APPENDIX A-2
GEOPHYSICAL SURVEY RECORDS

APPENDIX A-2.1
AQUA SURVEY'S SUMMARY OF FINDINGS

14 December 2017

Cover Memo for Aqua Survey's Summary of Findings

The dual-frequency separation figures generated by Aqua Survey, Inc. (ASI) were the result of data output from software packages and are not official interpretations. Discussions with Amec Foster Wheeler and ASI, in addition with review of collected XYZ data, provided instruction for Amec Foster Wheeler to create a dual-frequency separation file by subtraction of the 33 kHz and 200 kHz frequencies for each individual data point. This process was agreed upon by ASI and Amec Foster Wheeler to display dual-frequency separation data representative of river conditions. Thus, the dual-frequency separation figures created by Amec Foster Wheeler supersede the dual-frequency figures created by ASI.

END

Call Log Summary

To: Jamie Taylor, Aqua Survey, Inc.

From: David Young, Amec Foster Wheeler – Raleigh/Durham

Date: November 3, 2017 1530 EST

Subj. Sub-Bottom Reflector Confirmation

This call log summarizes the information discussed between David Young and Jamie Taylor of Aqua Survey, Inc. on November 3, 2017. The purpose of the conversation was to confirm that only 3 reflectors were identified while processing the sub-bottom data and that no additional strata was distinguishable.

MAIN TOPICS

- During post-processing of the sub-bottom data, Jamie Taylor of Aqua Survey, Inc. identified 3 reflectors, which suggests that 3 stratigraphic sediment layers with different sedimentological characteristics are present below the river bed surface. Jamie named the reflectors the following: Reflector 1, Reflector 2, and Reflector 20.
- As per the phone conversation, Jamie Taylor confirmed that only 3 sediment layers were distinguishable from the processing of the sub-bottom images. No additional layers exist between Reflector 2 and Reflector 20. The software used for the data processing can create up to 20 reflectors and automatically named the deepest reflector representing bedrock or dense sediment, Reflector 20. Therefore in the case of the Penobscot sub-bottom data, Reflector 20 is the same as Reflector 3.
- Jamie Taylor also agreed that the reflectors observed in the sub-bottom images are in accordance with the strata observed in sediment cores. Jamie confirmed the likely composition of each reflector: the sediment layer above Reflector 1 is likely non-cohesive silt and/or wood waste, the sediment layer above Reflector 2 (or above Reflector 20 at locations where Reflector 2 was not identified) is likely cohesive silt, and the sediment layer below Reflector 20 is likely dense, hard clay and/or bedrock.

END

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Call Log Summary

To: Jamie Taylor, Aqua Survey, Inc.

From: David Young, Amec Foster Wheeler – Raleigh/Durham

Date: March 9, 2018 0930 EST

Subj. Geophysical Survey Method Detection Confirmation

This call log summarizes the information discussed between David Young and Jamie Taylor of Aqua Survey, Inc. on March 9, 2018. The purpose of the conversation was to confirm that the bottom detection capabilities of the geophysical survey methods illustrated in the attached image are accurately presented.

MAIN TOPICS

- Each survey method accuracy resolution and signal frequency reflects the equipment specifications used by Aqua Survey, Inc. during survey activities and correspond to survey detection limits discussed in the US Army Corps of Engineers Hydrographic Surveying Manual (EM 1110-2-1003).
- Just based on frequency, higher frequencies will reflect off of less consolidated sediments. However, Aqua Survey, Inc. confirmed that there are additional method parameters that affect detection capabilities between survey methods. Multibeam and side scan sonar have different detection capabilities compared to dual-frequency due "tuning" the equipment or adjusting the power and gain to focus the signal on what appears to be the top most layer of sediment representing the riverbed surface. Less consolidated sediments can be detected with lower power and higher gain and more consolidated sediment is detected with higher power and lower gain. This explains why multibeam and side scan sonar methods can detect unconsolidated and/or consolidated sediments without interference from suspended sediments.
- Aqua Survey, Inc. confirmed that the interpretation of survey method detection capabilities and method specifications (i.e., survey frequency and resolution accuracy) included in the attached image are accurate.

END

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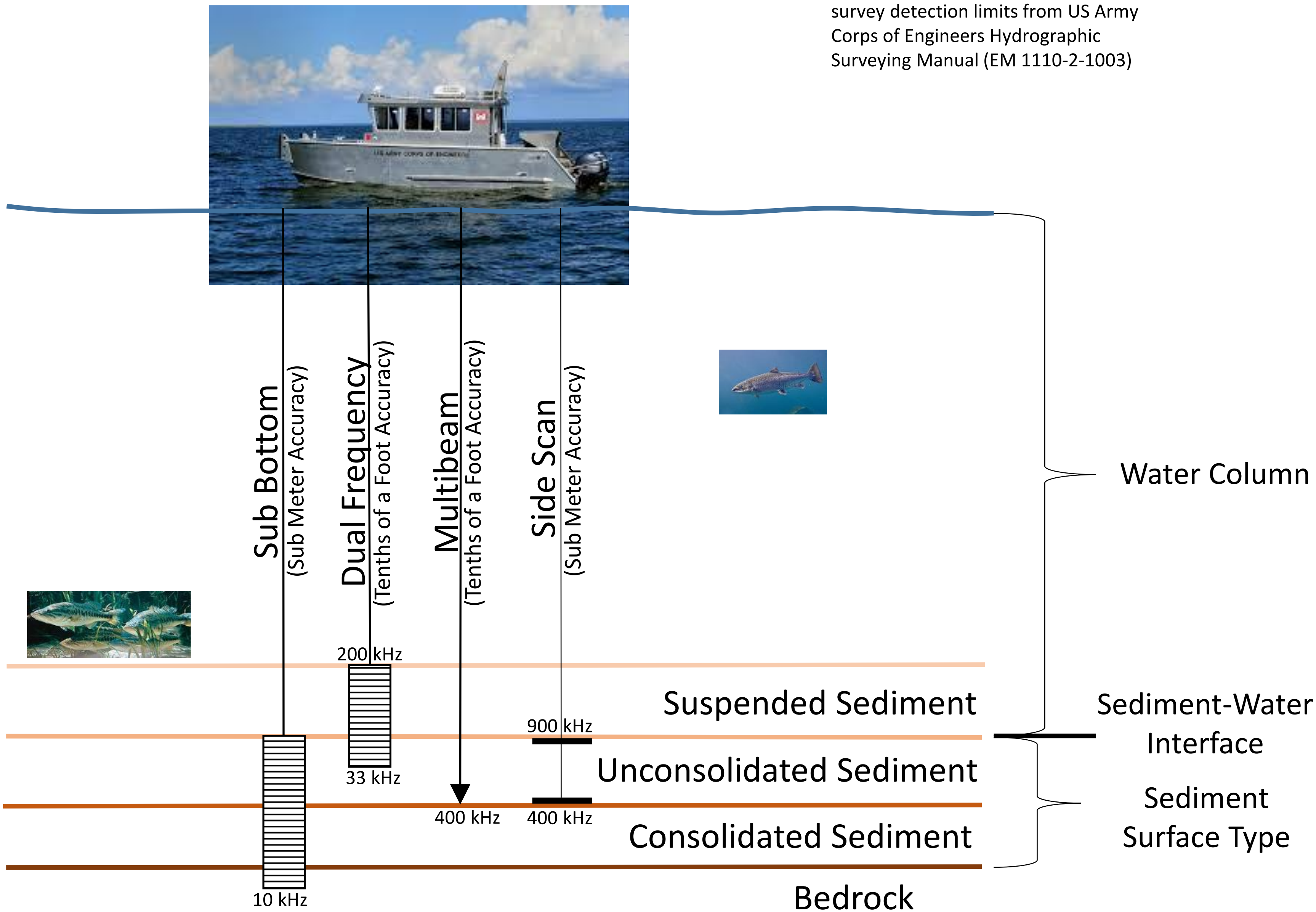
Geophysical Survey Method Bottom Type Detection

Note: Figure corresponds with survey detection limits from US Army Corps of Engineers Hydrographic Surveying Manual (EM 1110-2-1003)



Summary of Findings – Sub-Bottom Profile and Dual Frequency Surveys, Penobscot River, Maine

A geophysical remote sensing survey was conducted covering the specified project area along the Penobscot River from Bangor to Fort Point Cove, Maine. The study area stretched approximately 30 miles along the river and included locations at Bangor, Hampden, Frankfort Flats, Bucksport, Verona, Orrington, Odom Ledge, Gross Point, Orland, and Fort Point Cove. The geophysical survey was conducted between 21 through 31 July, 2017. Technologies and techniques employed included real time kinematic global positioning (RTK), differential global positioning (DGPS), sub bottom profiling, and dual frequency fathometer.

Project control was provided by a Hemisphere real-time kinematic global positioning system (RTK) with centimeter accuracy. RTK corrections were supplied through KeyNET service. Prior to commencing the survey, the RTK system was checked against a local NGS benchmark to insure positioning accuracy. The RTK antenna was mounted directly over the fathometer and sub-bottom profiler. All results are produced in Maine East State Plane NAD 83 coordinate system with units in US survey feet and North American Vertical Datum 1988 (NAVD 88) with depths produced in US survey feet.

An Odom Echotrac CVM dual frequency fathometer with 33 kHz (20-degree) and 200 kHz (4-degree) transducers was used for the dual frequency survey. Prior to the commencement of survey operations, a bar check was conducted to adjust for draft and speed of sound for both frequencies in order to insure accurate sounding data. A bar check was also conducted at the end of the day to be sure the settings continued to be correct. Survey lines were run perpendicular and parallel to shore at varied spacing throughout each survey area. Processing included removing erroneous data points and correcting the data to NAVD88 based on RTK GPS corrections. Each frequency was processed separately and the difference between the two layers was calculated providing a layer showing areas of separation. XYZ file records of high frequency depths, low frequency depths, and the separation between were provided for each study area.

High frequency depths ranged from -2 to 99 feet NAVD88 (Figures 1-11). Low frequency depths ranged from -6 to 103 feet NAVD88. (Figure 12-22). High frequency measurements will usually reflect the top layer of sediment and low frequency measurements will usually reflect through a soft penetrable layer such as loose silt. Dense sediments such as bedrock will cause the frequencies to read the same with a possible error of a few tenths of a foot. Low frequency measurements may be lost or erroneous in high currents, turbulent waters, and areas without well-defined sediment layers. The high and low frequency measurements were processed in Hypack's TIN Model software to calculate a separation layer. Figures 23 through 33 show the difference layer. Differences ranged from -6 to 7 feet.

A SyQwest Stratabox sonar system was used to collect the sub-bottom profiling data during the survey. During the survey, the transducer was hard-mounted to the side of the survey vessel with the navigational antenna mounted directly over the transducer, eliminating offset errors. The sensor was deployed at a depth of at least 2 feet to minimize interference from the vessel. The navigational data was logged at one-second intervals by the Stratabox digital recording system and electronically paired with the sub-bottom data to allow geo-referencing of all data collected.

Sub-bottom profilers use acoustic methods to generate high-resolution (on the order of 0.5-1 ft) cross-sectional images of the marine sub-bottom to depths of up to 100 ft beneath the seafloor. The transmitted sound pulses travel through the water column and sub-bottom and are reflected when changes in acoustic impedance (equivalent to a material's sonic velocity times its density) are encountered. Acoustic impedance changes commonly occur at boundaries between materials (e.g., interfaces between water and sediments, sediments and gas, different types of sediments, and sediments and buried objects). The reflected sound pulses travel back to the profiler where their amplitudes, as a function of travel-time, are digitally recorded.

All sub-bottom records were delivered as screen shot JPEG files. Sub-bottom reflector isopachs were manually picked and delivered as XYZ files. The isopachs that were delivered included seafloor to Reflector 1, seafloor to Reflector 2, and seafloor to Reflector 20. The seabed was manually tracked to define the surface and top layer of sediment. Reflector 1 represents the bottom of what appears to be indicative of very soft, loose sediment or woodchips. Reflector 2 represents a top to middle layer seen throughout the survey area indicative of soft sediment. Reflector 20 represents a layer of possible bedrock or dense sediment seen throughout most of the survey area. Figure 34 shows an example of Reflectors 1, 2, and 20 within the Bucksport area.

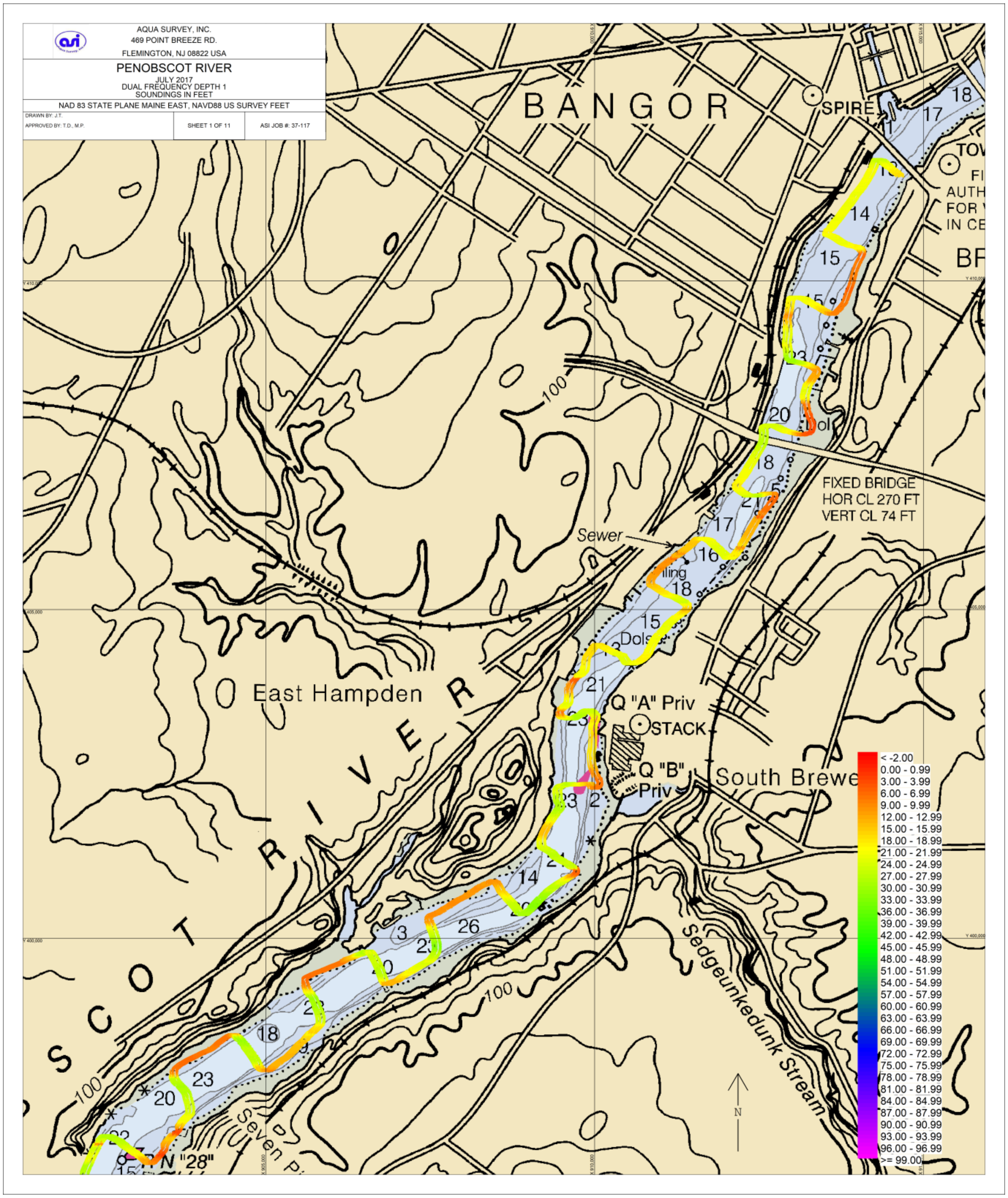


Figure 1. Dual frequency high frequency depth 1 bathymetry near Bangor.

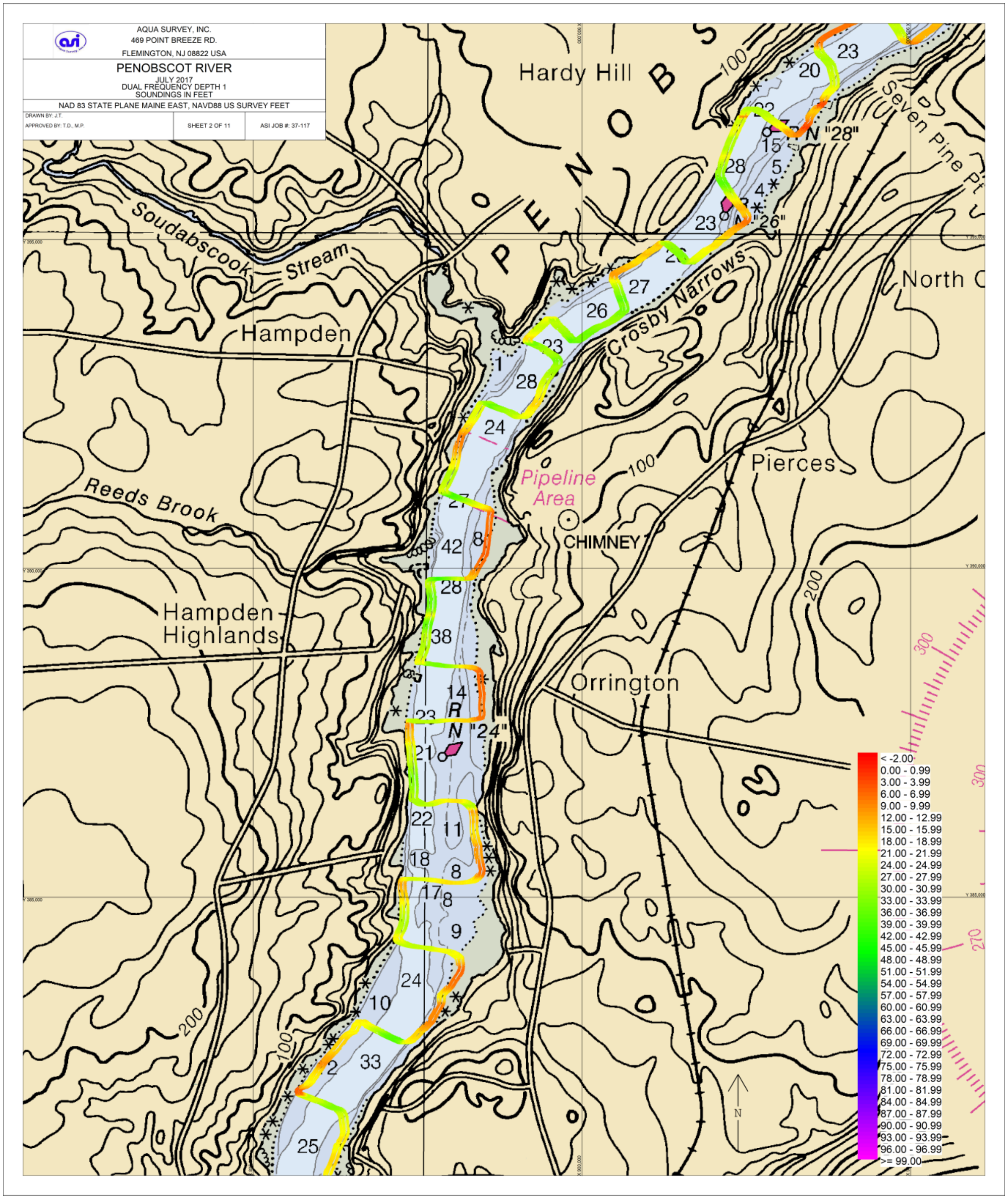


Figure 2. Dual frequency high frequency depth 1 bathymetry near Hampden.

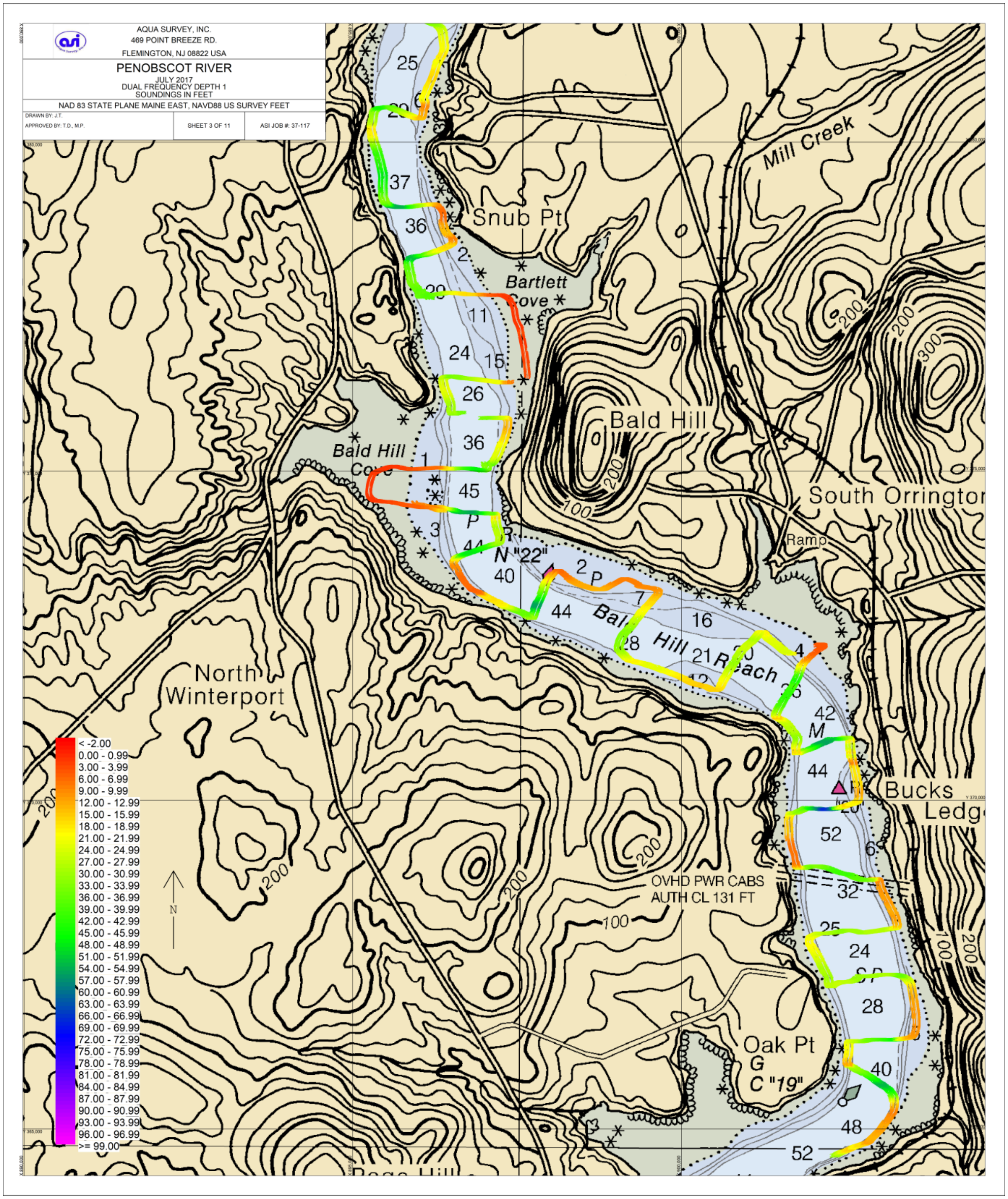


Figure 3. Dual frequency high frequency depth 1 bathymetry near North Winterport.

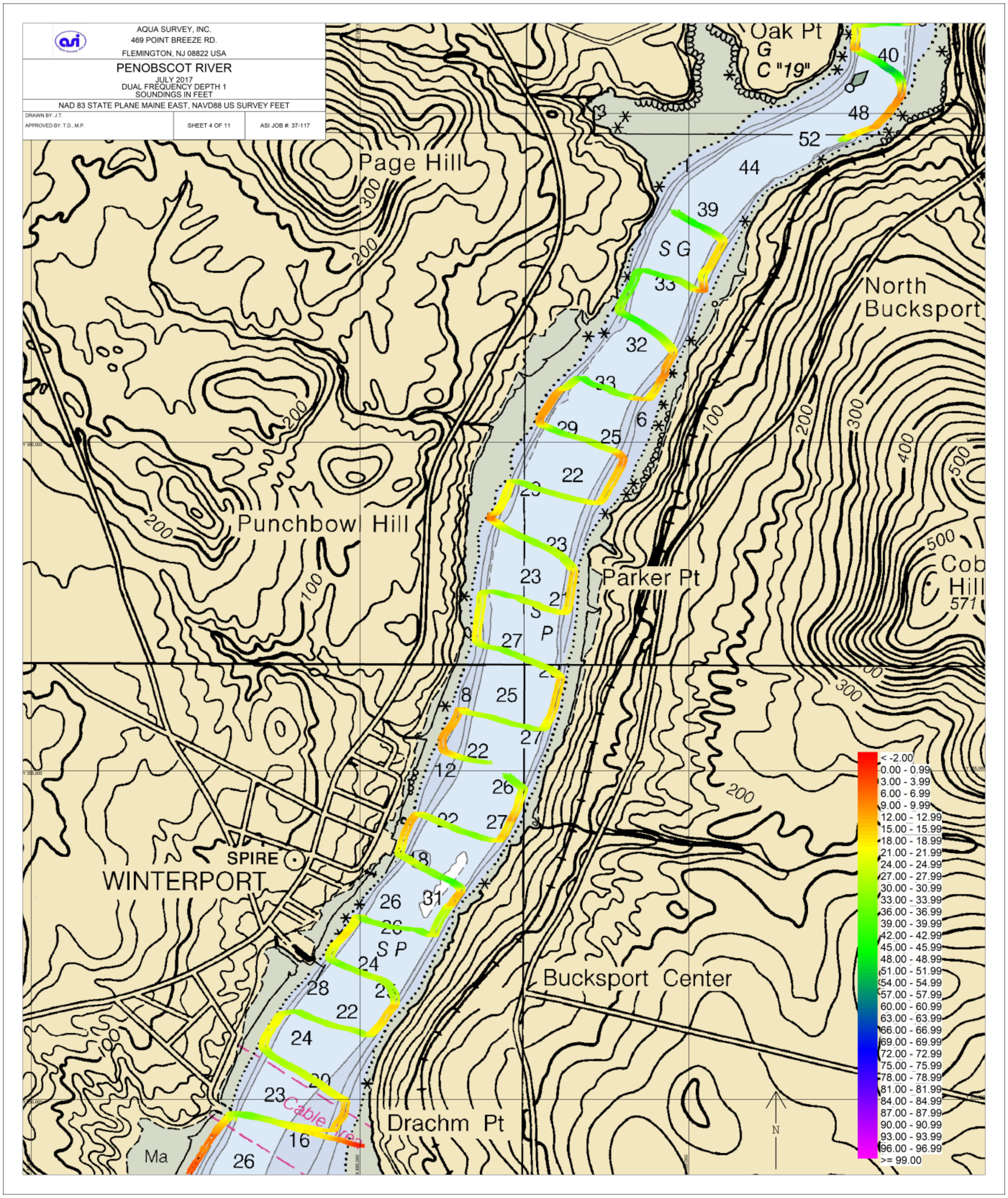


Figure 4. Dual frequency high frequency depth 1 bathymetry near Winterport.

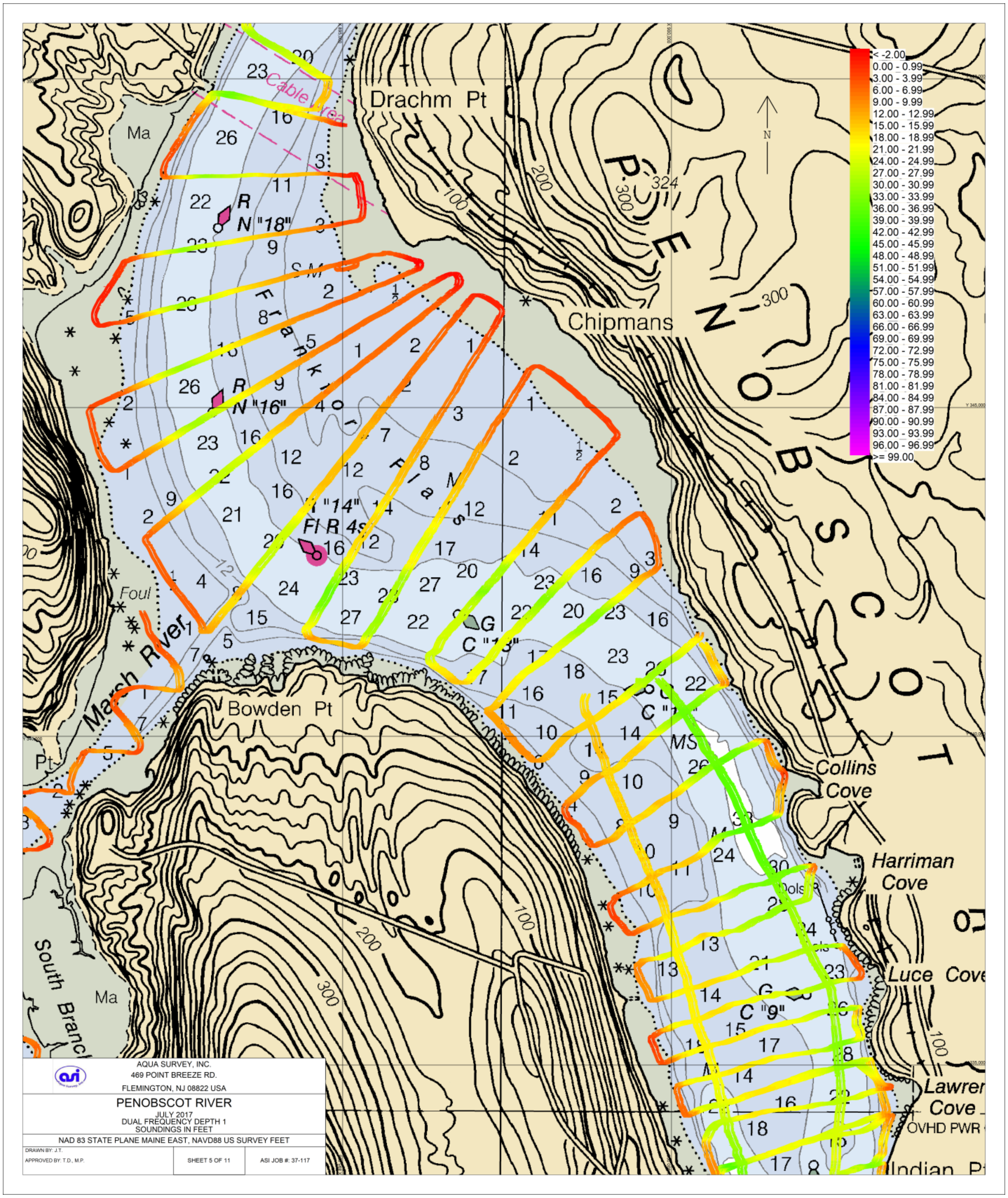


Figure 5. Dual frequency high frequency depth 1 bathymetry near Bowden Point.

