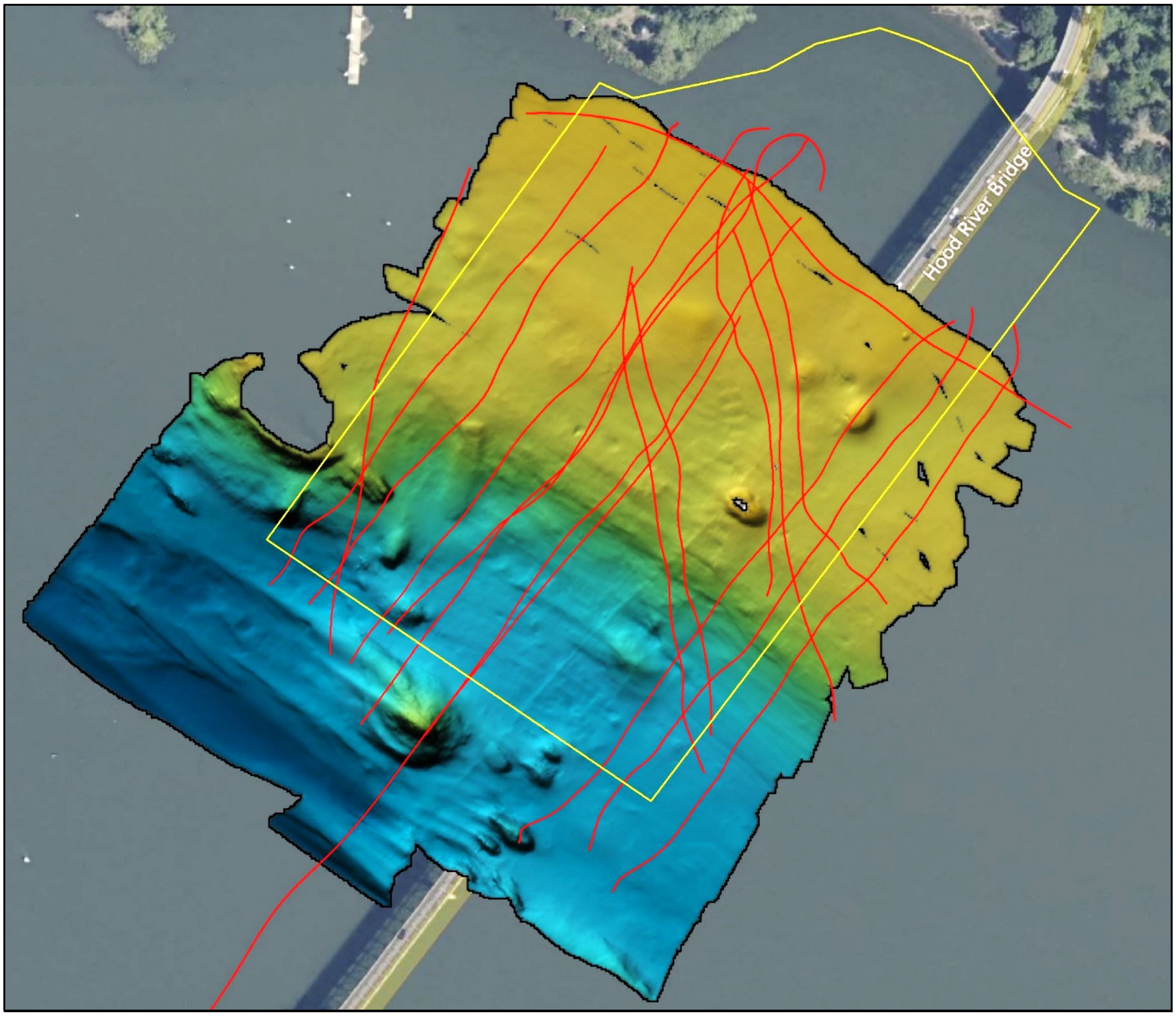


Figure 3. Side scan sonar survey transects; yellow outline is planned survey area.

On Thursday, March 11, 2021, the large chirp sub-bottom profiler was mobilized to the site. Due to the weight of the towfish (450 lbs. in air), which was too much for the 19-foot survey vessel, a set of floats were rigged to support the towfish and then secured to the starboard side of the vessel as shown in Figure 4. This arrangement proved very effective and did not impact the maneuverability of the survey vessel. Multiple test lines were collected to assess the optimum frequency band of the chirp signal based on the relatively shallow depth of interest below the riverbed. The initial sub-bottom survey was conducted using a 700 Hz-12 kHz, 20-millisecond (ms) output chirp signal and 4 pings per second. Figure 5 shows the initial chirp sub-bottom transects.

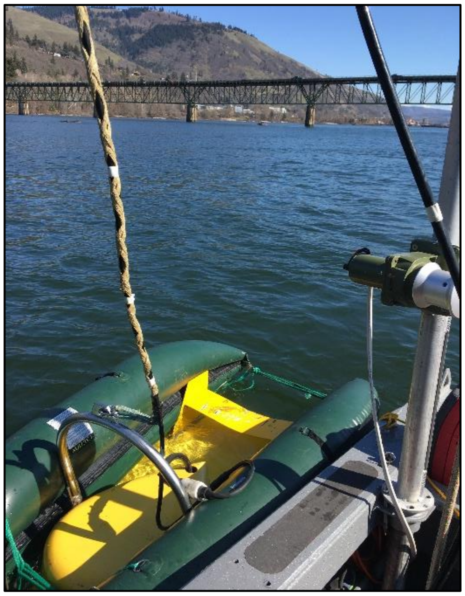


Figure 4. Large 512i chirp sub-bottom towfish supported by pontoons and secured to the starboard side of the survey vessel.

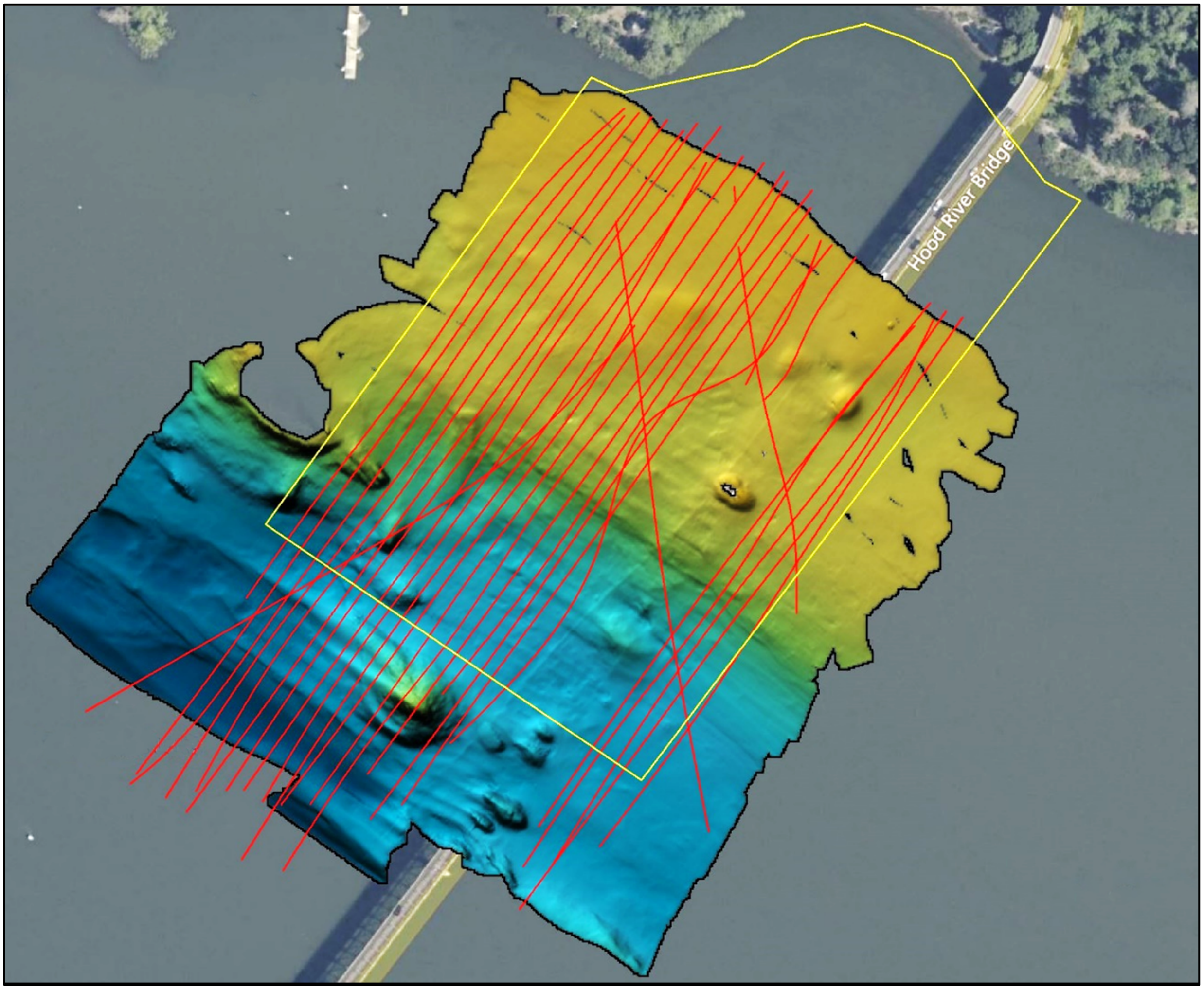


Figure 5. Initial chirp sub-bottom profiler (700 – 7200 Hz, 20 ms) transects; yellow outline is planned survey area.

On the afternoon of Thursday, March 11, 2021, while preparing for magnetometer survey with the sub-bottom system still rigged alongside the vessel, it was decided to log additional sub-bottom data using a very high-resolution setting. The sub-bottom was changed to a 1-10 kHz, 5-ms chirp output signal and 5 pings per second. Because the magnetometer needs to be deployed at a good distance behind the vessel to remove it from the magnetic signature of the boat, the slightly negative towfish would drag on the riverbed in the shallower areas and degrade the data. To avoid this, a float was rigged to the sensor, which allowed it to remain horizontal and just slightly below the surface of the water. This arrangement worked very well and reduced the chance of snagging the sensor on the numerous hazards in the area. The magnetometer was deployed behind the survey vessel at a distance of 57.5 feet (17.5 meters). The magnetometer data was recorded using Chesapeake technology SonarWiz acquisition software. Figure 6 shows the tracks of the combined magnetometer and second iteration sub-bottom profiler survey.

