OCS Study
BOEM 2019-013

Analyzing the Potential Impacts to Cultural Resources at Significant Sand Extraction Sites

Volume I: Technical Report

U.S. Department of the Interior
Bureau of Ocean Energy Management
Gulf of Mexico OCS Region

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Authors

G. Watts
R. Arnold
B. Forrest
K. McCoy
W. Robertson

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Tidewater Atlantic Research, Inc.
5290 River Road
Washington, NC 27889

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Abstract

The U.S. Department of the Interior (DOI), Bureau of Ocean Energy Management (BOEM) is required, under Section 106 of the National Historic Preservation Act (NHPA), to consider the effects of its permitted actions on significant historic properties. Through its Marine Minerals Program (MMP), BOEM has designated Significant Outer Continental Shelf (OCS) Sand Resource Extraction Zones, based on sediment thickness in selected areas of the Gulf of Mexico (GOM). These zones, along with similarly designated zones in Louisiana state waters, may be leased and used as sand sources for coastal restoration and protection projects.

Three of the Significant OCS Sand Resource Extraction Zones currently scheduled or under consideration for upcoming sand use projects include: Sabine Bank, which includes portions of the High Island, West Cameron and Sabine Pass lease block areas; Ship Shoal, which includes portions of the Ship Shoal and South Pelto lease block areas; and St. Bernard Shoals, which includes portions of the Main Pass and Chandeleur lease block areas.

The objectives of this study included use of both existing and newly acquired data sets to give BOEM insight into the potential impacts to shipwreck sites in specific sand and gravel extraction areas of potential effect (APE). The results will provide comparative data about the use of sand resources from relatively lower energy OCS environments and those located in more dynamic shallow water environments, such as Hewes Point, Chandeleur Islands, an area historically prone to a high occurrence of ship groundings. Data generated by this study will also help BOEM identify potential impacts to shipwreck sites in Significant OCS Sand Resource Extraction Zones. Information on the location, preservation, and extents of debris fields associated with vessel remains located in selected sand borrow areas help BOEM determine the most appropriate management strategies and mitigation measures to comply with Section 106 responsibilities under the National Historic Preservation Act. Geophysical and geotechnical data about the character and quality of sand resources generated by the investigation support developing a better understanding of the morphological evolution and sediment dynamics of dredge pits in the vicinity of existing cultural resources, and assessing the effectiveness of dredging setback buffers within or proximal to dredge pits. Remote sensing surveys were carried out at eight Sabine Bank sites, nine Ship Shoal sites, two St. Bernard Shoal sites, and five sites off the Chandeleur Islands, Louisiana. Field investigations off the Chandeleur Islands included research to relocate an 18th-century ballast pile identified and investigated in 1989. Specific areas of investigation were identified based on previous remote-sensing surveys and the locations of current and future sand resource extraction projects. Priority sites for archaeological diver investigation and core sampling were subsequently carried out at priority sites on Sabine Bank, Ship Shoal and off the Chandeleur Islands. Accoustic Doppler current profiler (ADCP) deployment and recovery operations were conducted off both Sabine Bank and Ship Shoal. The ADCP data, combined with a literature and data review, are a basis for a modeling plan to simulate changes to future borrow areas and how those changes can affect nearby cultural resources. In conjunction with investigation of the Hewes Point sites, a high probability area for relocating the ballast pile was investigated. That investigation included remote sensing and archaeological diver investigation of magnetic anomalies that successfully located and confirmed identification of the ballast pile site investigated in 1989. Data generated by the project identified the source of anomalies and sonar targets at a total of fourteen sites. Archaeological and geophysical data indicate that several sites could serve as valuable sources of data if used as locations for monitoring the impacts of

dredging, weather, currents and sea states. Relocation and identification of the Chandeleur ballast pile provides the opportunity for continued archaeological investigation of what could be the earliest shipwreck in the Mississippi Delta region of the GOM. During the entire course of the project, historical and cartographic research brought to light a considerable amount of new primary source information about the project area. That research also identified a number of previously unknown shipwrecks in the GOM.

Acknowledgements

The authors would like to thank and acknowledge a number of individuals, agencies, organizations and institutions for their assistance and contributions. Without their help, this project would not have been successful. We would first like to thank the Bureau of Ocean Energy Management (BOEM) for the opportunity to work with the agency on this investigation. We also thank the BOEM Contracting Officer's Representative, Mr. Douglas Jones, for his assistance in every phase of project activity and particularly in planning, organization and field work. BOEM and BSEE personnel, Mike Miner, Melanie Damour, Chris Horrell, and Jack Irion contributed significantly to project planning and conduct. While conducting the archaeological diver investigations on the Sabine Bank sites, Scott Sorset and Mark Belter provided valuable assistance. Administration of the contract with Tidewater Atlantic Research (TAR) was facilitated by the attention and assistance of Christie Tardiff and Paige Shin.

TAR project personnel were ably assisted in the site-specific archaeological diver field investigations by senior archaeologist John W. Morris, III and archaeologist Gregory O. Stratton. Project fieldwork was supported by several vessels and their crews. The remote sensing surveys carried out in 2013 and the archaeological diver investigations and core sampling in 2014 was carried out aboard the vessel *Kimberly Dawn* out of Bayou LaBatre, Alabama. Captain Perry Zirlott and his crew made both voyages comfortable and productive, in spite of frequent rough seas and bad weather. Archaeological diver investigations on the Sabine Bank sites in 2016 were carried out aboard the Blue Star Marine vessel *Mantis*. Captain Darrell Walker and his mates made day trips to the dive sites from Lake Charles, Louisiana and provided surface support for each investigation.

The final phase of field work, off the Chandeleur Islands in 2016, was carried out aboard two vessels out of Biloxi, Mississippi. Initial remote sensing designed to identify the Chandeleur ballast pile site was carried out aboard F/V *Miss Hospitality*. Under the command of Captain Kenny Barhanovich, *Miss Hospitality* provided a stable platform for remote sensing. Captain Kenny provided personal insight into locating the ballast pile and supporting the 1989 investigations. Diving on the Hewes Point and ballast pile sites was carried out from the F/V *Shearwater*. Captain Brandon Morano and his mate provided support for each phase of archaeological diver operations that ultimately relocated and identified the ballast pile.

Relocating and identifying the ballast pile site would not have been possible without the help of many individuals. Charles McGimsey, state archaeologist for the Louisiana Office of Cultural Development, provided a considerable contribution to the Chandeleur investigation. Dr. Ervan Garrison provided copies of his 1989 project notes and suggested other sources of useful data. Ms. Tiffany Bosarge with the Gulf Coast Research Laboratory assisted the TAR team in locating and contacting their personnel who were involved in supporting the 1989 investigation. Mr. Jim Jobling, one of the 1989 Texas A&M University project staff, located photographs, records and made contact with other members of the 1989 team to collect information related to the site location. One of his contacts, Tony Tripp, shared critical LORAN-C coordinates for the site he recorded in 1989. Those coordinates provided the key to relocating the ballast pile. TAR archaeologists used a NOAA program to convert the LORAN TDs to Louisiana State Plane coordinates. Archaeologist Ralph Wilbanks used his version of Seamarks software to make the same conversions for comparison and refining the search area. Jim Jobling was also responsible for attaching zinc anodes to the cannon with the stainless steel hose clamps that confirmed relocation of the site.

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1. Introduction

The United States Department of the Interior (DOI), Bureau of Ocean Energy Management (BOEM) is required under Section 106 of the National Historic Preservation Act (NHPA) to consider the effects of its permitted actions on significant historic properties. Through its Marine Minerals Program (MMP), BOEM has designated Significant Outer Continental Shelf (OCS) Sand Resource Extraction Zones, based on sediment thickness in selected areas of the Gulf of Mexico (GOM). These zones, along with similarly designated zones in Louisiana state waters, may be leased and used as sand sources for coastal restoration and protection projects. Three of the Significant OCS Sand Resource Extraction Zones currently scheduled or under consideration for upcoming sand use projects include: Sabine Bank, which includes portions of the High Island, West Cameron and Sabine Pass lease block areas; Ship Shoal, which includes portions of the Ship Shoal and South Pelto lease block areas; and St. Bernard Shoals, which includes portions of the Main Pass and Chandeleur lease block areas (Figure 1).

The objectives of this study included use of both existing and newly acquired data sets to give BOEM insight into the potential impacts to shipwreck sites in specific sand and gravel extraction areas of potential effect (APE). The results will provide comparative data about the use of sand resources from relatively lower energy OCS environments and those located in more dynamic shallow water environments, such as Hewes Point, Chandeleur Islands, an area historically prone to a high occurrence of ship groundings. Data generated by this study will also help BOEM identify potential impacts to shipwreck sites in Significant OCS Sand Resource Extraction Zones. Information on the location, preservation, and extents of debris fields associated with vessel remains located in selected sand borrow areas help BOEM determine the most appropriate management strategies and mitigation measures to comply with Section 106 responsibilities under the National Historic Preservation Act. Geophysical and geotechnical data about the character and quality of sand resources generated by the investigation support developing a better understanding of the morphological evolution and sediment dynamics of dredge pits in the vicinity of existing cultural resources, and assessing the effectiveness of dredging setback buffers within or proximal to dredge pits.

This analysis of the potential impacts to cultural resources at significant sand extraction areas in the GOM was carried out for BOEM by Tidewater Atlantic Research, Inc., based in Washington, North Carolina, and CB&I based in Boca Raton, Florida. Initially, the investigation focused on a review and assessment of GOM submerged cultural resource survey documents to identify appropriate sites for field investigation. Based on previous literature and consultation with BOEM personnel, priorities for field research at Sabine Bank, Ship Shoal, St. Bernard Shoal, and off the Chandeleur Islands were identified. Sites identified for additional investigation were prioritized as either primary or secondary significance. Research priorities identified in 2012 and 2013 were based both on the results of previous remote-sensing surveys and the locations of current and future sand resource extraction projects.

Initial priorities included eight sites at Sabine Bank, nine at Ship Shoal, and two at St. Bernard Shoal. In Louisiana state waters, four sites near previous dredging operations at Hewes Point off the Chandeleur Islands were given a high priority due to their potential association with an 18th-century ballast pile and associated cannon that were identified in the vicinity and investigated in 1989, though the exact location of the site was not recorded (Garrison et al. 1989b). During the course of the study, new information identified alternate potential locations for the ballast pile and cannon, and these locations were later added to the research design.

Field work was initiated in 2013. Remote sensing surveys were carried out at eight sites on Sabine Bank, nine sites on Ship Shoal, four at Hewes Point, and two at St. Bernard Shoal. Based on analysis of the remote sensing data, priority sites for archaeological diver investigation and core sampling were identified in conjunction with BOEM personnel. In 2014, archaeological diver investigation and core sampling operations were initiated at Sabine Bank and Ship Shoal. Operations were shifted to Ship Shoal due to adverse weather, currents, and sea states at Sabine Bank. In spite of continued marginal conditions, three sites on Ship Shoal were investigated and partial core samples collected. At two sites, modern vessel remains were identified as a spud barge and a fuel or oil transport barge. The third site was identified as modern structural debris.

Successful collection of core samples and ADCP deployment and recovery operations off Sabine Bank and Ship Shoal was accomplished in 2015. ADCP data were collected on significant sand resource areas Sabine Bank and Ship Shoal with a more detailed location description in Section 5.2.1. The next year, fieldwork focused on archaeological diver investigations at five sites on Sabine Bank and two sites off Hewes Point. Material at three of the five Sabine Bank sites proved to be modern structural debris likely associated with the oil and gas industry. Material at the remaining two sites proved to be vessel remains. One is the relatively intact hull remains of what could possibly be a supply vessel. The second was identified as the rig and machinery associated with a trawler.

Off Hewes Point, material associated with two remote sensing sites was identified by archaeological divers. Material at one site proved to be a brick or stone feature constructed with masonry. That feature appears to be associated with one of the numerous historically documented terrestrial structures built and rebuilt on Hewes Point. Candidates for identification include cisterns, chimney bases, or possibly part of a lighthouse structure. The second site off Hewes Point clearly represents the rig and machinery associated with a modern trawler.

In conjunction with the investigation of the Hewes Point sites, the high probability area for relocation of the ballast pile was investigated. That investigation included remote sensing and archaeological diver investigation of potentially significant magnetic anomalies. The first anomaly investigated by probing appeared to be a single metal object that could be a small cannon. At the second site, probing identified ballast, wood and metal objects. Subsequent excavation on one of the metal objects uncovered ballast and a cannon. A stainless steel hose clamp on one trunnion confirmed that the site was the one investigated in 1989.

Data generated by the project identified the source of anomalies and sonar targets at a total of fourteen sites. Archaeological and geophysical data indicates that several sites could serve as valuable sources of data if used as locations for monitoring the impacts of dredging, weather, currents, and sea states. Relocation and identification of the Chandeleur ballast pile provides the opportunity for continued archaeological investigation of what could be the earliest shipwreck in the Mississippi Delta region of the GOM.

During the entire course of the project, historical and cartographic research established an historical background context for the project area and identified new shipwrecks. That research included examination of primary and secondary source documents in libraries, historical societies, and archival repositories. Numerous internet sources of primary documents and cartographic material were investigated and relevant data collected. That research brought to light a considerable amount of new information about the maritime history of the GOM project area and a number of previously unidentified shipwrecks.

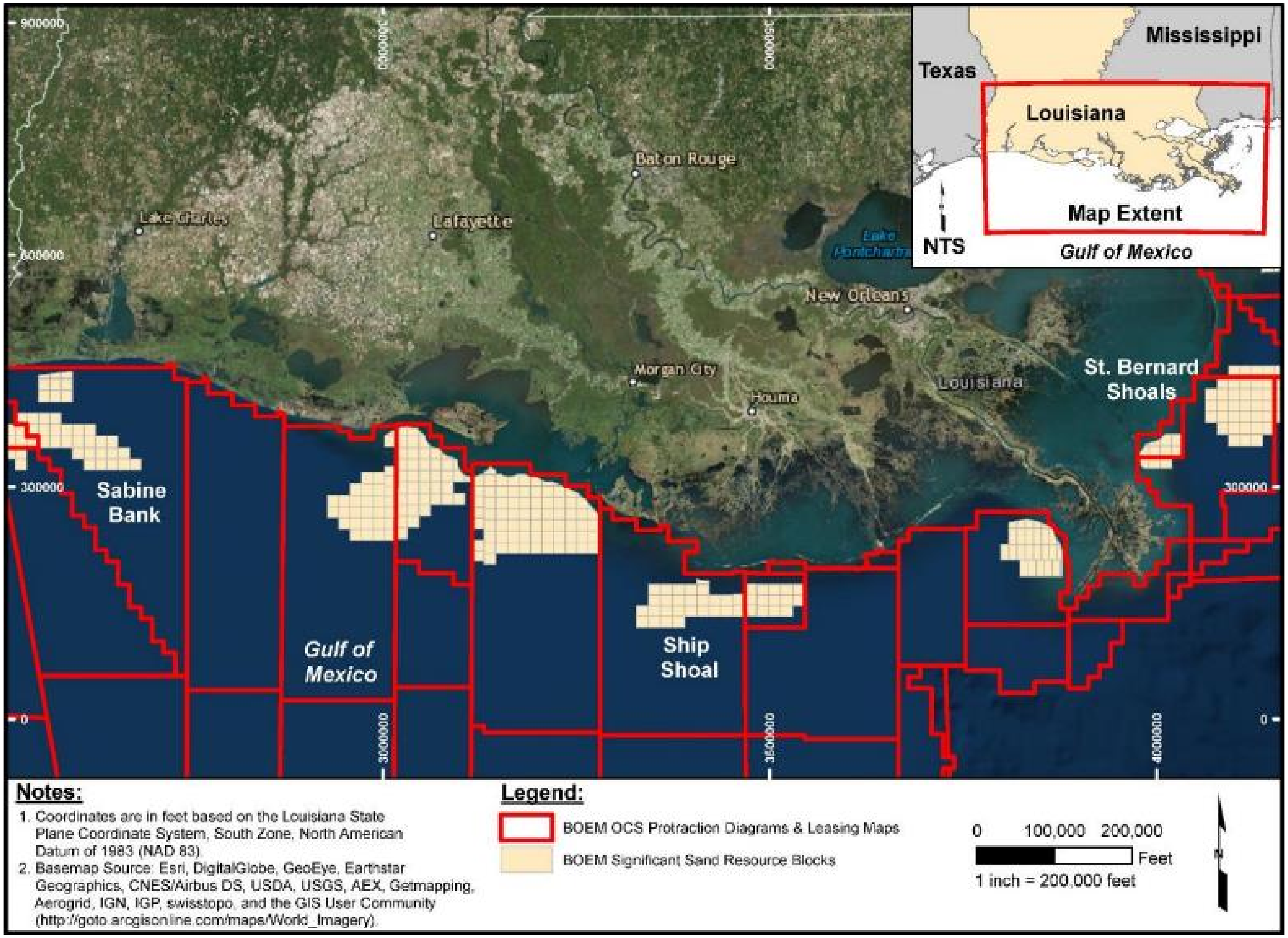

Figure 1. Significant OCS sand resource extraction zones.

1.1. Project Task Definition

To meet BOEM's goals, this investigation was divided into five tasks.

1.1.1. Task 1

During Task 1, remote sensing sampling surveys were conducted. The TAR team, which included TAR and CB&I, in consultation with BOEM archaeologists designed and conducted high-resolution remote sensing surveys within portions of the Ship Shoal, Sabine Bank, and St. Bernard Shoal Significant OCS Sand Resource Extraction Zones (see Figure 1) in an attempt to identify potential shipwreck sites that may be impacted by future sediment removal operations. Portions of each of these zones have been previously surveyed either by the oil and gas industry or for proposed sand and gravel extraction projects. Before designing these surveys, the TAR team compiled and reviewed these existing data and incorporated them into the survey design. BOEM requested that survey designs include a combination of site specific surveys of potential archaeological resources, refinement of previously collected datasets and data collection in previously unsurveyed areas. The surveys included bathymetry, a marine magnetometer, sidescan sonar, and sub-bottom profiler, with a maximum transect spacing of 30 m (98 ft.). For site-specific surveys at potential shipwreck locations, the survey extended at least 300 m (984 ft.) from the center point of each site to determine the horizontal extent of any associated debris.

1.1.2. Task 2

During Task 2, the TAR team analyzed the data that were collected during Task 1. The goal was to coordinate with BOEM to identify at least ten potential shipwreck sites for archaeological diver investigation. After these sites were identified, the TAR team conducted a Phase II archaeological field investigation at each location. Marine archaeologists performed testing applying a variety of techniques. These techniques were remote sensing and diving assessments that included documentation of exposed remains, hydraulic probing, limited excavation and, where possible, collection of underwater imagery, such as high-resolution digital photographic and video documentation. The TAR team also conducted site-specific investigations at a minimum of one potentially significant shipwreck site that was identified during State-mandated emergency response remote sensing surveys conducted before dredging in the Hewes Point, Chandeleur Island area (Tidewater Atlantic Research 2011). Multiple targets recorded near Hewes Point were suspected to be the potential location of a ballast pile and associated cannons that were discovered and investigated in 1989, though accurate documentation of its location had not survived (Garrison et al. 1989b). The Hewes Point study sites were selected due to their proximity to previous dredging operations, and additionally in an attempt to relocate the ballast pile and cannon site. Research conducted by the TAR team during the course of this study identified a higher-probability potential location for the ballast pile and cannon site off of the Chandeleur Islands, and this site was later added to the research design. Also during Task 2, the TAR team collected and analyzed cores and other geotechnical data sets to characterize sand resources in the vicinity of the potential shipwreck sites that had been identified.

1.1.3. Task 3

During Task 3, the TAR team conducted primary and secondary source archival research for each shipwreck or archaeological site discovered. The team made a significant effort to locate and copy extant photographic images, drawings, paintings, and/or builders plans of each vessel, if available. Research was directed toward placing each vessel in its historic context. BOEM specified that historic data and imagery acquired under this contract must be analyzed in such a way as to identify each site to the fullest extent possible and establish the vessel's type and date of construction, nationality, ownership (past and present), use history, mission and cargo (if any) at time of loss and factors contributing to its loss.

1.1.4. Task 4

During Task 4, a final report was developed that presented the assessments of the data collected in the archaeological, historical, geological and physical processes investigations. This task also included the development of a predictive conceptual model related to the forces driving sediment dynamics and pit evolution.

1.1.5. Task 5

Task 5 was conducted concurrently with the other tasks and included the production of materials that could be used for public outreach. Multiple outreach formats were considered for development including web sites, posters, teacher packets, and other informational sources detailing the project's history, scope of work, and results. Ultimately, the TAR team used Esri's Story Map application to create a web-based storyboard, combining ArcGIS project maps with narrative text, multimedia and other project-related imagery. The Story Map provides a synopsis of each of the project's key elements including a project overview; remote-sensing and archaeological diver investigation methodologies; the archival, cartographic and shipwreck analyses; data analyses and final report; prehistoric and historic archaeological site impact assessments; and the dredging impacts to cultural resources conceptual modeling. The Story Map is editable and may be hosted on a publicly-available webpage or restricted for BOEM's internal usage.

2. The Site Selection Process

At the beginning of Task 1, the TAR team compiled and reviewed existing in-house data and data provided by the Bureau of Ocean Energy Management (BOEM). The in-house data included sub-bottom, sidescan sonar, magnetometer, and vibracore data. These data were reviewed (and digitized where necessary) and incorporated into area-specific geographical information systems (GIS) projects. Cultural resource reports were then reviewed and any additional data that were identified were incorporated into the GIS projects. Additional data and remote-sensing survey reports from offshore oil and gas operations and marine minerals extraction projects were provided by BOEM. They were inventoried, formatted, and used to create maps of each of the investigation areas, including Sabine Bank, Ship Shoal, St. Bernard Shoals, Hewes Point, and the Chandeleur Islands. The data that were inventoried included vibracores, grab samples, geophysical data (bathymetry, sidescan sonar, and sub-bottom profiler), oil and gas infrastructure, previously identified avoidance areas, shipwrecks, magnetic anomalies, isopachs, and borrow areas. Over 500 datasets were compiled and reviewed. Those data sets included oil and gas lease remote sensing survey reports, sand source remote sensing survey reports, pre and post dredging survey reports, National Oceanographic and Atmospheric Administration (NOAA) remote sensing survey reports and MMS (Minerals Management Service)–BOEM published documents related to submerged cultural resources in the Gulf of Mexico (GOM) region.

The TAR team's analysis of the data focused on line spacing, magnetic anomalies, and sonar targets recommended for avoidance and identified shipwrecks. Most of the early surveys were carried out at a 50 meter (164 ft.) line spacing. That has been demonstrated to be too broad and is not considered sufficient by today's standards. Virtually all federal and state agencies recognize that a 50 meter (164 ft.) survey line spacing is insufficient to reliably identify a high percentage of historical vessel remains and require a 30 meter (98 ft.), or closer, survey line spacing for submerged cultural resource surveys. Despite this, some anomalies were recommended for avoidance in the Sabine Bank and Ship Shoal areas. Several modern vessels were also identified. As avoidance has been, and remains the most exercised option, few of the anomalies that were identified and recommended for avoidance were actually examined by archaeological divers. A review of sediment characteristics was also undertaken to assist in site selection. The goal was to select sites having shipwrecks adjacent to borrow sites and areas with different sediment types (i.e., sand and mixed sediment resources). The data compiled during Task 1 were used to facilitate planning for additional survey and wreck assessment activities.

2.1. Criteria

Based on the existing data that was reviewed by the TAR team, a preliminary geophysical investigation plan was developed. Site recommendations take into account the historic value of the potential shipwrecks, the geologic environment, and the proximity to borrow areas.

2.2. Selected Sites

For Sabine Bank, Ship Shoal, St. Bernard Shoals, and Hewes Point, primary and secondary priority investigation areas were identified. At Sabine Bank, three primary and three secondary areas were identified for investigation as shown in Figure 2.

At Ship Shoal, three primary areas and four secondary areas were identified (Figure 3). In the Chandeleur Island area, four secondary areas were identified in the vicinity of Hewes Point, and two primary areas were identified at St. Bernard Shoals (Figure 4). Also off the Chandeleurs, research identified a high priority area for investigation associated with relocation of the 18th century ballast pile investigated in 1989.

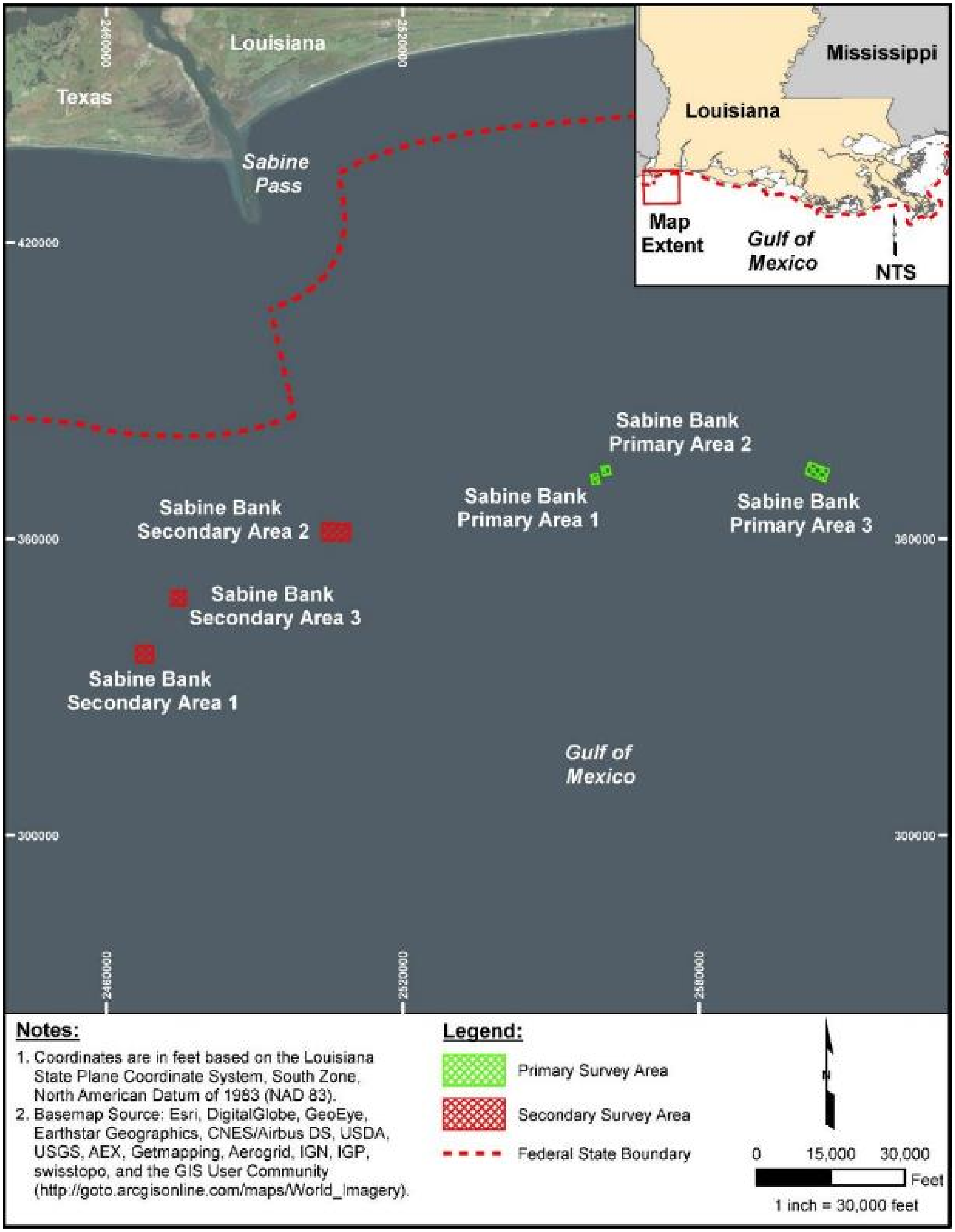

Figure 2. Survey areas identified within Sabine Bank.

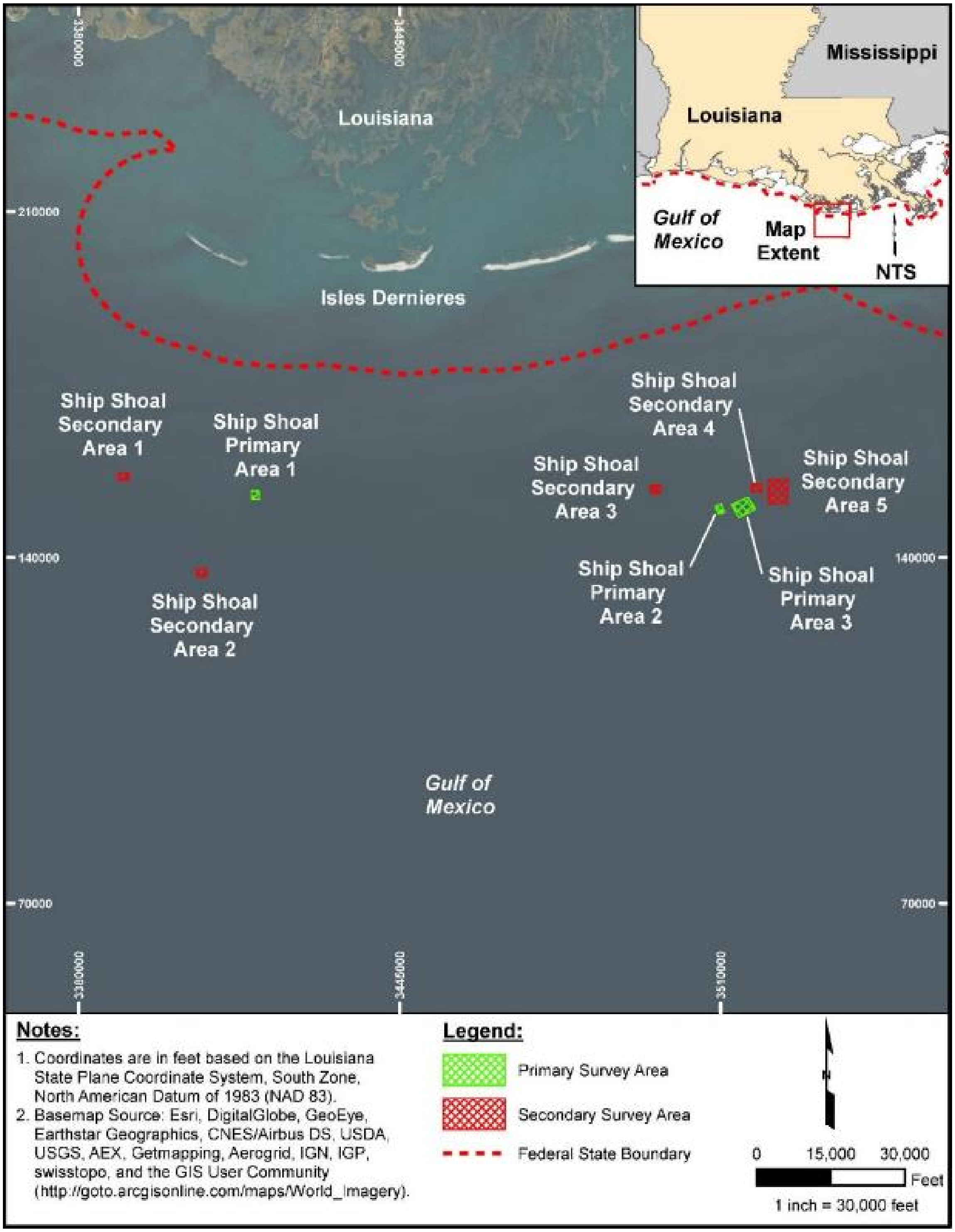

Figure 3. Survey areas identified within Ship Shoal.

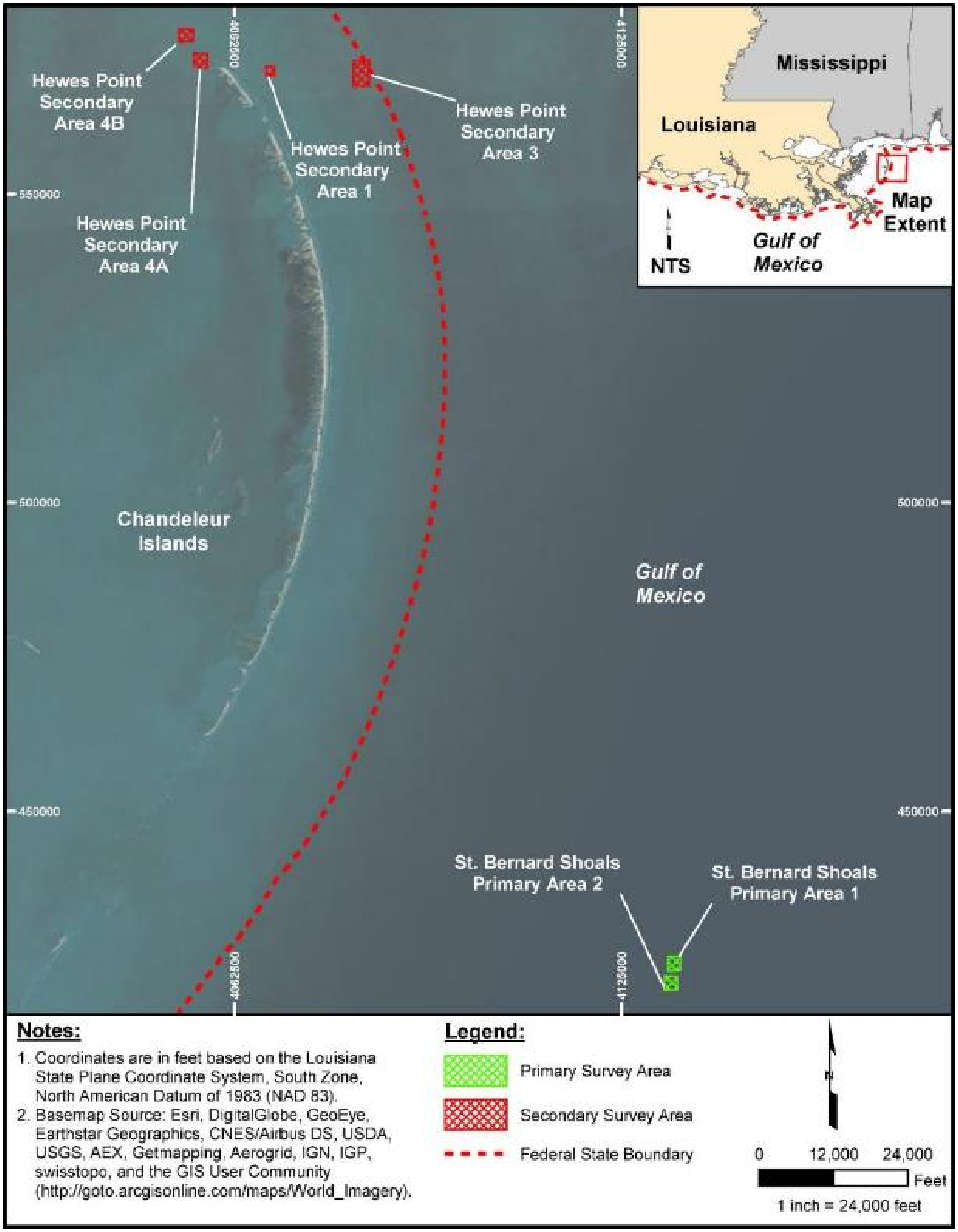

Figure 4. Survey areas identified within Hewes Point and St. Bernard Shoals.

3. Research Design and Methodology

3.1. Geophysical Survey

After BOEM finalized the geophysical survey plan, survey operations began. The TAR team conducted geophysical surveys within the areas identified during Task 1. A concurrent magnetometer, sub-bottom profiling, sidescan sonar, and bathymetric survey was conducted between September 3 and 16, 2013.

3.1.1. Remote Sensing Data Acquisition

On September 3, 2013, the Team arrived in New Orleans to transit to Prairieville, Louisiana, to pick up geophysical equipment, and then go to Cameron, Louisiana, for vessel and equipment mobilization. Mobilization began on September 4, 2013, and survey operations began the following day. On September 16, 2013, after collecting approximately 226 nautical miles of geophysical data, the vessel completed transit to Bayou La Batre and was demobilized.

Priority sites for the geophysical survey were identified based on analysis of previous data sets. Those data sets included oil and gas lease remote sensing survey reports, sand source remote sensing survey reports, pre and post dredging survey reports, NOAA remote sensing survey reports and MMS and BOEM published documents related to submerged cultural resources in the Gulf of Mexico (GOM) region. Survey location priorities were identified based on several criteria. Those criteria included proximity to previous and future sand source area borrow sites, previously identified and buffered anomalies and sonar targets and charted wreck and obstruction sites with an apparent and/or high potential for historically significant vessel remains.

Survey area priorities, surveyed dates and line miles, proximity borrow areas, buffers, diver investigation results and recommendations are summarized in Table 1 below. Additional data for the borrow areas, including project names, investigation dates and volumes are summarized in Table 2 below. Figures 5 through 16 show the survey area locations, geophysical tracklines, identified anomalies and sonar targets, and any proximity borrow areas.

Table 1: Summary of Survey Area investigations

Survey Area Priorities	Date Surveyed	Line Miles (naut. mi)	Proximity Borrow Areas	Buffers	Diver Investigation	Results	Recommendations
Sabine Bank Primary Area 1	09/06/2013-09/07/2013	13.89	BA HF	Previous Avoidance Buffer	Buffered Anomaly Cluster	Modern Debris	No Additional Investigation
Sabine Bank Primary Area 2	09/06/2013	14.19	BA HF & Sabine Bank BA1	Previous & Current Avoidance Buffers	No	Possible Vessel Remains	Buffer Avoidance or Assessment
Sabine Bank Primary Area 3	09/05/2013	24.97	BA JF	Previous & Current Avoidance Buffers	Sonar Vessel Image	Modern Vessel Remains	Monitoring and Buffer Avoidance
Sabine Bank Secondary Area 1	09/07/2013	11.20	None	Current Avoidance Buffers	Sonar Structure Image	Modern Debris	Buffer Avoidance or Assessment
Sabine Bank Secondary Area 2 SE	09/07/2013	5.63	Sabine Bank BA2	Current Avoidance Buffers	Complex Anomaly Cluster	Modern Vessel Remains	Buffer Avoidance or Assessment
Sabine Bank Secondary Area 2 NW					No	Possible Vessel Remains	Buffer Avoidance or Assessment
Sabine Bank Secondary Area 3 NE	09/07/2013	8.34	None	Previous & Current Avoidance Buffers	Complex Anomaly Cluster	Modern Structural Debris	No Additional Investigation
Sabine Bank Secondary Area 3 SW					No	Possible Vessel Remains	Buffer Avoidance or Assessment
Ship Shoal Primary Area 1 N	09/08/2013-09/09/2013	13.74	Ship Shoal Block 88 BA & Whiskey Is. Sand Source	Previous & Current Avoidance Buffers	No	Possible Vessel Remains	Buffer Avoidance or Assessment
Ship Shoal Primary Area 1 S					No	Possible Vessel Remains	Buffer Avoidance or Assessment
Ship Shoal Primary Area 2	09/10/2013	5.00	South Pelto SP-C	None	Complex Anomaly Cluster	Modern Debris	No Additional Investigation
Ship Shoal Primary Area 3	09/10/2013	22.77		Current Avoidance Buffers	No	Possible Vessel Remains	Buffer Avoidance or Assessment
Ship Shoal Secondary Area 1	09/09/2013	9.93	None	Current Avoidance Buffers	No	Possible Vessel Remains	Buffer Avoidance or Assessment
Ship Shoal Secondary Area 2	09/09/2013	10.99		Current Avoidance Buffers	Sonar Vessel Image	Modern Vessel Remains	Buffer Avoidance or Assessment
Ship Shoal Secondary Area 3	09/10/2013	4.75	South Pelto SP-B	Current Avoidance Buffers	Sonar Vessel Image	Charted Modern Vessel Remains	Dredging Impact Assessment
Ship Shoal Secondary Area 4	09/11/2013	9.27		Previous & Current Avoidance Buffers	No	Charted Obstruction	Buffer Avoidance or Assessment
Ship Shoal Secondary Area 5	09/11/2013	4.75		None	No	BOEM Shipwreck	No Additional Investigation
Hewes Point Secondary Area 1	09/14/2013	12.38	None	Current Avoidance Buffers	No	Possible Vessel Remains	Buffer Avoidance or Assessment
Hewes Point Secondary Area 3	09/12/2013-09/13/2013	21.42		Current Avoidance Buffers	No	Possible Vessel Remains	Buffer Avoidance or Assessment
Hewes Point Secondary Area 4A	09/14/2013	1.49	CH-C	None	Sonar Vessel Image	Modern Trawler Remains	Dredging Impact Assessment
Hewes Point Secondary Area 4B	09/14/2013	1.38		Current Avoidance Buffers	Sonar & Complex Anomaly Cluster	Inundated Terrestrial Structure	Buffer Avoidance or Assessment
St. Bernard Shoals Primary Areas 1&2	09/14/2013-09/15/2013	30.00	SB-C, SB-D & SB-E	Current Avoidance Buffers	No	Possible Vessel Remains	Buffer Avoidance or Assessment
TOTAL		**226.09**					

Table 2: Additional Borrow Area Data

Borrow Area Name	Project Name	Year Investigated	Design Volume (cy)	Year Dredged	Volume Excavated (cy)
CH-C	Louisiana Barrier Berm Oil Spill Response Project	2010	6,713,370	N/A	N/A
CH-B	Louisiana Barrier Berm Oil Spill Response Project	2010	871,032	2010	5,800,000 total from CH-A/B & HDA
CH-A	Louisiana Barrier Berm Oil Spill Response Project	2010	5,225,938	2010	5,800,000 total from CH-A/B & HDA
HDA	Louisiana Barrier Berm Oil Spill Response Project	2010	7,500,000	2010	5,800,000 total from CH-A/B & HDA
6A	Louisiana Barrier Berm Oil Spill Response Project	2010	N/A	N/A	N/A
SB-C	Louisiana Barrier Berm Oil Spill Response Project	2010	2,120,000	N/A	N/A
SB-D	Louisiana Barrier Berm Oil Spill Response Project	2010	310,000	N/A	N/A
SB-E	Louisiana Barrier Berm Oil Spill Response Project	2010	2,108,000	N/A	N/A
Borrow Area HF	Cameron Parish Shoreline Restoration Project (CS-33 SF)	2011	3,780,000	N/A	N/A
Borrow Area JF	Cameron Parish Shoreline Restoration Project (CS-33 SF)	2011	4,050,000	2013	1,900,000
South Pelto SP-A	Exploration for Restoration Quality Sand from Ship Shoal, Louisiana	2006	9,100,000	N/A	N/A
South Pelto SP-B	Exploration for Restoration Quality Sand from Ship Shoal, Louisiana	2006	6,410,000	N/A	N/A
South Pelto SP-C	Caminada Headland Beach and Dune Restoration Increment 1 (BA-45)	2012	5,000,000	2013–2014	3,000,000
Sabine Bank BA1	Holly Beach Breakwater Enhancement Project (CS-01)	2002	3,900,000	N/A	N/A
Sabine Bank BA2	Holly Beach Breakwater Enhancement Project (CS-01)	2002	10,100,000	N/A	N/A
Whiskey Island Sand Source	Caillou Lake Headlands Beach and Dune Restoration	N/A	N/A	N/A	N/A
Ship Shoal Block 88 Borrow Area	Caillou Lake Headlands Beach and Dune Restoration (TE-100)	2014	16,132,601	2016–ongoing	7,500,000 dredged to date; 10,000,000 total will be removed upon completion

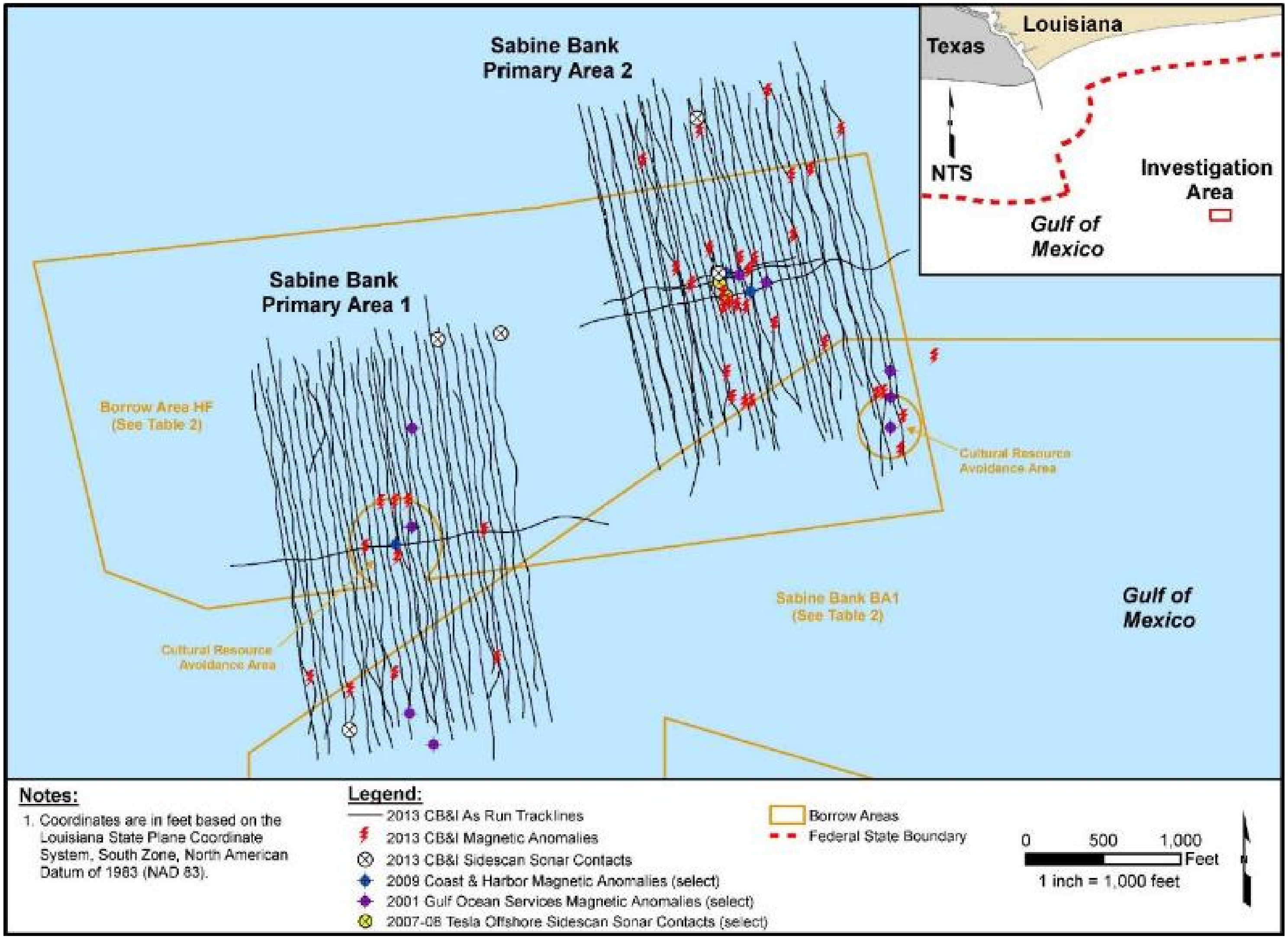

Figure 5. Investigation map for Sabine Bank Primary Areas 1 and 2.