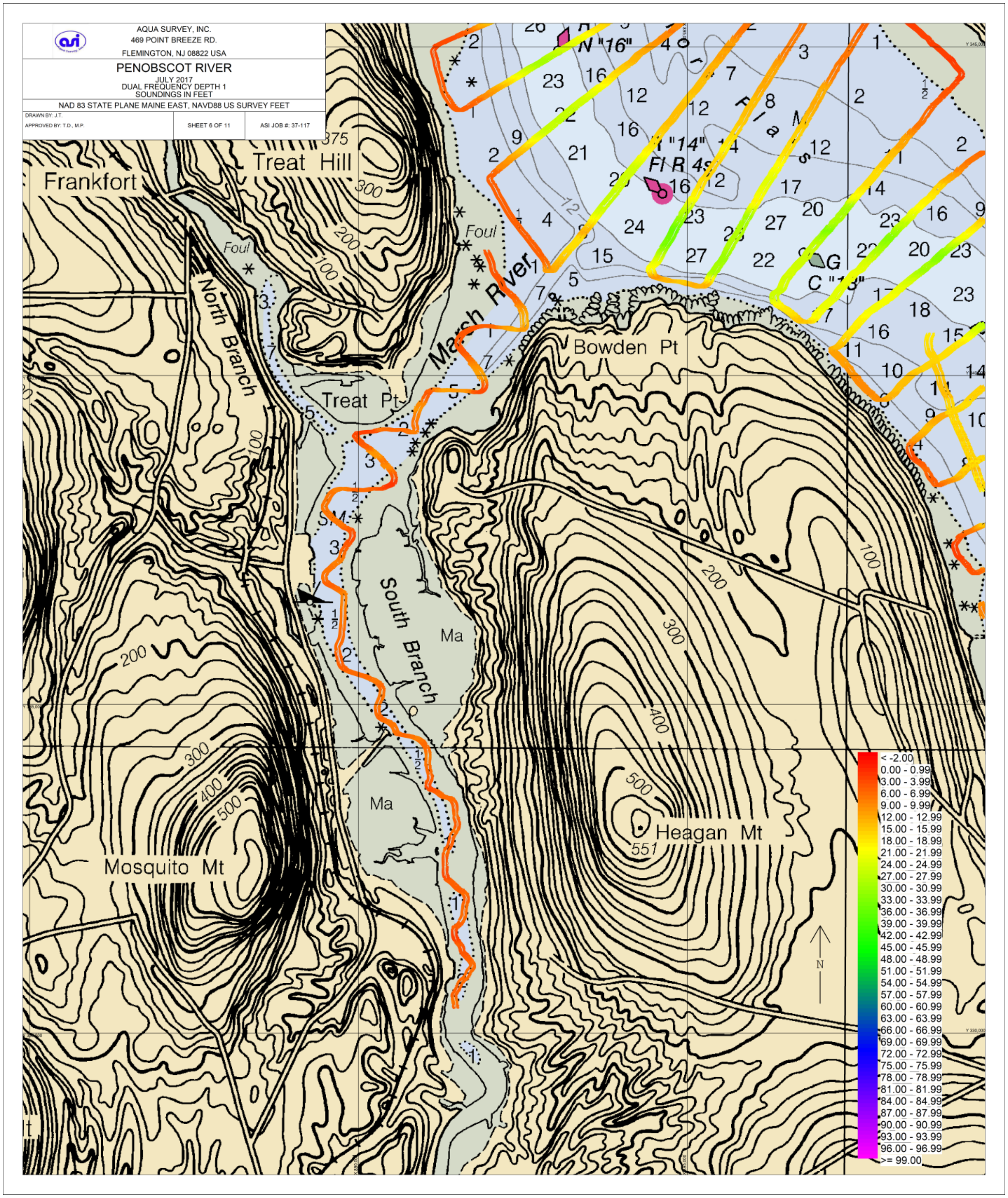


Figure 6. Dual frequency high frequency depth 1 bathymetry near South Branch.

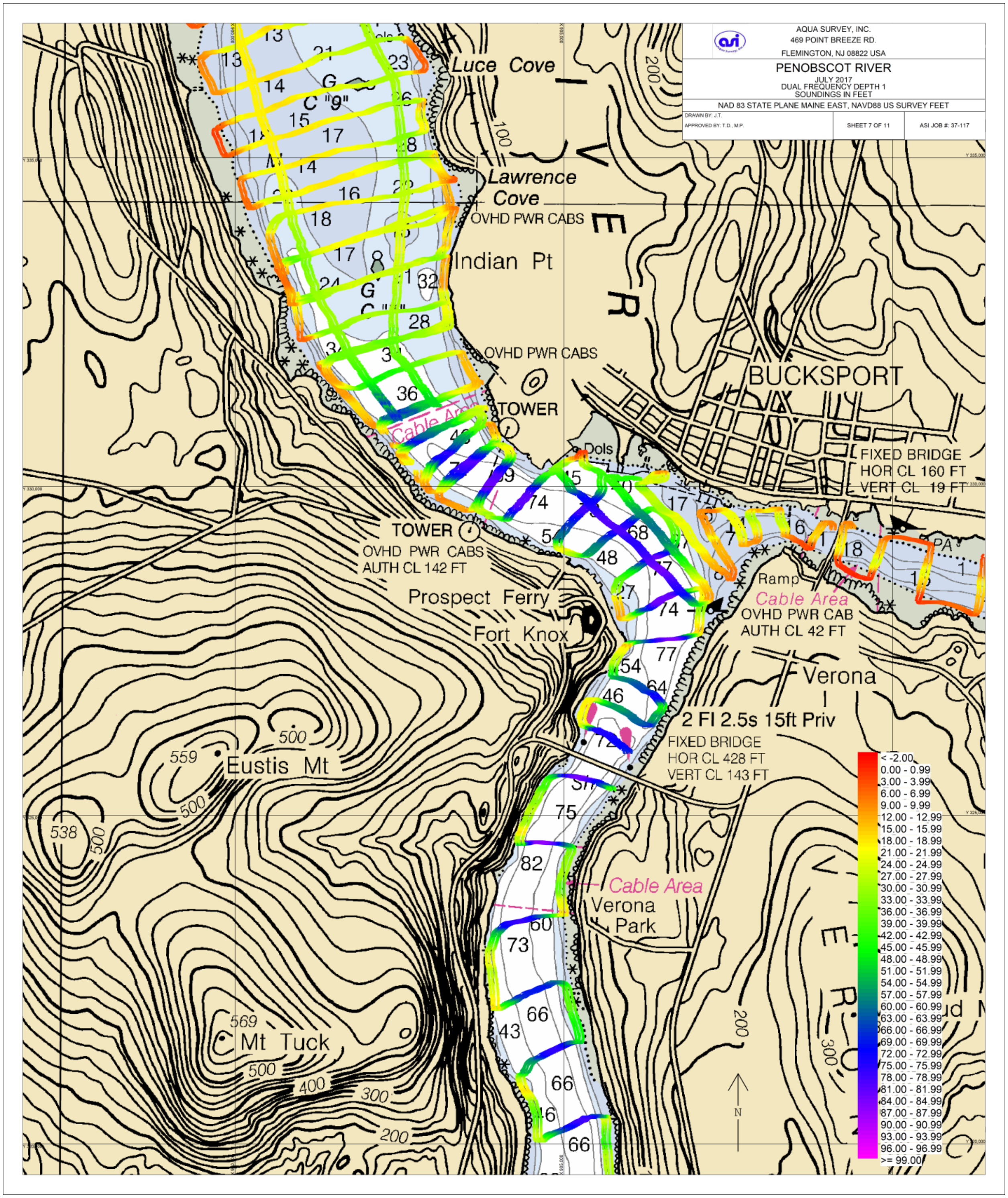


Figure 7. Dual frequency high frequency depth 1 bathymetry near Bucksport.

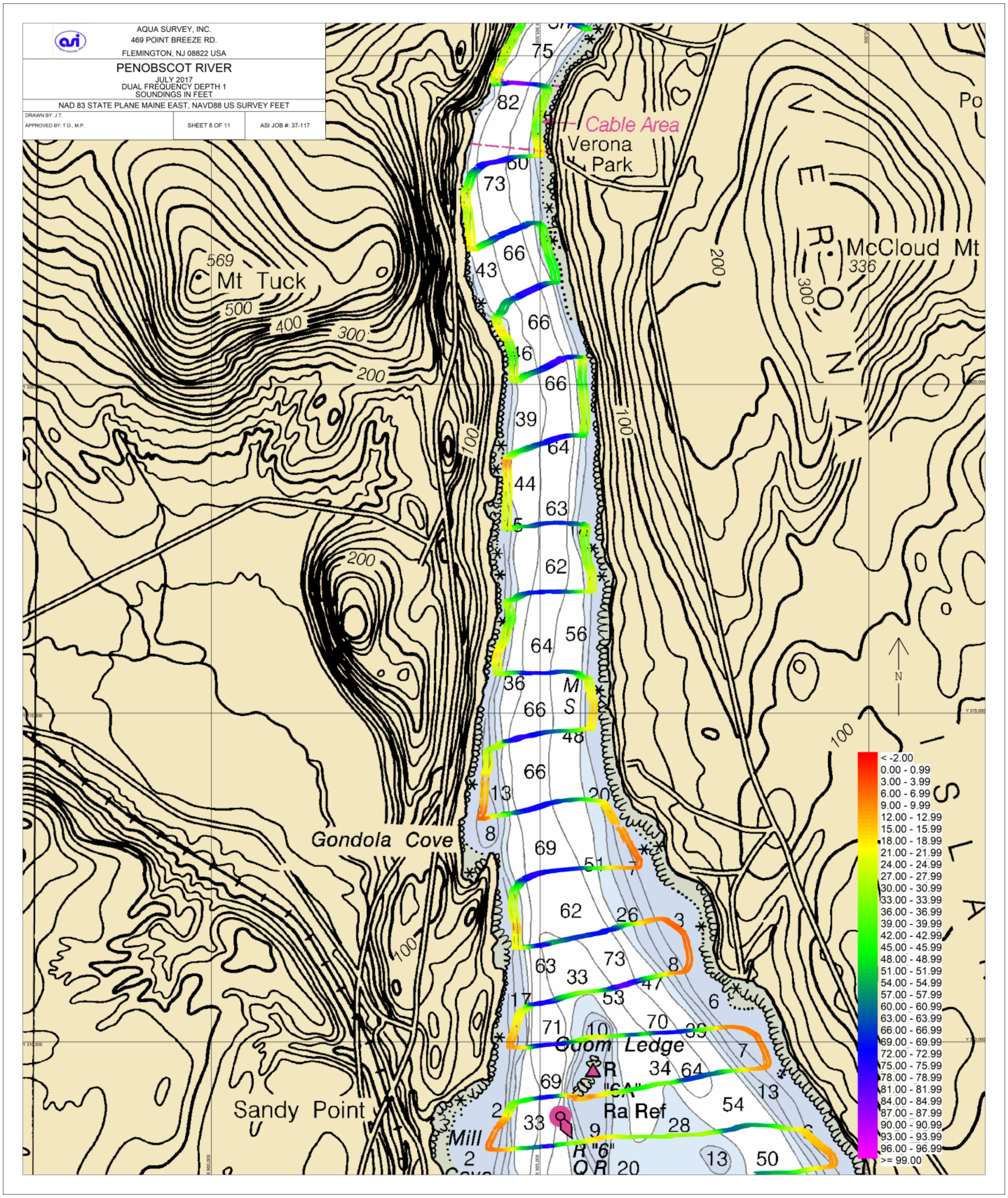


Figure 8. Dual frequency high frequency depth 1 bathymetry near Verona.

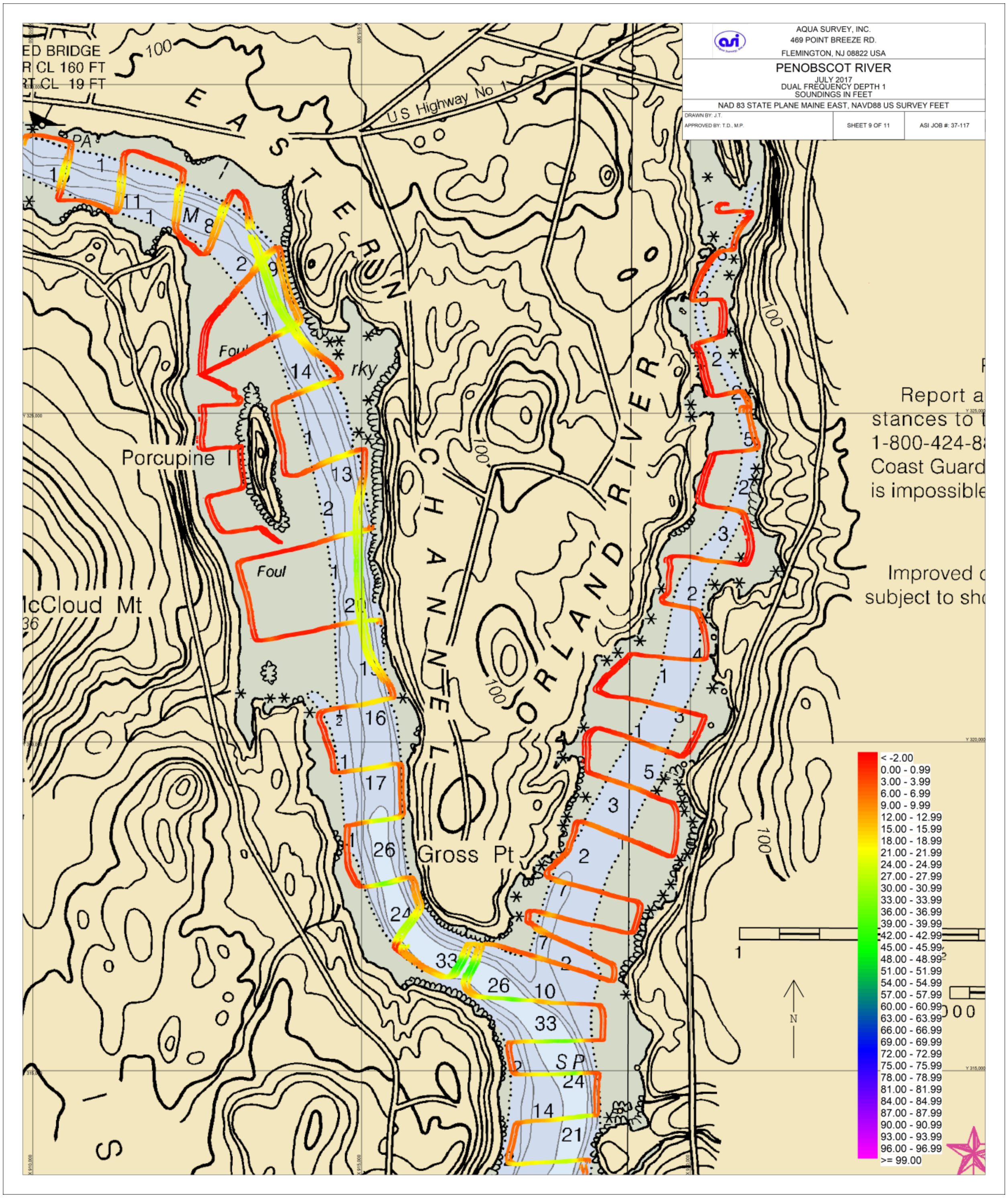


Figure 9. Dual frequency high frequency depth 1 bathymetry near Gross Point.

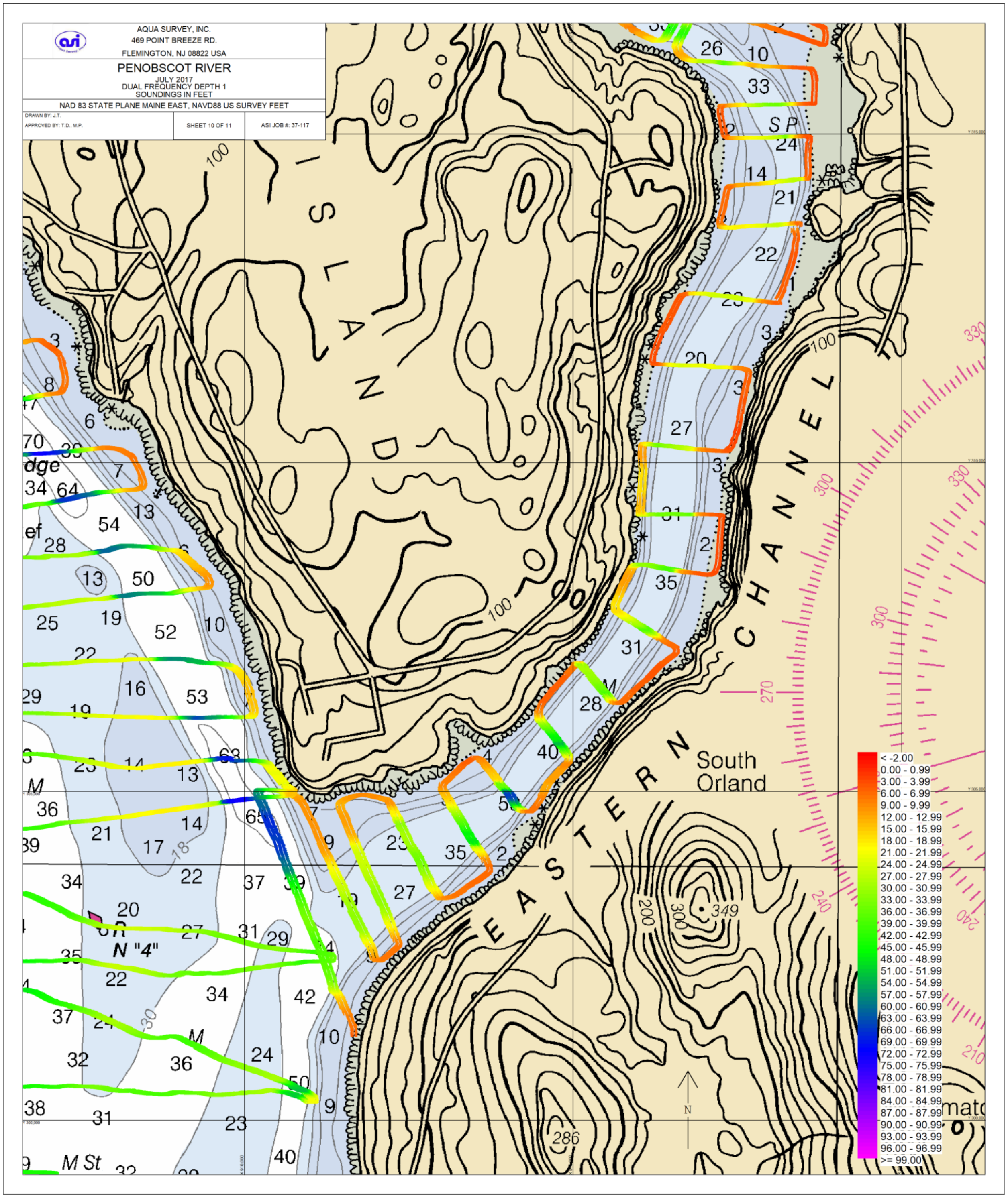


Figure 10. Dual frequency high frequency depth 1 bathymetry near South Orland.

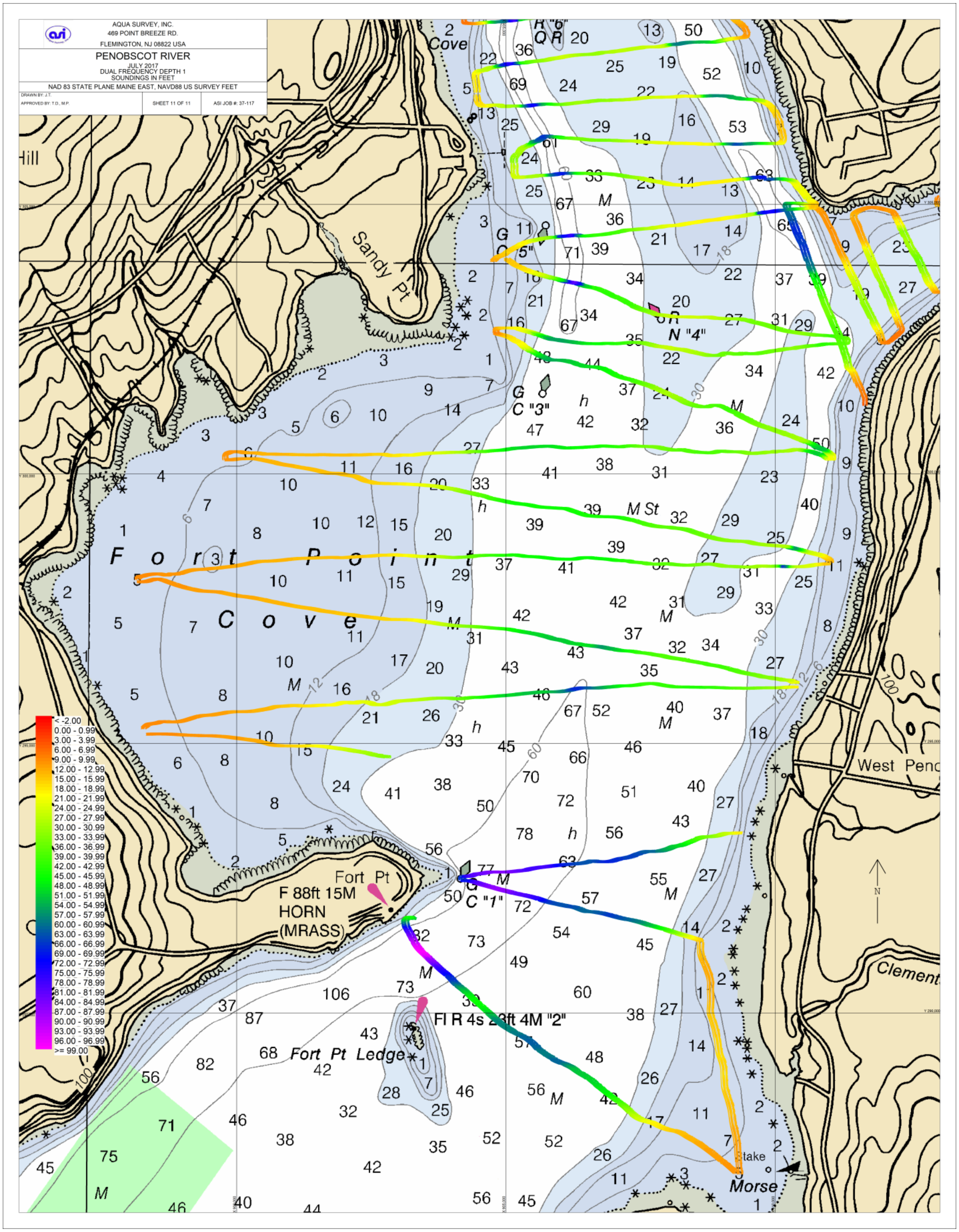


Figure 11. Dual frequency high frequency depth 1 bathymetry near Fort Point Cove.

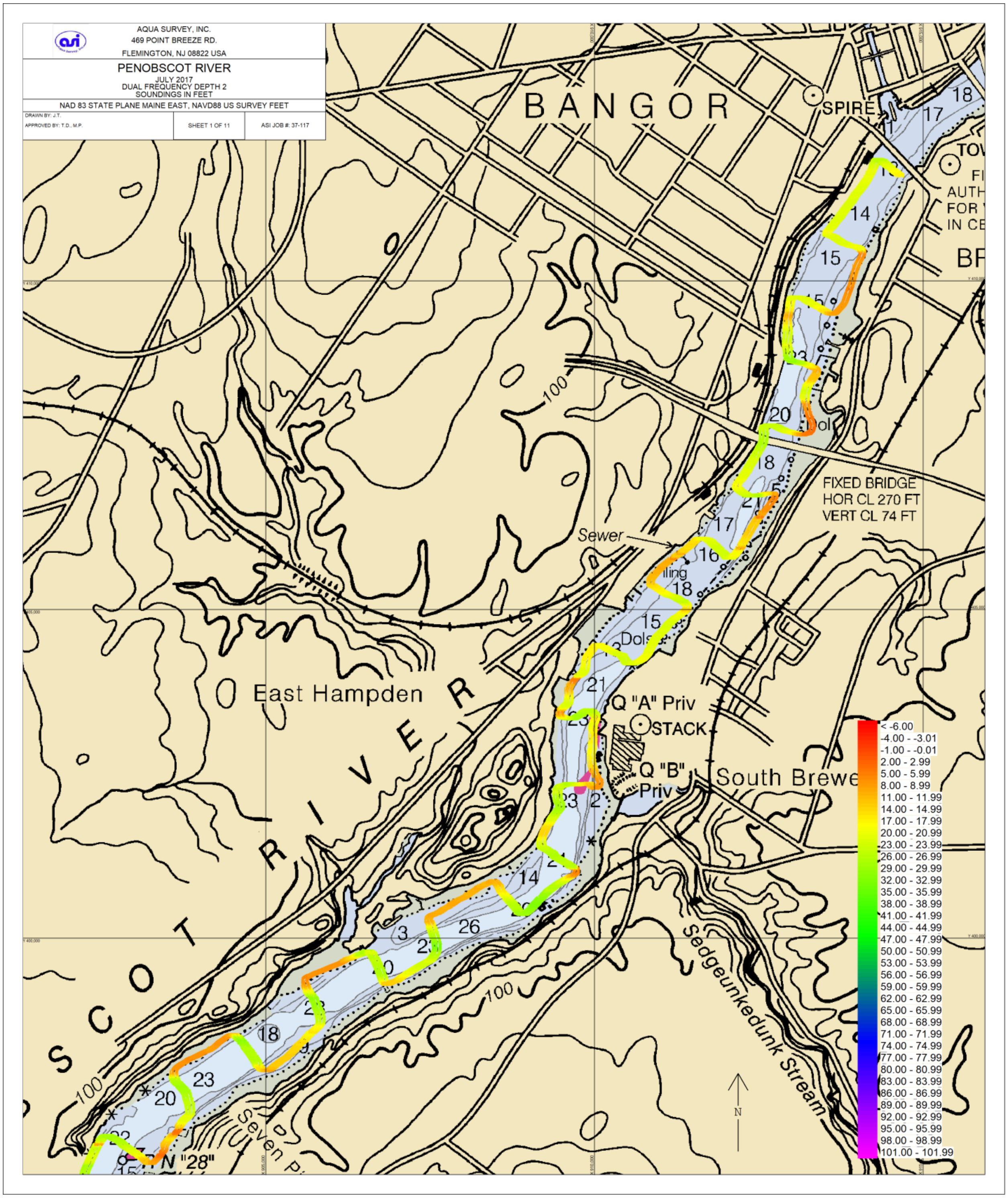


Figure 12. Dual frequency low frequency depth 2 bathymetry near Bangor.

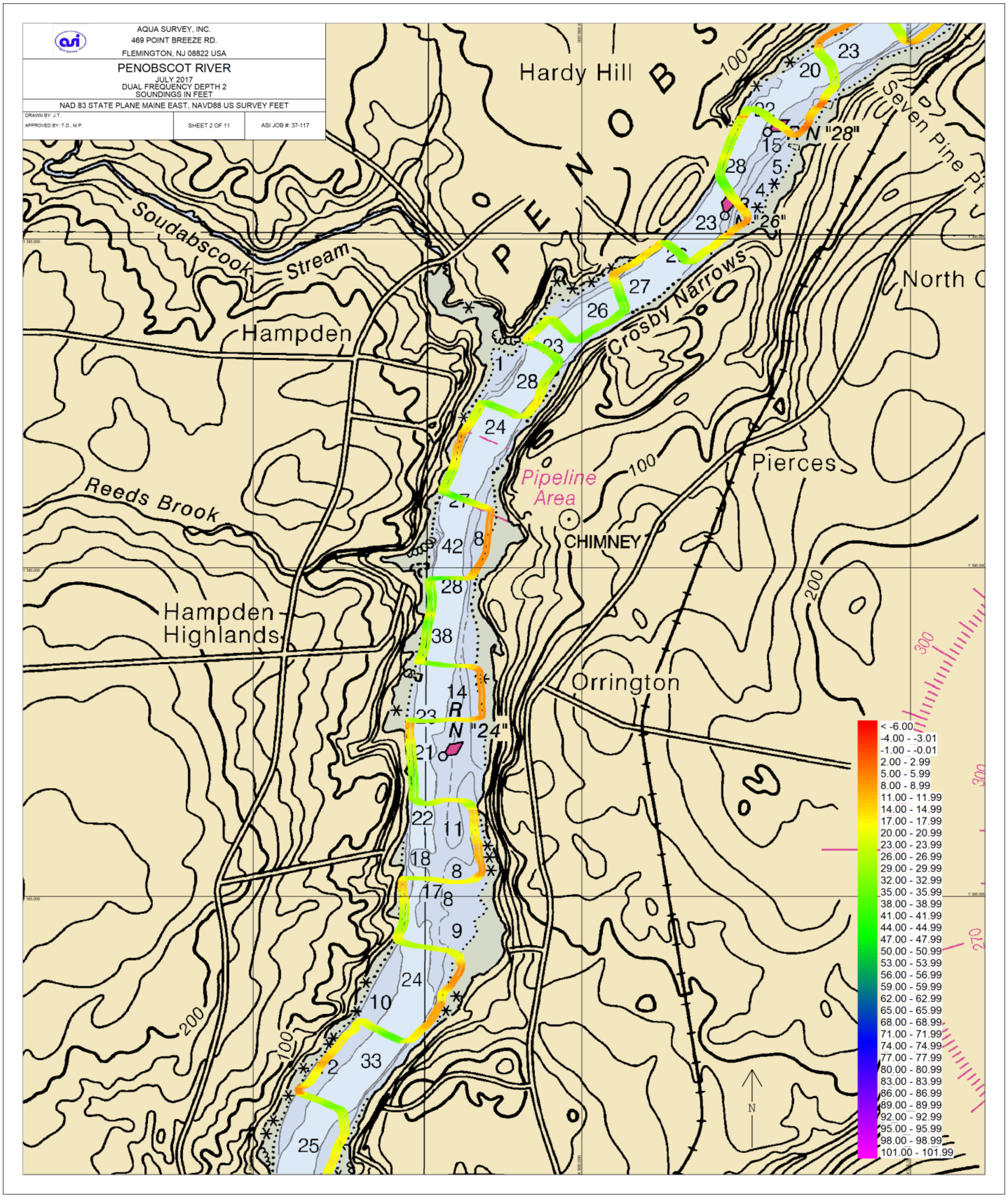


Figure 13. Dual frequency low frequency depth 2 bathymetry near Hampden.

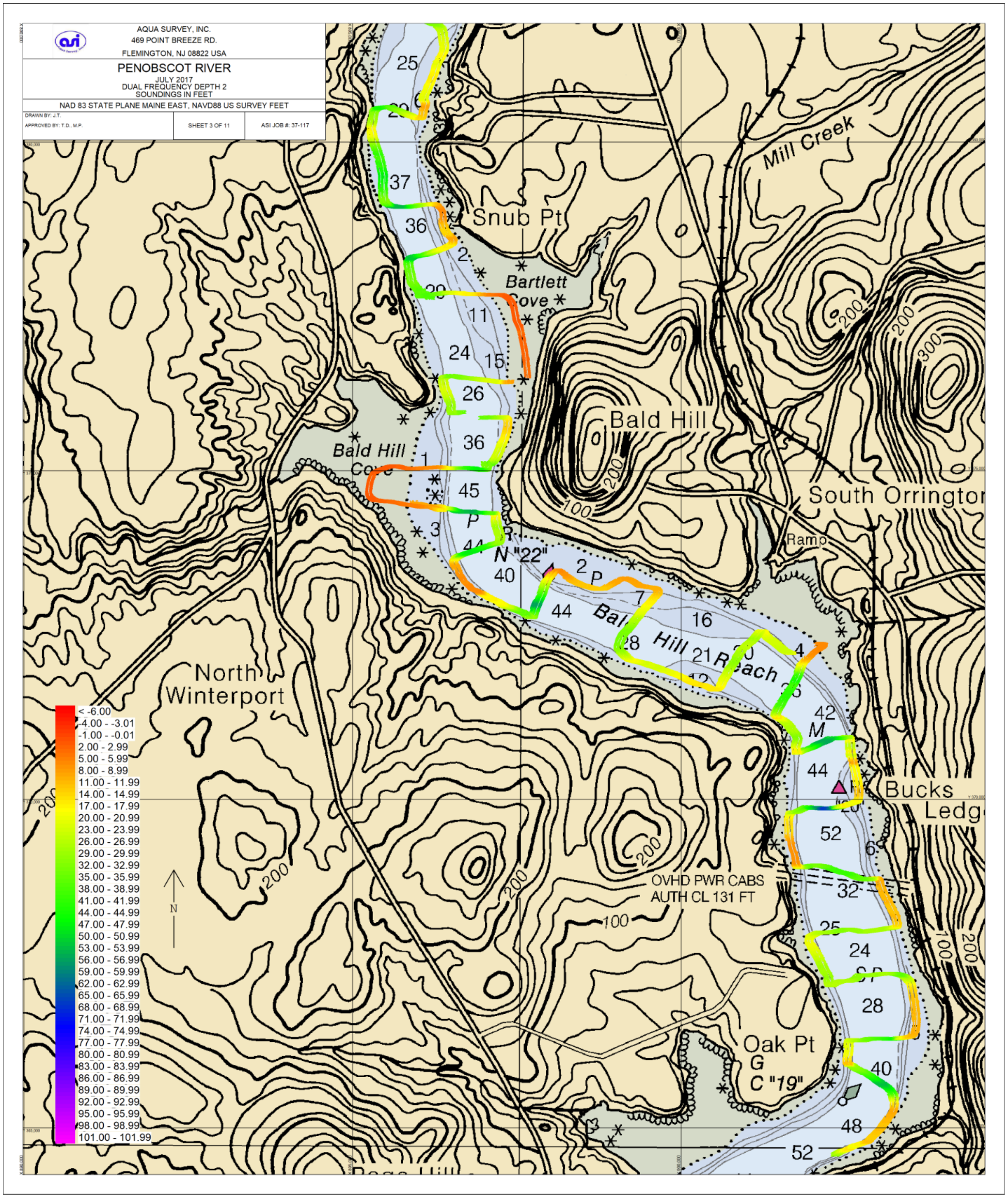


Figure 14. Dual frequency low frequency depth 2 bathymetry near North Winterport.