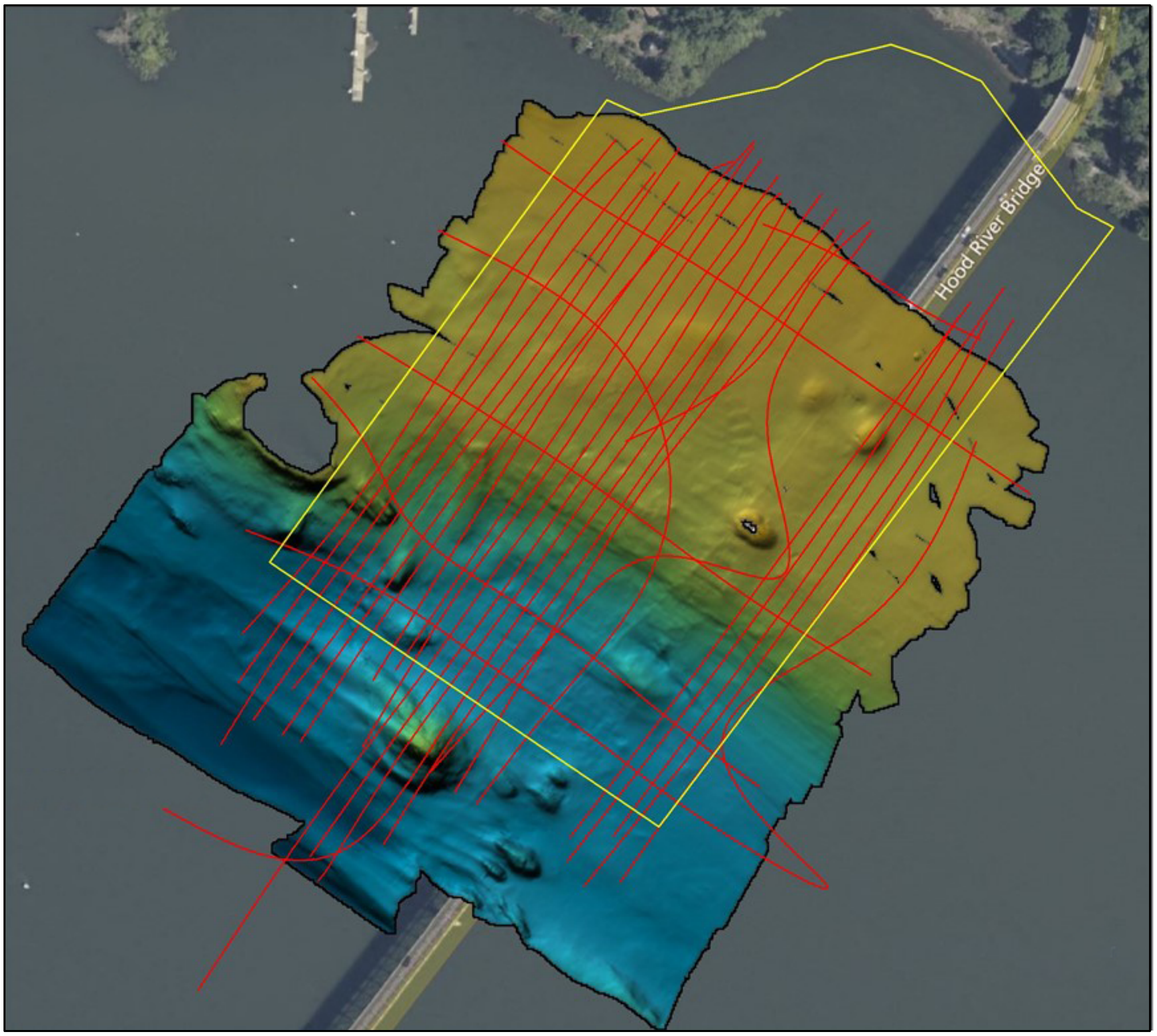


Figure 6. Magnetometer and secondary chirp sub-bottom profiler (1-10 Hz, 5 ms) transects; yellow outline is planned survey area.

3.3 Positioning and Navigation

Horizontal positions were acquired with a Trimble Applanix Position and Orientation System for Marine Vessels (POS/MV-320 version 5) combined inertial and RTK-GNSS. The POS/MV system integrates two GNSS receivers with a motion reference unit. This system not only provides motion information (heading, roll, pitch, and heave) to compute X, Y, Z data from the multibeam sonar measurements, it also provides accurate inertial navigation through GNSS outages for up to 30 seconds. RTK corrections were received from the Washington State Reference Network (WSRN) using broadcast to each survey vessel from a Trimble SPS851 GNSS base station.

To improve position accuracy, the PosPac® (raw GNSS and inertial) logged data file aboard the survey vessel was post-processed using Applanix POSPac-MMS software version 8.6, to generate a Post-Processed Kinematic (PPK) solution that is tightly coupled with inertial data using Applanix PosPac® software for a Smoothed Best Estimate of Trajectory (SBET).

A SmartBase network solution was used to post-process the SBET. The GNSS stations are automatically imported by POSPac-MMS from GNSS stations maintained by National Geodetic Survey (NGS) Continuously Operating Reference Stations (CORS) and University NAVSTAR Consortium (UNAVCO), referenced in the World Geodetic System 1984 (WGS84)/International Terrestrial Reference Frame 2014 (ITRF14). After post-processing, the SBET was exported and transformed from POSPac-MMS to NAD83(2011) reference frame and imported into CARIS. The exported NAD83(2011) SBET was differenced in POSPac-MMS relative to the RTK-GNSS positions from the WSRN and were within agreement relative to system and network accuracies.

Position data were used in real-time to provide navigation information to the vessel operator and were time-tagged and logged with multibeam and other ancillary data. The actual survey tracks were displayed with multibeam swath coverage in real-time on a monitor located at the helm to aid in a systematic survey of the area.

3.4 Vertical Positioning

All bathymetric data were time-tagged and recorded relative to the vertical reference point of the survey platform, which is relatively close to the water surface. Using a fixed vertical reference for both the sonar and RTK-GNSS systems, as opposed to using the water surface and making water surface observations, provides improved vertical accuracy as it considers dynamic changes in draft and local water surface variations in the vicinity of the survey. The sonar fixed draft was used to reference the soundings to the project vertical datum. Vertical reference point measurements, which approximately represent the water surface elevation, were obtained using each navigation system: the Trimble Applanix POS/MV 320 and the Trimble SPS851 RTK-GNSS receiver. After editing, a 60-second average of RTK-GNSS observations were computed to remove wave-induced vertical motion, which was accounted for with heave measurements from the POS/MV and applied as a “tide” file to correct multibeam soundings. All bathymetric data is relative to NAVD88 GEOID12B elevations.

3.5 Bathymetric Data Acquisition

The multibeam hydrographic survey equipment consisted of a single Teledyne Reson SeaBat T50P multibeam bathymetric sonar, Applanix POS/MV combined inertial and RTK-GNSS positioning and motion reference system, a secondary Trimble SPS851 RTK-GNSS rover receiver, HYPACK/HYSWEEP navigation and acquisition software and an AML Oceanographic Smart•X sound speed profiler.

The S/V Riverhawk was equipped with a single high-resolution Teledyne Reson SeaBat T50P dual-frequency multibeam sonar, capable of operating at 200 to 400 kHz, and an integrated AML MicroX with an SV exchange sound speed sensor. The Teledyne Reson SeaBat T50P sonar was deployed over the starboard side of the vessel and secured with a custom mount and was operated at 400 kHz, while mechanically tilted 30 degrees outboard, producing a 210-degree combined swath of 512 equal angle overlapping beams, with each beam using a 0.5-degree across-track angle and 1.0-degree along-track angle.

The Trimble Applanix POS/MV motion reference sensor was utilized to measure and record vessel position, heading (yaw), heave (vertical movement from seas), pitch and roll. By utilizing vessel speed over ground and heading data provided by GNSS, the POS/MV can isolate horizontal accelerations from vessel turns and provide highly accurate motion data. The POS/MV data were used to derive sonar beam orientation and position individual soundings.

The navigation and survey acquisition system was utilized via a personal computer running HYPACK/HYSWEEP version 2020 software. HYPACK/HYSWEEP software was used for multibeam and sensor data acquisition and allowed the swath bathymetric data to be displayed as a painted color image on the navigation screen. This real-time display gave the hydrographer immediate indications of data quality and coverage.

4.0 MULTIBEAM EQUIPMENT CALIBRATION

4.1 Calibration Tests

To confirm alignment of the multibeam sonar relative to position and attitude sensors and verify delay times applied to the time-tagged sensor data, a calibration test was conducted. This consisted of a series of lines run in a specific pattern, which were used in pairs to analyze roll, pitch, and heading alignment angles for the multibeam sonar head as well as latency (time delays) in the time tagging of the sensor data. Table 2 lists the applied correctors for sensor bias determined through analysis of the patch test data. The latency was zero.

Table 2: Survey Multibeam Correctors

Survey Multibeam Correctors			
Date	**Pitch**	**Roll**	**Yaw**
03/09/2021	-1.20	-29.78	-0.30
03/09/2021	-2.50	-30.50	-1.10

4.2 Multibeam Bar Check

To confirm the draft of the multibeam sonar head, a bar check was performed during each deployment by lowering a flat plate to a known distance from the water surface and placing it under the sonar head.

The recorded sound velocity-corrected sonar depth was then compared to the known depth of the bar. The bar check conducted showed agreement between measured values relative to the known bar depth and was within 0.00 feet on the multibeam sonar.

4.3 Sound Speed

Detailed measurements of the sound speed profile (SSP) through the water column are crucial in multibeam surveys. Changes in the SSP will not only affect acoustic distance measurements but can also cause refraction or bending of the sonar path as it passes through layers in the water column with different velocities. An AML Oceanographic Smart•X was used to measure the speed of sound of the water column and the depth at which the SSP was measured. Casts were taken during survey operations over both a temporal and spatial distribution to track sound speed profile changes. In total, four SSP measurements were collected and applied to the multibeam data.

5.0 DATA PROCESSING

5.1 Multibeam Bathymetry

Processing of multibeam data was conducted utilizing Caris Hydrographic Information Processing System (HIPS) version 11.3.8 multibeam analysis and processing software and EIVA NaviModel Producer version 4.3.1.

In Caris HIPS, the patch test data was analyzed, and alignment corrections were calculated and applied during processing. Trimble Applanix POS/MV True Heave® was applied to correct for wave-induced vertical motion. In addition, the real-time navigation solution was overwritten with the post-processed Smoothed Best Estimated Trajectory (SBET) solution, which included updated heading, attitude, and navigation. Sound speed profiles from the numerous profiles acquired while the vessel was underway were used to correct multibeam slant range measurements and compensate for any ray path bending. The algorithm used to apply casts was nearest in time. In the Caris subset editor, a set of lines was reviewed together for line-to-line comparison to ensure agreement to one another in a Caris session.