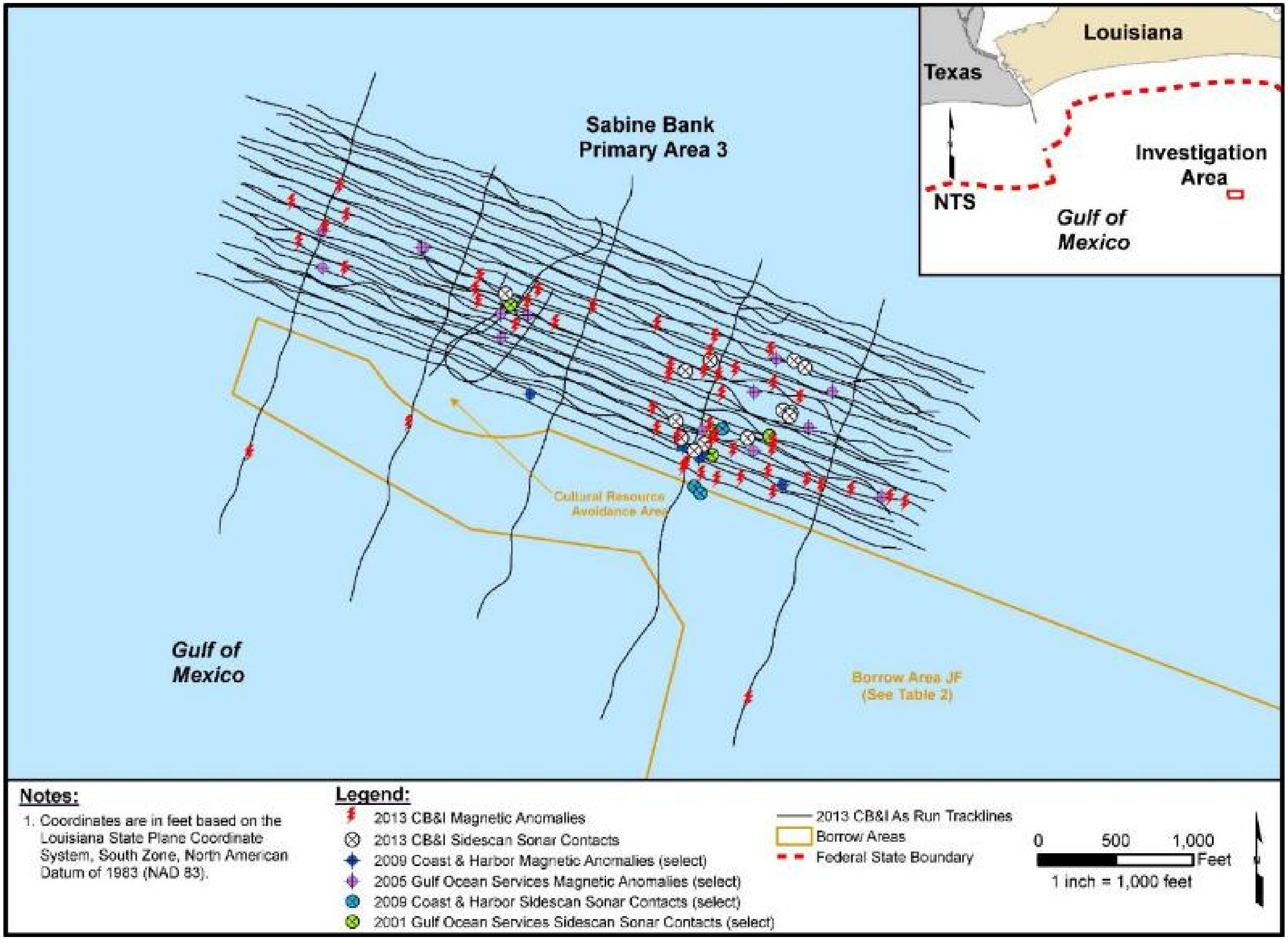

Figure 6. Investigation map for Sabine Bank Primary Area 3.

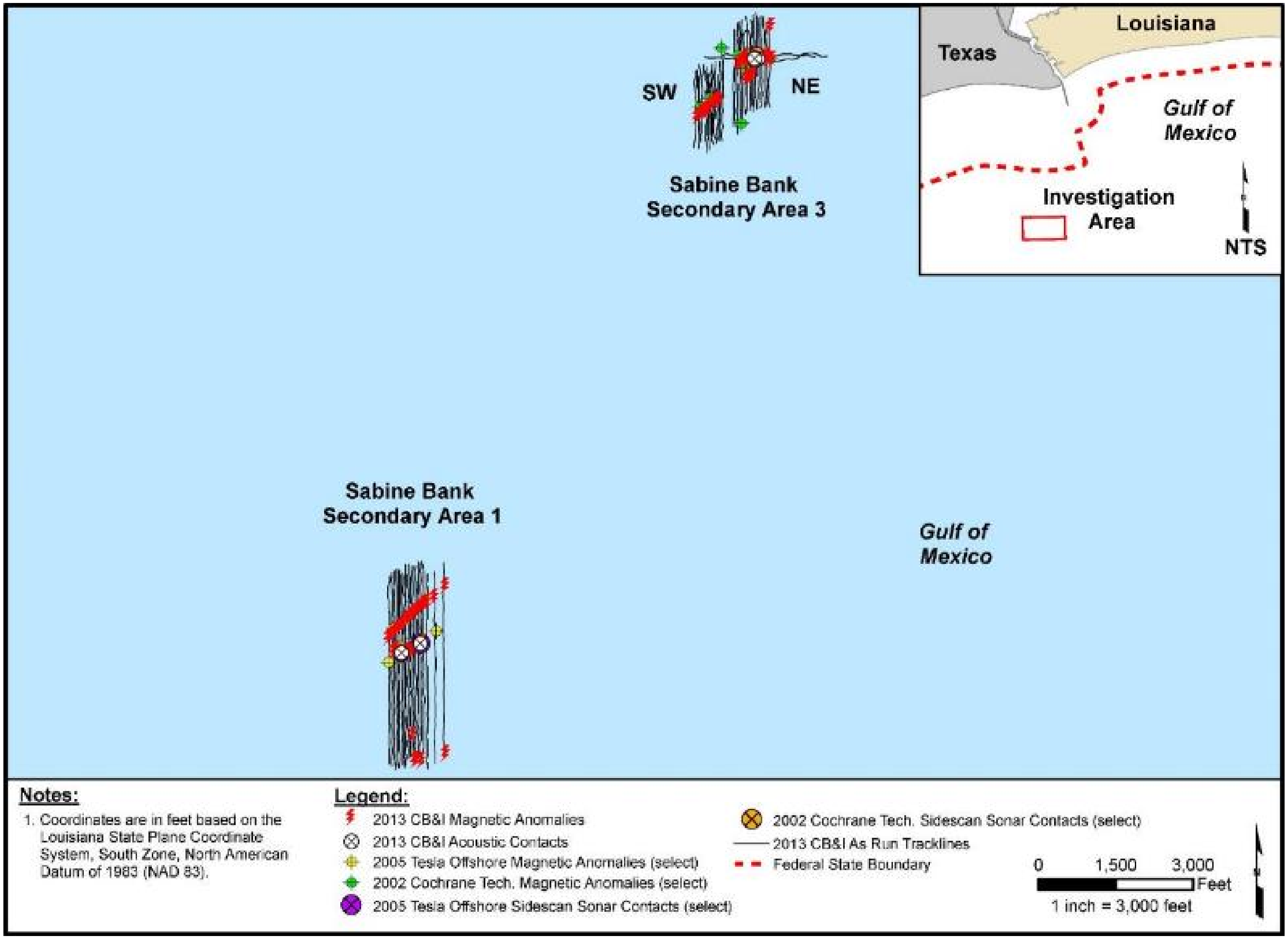

Figure 7. Investigation map for Sabine Bank Secondary Areas 1 and 3.

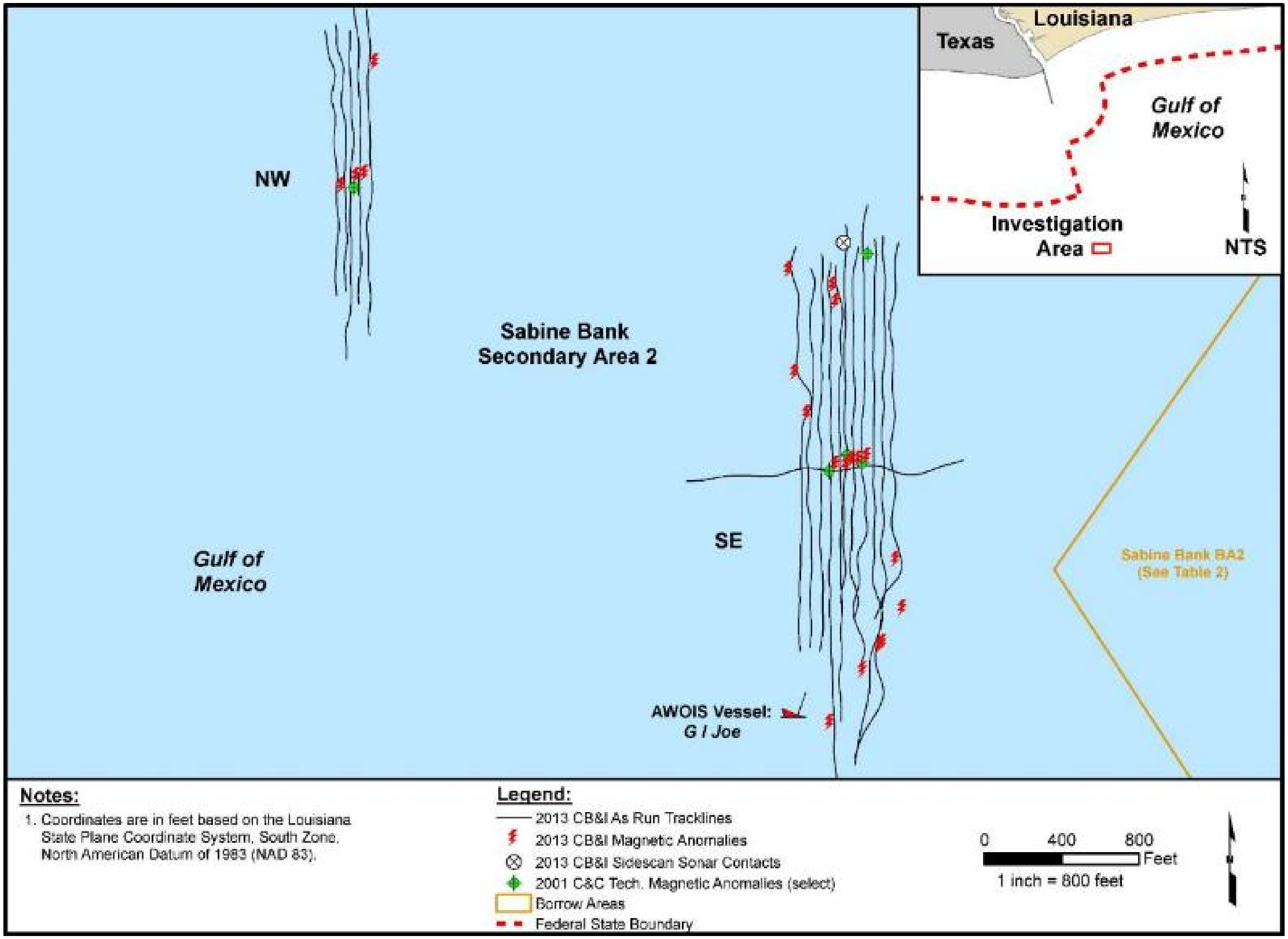

Figure 8. Investigation map for Sabine Bank Secondary Area 2.

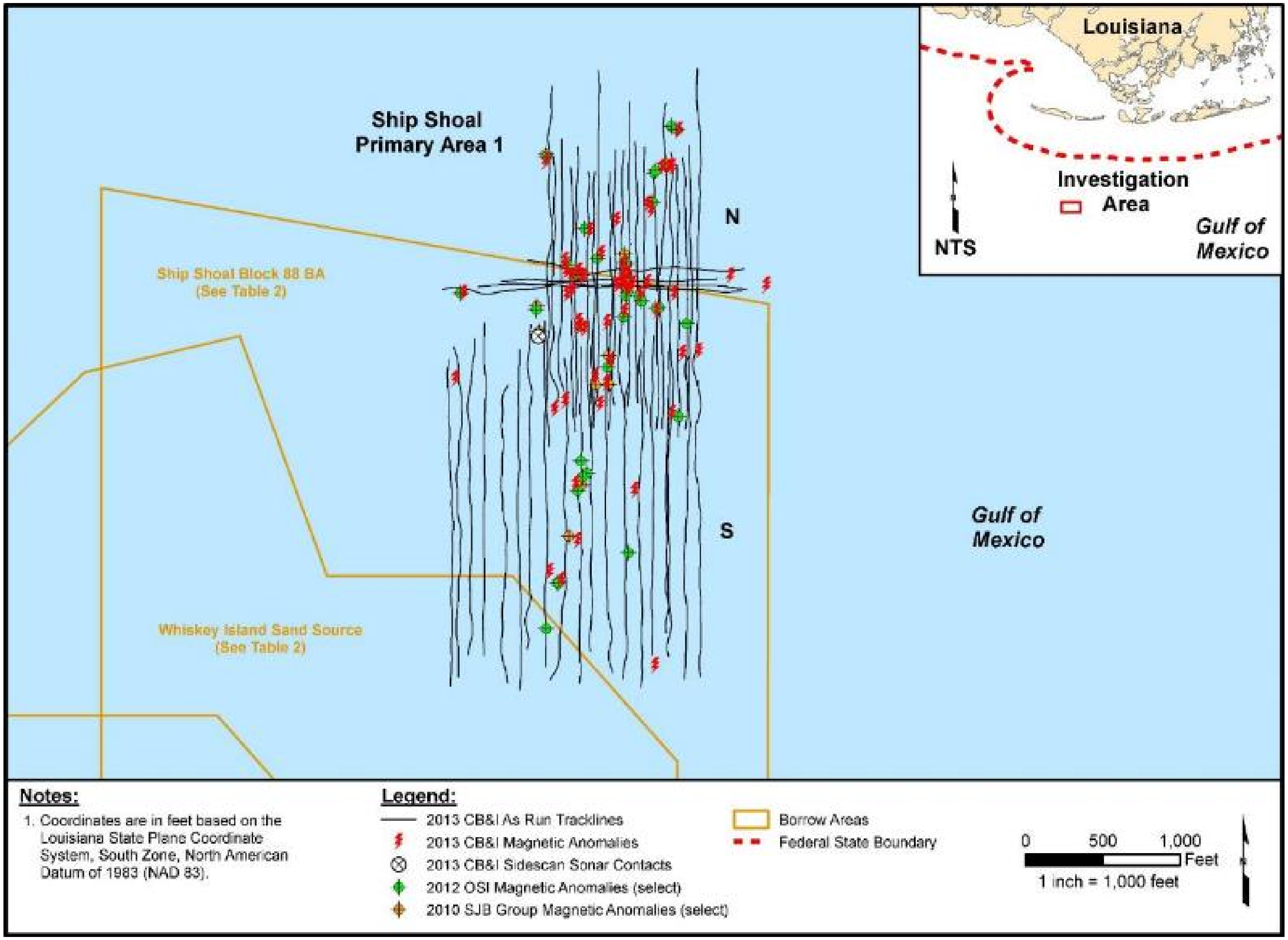

Figure 9. Investigation map for Ship Shoal Primary Area 1.

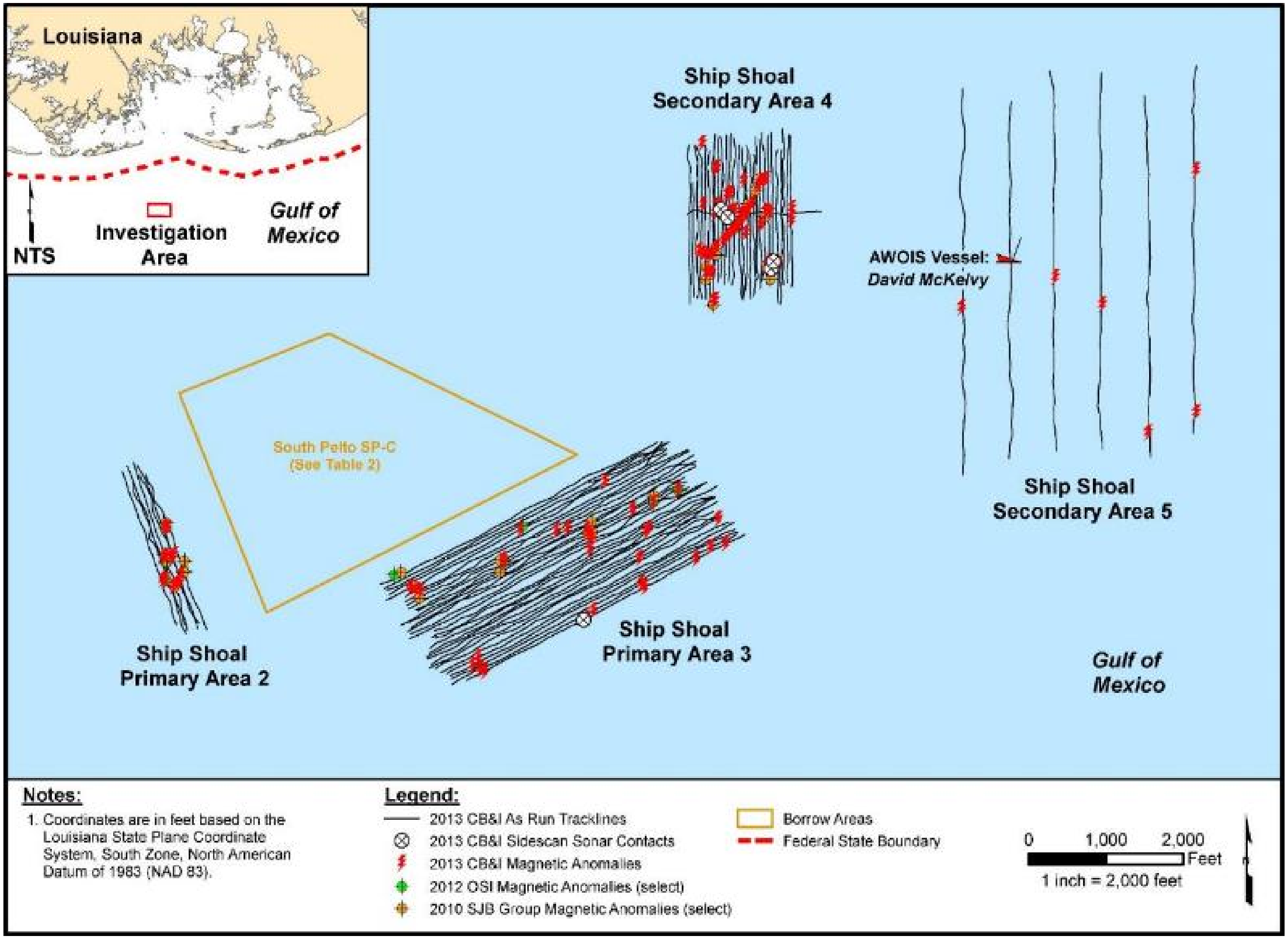

Figure 10. Investigation map for Ship Shoal Primary Areas 2 and 3, and Secondary Areas 4 and 5.

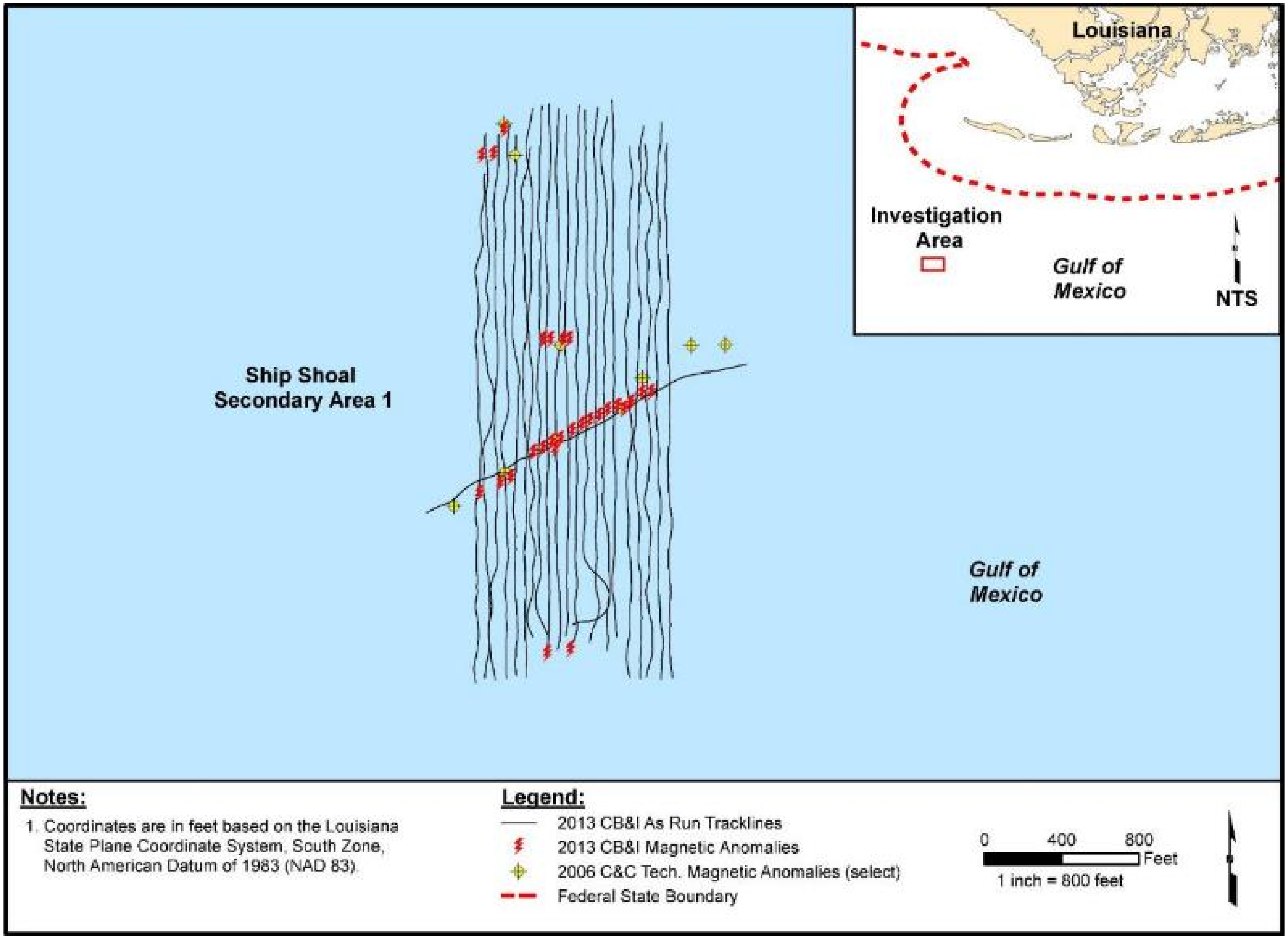

Figure 11. Investigation map for Ship Shoal Secondary Area 1.

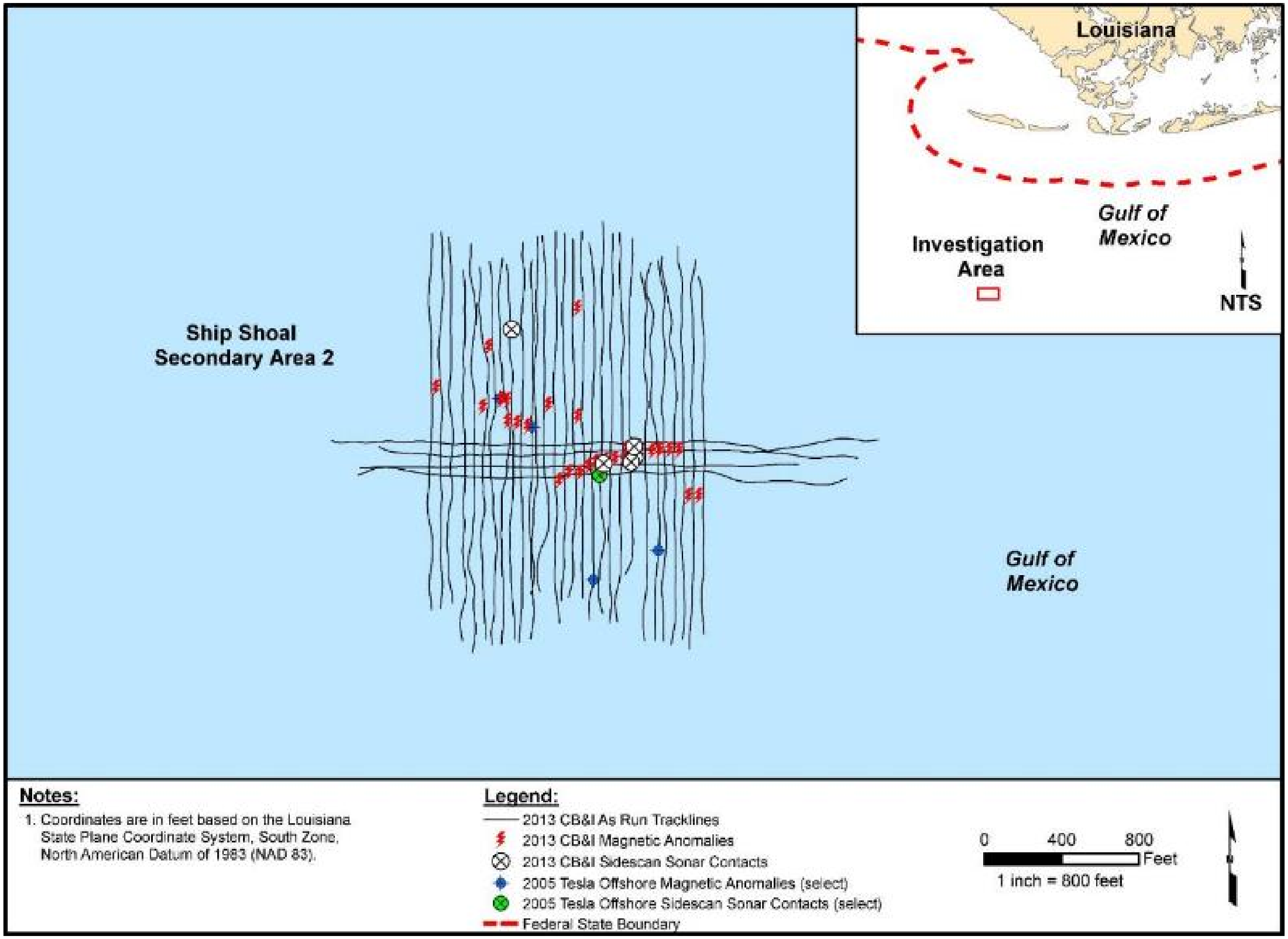

Figure 12. Investigation map for Ship Shoal Secondary Area 2.

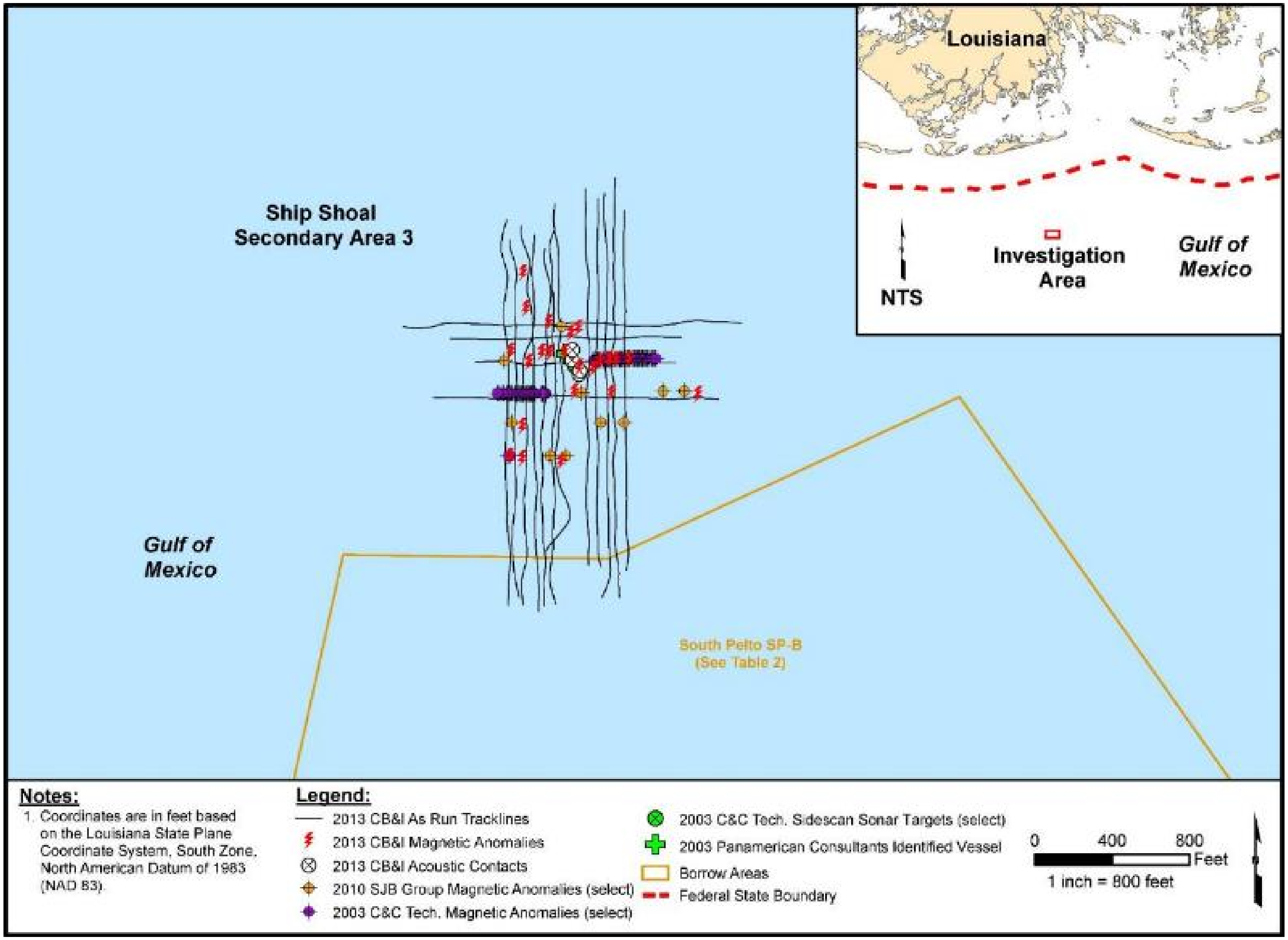

Figure 13. Investigation map for Ship Shoal Secondary Area 3.

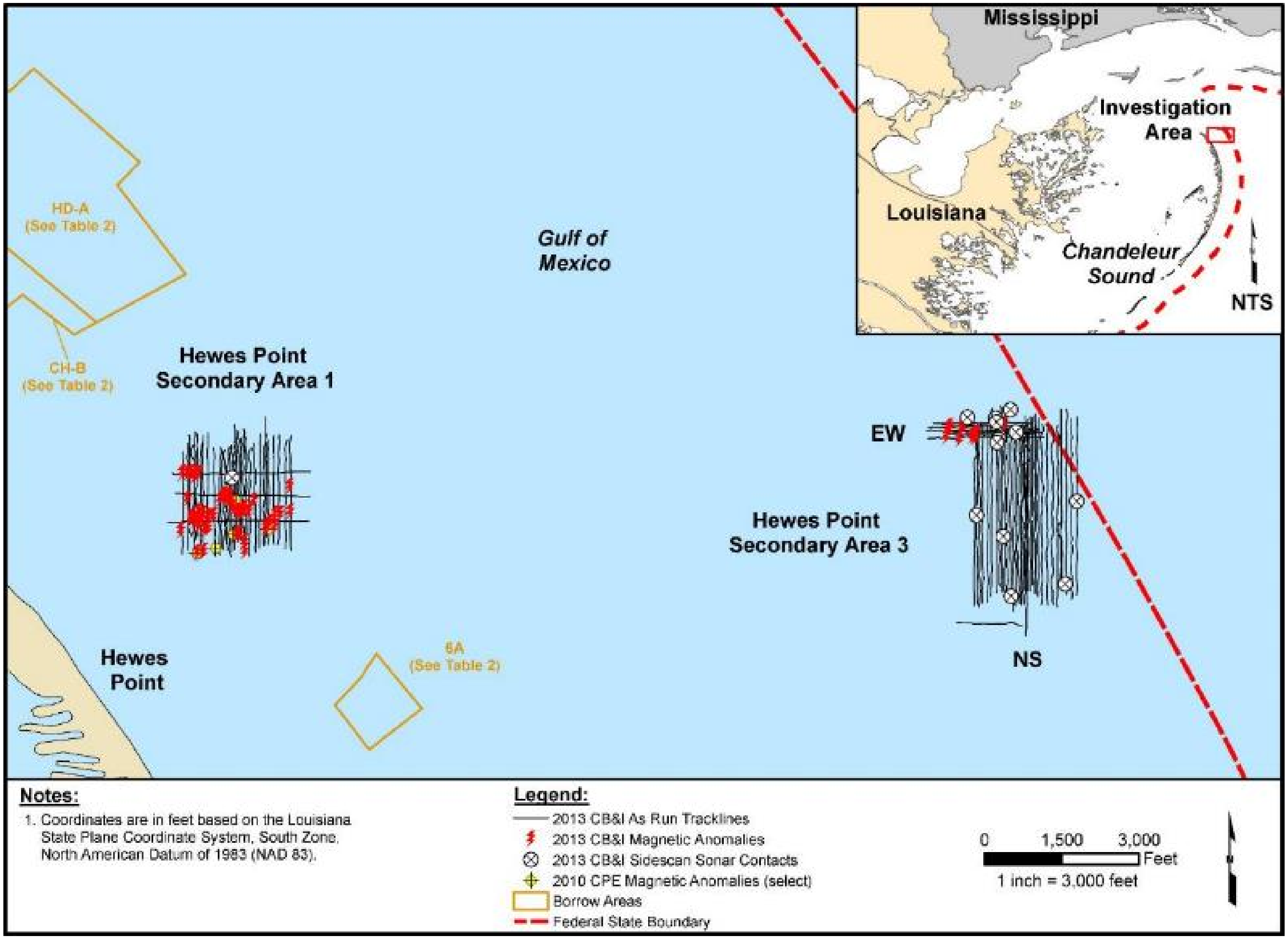

Figure 14. Investigation map for Hewes Point Secondary Areas 1 and 3.

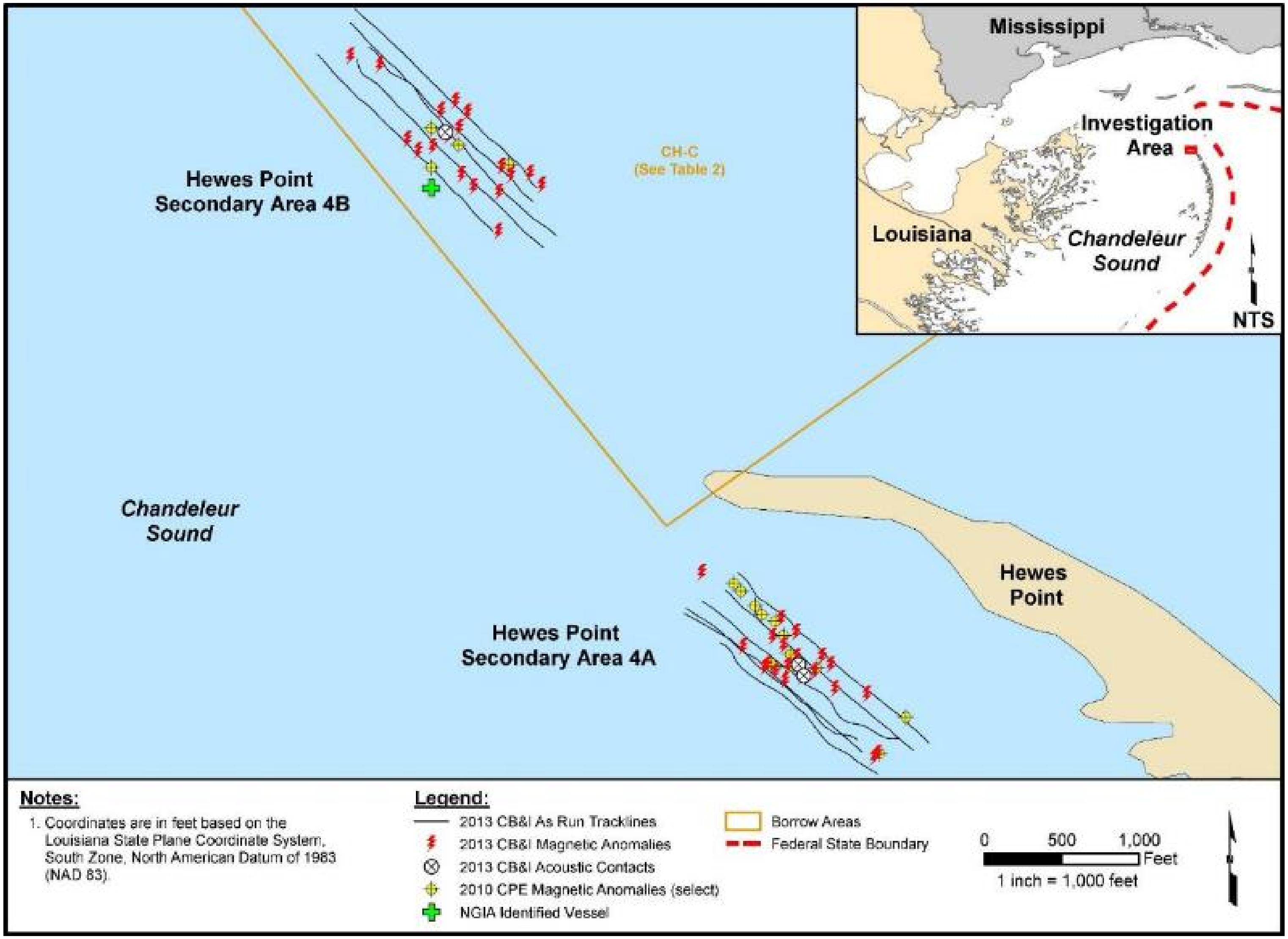

Figure 15. Investigation map for Hewes Point Secondary Areas 4A and 4B.

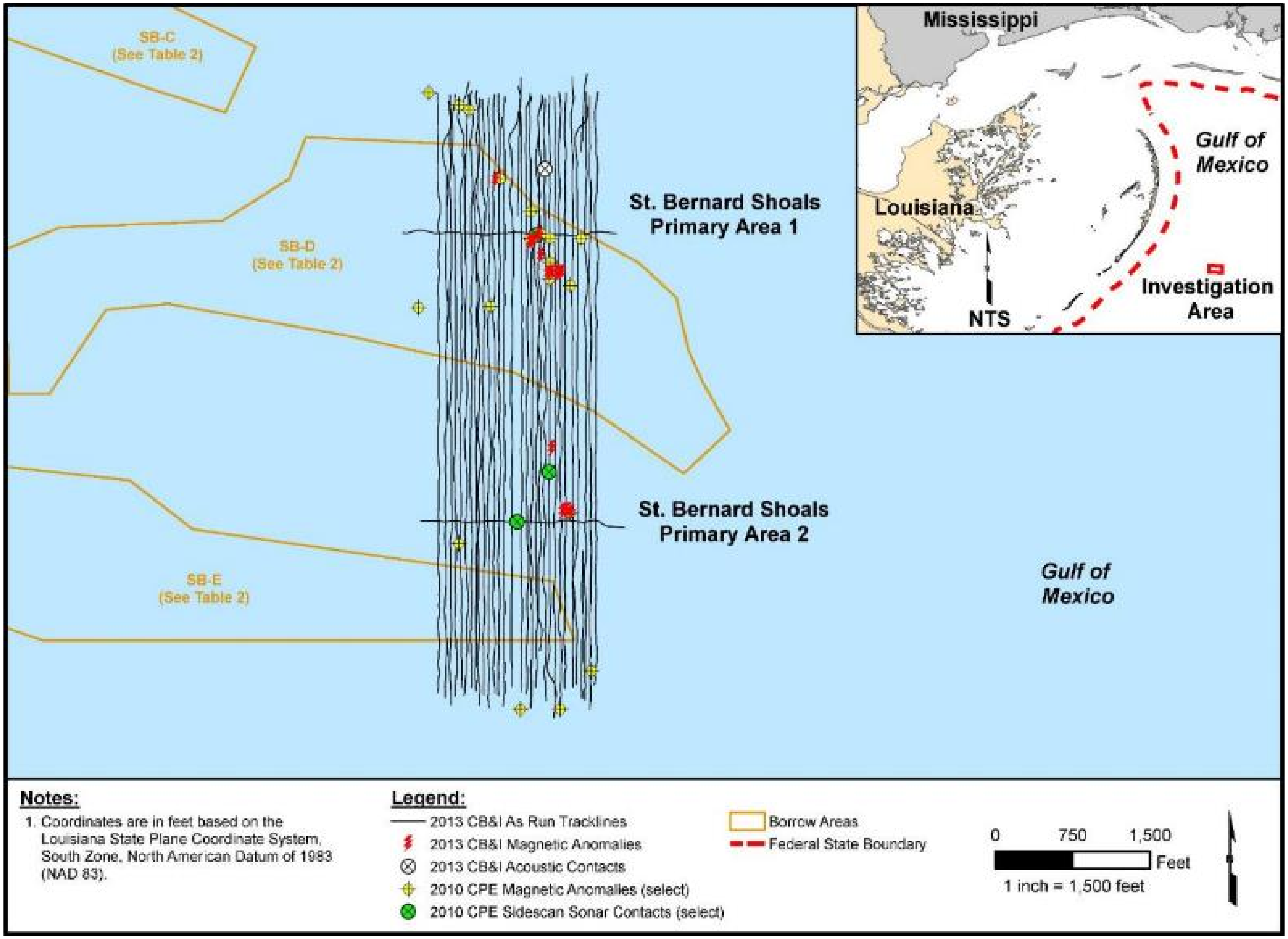

Figure 16. Investigation map for St. Bernard Shoals Primary Areas 1 and 2.

3.1.1.1. Remote Sensing Equipment and Methods

The geophysical and hydrographic data were collected under supervision of a Certified Hydrographer. The bathymetric, sidescan sonar, seismic reflection profiling, and magnetometer surveys were conducted concurrently using the setup illustrated in Figure 17. Sector scanning sonar data were also collected at some locations. The collection and processing of this data is described below. The geophysical equipment used during the Task 1 investigations is listed in Table 3 and described below.

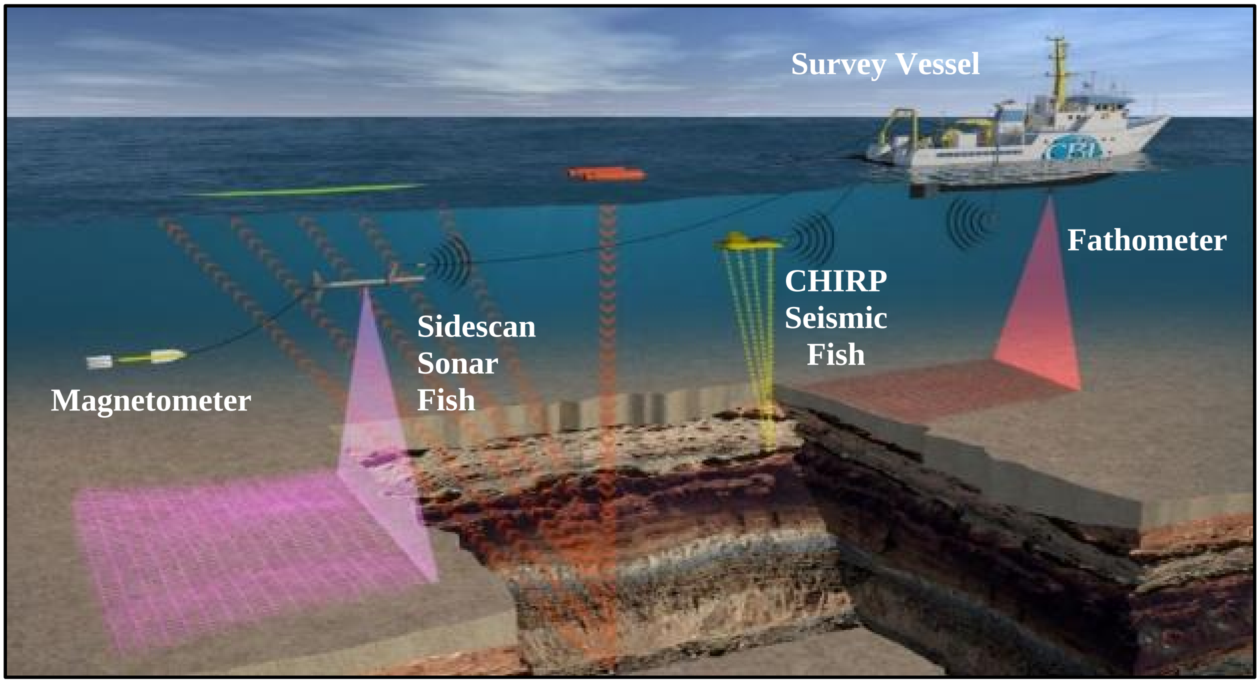

Figure 17. Schematic diagram showing the deployment of a joint seismic reflection profile, bathymetric, magnetometer, and sidescan sonar survey.

Table 3: Equipment used during the Task 1 geophysical investigations

Equipment Type	Description
Navigation	Trimble DGPS and C-Nav 3050 interfaced with Hypack Inc.'s Hypack 2013® software
Sounder (bathymetry)	Odom Hydrographic Systems, Inc. Single Beam Echo Sounder
Sub-bottom profiler (seismic reflection)	EdgeTech X-STAR SB-512i Sub-bottom Profiler
Sidescan sonar	EdgeTech 4200 Dual Frequency Sidescan Sonar
Sector scanning sonar	Kongsberg Mesotech Sector Scanning Sonar
Magnetometer	Geometrics G-882 Digital Cesium Marine Magnetometer interfaced with Hypack Inc.'s Hypack 2013® software

3.1.1.1.1. Motion Compensation

A Teledyne TSS Dynamic Motion Sensor heave sensor (DMS-H) was used to compensate for survey vessel motion caused by vessel maneuvering and/or sea state. The DMS-H provides motion measurements for vessel heave, pitch, and roll in real time. The motion data were sent to Hypack 2013® software where it was recorded and applied to sounding data for real time review by the survey crew.

3.1.1.1.2. Datums

All vertical data were collected in the North American Vertical Datum of 1988 (NAVD88). All horizontal data were collected in the Louisiana State Plane Coordinate System, South Zone, North American Datum of 1983 (NAD83). All horizontal and vertical data were collected in U.S. survey feet.

3.1.1.1.3. Navigation and Water Levels

A Trimble Differential Global Positioning System (DPGS) and a C-Nav 3050 were used for vessel navigation and horizontal positioning for all data sets. The C-Nav 3050 uses a subscription-based Satellite-Based Augmentation System (SBAS) correction and provides differential accuracy in areas outside the range of United States Coast Guard beacons or Real-Time Kinematic (RTK) GPS base station VHF corrections. Water level corrections were based on a combination of National Oceanic and Atmospheric Administration (NOAA) water level data, predicted tide data, and SBAS GPS derived water level correction.

3.1.1.1.4. Hypack Inc.'s Hypack 2013® Data Collection and Processing System

Navigational, magnetometer, and depth sounder systems were interfaced with an onboard computer, and the data were integrated in real time using Hypack Inc.'s Hypack 2013® software. Hypack 2013® is a state-of-the-art navigation and hydrographic surveying system. The location of the fish tow-point or transducer mount on the vessel in relation to the GPS was measured, recorded, and entered into the Hypack 2013® survey program. The length of cable deployed between the tow-point and each towfish also was measured and entered into Hypack 2013®. Hypack 2013® then takes these values and monitors the actual position of each system in real time. Online screen graphic displays include the pre-plotted survey lines, the updated boat track across the survey area, adjustable left or right indicator, as well as other positioning information such as boat speed, quality of fix measured by Position Dilution of Precision (PDOP), and line bearing. The digital data are merged with the positioning data, video displayed and recorded to the acquisition computer's hard disk for post processing and/or replay.