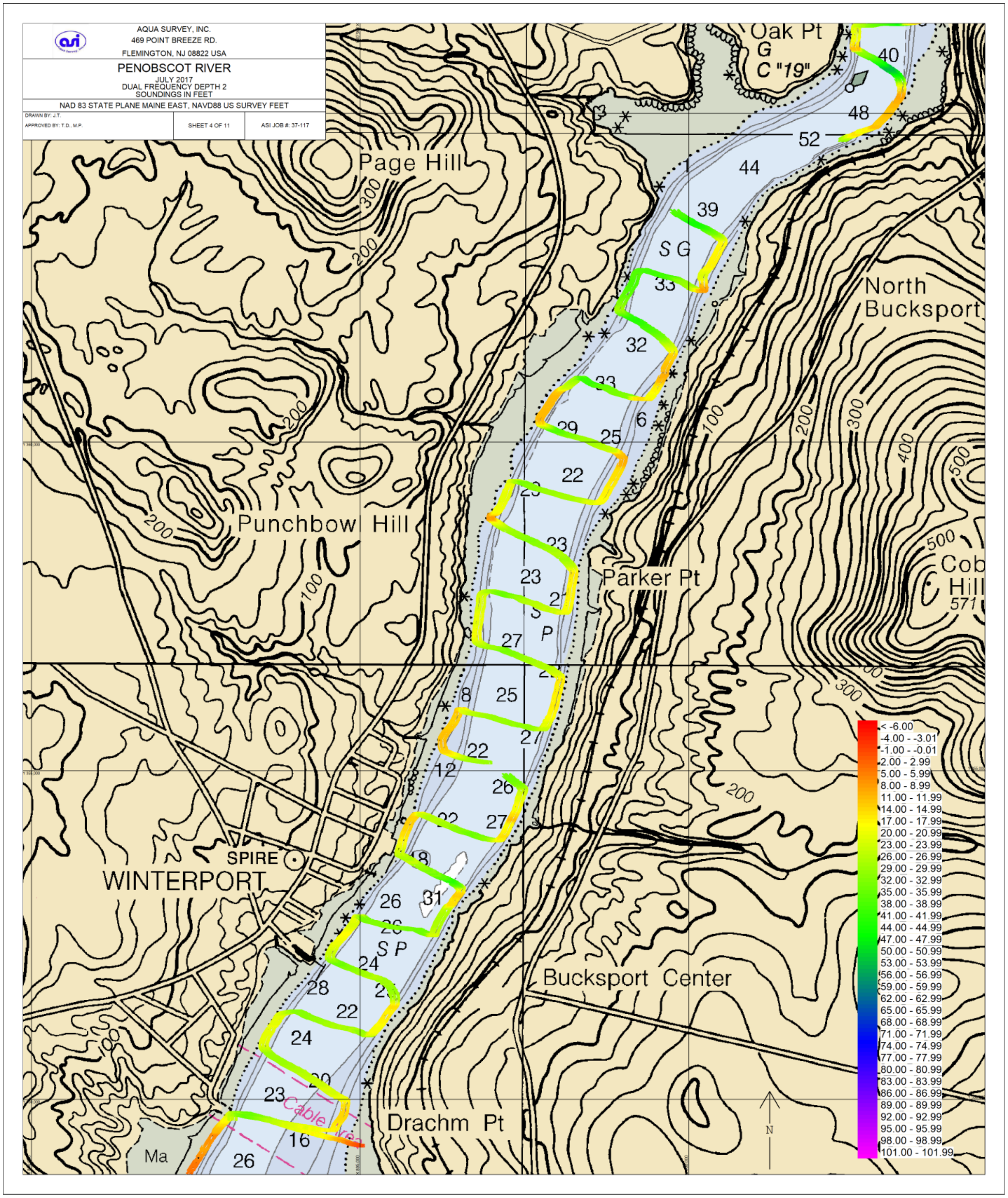


Figure 15. Dual frequency low frequency depth 2 bathymetry near Winterport.

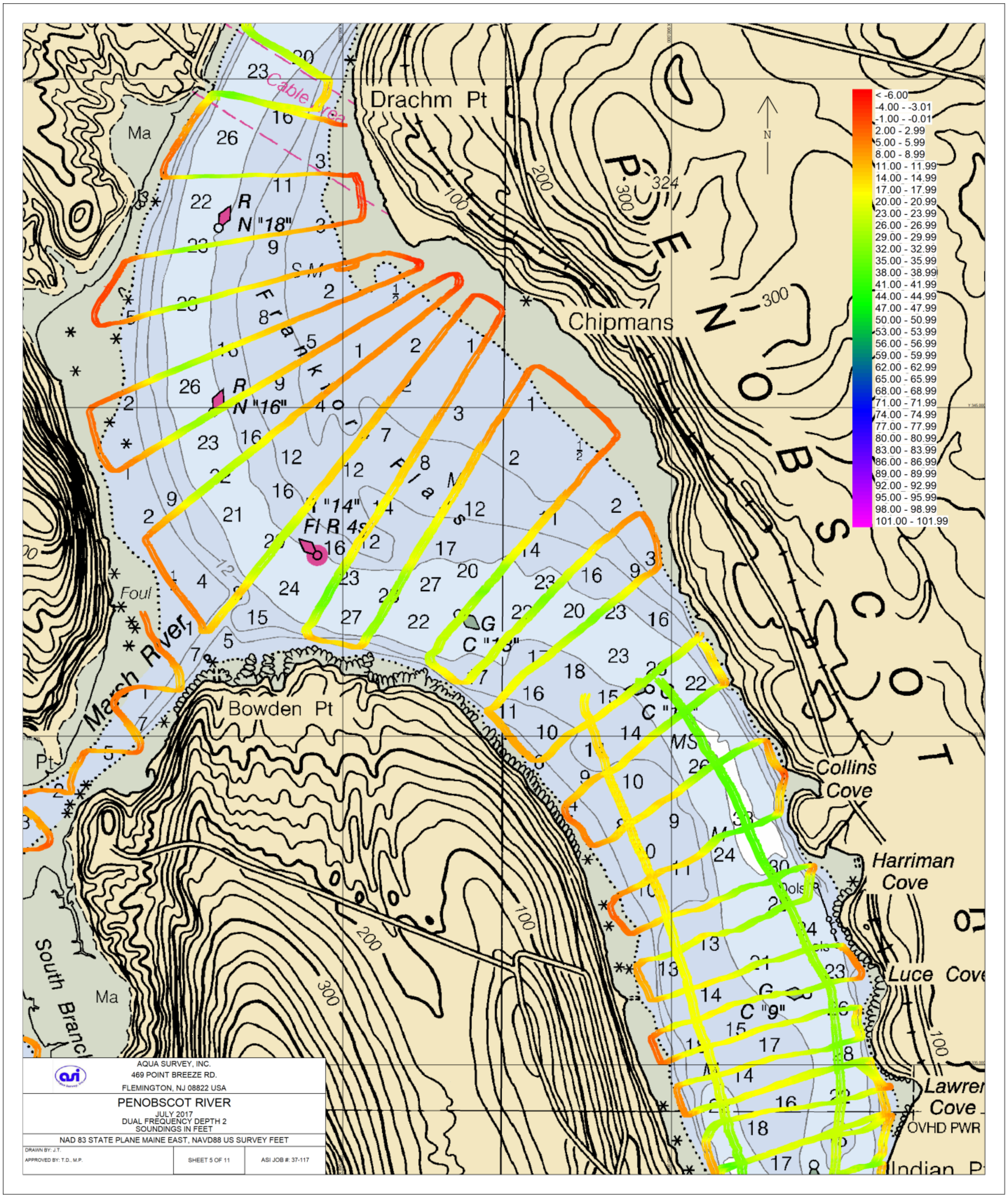


Figure 16. Dual frequency low frequency depth 2 bathymetry near Bowden Point.

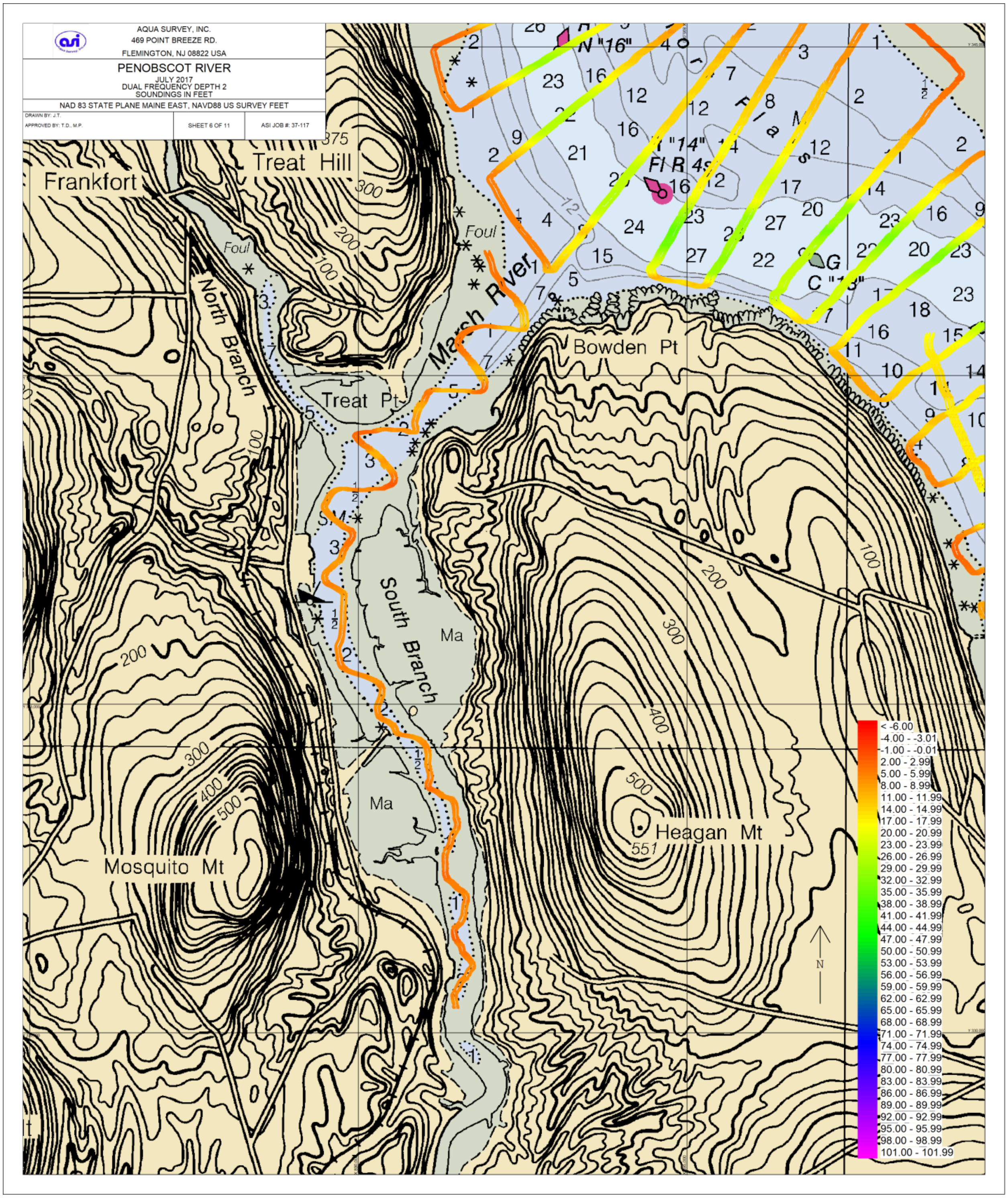


Figure 17. Dual frequency low frequency depth 2 bathymetry near South Branch.

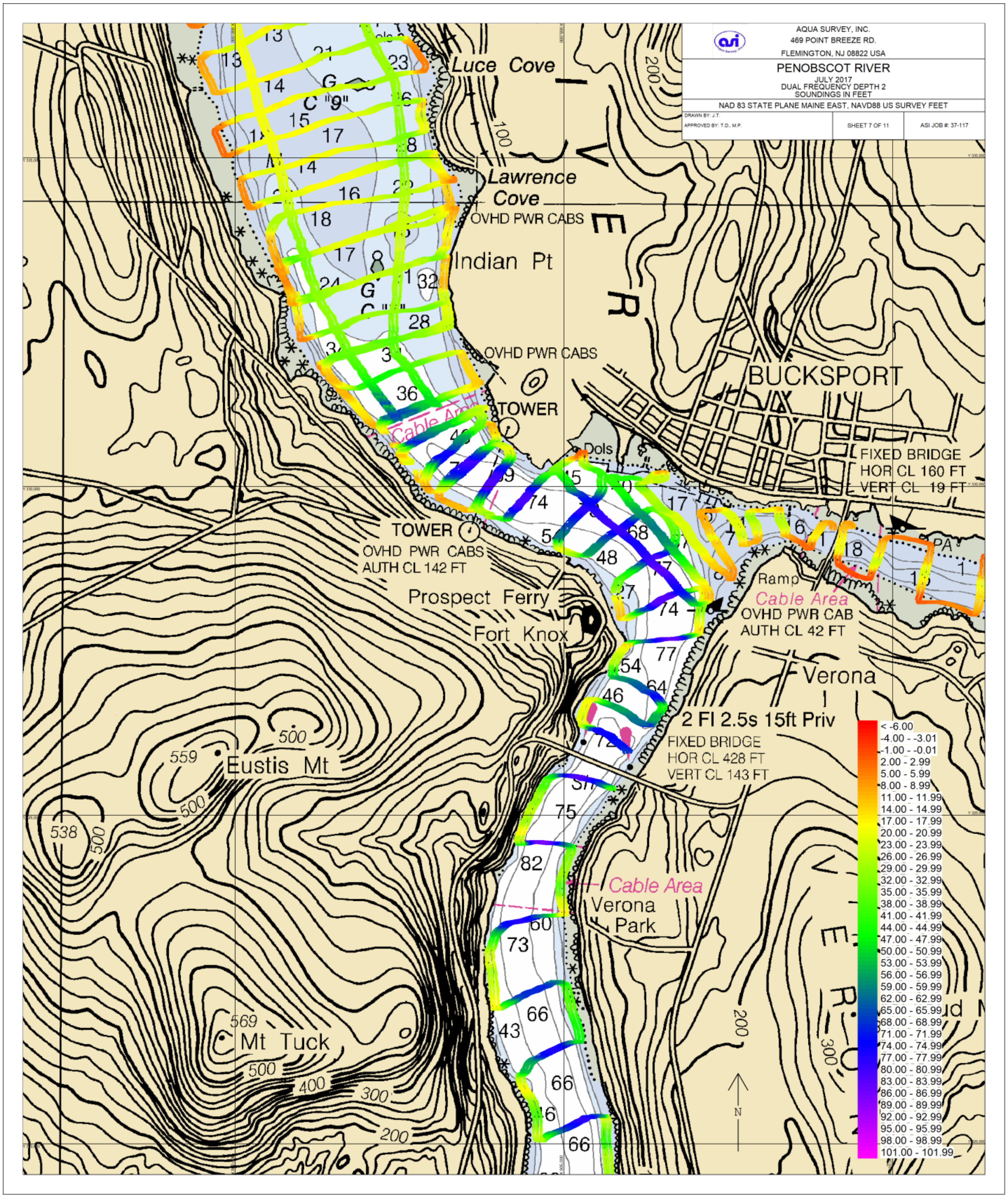


Figure 18. Dual frequency low frequency depth 2 bathymetry near Bucksport.

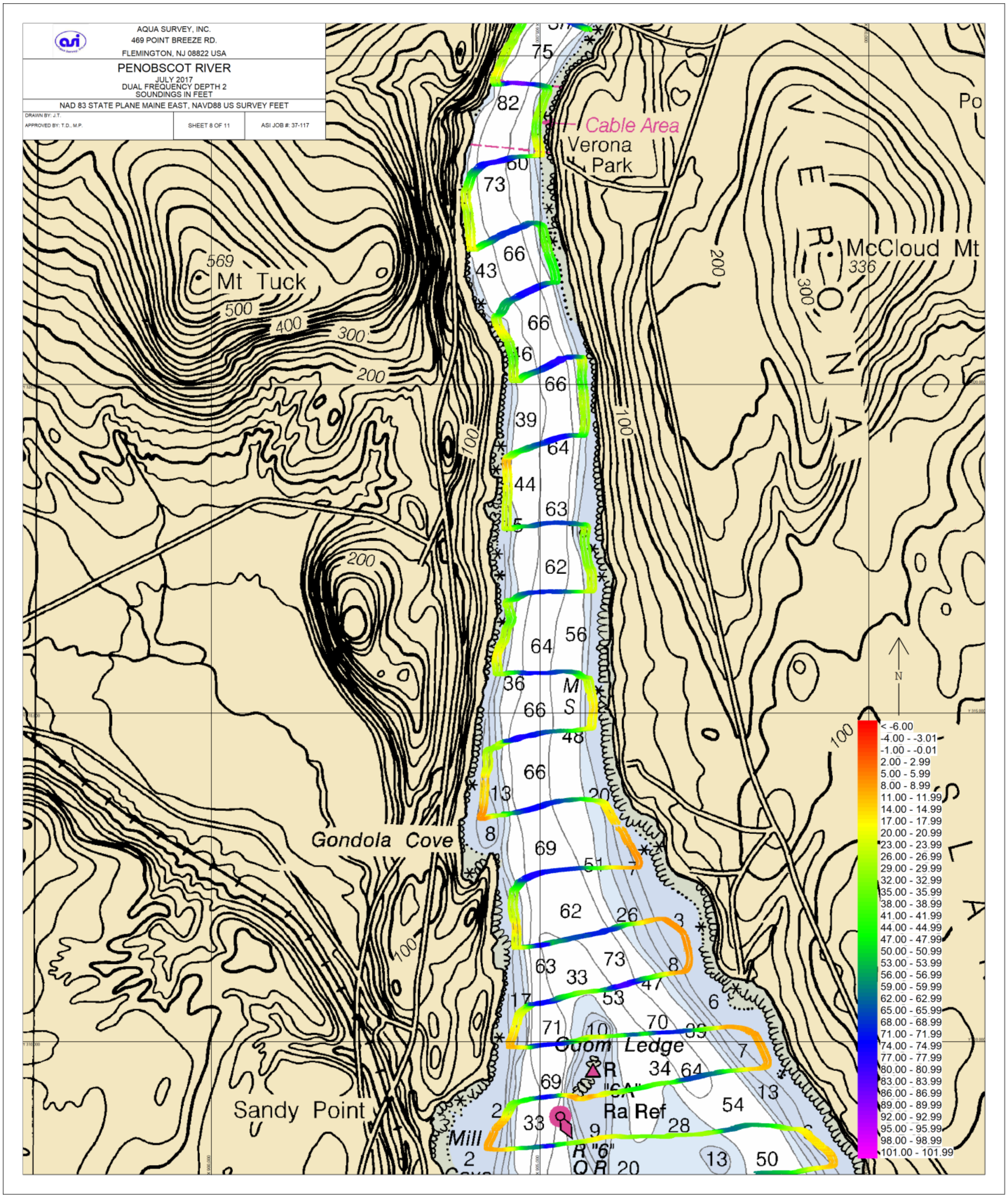


Figure 19. Dual frequency low frequency depth 2 bathymetry near Verona.

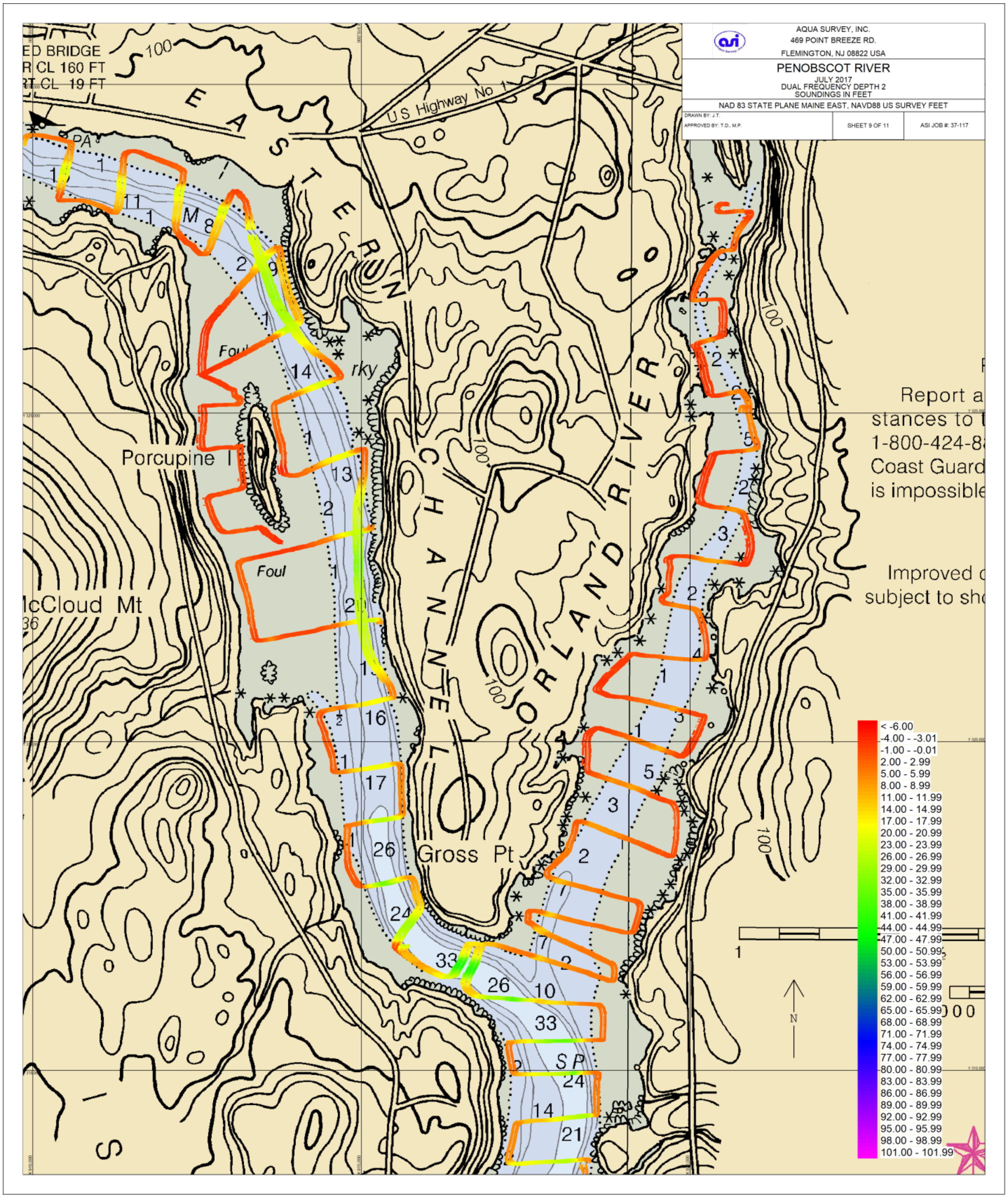


Figure 20. Dual frequency low frequency depth 2 bathymetry near Gross Point.

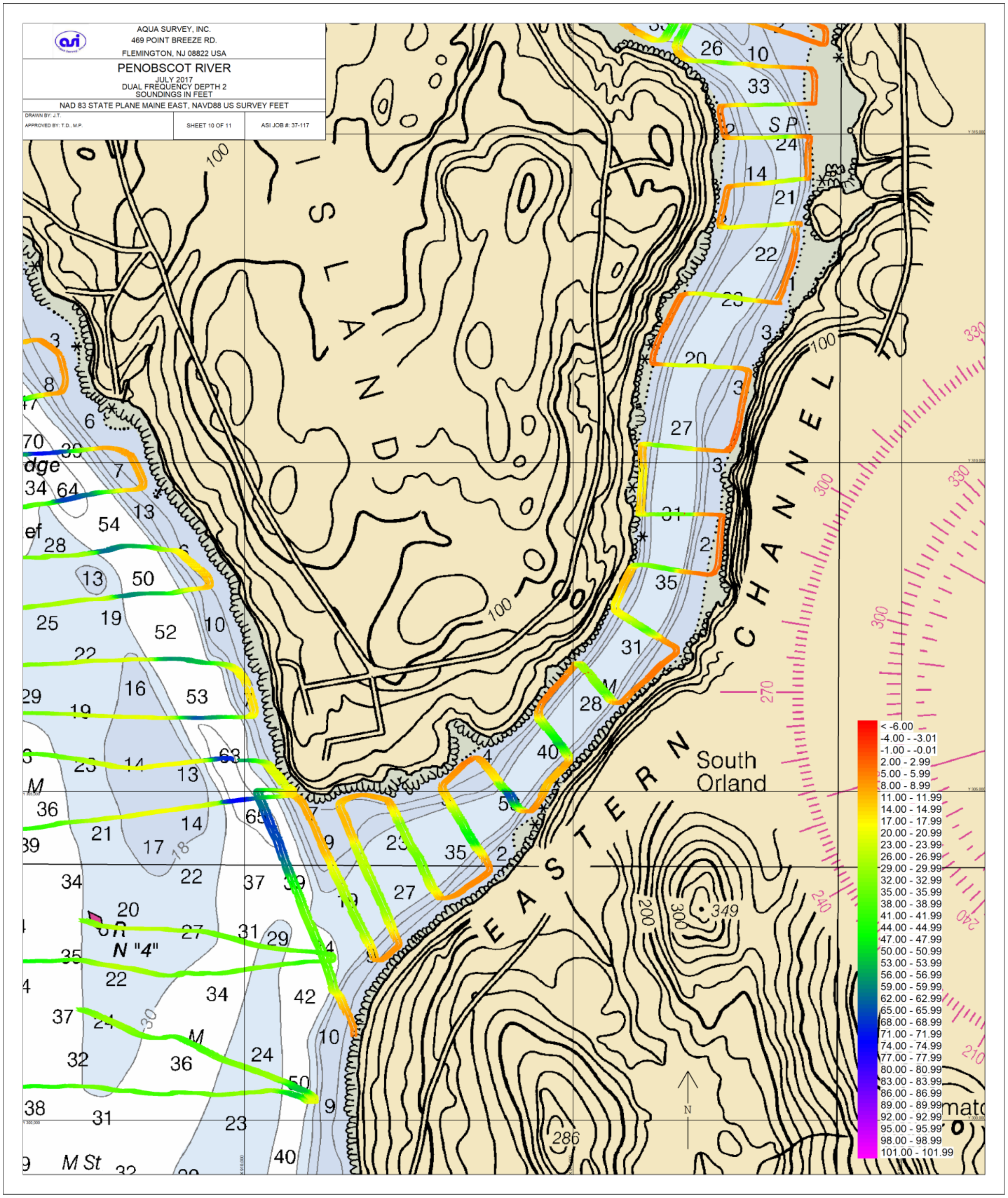


Figure 21. Dual frequency low frequency depth 2 bathymetry near South Orland.

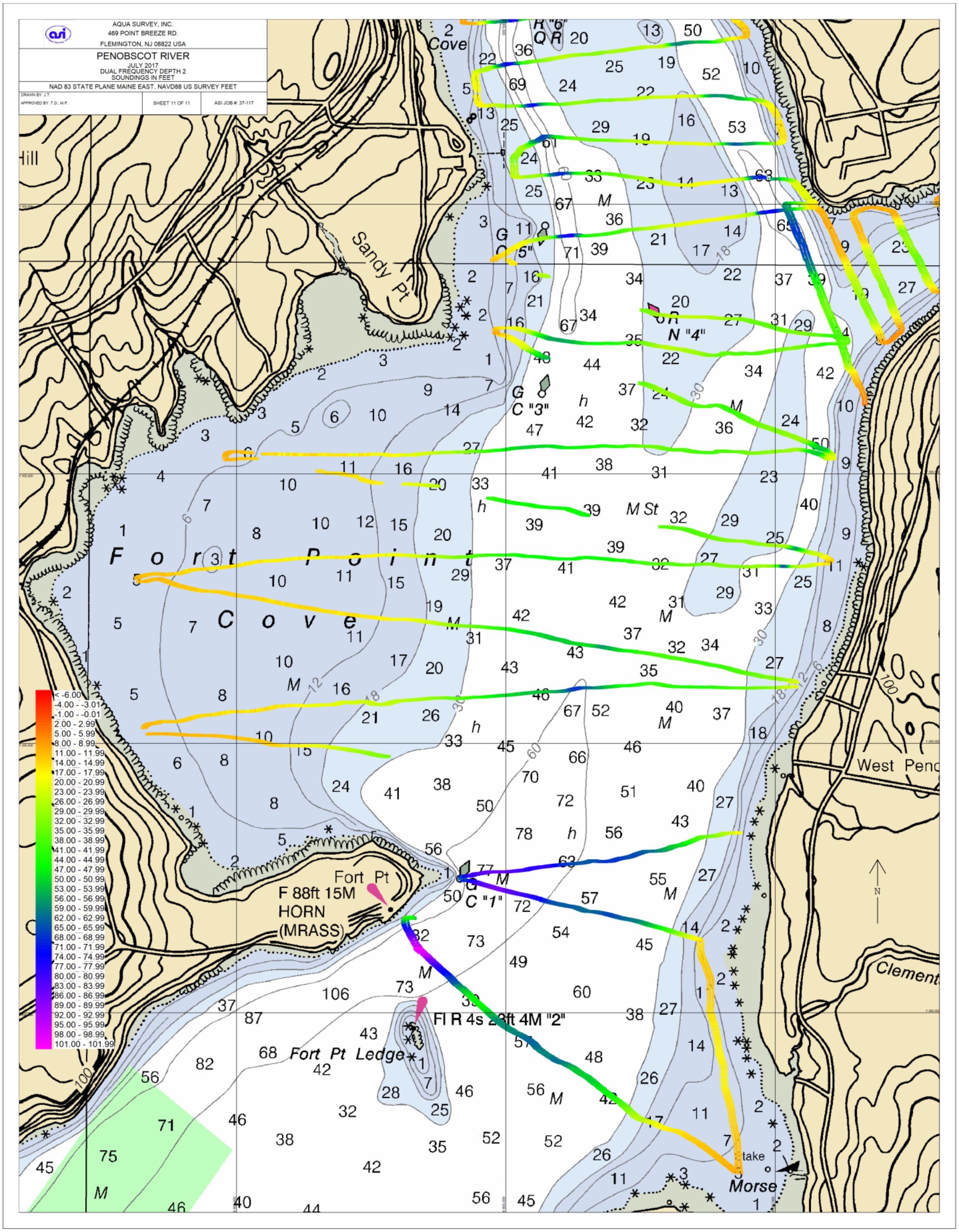


Figure 22. Dual frequency low frequency depth 2 bathymetry near Fort Point Cove.