The full-resolution, corrected, and partially edited data was exported from Caris and imported into EIVA NaviModel Producer for the final analysis and editing of the erroneous data points and fliers. Where needed for subtle surface cleaning, in areas of relatively level seafloor, a subset of the data was selected and the EIVA EC-3D algorithm was implemented. In this method, points falling within a one-meter sphere are compared to the average surface within the same sphere and flagged if the points exceeded a user set limit of approximately +/- 0.15 feet from the average surface. During this process, the hydrographer views the statistics and points to make experience-based decisions on adjusting the statistical values, by use of a slider bar to adjust the parameters for the acceptance or rejection of data points.

5.2 Side Scan Sonar

Side scans operate by emitting a fan-shaped acoustic pulse that radiates outward from the sonar towfish in a direction perpendicular to the heading of the instrument, to the “side,” port and starboard. The fan-shape of the pulse is oriented so that only a very narrow strip of the seafloor receives any energy. As the transmitted energy encounters the seafloor and objects on it, some energy is reflected back and received at the sonar transducer, which converts the returning acoustic pressure wave into electrical voltage, which is recorded relative to the elapsed time from the initial transmission. This roundtrip of the acoustic pulse is commonly referred to as a "ping." The faster the ping rate, the shorter the distance that can be mapped before the process is repeated for the next ping. Stronger reflections from the seabed or objects create higher voltages or signals; conversely, when no energy returns due to the pulse being blocked from advancing outward by objects proud of the bottom, no signal is returned and an acoustic shadow is created. Acoustic shadows are an important component in understanding a side scan sonar image as they can help lend a sense of vertical dimension.

The side scan sonar data for this project was processed using Chesapeake Technologies' SonarWiz (V7.07.04) sonar processing software. Each side scan sonar transect was imported, bottom-tracked, and gain adjusted. Layback corrections and heading offsets were adjusted subtly, on a line-by-line basis, to help register the imagery to the multibeam data, which established target positions with a high degree of accuracy. Although both high (600 kHz) and low (300 kHz) data was recorded, only the high-frequency data was used for interpretation due to the higher detail and resolution it provided. Data was acquired on both the 25- and 35-meter (75- and 100-foot, respectively) ranges for the main transects; however, a few transects were run with wider swath settings (100 meter; 330 foot) to provide an overview of the area, as shown in Figure 7.

5.3 Sub-Bottom Profiler

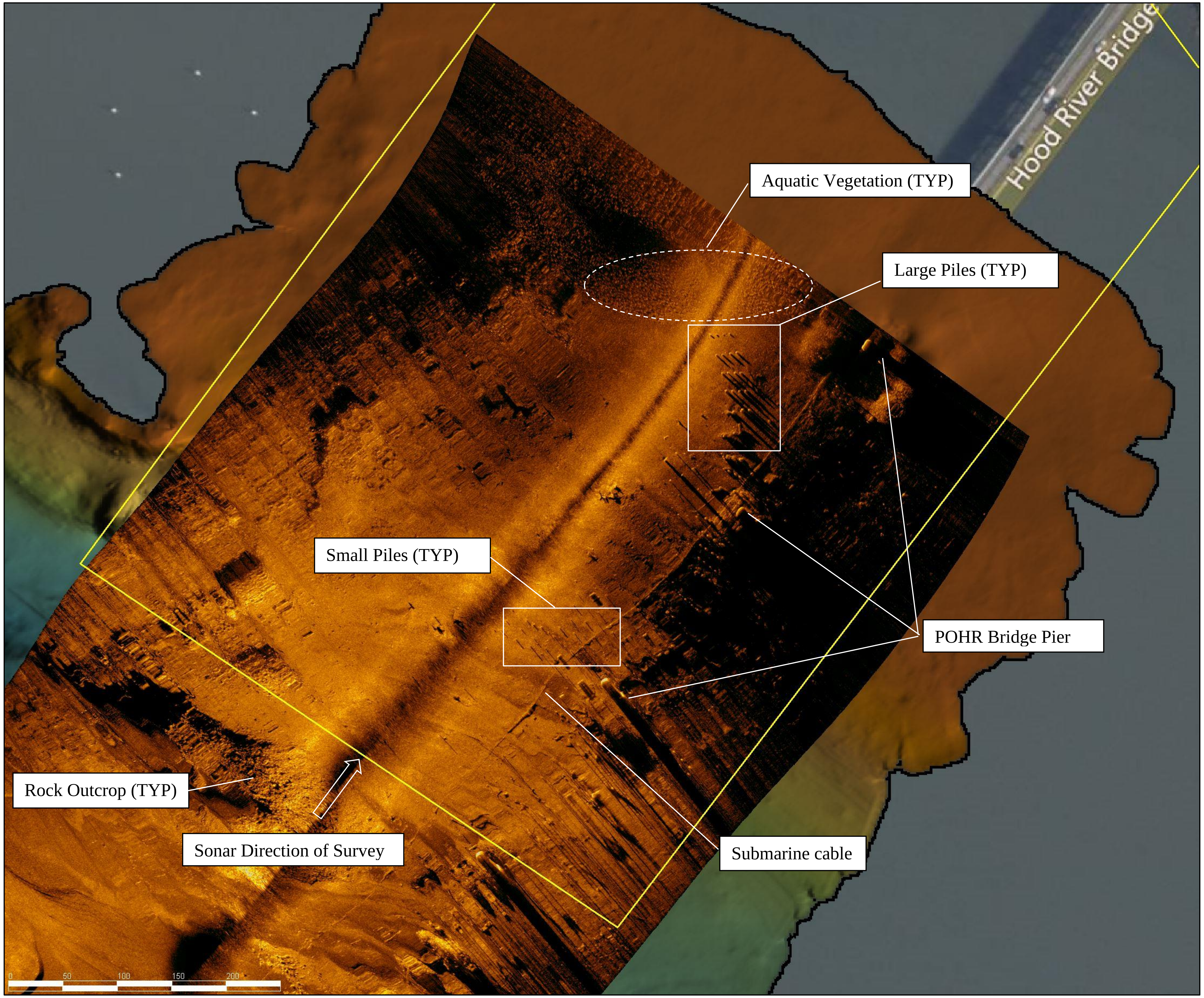
Sub-bottom profilers are low-frequency acoustic systems designed to penetrate bottom material and provide a cross-sectional profile of the seafloor or riverbed beneath the survey transect. The low-frequency aspects of these systems limit their resolution; but, in general, they may show regions of anomalous return off of objects which may be of archaeological interest. Due to the relatively broad beam widths, sub-bottom profilers can detect pipes, wreckage, or other objects that may exhibit a cylindrical, or partially cylindrical, profile to the direction of the survey transect, by receiving acoustic returns from the normal faces of the targets as the instrument approaches, passes over, and moves away from the object. This return is typically displayed as a hyperbolic shape with the apex of the hyperbole defining the closest point of approach the instrument made to the target.

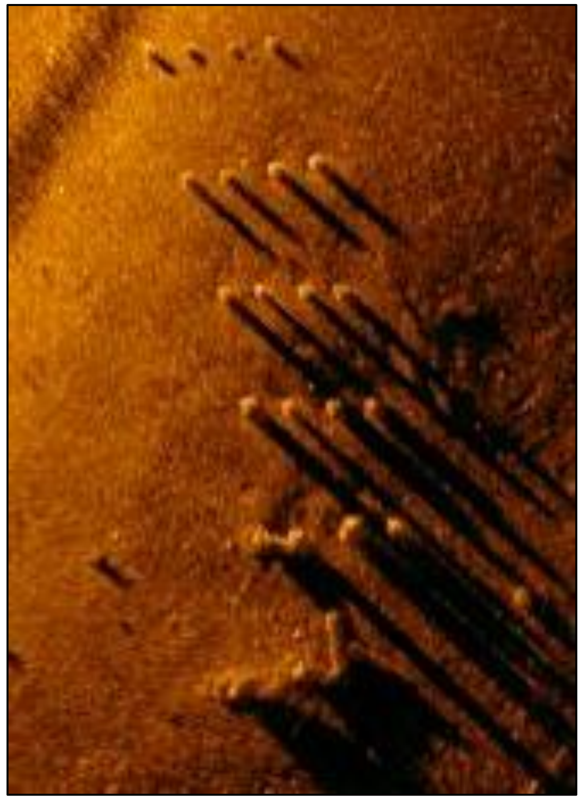
The sub-bottom profiler data was also processed using Chesapeake Technologies' SonarWiz (V7.07.04) sonar processing software. The data was imported, bottom tracked, and gain adjusted before being reviewed for anomalous features.

5.4 Magnetometer

A marine magnetometer is an instrument that can measure the Earth's total magnetic field, which is influenced by many things, including the presence of objects containing ferrous material.

The magnetometer data was also processed in Chesapeake Technologies' SonarWiz (V7.07.04) processing software. The software applied the 17.5-meter (56.5-foot) layback offset to the magnetic readings and allowed the data to be reviewed with filters applied to remove the broad, high-level readings and accentuate the residual readings of smaller local objects. The data was adjusted by removing the average total field observed within the survey area on May 10, 2021, which was approximately 52,000 nT (nanoTesla or gamma). The data was gridded at a 5-foot interval using a nearest neighbor method. A color zone and 10-nT contour interval image, Figure 8, were created and compared to the other datasets — multibeam, side scan, and sub-bottom — for target correlation.