3.1.1.1.5. Bathymetric Survey

The bathymetric survey was conducted using an ODOM Hydrotrac echosounder with digitizer operating at 200 kHz on the R/V *Kimberly Dawn*. Data were digitally stored using Hypack 2013®. A Trimble DPGS, C-Nav 3050, and a TSS dynamic motion sensor were used onboard the survey vessel to provide navigation, water level corrections, and dynamic motion corrections. NOAA water level data and predicted tides stations were used to verify and/or adjust water level corrections for bathymetric readings. To maintain the vessel navigation along the profile lines, Hypack 2013® navigation software was used. This software provided horizontal position to the sounding data which allowed real-time review of the data in plan view or cross-section format.

Hypack 2013® also provided navigation to the helm to minimize deviation from the online azimuth.

3.1.1.1.6. Magnetometer Survey

High-resolution magnetic remote sensing was used to identify ferrous objects that could represent potential cultural resources or shallow hazards. A Geometrics G-882 Digital Cesium Marine Magnetometer, capable of a ±0.1 gamma resolution, was used to perform an investigation of magnetic anomalies within the survey areas (Figure 18). The Hypack 2013® software recorded magnetic anomalies directly from the magnetometer. The G-882 was floated between 175 and 200 ft. (53 to 61 m) behind the survey vessel to minimize recording magnetic signatures from the survey vessel. To produce a magnetic record of sufficient resolution, the sensor was deployed and maintained in the water column approximately 10 to 20 feet above the seafloor. A computer recorder provided a continuous record of the magnetic background and target signatures. Positioning data generated by the navigation system were tied to magnetometer records by regular annotations to facilitate target location and anomaly analysis. Annotations included line number, date and time of start and end of each line, and target identification.

Figure 18. Geometrics G-882 Digital Cesium Marine Magnetometer used to identify magnetic anomalies within the survey areas.

3.1.1.1.7. Sub-Bottom Profiler Survey

A chirp sub-bottom profiler was used to image shallow (<50 ft., <15 m) subsurface sedimentary stratigraphy and to identify potential cultural resources, paleolandforms, manmade objects/infrastructure, and other subsurface features of interest. The use of chirp sub-bottom profilers allowed for imaging and mapping of paleochannel complexes and common stratigraphic layers throughout the study area. An EdgeTech X-STAR Sub-Bottom Profiler with an SB-512i towfish was used to conduct the seismic-reflection sub-bottom profile surveys (Figure 19).

The X-STAR full spectrum sonar is a versatile wideband FM sub-bottom profiler that collects digital normal incidence reflection data over many frequency ranges. This instrumentation generates cross-sectional images of the seabed (to a depth of up to 50 ft. (15 m) in this survey). The X-STAR SB-512i transmits an FM pulse that is linearly swept over a full spectrum frequency range (also called a "chirp pulse"). The tapered waveform spectrum results in images that have virtually constant resolution with depth. The chirp systems have an advantage over 3.5 kHz and "boomer" systems in sediment delineation because the reflectors are more discrete and less susceptible to ringing from both vessel and ambient noise. The full-wave rectified reflection horizons are cleaner and more distinct than the half-wave rectified reflections produced by older analog systems.

The X-STAR SB-512i, the newest model in the EdgeTech suite of chirp full spectrum sub-bottom towfish, differs from the older X-STAR SB-512 (which had four 6" diameter transducers) by having a single 13" diameter low frequency transducer and a single 6.5" diameter high frequency transducer. The new low frequency transducer provides more low frequency energy at all pulse settings, which allows deeper penetration of seafloor sediments while at the same time maintaining the high-resolution of the original configuration.

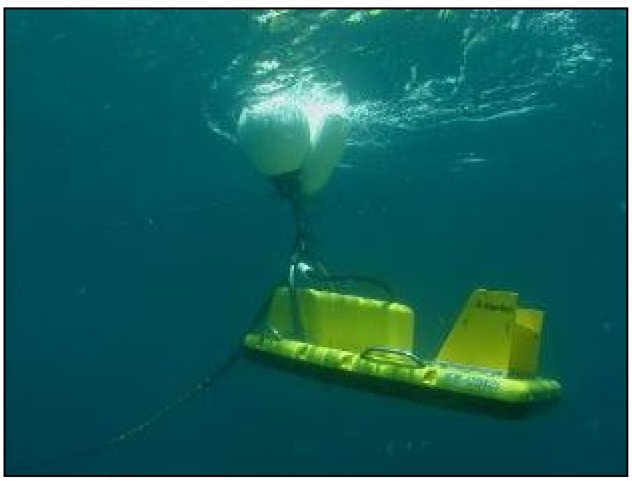

Figure 19. EdgeTech X-STAR SB-512i sub-bottom profiling system shown after deployment.

3.1.1.1.8. Sidescan Sonar Survey

Sidescan sonar data were collected to verify the location and extent of unconsolidated sediment and to map ocean bottom features such as benthic habitats, exposed pipelines, cables, shipwrecks, and other potential cultural resources. The TAR team conducted the sidescan sonar survey using an EdgeTech 4200 (Figure 20). The EdgeTech sidescan sonar systems use full-spectrum chirp technology to deliver wide-band, high-energy pulses coupled with high-resolution and good signal-to-noise ratio echo data. The sonar package included a portable configuration with a laptop computer running EdgeTech's Discover® acquisition software and dual frequency towfish running in high definition mode. The EdgeTech 4200 multi-purpose sidescan sonar system consists of a dual frequency towfish operating at 600/1600 kHz, with maximum range scales of 246 ft. (75 m) to either side of the towfish at 600 kHz and 492 ft. (150 m) to either side of the towfish at 1600 kHz.

Figure 20. EdgeTech 4200 dual frequency sidescan sonar system.

3.1.1.1.9. Sector Scan Sonar Survey

Sector scan sonar data were acquired before dives or vibracoring operations to verify that the area was free of obstructions. The sector scan sonar was also used to identify potential cultural resources and direct archaeological divers to those sites in low visibility conditions. BOEM provided a Kongsberg Mesotech MS1000 sonar system for use during this project. This system consists of a high-resolution, single-beam scanning sonar, using a 0.9 degree fan beam imaging transducer to scan the specified regions about the proposed vibracore sites. The sonar package included a portable configuration with a laptop computer running the Kongsberg MS1000 acquisition software and a 675-kHz frequency high-resolution scanning sonar head. The sonar head was mounted within a tripod, allowing the head to freely rotate 360 degrees.

During the 2014 Phase II investigations, the sector scan sonar was deployed from the survey vessels via the stern of the R/V *Kimberly Dawn* and the bow of the M/V *Thunderforce*. During the 2016 Phase II operations the sector scan was deployed from convenient locations aboard the M/V *Mantis* and F/V *Shearwate*r. Scanning was used to view any obstructions for diver safety, diver assisted vibracores, pneumatic vibracores, and any anchoring. The survey was conducted in such a manner as to protect any potential cultural resources. The sonar's rotating head provided scans of 0.5 to 100 meters (1.6 to 328 ft.) in all directions imaging full coverage of the site. MS 1000 sonar data were correlated with positioning data (DGPS via Hypack 2013®). The positioning data allowed the operator to determine the total area covered, set targets, and review data in real-time. All data were time tagged and digitally recorded to a disk for post processing and/or replay.

3.1.1.1.10. Acoustic Doppler Current Profile (ADCP) Collection

To obtain measurements of surface waves, tidal fluctuations, and current speeds and direction, ADCP's were deployed at sites at Sabine Bank (Figure 21) and Ship Shoal (Figure 22) on December 8, 2014 and December 9, 2014 respectively. Sabine Bank and Ship Shoal locations were selected as they are primary sand source options for future beach nourishment projects. The winter deployment was chosen to take advantage of higher storm rates and the increased possibility of capturing a storm event. A Nortek AWAC ADCP and a TRDI Workhorse Sentinel ADCP were deployed. Both locations were measured at 200 pings per ensamble, 1.5 seconds per ping, ensamble intervals of 300 seconds (5 minutes) with a bin size of 0.5 meters. The ADCP's were retrieved on January 21, 2015. The greater than one month deployment was designed to capture a full tidal cycle at the respective location. The data were downloaded and reviewed for quality and completeness.

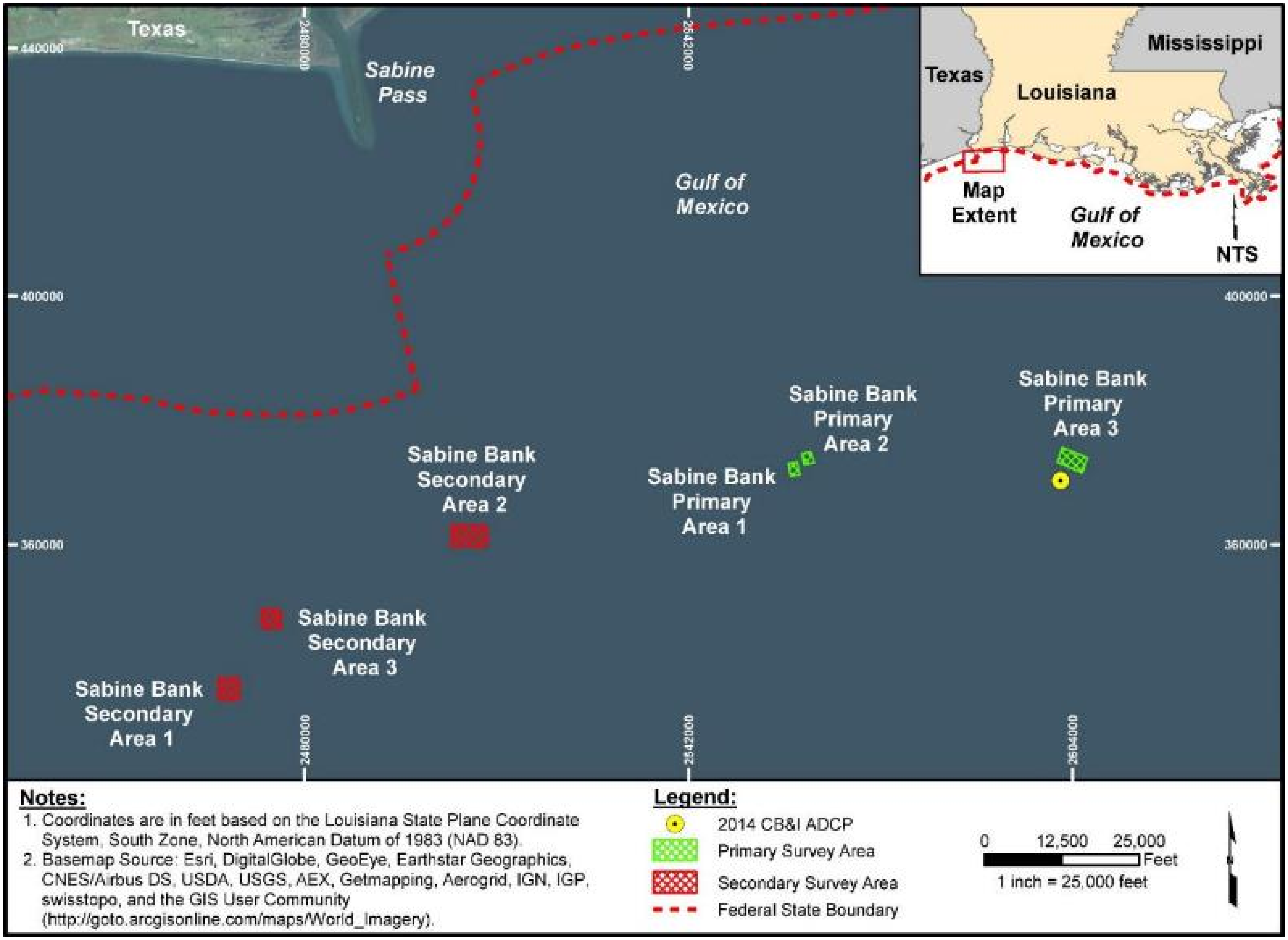

Figure 21: Sabine Bank ADCP location.

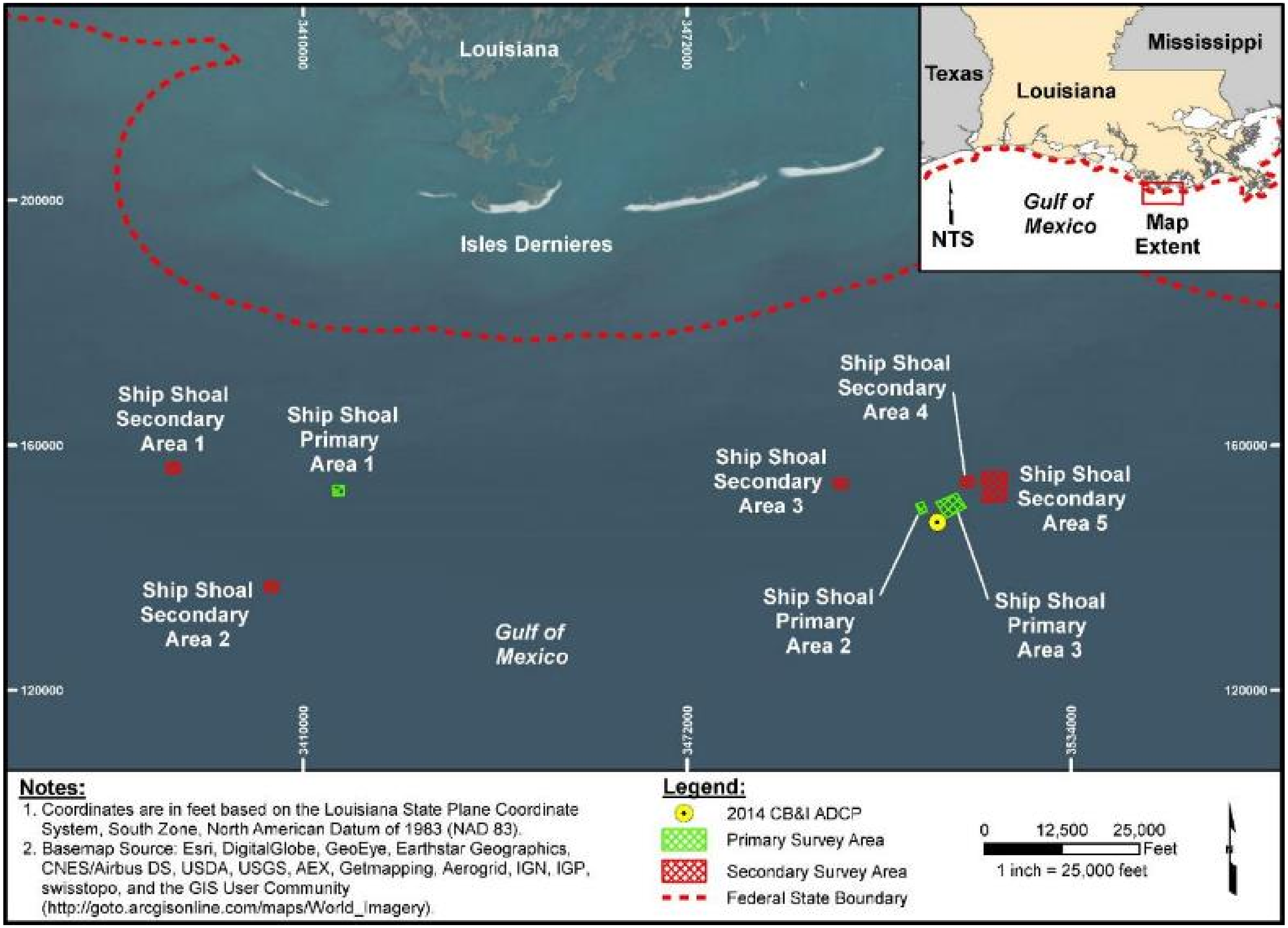

Figure 22: Ship Shoal ADCP location.

3.1.2. Data Processing

The data collected during the Task 1 geophysical investigations were analyzed to identify potential sites for archaeological diver investigation.

3.1.2.1. Bathymetric Data

After field work was completed, data were edited and processed using Hypack 2013®. The offshore raw digital data were viewed and edited in Hypack 2013® using Single Beam Max. Water level corrected data were exported and a comma delimited XYZ file was created. All overlapping profile data were compared in cross section format to ensure system accuracy. For surface and map creation the final XYZ data files were processed through Golden Software's Surfer 12 for interpolation and grid creation. Esri's ArcGIS 10.3 was used for final interpolation and presentation.

3.1.2.2. Magnetometer Data

The magnetometer data were post-processed using Hypack®. Raw data from each survey line was systematically reviewed and each anomaly identified according to survey line, geographical location coordinates, anomaly sequence on line, signature characteristics, signature intensity, and signature duration. Edited magnetic data were converted to a sorted data file in Hypack®. The sorted data file was contoured using Surfer software for analysis and presentation. Contoured data maps of each survey area were prepared as Esri GIS maps to identify anomaly distribution, potentially significant anomalies and/or clusters, recommended buffers, and sonar target associations.

3.1.2.3. Sub-bottom Profile Data

Post-collection processing of the sub-bottom profiler data was completed using Chesapeake Technology, Inc.'s SonarWiz 6© software. This software allows the user to apply specific gains and settings in order to produce enhanced sub-bottom imagery that can be interpreted and digitized for specific stratigraphic facies relevant to the project goals. The data were continuously bottom-tracked to allow for the application of real-time gain functions in order to have an optimal in-the-field view of the data.

CB&I geophysicists processed the imagery to reduce noise effects (commonly due to the vessel, sea state, or other natural and anthropogenic phenomenon) and enhance stratigraphy. This was done using the processing features available in SonarWiz 6©, including AGC and swell filter. In order to appropriately apply the swell filter and AGC functions, the sub-bottom data were bottom-tracked to produce an accurate baseline representation of the seafloor. Once this was done through a process of automatic bottom tracking (based on the high-amplitude signal associated with the seafloor) and manual digitization where required, the swell filter and AGC were applied to the data. The swell filter is based on a ping averaging function that removes vertical changes in the data due to towfish movement caused by the sea state and/or towfish motion. The swell filter was increased or decreased depending on the period and frequency of the sea surface wave conditions. However, special care was taken during this phase to not remove or smooth over geologic features that are masked by the sea state noise. The user was able to remove the noise within the water column, increase the contrast within the stratigraphy, and increase the amplitude of the stratigraphy with depth, accounting for some of the signal attenuation normally associated with sound penetration over time.

3.1.2.4. Sidescan Sonar Data

Post-processing of the sidescan sonar data was completed using Chesapeake Technology, Inc.'s SonarWiz 6© software. This software allows the user to apply specific gains and settings in order to produce enhanced sidescan sonar imagery.

The first step in data processing was to import the raw sidescan sonar data into the SonarWiz 6© software. Data were bottom-tracked to remove the water column (nadir). Bottom tracking was achieved by using an automated bottom tracking routine which determines the first return signal in the data and provides an accurate baseline representation of the seafloor and eliminates the water column from the data. In some cases manual bottom tracking was necessary when the automated bottom tracking could not accurately determine the first return in the sidescan sonar record. In this case, the processor manually determines the first return in the data.

Once the data were bottom-tracked, they were processed to reduce noise effects (commonly due to the vessel or sea state) and enhance the seafloor definition. In most cases automatic time-varying gain (TVG) was sufficient to provide the best imagery. TVG divided the data into parallel swaths and equalized backscatter of each swath to create a normalized image highlighting contrast change throughout the image. This created a better mosaic and allowed the processer to identify areas with similar acoustic properties. In areas with high levels of noise in the data it was necessary to apply automatic gain control (AGC) which normalized the data by strengthening quiet regions and soft returns while simultaneously reducing or eliminating overly strong returns by obtaining a local average at a given point. After processing each line, the data were inspected and interpreted.

3.1.2.5. Sector Scanning Sonar Data

Post-processing of the sector scan data was completed using Kongsberg's MS 1000 processing software. This software allows the user to apply specific gains and settings in order to produce enhanced imagery that can be georeferenced for mapping. Data were imported into the processing software to identify potential cultural resource features. A track plotter module was used to plot the scanned area, geo-reference targets, and create geotiffs for future plotting. This step provided an accurate location of potential cultural resources. Once the locations were observed and cleared by an archaeologist, vibracores were collected within 50 feet (15 m) of the proposed core site.

3.2. Core Boring Collection

During Task 2, the TAR team collected and analyzed sediment cores to characterize sand resources in the vicinity of the potential shipwreck sites that were identified. Nine vibracores were collected from Ship Shoal (Figure 23) between August 21 and August 24, 2014. Ten vibracores were collected from Sabine Bank (Figure 24) between February 1 and February 3, 2015. At Sabine Bank, archaeologists cleared each site before a vibracore was collected.

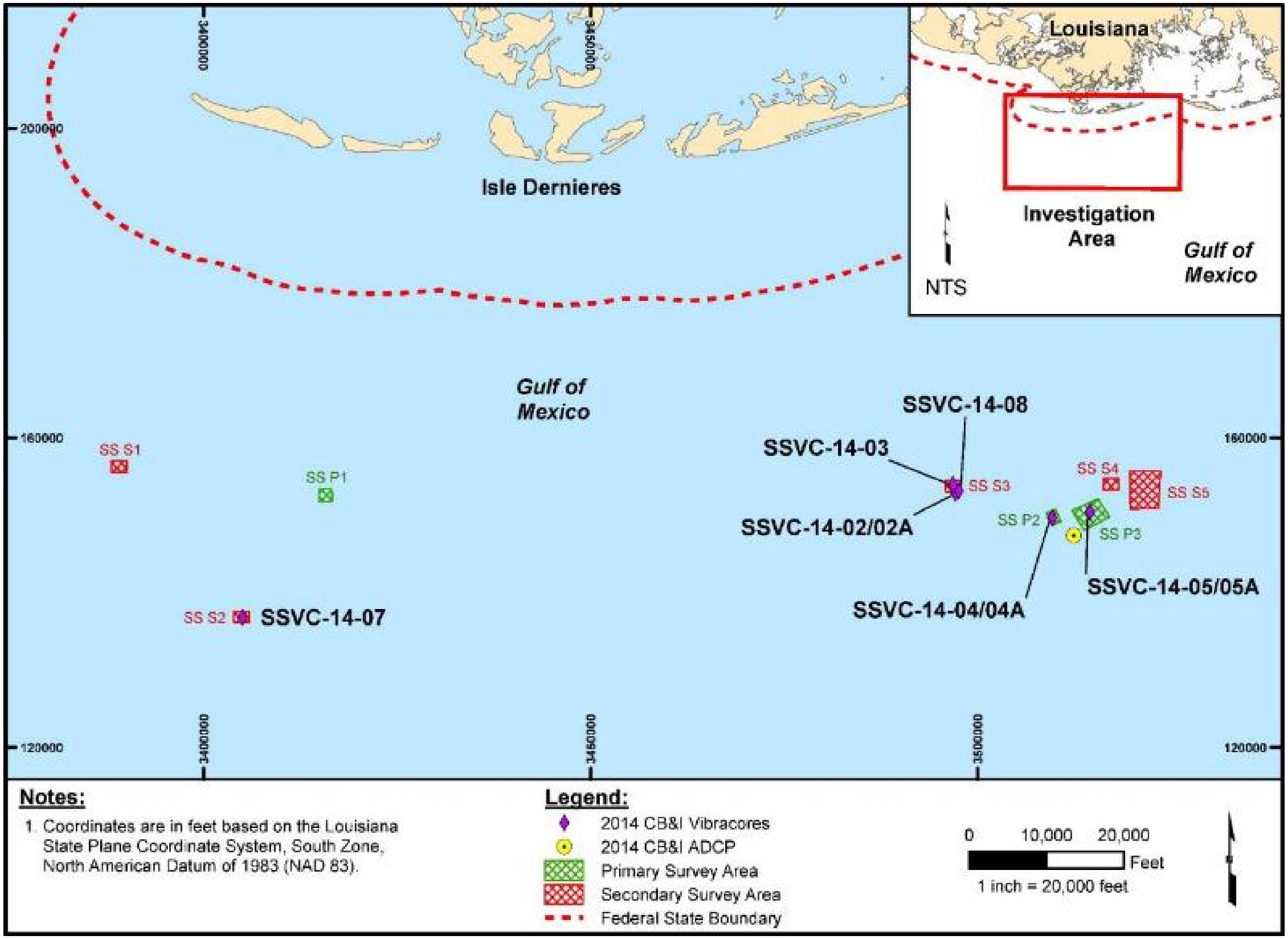

Figure 23: Ship Shoal vibracore locations.

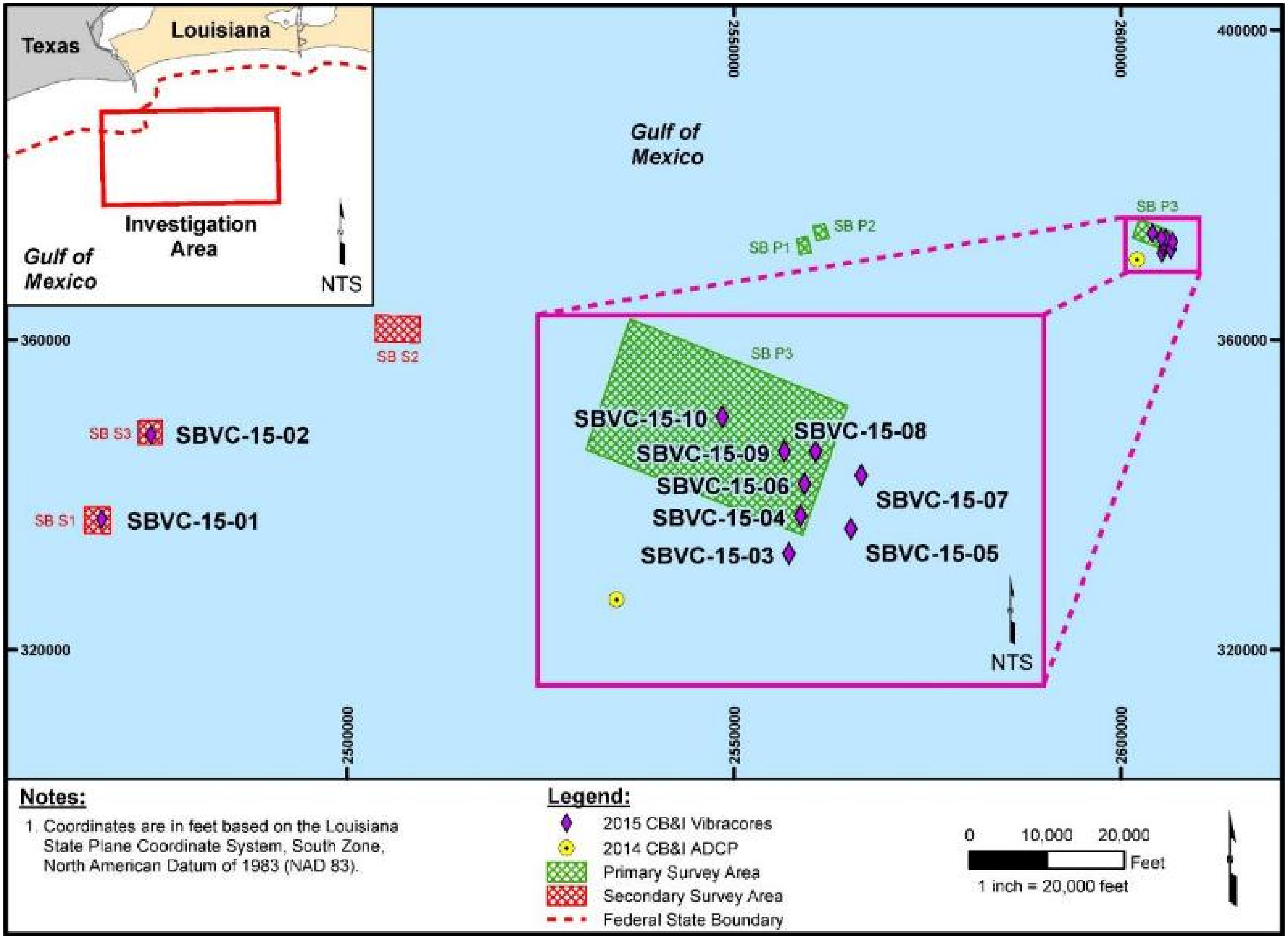

Figure 24: Sabine Bank vibracore locations.

3.2.1. Equipment and Methods

Vibracores were collected using two methods. The vibracores collected from Sabine Bank were collected using a pneumatic vibracore system and the vibracores collected from Ship Shoal were collected using a diver-operated vibracore system.

The pneumatic system is a self-contained, freestanding pneumatic vibracore unit with an air-driven vibratory hammer assembly, an aluminum H-beam which acts as the vertical beam upright on the seafloor, 20 ft. (6 m) long steel tubes measuring 4” in diameter (with a plastic core liner), and a drilling bit with a cutting edge. An air hose array provides compressed air from the compressor on deck to drive the vibracore. The vibracore unit was truck-crane deployed from the M/V *Thunderforce*.

If recovery was less than 80% of the expected penetration, the pipe was removed, a new pipe inserted, and a jet pump hose was attached just below the vibracore head. The rig was, again, lowered to the bottom and jetted into the sediment just above refusal depth. The jet was then turned off and the vibrator resumed collecting the lower part of the core. Each vibracore was attempted up to three times until 80% recovery was obtained.

The diver operated vibracore system used to collect the Ship Shoal vibracores used scientific divers and a pneumatic vibracore system configured to collect undisturbed sediment cores up to 20 feet (6 m) in length. The BH-4 style vibrator apparatus was a single piston, pneumatically driven vibrator that was retrofitted to a 3-inch aluminum pipe. An air hose array provided compressed air from a compressor on the deck of the support vessel.

The vibracores were measured, marked, and cut into 5-ft. (1.5 m) sections on deck. The cores were labeled and transported to CB&I’s office in Boca Raton, Florida. The vibracores were split and logged by describing sedimentary properties by layer in terms of layer thickness, color, texture (grain size), composition, and presence of clay, silt, gravel, or shell and any other identifying features. Wet Munsell color was determined in accordance with American Society for Testing and Materials (ASTM) Standard Materials Designation D2488-00 for description and identification of soils (visual-manual procedure) (ASTM, 2009). The vibracores were digitally photographed against an 18% gray background (Volume III: Appendix RR). This is the standard reference value against which all camera light meters are calibrated. Sediment samples were obtained from irregular intervals based on distinct layers in the sediment sequence. The unsampled half of each core was then archived.

The techniques used for particle size analysis are dependent on the nature of the sediment. Although sieve analysis is suitable for sand and gravel fractions, it is not the most appropriate method for silt and clay fractions.

3.2.2. Sediment Grain Size (Mechanical) Analysis

During sieve analysis, dry and washed Munsell colors were noted. Sieve analyses were conducted on all sediment samples in accordance with American Society for Testing and Materials Standard Materials Designation D422-63 for particle size analysis of soils (ASTM, 2007). This method covered the quantitative determination of the distribution of sand size particles. For sediment finer than the No. 230 sieve (4.0 phi), Designation D1140-00 was followed (ASTM, 2006). Mechanical sieving was accomplished using calibrated sieves with a gradation of half-phi intervals. Additional sieves representing key ASTM sediment classification boundaries were included. Weights retained on each sieve were recorded cumulatively.

Grain-size data were entered into the gINT® software program, which computes the mean and median grain size, sorting, and silt/clay percentages for each sample using the moment method (Folk, 1974). A summary of grain size results were displayed on the vibracore logs (Volume III: Appendix QQ). Granularmetric reports and grain size distribution curves were compiled for each sample (Volume III: Appendix SS; Volume III: Appendix TT).

3.2.2.1. Carbonate Content Determination

Carbonate content was determined by percent weight on 24 Sabine Bank and 15 Ship Shoal samples using the acid leaching methodology described in Twenhofel and Tyler (1941). Results were entered into the gINT® software and displayed on the granularmetric reports (Volume III: Appendix SS).

3.2.2.2. Clay Sample Analysis

Clays are distinguished from other fine-grained soils by differences in size and mineralogy. Silts, which are fine-grained soils, tend to have larger particle sizes than clays. However, there is some overlap in both particle size and other physical properties and many deposits include both silts and clays. One method of distinguishing between silt and clay is based on the plasticity properties of the soil, as measured by the soil's Atterberg Limits.

Clay was identified visually based on the cohesiveness of the sediment. Field torvane tests were conducted during vibracore logging in accordance with ASTM Standard Methods Designation D4648-13 for field vane shear tests in cohesive soils (ASTM, 2013). These tests were conducted to characterize the clay material. The results of the torvane tests are provided on the vibracore logs in Volume III: Appendix QQ.

3.3. Archaeological Diver Site Investigation Methodology

Remote-sensing magnetic anomalies and/or sonar targets determined to require further investigation were relocated using a differential global positioning system. Anomaly and/or target relocation was refined using a cesium vapor magnetometer, a high resolution sidescan sonar or sector scan sonar. Each site was buoyed to provide a reference for anchoring and conducting diving activity.

Once each site was relocated, the magnetic anomaly and/or sonar target was investigated by SCUBA-equipped archaeological divers. Their objective was to identify and assess the significance of cultural material generating the signature. At each anomaly and/or target location, the buoy provided a surface navigational reference. Where necessary, a second buoy was deployed to refine the anomaly and/or target location, serve as a second surface reference and facilitate carrying out a systematic search of the site.

At each site, divers carried out a systematic search of the bottom surface to identify exposed cultural material. To ensure systematic coverage of the bottom surface in low visibility, diver examinations were controlled by a line attached to the target buoy. Where tidal conditions and poor visibility made systematic visual search techniques impossible, concentric circles were examined at distances no greater than the limits of visibility, or five feet in zero visibility conditions. Where a bottom surface examination failed to identify material generating the anomaly, the search pattern was re-examined using a hand-held underwater proton precession magnetometer capable of identifying ferrous objects below the bottom surface.

Sub-bottom anomaly locations were further refined using a Quantro Sensing handheld underwater proton precession magnetometer to locate the point of maximum signature strength. That point was identified by non-magnetic buoy clump or reference rods pushed or washed into the sediment. A bottom surface grid or baselines were deployed and hydraulic probes were used to systematically investigate the sediment for cultural material. Where material generating an anomaly lay more than 5 feet below the bottom surface, additional hydraulic probing was carried out to determine the archaeological nature and areal extent of material generating the signature.

Where probing identified near surface sub bottom material, induction dredge excavation was employed to remove overburden and expose diagnostic material. Any exposed material that proved to be historically significant was mapped in situ using both conventional measured drawings, and where visibility permitted underwater video or photography. All relevant stratigraphy, features and cultural material was documented in accordance with standards for archaeological techniques.

Where material at the site proved to be modern vessel remains or structural debris, a sketch map was prepared in conjunction with a narrative description and, where visibility permitted, video or photographic documentation. Where material was determined to have no significance in terms of criteria established for the NRHP, no additional investigation was carried out unless there was reason to believe that modern material could obscure other historically significant submerged cultural resources.

Where sites were potentially significant and possibly eligible for NHRP consideration, the on-site investigation was be expanded to provide both identification and assessment. On-site baselines provided a reference for data collection. All material exposed above the bottom surface was mapped and recorded on a preliminary site plan. Once a plan was developed using trilateration or other mapping techniques, photography was used (where possible) to record structural details. Where essential for analysis, diagnostic material could be recovered to assist in determining and documenting the nature, scope, and significance of the archaeological record at the site. Data generated by on-site investigation activity was computer cataloged for analysis and used in the development of the report document.

Assessment of each target was designed to identify the type of cultural material generating the signature and provide a reliable dating context. In addition to identification and dating, efforts focused on establishing and assessing the nature and significance of material generating each anomaly and/or sonar target. Attention was given to on-site preservation, dredging or other disturbance of the site, environmental conditions and research potential. At each site, investigation was designed to collect sufficient data to support a preliminary assessment of NRHP eligibility.

4. Archaeological Signature Analysis and Assessment

The problems associated with identifying shipwrecks based on magnetic remote sensing data have been discussed by several authors and has received considerable attention in the body of literature dealing with the subject. Pearson and Saltus (1990:32) state "even though a considerable body of magnetic signature data for shipwrecks is now available, it is impossible to positively associate any specific signature with a shipwreck or any other feature." There is no doubt that the only positive way to verify a magnetic source object is through physical examination. With that said, however, the size and complexity of a magnetic signature does provide a usable key for distinguishing between modern debris and shipwreck remains (see Garrison et al., 1989a; 1989b; Irion and Bond 1984).

In a study conducted for MMS addressing magnetic anomalies in the northern Gulf of Mexico (GOM), Garrison et al. (1989a; 1989b) indicated that a shipwreck signature will cover an area between 10,000 and 50,000 square meters. Using the Garrison et al. (1989a; 1989b) study, as well as years of "practical experience," in an effort to assess potential significance of remote-sensing targets, the Pearson et al. (1991) study developed general characteristics of magnetometer signatures most likely to represent shipwrecks. The report states that "the amplitude of magnetic anomalies associated with shipwrecks varies considerably, but, in general, the signature of large watercraft or portions of watercraft, range from moderate to high intensity (> 50 gammas) when the sensor is at distances of 20 feet or so" (Pearson et al., 1991:70). Using a table of magnetic data from various sources as baseline data, the report goes on to state that "data suggests that at a distance of 20 feet or less, watercraft of moderate size are likely to produce a magnetic anomaly (this would be a complex signature [i.e., a cluster of dipoles and/or monopoles]) greater than 80 or 90 feet across the smallest dimension" (Pearson et al., 1991:70).

While establishing baseline amounts of amplitude and duration reflective of the magnetic characteristics for a shipwreck site, the report "recognizes that a considerable amount of variability does occur" (Pearson et al., 1991:70). Generated in an effort to test the 50-gamma/80-foot criteria and to determine the amount of variability, Table 17 lists numerous shipwrecks as well as single and multiple-source objects located by magnetic survey and verified by divers. All shipwrecks met and surpassed the 50-gamma/80-foot criteria, with one exception. *Emanuel Point II*'s magnetic deviation falls below the cut off, although duration is above. Subsequent archaeological examinations have determined that *Emanuel Point II* contains very little iron (Cook, 2009).

Burns (2010) classified anomalies potentially associated with historic shipwrecks as having four diagnostic characteristics:

1. Multiple peak anomalies or spatial frequency
2. Differential amplitude anomalies (dipolar or multicomponent)
3. Long gradients and long durations
4. Anomalies detected on multiple lines

The same author's characteristics of modern debris included:

1. Single peak anomalies with little or no spatial frequency

2. Few if any differential amplitude anomalies (monopolar)
3. Sharp gradients and short durations
4. Anomalies detected on a single line

In his article entitled *Archaeological Interpretation of Marine Magnetic Data*, Gearhart (2011) expands on Garrison's 1989 premise and argues that while "one cannot distinguish between the anomaly produced by a shipwreck and one produced by a similarly complex concentration of magnetic debris…shipwreck anomalies can be characterized by their induced magnetic fields and are distinguishable from a significant proportion of simple-source anomalies." The author goes on to state, "the most important parameter to consider when interpreting anomalies based on magnetic induction is the direction of magnetic moment" (Gearhart 2011:106) and "deviation from the northerly magnetic moment direction, common to all induced anomalies, has proven to be the single most powerful discriminator between simple-source anomalies and complex-source anomalies, including shipwrecks" (Gearhart 2011:102).

Clearly there is currently no accurate statistical, mathematical, or geometrical formula for reliably identifying potentially significant submerged cultural resources and distinguishing them from modern debris based entirely on their magnetic signatures. The spectrum of signature characteristics associated with potentially significant material and the signature characteristics associated with small single objects and modern debris are very difficult to resolve. Assessment of potential significance and recommendations for buffering anomalies is best based on the combination of anomaly attributes, historical patterns of navigation in the project area, documented shipwreck losses, and a responsible balance between historical and economic priorities.

Though there are no absolute criteria for identification of potentially significant magnetic anomalies and/or acoustic target signatures, experience and available literature confirm that reliable analysis must be made on the basis of certain characteristics. Magnetic signatures must be assessed on the basis of three basic factors. The first factor is intensity and the second is duration. The third consideration is the nature of the signature or "complexity;" e.g., positive monopolar, negative monopolar, dipolar, or multi-component. Unfortunately, shipwreck sites have been demonstrated to produce each signature type under certain circumstances. Some shipwreck signatures are more apparent than others.

Large vessels, whether iron or wood, produce signatures that can be reliably identified. Smaller vessels, or disarticulated vessel remains, are more difficult to identify. Their signatures are frequently difficult, if not impossible, to distinguish from single objects and/or modern debris. In fact, some small vessels produce little or no magnetic signature. Unless ordnance, ground tackle, or cargo associated with the hull produces a detectable signature, some sites are impossible to identify magnetically. The final decision concerning potential significance must be made on the basis of anomaly attributes, historical patterns of navigation in the project area, and a responsible balance between historical and economic priorities.

Acoustic signatures must also be assessed on the basis of several basic characteristics. Perhaps the most important factor in acoustic analysis is the configuration of the signature. As the acoustic record represents a reflection of specific target features, wreck signatures are often a highly detailed and accurate image of architectural and construction features. On sites with less structural integrity, signatures often reflect more of a geometric pattern that can be identified as structural material.

Where hull remains are disarticulated, the pattern can be little more than a texture on the bottom surface representing structure, ballast, or shell hash associated with submerged deposits. Unfortunately, shipwreck sites have been demonstrated to produce a variety of signature characteristics under different circumstances. Like magnetic signatures, some acoustic shipwreck signatures are more apparent than others. Large vessels, whether iron or wood, produce signatures that can be reliably identified.

Smaller vessels, or disarticulated vessel remains are inevitably more challenging. Their signatures are frequently difficult, if not impossible, to distinguish from concentrations of modern debris. In fact, some small vessels produce little or no acoustic signature. As a consequence, acoustic targets must be subjectively assessed according to intensity of return over background, elevation above bottom, and geometric image characteristics. The final decision concerning potential significance of less readily identifiable targets must be made on the basis of anomaly attributes, historical patterns of navigation in the project area, and a responsible balance between historical and economic priorities.

Seismic data generated by sub-bottom profilers can reveal evidence of relict landforms. Certain types of relict landforms such as river channels and confluences, lagoons, and bays have a high potential for association with inundated prehistoric habitation sites. Although the process of inundation may have destroyed much of a prehistoric site's integrity, significant evidence of paleo and archaic habitation has been identified on the Outer Continental Shelf. Detailed analysis of the sub-bottom data can identify those landforms.

Archaeological analysis of the magnetic data generated by the remote sensing survey was carried out using Hypack® and Quicksurf®. Each line of raw magnetic data was reviewed and edited using Hypack's Single Beam Editor© to identify and characterize anomalies and to remove spurious data. Edited data files were saved and then sorted to produce geo-referenced XYZ format ASCII data for contouring. Each anomaly was saved as a target designation that included the line number, geographical coordinates, target number on line, signature characteristics, signature intensity, and signature duration. Using Quicksurf®, magnetic ASCII data generated during post-processing were contour plotted for additional analysis, accurate location, and graphic representation. A Microsoft© Excel© spreadsheet file that contained each of the definitive anomaly characteristics and an assessment of potential significance was created. The spreadsheet was used to create an anomaly shapefile for inclusion in a project GIS. The contoured data was edited in AutoCAD® and the contours saved as a DWG or DXF for inclusion in the project GIS. Contoured data maps of each survey area were prepared as Esri GIS® projects to identify anomaly distribution, potentially significant anomalies and/or clusters, recommended buffers and sonar target associations. Magnetic contour lines associated with each anomaly signature are represented in red and blue. Red lines represent positive 5-gamma contours and blue lines represent 5-gamma negative contours.

Sidescan sonar acoustic records were analyzed using SonarWiz® software. Each line of data was reviewed to identify targets on the basis of configuration, areal extent, target intensity and contrast with background, elevation and shadow image. Each target image and associated data was saved in SonarWiz® and reproduced in a software generated report. A Microsoft© Excel© spreadsheet file that contained each of the targets and an assessment of potential significance was created for each survey area. Those Microsoft© Excel© spreadsheets were also used to create shapefiles for inclusion in a project GIS. SonarWiz® was also used to create a georeferenced sonar coverage mosaic of the survey area for inclusion in the GIS project. Potentially significant sonar targets and/or target clusters were buffered and recommended for avoidance or additional investigation.

Sub-bottom profiler acoustic records were also analyzed using SonarWiz®. Each line of data was reviewed to identify features that could be associated with anomalies and sonar targets. Features that represent relict landforms were also identified to determine if there might be a potential association with prehistoric submerged cultural resources. An Excel© spreadsheet file that contained each of the features and an assessment of potential significance was created for each survey area. Each landform image was captured and included in a target report produced with SonarWiz©.

4.1. Sabine Bank

4.1.1. Primary Area 1

Sabine Bank Primary Area 1 (SB P1) was selected for investigation based on data from previous remote-sensing surveys that identified anomalies with signature characteristics that could be associated with historical vessel remains (Figure 25; Figure 26). Those anomalies were buffered and recommended for avoidance. Previous dredging in Borrow Area HF was designed to avoid the buffered site. As future dredging in Borrow Area HF and Sabine Bank BA1 (see Table 2) is planned, identification of material generating the buffered anomalies was determined to be a high priority.

SB P1 was surveyed on September 6, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SB P1 identified 10 magnetic anomalies (Figure 27; Volume III: Appendix A) and three sonar targets (Figure 28; Volume III: Appendix B).

Five magnetic anomalies (015-1, 016-1, 017-1, 018-1, and 100-1), included in Buffer A, form a cluster and are considered to have a high potential association with historical vessel remains and/or other potentially significant submerged cultural resources (Figure 29). None of the sonar targets were associated with that cluster of magnetic anomalies or any of the single magnetic anomalies.

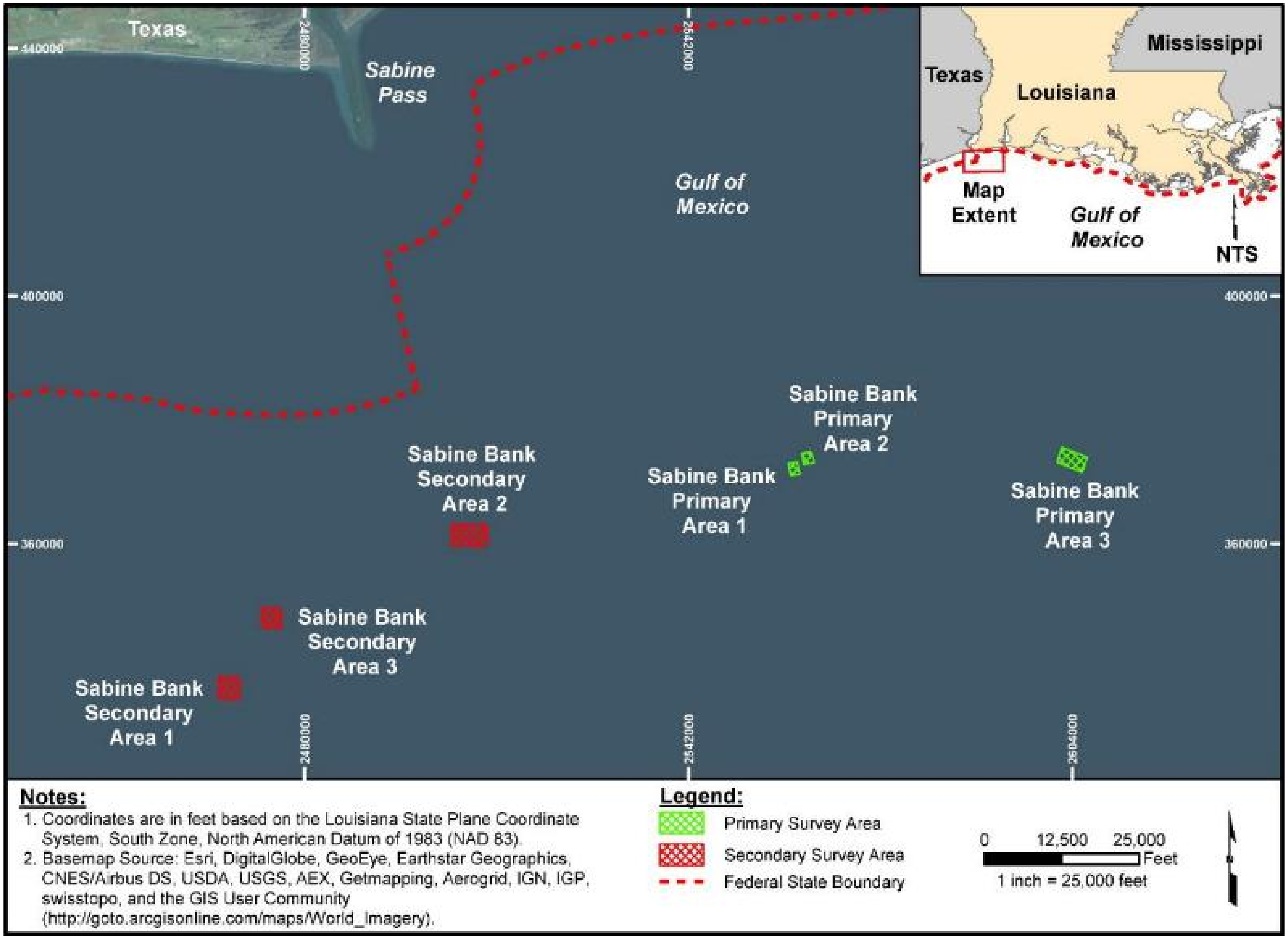

Figure 25: Sabine Bank survey areas.