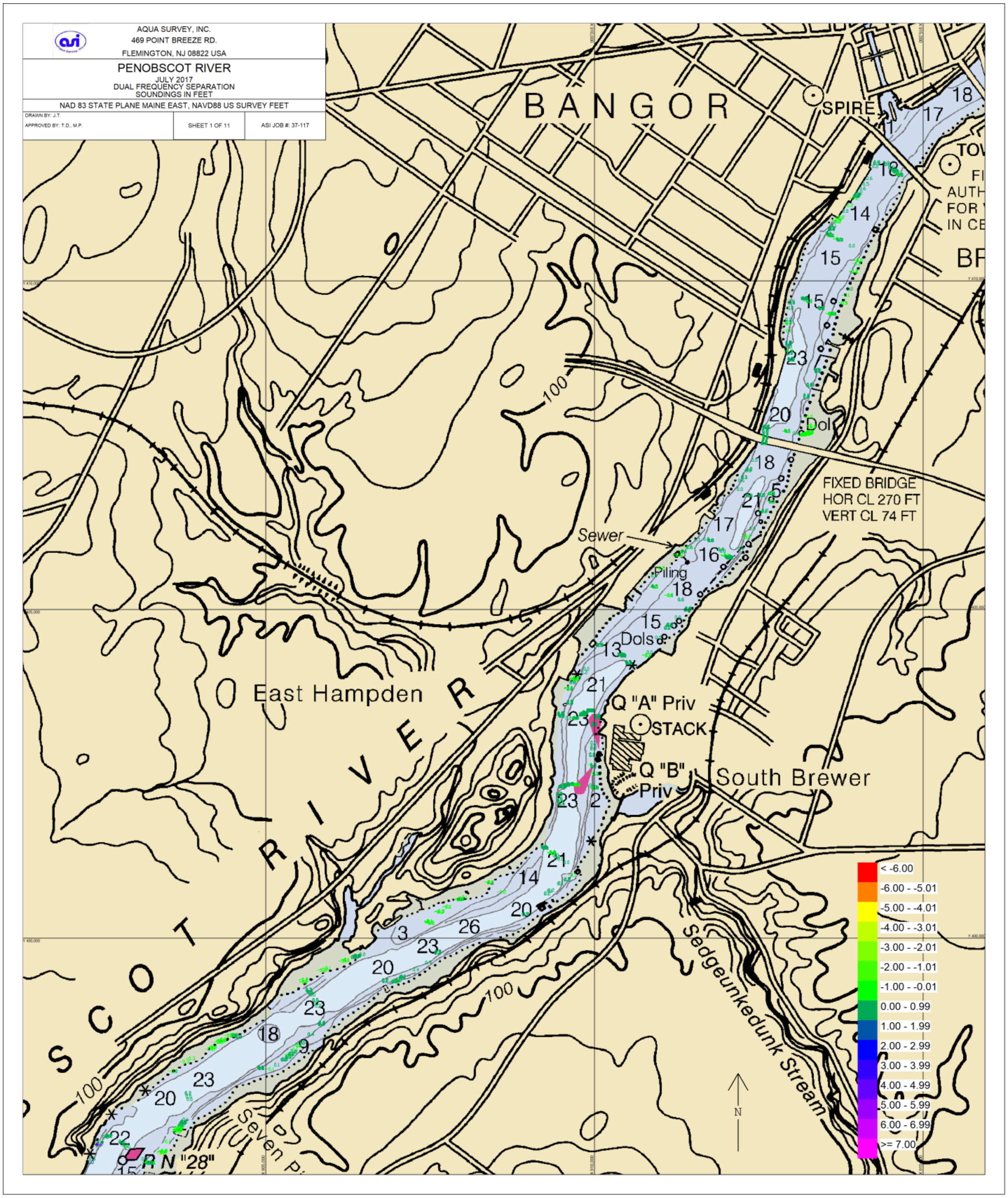


Figure 23. Dual frequency separation near Bangor.

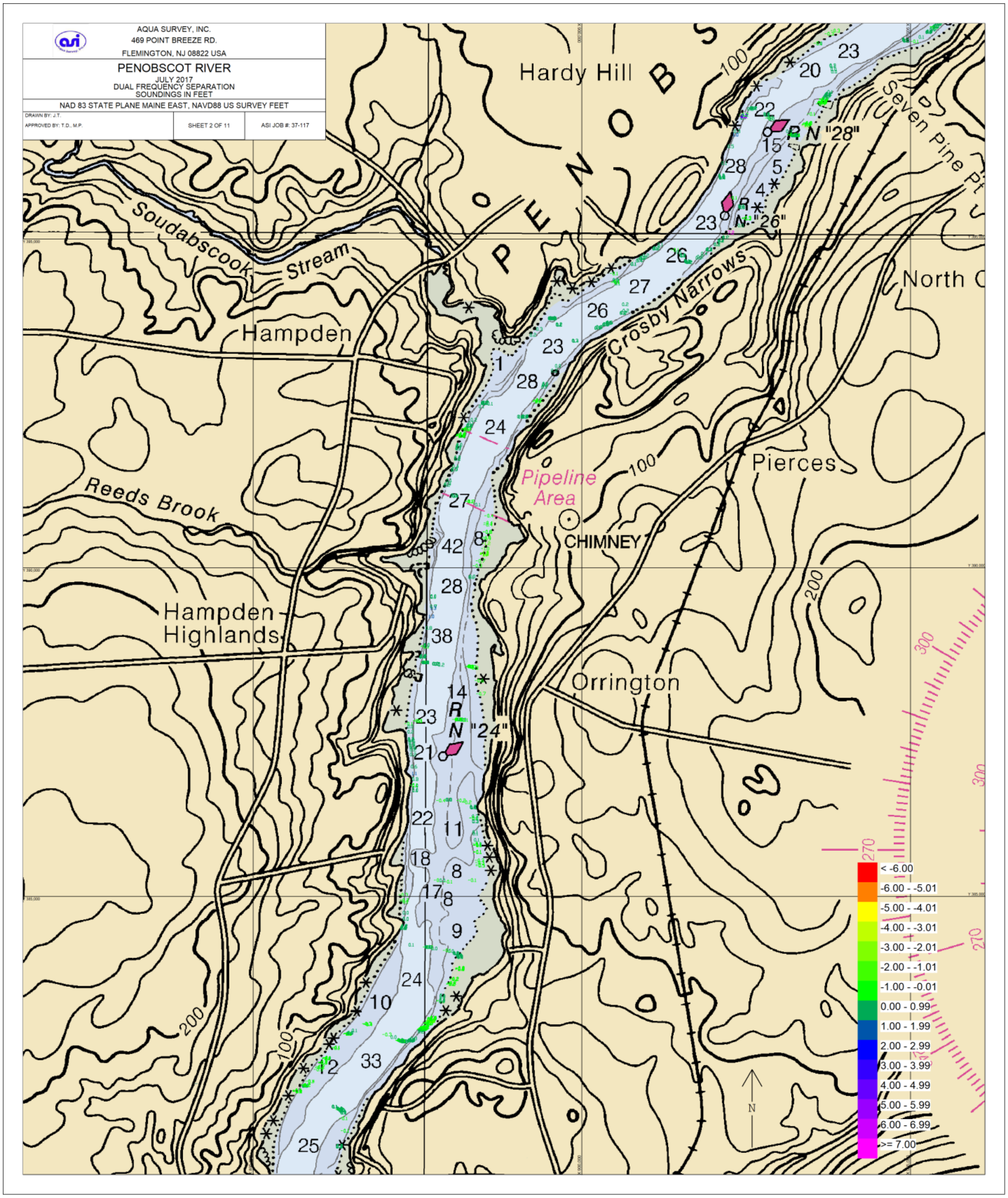


Figure 24. Dual frequency separation near Hampden.

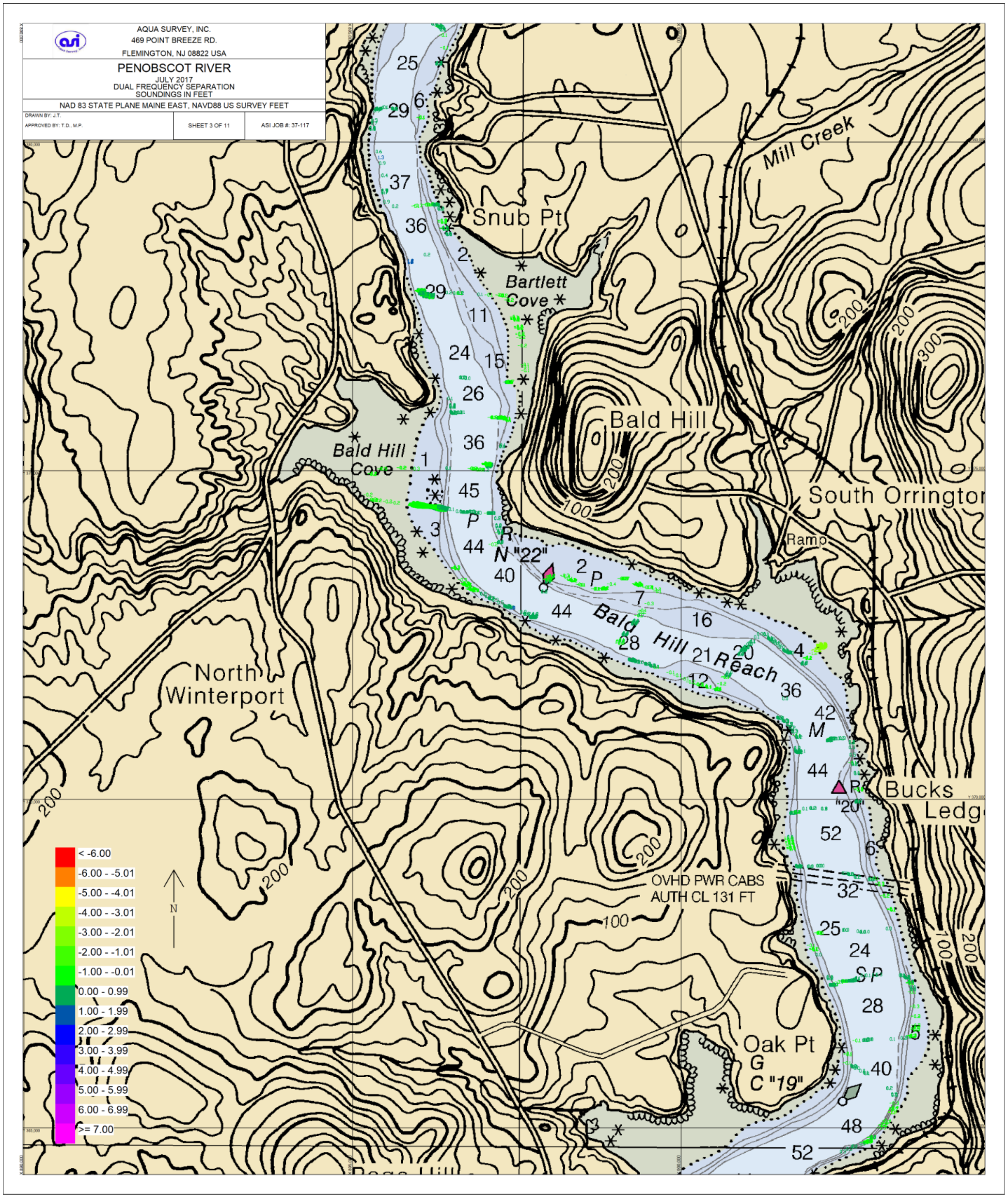


Figure 25. Dual frequency separation near North Winterport.

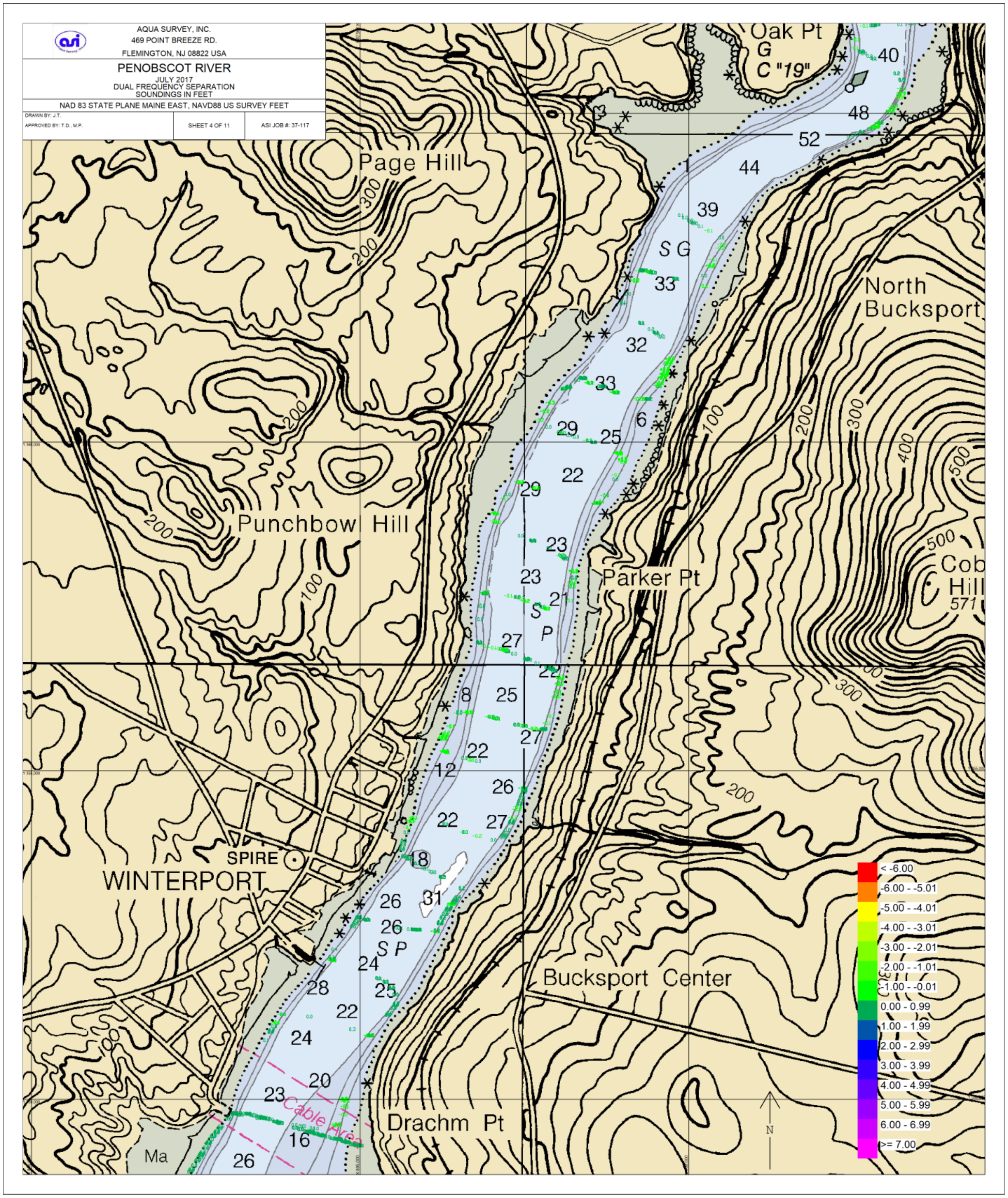


Figure 26. Dual frequency separation near Winterport.

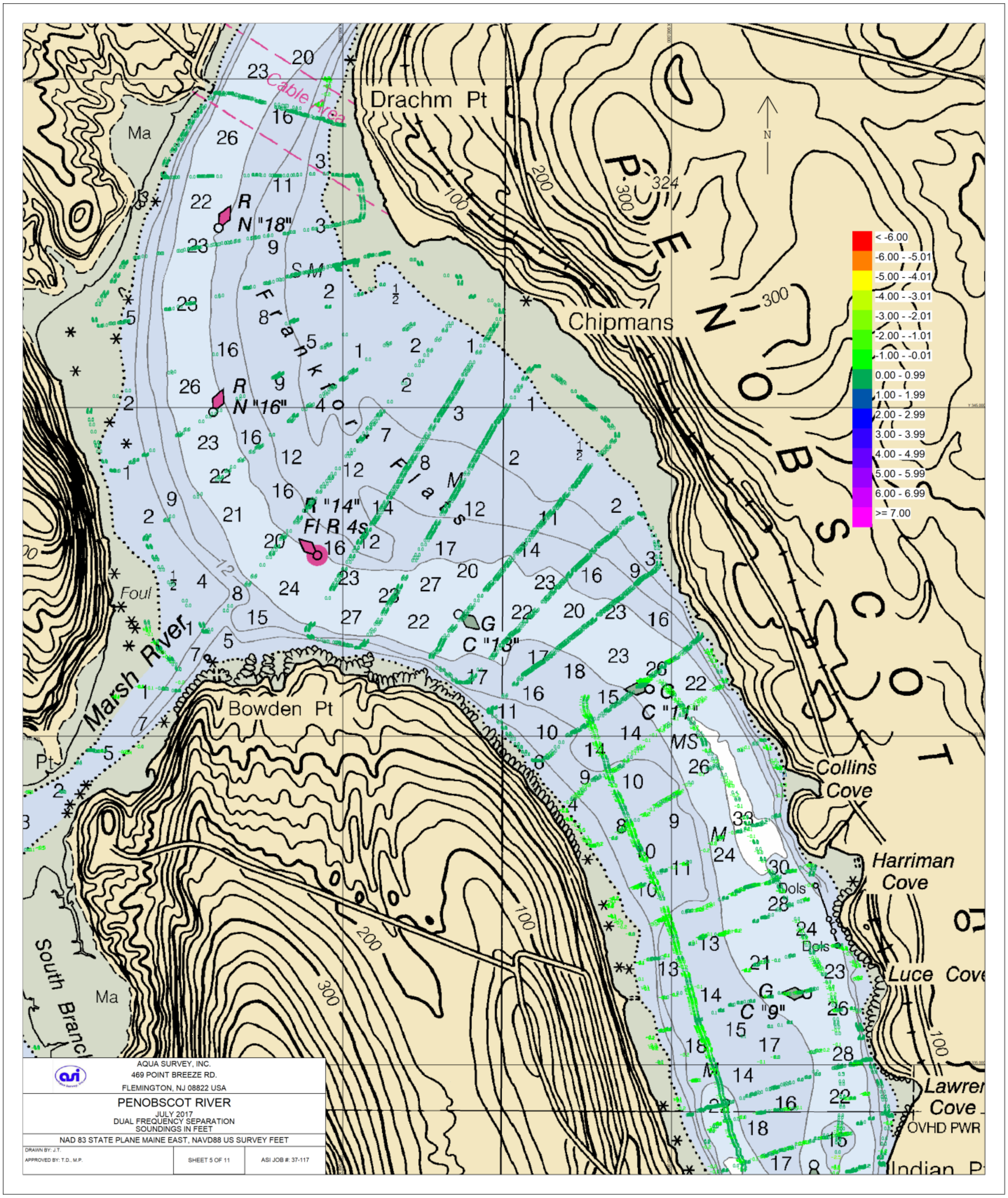


Figure 27. Dual frequency separation near Bowden Point.

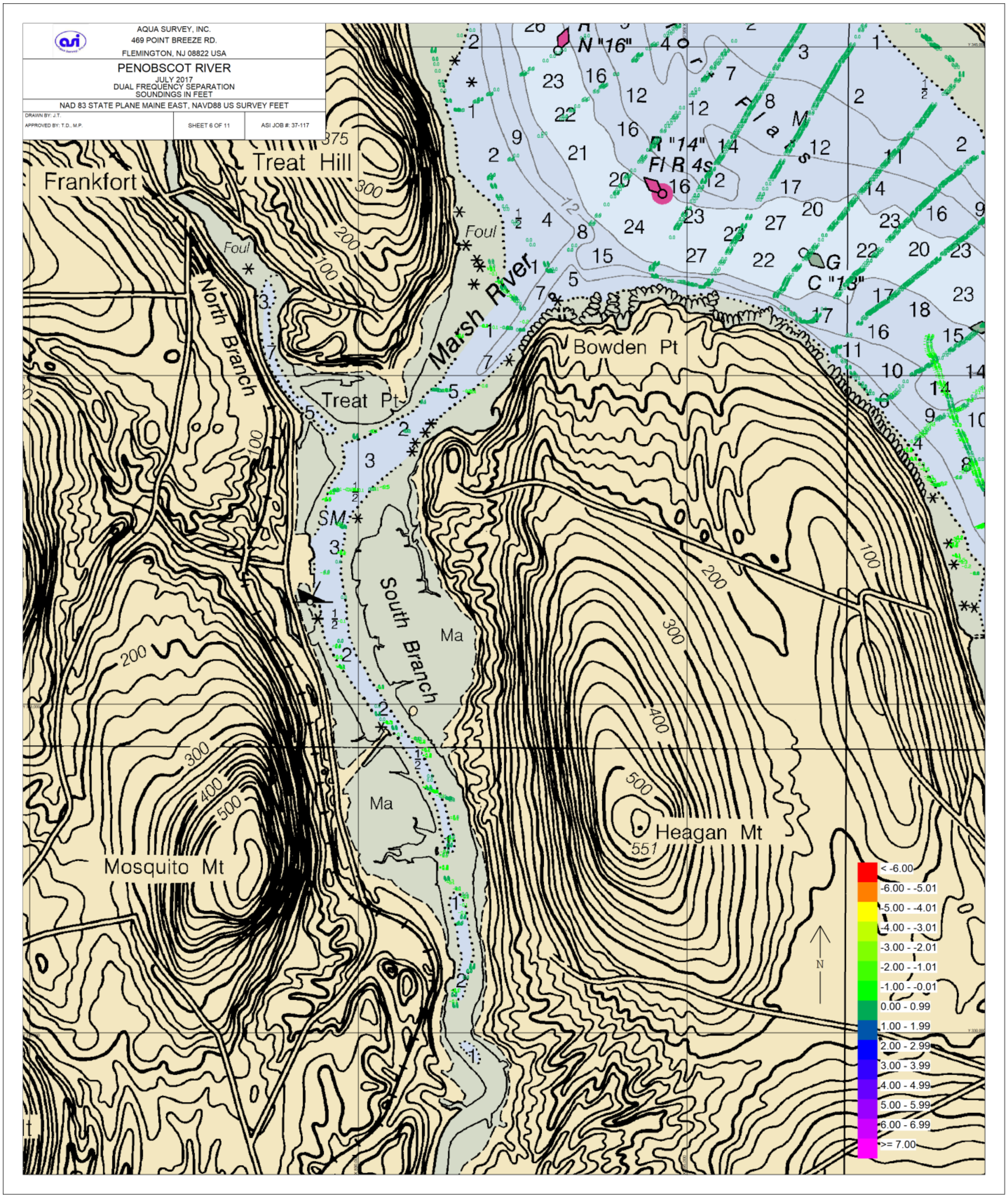


Figure 28. Dual frequency separation near South Branch.

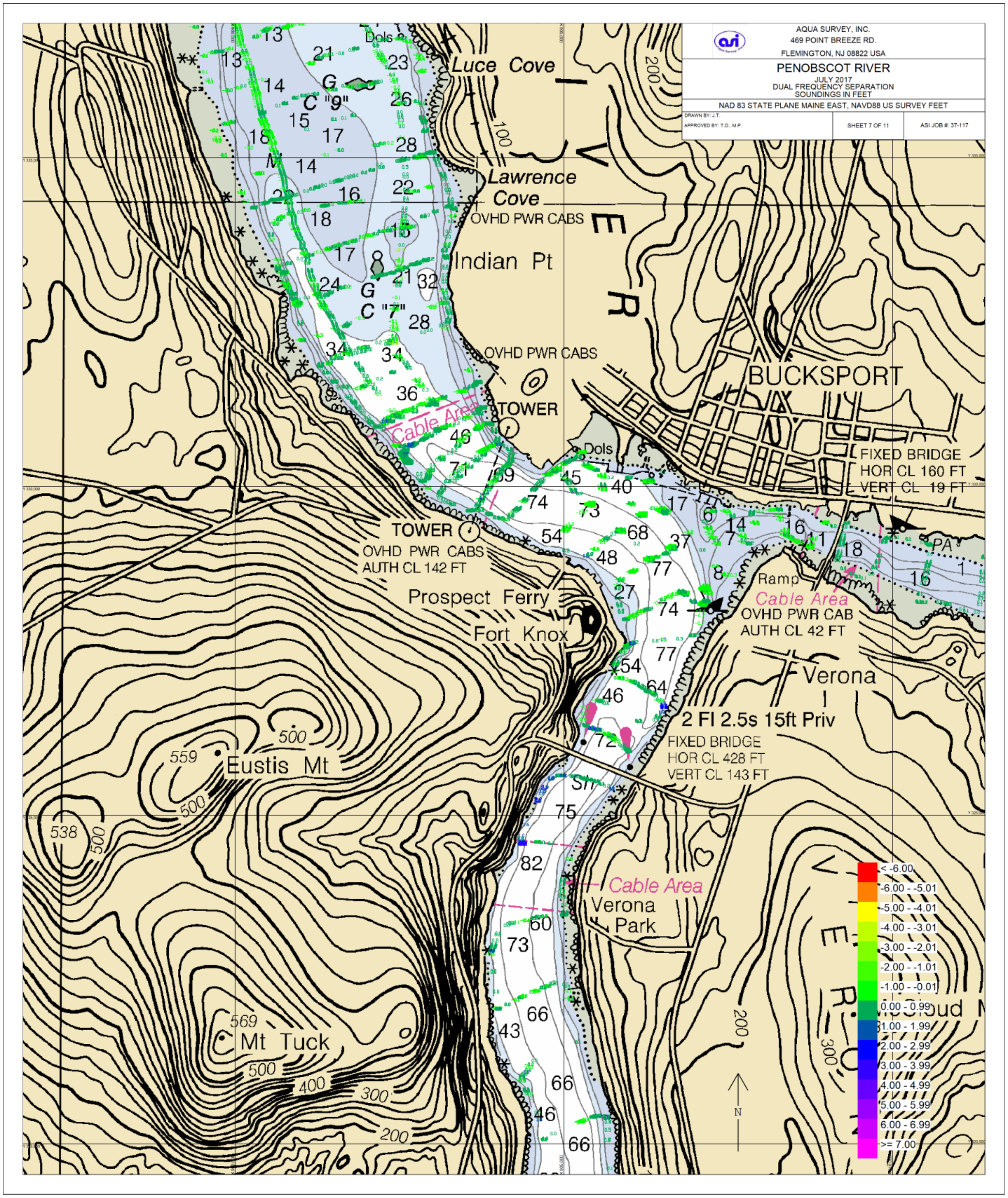


Figure 29. Dual frequency separation near Bucksport.

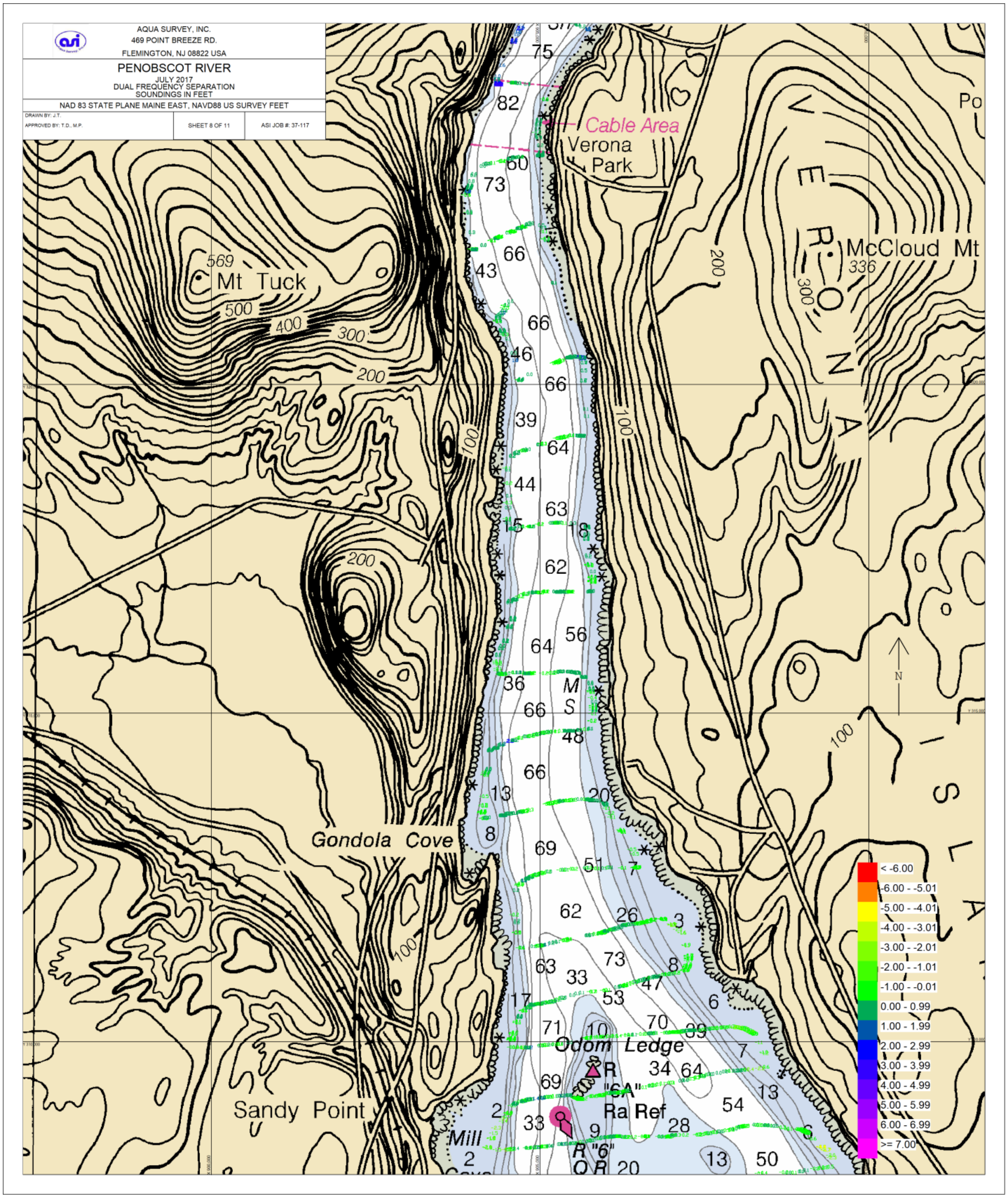


Figure 30. Dual frequency separation near Verona.