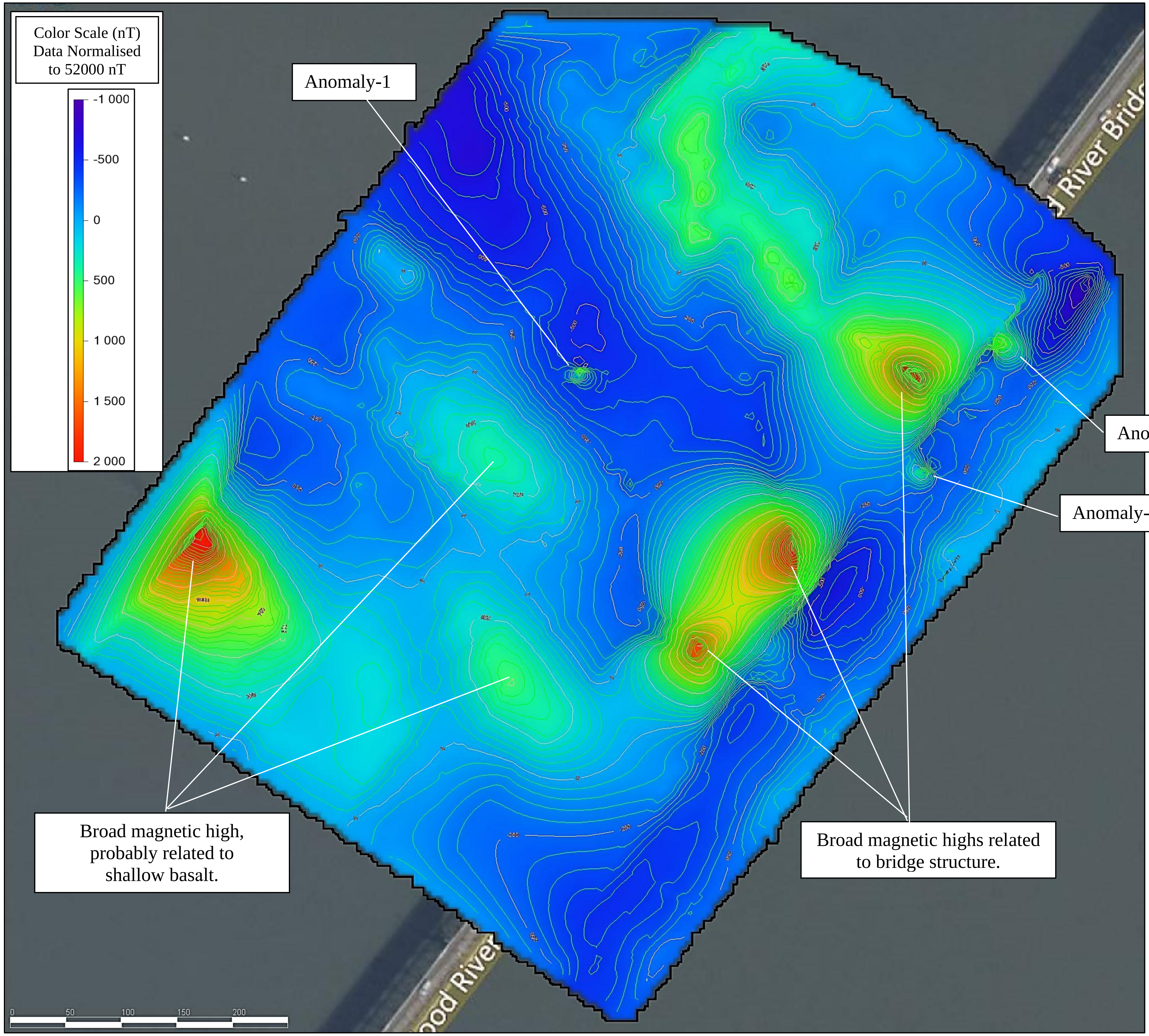




Large Piles (enlarged); note acoustic shadows.

Small Piles (enlarged); note acoustic shadows.

Figure 7. Side scan overview line River-X1. 100 meters per side (330 feet); 200-meter total swath (660-feet). Bright yellow represents strong acoustic return; dark brown/black equals weak or no return.



Broad magnetic high, probably related to shallow basalt.

Broad magnetic highs related to bridge structure.

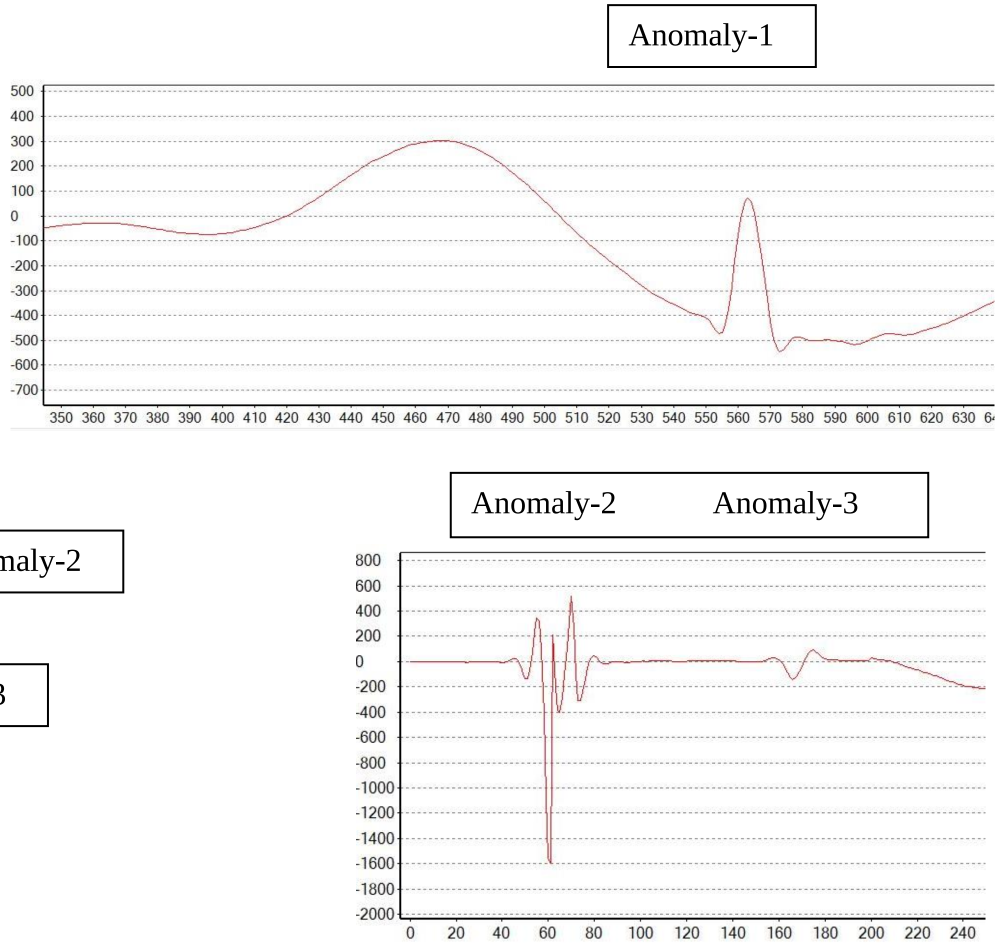


Figure 8. Earth's Total Magnetic Field normalized by 52,000 nT and contoured at 50 nT contour interval.

6.0 INTERPRETATION AND RESULTS

After careful review of the multibeam, side scan, sub-bottom and magnetometer datasets, over 300 targets were identified. A concerted effort was made to reconcile any targets which may have been identified multiple times due to overlapping data or detection by various types of equipment; however, due to the density of targets, some redundancy may exist. In addition to the numerous targets listed in Appendix A, several morphological features are worth noting, which, due to their geometry, may represent man-made features, such as access ramps for construction, and are shown in Figure 9.

The survey data acquired by all four geophysical sensors were of good quality, but the nature of the survey area made certain datasets more useful than others for assessing possible features of interest in support of the archaeological assessment of the site. The proximity of basalt outcrops and the steel bridge structure limited the magnetometer's effectiveness to some degree, although a few isolated targets were noted. The sub-bottom profiler data showed no strong anomaly presenting the classic hyperbolic return signature that may be expected from large debris and wreckage, although some minor hyperbolic targets were logged.

The majority of the targets delineated appear to be piles, either from the old exit ramp from the first bridge, or possibly associated with construction staging when the bridge was retrofitted and new bridge piers built. Figures 10 and 11 show the distribution of pilings found within the survey area.

Of the three distinct magnetometer anomalies, anomaly 2 correlates with an apparent large tire, which is well mapped in the side scan and bathymetric data. Due to the extremely shallow water, the magnetometer came very close to this target, which would explain the strong signature collected on two separated transects. The magnetometer anomaly 3 correlates with an apparent pile of material just upstream from a new bridge pier and may represent something buried within the material (Figure 12).

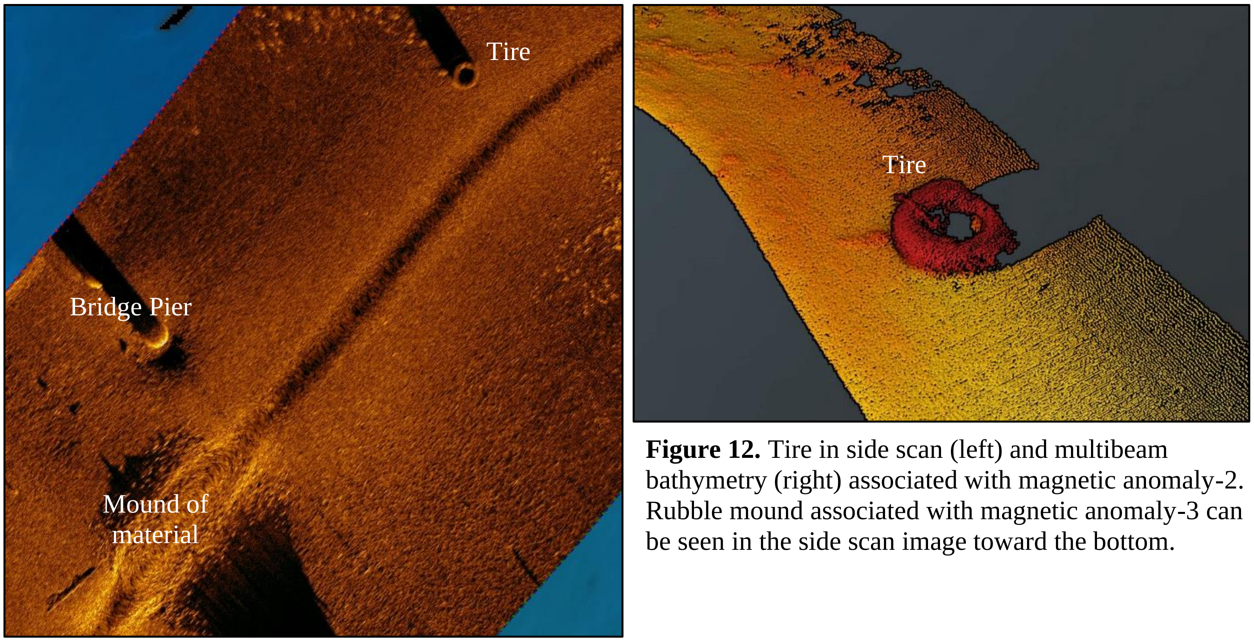


Figure 12. Tire in side scan (left) and multibeam bathymetry (right) associated with magnetic anomaly-2. Rubble mound associated with magnetic anomaly-3 can be seen in the side scan image toward the bottom.