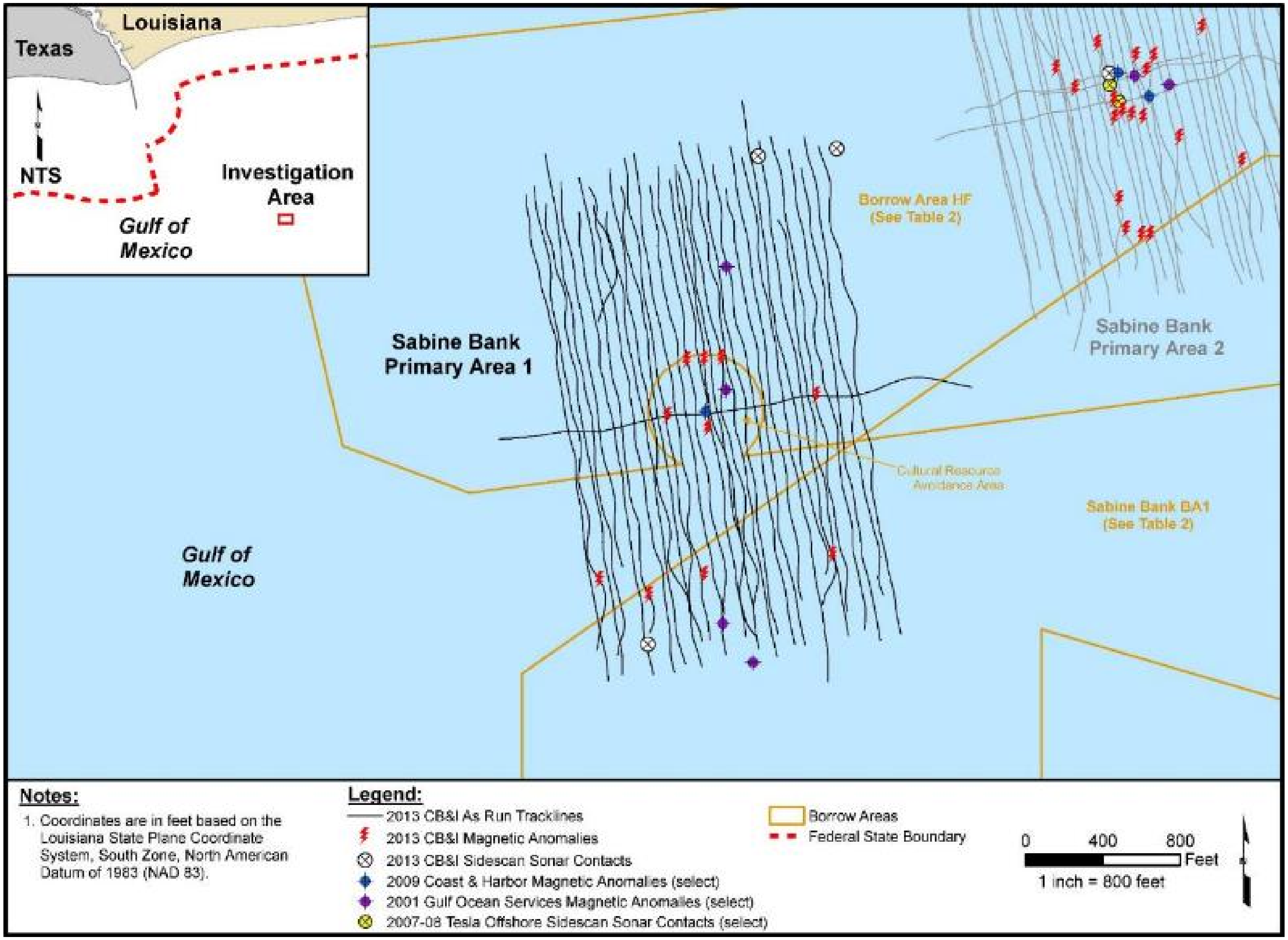

Figure 26. Magnetic anomalies and sonar targets identified in Sabine Bank Primary Area 1.

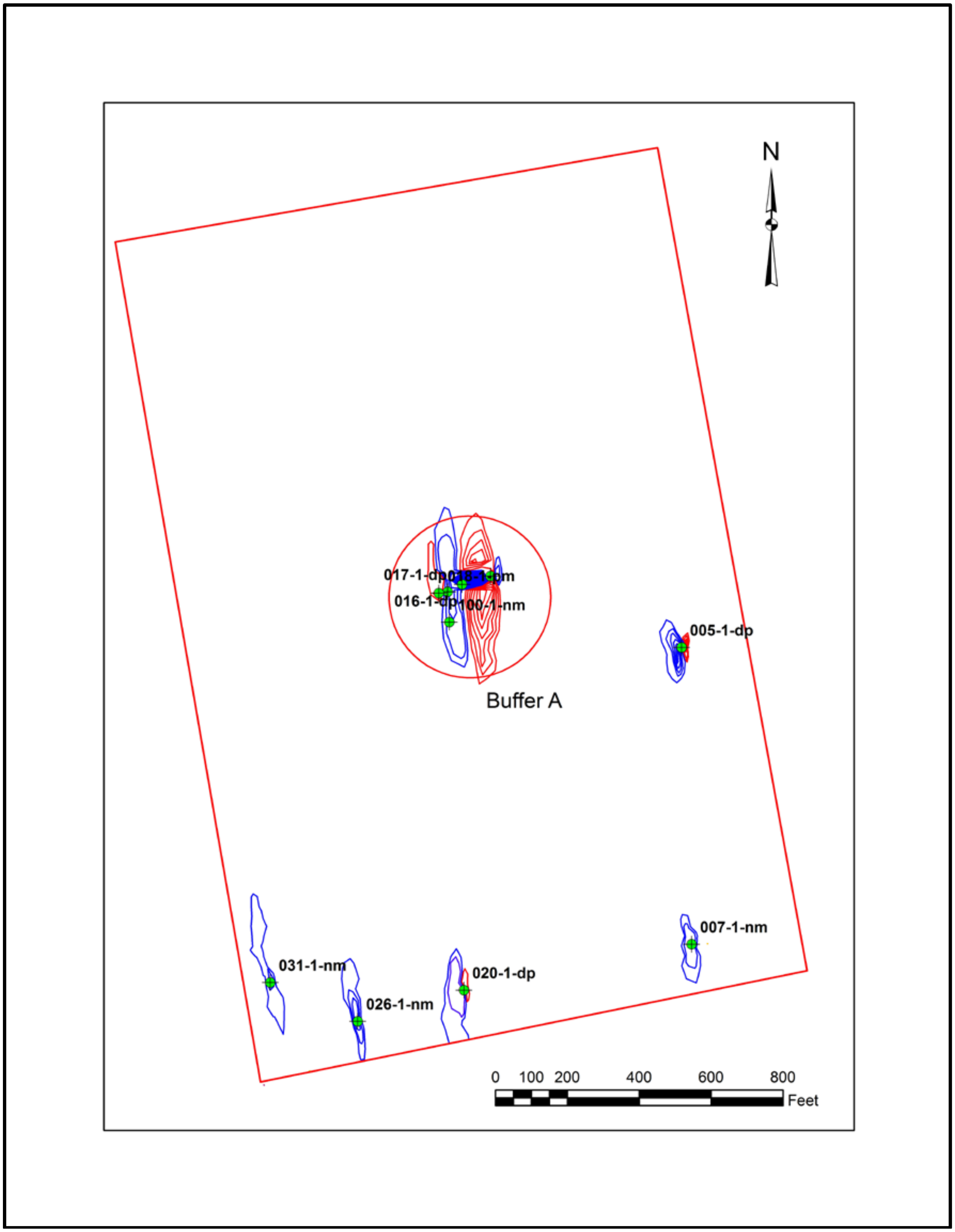

Figure 27. SB P1 survey area shown with magnetic anomalies, contours, and Buffer A.

Figure 28. SB P1 sonar coverage mosaic with sonar targets.

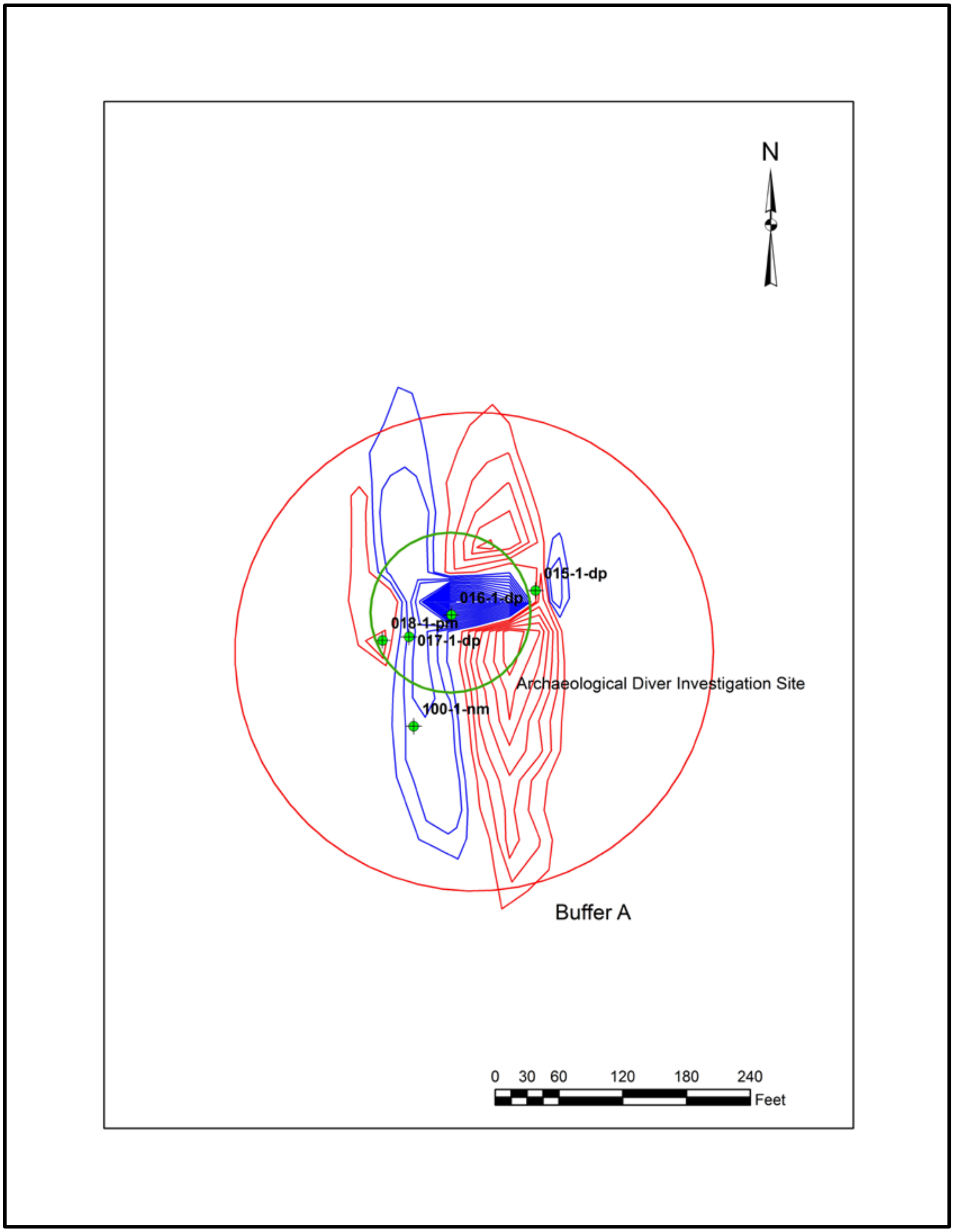

Figure 29. SB P1 magnetic anomaly cluster investigated by marine archaeologists.

The magnetic anomaly cluster site was identified as a high priority for an archaeological diver investigation. That investigation was initiated on June 15, 2016. High currents and vessel-related problems frustrated attempts to carry the investigation beyond using a hand-held magnetometer to identify a location to probe.

A second attempt to identify material generating the magnetic anomalies was carried out on June 18, 2016. Archaeologists relocated the site and refined the location of material generating the signatures using a hand-held underwater magnetometer. A five-horsepower centrifugal pump powered a 10-foot hydraulic probe used to identify cultural material generating the magnetic signatures. Systematic probing identified the source of the anomalies as modern wire rope 4-5 feet below the bottom surface. No additional material or associated structure could be identified within 10 feet of the bottom surface by additional probing in concentric circles in the cluster vicinity.

None of the remaining magnetic anomalies, or any of the three sonar targets, are considered to have signature characteristics strongly suggestive of potentially significant submerged cultural resources. Targets SS 001 and SS 002 lie outside the survey area northern border and inside previously dredged Borrow Area HF. Target SS 001 appears to be a small, single object (Figure 30). That target was located off the data collection trackline and may have been beyond magnetic detection as no associated anomaly was identified. Target SS 002 (Figure 31) could be a geological feature within a cluster of depressions. No magnetic signature was associated with Target SS 002.

Target SS 003 lies just inside the southwestern border of the survey area and could represent one or more large tires and linear debris (Figure 32). Material in the sonar image could possibly be associated with magnetic anomaly 026-1.

As material generating the previously buffered anomaly cluster proved to be modern wire rope without any associated vessel structure or other potentially significant cultural material, no additional investigation at the site is recommended. All of the remaining magnetic anomalies appear to be associated with small single objects. Because they do not have more complex signatures generally associated with potentially significant submerged cultural resources, no additional investigation at those sites is recommended. Likewise, none of the sonar targets appear to represent vessel remains or other potentially significant cultural material and all lie in areas previously dredged. No additional investigation of those targets is recommended.

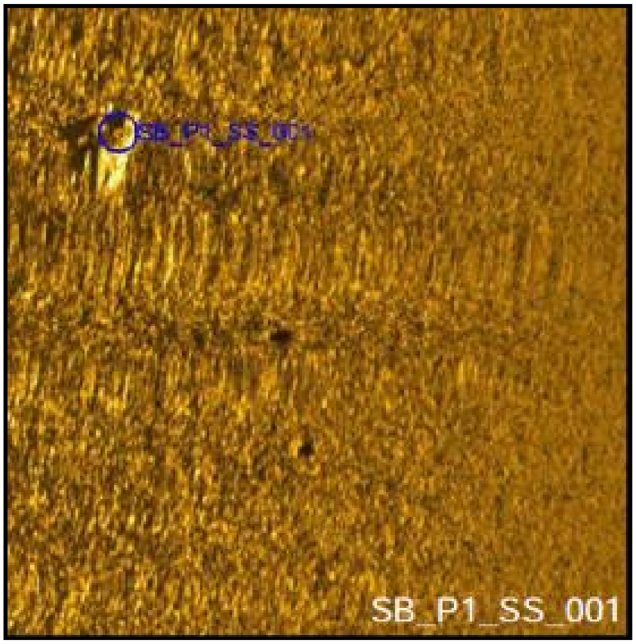

Figure 30. SB P1 sonar target SS 001.

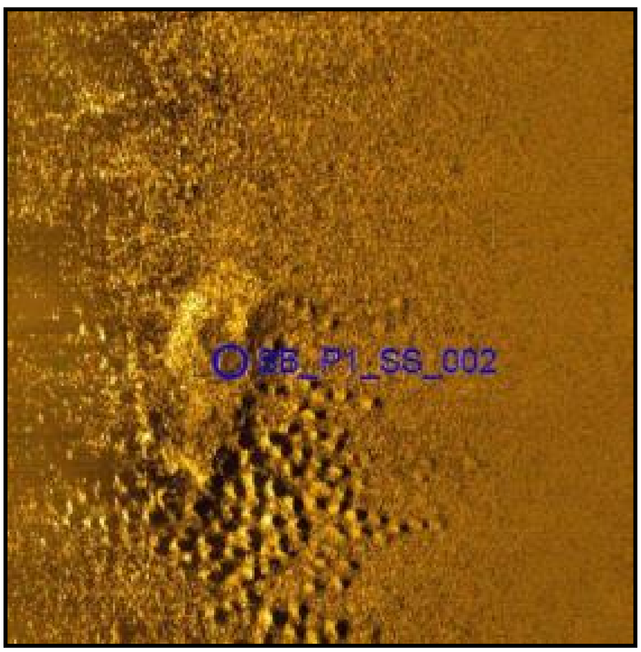

Figure 31. SB P1 sonar target SS 002.

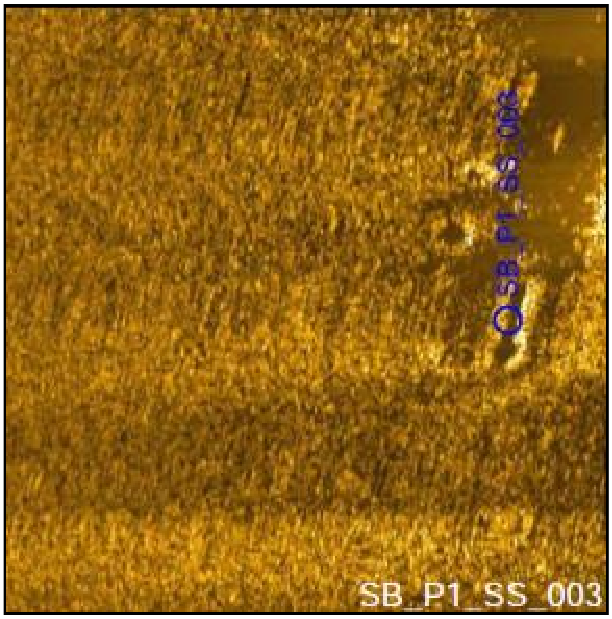

Figure 32. SB P1 sonar target SS 003.

4.1.2. Primary Area 2

Sabine Bank Primary Area 2 (SB P2) was selected for investigation based on data from previous remote-sensing surveys (Figure 33). Because the majority of SB P2 lies within Sabine Bank BA1 & Borrow Area HF (see Table 2), additional remote sensing was determined to be advisable. Those two previously permitted borrow sites are scheduled for additional sand recovery.

SB P2 was surveyed on September 6, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SB P2 identified twenty magnetic anomalies (Figure 34; Volume III: Appendix C) and two sonar targets (Figure 35, Volume III: Appendix D).

Eleven anomalies (015-1, 016-1, 017-1, 018-1, 019-1, 020-1, 021-1, 021a-1, 100a-1, 101a-1, and 101b-1) form a cluster and have been identified by Buffer A (Figure 36). Sonar image SS-002 (Figure 37) confirms a cluster of low relief features on the bottom surface that could be associated with those magnetic anomalies.

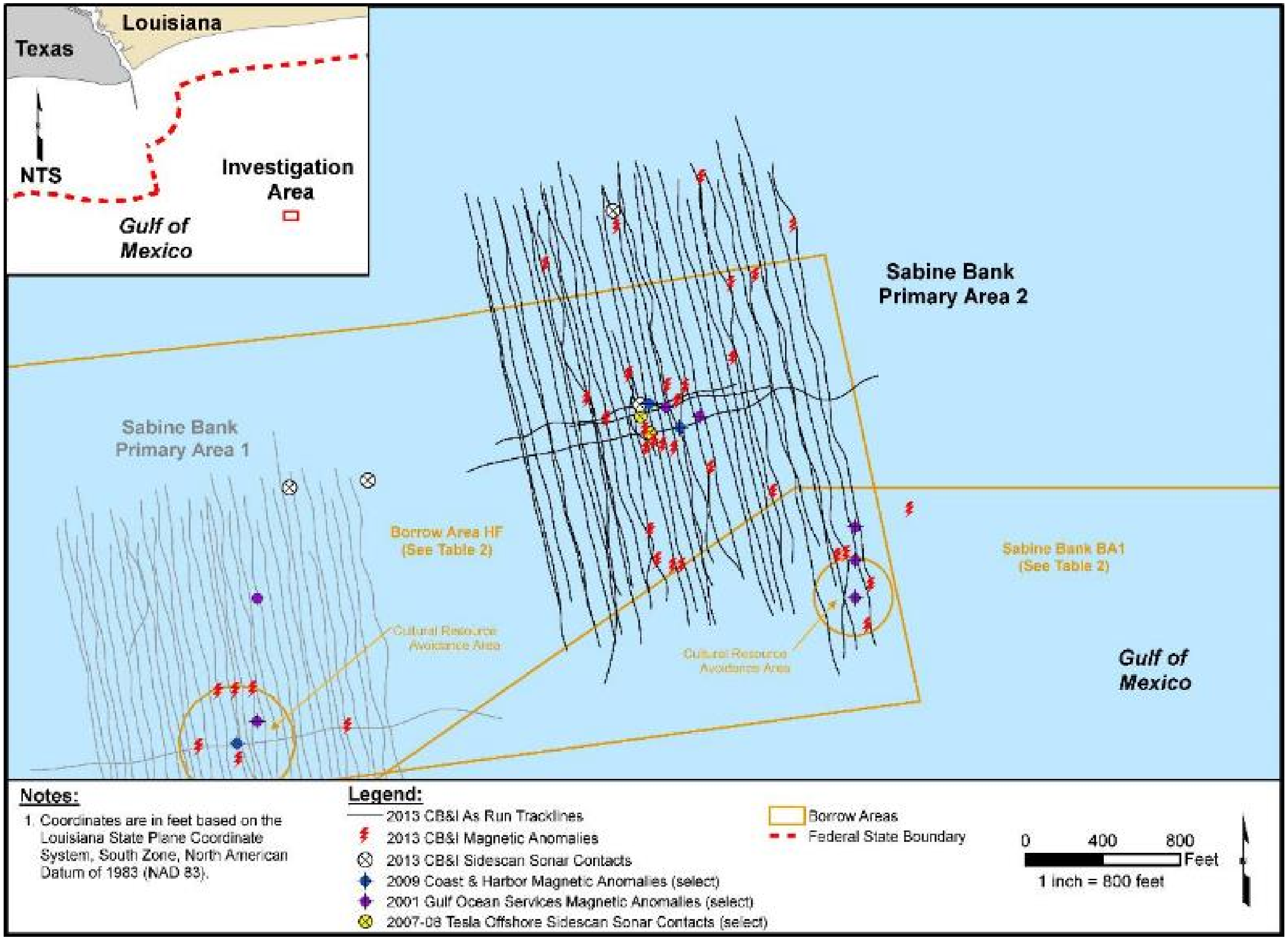

Figure 33: Magnetic anomalies and sonar targets identified in Sabine Bank Primary Area 2.

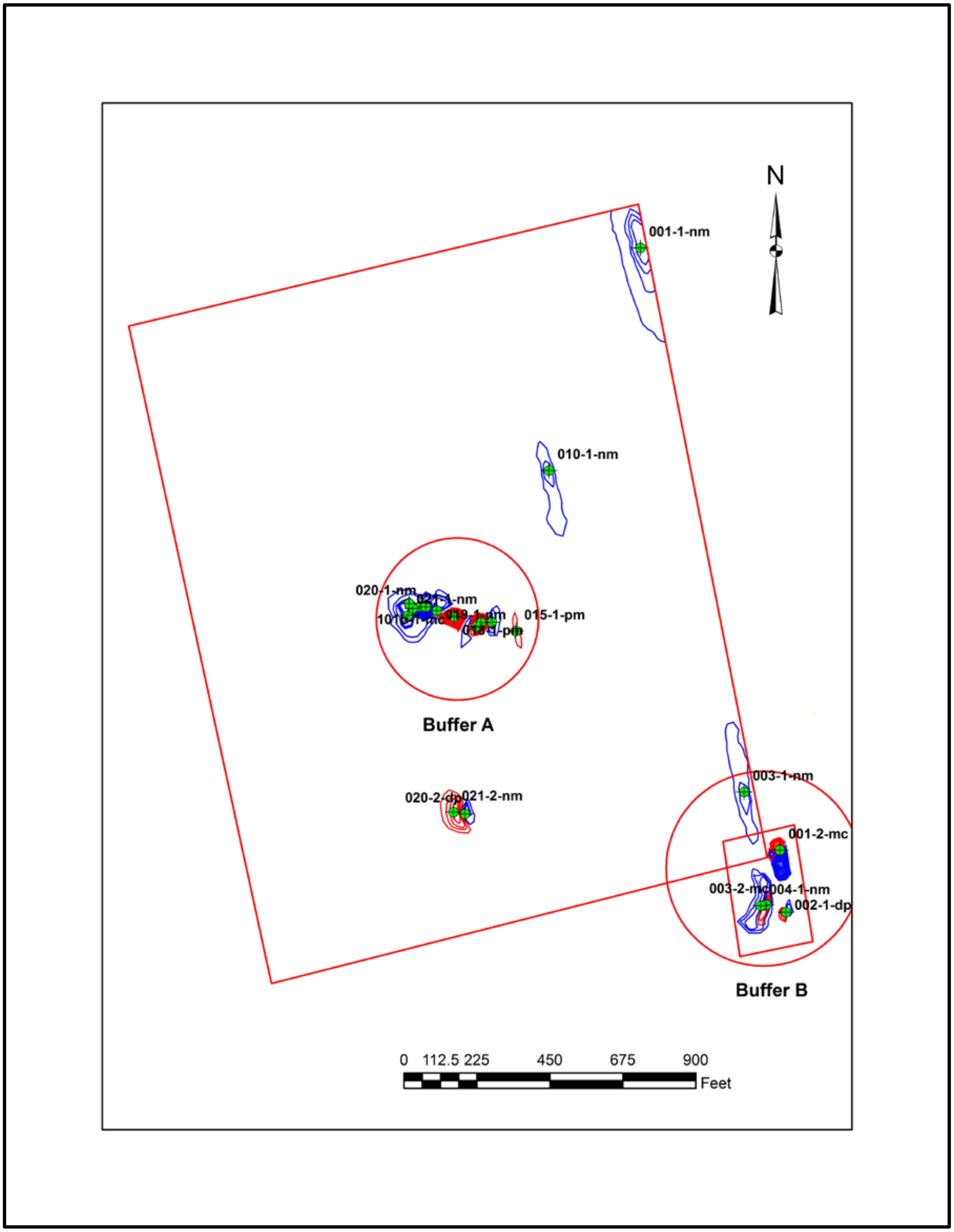

Figure 34. SB P2 showing magnetic anomalies, contours, and buffers.

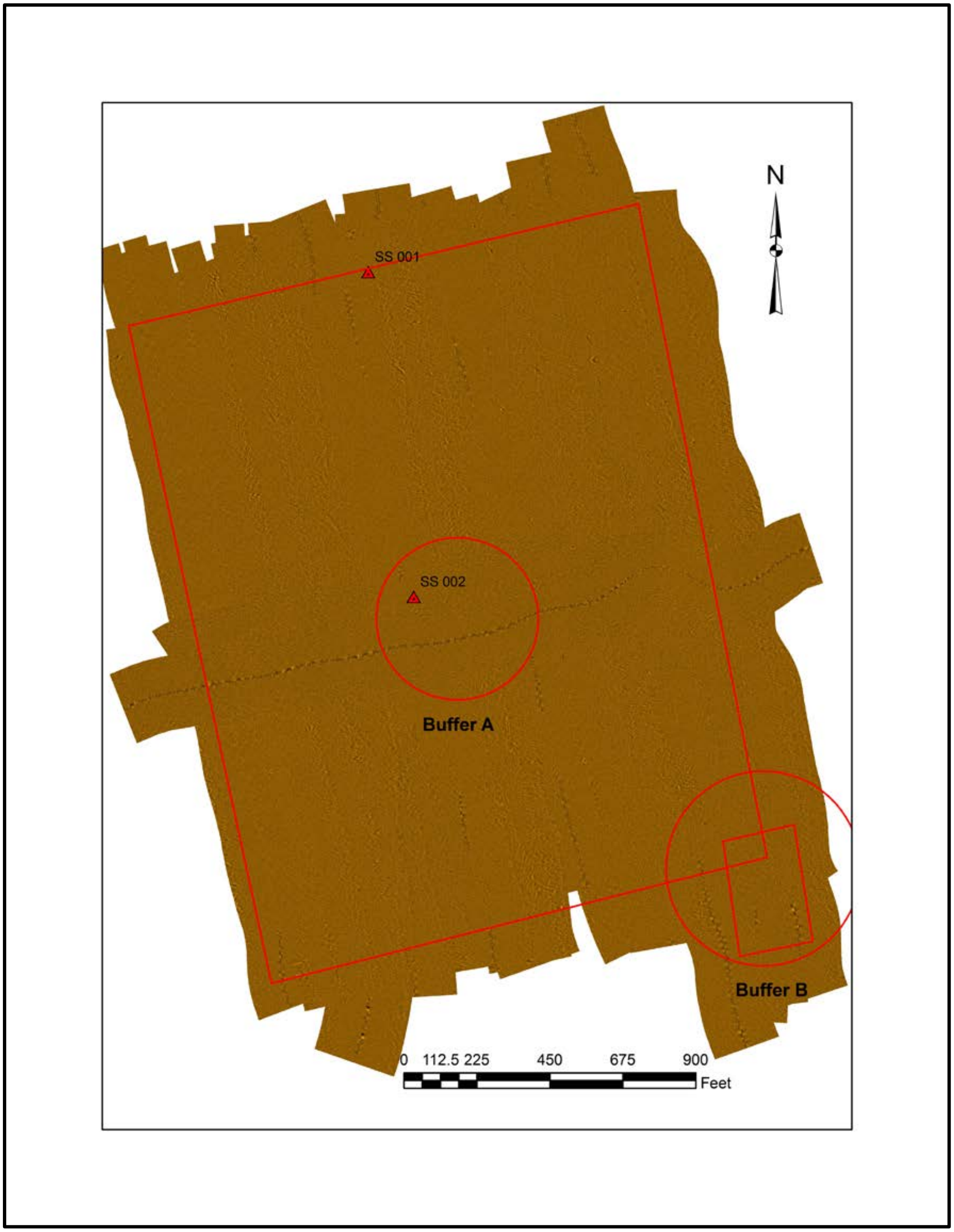

Figure 35. SB P2 sonar coverage mosaic with sonar targets.

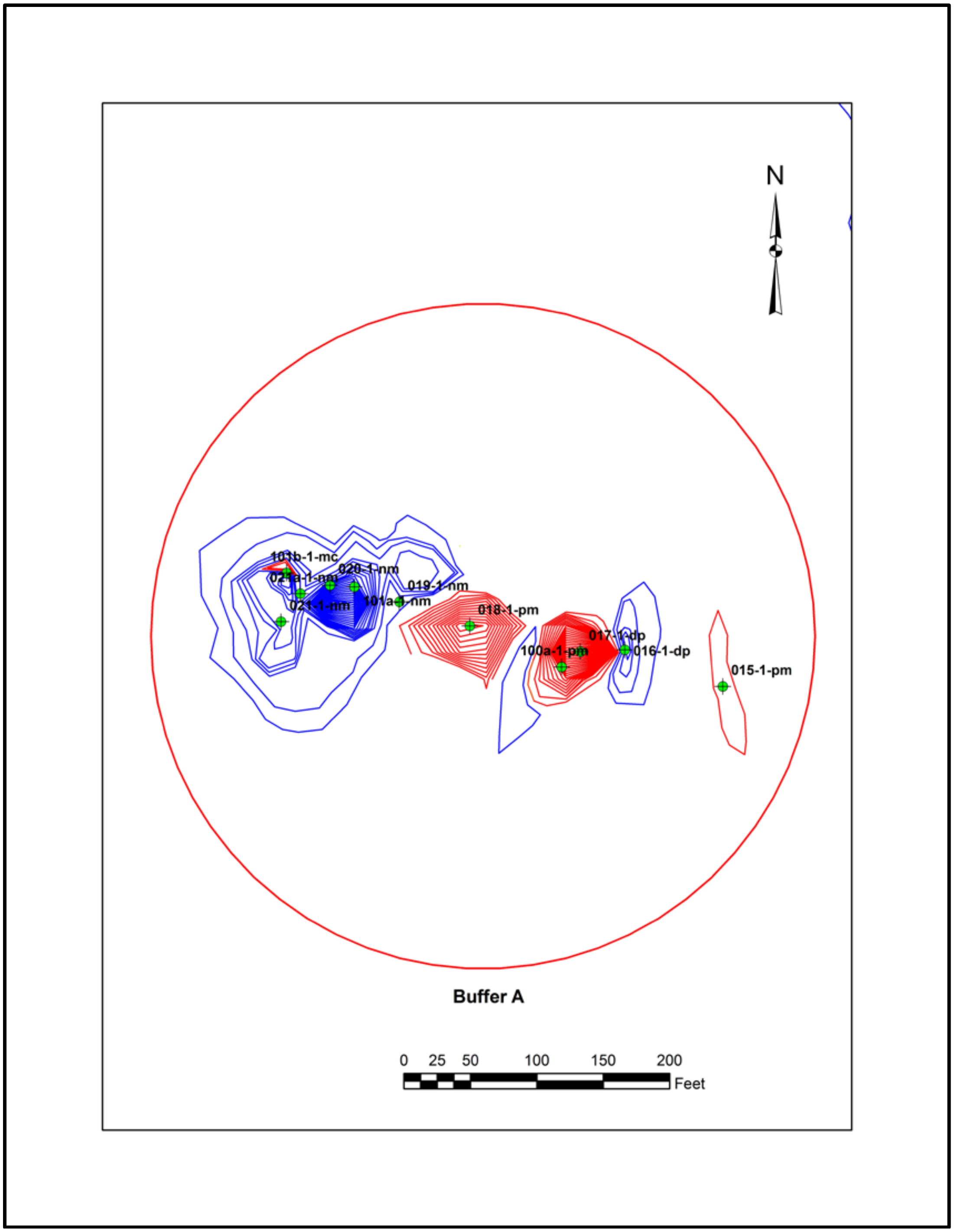

Figure 36. SB P2 Buffer A magnetic contours and anomalies.

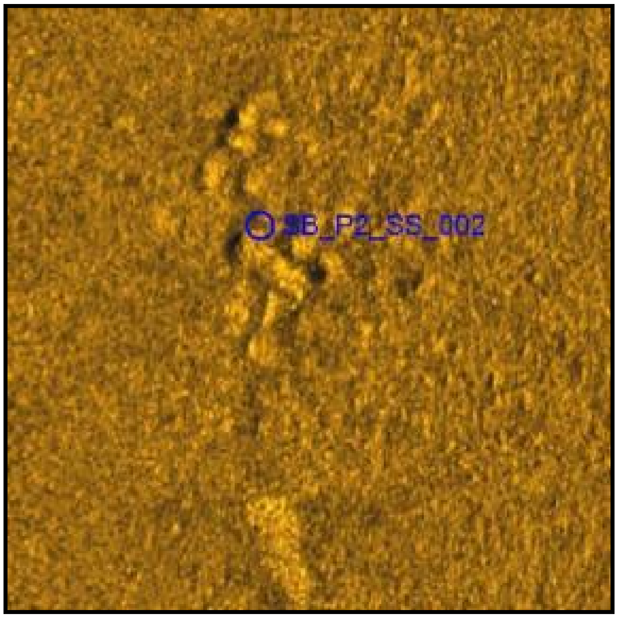

Figure 37. SB P2 SS 002 sonar image of bottom surface feature associated with magnetic anomalies in Buffer A.

Anomalies (001-2, 002-1, 003-1, 003-2, and 004-1) could also be associated with vessel remains and are identified by Buffer B (Figure 38). Both clusters of magnetic anomalies could be associated with shipwreck remains and/or other potentially significant submerged cultural resources.

However, the association with potentially significant submerged cultural resources is considered moderate in both buffer areas. All of those magnetic anomalies lie within previously dredged Sabine Bank BA1 & Borrow Area HF. As a consequence, modern debris cannot be eliminated as the source of magnetic anomalies in both buffers.

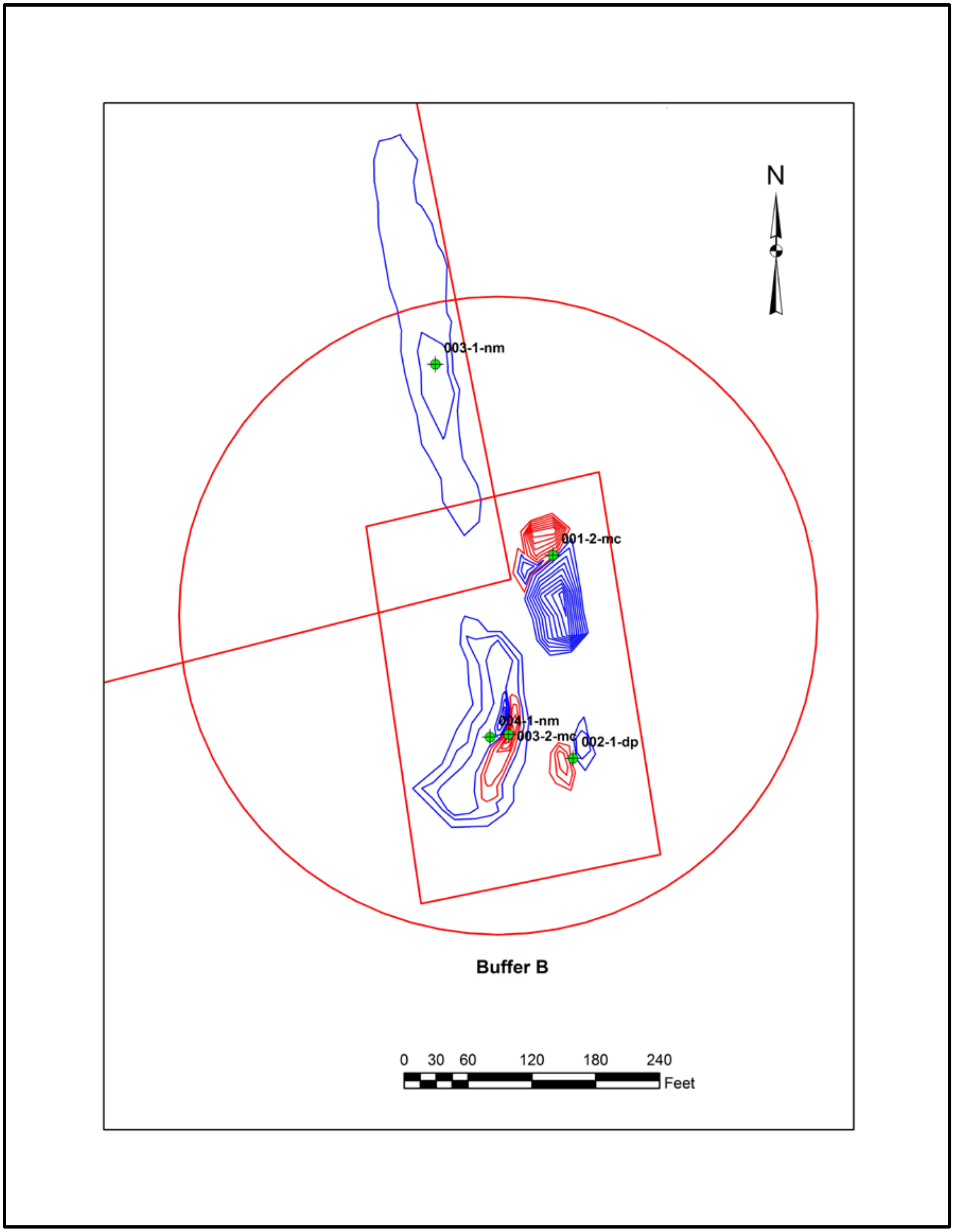

Figure 38. SB P2 Buffer B magnetic contours and anomalies.

With the exception of Anomaly 001-1, the remaining magnetic anomalies in SB P2 do not appear to have signature characteristics that are suggestive of potentially significant submerged cultural resources and all also lie in areas previously dredged. Anomaly 001-1 could be associated with potentially significant material that lies outside the survey area and beyond the limits of previous dredging.

Magnetic anomalies and the sonar target in Buffer A and the anomalies in Buffer B were not, in conjunction with this project, determined to be one of the high priorities for archaeological diver investigation. However, as the magnetic anomalies and sonar target in Buffer A have a potentially high association with vessel remains or other submerged cultural resources, continued avoidance is recommended. The anomalies within Buffer B have a moderate potential for association with vessel remains or other submerged cultural resources so avoidance is also recommended.

In the event that bottom-disturbing activity is proposed for either or both areas and avoidance of the recommended buffers is not possible, archaeological diver investigation is recommended. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.1.3. Primary Area 3

Sabine Bank Primary Area 3 (SB P3) was selected for investigation based on data from previous and current remote-sensing surveys that identified the remains of a vessel (Figure 39). SB P3 is also the location of previous navigation references that included a lighthouse and buoys. Buoy G3 currently identifies the Sabine Bank (Figure 40). The shipwreck and remains of navigation references lie in the immediate vicinity of Borrow Area JF (see Table 2) permitted for dredging.

SB P3 was surveyed on September 5, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SB P3 identified 50 magnetic anomalies (Figure 41; Volume III: Appendix E) and 14 sonar targets (Figure 42; Volume III: Appendix F). Five of the anomalies (012-2, 013-2, 014-1, 015-1, and 016-1) form a cluster (Figure 43) associated with a sonar image (SSS 14) of the hull remains of a sunken vessel (Figure 44). That site was designated as a high priority for archaeological diver investigation. That investigation was carried out on June 13, 2016. Archaeologists confirmed that the wreck remains are those of a modern vessel.

Eight vibracores were collected in and around SB P3: SBVC-15-03 through SBVC-15-10. Each vibracore indicated sandy material overlaying clay. The sandy material ranged in grain size from 0.17 to 0.48 mm. The thickness of the sandy layer on surrounding cultural resources should be limited to the upper sandy layer and the sand-mud interface as future mining for sediment resources will be constrained to the sandy layer.

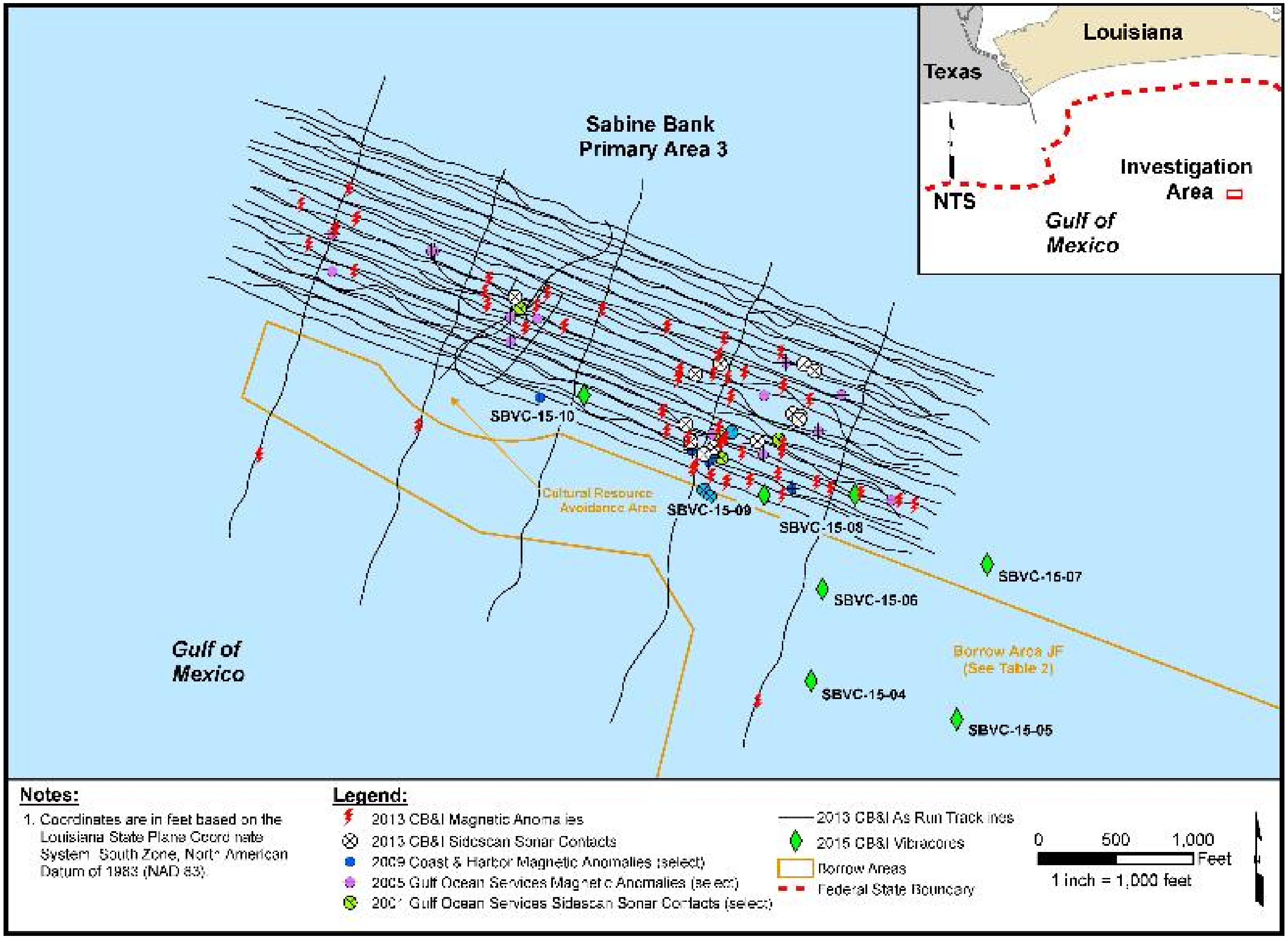

Figure 39. Magnetic anomalies and sonar targets identified in Sabine Bank Primary Area 3.

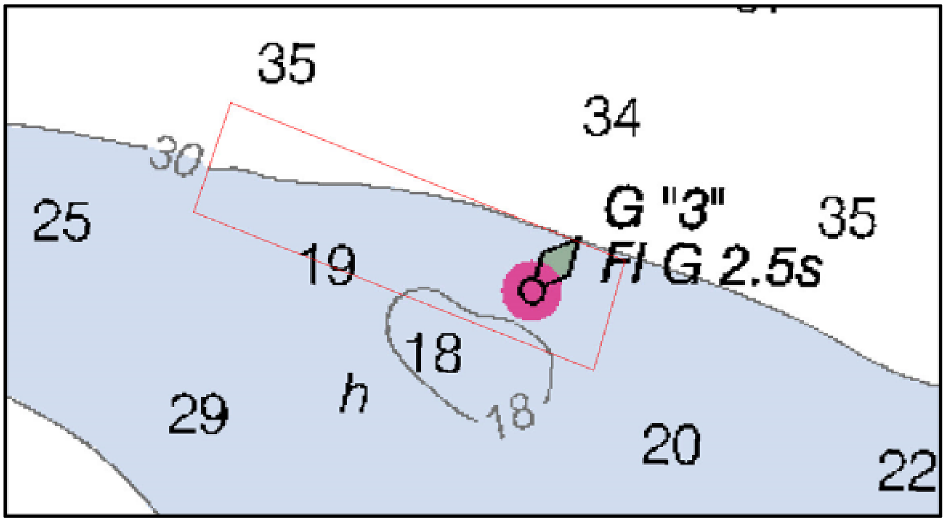

Figure 40. SB P3 survey location and navigation reference G3.