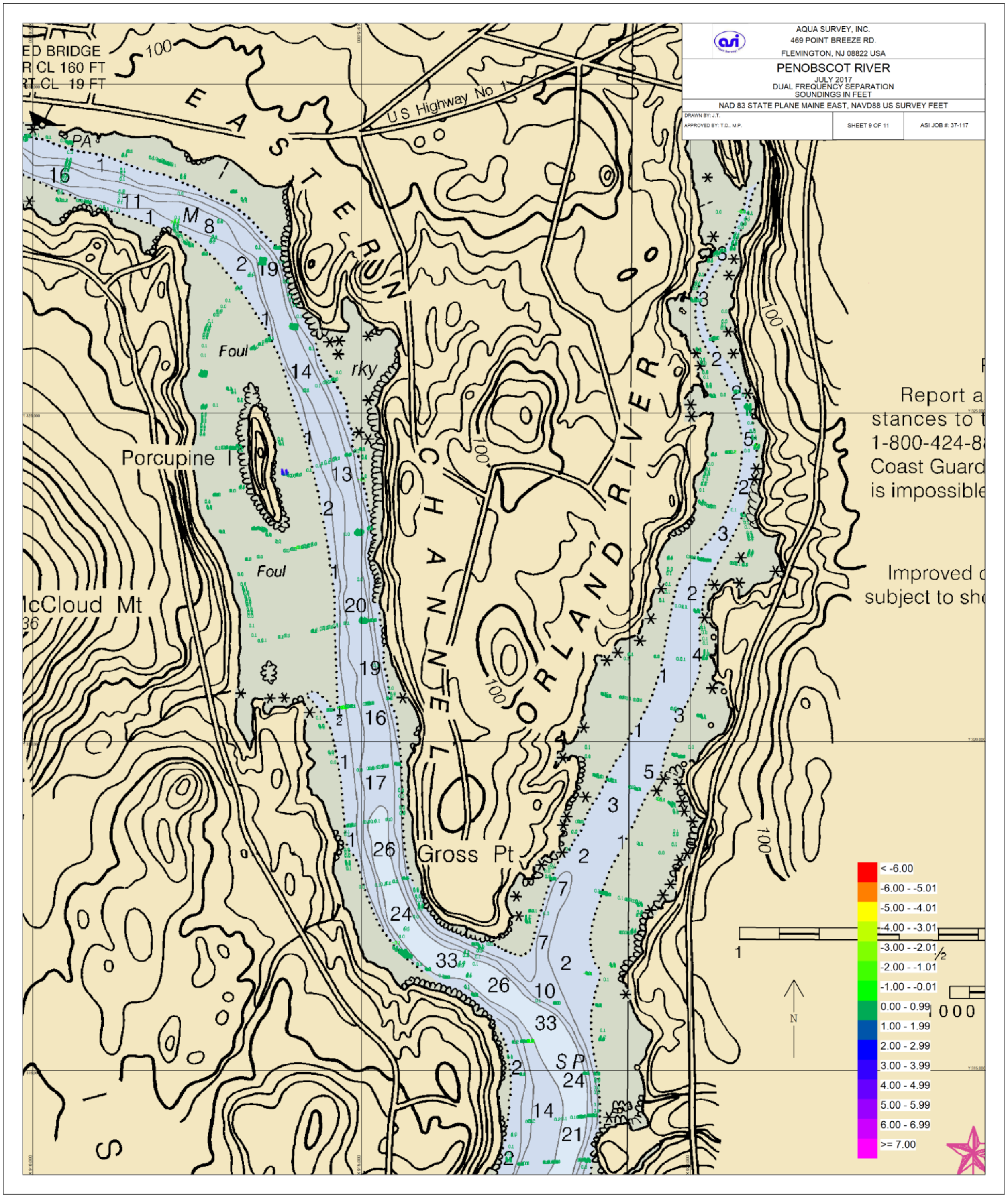


Figure 31. Dual frequency separation near Gross Point.

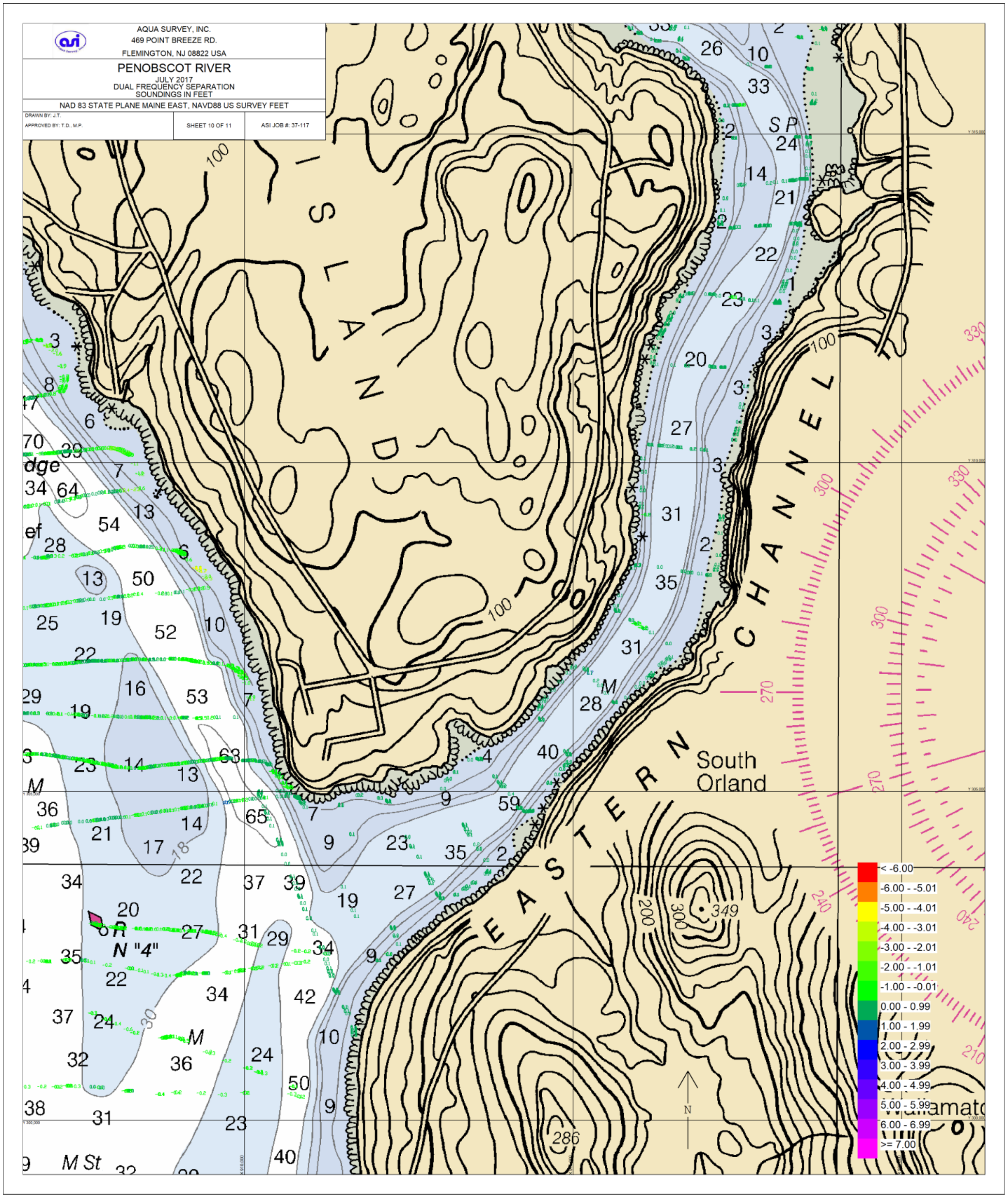


Figure 32. Dual frequency separation near South Orland.

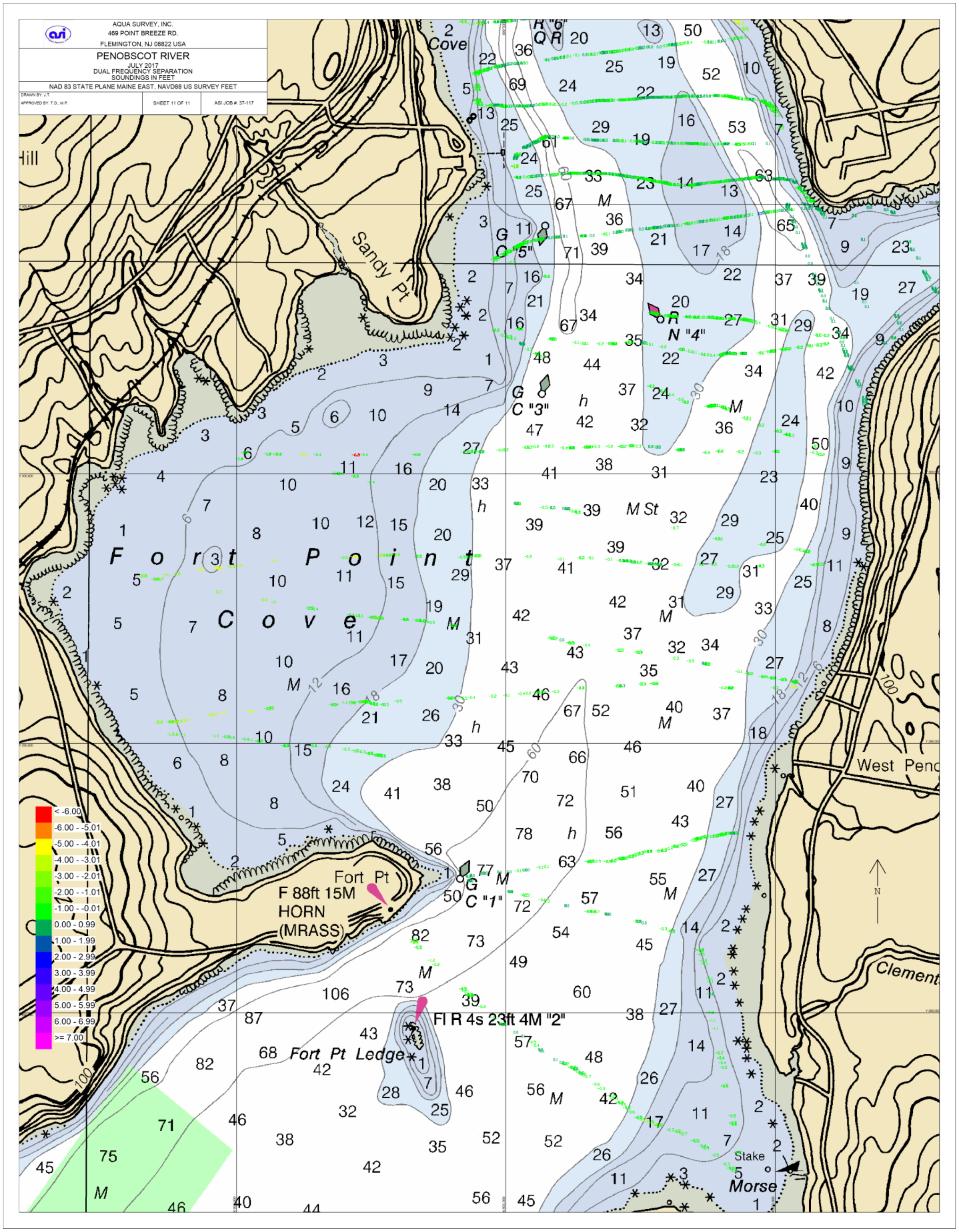


Figure 33. Dual frequency separation near Fort Point Cove.

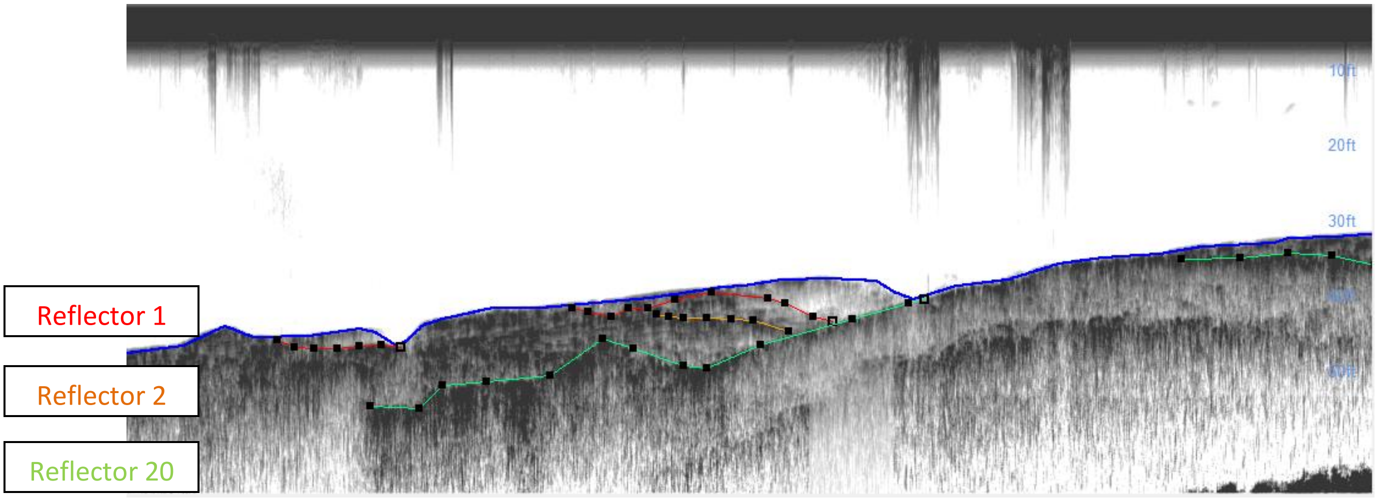


Figure 34. An example of sub-bottom data record (20170723152753) showing Reflectors 1 (red), 2 (brown), and 20 (green).

APPENDIX A-2.2
DUAL-FREQUENCY XYZ DATA
(Electronic Delivery)

APPENDIX A-2.3
SUB-BOTTOM SEDIMENT AND WOOD WASTE XYZ DATA
(Electronic Delivery)

APPENDIX A-2.4
SUB-BOTTOM IMAGE LOCATION MAPS

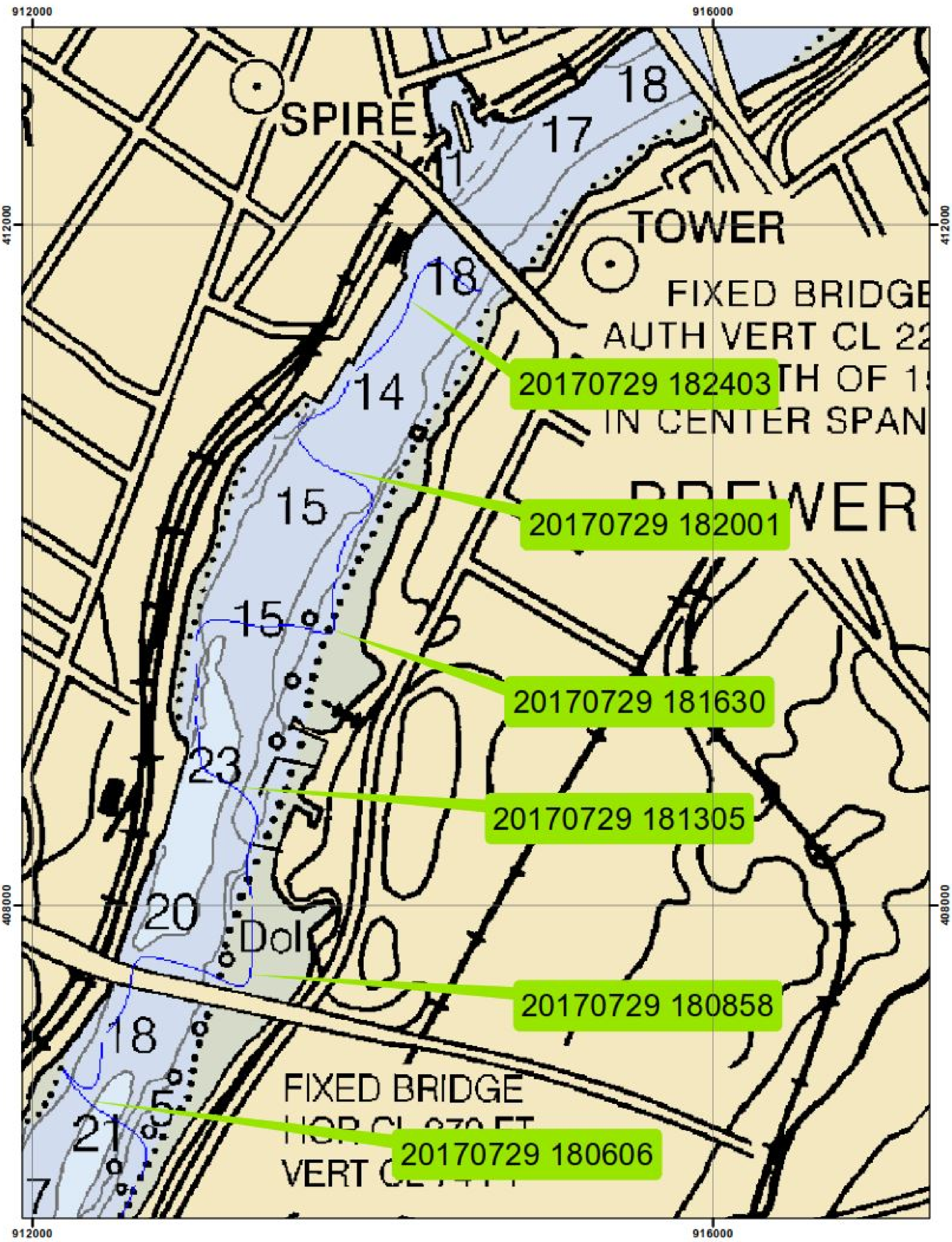


Figure A2-1
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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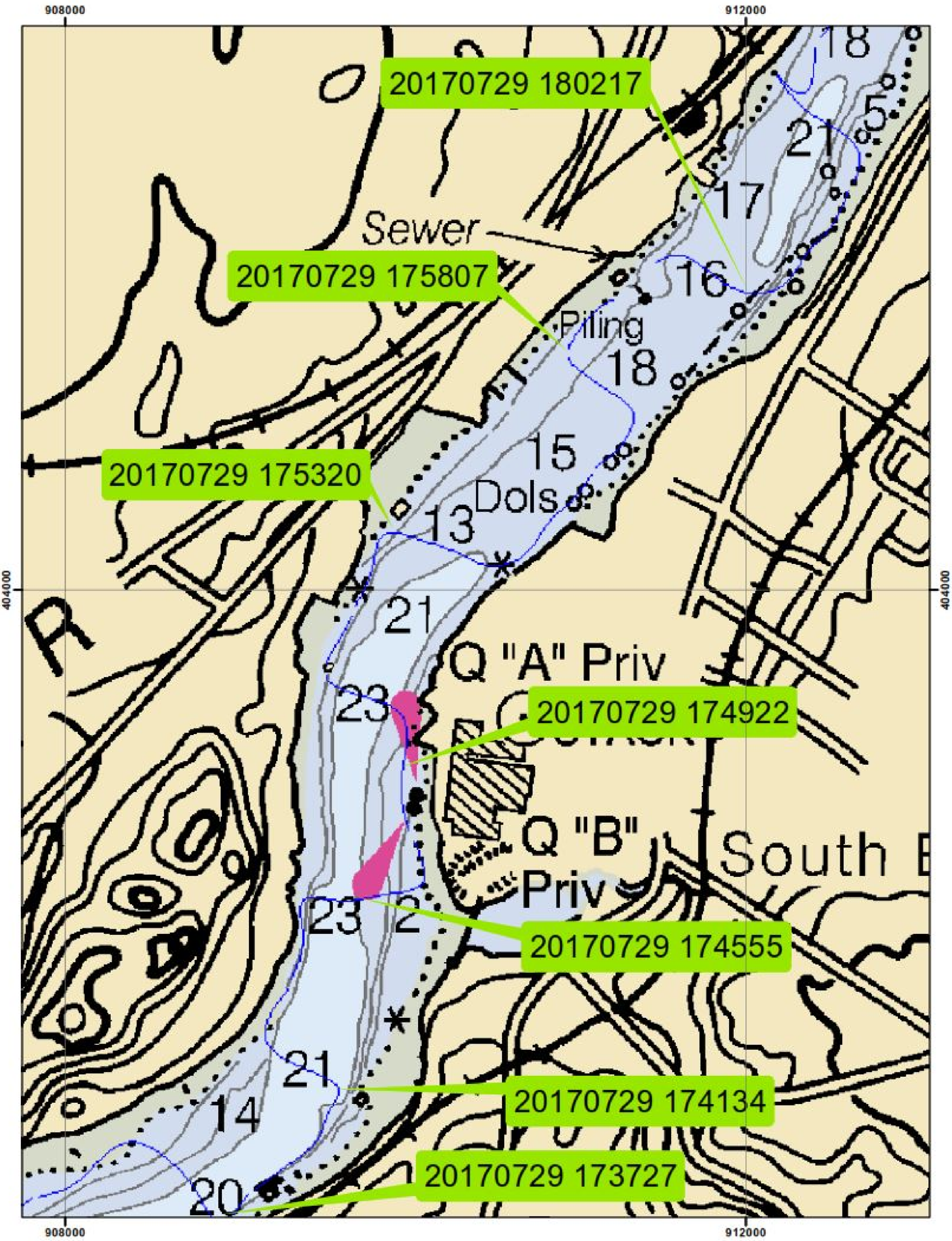

Figure A2-2
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

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Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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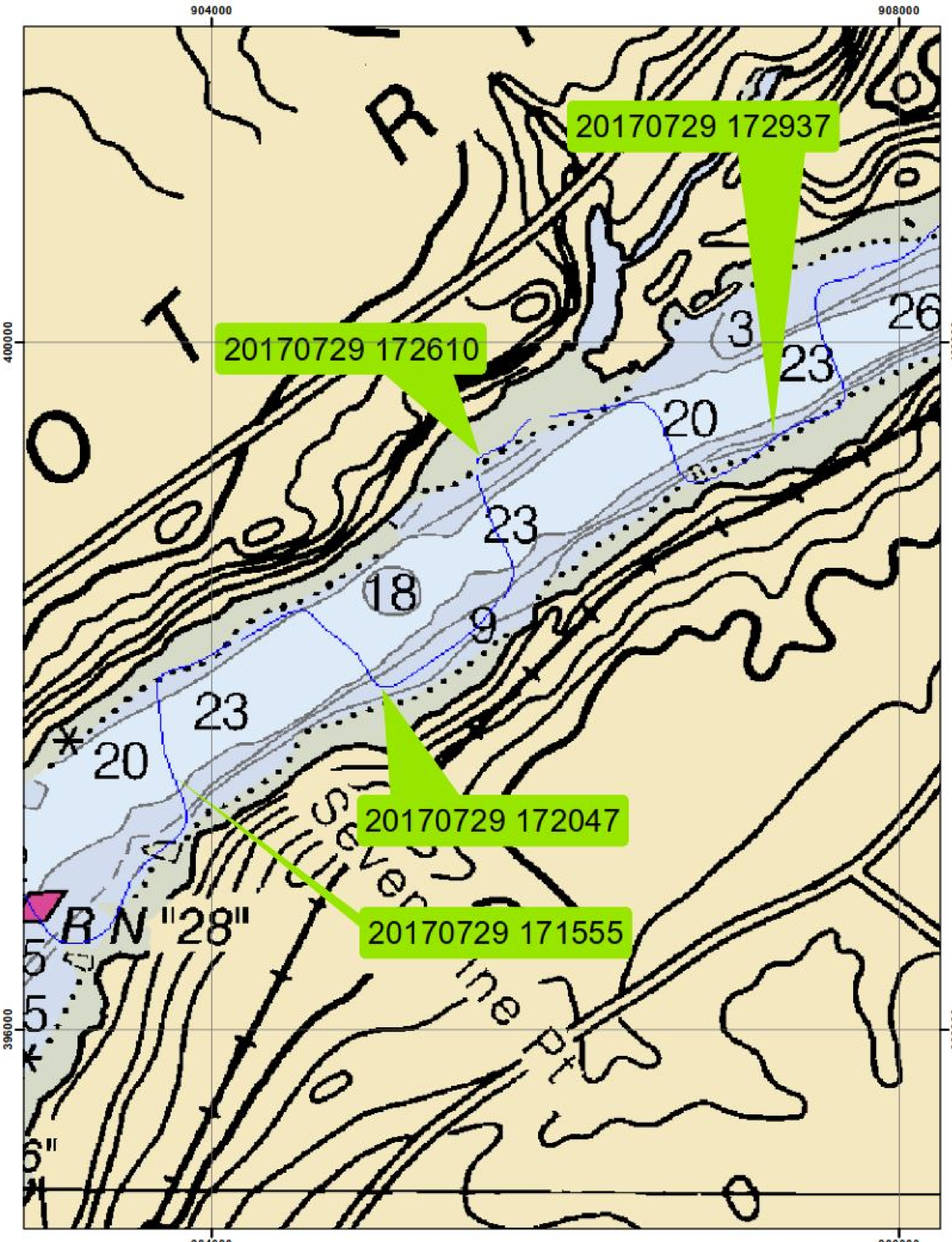

amec foster wheeler

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Figure A2-3
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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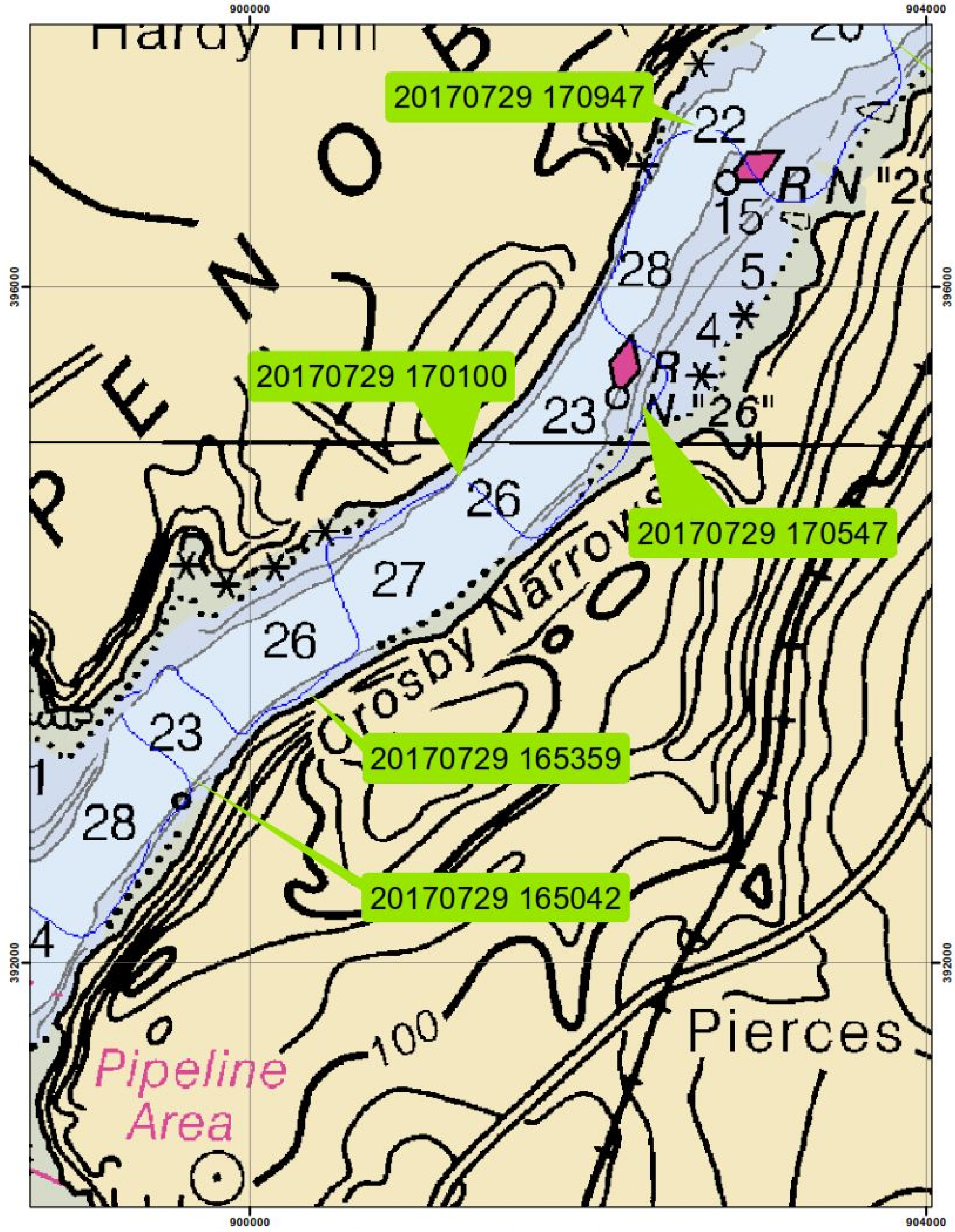