The sub-bottom profiler data showed a very distinct reflector running through most of the data, at a depth below the river bottom of approximately 2-5 feet, that may represent the pre-impoundment ground surface (Figure 13).

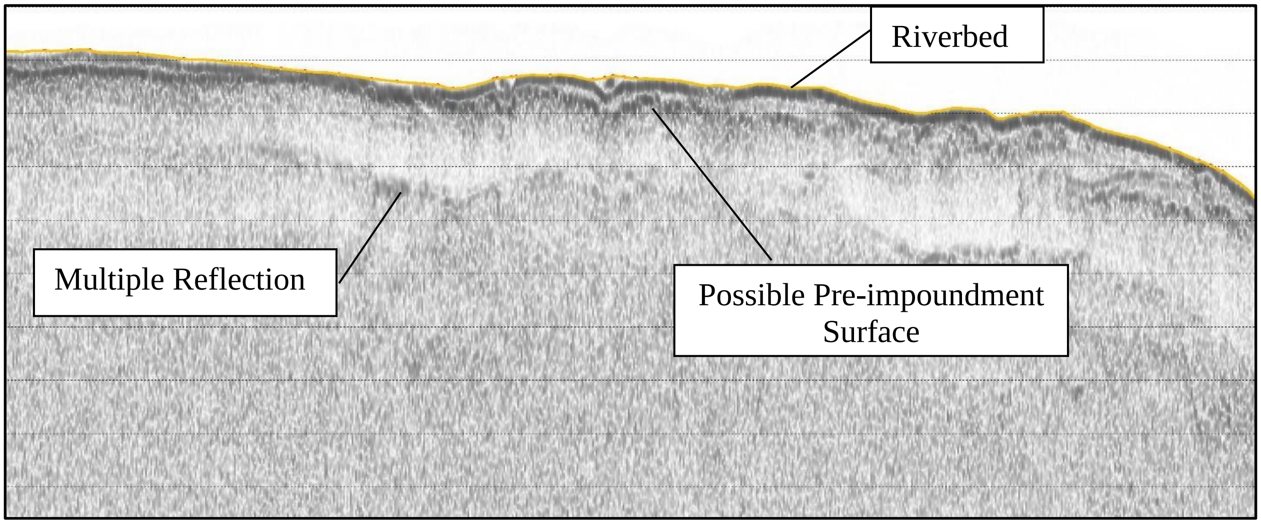


Figure 13. Sub-bottom line 2335 showing strong subsurface reflector, which may represent the old ground surface prior to flooding by the Bonneville Dam. Horizontal scale lines at 5-foot.

The multibeam data also clearly defined some large sections of relic nets streaming downstream from some of the piles under the existing bridge (Figure 14). No floats or lines were noted above the water in these areas.

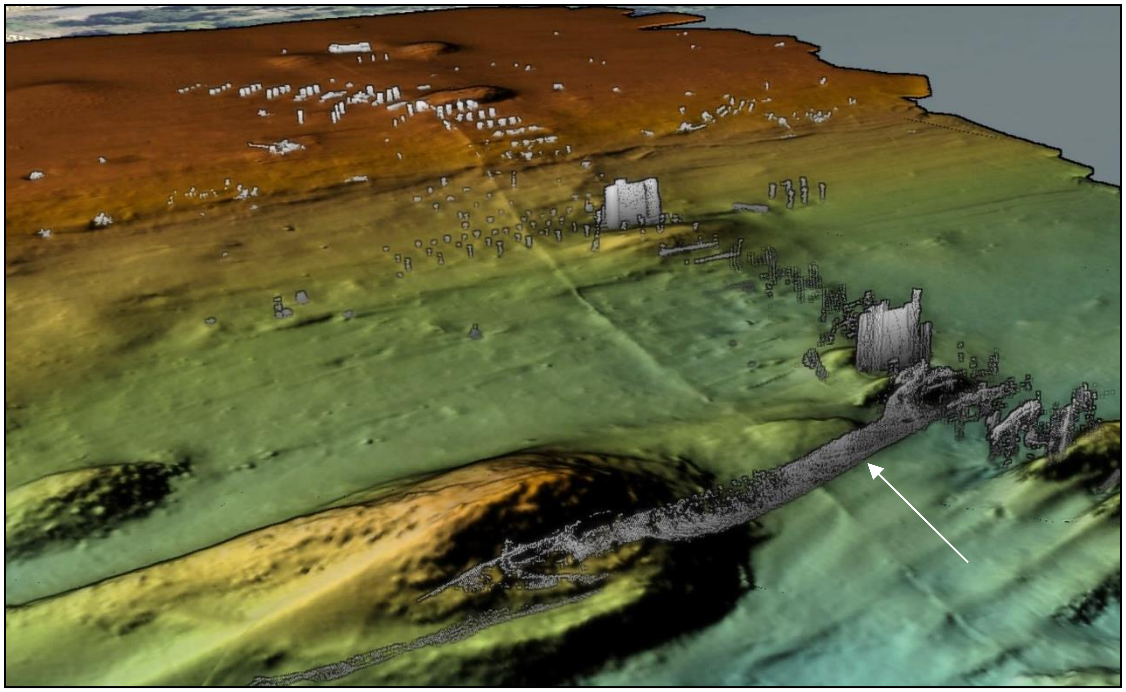


Figure 14. Oblique view of multibeam data looking North showing large section of relic net (white arrow) streaming from abandoned piles under the existing Hood River Bridge.

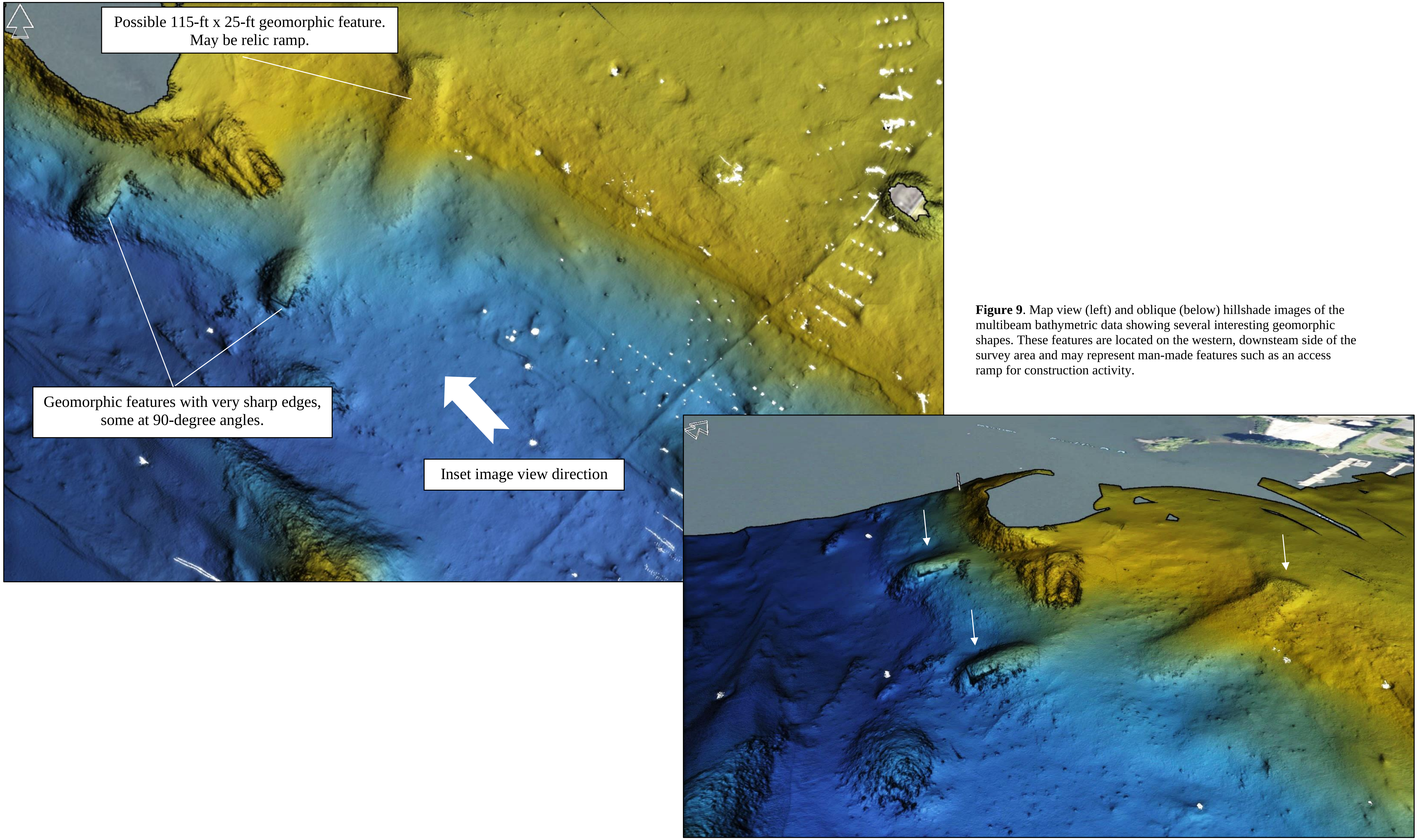


Figure 9. Map view (left) and oblique (below) hillshade images of the multibeam bathymetric data showing several interesting geomorphic shapes. These features are located on the western, downsteam side of the survey area and may represent man-made features such as an access ramp for construction activity.