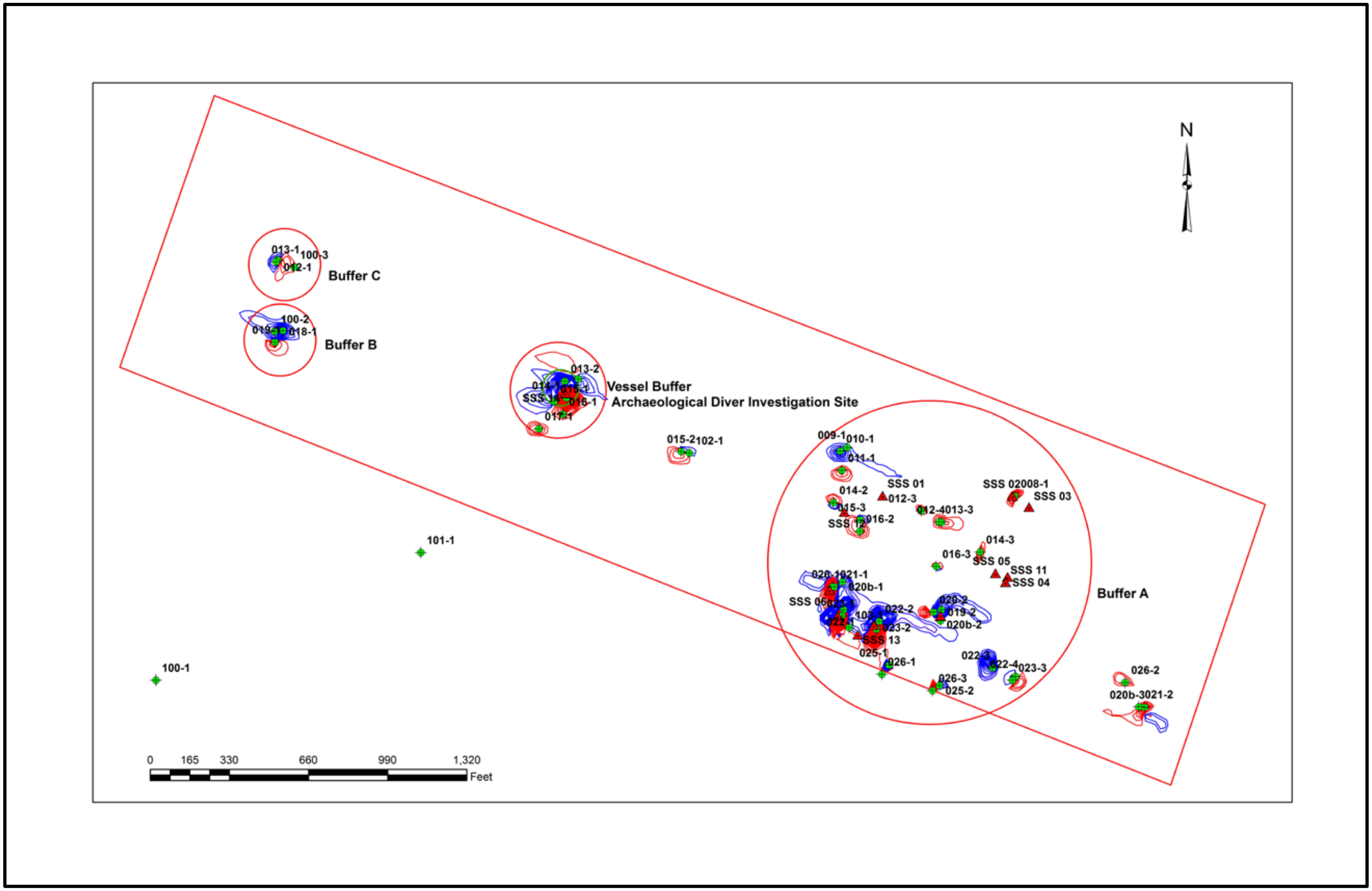

Figure 41. SB P3 survey area showing magnetic anomalies, contours and buffers.

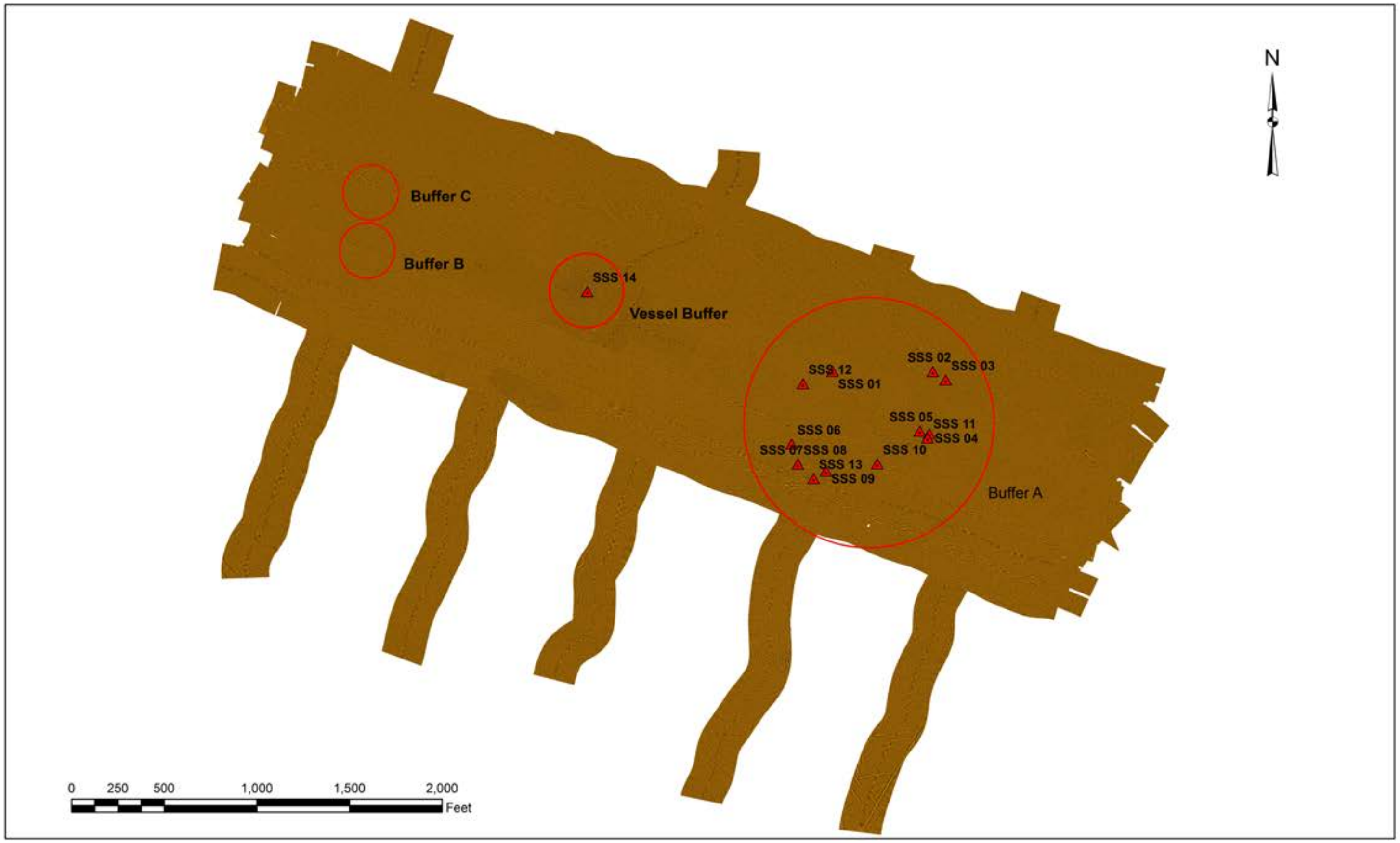

Figure 42. SB P3 sonar coverage mosaic with sonar targets.

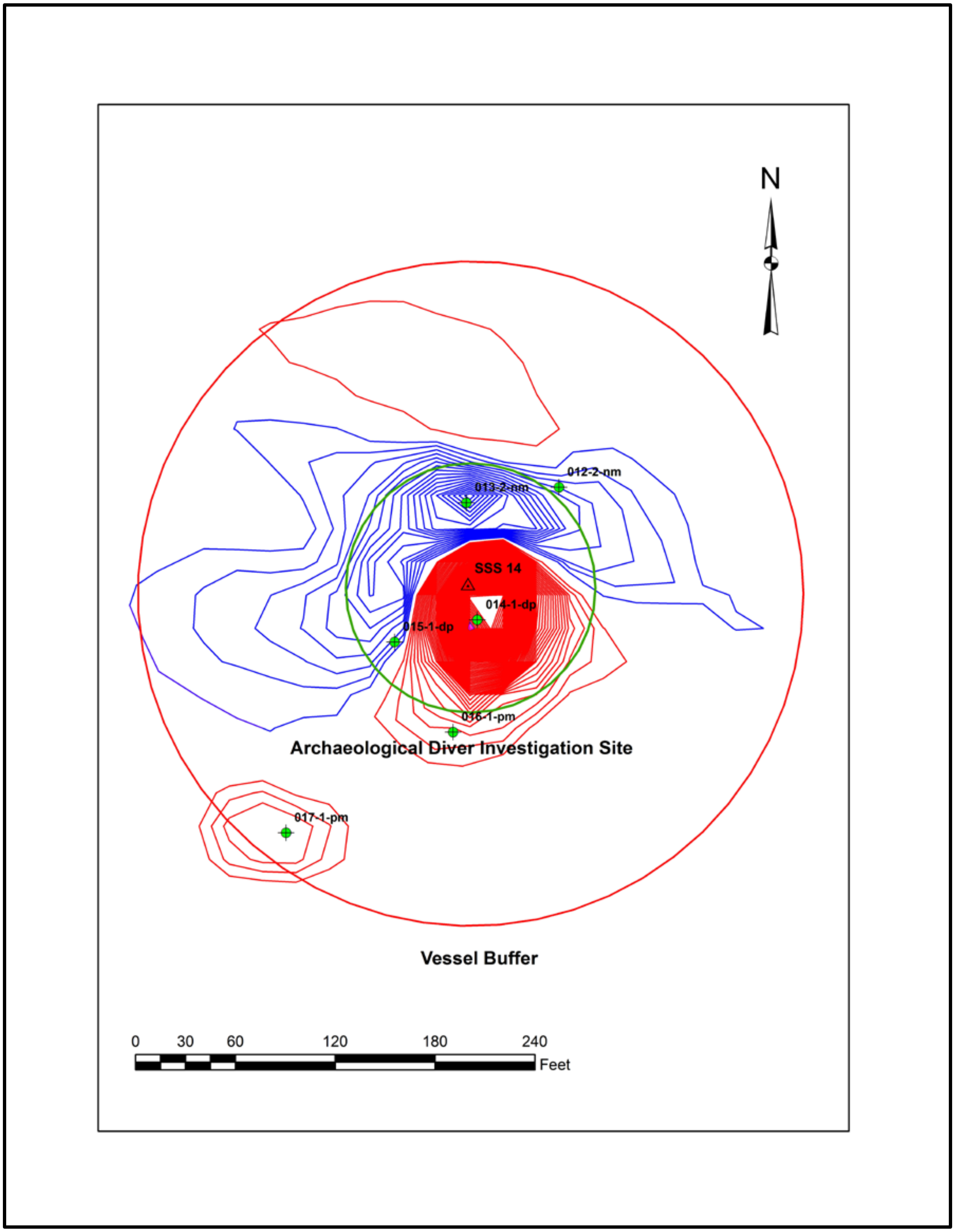

Figure 43. SB P3 magnetic contours and anomalies associated with vessel remains investigated by archaeological divers.

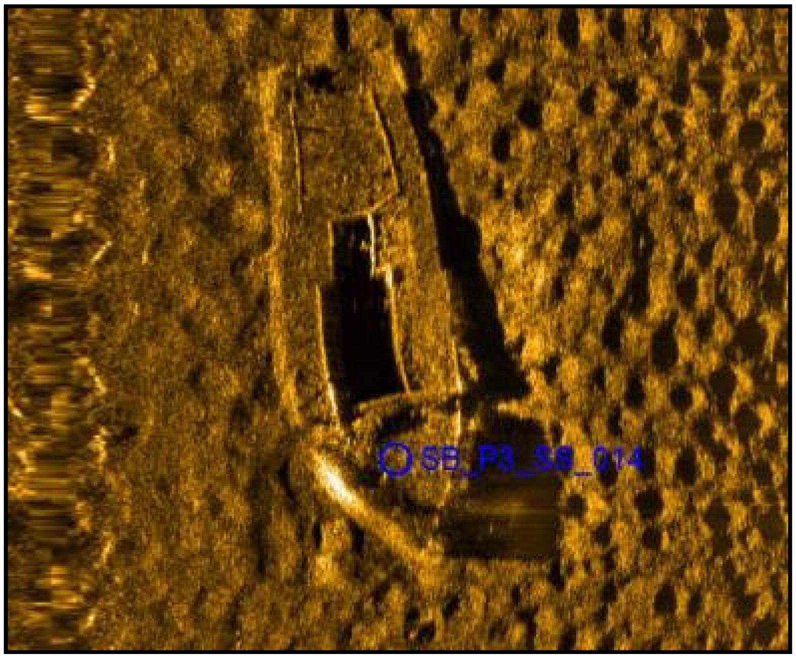

Figure 44. Target SSS 14, sonar image of SB P3 modern vessel remains.

Combing attached to the deck of the vessel in the SB P3 survey area provides an outline of the deckhouse and what is likely the engine room hatch. Additional combing on the aft deck might indicate an area isolated for culling and the deck camber at the transom could suggest a net reel configuration. However, there was no apparent evidence of masts, booms, tackle, and machinery that would have supported fishing. Another possibility, perhaps more likely, is that the vessel served as a supply or crew boat associated with post-World War II oil and gas industry activities. A trawl door lodged in a damaged area of the hull on the port side aft of the bow appears to have been fouled by another vessel subsequently trawling in the area (Figure 45).

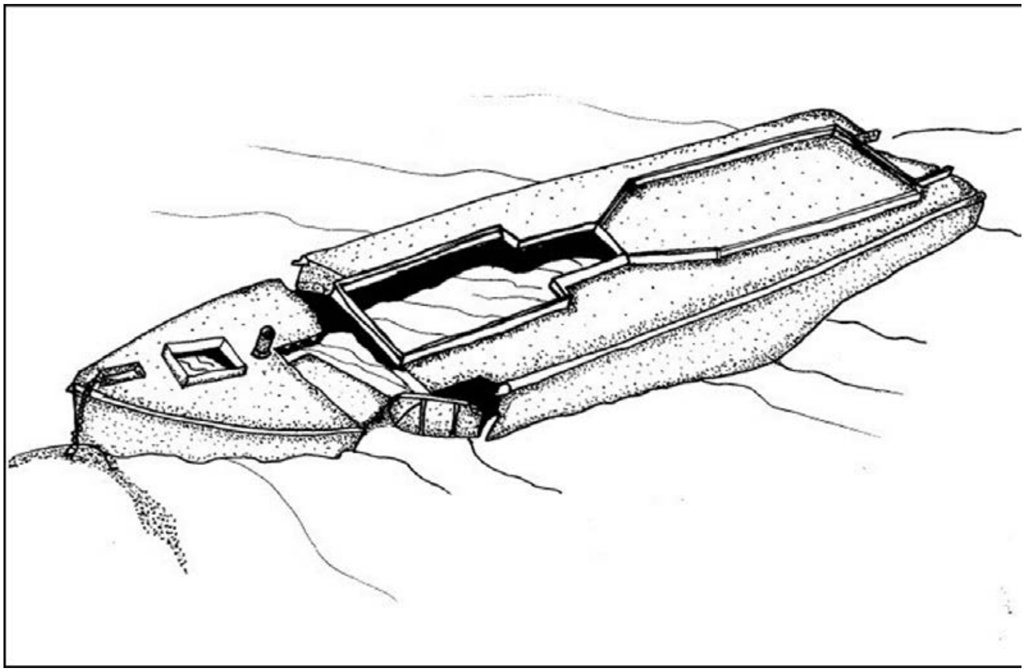

Figure 45: Drawing of the SB P3 modern vessel remains.

The absence of machinery and tackle for trawling suggests the possibility that the vessel remains in the SB P3 survey area could be associated with oil and gas industry activity. Although small at 55 feet in length and roughly 18 feet in beam, the vessel could have been adapted or constructed to transport supplies. The aft deck combing could have been designed to accommodate transporting cargoes like mud for drilling.

Though the wreck does not appear to meet qualifications for NRHP eligibility, it could provide an opportunity to study the impacts of dredging on buffers designed to protect significant submerged cultural resources. A broad cluster of 30 magnetic anomalies and 12 sonar targets in the southeastern third of the SB P3 survey area should be considered potentially significant. Those magnetic anomalies and sonar targets are identified by 1,350-foot (411 m) diameter Buffer A (Figure 46).

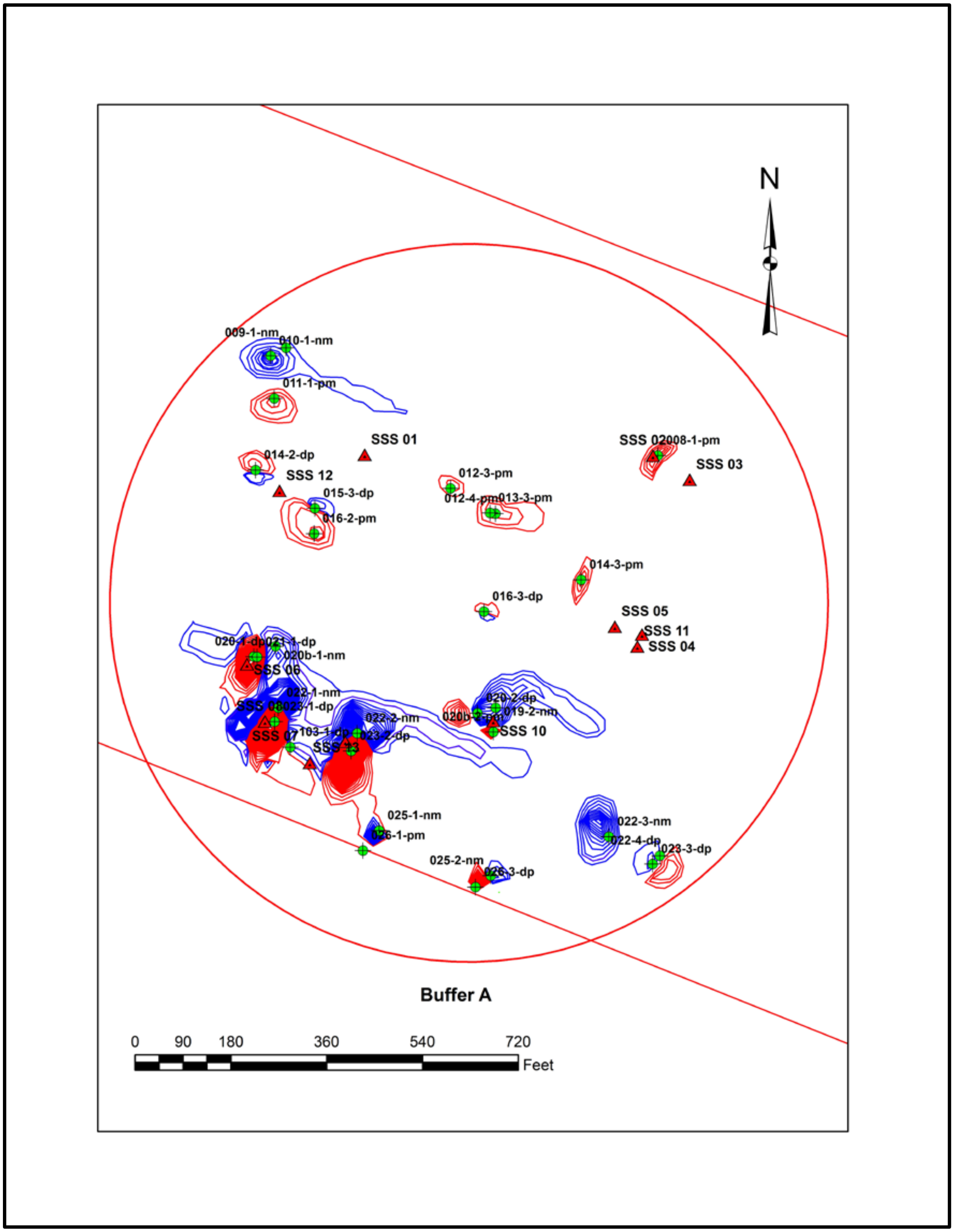

Figure 46. SB P3 survey area magnetic anomalies, contours, and sonar targets in Buffer A.

Although three Buffer A magnetic anomalies are associated with the "G 3" buoy that identifies Sabine Bank, many could be associated with the historic early 20th-century light structure built to facilitate safe navigation in the area. Historical research associated with this project provides interesting insight into the historic structure and its associated maintenance and service activities. The concentration of magnetic anomalies and sonar targets, adjacent to the south perimeter of the survey area, lie immediately adjacent to Sabine Bank Borrow Area JF. As those magnetic anomalies and sonar targets could represent material associated with the former light structure and its maintenance and service activity additional, investigation is recommended. Archaeological diver investigation should be designed to identify material generating the magnetic anomalies and sonar targets, to determine their historical and archaeological significance, and to assess the impacts of previous and future dredging.

In the western portion of the survey area, two additional magnetic anomaly clusters, containing three anomalies each, may also be associated with potentially significant submerged cultural resources. They are identified by 300-foot (91 m) diameter Buffer B (Figure 47) and 300-foot (91 m) diameter Buffer C (Figure 48). Both clusters have collective magnetic signatures that could be associated with small vessel remains. In the event that dredging activity is proposed in the immediate vicinity of those two buffers, avoidance or additional investigation is recommended. Archaeological diver investigation should be designed to identify material generating the magnetic anomalies and sonar targets, to determine their historical and archaeological significance, and to assess the impacts of previous and future dredging.

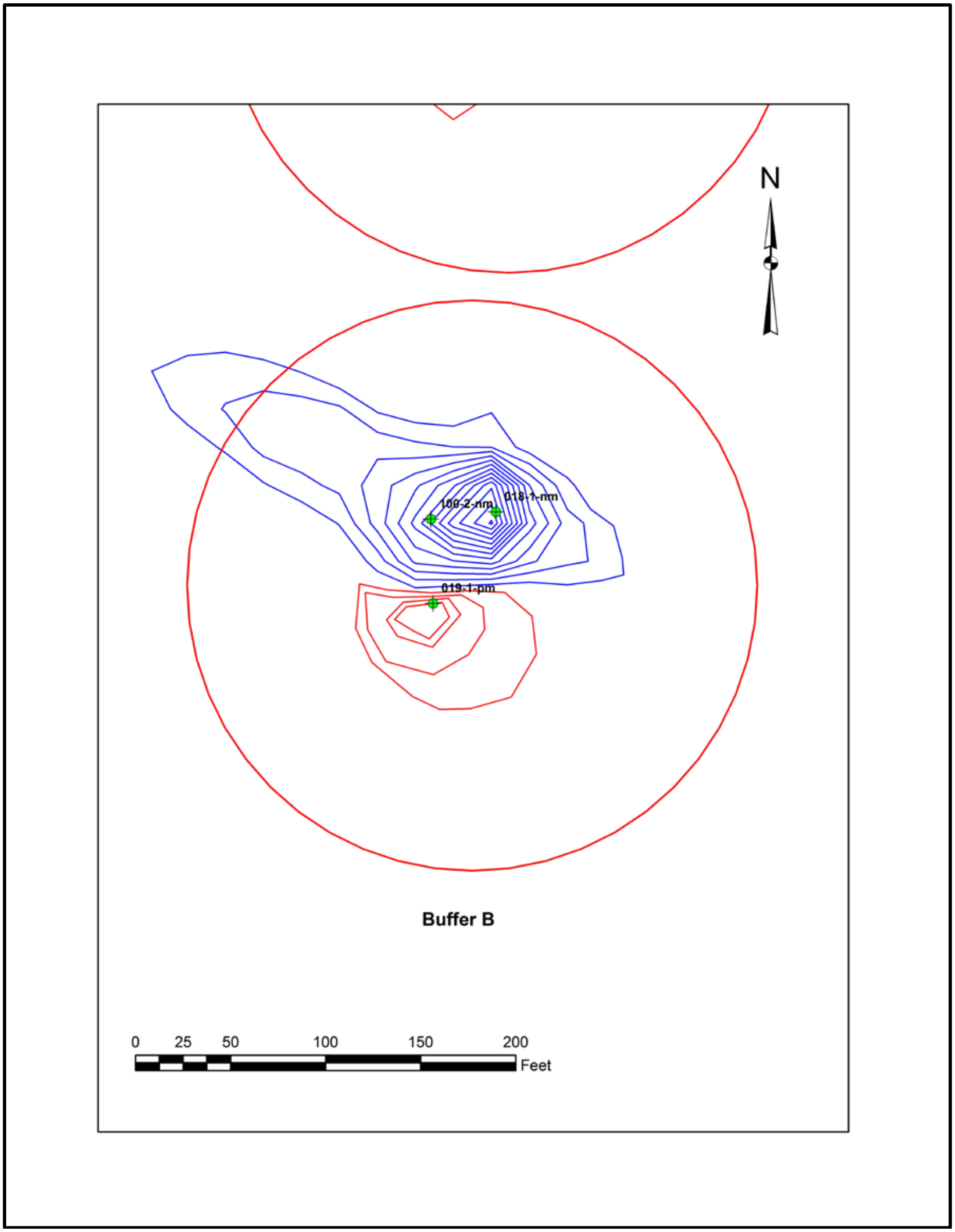

Figure 47. SB P3 magnetic anomalies and contours in Buffer B.

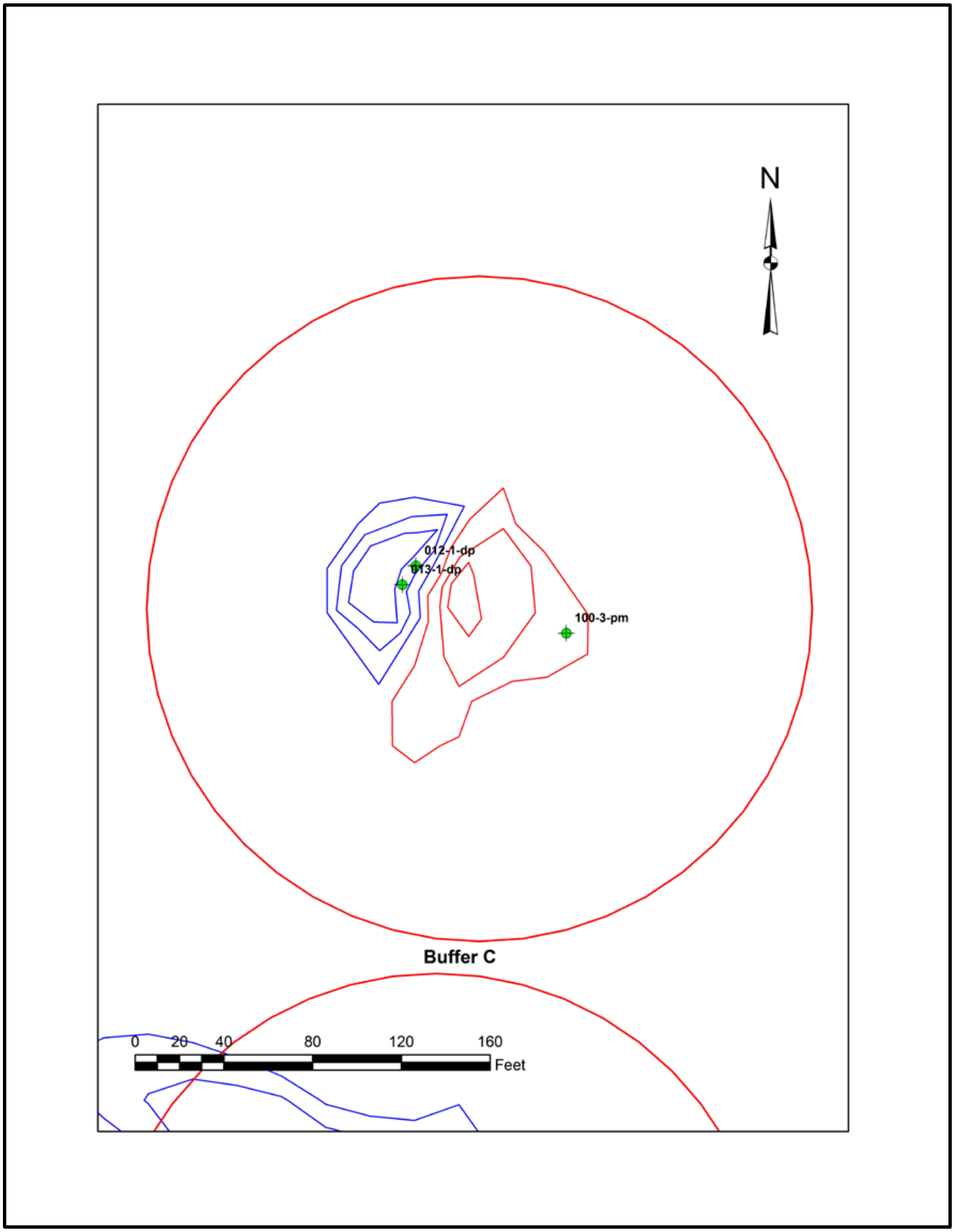

Figure 48. SB P3 magnetic anomalies and contours in Buffer C.

The remaining nine magnetic anomalies include six low- and moderate-intensity short duration signatures in the survey area that are suggestive of small, single ferrous objects with a low potential for association with small vessel remains or more complex submerged cultural resources. The final three magnetic anomalies were identified on tie lines and lie well outside the survey area.

Although remains of the modern vessel identified in area SB P3 do not apparently meet NRHP eligibility criteria, the shipwreck could serve as a good candidate for assessing dredging impacts on submerged cultural resources. More detailed investigation and documentation of the site could be combined with periodic assessment to quantify impacts to the vessel and to assess the protection afforded by various buffer designs and sizes.

In conjunction with this project, the magnetic anomalies and sonar target in Buffer A were not investigated by archaeological divers. However, Buffer A should be a high priority for future archaeological diver investigation in the event that dredging or other bottom disturbing activity in the vicinity is authorized. The magnetic anomalies and sonar targets in Buffer A have a high potential for association with vessel remains and navigation references such as the historic Sabine Bank lighthouse or other associated submerged cultural resources. Consequently, avoidance is recommended. The magnetic anomalies within Buffer B and Buffer C have a moderate potential for association with vessel remains or other submerged cultural resources. Avoidance of those buffers is also recommended.

In the event that bottom-disturbing activity is proposed for any or all of the buffered areas and avoidance is not possible, archaeological diver investigation is recommended. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.1.4. Secondary Area 1

Sabine Bank Secondary Area 1 (SB S1) was selected for remote sensing due to a large primary cluster of magnetic anomalies and a sonar image that could be associated with vessel remains (Figure 49). Additional remote-sensing data confirmed a complex of exposed structural material on the seabed and identified two small clusters of magnetic anomalies that have a moderate potential for association with historical vessel remains. Archaeological diver investigation was carried out at the primary site to identify and assess the potential significance of material generating a complex sonar target and the associated magnetic anomaly.

SB S1 was surveyed on September 7, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SB S1 identified thirty-three magnetic anomalies (Figure 50; Volume III: Appendix G), three sonar targets, and one sub-bottom target (Figure 51; Volume III: Appendix H).

One vibracore was collected in SB S1: SBVC-15-01. SBVC-15-01 indicated clay layers overlaying sand. The sandy material ranged in grain size from 0.16 to 0.21 mm. The overlying clay layers are approximately 4 feet thick. The thickness of the sandy layer was approximately 10 feet thick. Future work on modeling potential borrow area affects to surrounding cultural resources should take into account the removal and placement of the overburden along with the stability of the sandy walls of the borrow area.

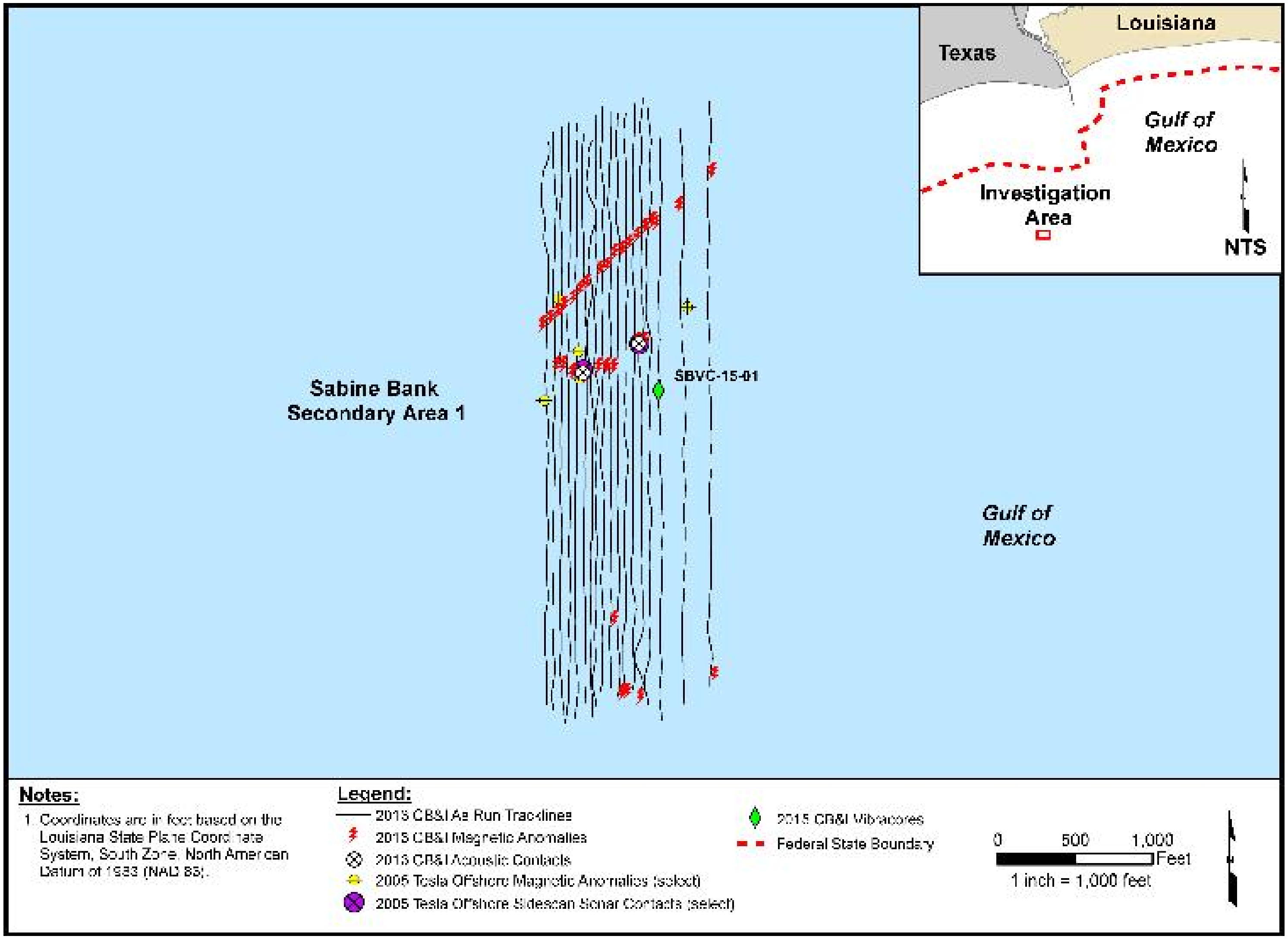

Figure 49. Magnetic anomalies and acoustic targets identified in Sabine Bank Secondary Area 1.

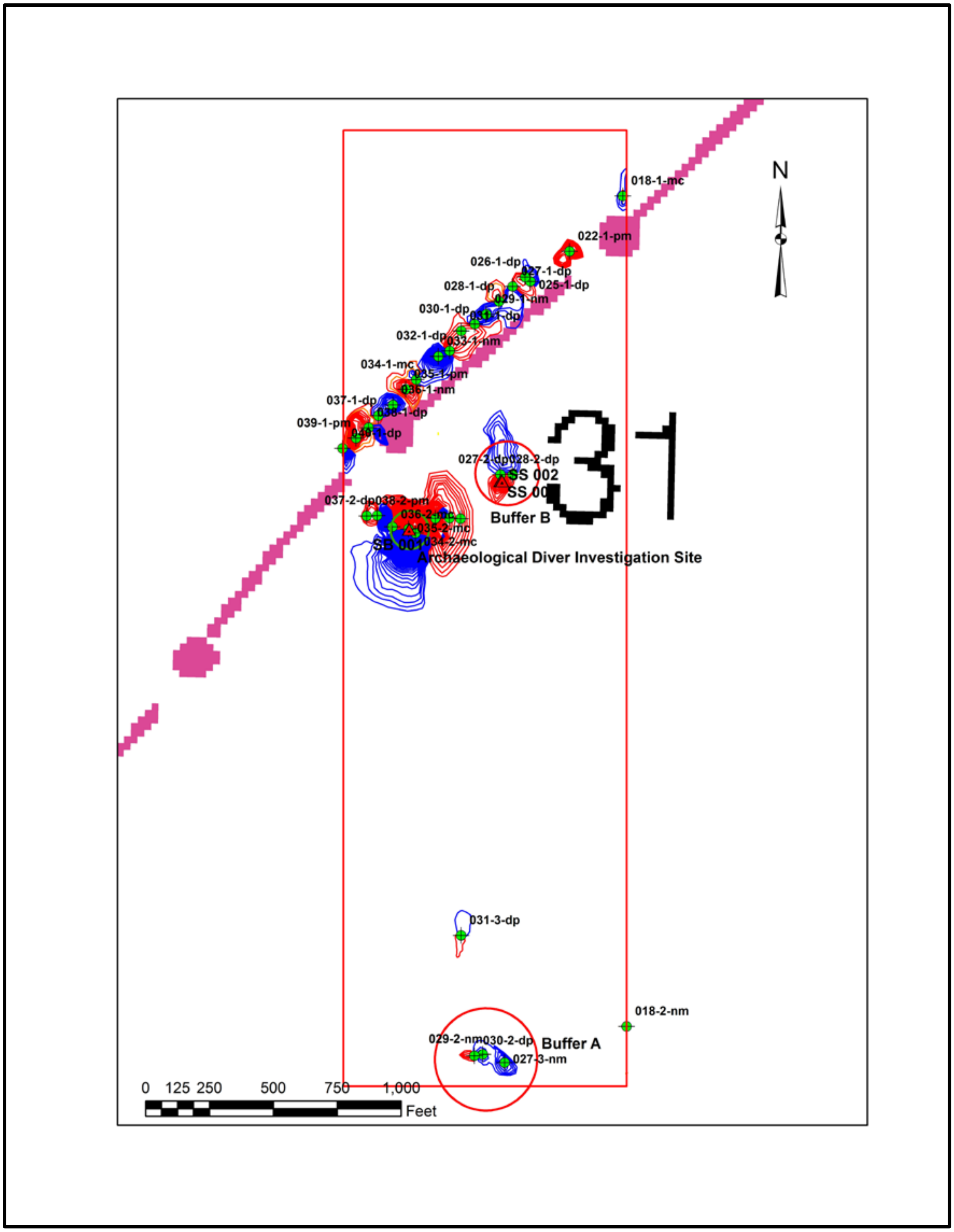

Figure 50. SB S1 magnetic anomalies, contours, and buffers.

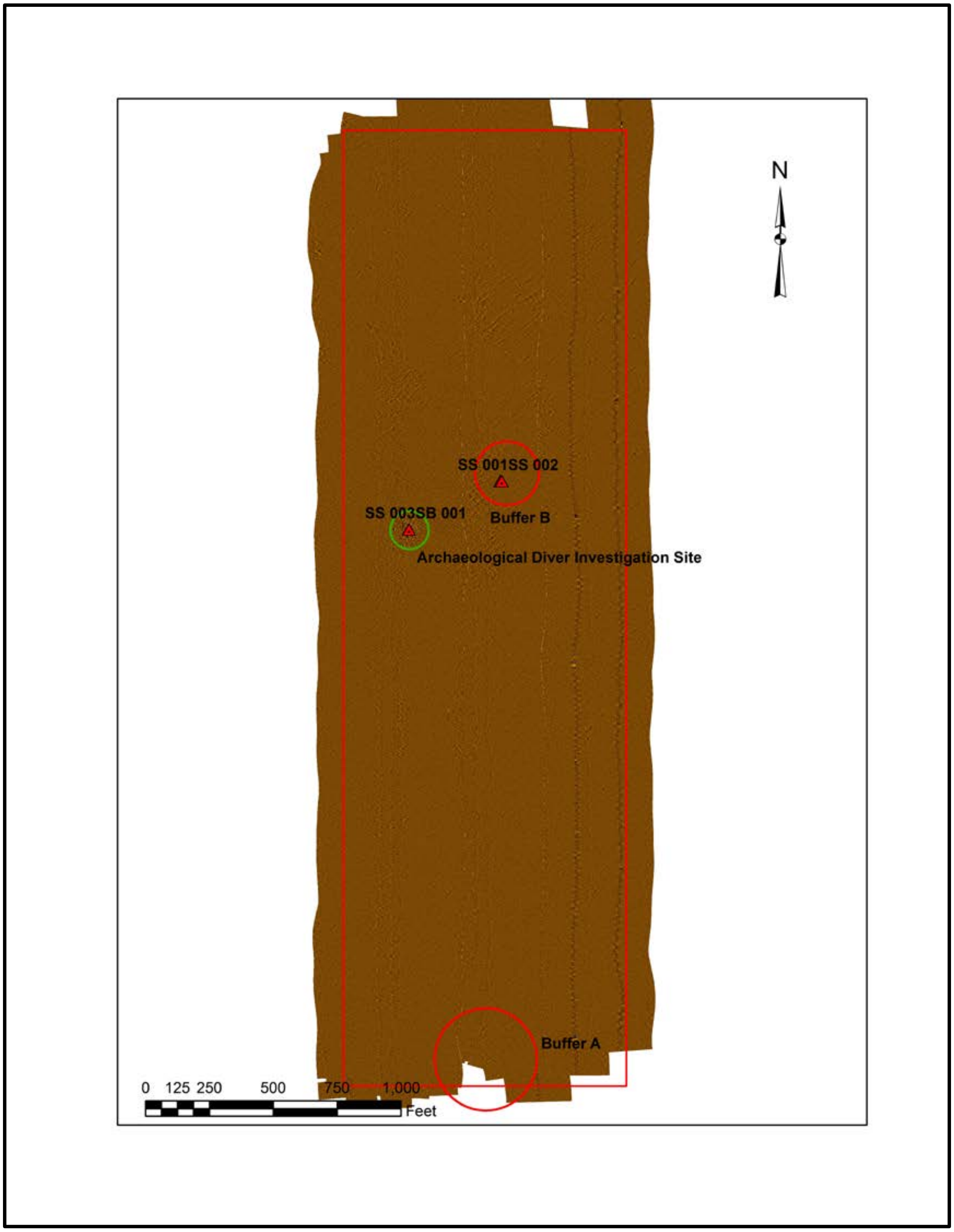

Figure 51. SB S1 sonar coverage mosaic with acoustic targets.

Eight magnetic anomalies (031-2, 032-2, 033-2, 034-2, 035-2, 036-2, 037-2, and 038-2) are associated with a cluster of modern structural debris immediately south of a charted pipeline (Figure 52). Sonar image SS 003 (Figure 53) confirms the concentration of structural debris on the bottom surface. Sub-bottom profiler data suggests that additional material associated with the exposed debris may be buried, and in all likelihood that material also represents modern structural debris (Figure 54; Volume III: Appendix H).

Archaeological diver investigation of this exposed debris at the site was carried out on June 16, 2016. In spite of poor visibility varying six inches or less, the investigation confirmed material at the site consisted of modern debris. Most of the debris consisted of angle iron, I-beams, threaded drill string, iron bars, iron plates, and associated beams. Disarticulated structural elements at the site appeared to represent salvaged material from an oil well, gas well, or platform. The material could be associated with a structure cut down at the site or possibly material lost overboard from a salvaged structure.

Three additional magnetic anomalies, 027-3, 028-2, and 030-2, identified adjacent to the southern border of the survey area represent a cluster that could be associated with historical vessel remains or other potentially significant submerged cultural resources. Those magnetic anomalies are recommended for avoidance. A 400-foot (122 m) diameter buffer (Buffer A) is suggested to protect material generating those signatures. In the event that avoidance is not possible, additional investigation is recommended to identify and assess the significance of that material (Figure 55).

Two magnetic anomalies (027-2 and 028-2) appear to represent another cluster of small objects (Figure 56). Sonar images of material on the bottom surface in the area (SS 001 and SS 002) suggest that the magnetic anomalies could be associated with elements of structure and possibly ballast (Figure 57; Figure 58). Material generating those magnetic signatures could represent small vessel remains, and a 250-foot (76 m) diameter buffer (Buffer B) is suggested for avoidance. The signatures could also represent modern debris associated with construction and/or servicing of the pipeline north of the site.

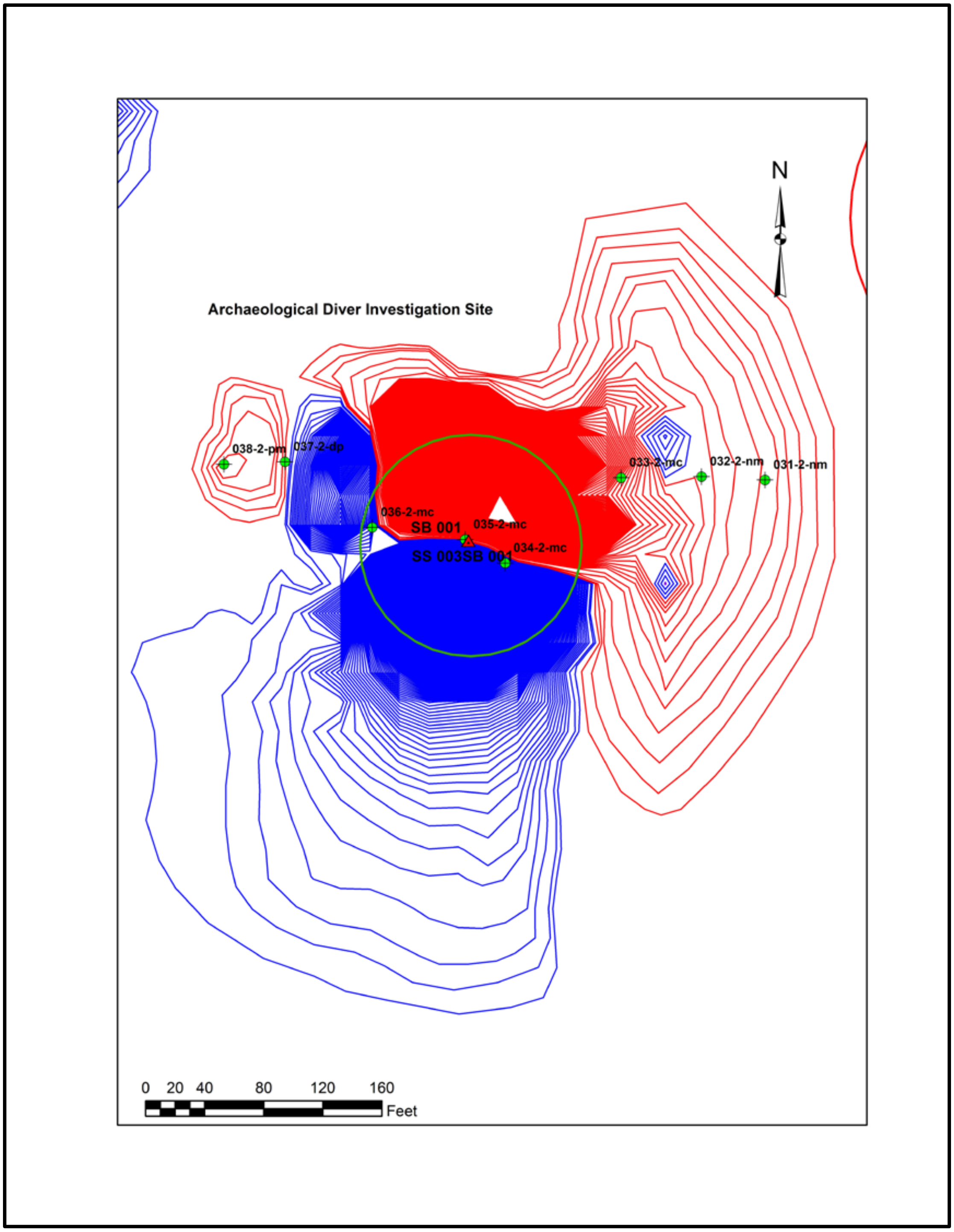

Figure 52. Magnetic anomaly cluster and acoustic targets at SB S1 archaeological diver investigation site.