Figure A2-4
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

N

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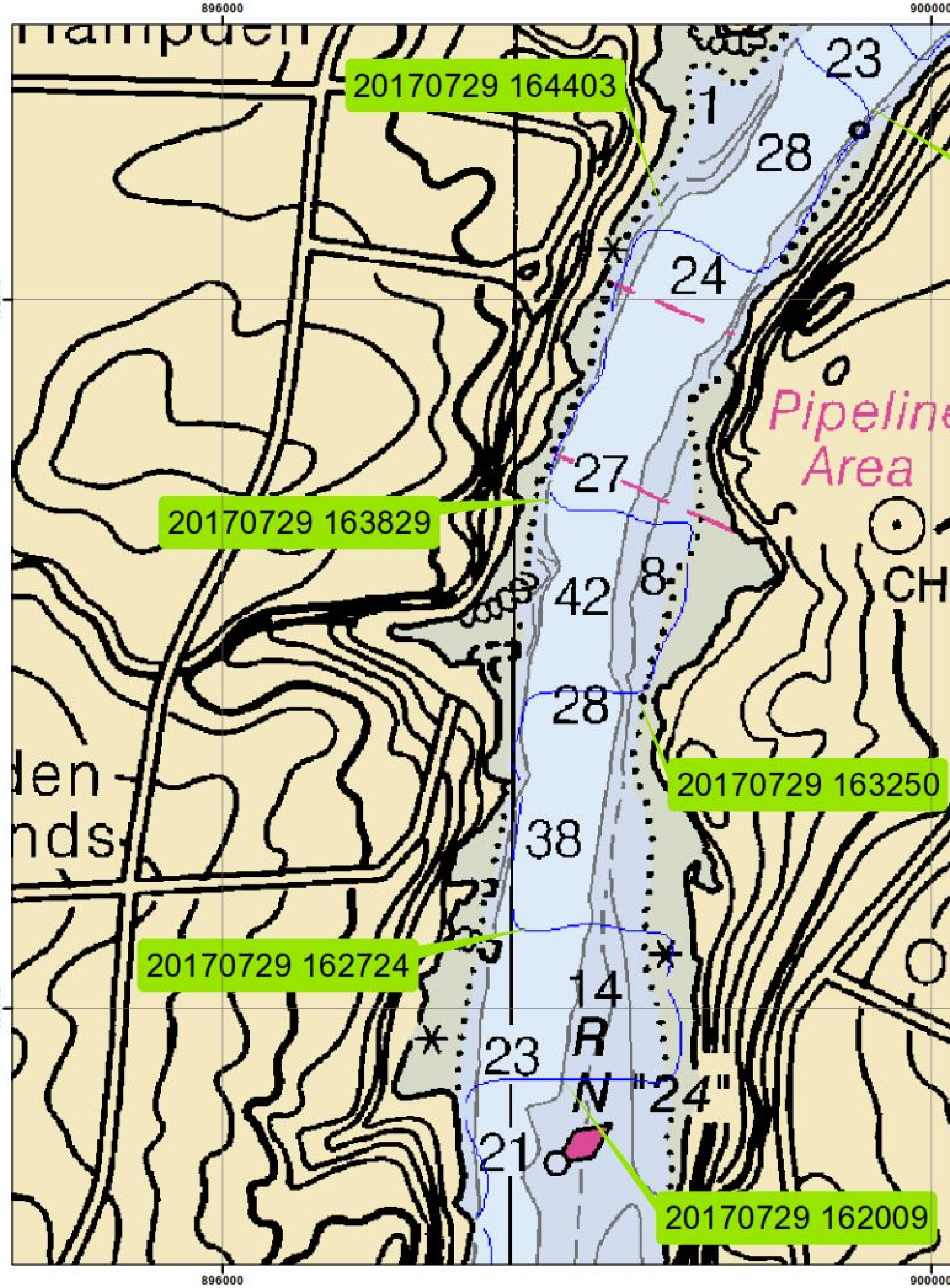

amec foster wheeler

Figure A2-5
2017 Sub-Bottom Image Locations

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2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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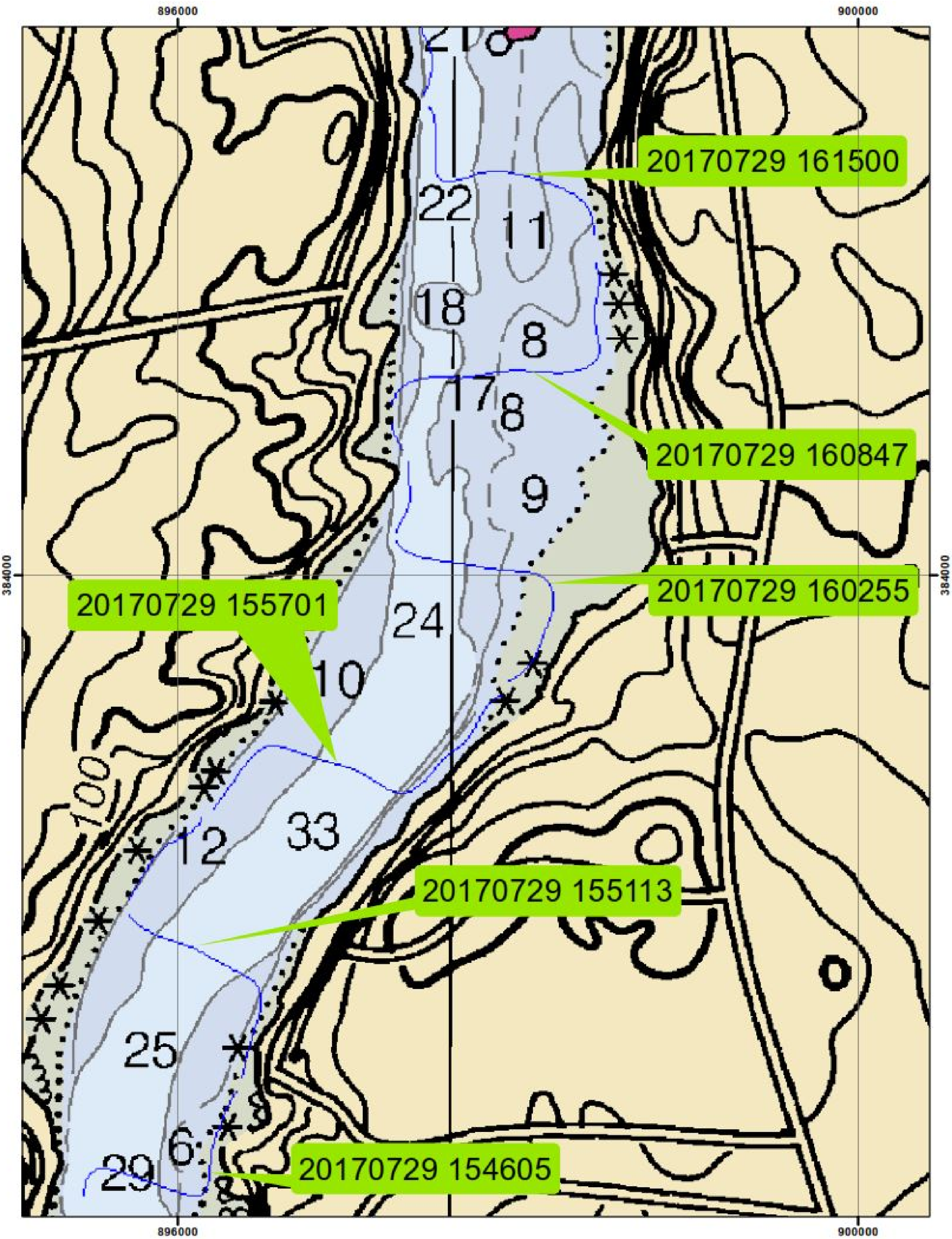

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Figure A2-6
2017 Sub-Bottom Image Locations

amec foster wheeler

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2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

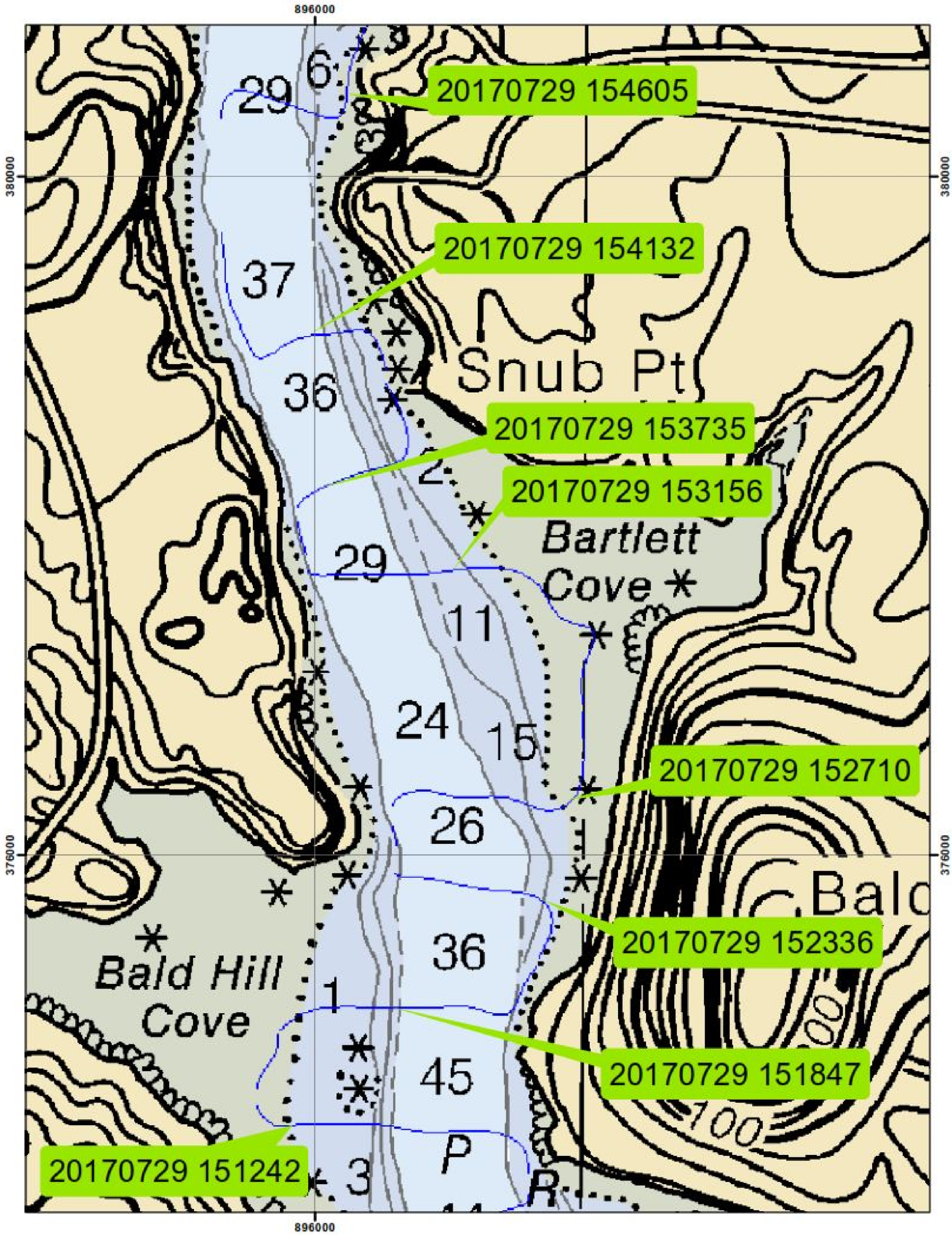

Figure A2-7
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

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Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

Document: P:\Comm-Ind\Projects\Clients M to S\Penobscot(GIS)\Work Order 4A-060\Sub Bottom Image Locations\7.mxd 12/14/2017 5:05:33 PM david.young2

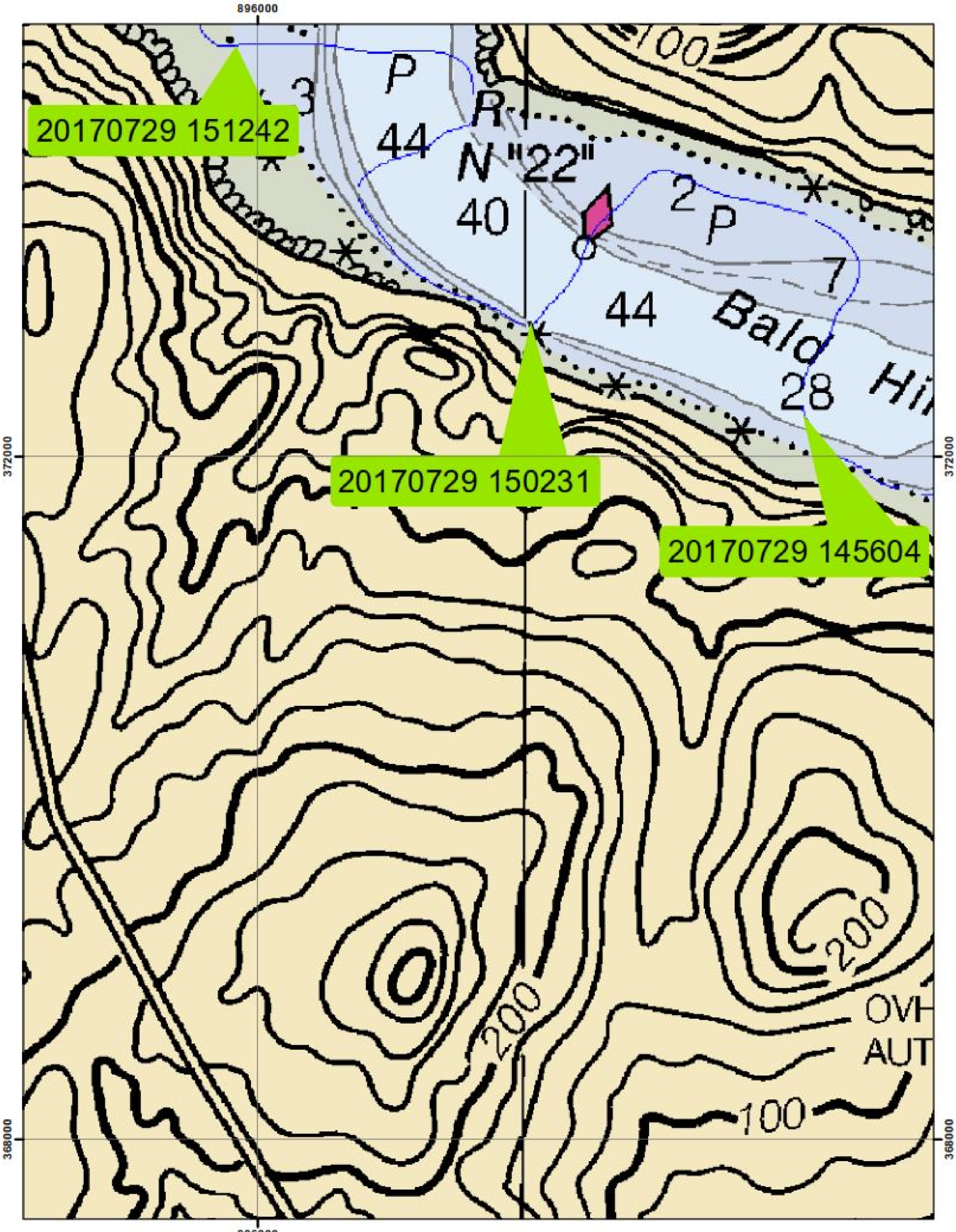

Figure A2-8
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052 | Prepared/Date: 12/14/2017 | Checked/Date: 12/14/2017 | NAD83 State Plane Maine East, US Survey Feet

amec foster wheeler

N

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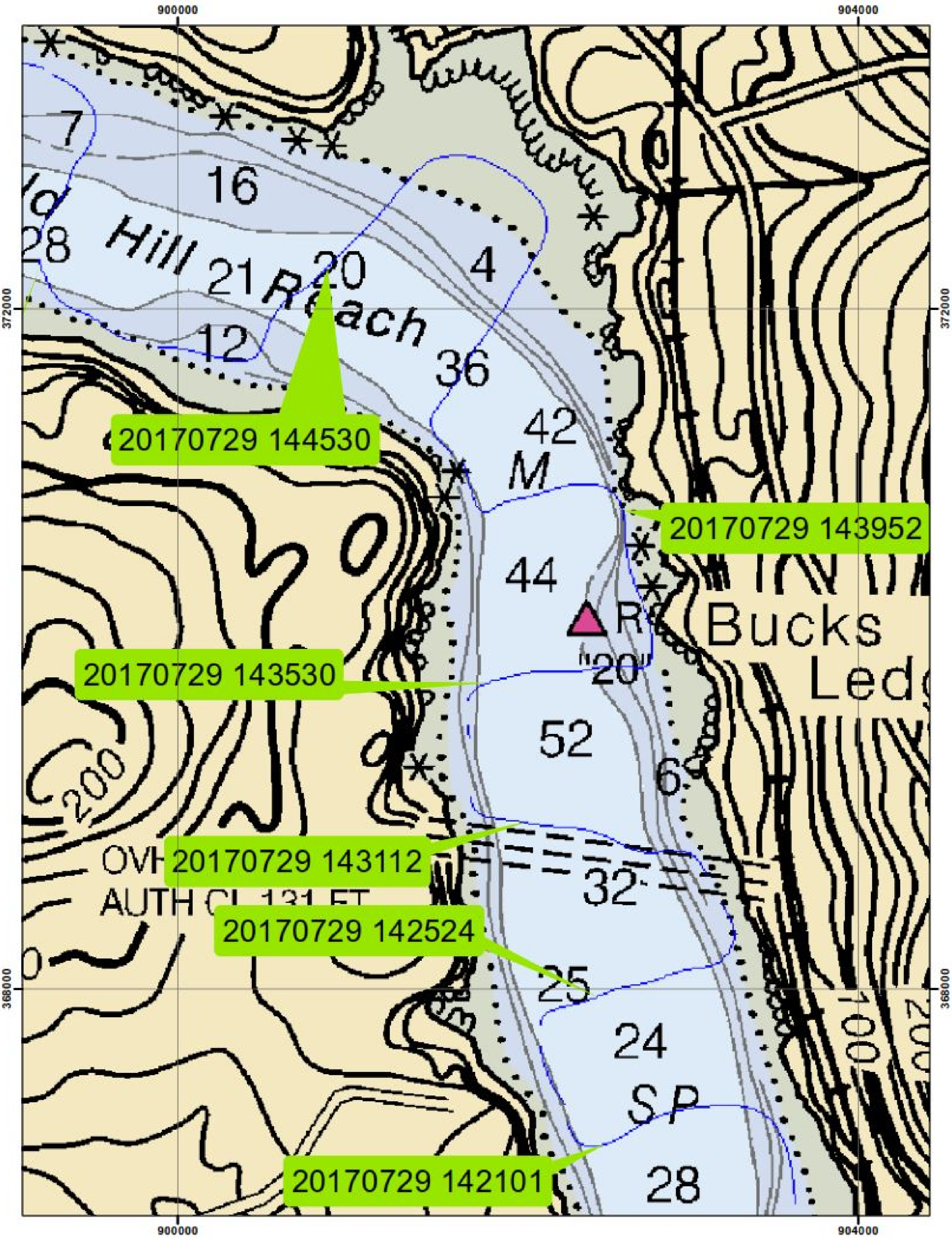

amec foster wheeler

N

Figure A2-9
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

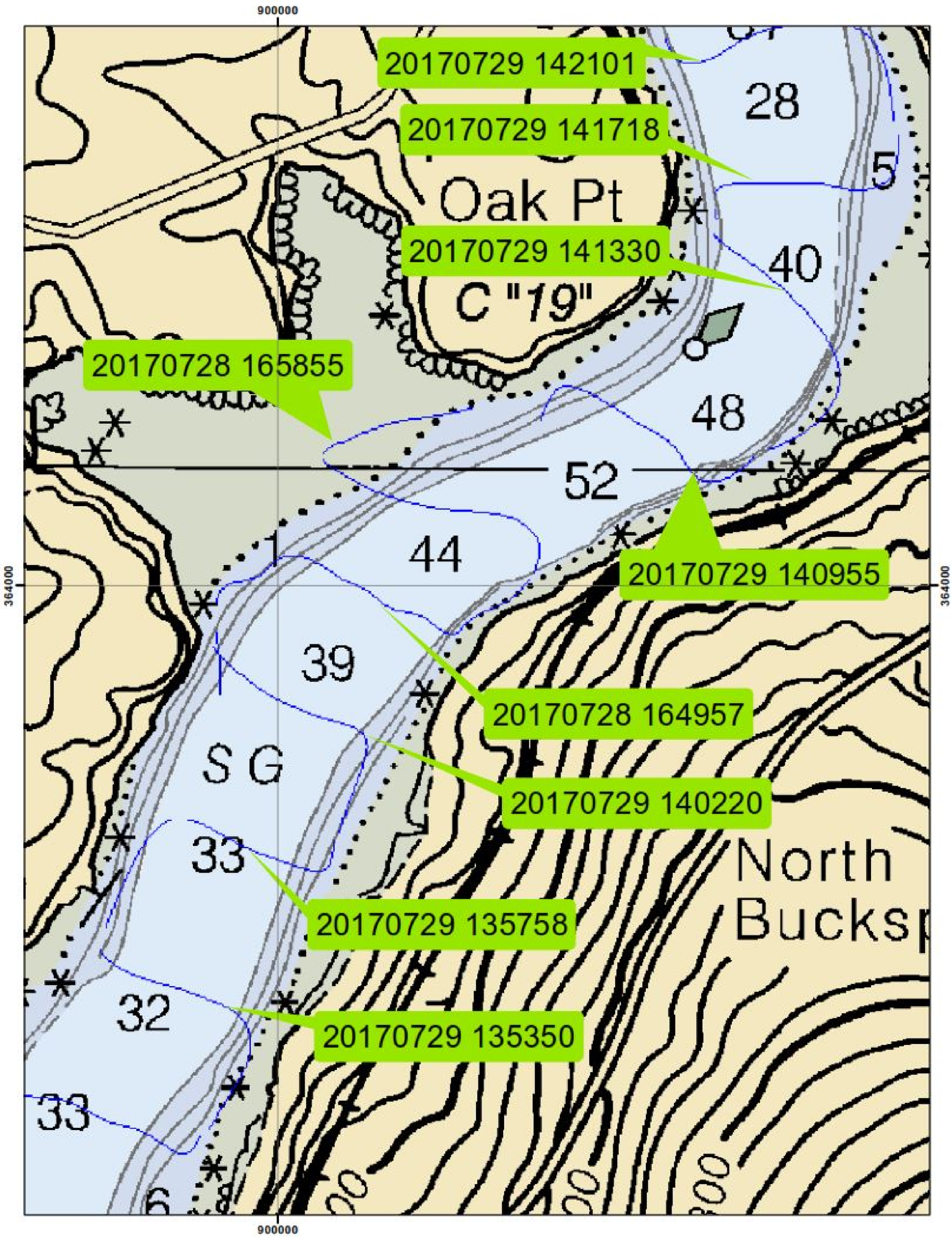

Figure A2-10
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

N

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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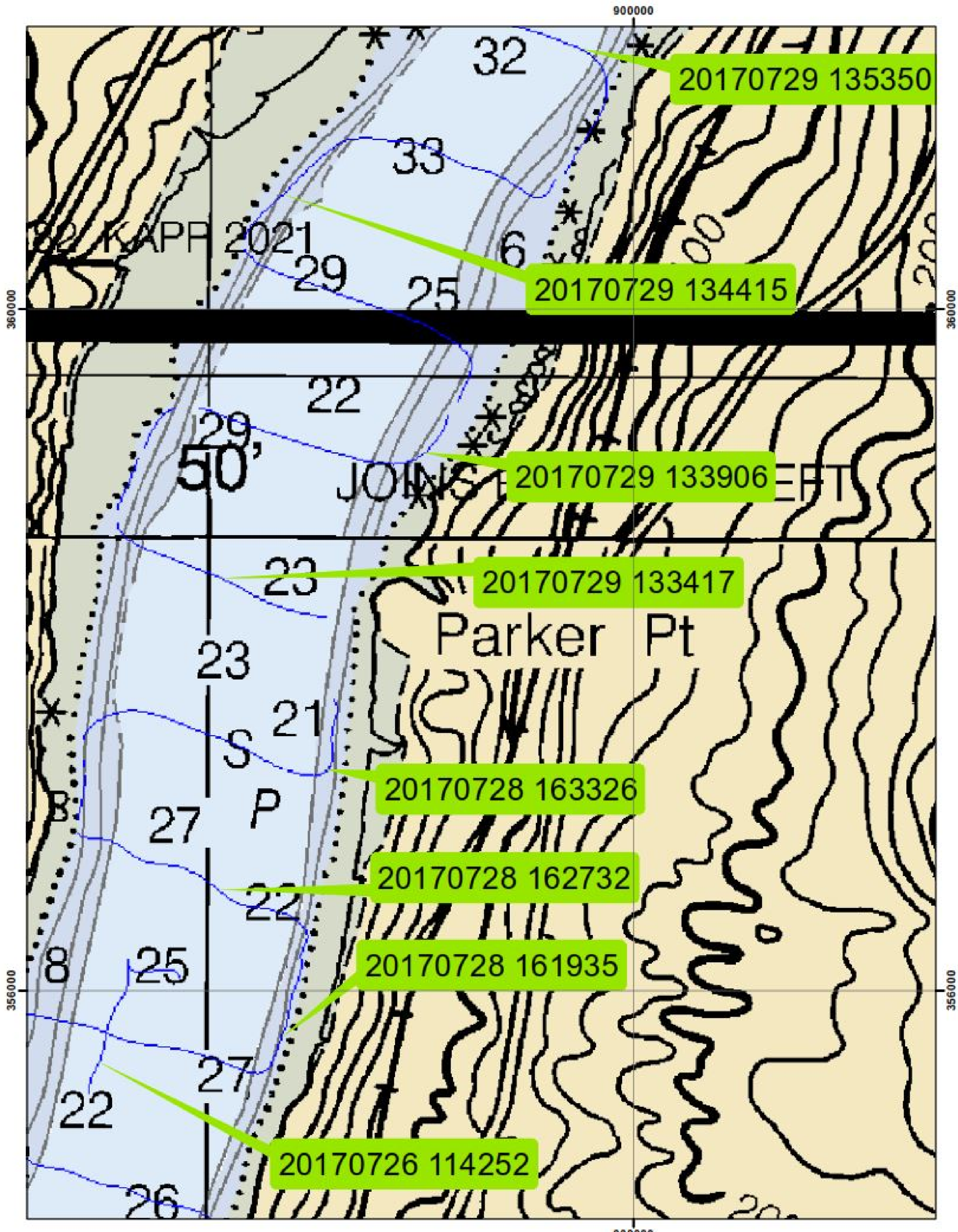

Figure A2-11
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

N

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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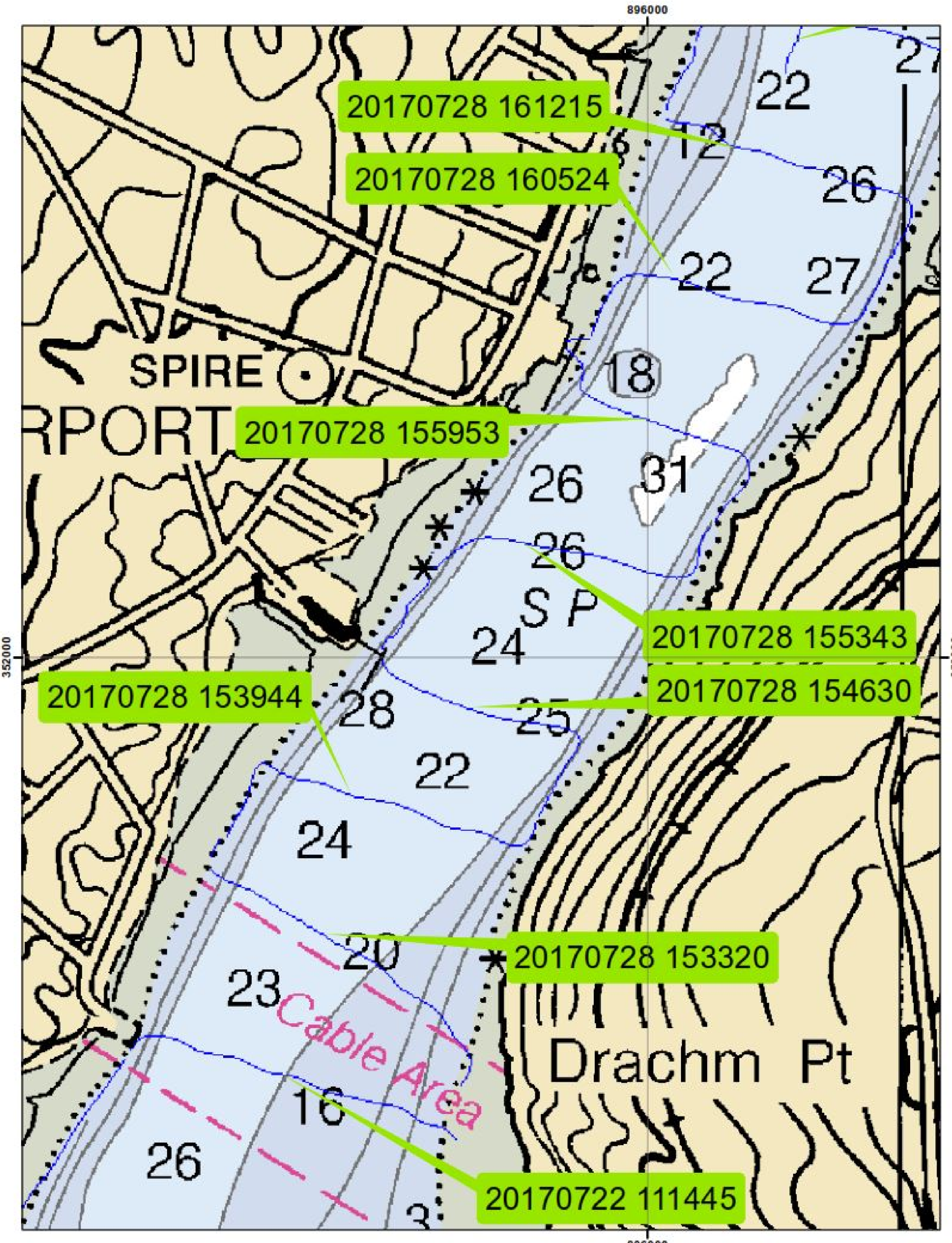

amec foster wheeler

N

Figure A2-12
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052 | Prepared/Date: 12/14/2017 | Checked/Date: 12/14/2017 | NAD83 State Plane Maine East, US Survey Feet

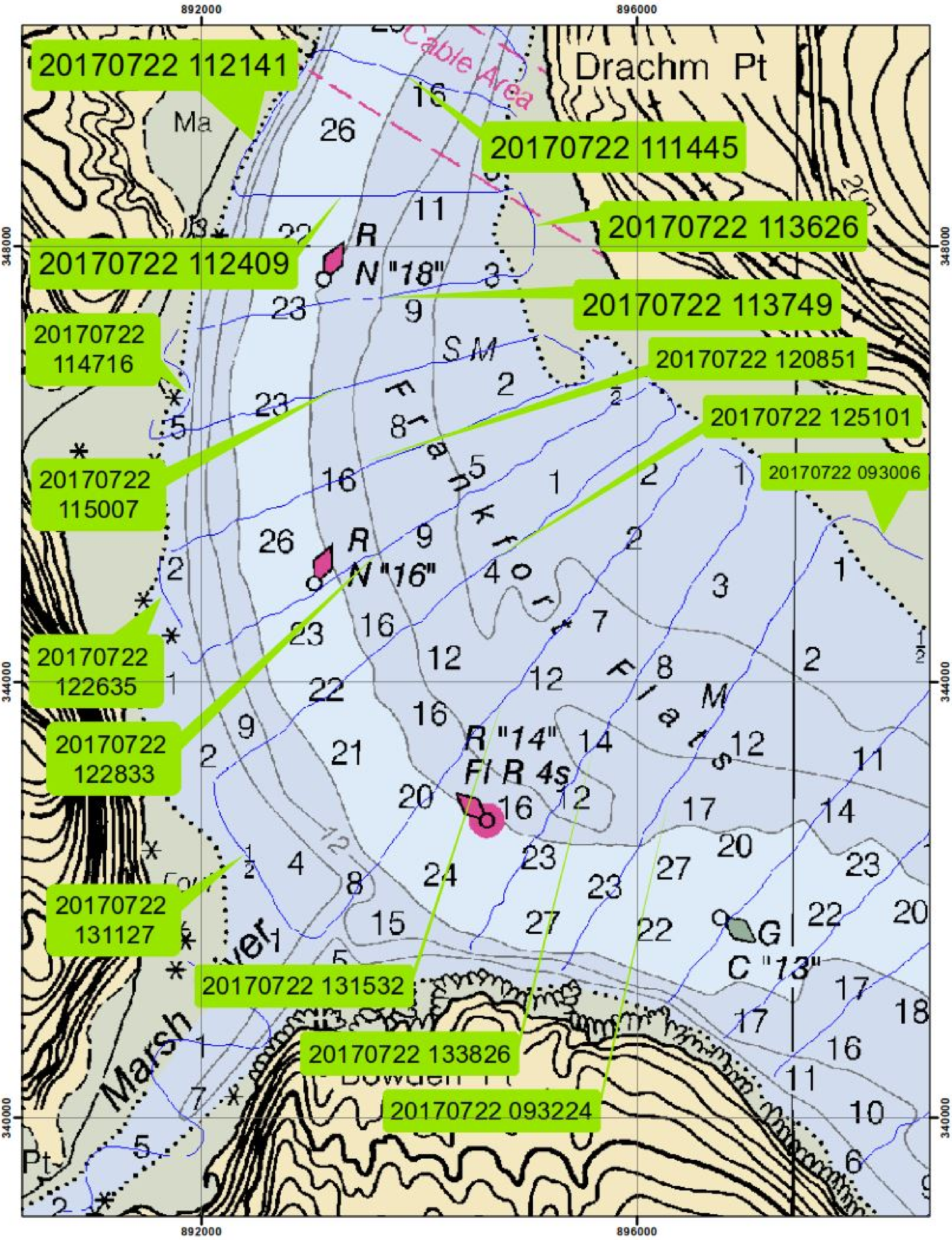

Figure A2-13
2017 Sub-Bottom Image Locations

amec foster wheeler

N

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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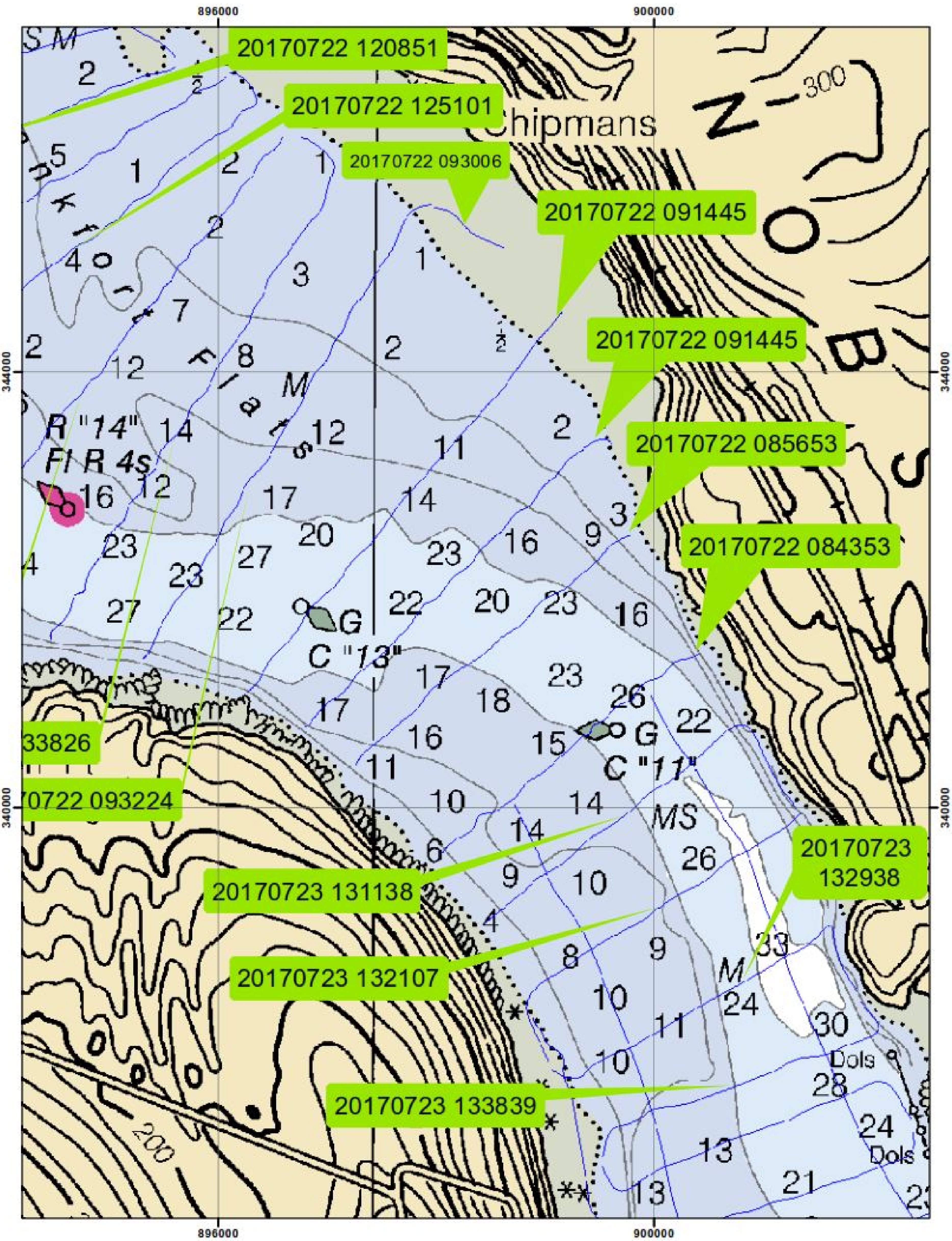