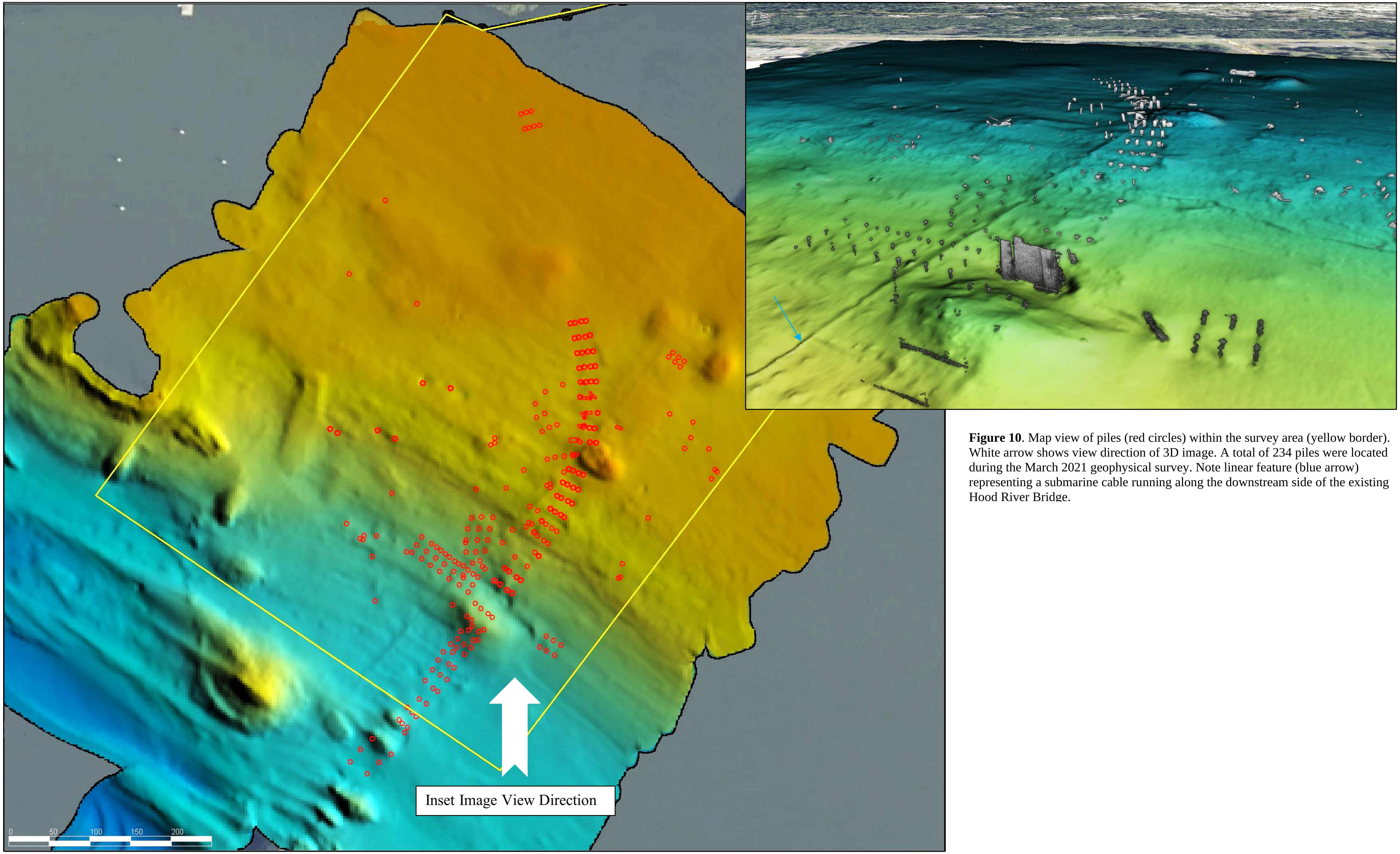


Figure 10. Map view of piles (red circles) within the survey area (yellow border). White arrow shows view direction of 3D image. A total of 234 piles were located during the March 2021 geophysical survey. Note linear feature (blue arrow) representing a submarine cable running along the downstream side of the existing Hood River Bridge.

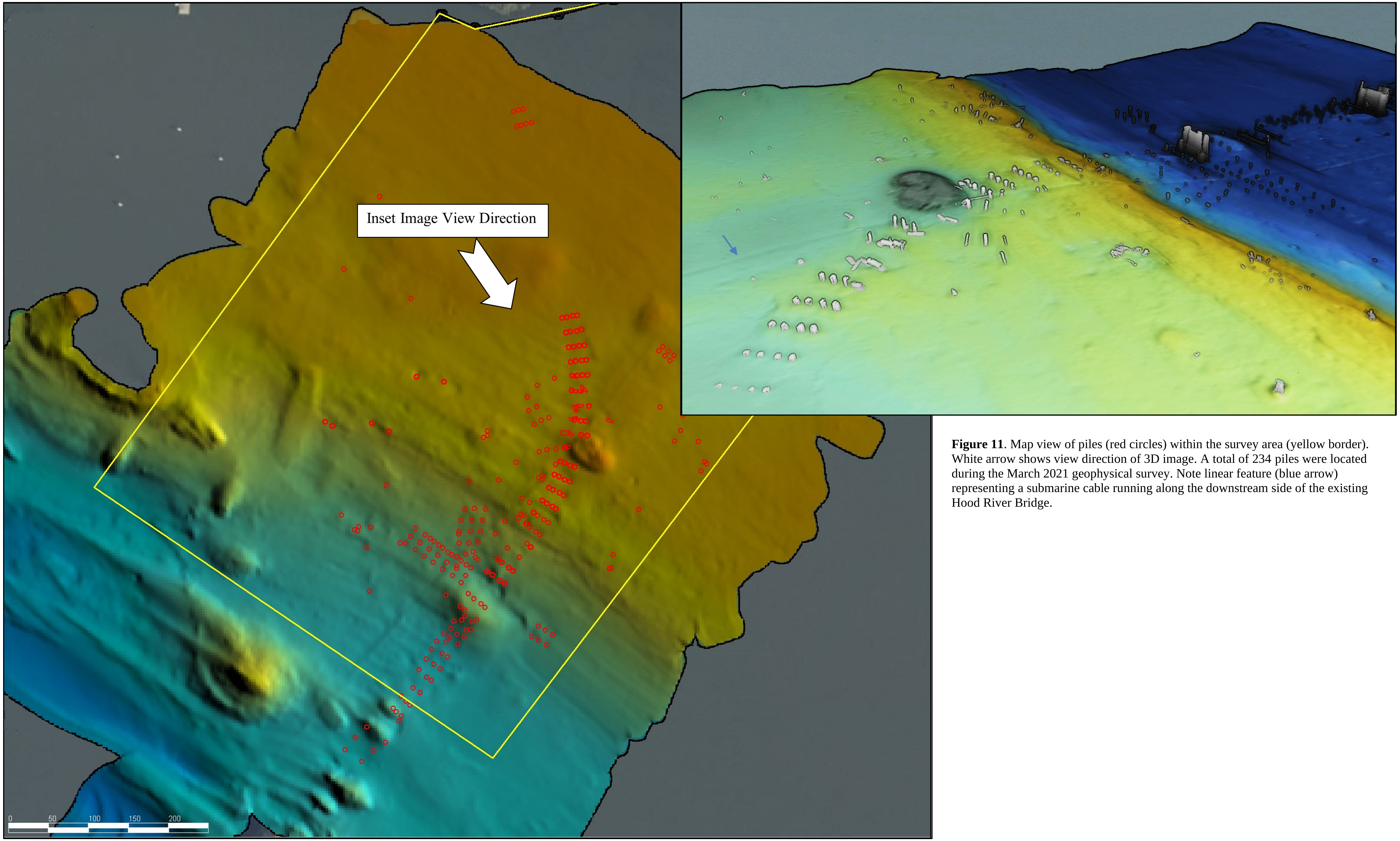


Figure 11. Map view of piles (red circles) within the survey area (yellow border). White arrow shows view direction of 3D image. A total of 234 piles were located during the March 2021 geophysical survey. Note linear feature (blue arrow) representing a submarine cable running along the downstream side of the existing Hood River Bridge.

7.0 SUMMARY

A successful geophysical survey was conducted near the Hood River Bridge in March of 2021 to assess possible targets or anomalies in support of archeological studies supporting the planning of the new bridge. Over 300 targets were catalogued, and a comprehensive dataset of various sensors was recorded, which could be useful for other project applications in the future.

It may be useful to investigate some of the features highlighted by this survey by using a small, remotely operated vehicle (ROV) to obtain photographic or video imagery of features of interest.

APPENDIX A

Hood River Bridge Target List

Hood River Bridge Target List, Washington SPCS – S Zone, USFT

Target I.D.	X	Y	Description
1	1387018	143143	Large Pile
2	1387023	143143	Large Pile
3	1387031	143145	Large Pile
4	1387036	143146	Large Pile
5	1387022	143125	Large Pile
6	1387028	143125	Large Pile
7	1387035	143127	Large Pile
8	1387041	143128	Large Pile
9	1387025	143107	Large Pile
10	1387032	143107	Large Pile
11	1387039	143108	Large Pile
12	1387045	143109	Large Pile
13	1387028	143088	Large Pile
14	1387035	143089	Large Pile
15	1387042	143090	Large Pile
16	1387048	143091	Large Pile
17	1387030	143071	Large Pile
18	1387036	143071	Large Pile
19	1387042	143072	Large Pile
20	1387049	143072	Large Pile
21	1387029	143053	Large Pile
22	1387051	143033	Large Pile
23	1387033	143017	Large Pile
24	1387040	143015	Large Pile
25	1387047	143015	Large Pile
26	1387020	142982	Large Pile
27	1387016	142965	Large Pile
28	1387021	142963	Large Pile
29	1387028	142960	Large Pile
30	1387033	142958	Large Pile
31	1387008	142949	Large Pile
32	1387014	142946	Large Pile
33	1387021	142943	Large Pile
34	1387027	142940	Large Pile
35	1387001	142932	Large Pile
36	1387007	142930	Large Pile
37	1387014	142926	Large Pile
38	1387019	142923	Large Pile
39	1386993	142917	Large Pile

40	1386999	142913	Large Pile
41	1387006	142909	Large Pile
42	1387010	142906	Large Pile
43	1386983	142902	Large Pile
44	1386978	142859	Large Pile
45	1386956	142830	Large Pile
46	1386951	142834	Large Pile
47	1386943	142840	Large Pile
48	1386938	142844	Large Pile
49	1386947	142814	Large Pile
50	1386940	142818	Large Pile
51	1386931	142825	Large Pile
52	1386924	142829	Large Pile
53	1386973	142888	Large Pile
54	1387041	142998	Large Pile
55	1387049	142997	Large Pile
56	1386837	143070	Large Pile
57	1386804	143002	Large Pile
58	1386781	142884	Large Pile
59	1386765	142879	Large Pile
60	1386776	142859	Large Pile
61	1386779	142805	Large Pile
62	1386921	142995	Large Pile
63	1386925	142997	Large Pile
64	1386925	143003	Large Pile
65	1386837	142883	Small Pile
66	1386830	142872	Small Pile
67	1386824	142864	Small Pile
68	1386836	142856	Small Pile
69	1386842	142865	Small Pile
70	1386848	142874	Small Pile
71	1386854	142870	Small Pile
72	1386859	142866	Small Pile
73	1386854	142857	Small Pile
74	1386847	142848	Small Pile
75	1386865	142862	Small Pile
76	1386870	142858	Small Pile
77	1386864	142849	Small Pile
78	1386858	142840	Small Pile
79	1386876	142853	Small Pile
80	1386881	142850	Small Pile
81	1386875	142840	Small Pile
82	1386869	142832	Small Pile
83	1386923	142906	Small Pile