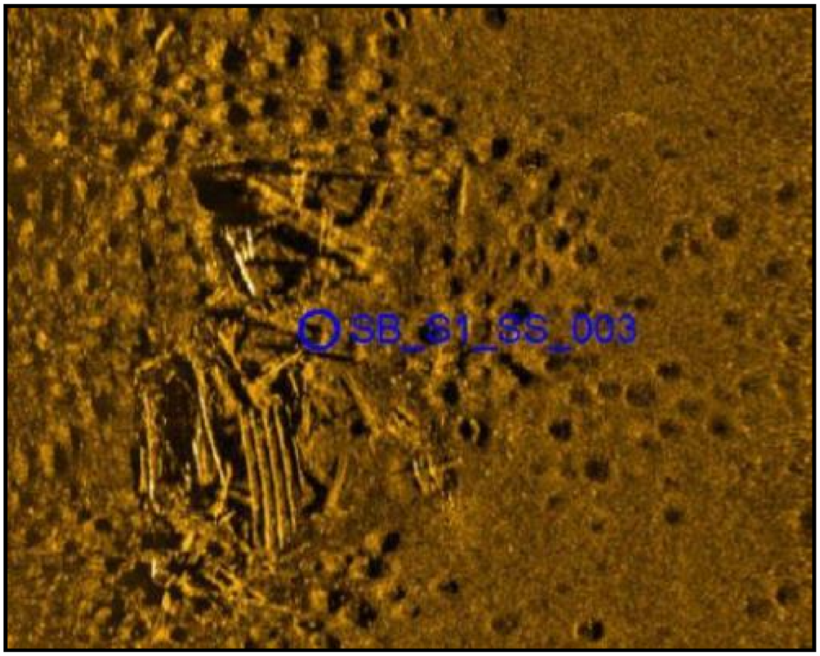

Figure 53. SB S1 sonar image SS 003 showing exposed bottom surface debris.

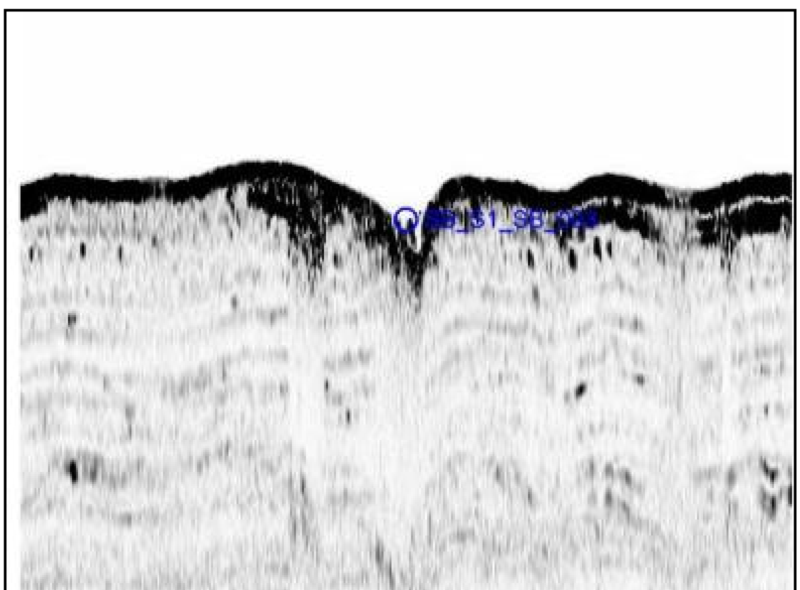

Figure 54. SB S1 sub-bottom profiler image SB 003 of buried feature associated with exposed debris.

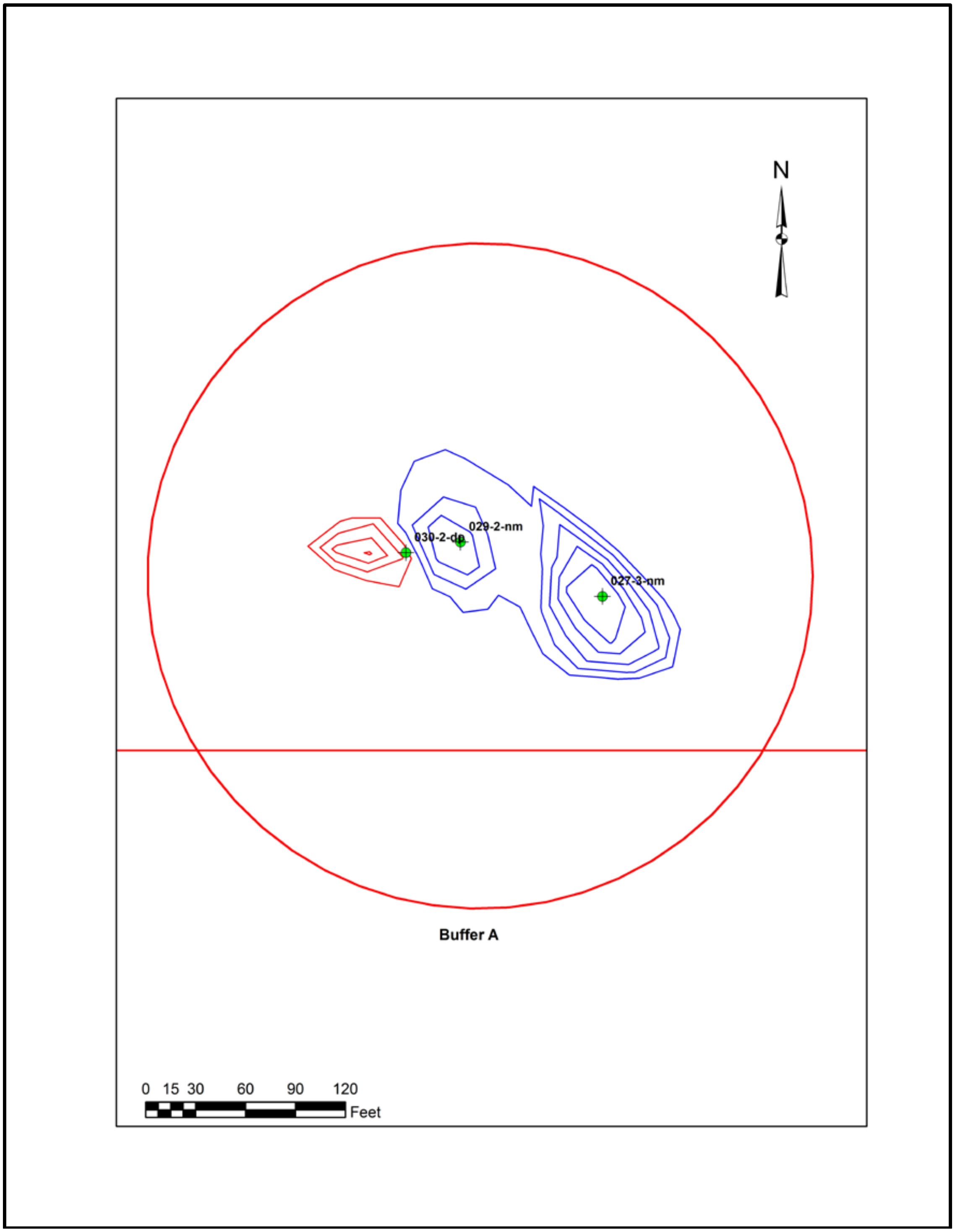

Figure 55. Buffer A magnetic anomalies and contours in SB S1.

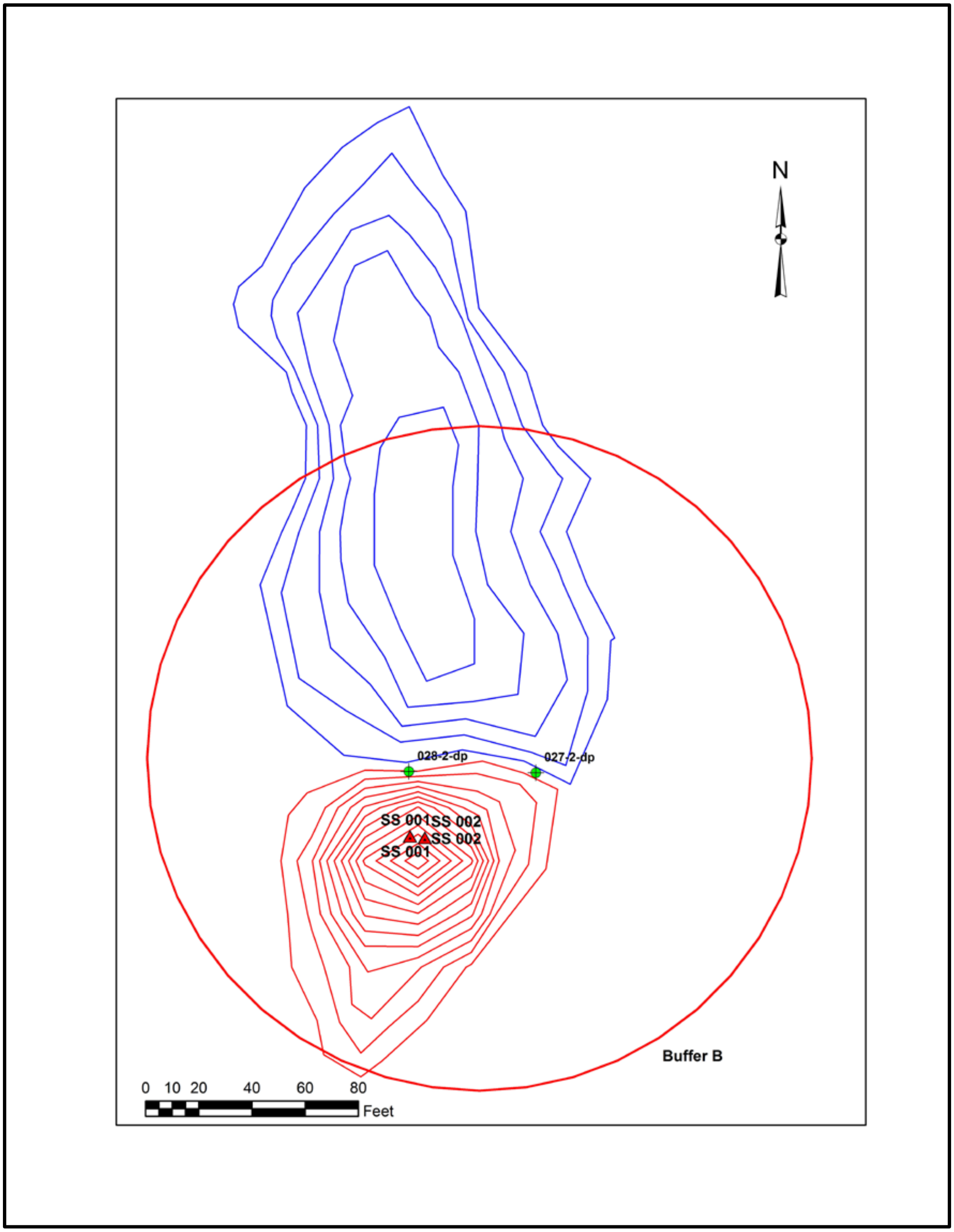

Figure 56. SB S1 Buffer B magnetic anomalies, contours, and sonar targets.

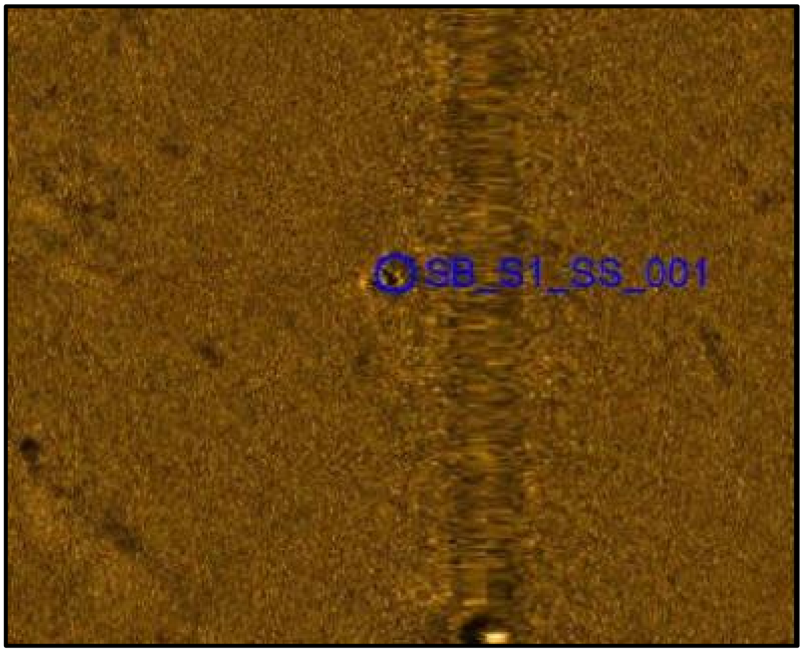

Figure 57. SB S1 Buffer B bottom surface structure and possibly ballast.

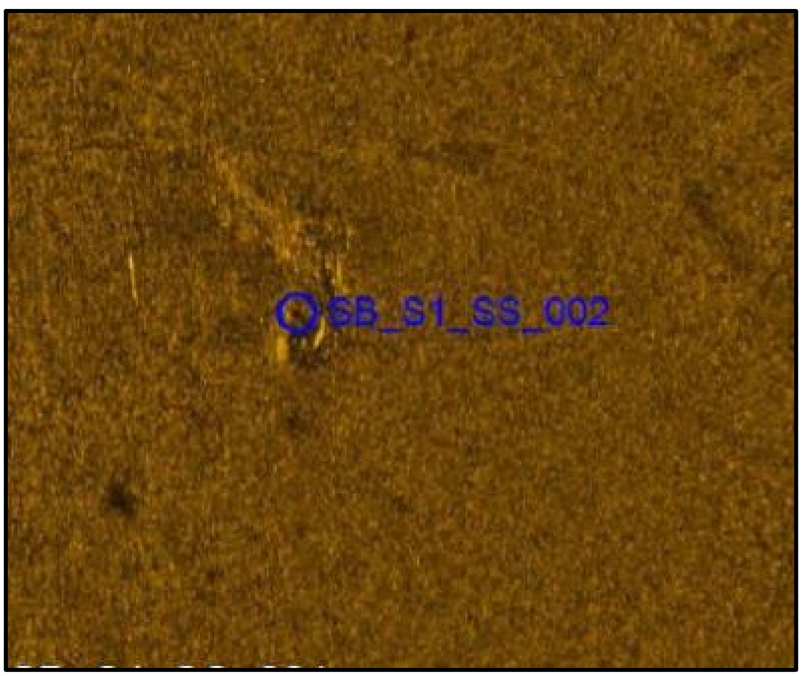

Figure 58. SB S1 Buffer B small objects and possibly ballast.

Of the remaining magnetic anomalies, 18 are associated with the charted pipeline. Two magnetic anomalies appear to be associated with small single objects and do not have more complex signatures generally associated with potentially significant submerged cultural resources.

SB S1 magnetic anomalies in Buffer A and SB S1 magnetic anomalies and sonar targets in Buffer B were not investigated by archaeological divers in conjunction with this project. However, both buffers should be a moderate priority for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized. The magnetic anomalies within Buffer A have a moderate potential for association with vessel remains or other submerged cultural resources. The magnetic anomalies and sonar targets in Buffer B have a high potential for association with vessel remains and/or other associated submerged cultural resources. In addition to elements of structure, sonar images from Buffer B illustrate what could be a ballast scatter.

In the event that bottom-disturbing activity is proposed for any or all of the buffered areas and avoidance is not possible, archaeological diver investigation is recommended. Archaeological diver investigation should be designed to identify material generating the signatures and assess its significance in terms of NRHP eligibility.

4.1.5. Secondary Area 2 SE

Sabine Bank Secondary Area 2 SE (SB S2 SE) was selected for remote sensing, in part due to plans for dredging the nearby Sabine Bank BA2 (see Table 2) site (Figure 59), and in part due to a charted shipwreck on the current National Oceanic and Atmospheric Administration (NOAA) Chart 11341-1 (Figure 60). The Automated Wrecks and Obstruction Information System (AWOIS) identified the vessel as *G. I. Joe*. Historical research identified *G. I. Joe* as a trawler lost in July 1965.

On 25 July 1965, regional newspapers published accounts related to the explosion of *G.I. Joe* approximately 18 miles from Sabine Pass. According to the vessel's captain "no explosives were aboard the diesel-powered wooden-hulled vessel" (The Shreveport Times 1965). An excerpt of one feature, entitled "Shrimp Boat Blast Kills Man in Gulf," follows,

> Warren L. Scott of Morgan City, captain of the sunken G. I. Joe, escaped injury by leaping into the water. He was rescued minutes later by crewmen of the nearby Pisces out of Port Arthur. Scott and [Charles] Edwards were the only persons aboard the boat owned by Willie Auchion of Morgan City. At nightfall, the Coast Guard called off the search for the missing man. Scott said Edwards, who had been a crewman only a week, was lying on the left side of the boat. 'It sank in about two minutes,' Scott said, 'I barely had time to get off'. (The Shreveport Times 1965:14)

In follow-up stories, *The Lake Charles American-Press* (27 July 1965:24) and *The Orange Leader* (26 July 1965:8) both commented that Port Arthur marine inspection officers were expected to conduct an investigation aimed at determining the cause of the explosion."

Magnetometer data confirmed a charted pipeline passing through the shipwreck symbol. Data also confirmed a previously identified, potentially significant and buffered cluster of magnetic anomalies north of the wreck symbol. That cluster of magnetic anomalies was previously thought to have a potential association with historical vessel remains. The site was selected for archaeological diver investigation.

SB S2 SE was surveyed on September 7, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SB S2 SE identified sixteen magnetic anomalies (Figure 61; Volume III: Appendix I) and one sonar target (Figure 62; Volume III: Appendix J).

Five magnetic anomalies (054-1, 055-1, 056-1, 057-3, and 200-1) form a cluster with a high potential for association with shipwreck remains. The site was selected for archaeological diver investigation (Figure 63).

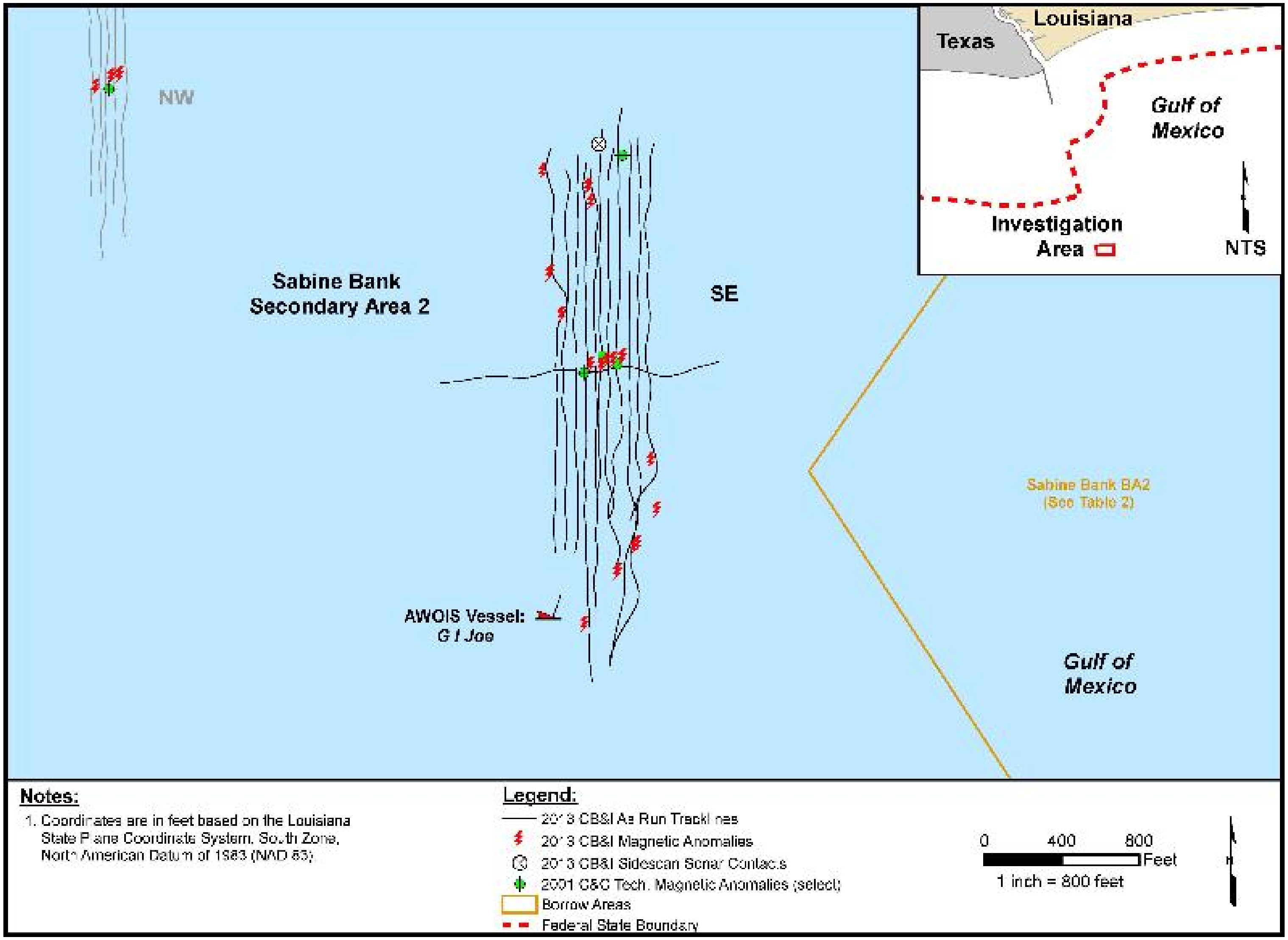

Figure 59. Magnetic anomalies and sonar targets identified in Sabine Bank Secondary Area 2 SE.

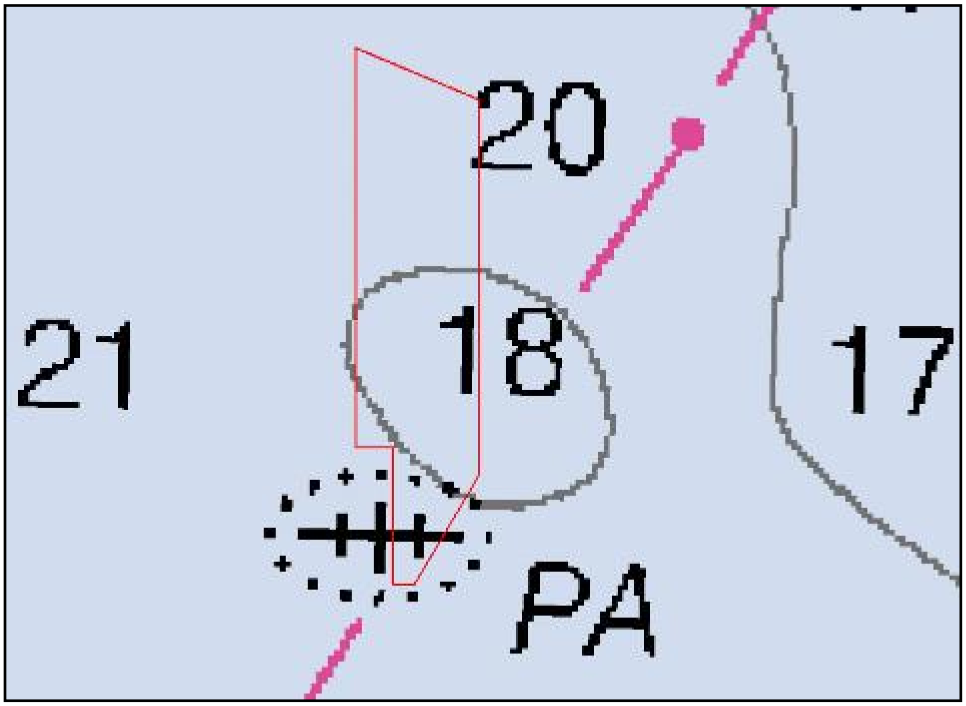

Figure 60. SB S2 SE survey location on NOAA Chart 11341 showing wreck and pipeline.

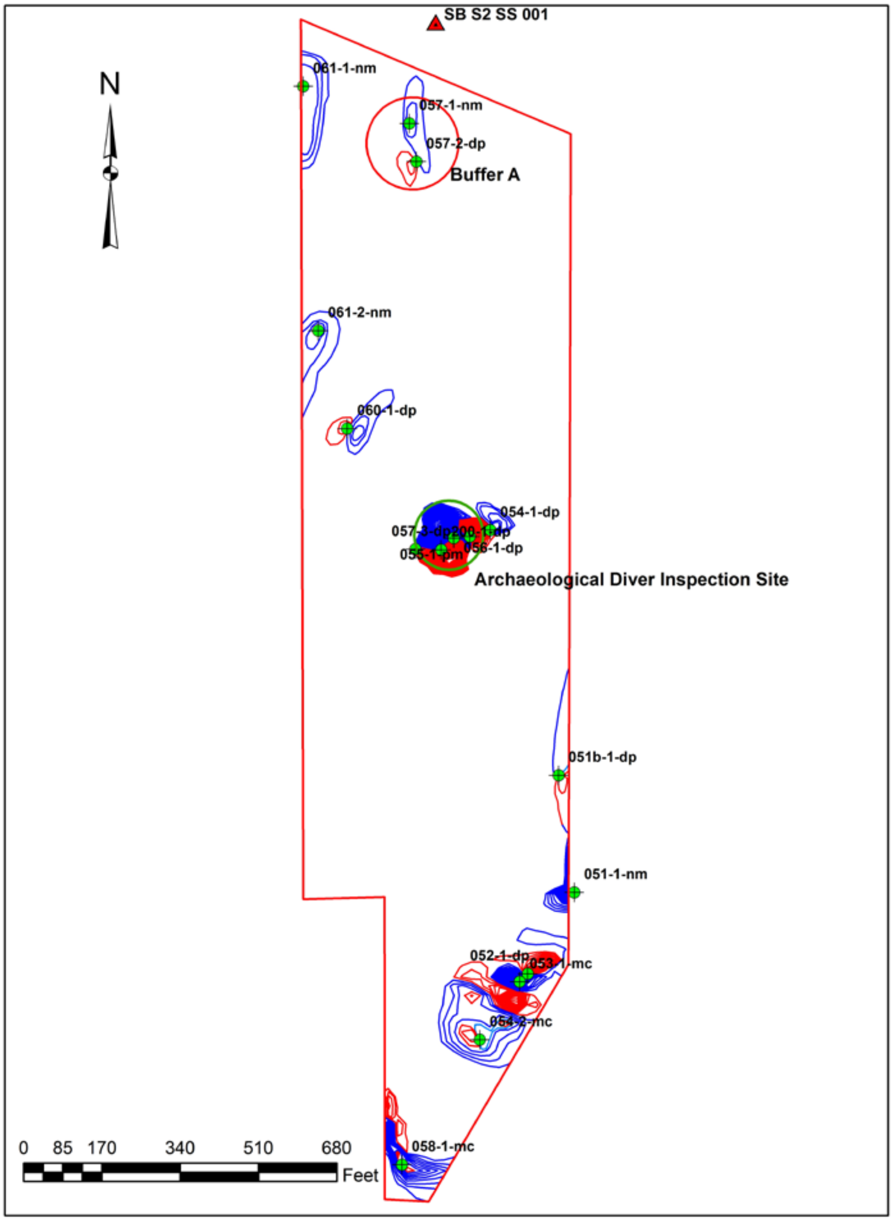

Figure 61. SB S2 SE magnetic anomalies, contours, and Buffer A.

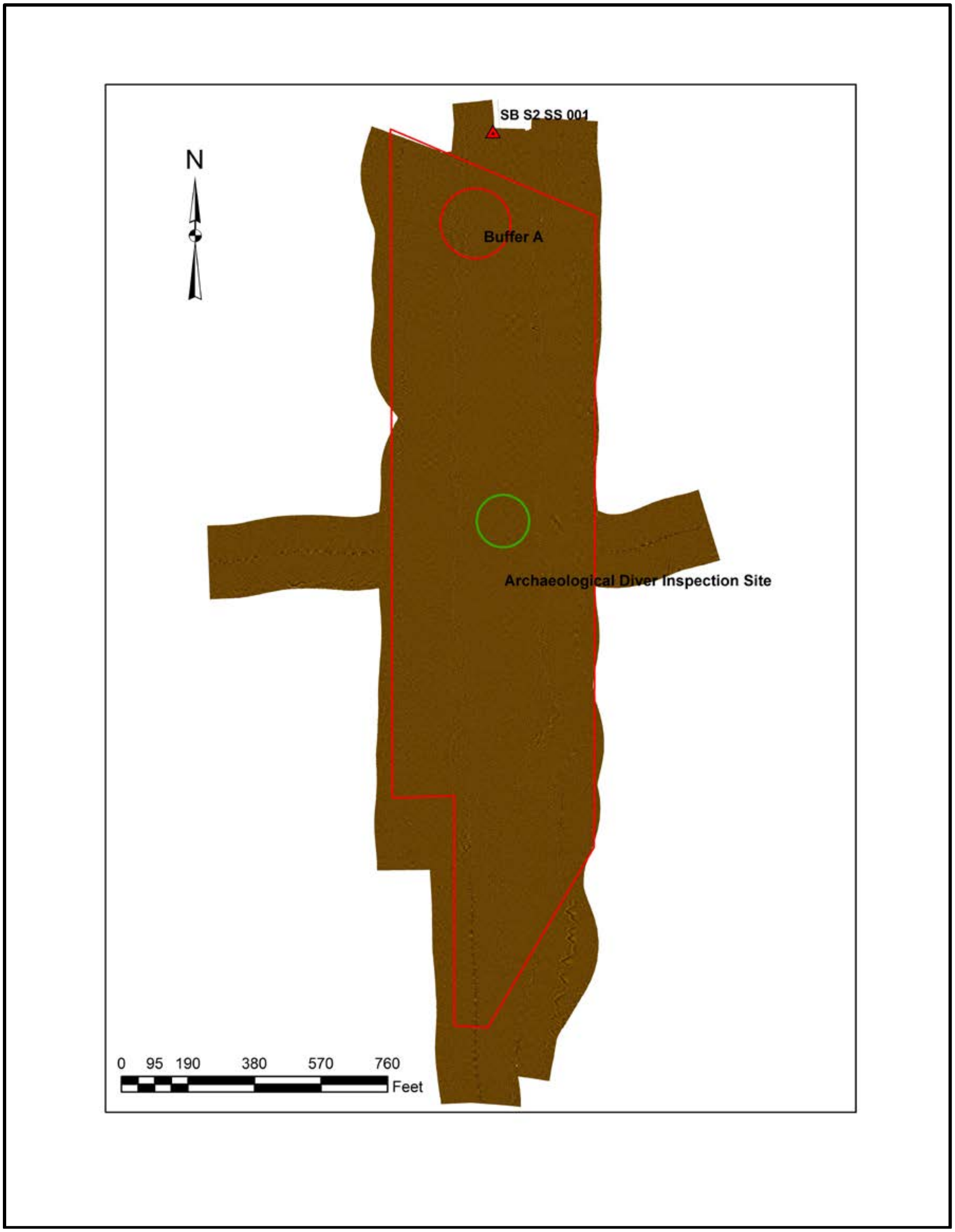

Figure 62. SB S2 SE sonar coverage mosaic with sonar target.

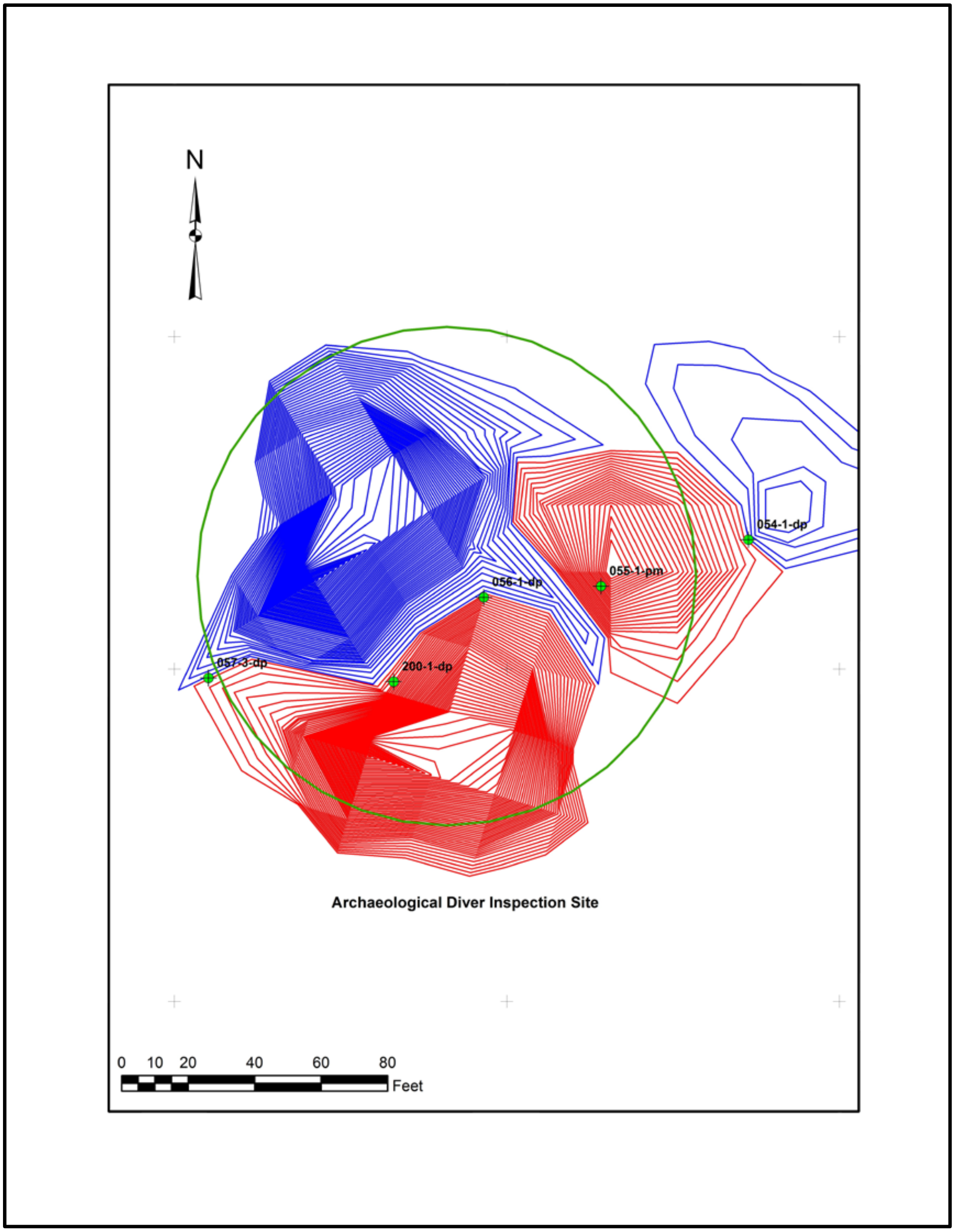

Figure 63. SB S2 SE magnetic anomaly cluster selected for archaeological diver investigation.

Archaeological diver investigation of the magnetic anomaly cluster identified in SB S2 SE was carried out on June 14 and 17, 2016. The initial investigation, conducted on June 14, identified a section of modern pipe extending vertically out of the sediment. A second and smaller diameter section of pipe was welded perpendicularly to the first to form part of a trawl rig. Stainless wire rope and tarred net were fouled on the section of pipe extending across the seabed (Figure 64). Currents at the time proved to be too strong and seas too rough to probe the site for associated hull remains.

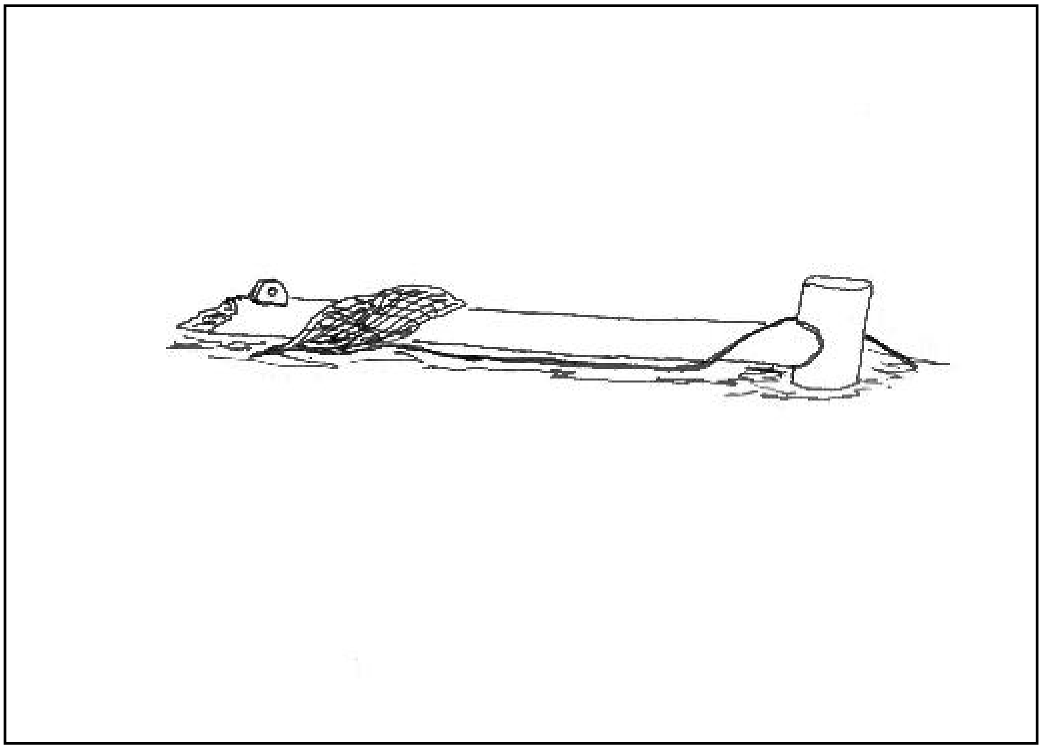

Figure 64. SB S2 SE diver drawing of exposed boom, wire rope, and tarred net.

The second investigation at SB S2 SE was carried out on June 17, 2016. Once the surface material was located, an archaeological diver was directed to the site using the BOEM sector scan sonar. A buoy was attached to the second feature at the site (Figure 65) and the hydraulic probe was used to clear away sediment, allowing observation of additional details (Figure 66). Heavy concretion prevented positive identification, however, copper tube, pipe manifolds with flanges, and valves confirmed the feature is also modern and possibly engine or other machinery-related debris. Following examination of the second feature, concentric circles were probed out to a distance of 30 feet (9 m) from the exposed feature. Systematic probing identified one additional metal feature at a depth of 5 feet (1.5 m) below the bottom surface. No evidence of vessel structure was found in conjunction with the exposed debris.

Figure 65. Image of second feature located at SB S2 SE.

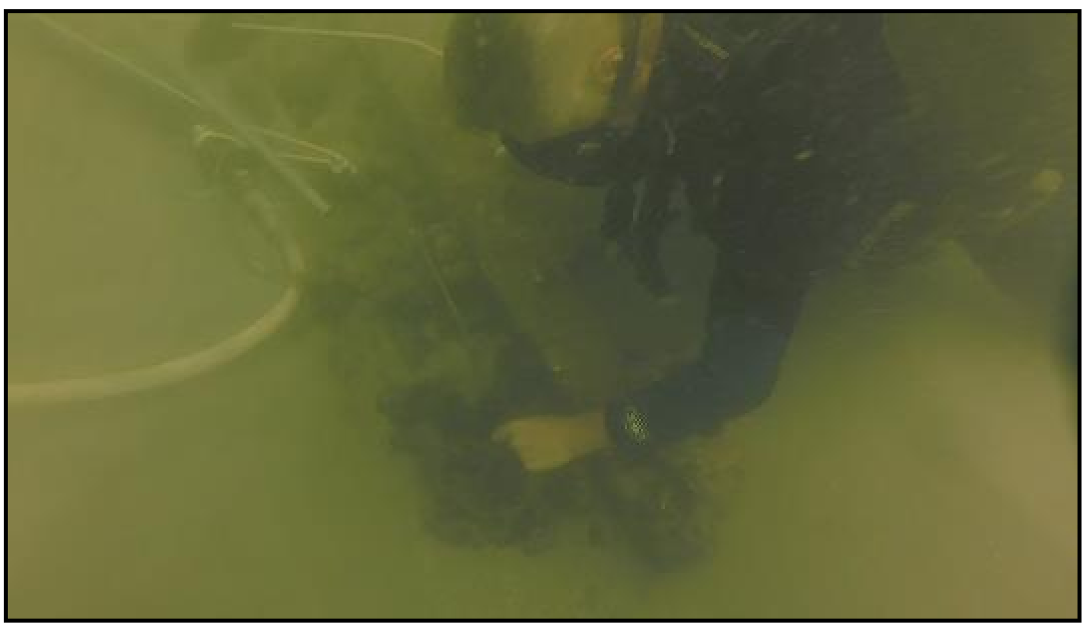

Figure 66. Image of diver using hydraulic probe to expose second feature at SB S2 SE.

Five additional magnetic anomalies (051-1, 052-1, 053-1, 054-2, and 058-1) were identified along the charted pipeline alignment. Magnetic anomalies 054-2 and 058-1 are located within the charted wreck symbol but do not appear to be associated with shipwreck remains. Two magnetic anomalies (057-1 and 057-2) form a cluster with signature characteristics that could have a moderate association with small vessel remains. Both are included within Buffer A (Figure 67).

The remaining four magnetic anomalies do not have signature characteristics that appear to be associated with historical vessel remains or other potentially significant submerged cultural resources. One (051-1) is located outside the survey area border. Two (061-1 and 061-2) are close enough to the survey area border to be associated with more significant source material that lies beyond the scope of available data. The single sonar target, SS 001, includes a linear object and a scatter of several small objects (Figure 68). Those targets lie outside the northern perimeter of the survey area and are not associated with any magnetic anomaly or cluster of magnetic anomalies.

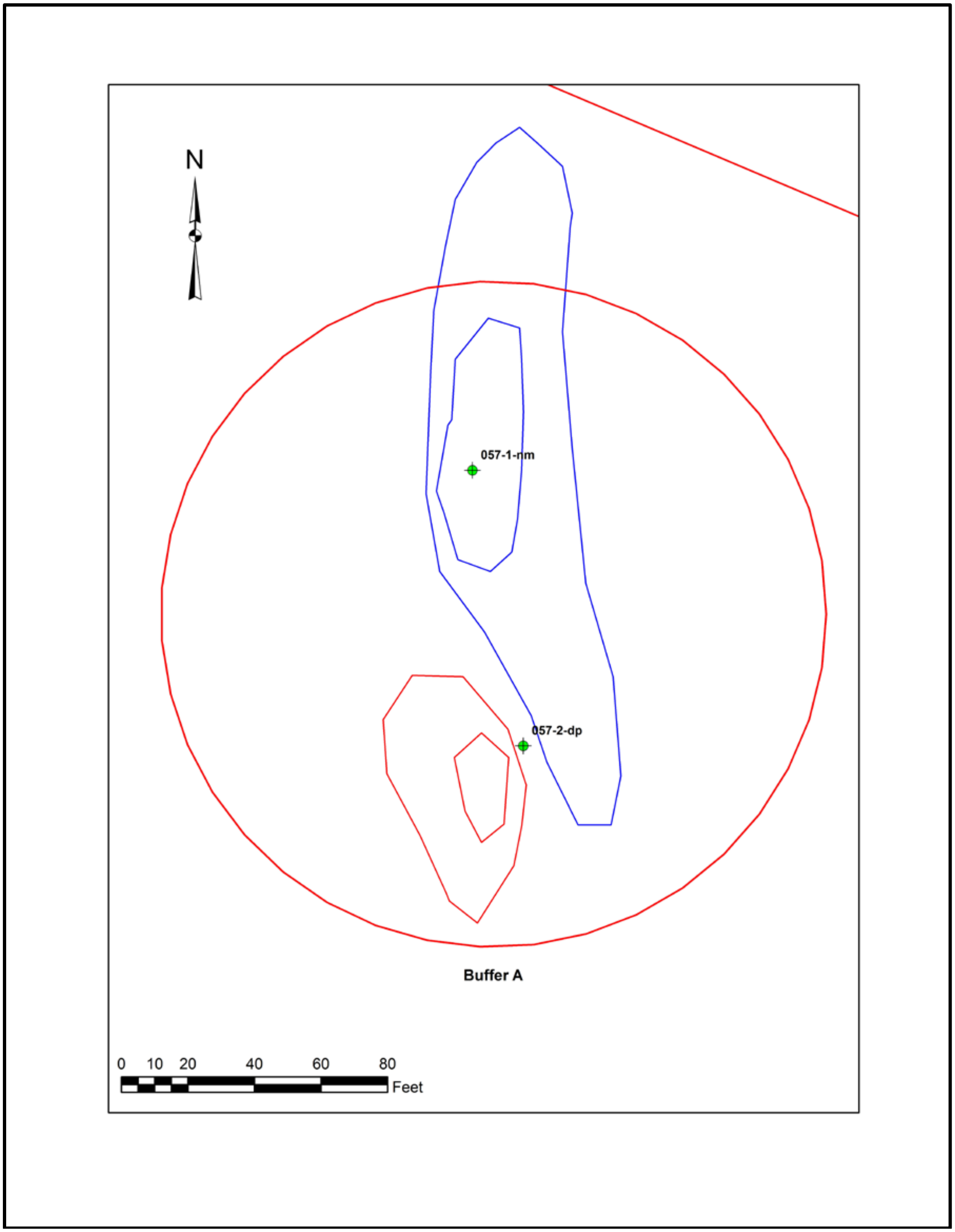

Figure 67. SB S2 SE Buffer A magnetic anomalies and contours.