Figure A2-14
2017 Sub-Bottom Image Locations

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2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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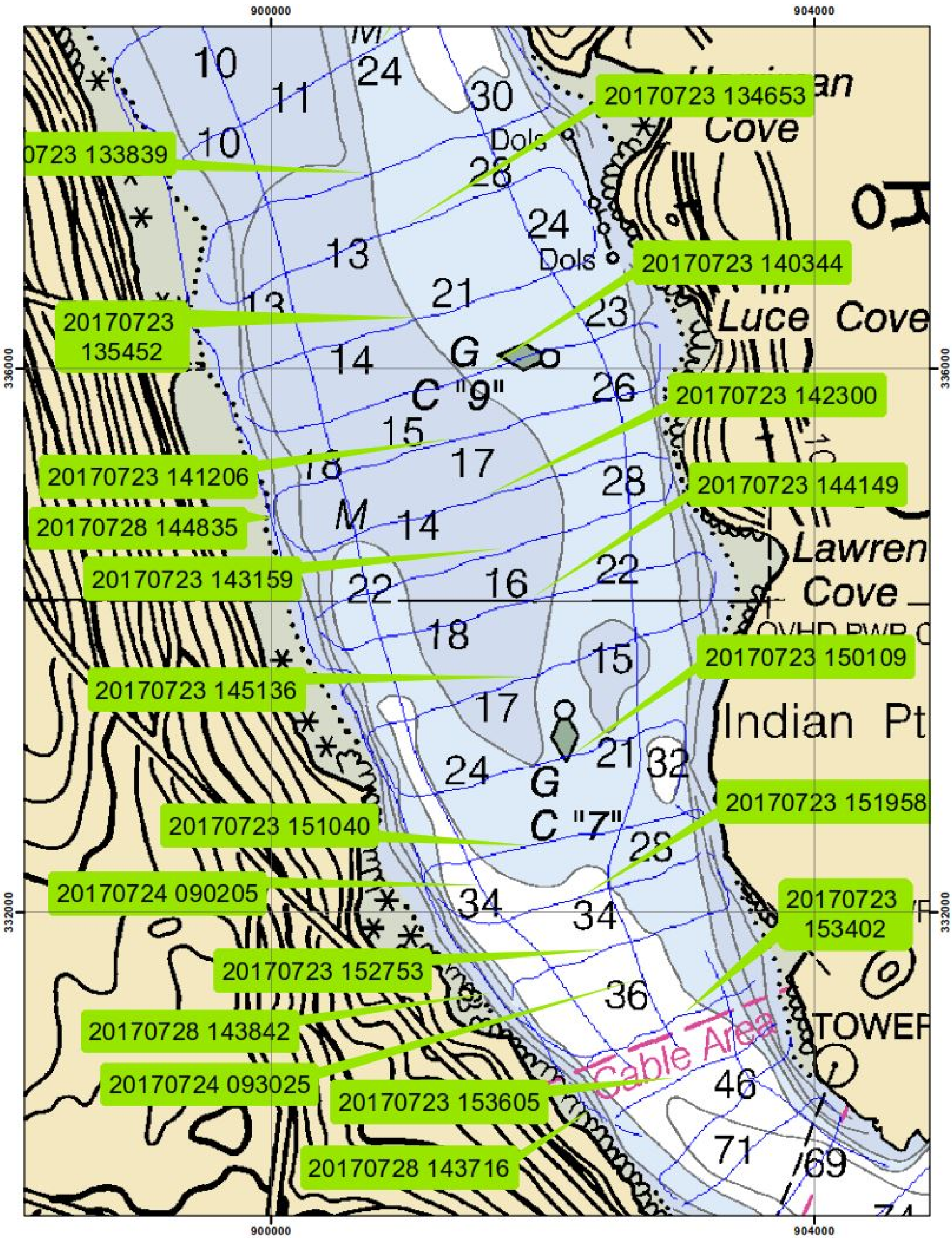

Figure A2-15
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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N

Project: 3616166052 | Prepared/Date: 12/14/2017 | Checked/Date: 12/14/2017 | NAD83 State Plane Maine East, US Survey Feet

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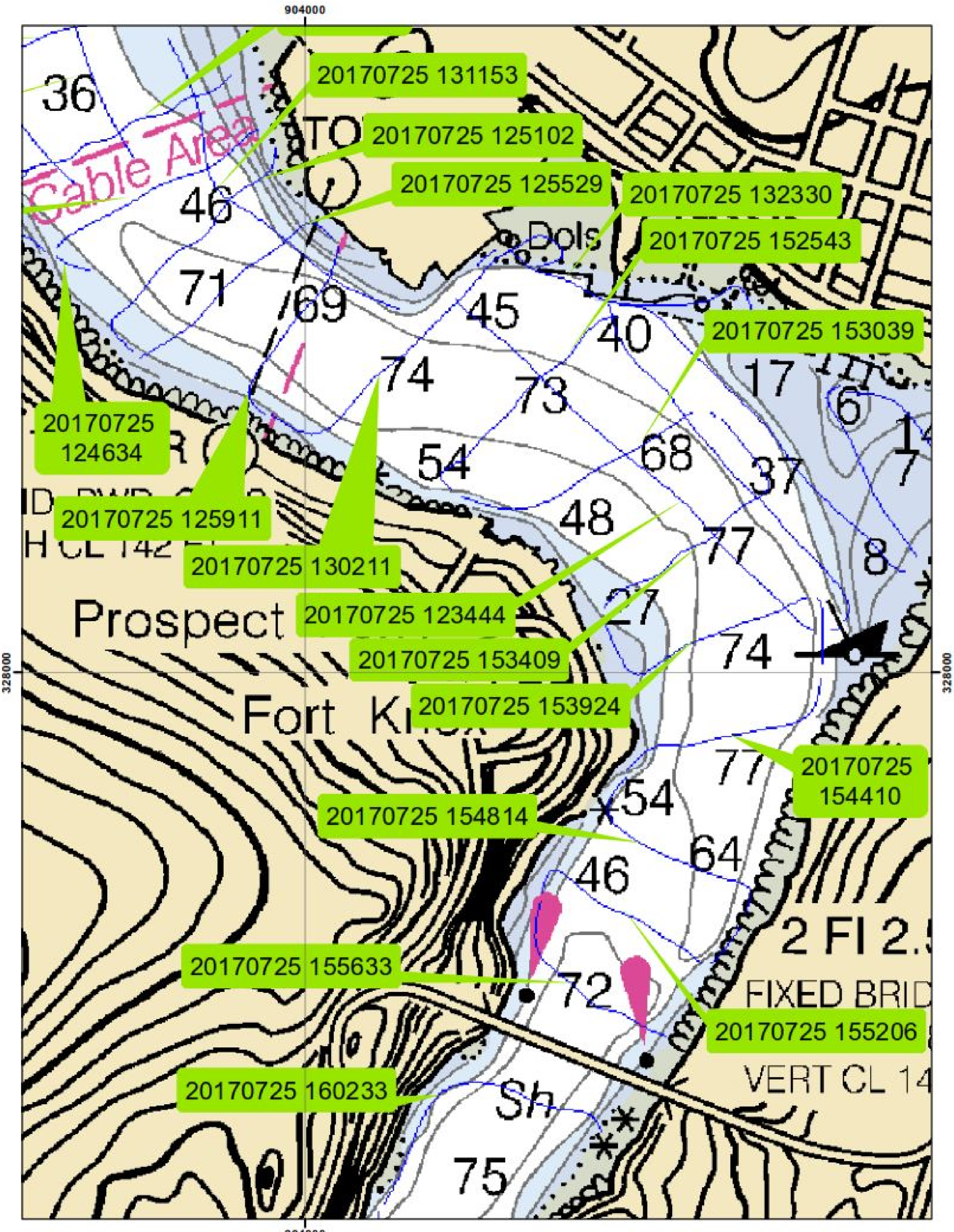

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N

Figure A2-16
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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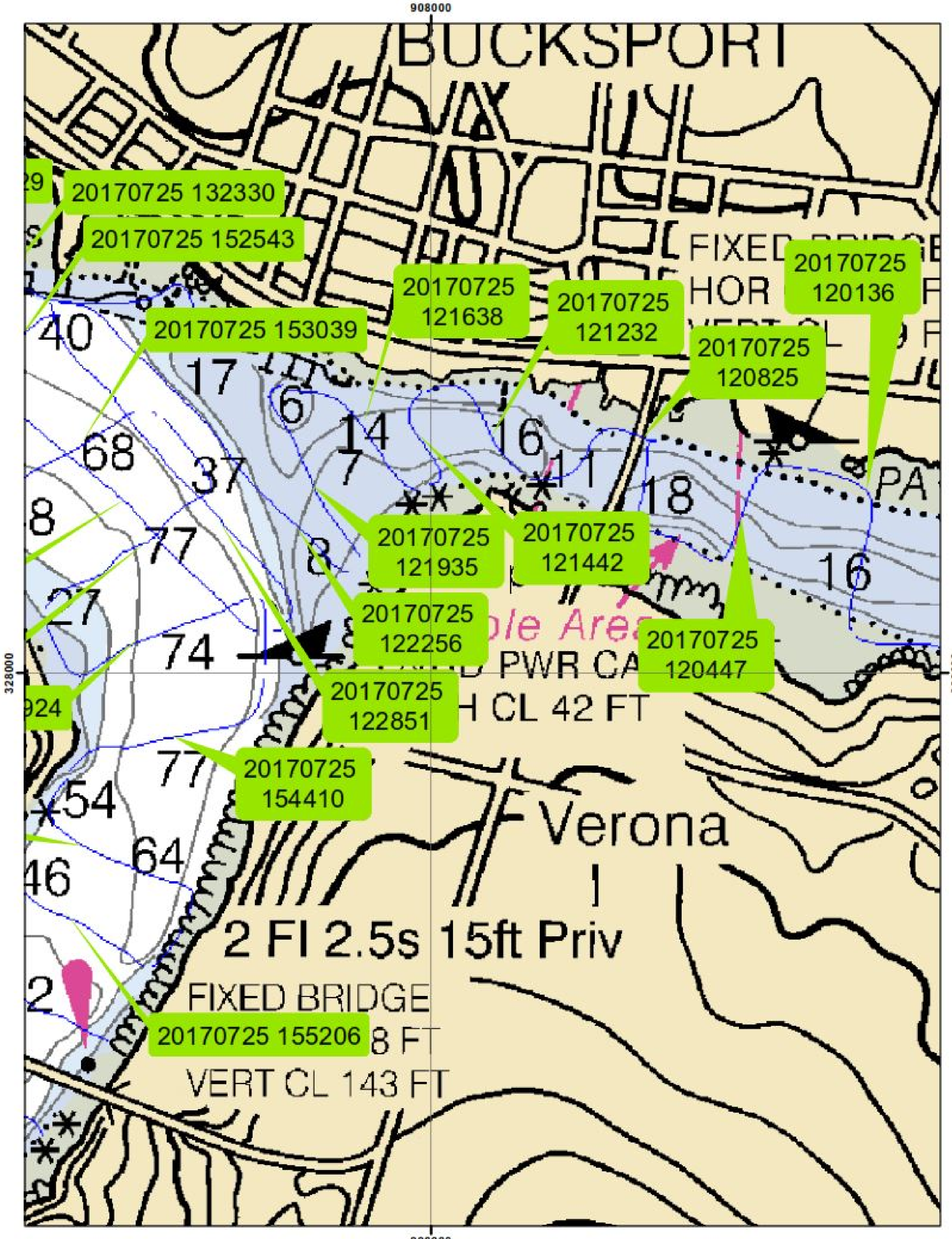

amec foster wheeler

N

Project: 3616166052 | Prepared/Date: 12/14/2017 | Checked/Date: 12/14/2017 | NAD83 State Plane Maine East, US Survey Feet

Figure A2-17
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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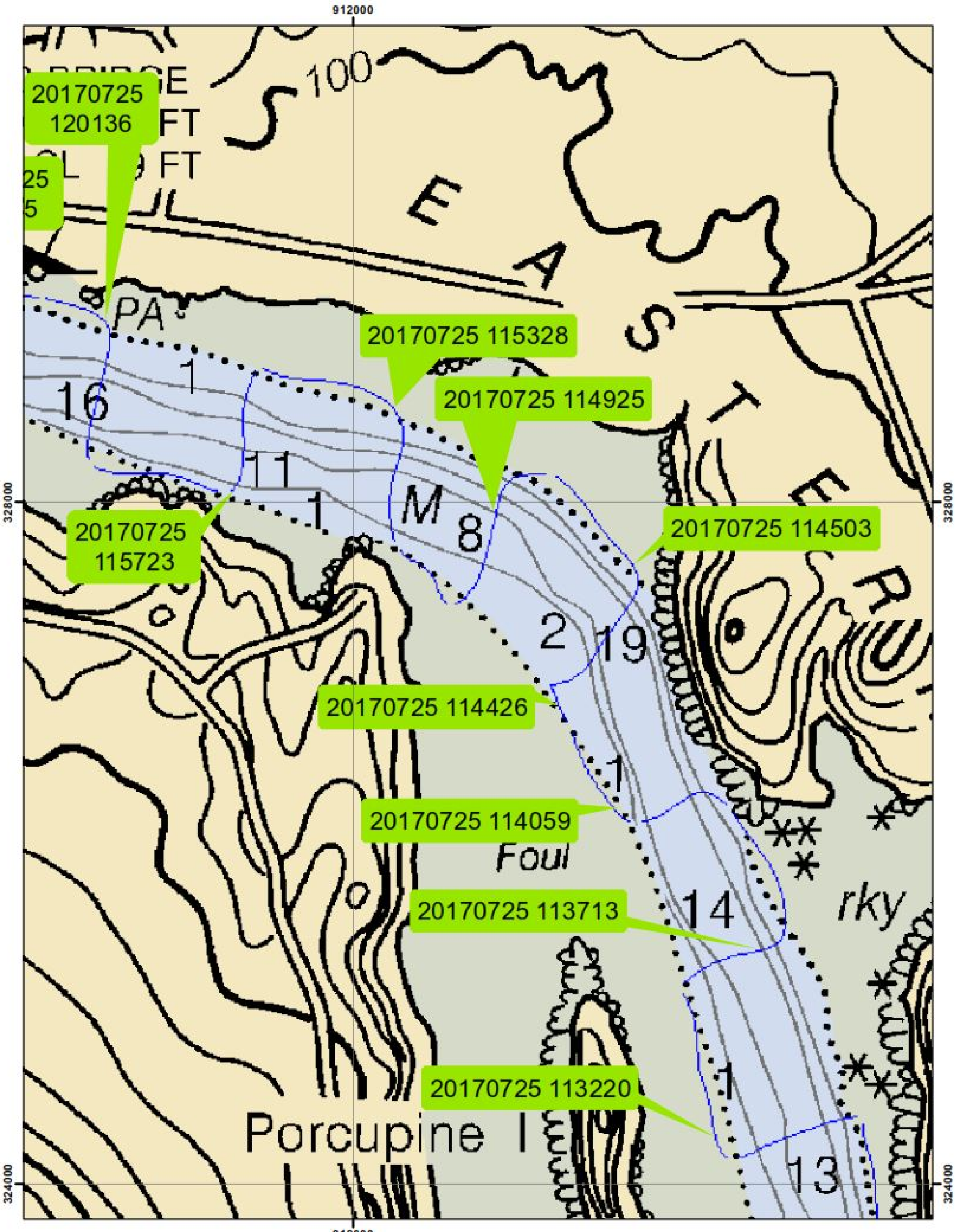

Figure A2-18
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

N

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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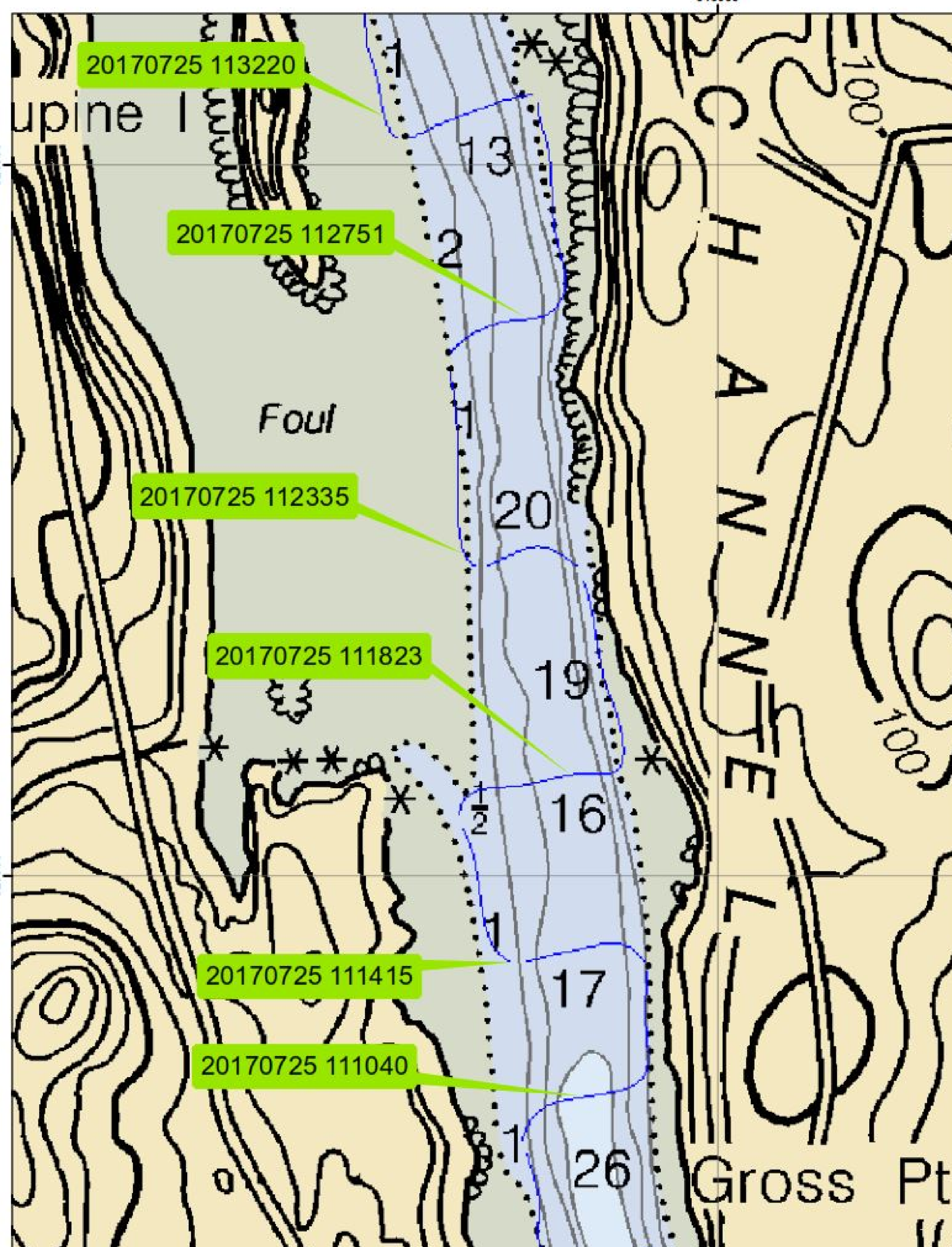

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Figure A2-19
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

Project: 3616166052 | Prepared/Date: 12/14/2017 | Checked/Date: 12/14/2017 | NAD83 State Plane Maine East, US Survey Feet

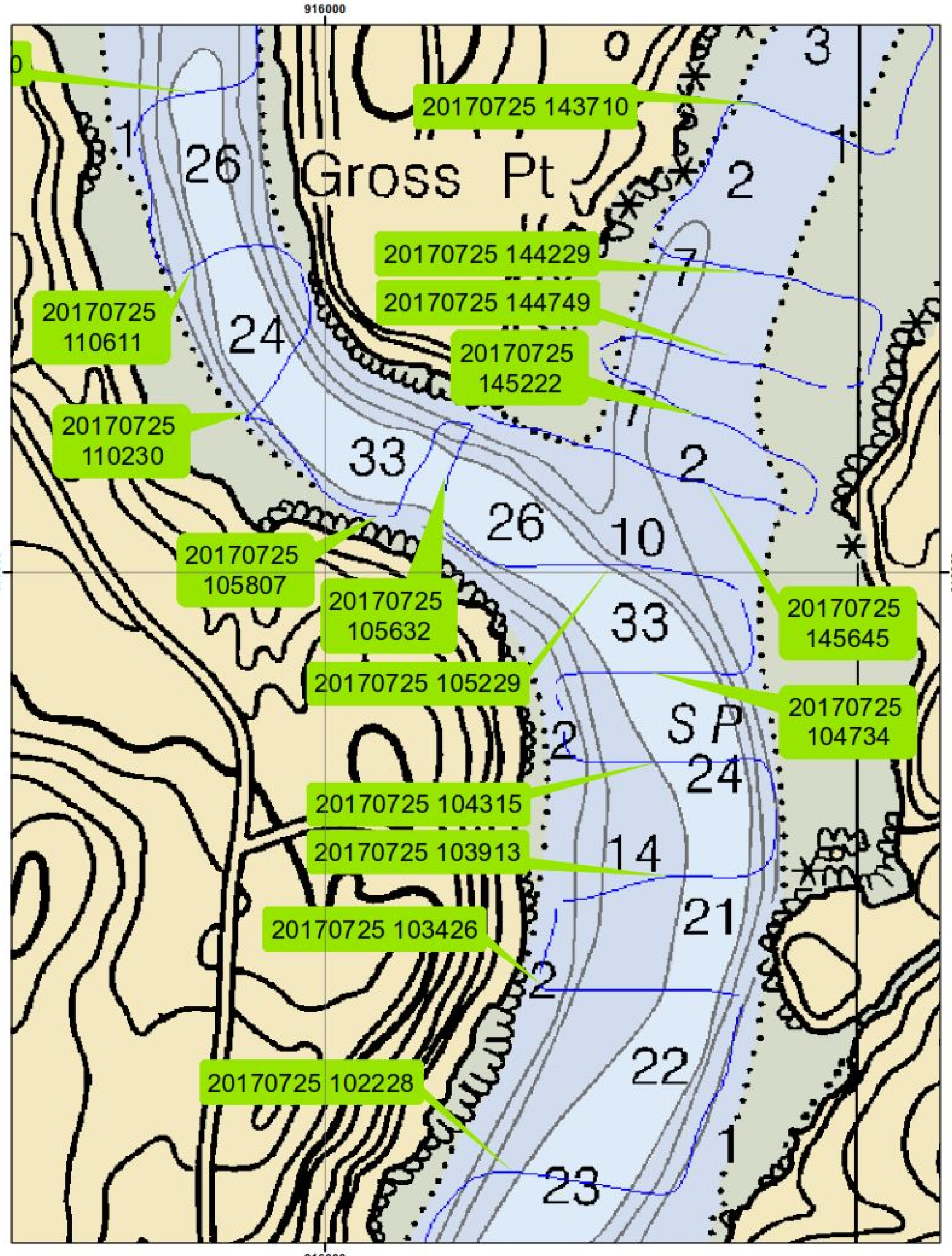

Figure A2-20
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

amec foster wheeler

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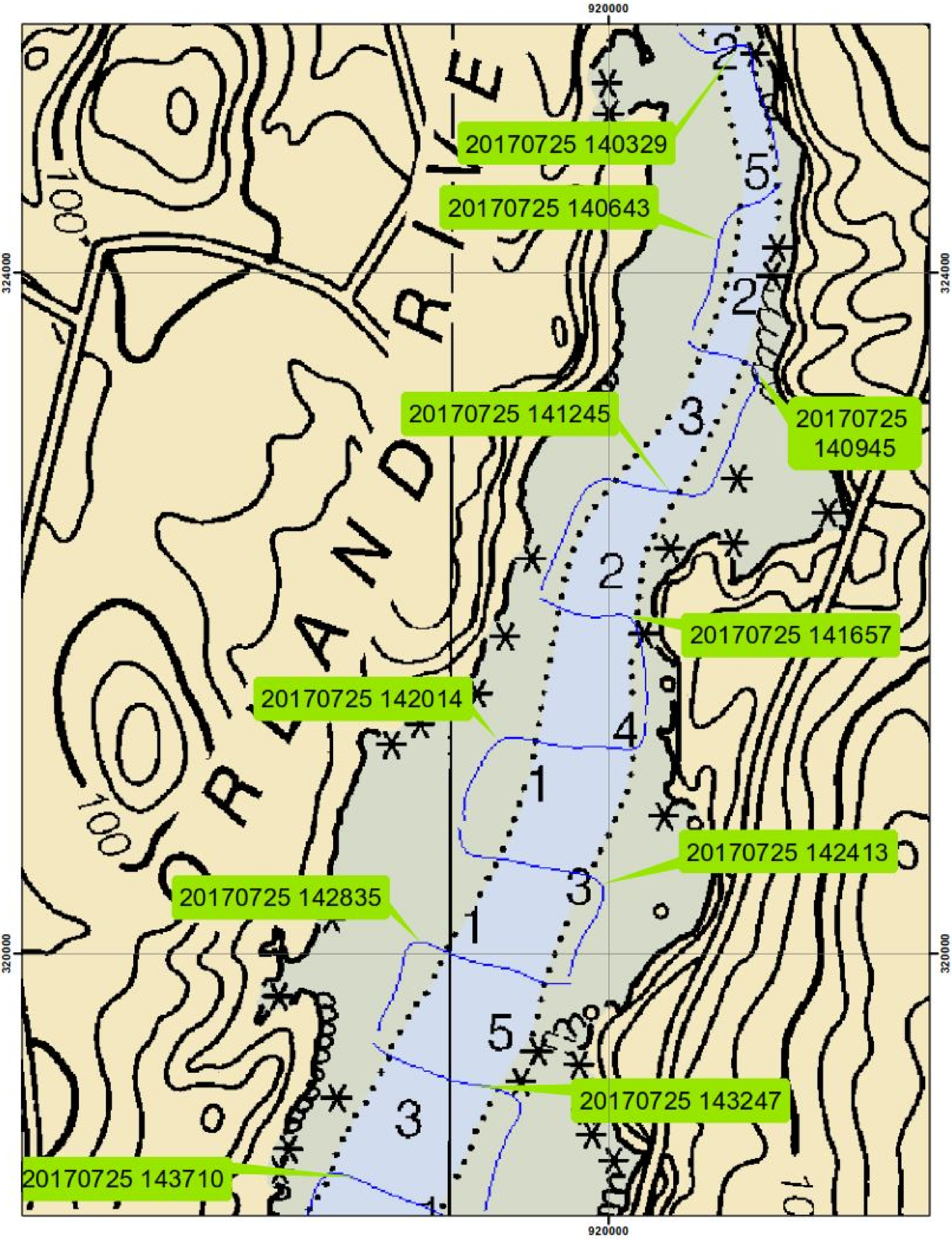

Figure A2-21
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052 | Prepared/Date: 12/14/2017 | Checked/Date: 12/14/2017 | NAD83 State Plane Maine East, US Survey Feet

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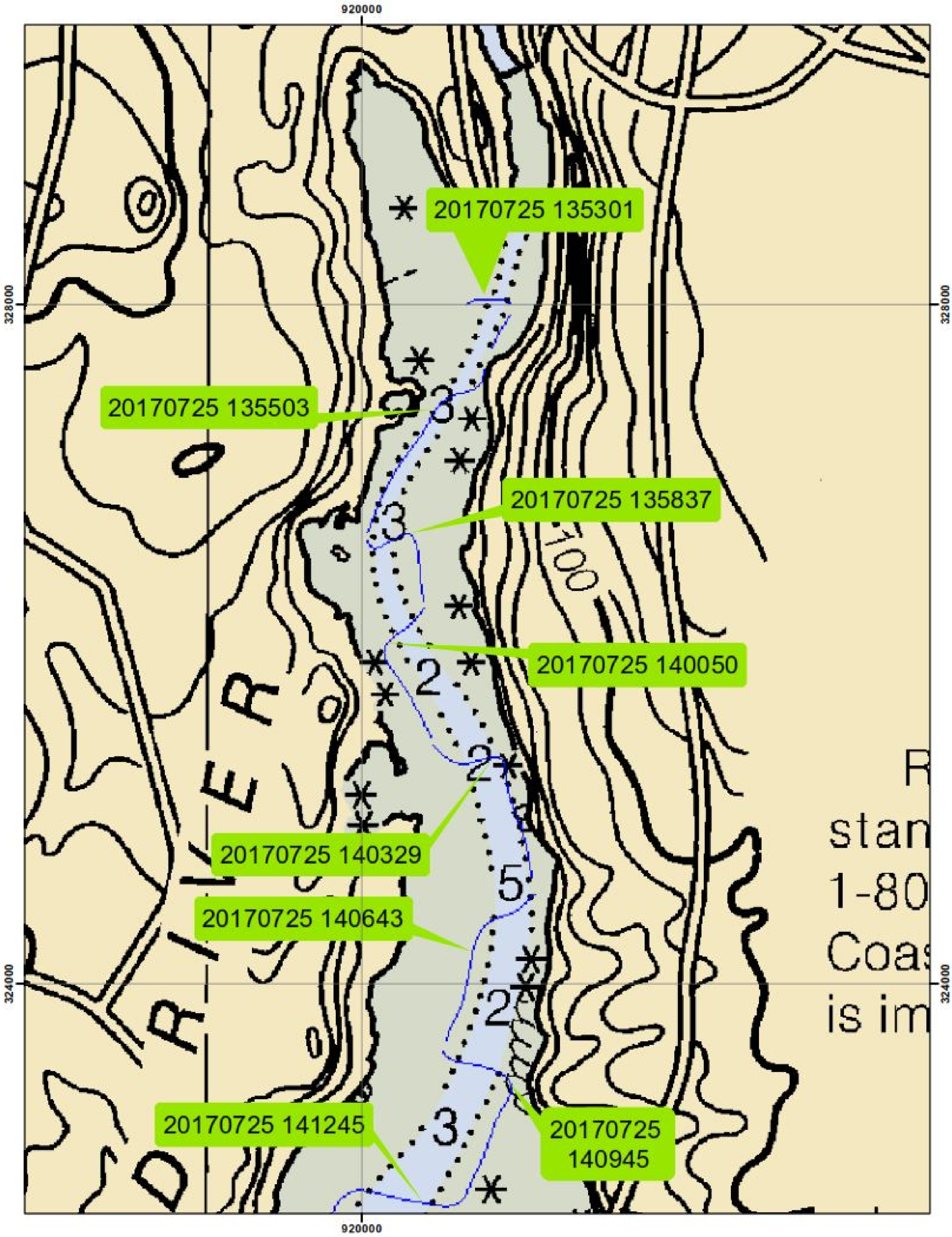