84	1386909	142907	Small Pile
85	1386897	142906	Small Pile
86	1386919	142892	Small Pile
87	1386906	142892	Small Pile
88	1386892	142892	Small Pile
89	1386890	142879	Small Pile
90	1386890	142876	Small Pile
91	1386904	142879	Small Pile
92	1386916	142879	Small Pile
93	1386890	142864	Small Pile
94	1386902	142864	Small Pile
95	1386913	142866	Small Pile
96	1386913	142843	Small Pile
97	1386910	142847	Small Pile
98	1386907	142853	Small Pile
99	1386898	142850	Small Pile
100	1386887	142847	Small Pile
101	1386893	142842	Small Pile
102	1386887	142836	Small Pile
103	1386887	142833	Small Pile
104	1386882	142824	Small Pile
105	1386893	142815	Small Pile
106	1386898	142824	Small Pile
107	1386905	142834	Small Pile
108	1386899	142837	Small Pile
109	1386818	142864	Small Pile
110	1386902	142801	Small Pile
111	1386908	142795	Small Pile
112	1386917	142789	Small Pile
113	1386922	142785	Small Pile
114	1386980	142749	Small Pile
115	1386988	142761	Small Pile
116	1386988	142744	Small Pile
117	1386997	142757	Small Pile
118	1386998	142738	Small Pile
119	1387006	142751	Small Pile
120	1386965	142847	Small Pile
121	1386949	142858	Small Pile
122	1386935	142876	Small Pile
123	1386947	142891	Small Pile
124	1386971	142898	Small Pile
125	1386967	142900	Small Pile
126	1386964	142895	Small Pile
127	1386978	142914	Small Pile

128	1386968	142919	Small Pile
129	1386939	142942	Small Pile
130	1386993	142943	Small Pile
131	1386993	142947	Small Pile
132	1386989	142945	Small Pile
133	1387009	142961	Small Pile
134	1387010	142981	Small Pile
135	1386999	142979	Small Pile
136	1386989	142977	Small Pile
137	1386983	143011	Small Pile
138	1386992	143016	Small Pile
139	1387001	143019	Small Pile
140	1386976	143028	Small Pile
141	1386987	143059	Small Pile
142	1386974	142863	Small Pile
143	1386990	142874	Small Pile
144	1386985	142878	Small Pile
145	1386977	142884	Small Pile
146	1386987	142898	Small Pile
147	1386995	142893	Small Pile
148	1387001	142889	Small Pile
149	1387151	143090	Small Pile
150	1387164	143003	Small Pile
151	1387157	142990	Small Pile
152	1387139	143032	Small Pile
153	1387167	143022	Small Pile
154	1387112	142906	Small Pile
155	1387078	142834	Small Pile
156	1387081	142850	Small Pile
157	1387076	142832	Small Pile
158	1386829	142664	Small Pile
159	1386824	142669	Small Pile
160	1386818	142675	Small Pile
161	1386842	142679	Small Pile
162	1386856	142694	Small Pile
163	1386850	142698	Small Pile
164	1386867	142709	Small Pile
165	1386859	142714	Small Pile
166	1386876	142723	Small Pile
167	1386869	142728	Small Pile
168	1386878	142747	Small Pile
169	1386888	142739	Small Pile
170	1386899	142756	Small Pile
171	1386884	142768	Small Pile

172	1386905	142757	Small Pile
173	1386894	142769	Small Pile
174	1386897	142781	Small Pile
175	1386891	142786	Small Pile
176	1386912	142770	Small Pile
177	1386896	142748	Small Pile
178	1386887	142751	Small Pile
179	1386880	142758	Small Pile
180	1386906	142767	Small Pile
181	1386897	142774	Small Pile
182	1386833	142685	Small Pile
183	1386819	142651	Small Pile
184	1386808	142660	Small Pile
185	1386812	142655	Small Pile
186	1386799	142618	Small Pile
187	1386776	142637	Small Pile
188	1386749	142609	Small Pile
189	1386762	142623	Small Pile
190	1386784	142608	Small Pile
191	1386770	142594	Small Pile
192	1387142	143107	Small Pile
193	1387149	143101	Small Pile
194	1387156	143096	Small Pile
195	1387145	143096	Small Pile
196	1387137	143102	Small Pile
197	1386970	143401	Small Pile
198	1386964	143399	Small Pile
199	1386958	143398	Small Pile
200	1386980	143384	Small Pile
201	1386973	143383	Small Pile
202	1386967	143381	Small Pile
203	1386962	143380	Small Pile
204	1386792	143293	Small Pile
205	1386815	142644	Small Pile
206	1386841	142707	Small Pile
207	1386850	142721	Small Pile
208	1386856	142732	Small Pile
209	1386863	142742	Small Pile
210	1386874	142742	Small Pile
211	1386871	142752	Small Pile
212	1386831	143166	Small Pile
213	1386748	143203	Small Pile
214	1386872	143064	Small Pile
215	1386782	143012	Small Pile

216	1386733	143009	Small Pile
217	1386725	143014	Small Pile
218	1386800	142936	Small Pile
219	1386745	142899	Small Pile
220	1386766	142884	Small Pile
221	1386761	142880	Small Pile
222	1386874	142799	Small Pile
223	1387008	143068	Small Pile
224	1386986	143033	Small Pile
225	1386975	143045	Small Pile
226	1386960	142964	Small Pile
227	1386903	142941	Small Pile
228	1387189	142953	Small Pile
229	1387194	142965	Small Pile
230	1387196	142962	Small Pile
231	1387186	142990	Small Pile
232	1387271	143179	Small Pile
233	1387074	143057	Small Pile
234	1387090	142997	Small Pile
235	1387033	143070	Broken Pile - Center
236	1387033	143052	Broken Pile - Center
237	1387039	143052	Broken Pile - Center
238	1387042	143056	Broken Pile - Center
239	1387046	143054	Broken Pile - Center
240	1387040	143034	Broken Pile - Center
241	1387035	143031	Broken Pile - Center
242	1387032	143031	Broken Pile - Center
243	1387032	143018	Broken Pile - Center
244	1387076	143016	Broken Pile - Center
245	1387022	143000	Broken Pile - Center
246	1387028	142999	Broken Pile - Center
247	1387024	142983	Broken Pile - Center
248	1387037	142959	Broken Pile - Center
249	1386939	143366	Debris
250	1387109	142943	Debris
251	1387185	142980	Debris
252	1387195	142977	Debris
253	1386970	142765	Debris
254	1386935	143363	Debris
255	1386777	143047	Debris
256	1386798	143099	Debris
257	1386811	143089	Debris
258	1386831	143086	Debris
259	1386915	143074	Debris

260	1386943	143061			Debris
261	1386729	143200			Tire
262	1386593	143408			Tire
263	1386699	143196			Tire
264	1387077	142998			Tire
265	1387260	143193			Tire
266	1386905	143422	1386912	143415	Linear
267	1386743	143199	1386743	143192	Linear
268	1386657	143024	1386659	143015	Linear
269	1386548	143096	1386555	143086	Linear
270	1386742	142896	1386729	142874	Cable/rope
271	1386639	142934	1386637	142865	Cable/rope
272	1386635	143357	1386633	143342	Cable/rope
273	1386752	142879	1386752	142865	Cable/robe
274	1386635	142564	1387124	143110	Submarine Cable
275	1387073	142994	1387075	142971	Cable/rope
276	1387175	143080	1387164	143070	Cable/rope
277	1386813	143363			Sub-bottom
278	1386902	143289			Sub-bottom
279	1387081	143354			Sub-bottom
280	1387311	143238			Sub-bottom
281	1387271	143180			Sub-bottom
282	1387074	143059			Sub-bottom
283	1387090	142998			Sub-bottom
284	1387166	142906			Sub-bottom
285	1387099	142920			Sub-bottom
286	1387057	142911			Sub-bottom
287	1386997	142922			Sub-bottom
288	1386907	142986			Sub-bottom
289	1386843	143075			Sub-bottom
290	1386847	143125			Sub-bottom
291	1386792	143154			Sub-bottom
292	1386718	143185			Sub-bottom
293	1386690	143149			Sub-bottom
294	1386727	143128			Sub-bottom
295	1386726	143121			Sub-bottom
296	1386654	143097			Sub-bottom
297	1386655	143062			Sub-bottom
298	1386609	143033			Sub-bottom
299	1386620	143018			Sub-bottom
300	1387267	143190			Mag
301	1387206	143082			Mag
302	1386895	143165			Mag

APPENDIX B

Additional Cross River Data

APPENDIX B – ADDITIONAL CROSS RIVER DATA

Additional data was collected during transits between the Port of Hood River Marina, on the Oregon side of the Columbia River, and the primary survey site on the Washington side of the river. The transects were run generally along, or close to, the currently planned alignment of the new Hood River Bridge. These transect lines were used for adjusting and checking the systems, as well as to gain some more regional context for understanding bottom condition in the area. The data could be evaluated at a higher detail level at a later time, as part of a separate contract, if needed. The attached images, Figures 1-4, display the bathymetric, side scan and sub-bottom data collected across the river. Magnetometer data was not collected due to the sensor being set up for shallow water work in the primary survey area.