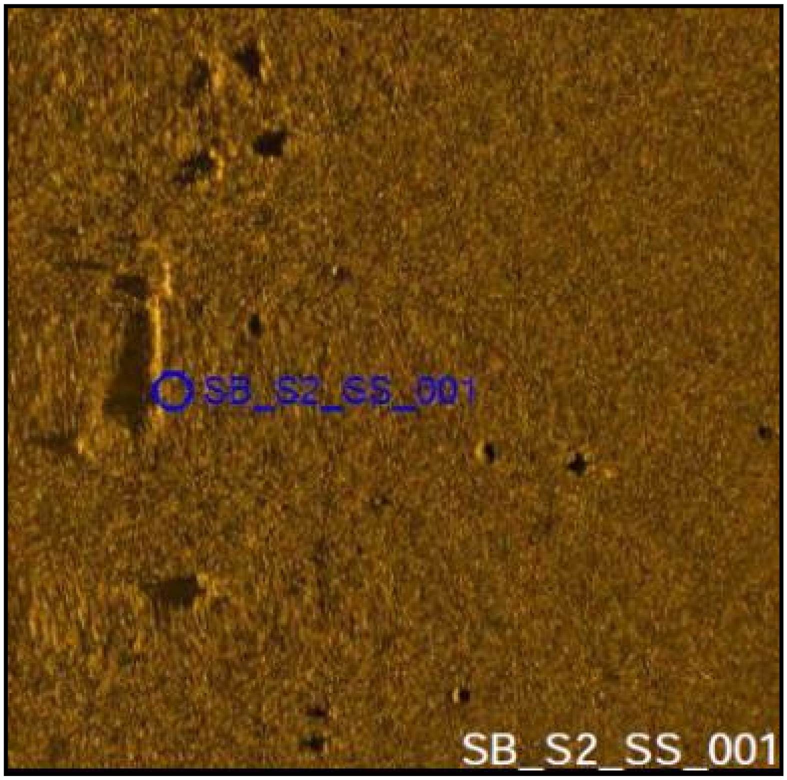

Figure 68. SB S2 SE linear object and cluster of small objects north of survey area.

Archaeological diver investigation of the primary cluster of anomalies confirmed that material generating those signatures represents the remains of a modern trawler. As probing failed to identify any associated structural material, no additional investigation of the site is recommended. Although impossible to confirm based on available data, material accessible at the SB S2 SE site can be considered to be in keeping with the diesel-powered wood hull of the trawler *G I Joe*.

Magnetic anomalies within Buffer A have a moderate potential for association with vessel remains or other submerged cultural resources. Archaeological divers in conjunction with this project did not investigate magnetic anomalies in Buffer A. However, Buffer A should be a moderate priority for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.1.6. Secondary Area 2 NW

Sabine Bank Secondary Area 2 NW (SB S2 NW) was selected for remote sensing, in part due to plans for dredging the nearby Sabine Bank BA2 (see Table 2) borrow site, and in part due to a previously identified and potentially significant magnetic anomaly (Figure 69).

SB S2 NW was surveyed on September 7, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SB S2 NW identified four magnetic anomalies (Figure 70; Volume III: Appendix K) and no acoustic targets (Figure 71). Three magnetic anomalies (107-1, 108-1, and 109-1) form a cluster with a high potential for association with shipwreck remains. Those three are identified as Buffer A (Figure 72). The remaining magnetic anomaly (106-1) has signature characteristics of a small ferrous object that has a low potential for association with historical shipwreck remains.

Magnetic anomalies within Buffer A have a high potential for association with vessel remains or other submerged cultural resources. In conjunction with this project, archaeological divers did not investigate magnetic anomalies in Buffer A. However, Buffer A should be a high priority for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. Archaeological diver investigation should be designed to identify material generating the signatures and assess its significance in terms of NRHP eligibility.

One vibracore was collected in SB S3: SBVC-15-02. SBVC-15-02 indicated sand overlying clay. The sandy material had a grain size of 0.16 mm and was 6.3 feet thick. Future work on modeling potential borrow area affects to surrounding cultural resources should focus on the first 6.3 feet along with the sand-clay interface as future beach nourishment dredging will be confined to these layers.

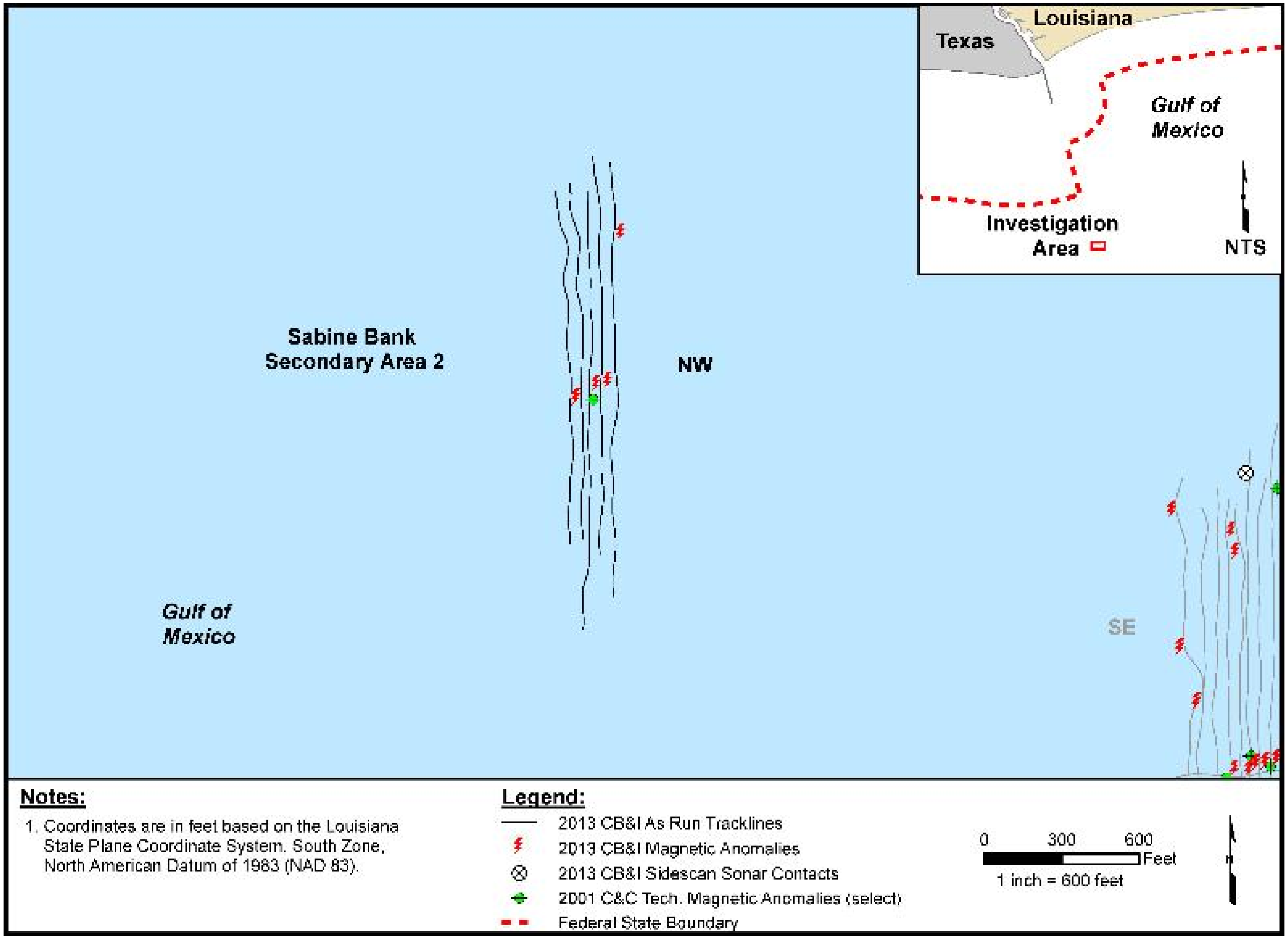

Figure 69: Magnetic anomalies identified in Sabine Bank Secondary Area 2 NW.

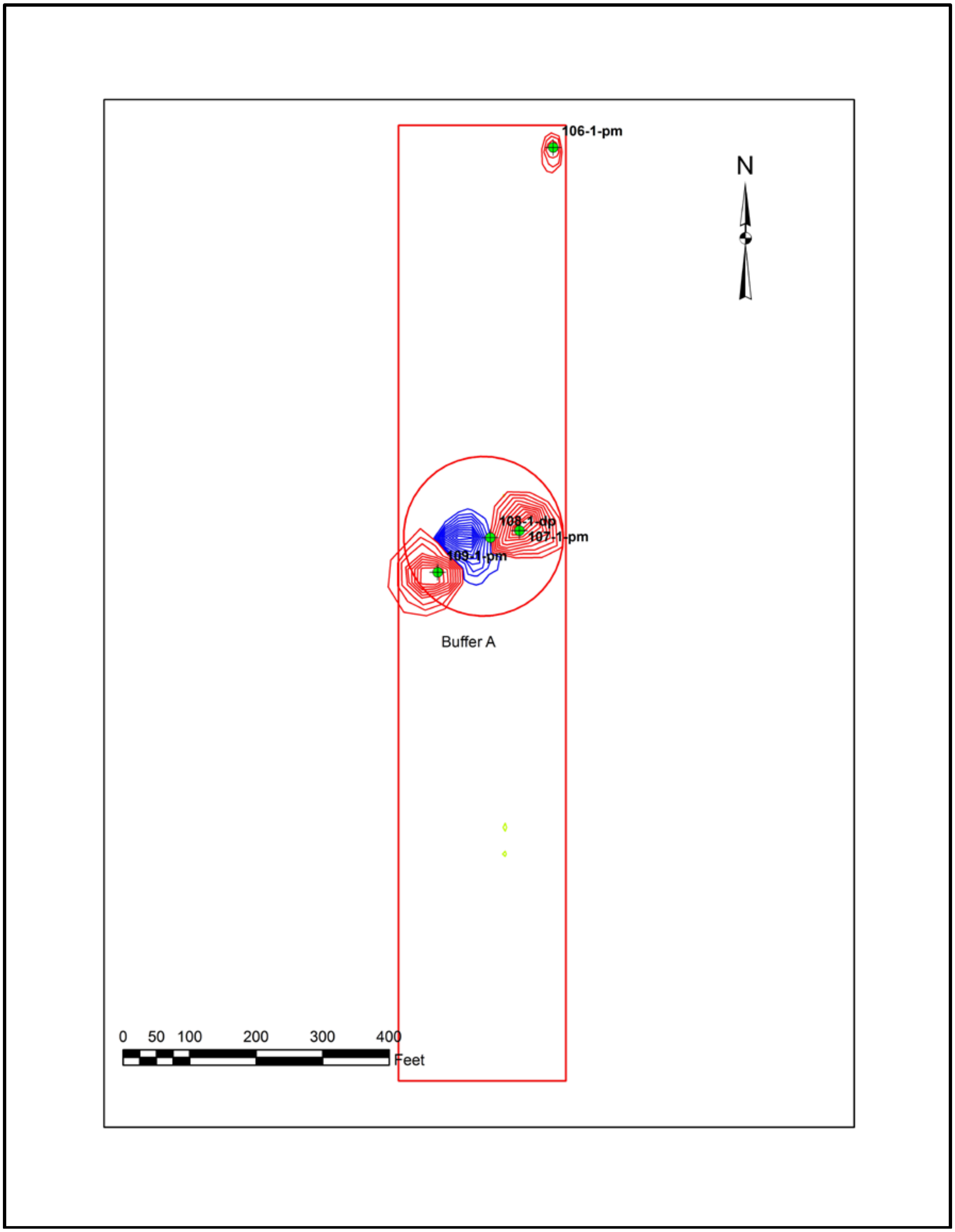

Figure 70. SB S2 NW magnetic anomalies, contours, and Buffer A.

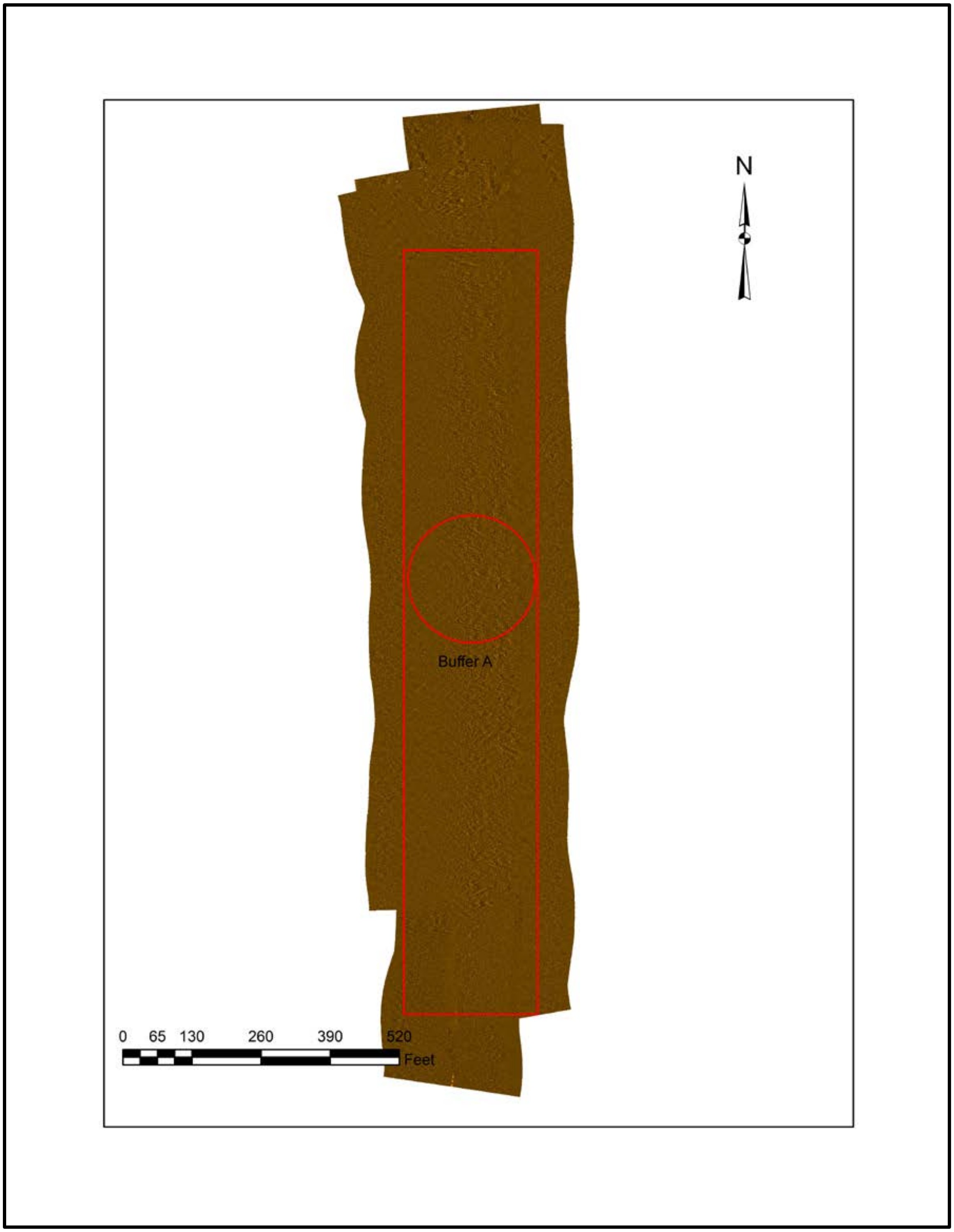

Figure 71. SB S2 NW sonar coverage mosaic.

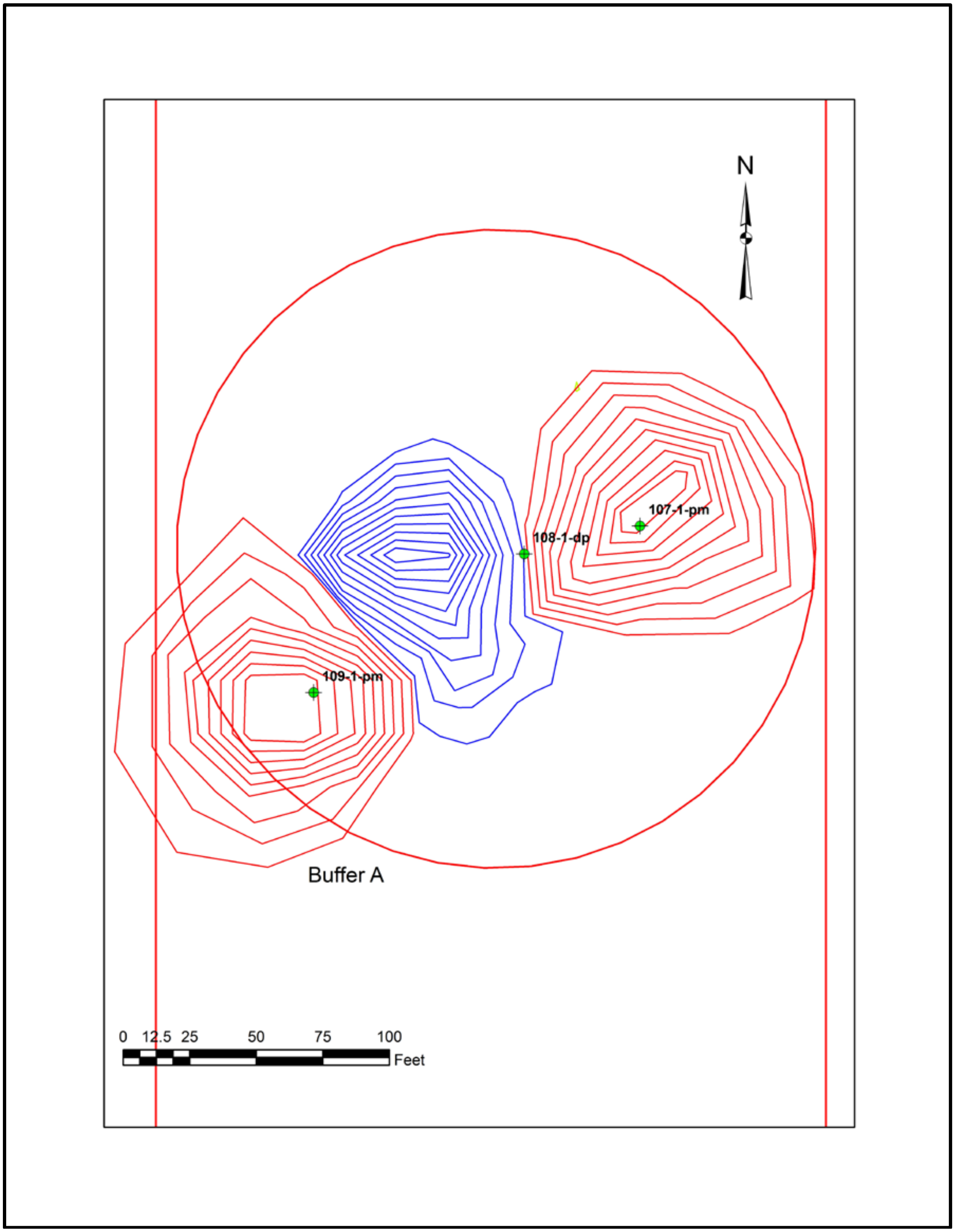

Figure 72. SB S2 NW Buffer A magnetic anomalies and contours.

4.1.7. Secondary Area 3 NE

Sabine Bank Secondary Area 3 NE (SB S3 NE) was selected for remote sensing, due to a previously identified cluster of magnetic anomalies and a sonar target potentially associated with historical vessel remains (Figure 73). Those data were generated during anoil and gas industry survey in the High Island lease block area, and an avoidance buffer was placed around the anomalies and sonar target. SB S3 NE was surveyed on September 7, 2013.

Line-by-line analysis of the magnetic and acoustic data associated with SB S3 NE identified nineteen magnetic anomalies (Figure 74; Volume III: Appendix L), two sonar targets, and two sub-bottom targets (Figure 75; Volume III: Appendix M). Additional survey data confirmed the previous industry survey findings, and the site was selected for archaeological diver investigation.

Fifteen magnetic anomalies (014-1, 014-2, 015-1, 016-1, 017-1, 018-1, 019-1, 020-1, 021-1, 022-1, 023-1, 024-1, 025-1, 026-1, 100-1, and 100b-1) form a broad cluster (Figure 76). Two sonar images (SB S3 SS 001 and SB S3 SS 002) are associated with the magnetic anomalies identified for archaeological diver investigation. Image SB S3 SS 002 documents structural remains and debris at the site (Figure 77). Image SB S3 SS 001 identifies additional debris likely associated with that same structure (Figure 78). Sub-bottom profiler data suggests that additional structures associated with the exposed debris may be buried, and in all likelihood that material also represents modern structural debris (Figure 79; Volume III: Appendix M).

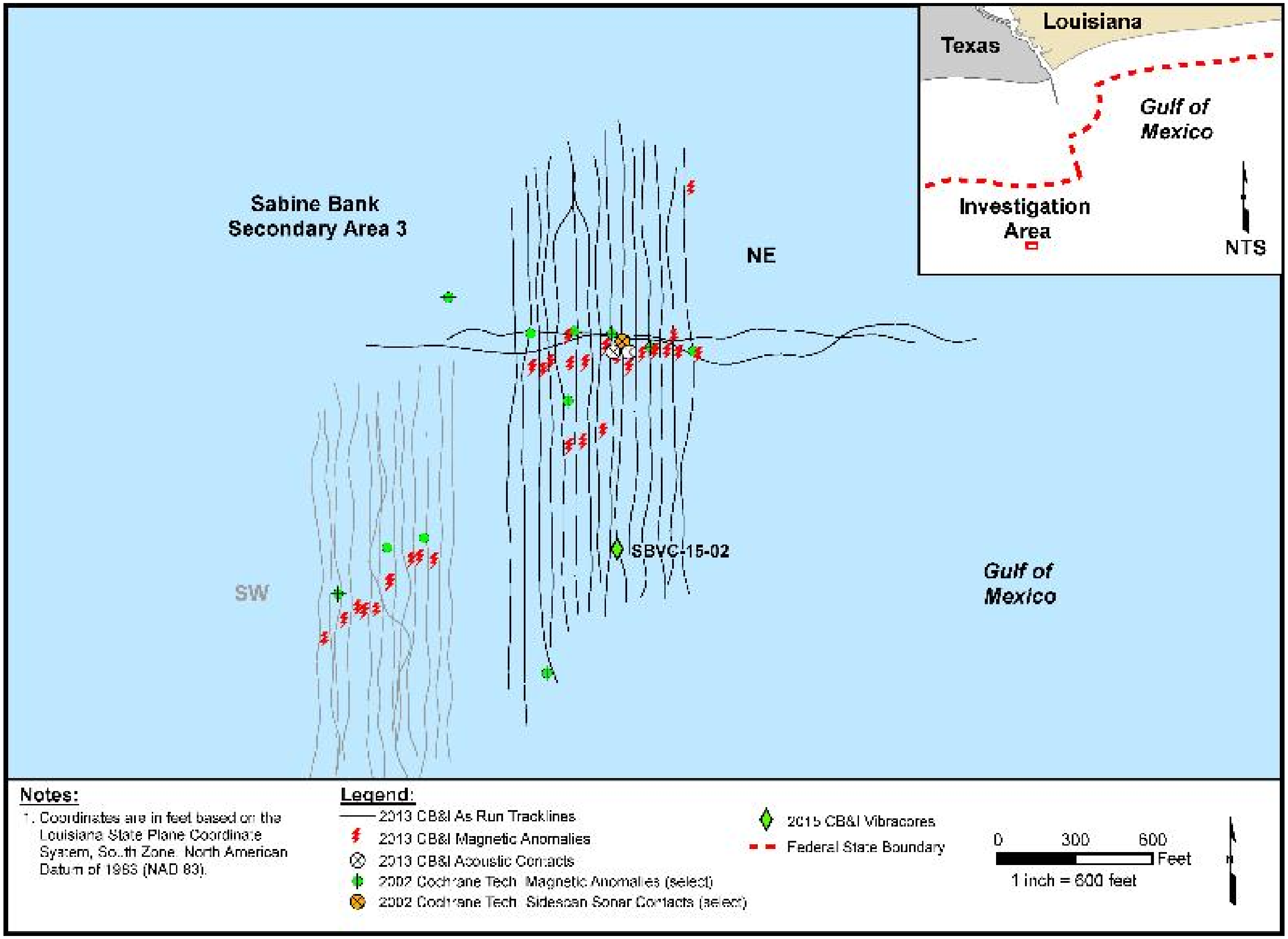

Figure 73: Magnetic anomalies and acoustic targets identified in Sabine Bank Secondary Area 3 NE.

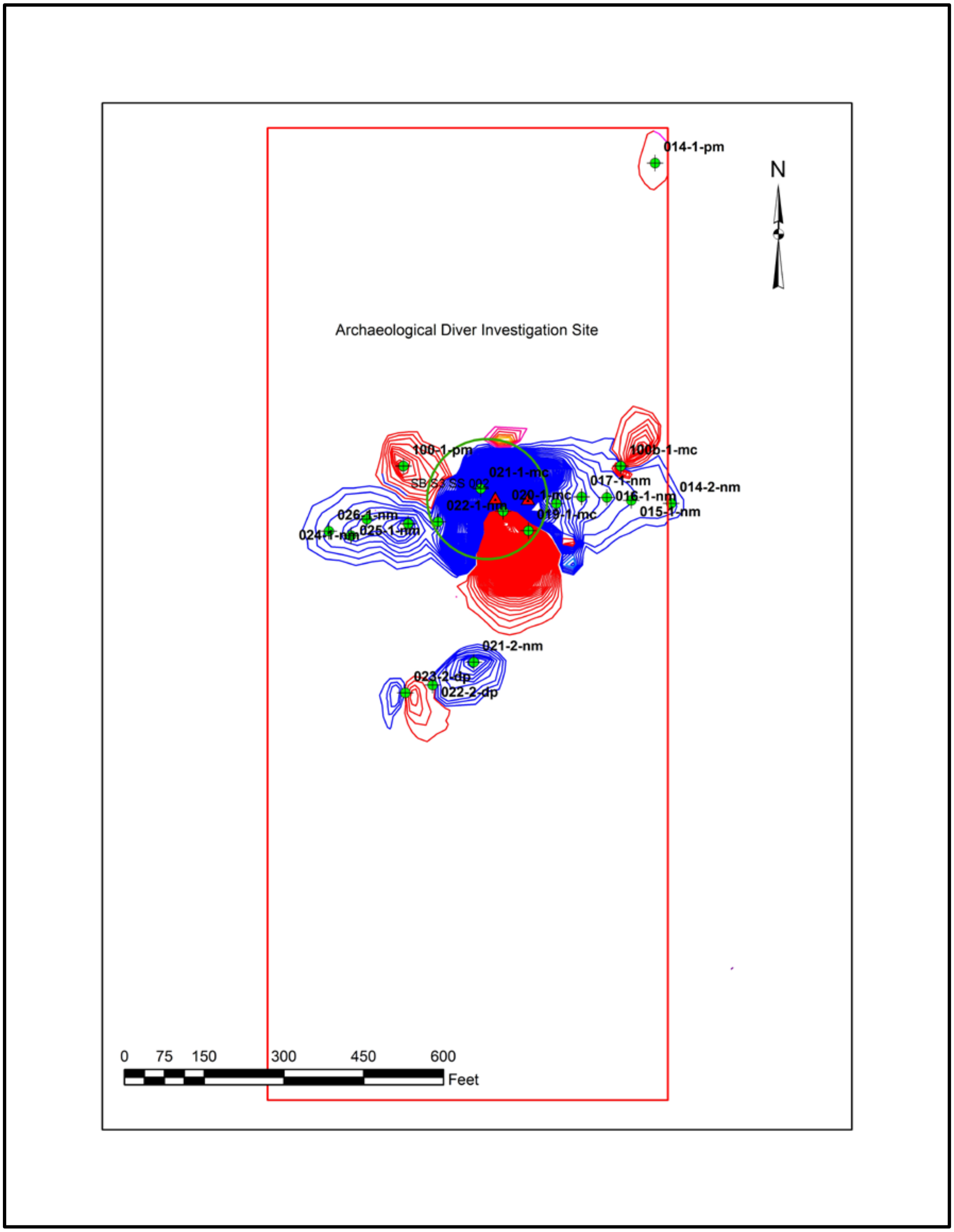

Figure 74. SB S3 NE magnetic anomalies, contours, and archaeological diver investigation site.

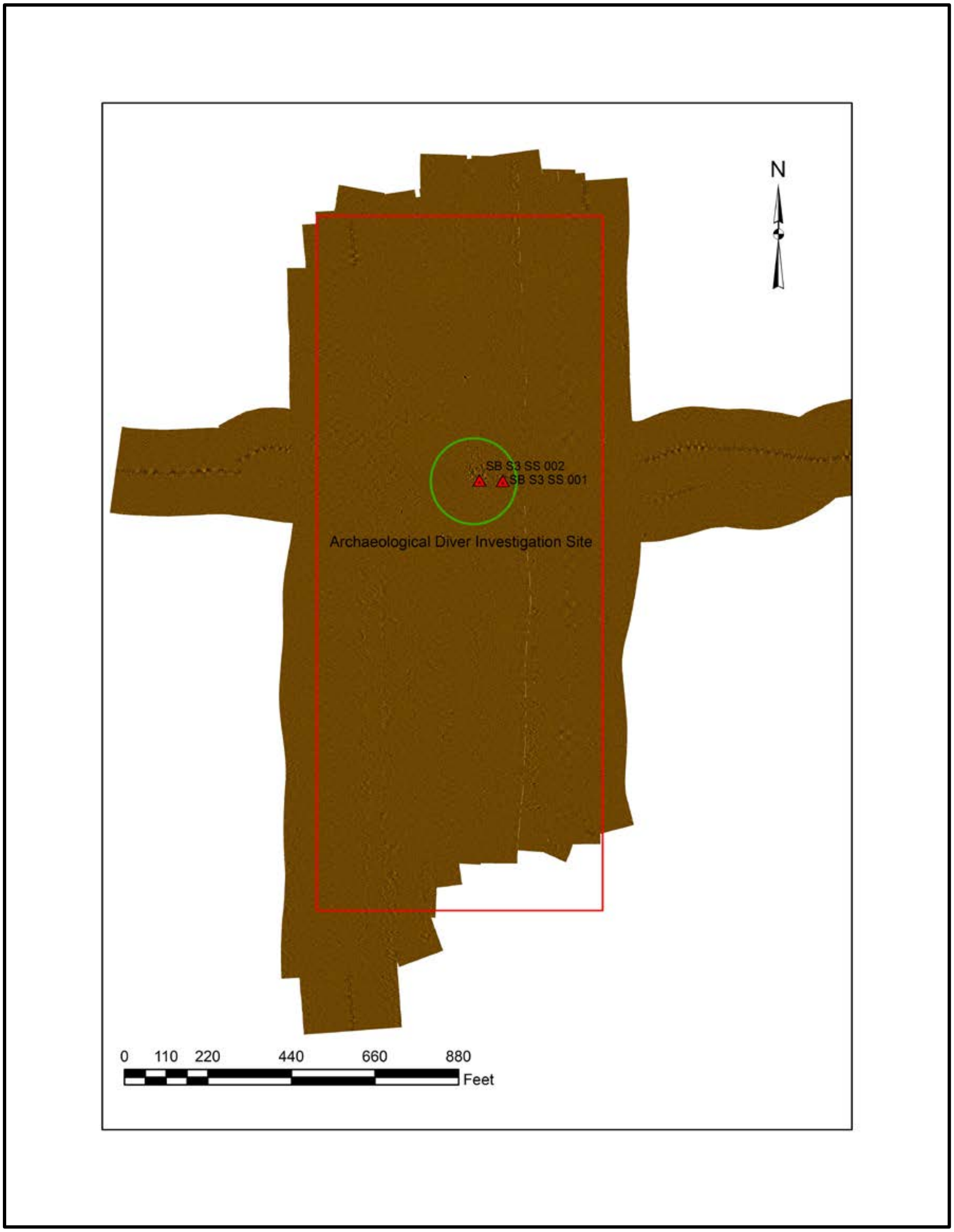

Figure 75. SB S3 NE sonar coverage mosaic with acoustic targets.

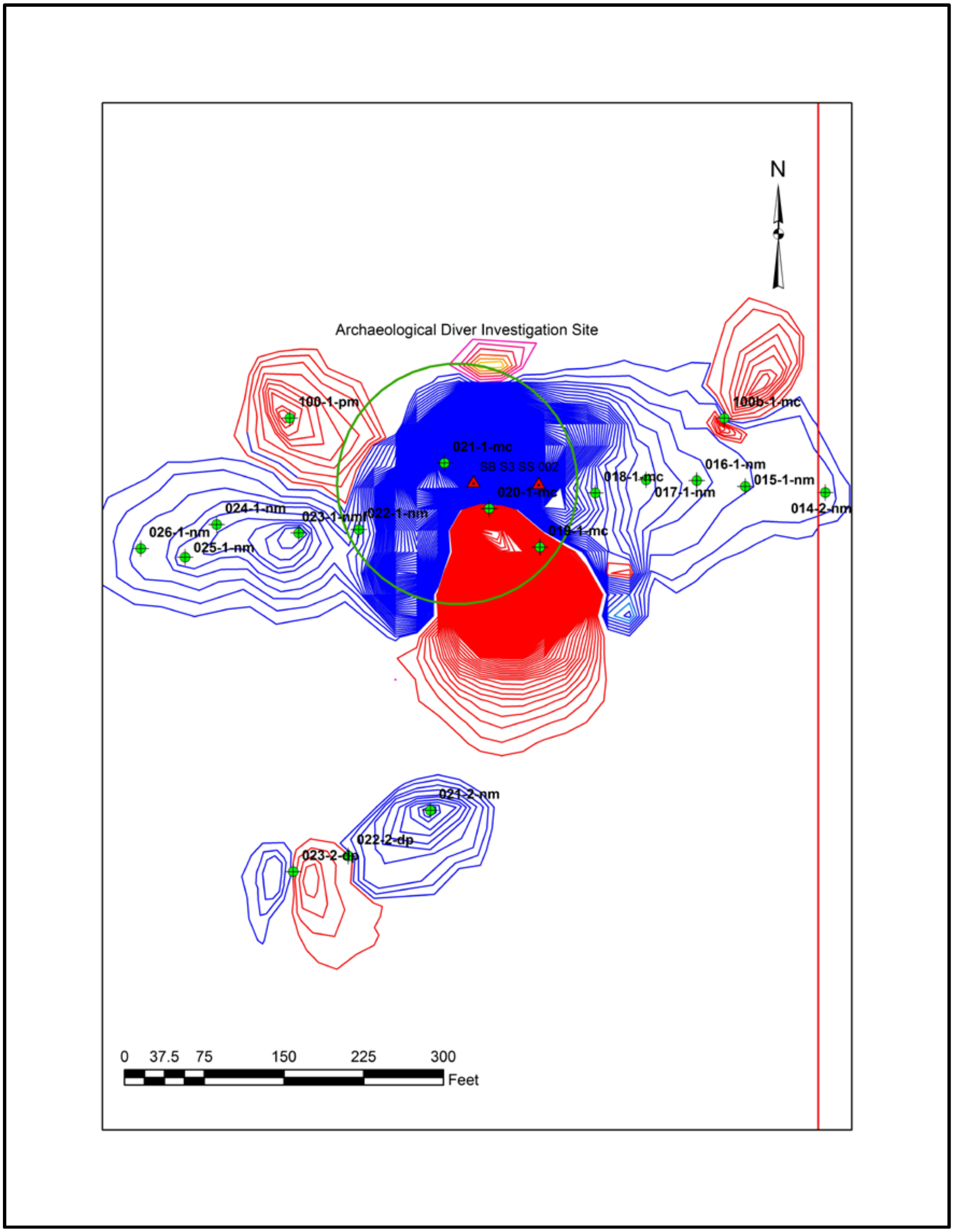

Figure 76. SB S3 NE magnetic anomaly cluster associated with archaeological diver investigation.

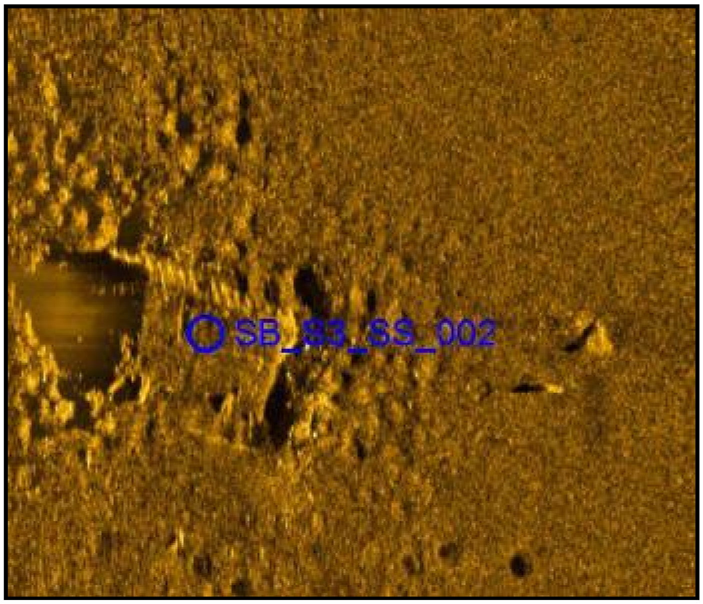

Figure 77. SB S3 NE sonar image (SB S3 SS 002) of exposed structure and debris.

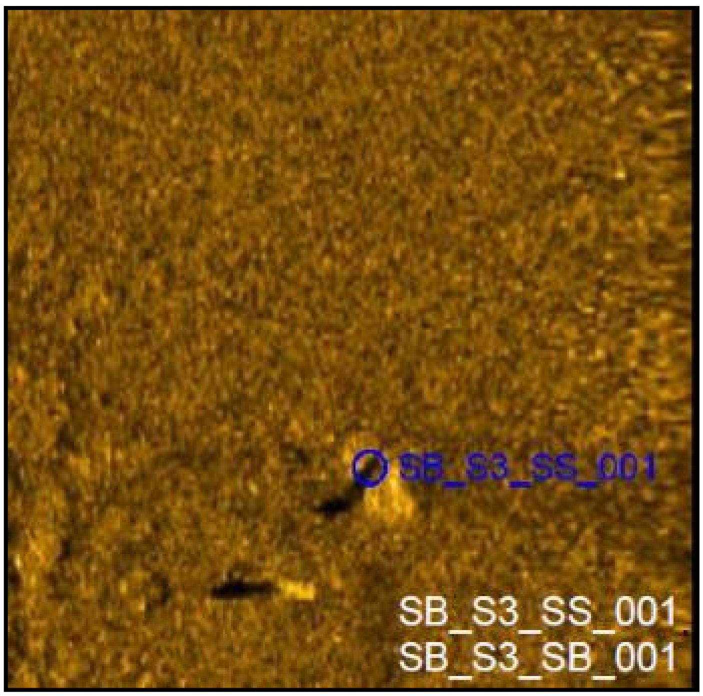

Figure 78. SB S3 NE sonar image (SB S3 SS 001) of additional exposed debris.

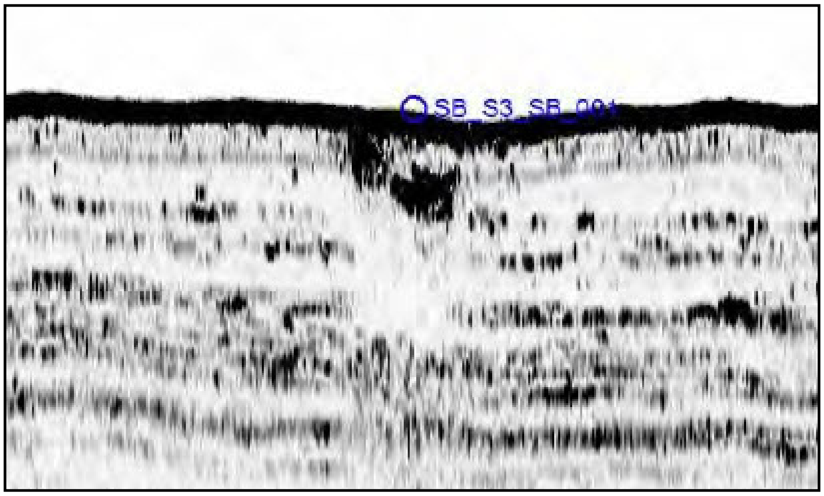

Figure 79. SB S3 NE sub-bottom profiler image (SB S3 SB 001) of buried feature associated with exposed debris.

Archaeological diver investigation of the exposed structure at SB S3 NE was carried out on 16 June 2016. Although visibility was very low, at approximately six inches, material at the site was identified as elements of a modern welded iron or steel structure. The exposed structure measured 18 feet by 25 feet and consisted of welded plate. Features along one side of the structure were identified as two-foot tall triangular gussets with a base measuring roughly 18 inches. The gussets were attached every two feet. Additional sections of broken plate structure were scattered about the bottom. Design and construction evidence suggests a possible association with a gas or oil-rig structure and not the remains of a vessel.

Three additional magnetic anomalies (021-2, 022-2, and 023-2) form a cluster immediately south of the magnetic anomaly cluster associated with exposed structure and debris identified in sonar images. It is possible that those magnetic anomalies represent material unrelated to the structure and debris examined by archaeological divers. However, the proximity to that structure strongly suggests that material associated with the magnetic anomaly cluster is in all likelihood additional modern structural debris. The remaining magnetic anomaly (014-1) has signature characteristics indicative of a small single object.

Archaeological diver investigation of the primary cluster of magnetic anomalies confirmed that material generating those signatures represents modern structural debris. Association with vessel remains does not appear likely. A more likely association is with an oil or gas structure either cut down at the site or lost overboard from a salvage vessel. Because material at the site does not appear to meet eligibility criteria for the NRHP, no additional investigation or avoidance of the site is recommended.

4.1.8. Secondary Area 3 SW

Sabine Bank Secondary Area 3 SW (SB S3 SW) was selected for remote sensing due to a previously identified cluster of magnetic anomalies and a sonar target that could be associated with historical vessel remains (Figure 80). Those data were generated during an oil and gas industry survey in the High Island lease block area, and an avoidance buffer was placed around the anomalies and sonar target. SB S3 SW was surveyed on September 7, 2013.

Line-by-line analysis of the magnetic and acoustic data associated with SB S3 SW identified 10 magnetic anomalies (Figure 81; Volume III: Appendix N). No sonar targets (Figure 82) or sub-bottom features were identified in the acoustic data.

Five magnetic anomalies in survey area SB S3 SW (034-1, 035-1, 036-1, 037a-1, and 037-1) form a broad cluster with a high potential for association with shipwreck remains or other potentially significant submerged cultural resources. Those five have been identified as Buffer A (Figure 83). Four magnetic anomalies (038-1, 039-1, 040-1, and 041-1) are also potentially associated with vessel remains or other submerged cultural resources and have been included in Buffer B (Figure 84).

The remaining magnetic anomaly (042-1) has moderate potential for association with vessel remains and could be related to material generating magnetic anomalies in Buffer B. In the event that investigation of magnetic anomalies in Buffer B identifies associated material as historically or archaeologically significant, the source of Anomaly 042-1 should also be identified and assessed.

Magnetic anomalies within Buffer A and Buffer B have signature characteristics and spatial association that suggest a high potential for association with vessel remains or other submerged cultural resources. Archaeological divers in conjunction with this project did not investigate magnetic anomalies in Buffer A and Buffer B. However, both areas should be a high priority for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. An archaeological diver investigation should be designed to identify material generating the signatures and assess its significance in terms of NRHP eligibility.

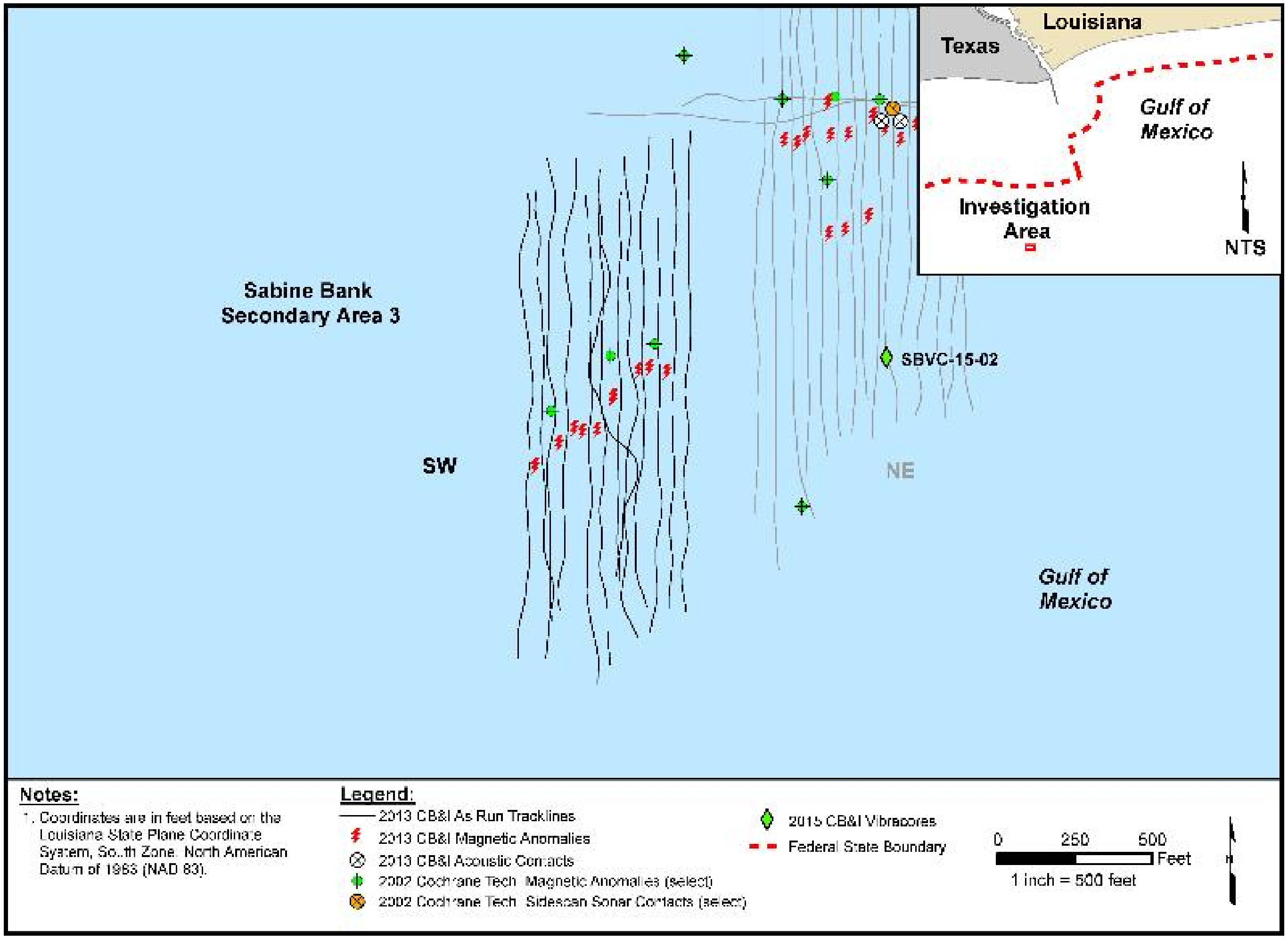

Figure 80: Magnetic anomalies identified in Sabine Bank Secondary Area 3 SW.