Figure A2-22
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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N

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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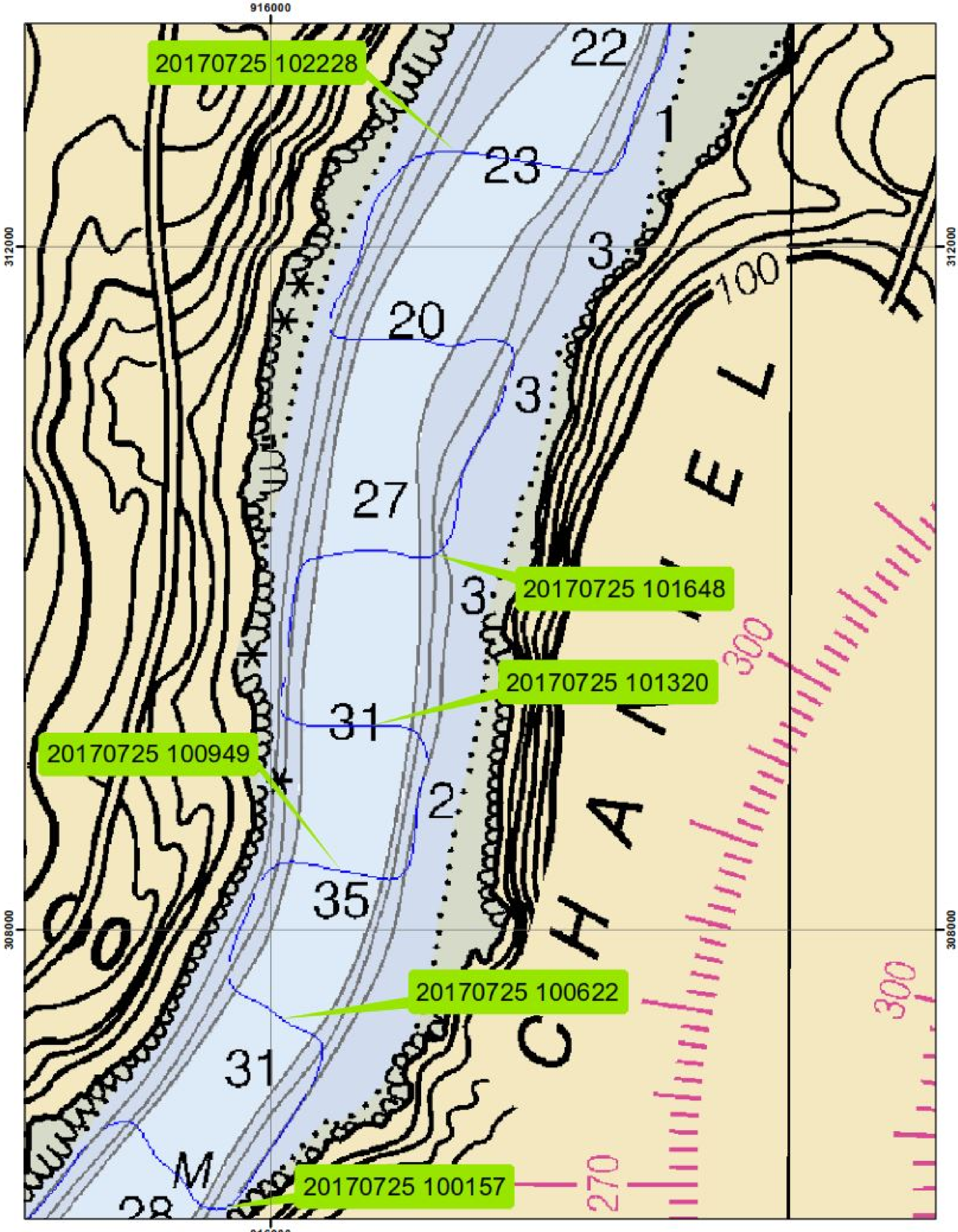

Figure A2-23
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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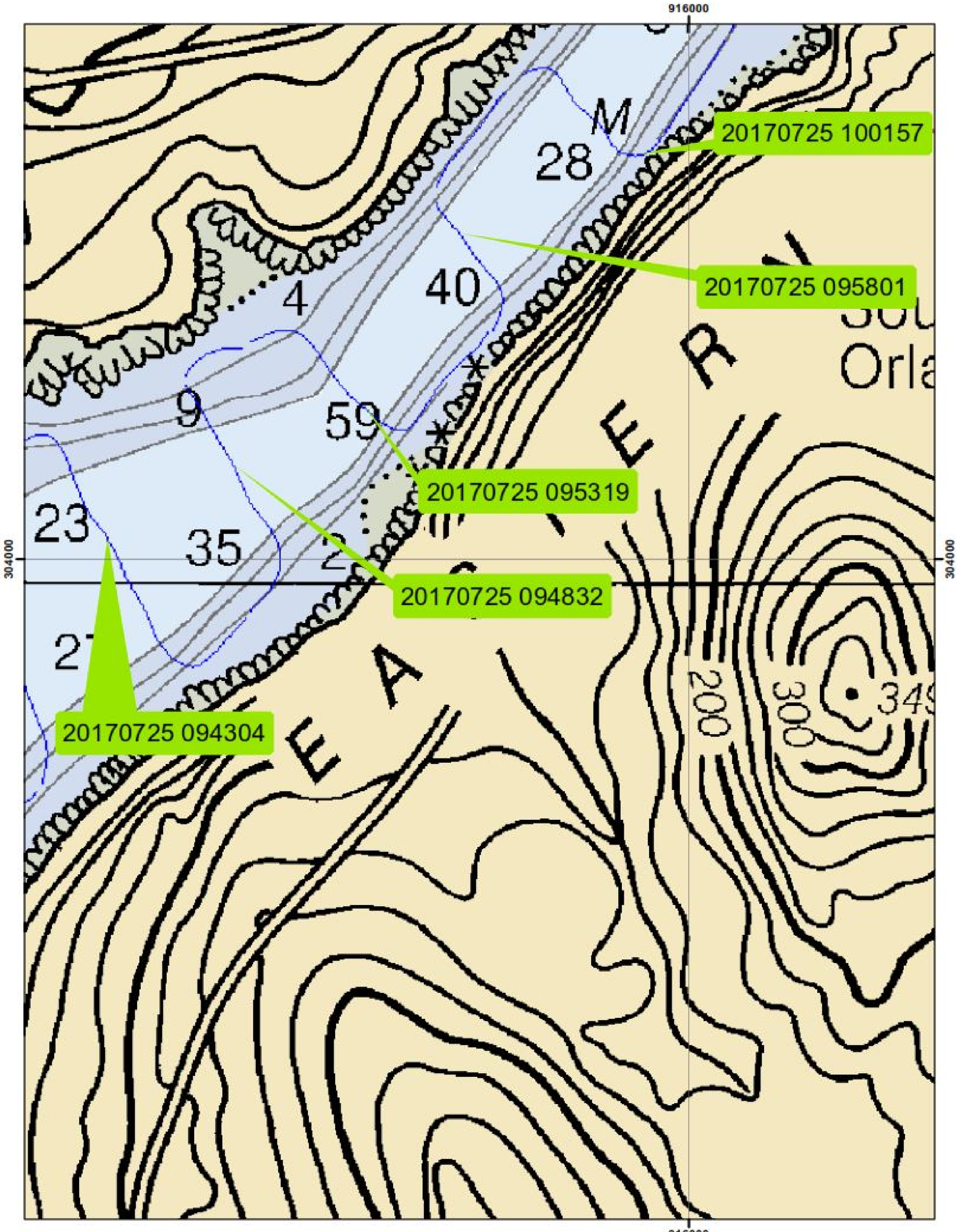

Figure A2-24
2017 Sub-Bottom Image Locations

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2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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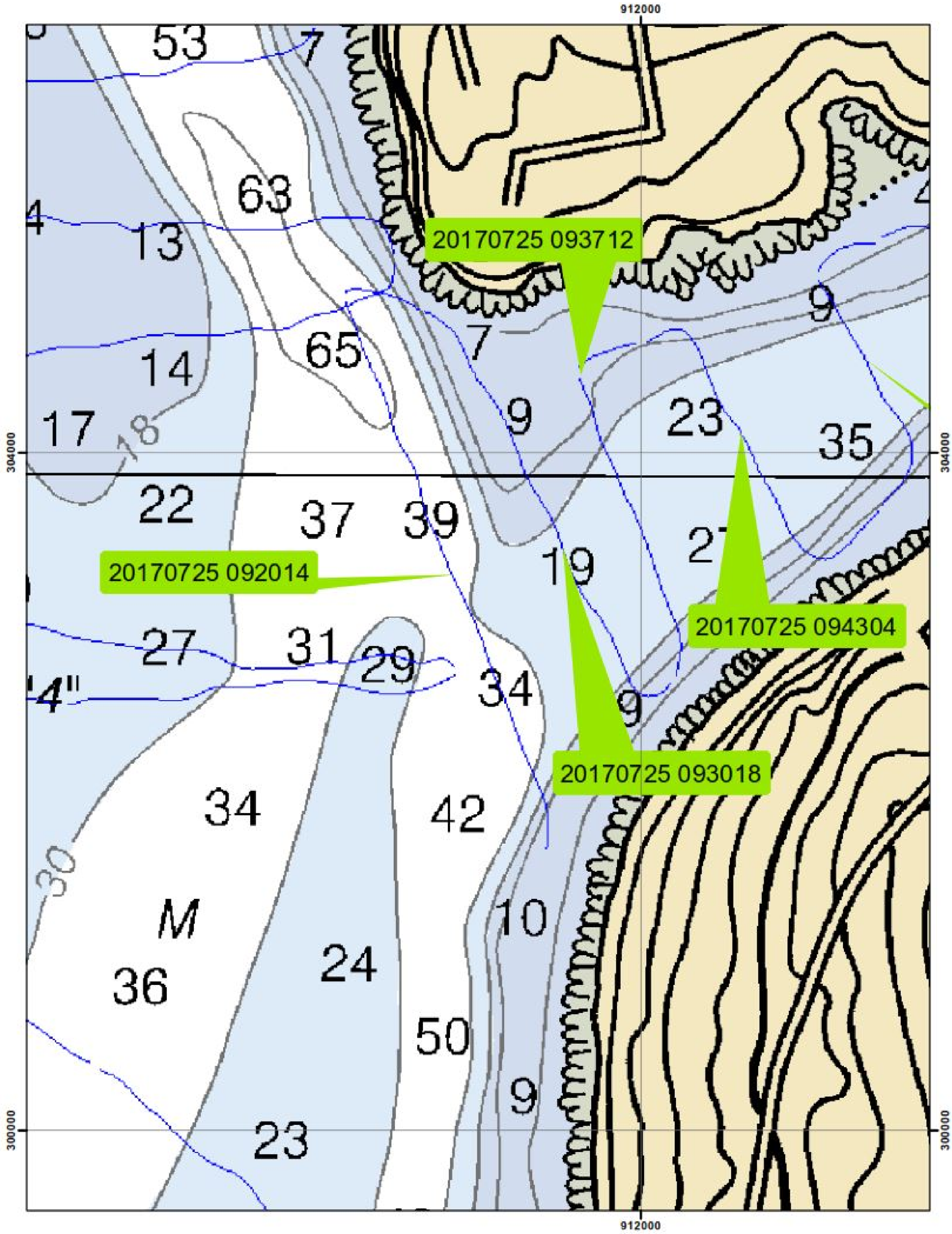

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Figure A2-25
2017 Sub-Bottom Image Locations

N

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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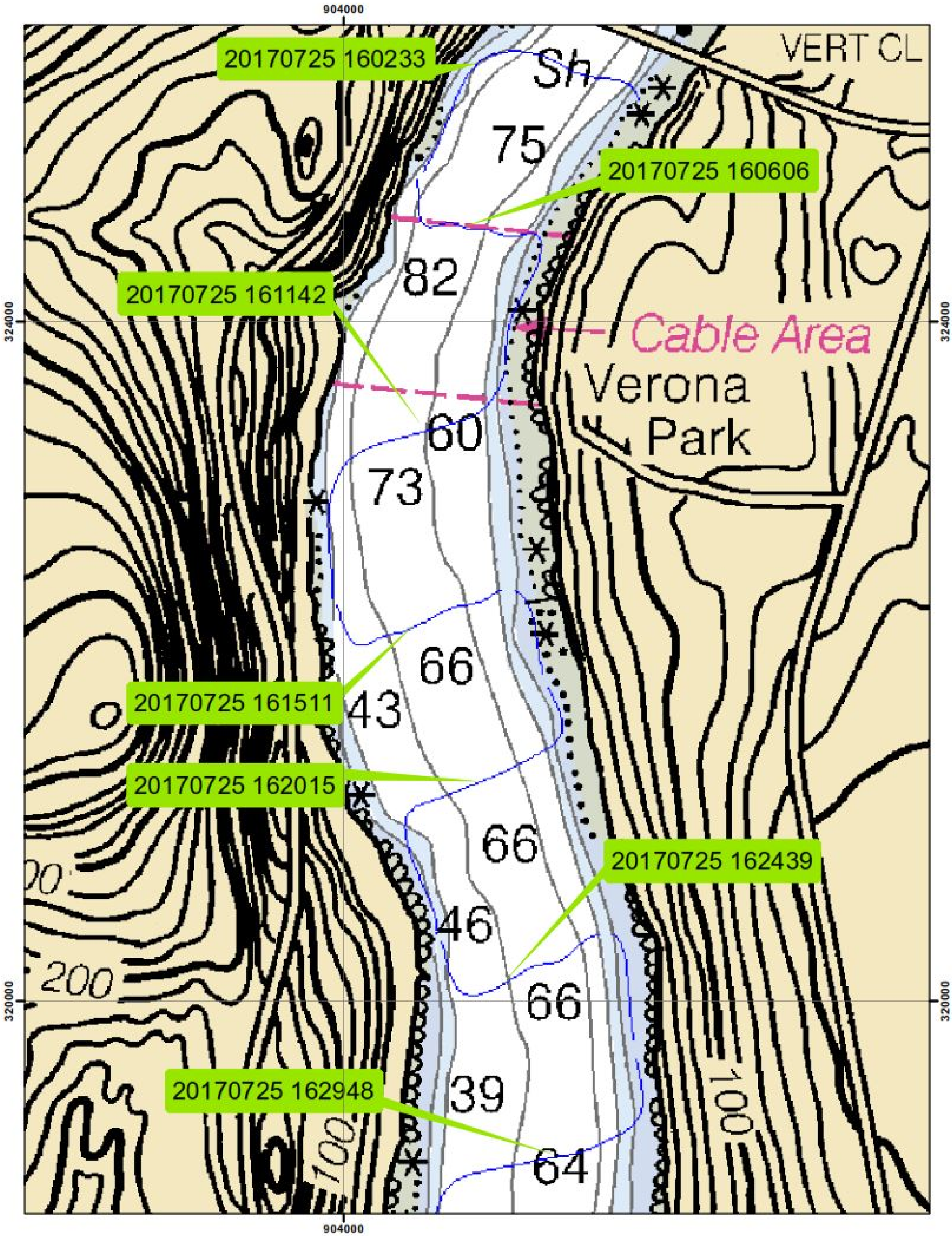

Figure A2-26
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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N

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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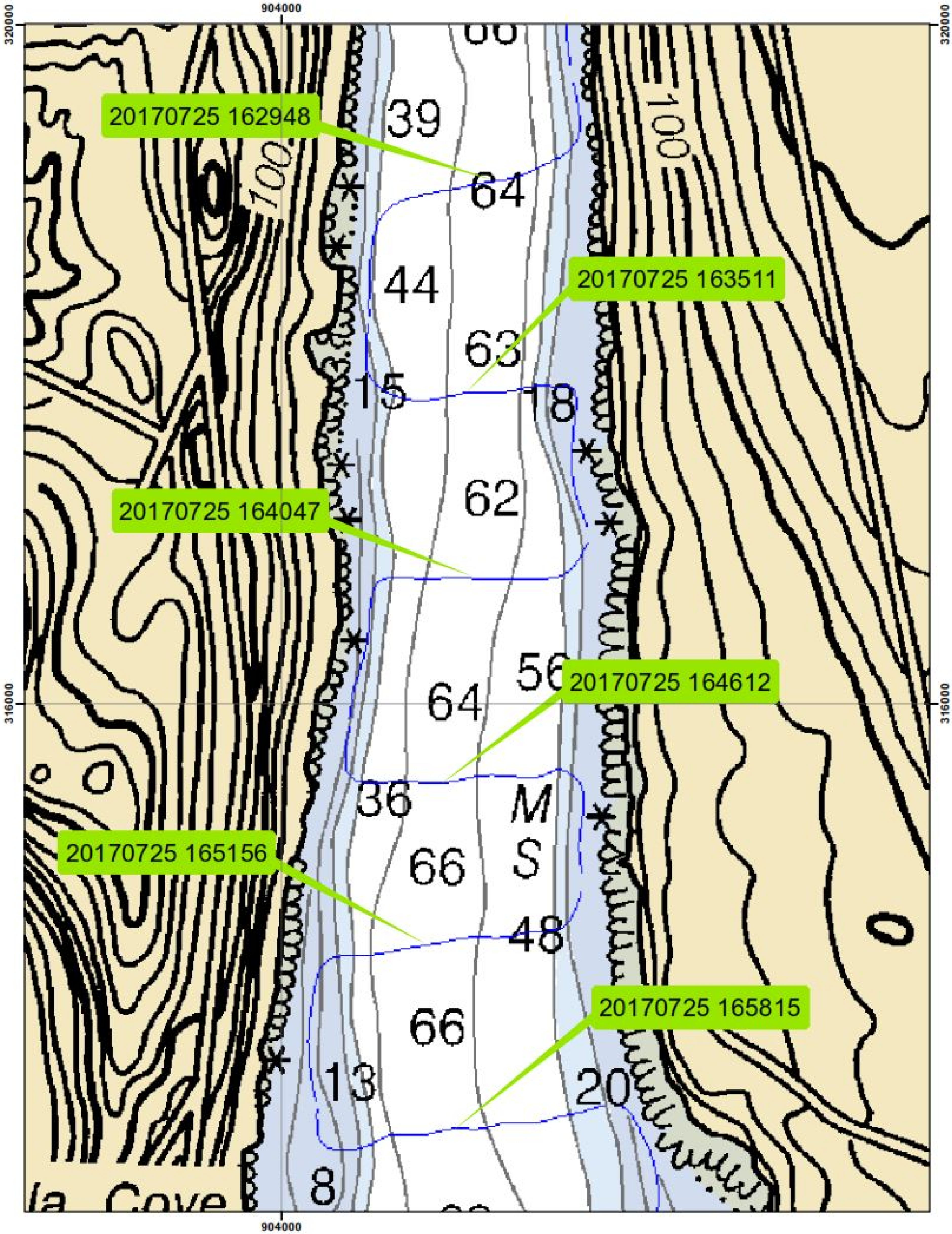

Figure A2-27
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

amec foster wheeler

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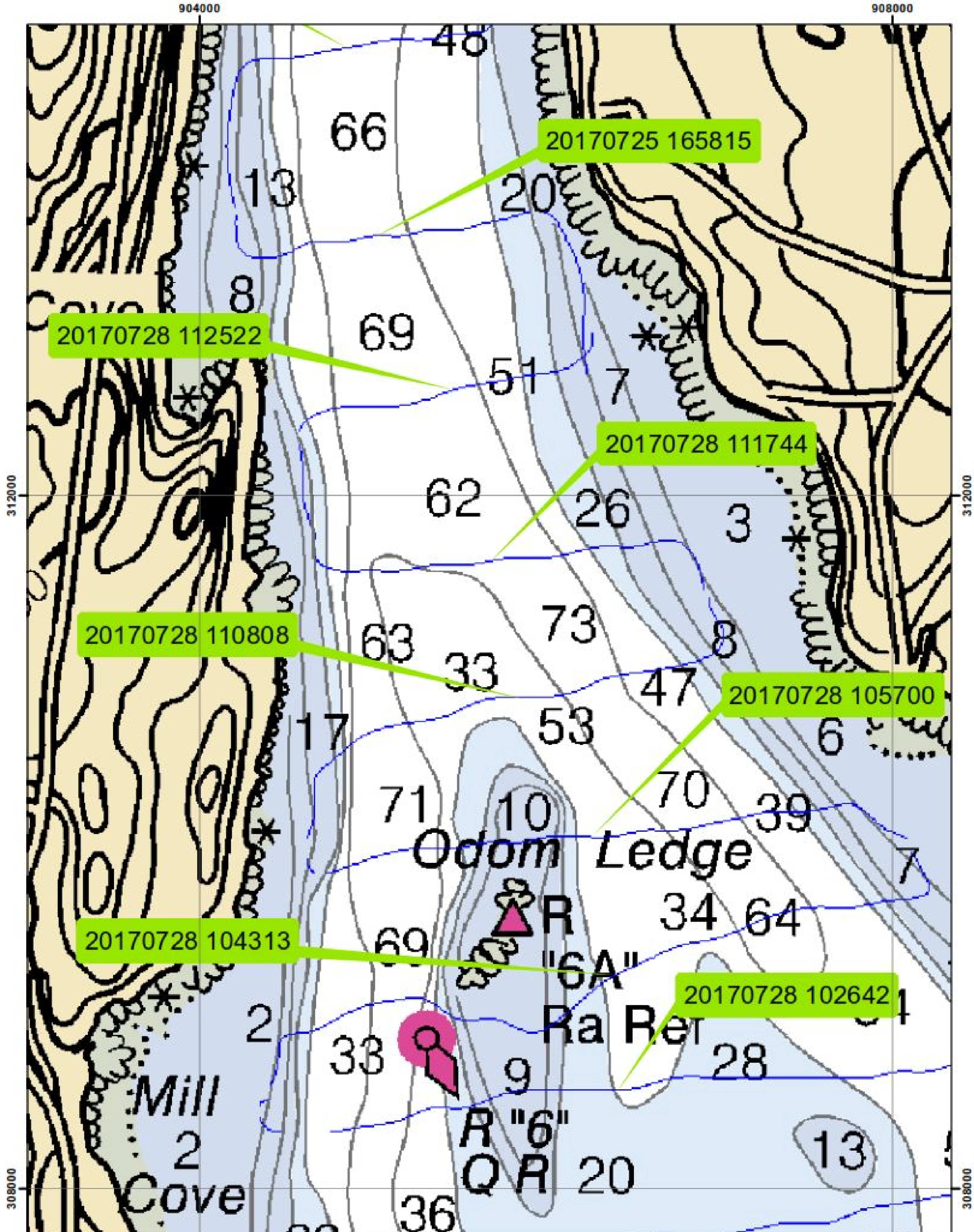

Figure A2-28
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

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N

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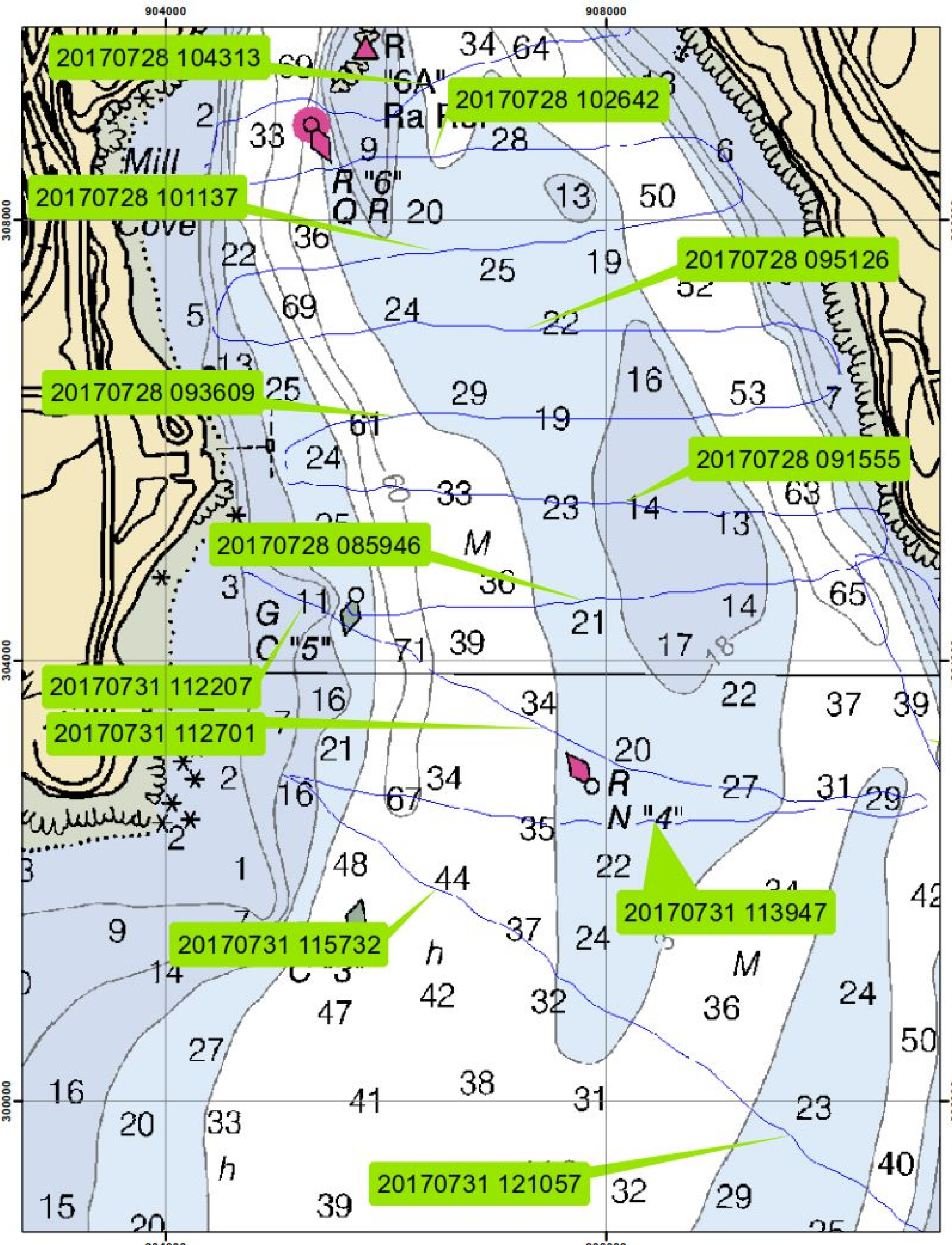

Figure A2-29
2017 Sub-Bottom Image Locations

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N

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

Project: 3616166052	Prepared/Date: 12/14/2017	Checked/Date: 12/14/2017	NAD83 State Plane Maine East, US Survey Feet

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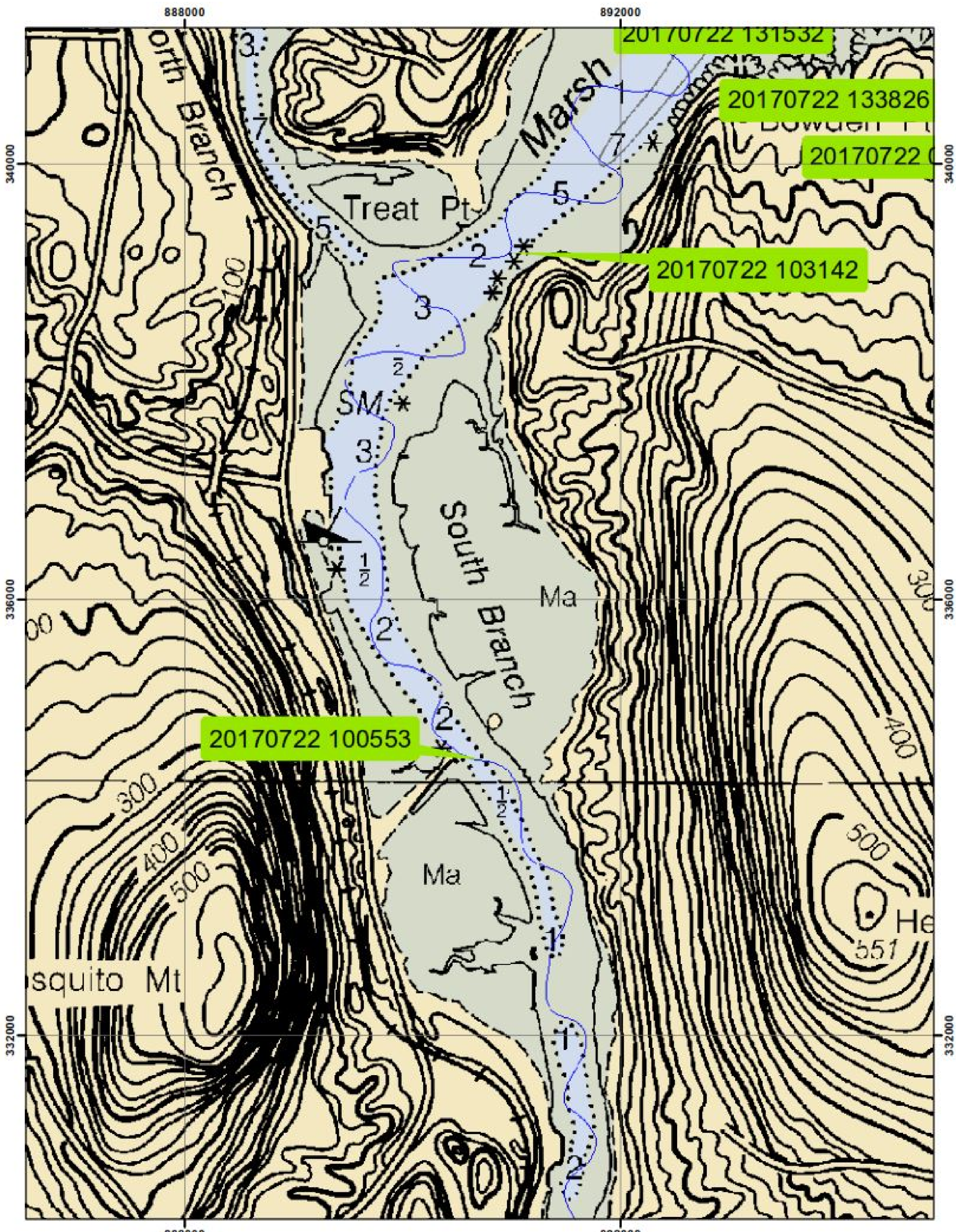

Figure A2-30
2017 Sub-Bottom Image Locations

2017 Mobile Sediment Characterization
Penobscot River Phase III Engineering Study

N

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APPENDIX A-2.5
SUB-BOTTOM IMAGES
(Electronic Delivery)