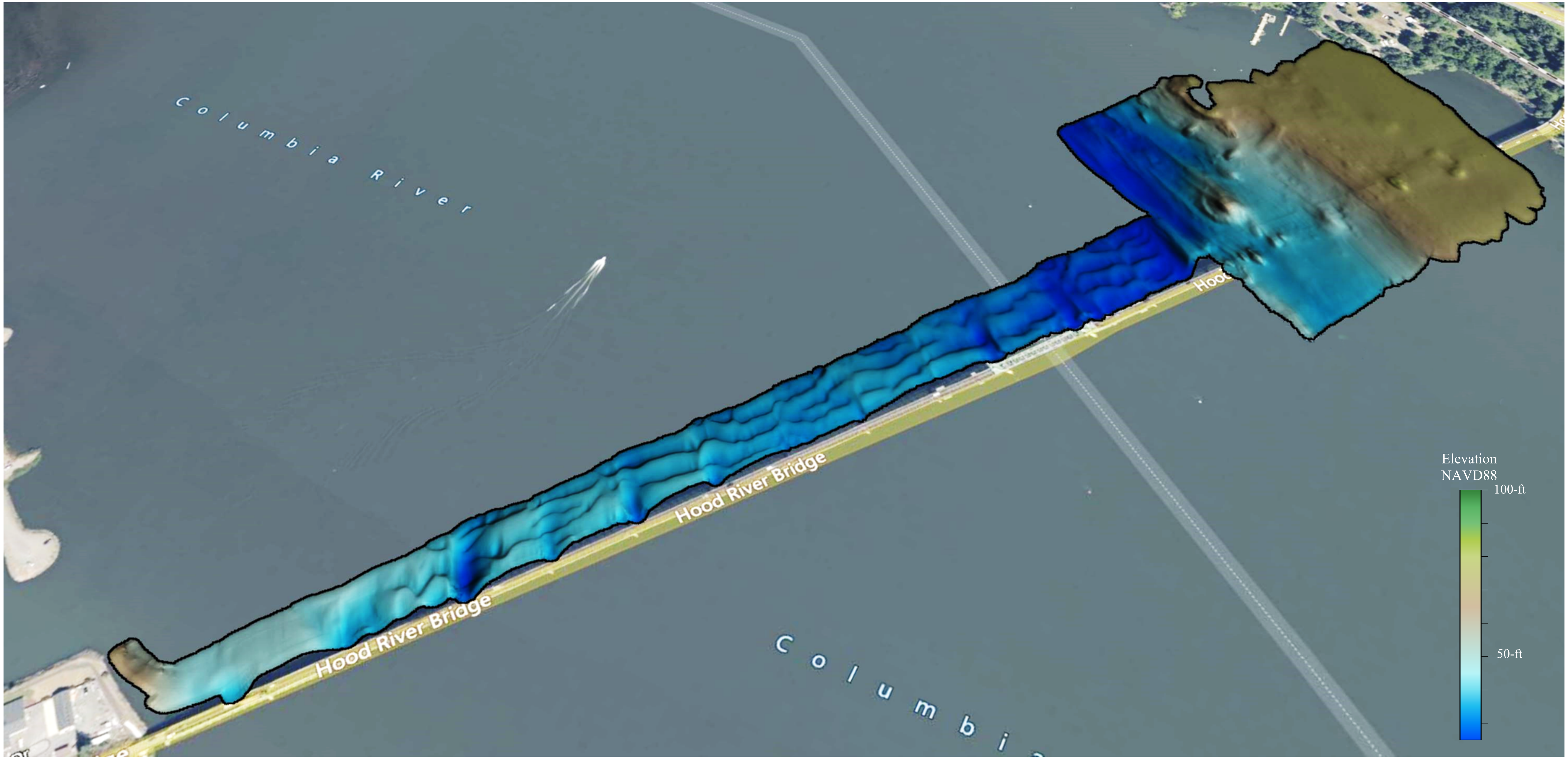


Figure 1: Additional multibeam bathymetric data collected across the Columbia River during March 2021 geophysical survey for the Port of Hood River. View looking NW.

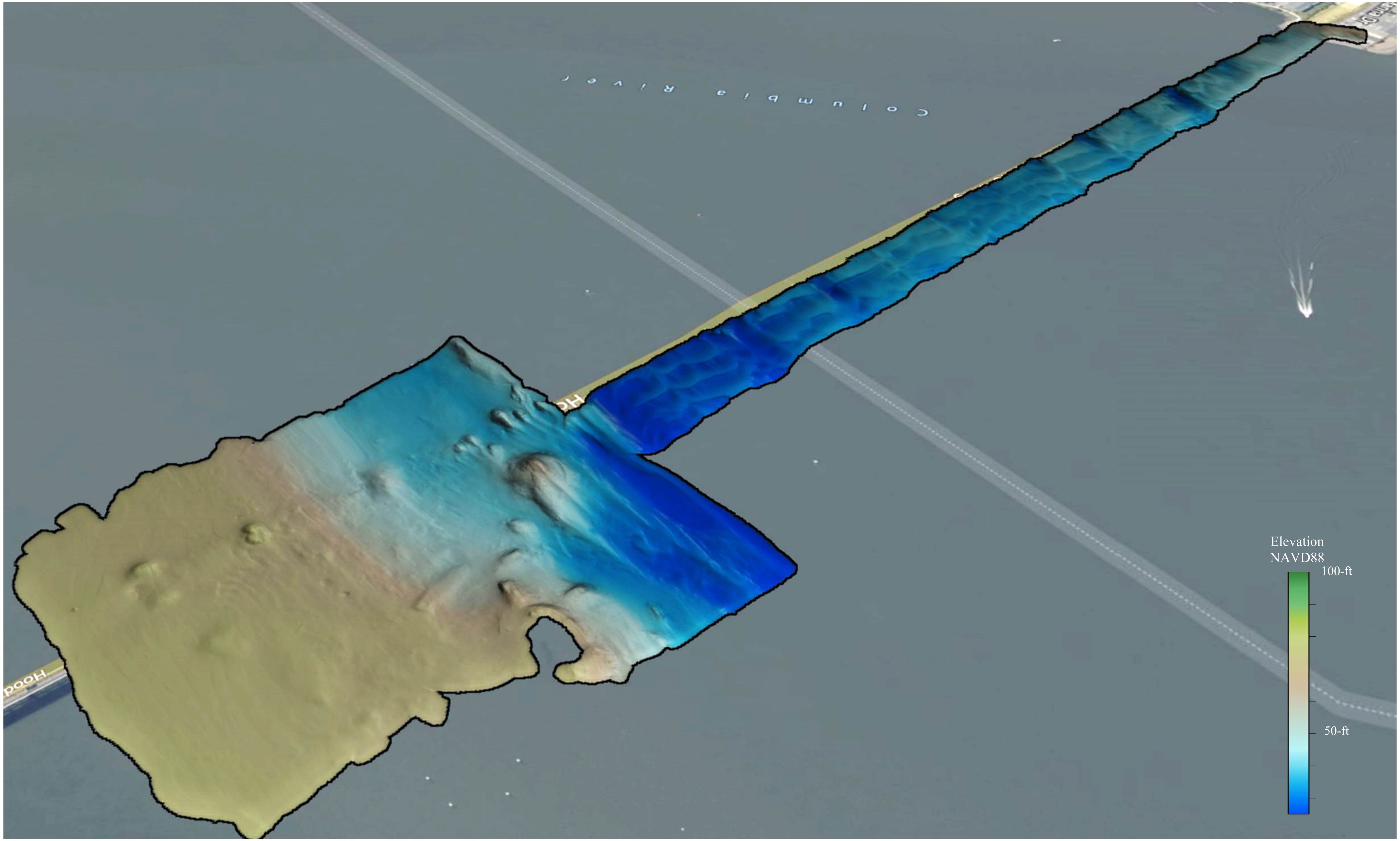


Figure 2: Additional multibeam bathymetric data collected across the Columbia River during March 2021 geophysical survey for the Port of Hood River. View looking SE.

Figure 3: Additional side scan sonar data collected across the Columbia River during March 2021 geophysical survey for the Port of Hood River. Range is 300 feet per side, total swath is 600 feet. Bridge piers from existing bridge are clearly visible (white arrow, TYP). Large sand waves dominate the image (yellow arrow, TYP).

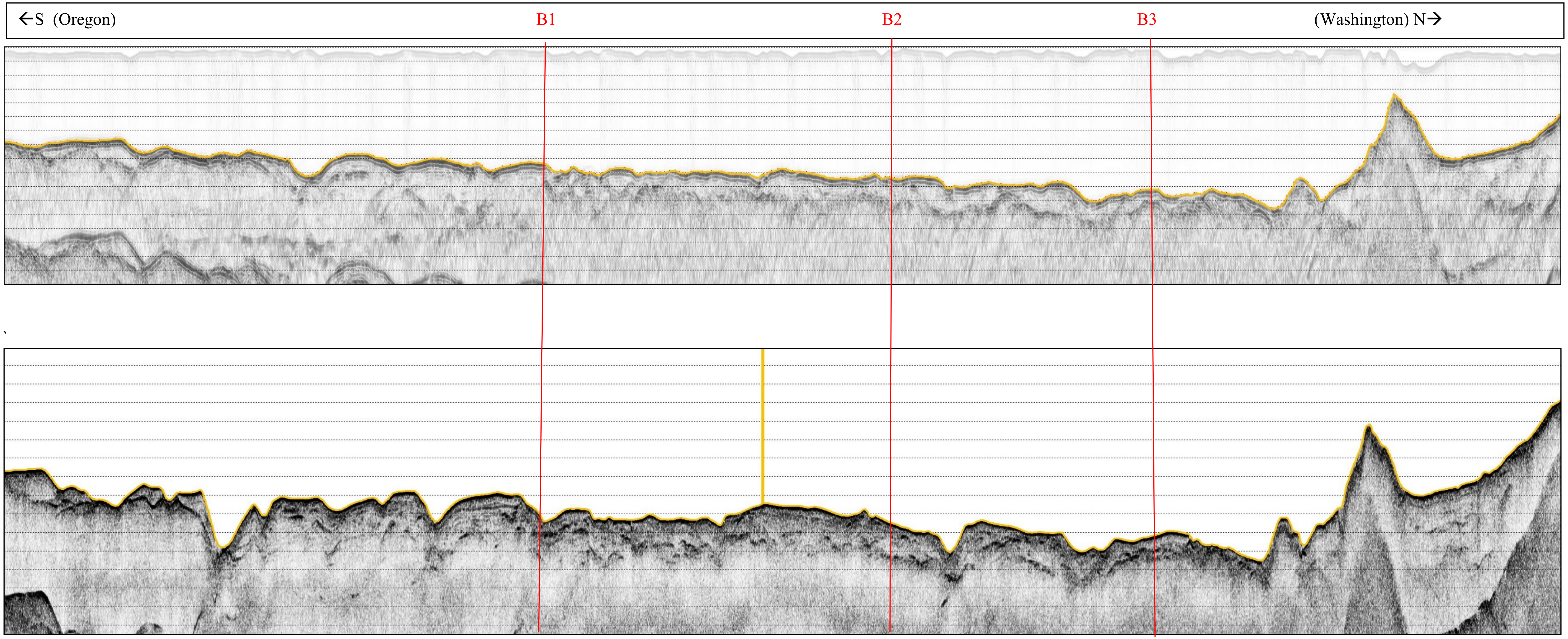


Figure 4: Additional chirp sub-bottom profiler collected across the Columbia River during March 2021 geophysical survey for the Port of Hood River.

Top: Line 1831, 0.4-4.0 kHz 40ms pulse, Scale 5-foot/division
Bottom: Line 0017 0.7-12 kHz 20ms pulse, Scale 5-foot/division
Boring locations B1-B3 are approximate and for general reference only.