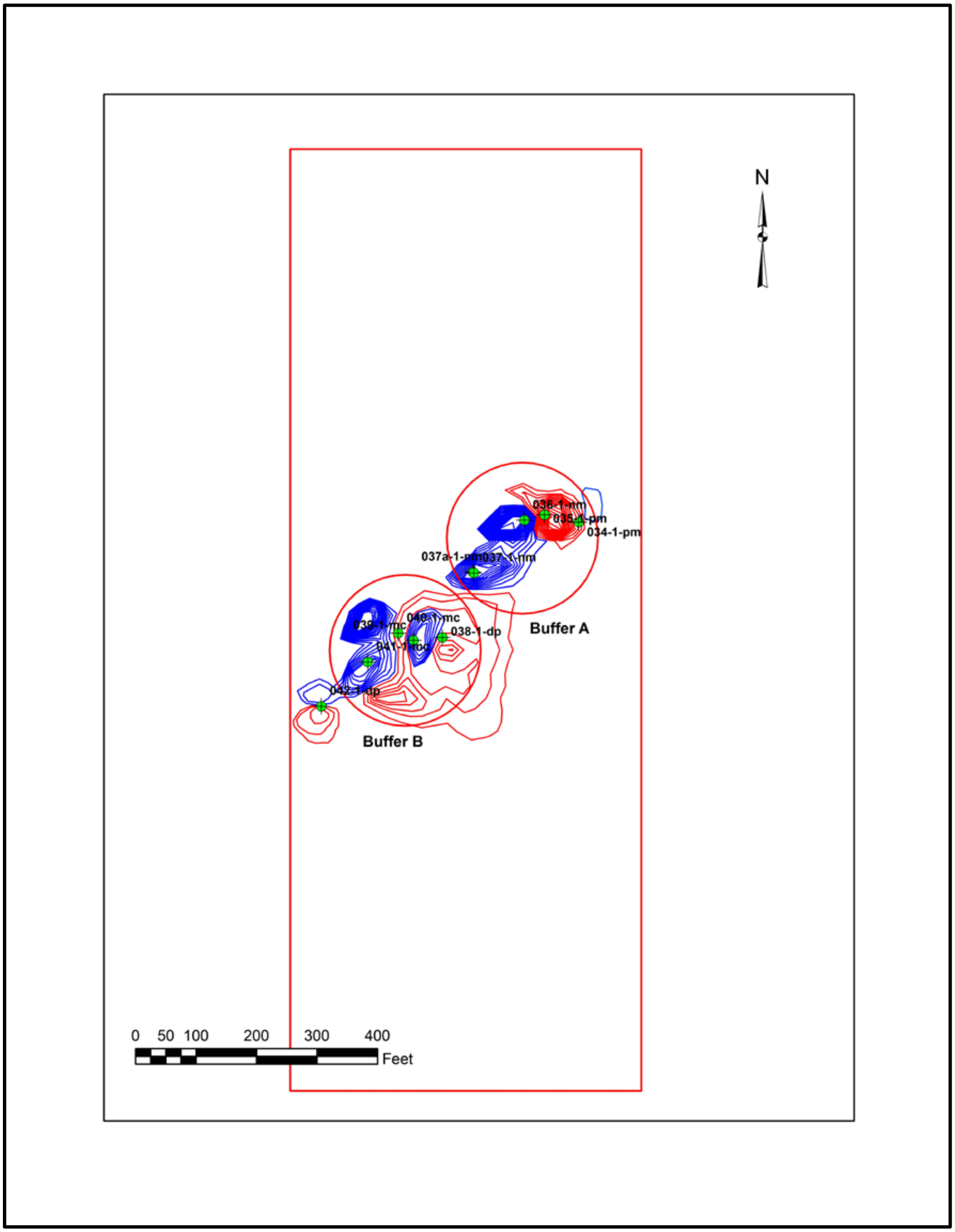

Figure 81. SB S3 SW magnetic anomalies, contours, and buffers.

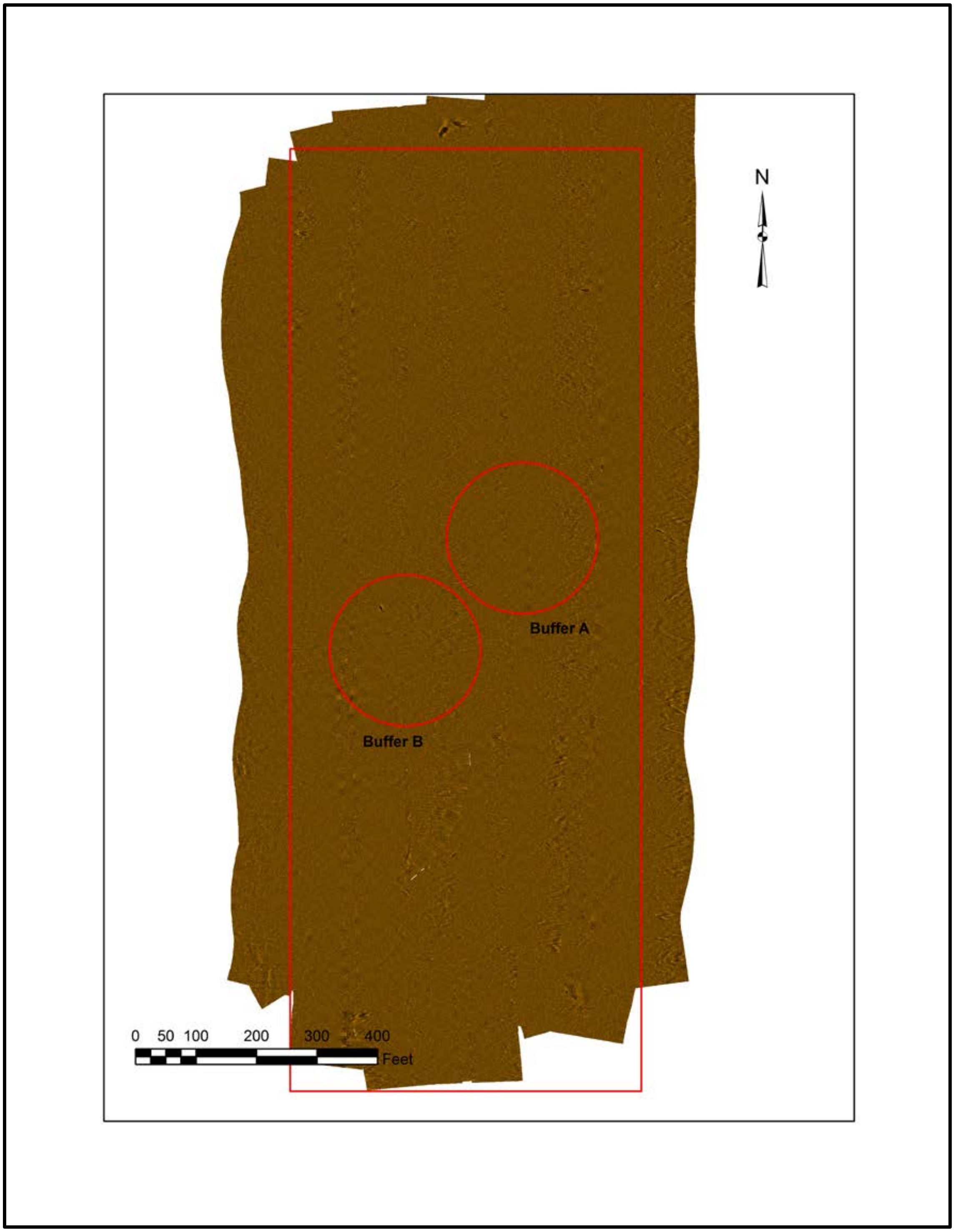

Figure 82. SB S3 SW sonar coverage mosaic.

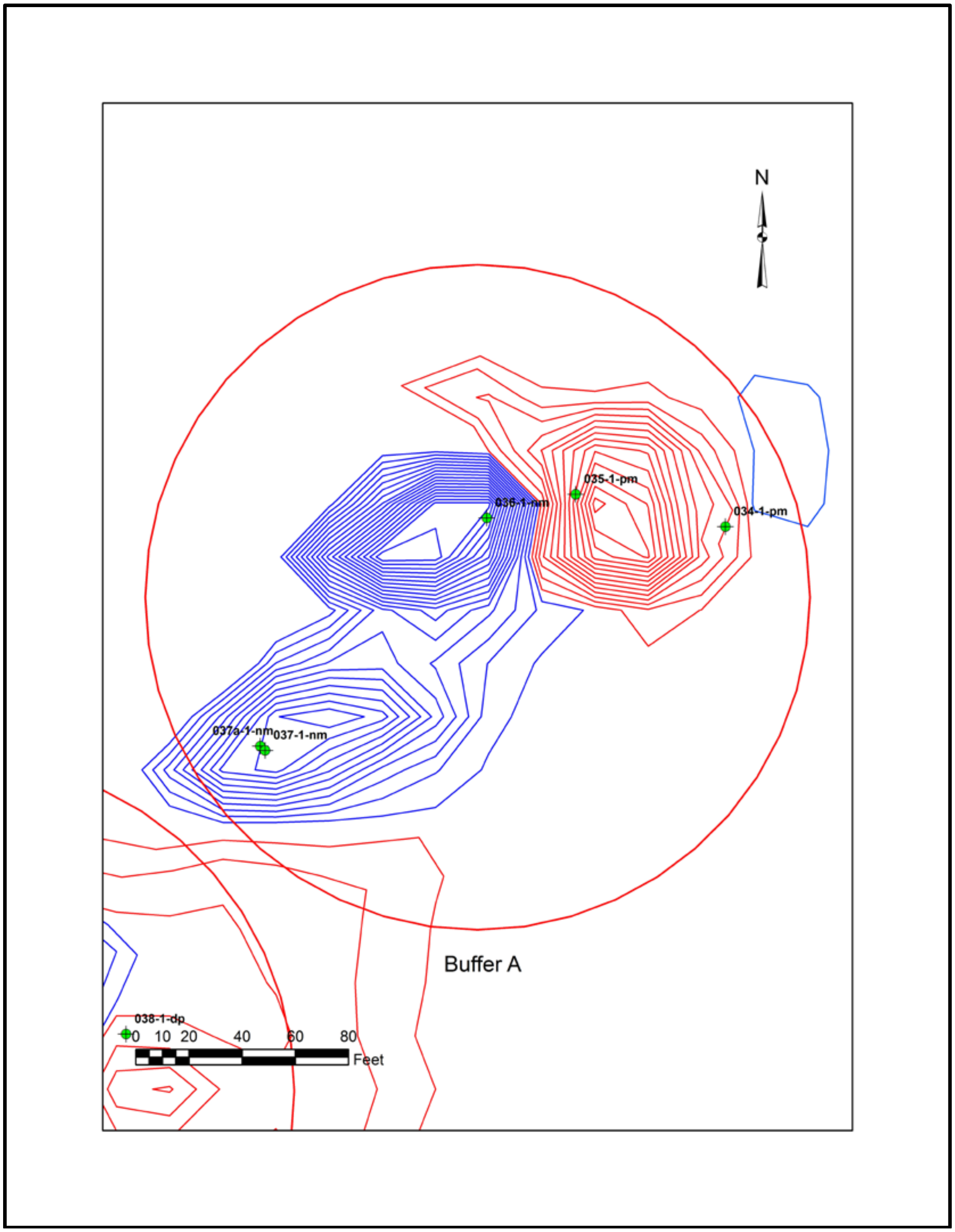

Figure 83. SB S3 SW Buffer A magnetic anomalies and contours.

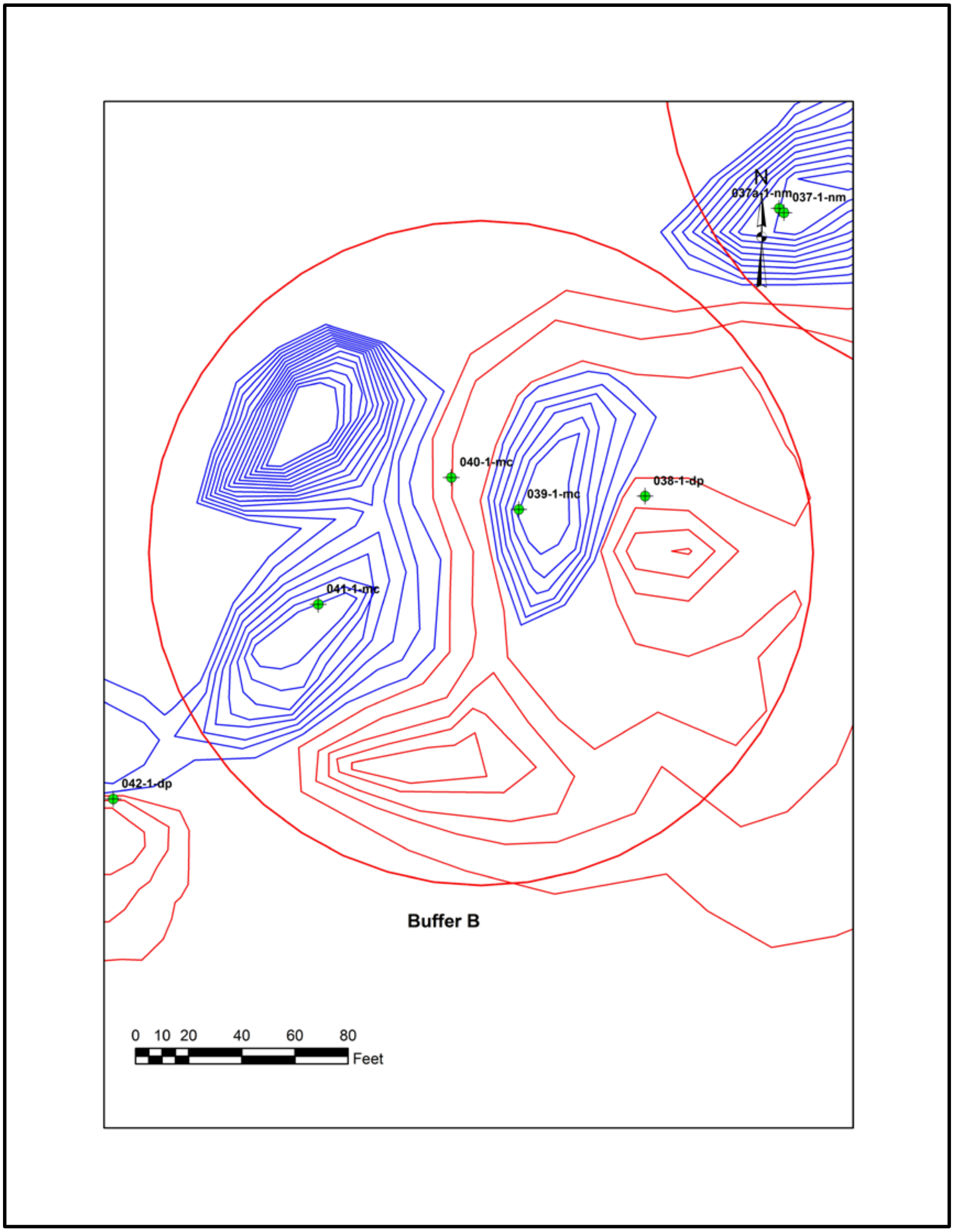

Figure 84. SB S3 SW Buffer B magnetic anomalies and contours.

4.2. Ship Shoal

4.2.1. Primary Area 1 N

Ship Shoal Primary Area 1 N (SS P1 N) was selected for remote sensing due to previously identified magnetic anomalies that could be associated with historical vessel remains or other potentially significant submerged cultural resources (Figure 85, Figure 86). In addition, the southern half of SS P1 N is located in a previously permitted borrow area (Ship Shoal Block 88 Borrow Area; see Table 2) that could be re-used.

SS P1 N was surveyed on 8 September 8, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS P1 N identified 43 magnetic anomalies (Figure 87; Volume III: Appendix O). One small sonar target outside the survey perimeter was identified. No sub-bottom features were identified in the acoustic data (Figure 88).

Three clusters of magnetic anomalies in SS P1 N have collective signature characteristics that could be associated with vessel remains. The 10 magnetic anomalies (008-2, 009-1, 010-1, 011-1, 011-2, 012-2, 100-1, 101-3, 102-3, and 103-2) in Buffer A appear to have individual and collective signature characteristics with a high potential for association with potentially significant submerged cultural resources (Figure 89).

Three magnetic anomalies (004-1, 005A-1, and 006-1) in Buffer B appear to have collective signature characteristics with a moderate potential for association with small vessel remains or other submerged cultural resources (Figure 90). Six additional magnetic anomalies (016-1, 017-1, 018-1, 019-1, 101-1, and 101-2) are included in Buffer C (Figure 91). Those six also have a high potential for association with historical vessel remains or other significant submerged cultural resources.

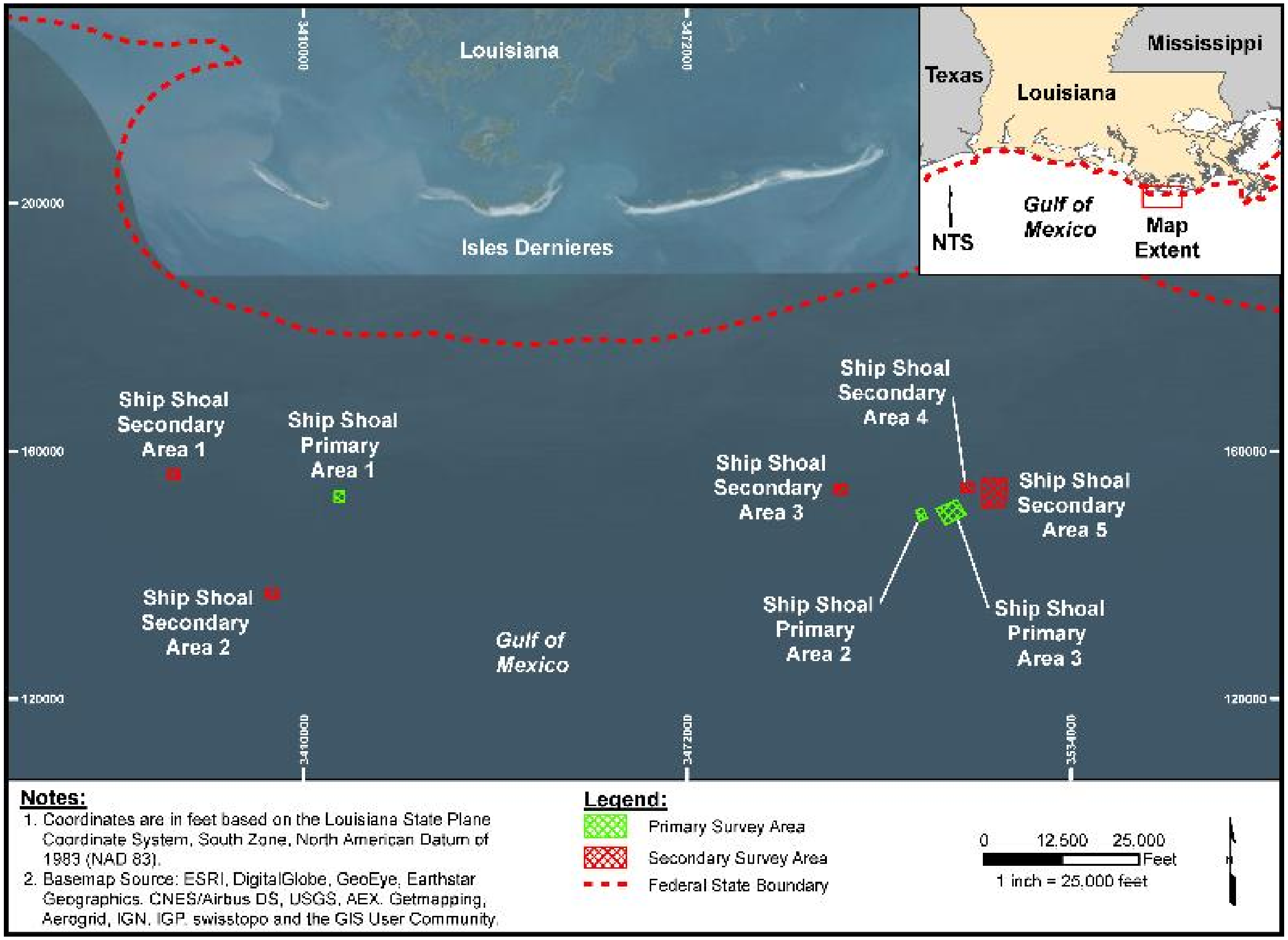

Figure 85: Ship Shoal study area.

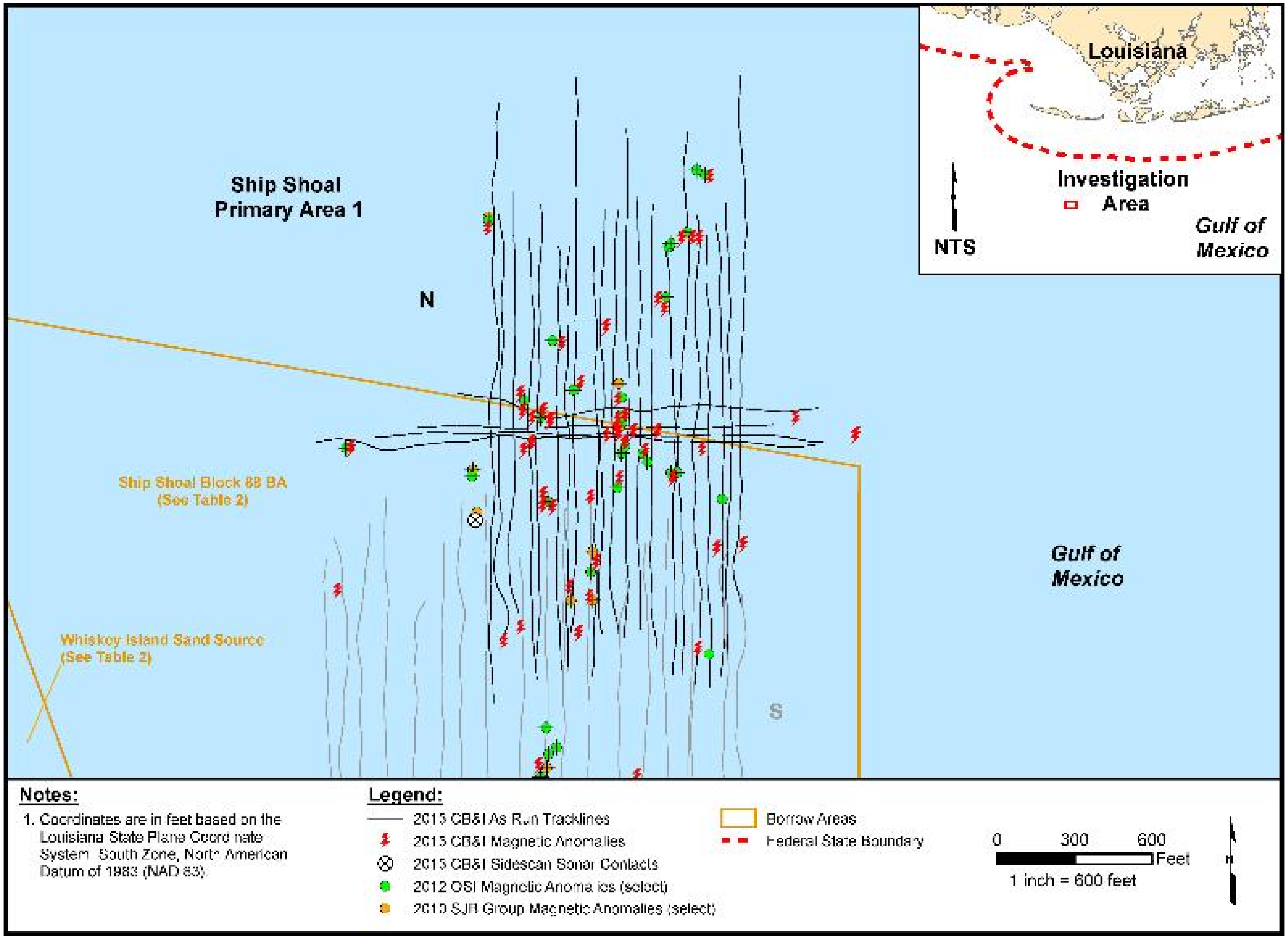

Figure 86. Magnetic anomalies identified in Ship Shoal Primary Area 1 N.

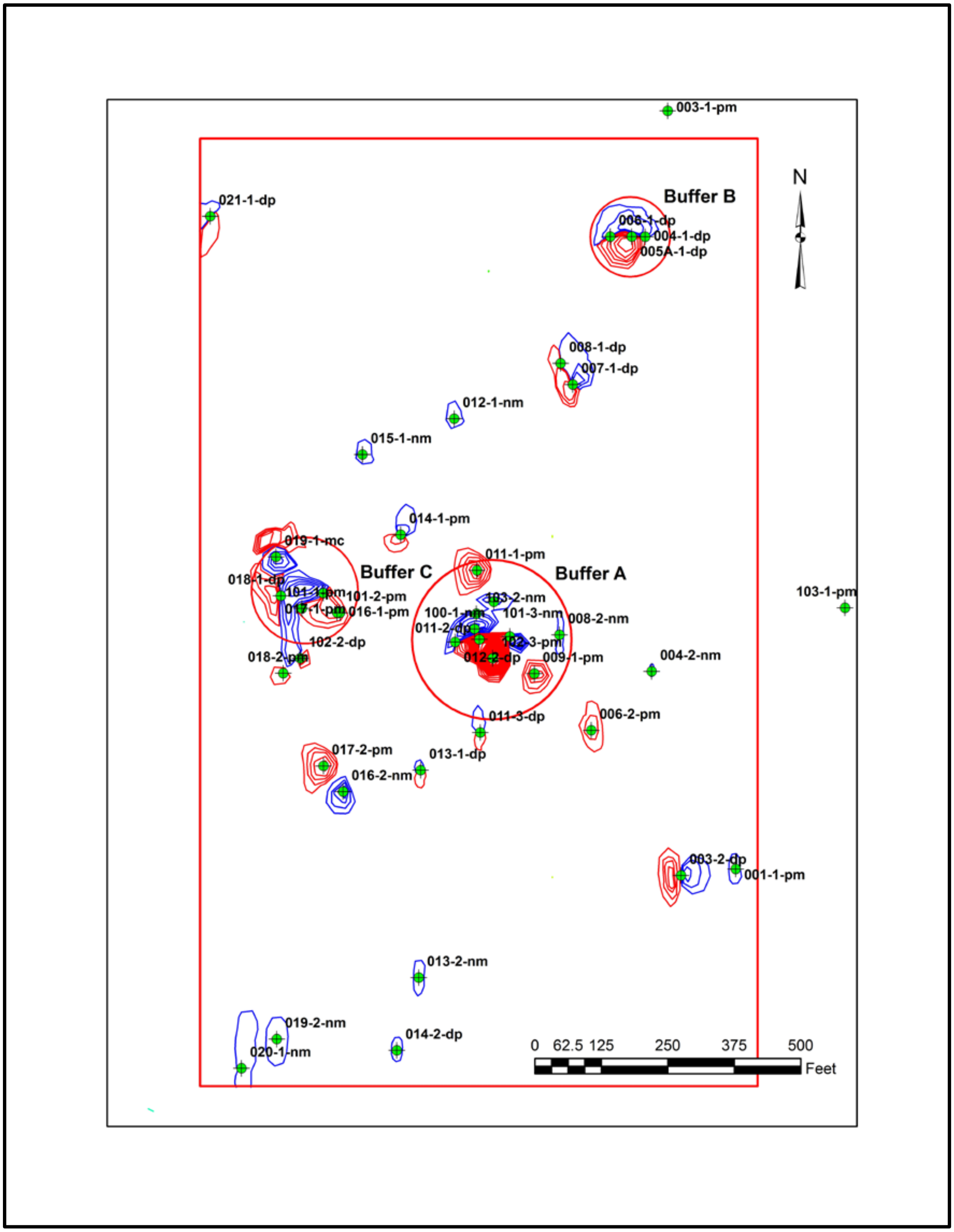

Figure 87. SS P1 N magnetic anomalies, contours, and buffers.

Figure 88. SS P1 N sonar coverage mosaic.

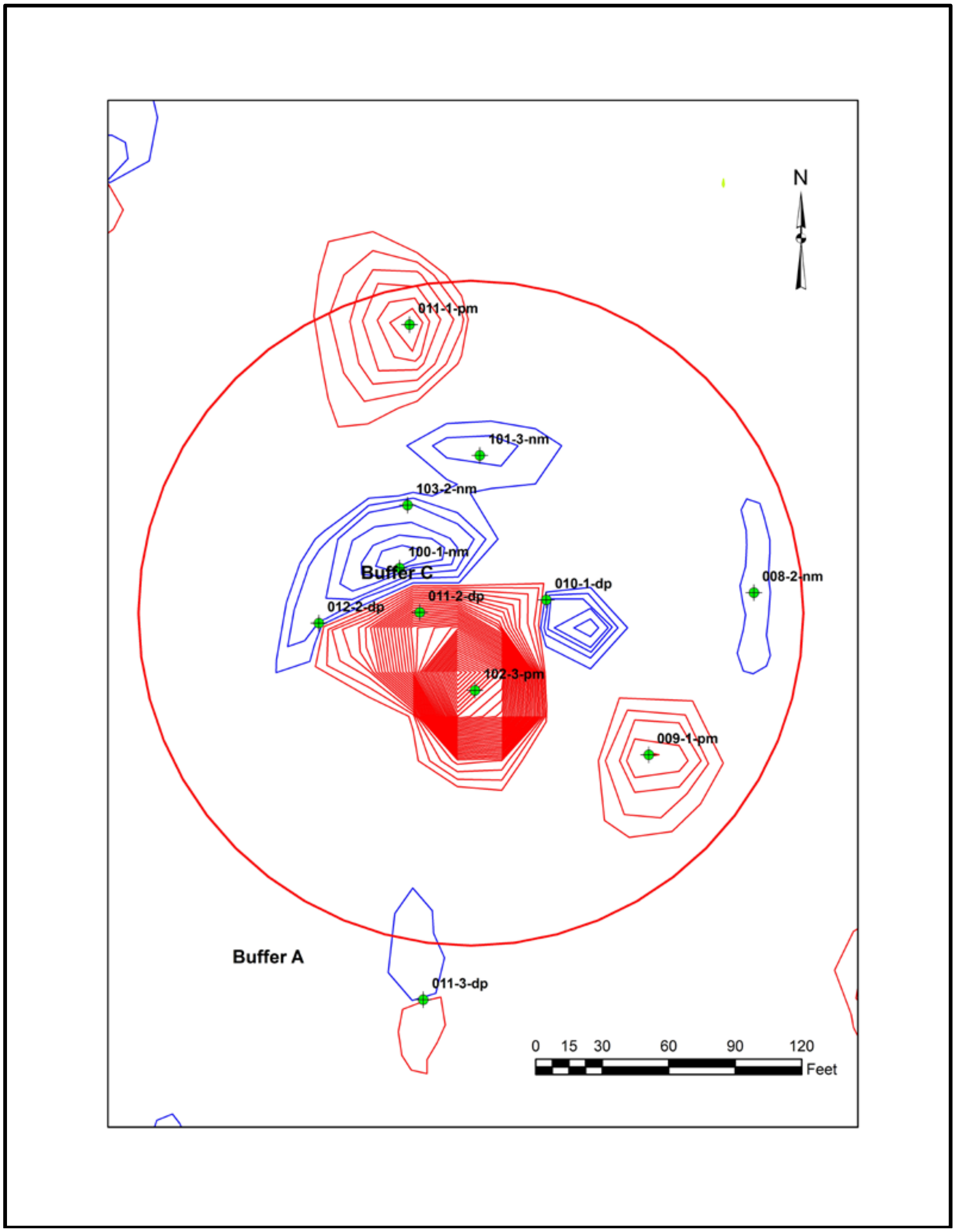

Figure 89. SS P1 N Buffer A magnetic anomalies and contours.

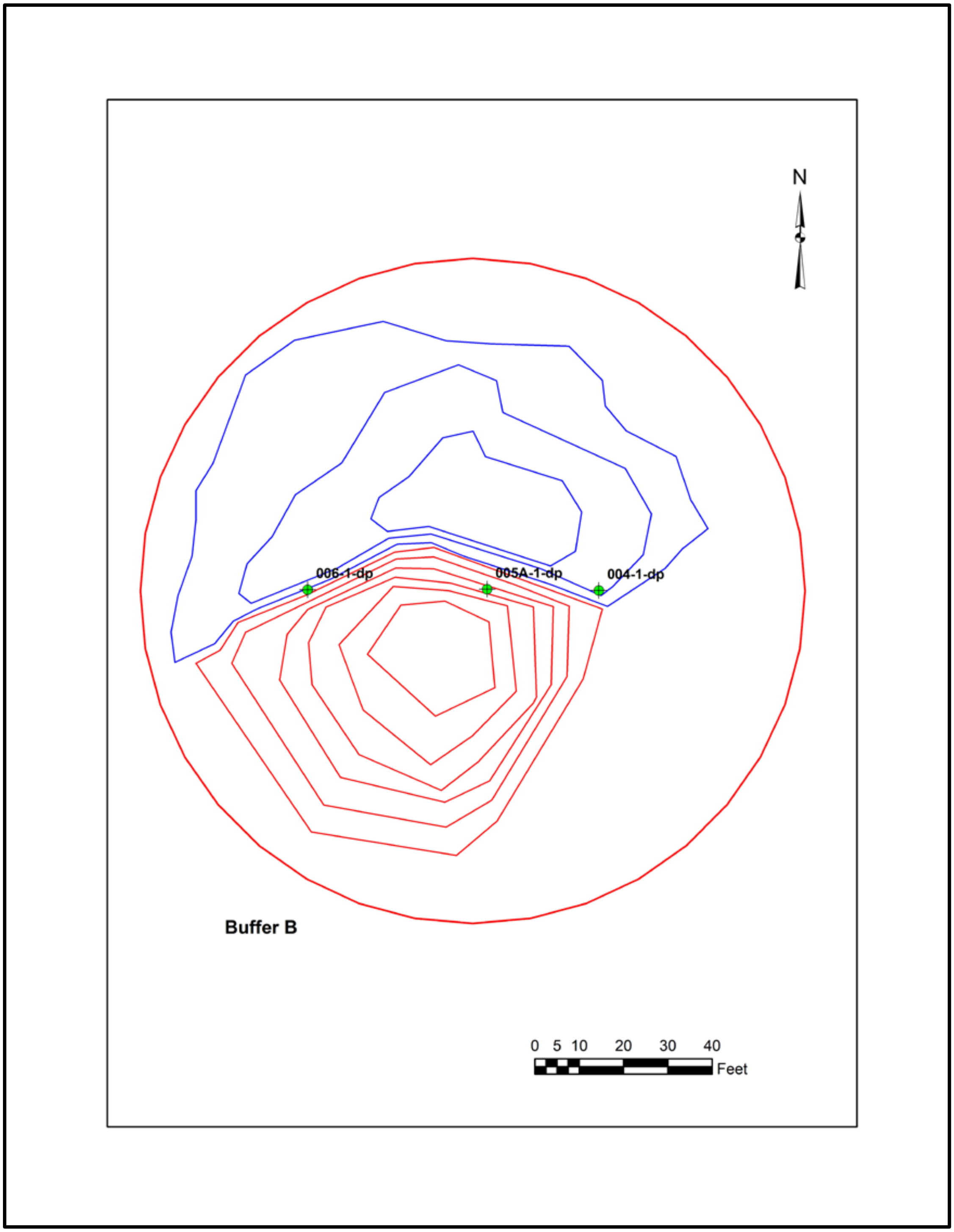

Figure 90. SS P1 N Buffer B magnetic anomalies and contours.

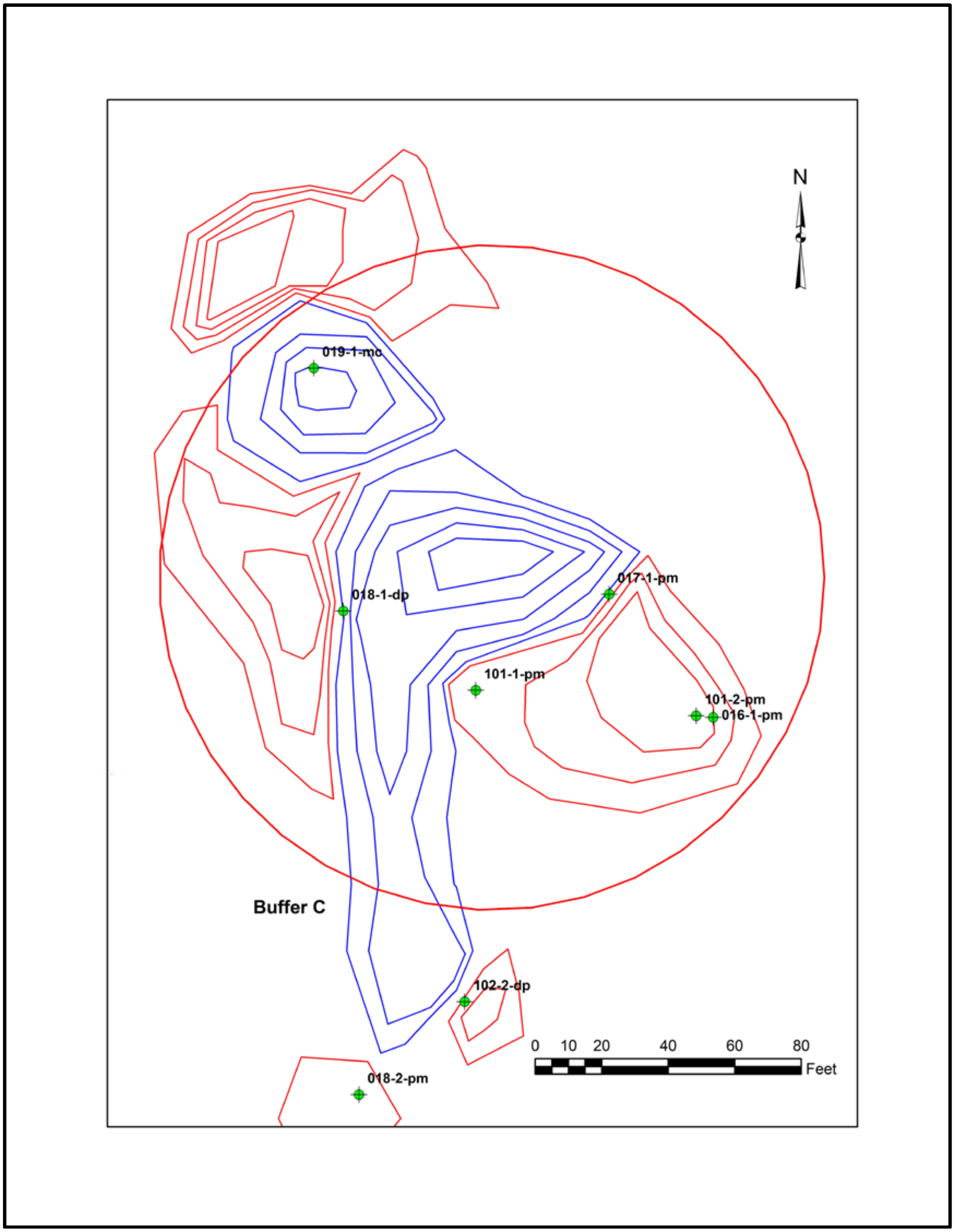

Figure 91. SS P1 N Buffer C magnetic anomalies and contours.

The remaining 24 magnetic anomalies all appear to represent small and moderate size objects such as traps, small anchors or machinery, and/or short sections of pipe, chain, wire, or cable. Magnetic anomalies within Buffer A and Buffer C have signature characteristics and spatial associations that suggest a high potential for association with vessel remains or other submerged cultural resources. Magnetic anomalies in Buffer B appear to have signature characteristics and spatial associations that suggest a moderate potential for association with small vessel remains or other submerged cultural resources.

None of the buffered magnetic anomaly clusters in SS P1 N were selected for archaeological diver investigation during this project. However, all three buffer areas should be priorities for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. An archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.2.2. Primary Area 1 S

Ship Shoal Primary Area 1 S (SS P1 S) was selected for remote sensing, due to previously identified magnetic anomalies that could be associated with historical vessel remains or other potentially significant submerged cultural resources (Figure 92). In addition, SS P1 S is entirely located in a previously permitted borrow area (Ship Shoal Block 88 Borrow Area; see Table 2) that could be reutilized. The southwest corner of SS P1 S also lies in the Whiskey Island Sand Source Borrow Area. At the time of the current investigation no dredging had been carried out in the permitted area.

SS P1 S was surveyed on September 9, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS P1 S identified 11 magnetic anomalies (Figure 93; Volume III: Appendix P) and one sonar target in the survey area (Figure 94, Volume III: Appendix Q). Image SS 001 identifies a small single object (Figure 95).

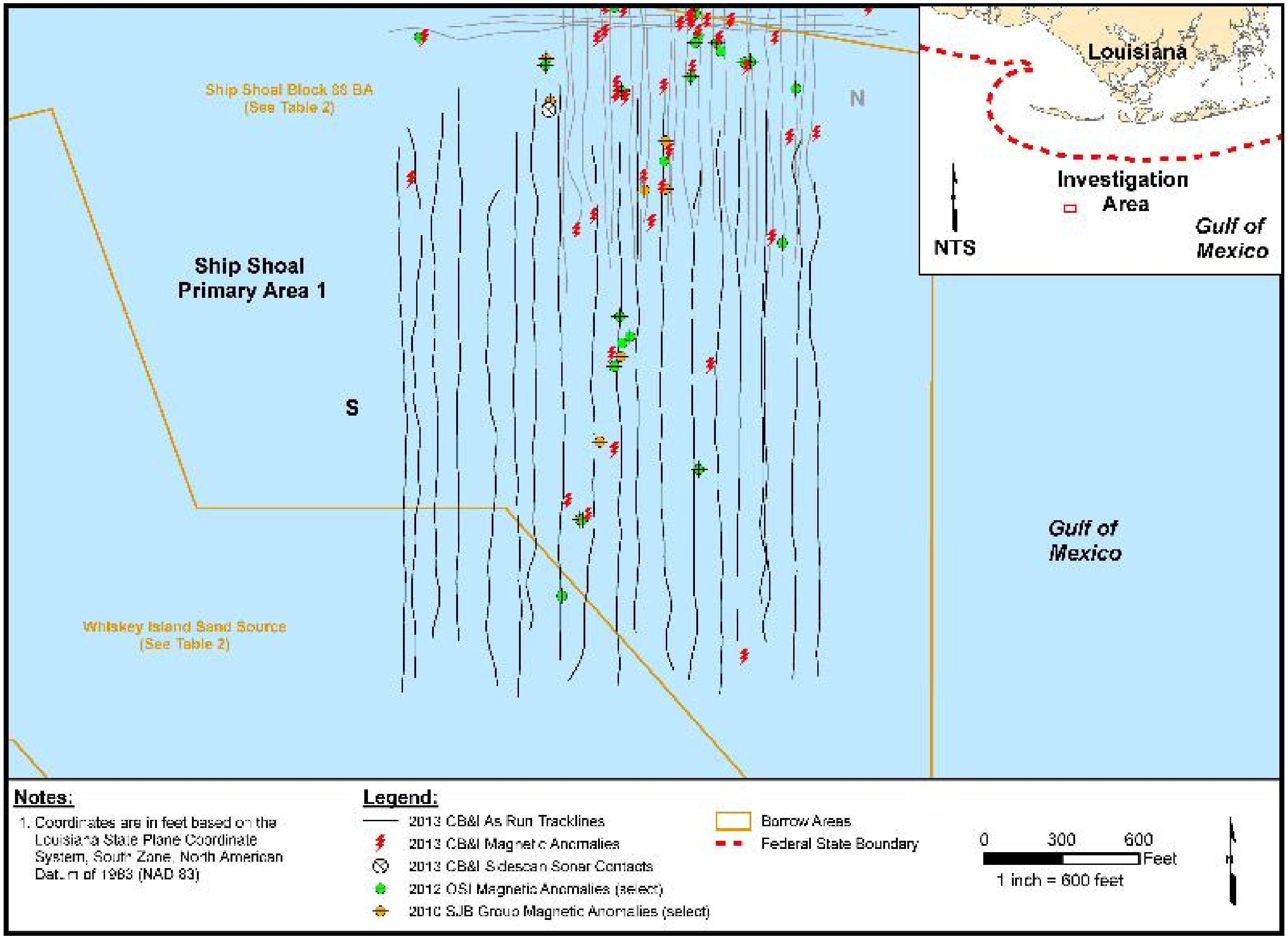

Figure 92: Magnetic anomalies and sonar target identified in Ship Shoal Primary Area 1 S.

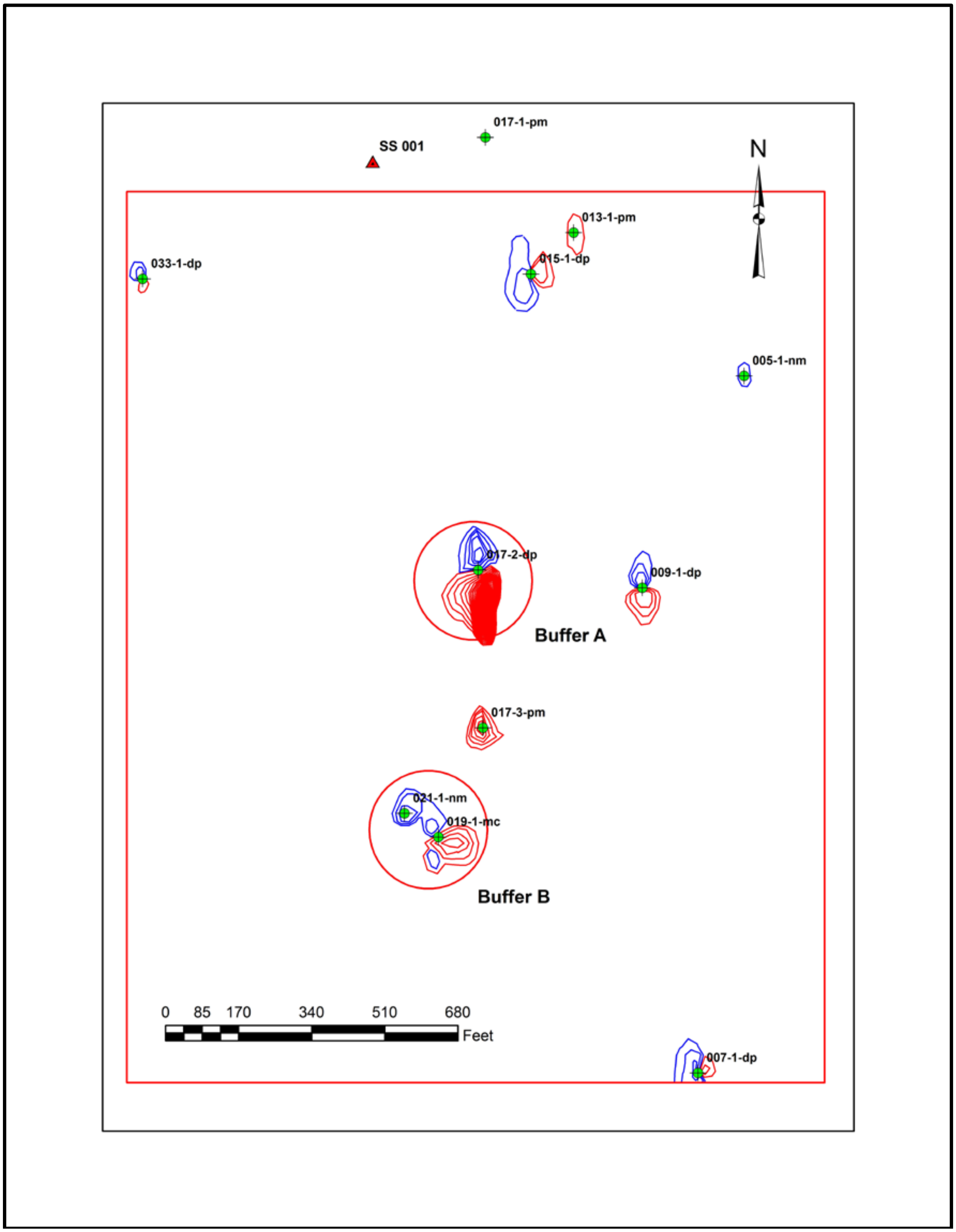

Figure 93. SS P1 S magnetic anomalies, contours, and buffers.

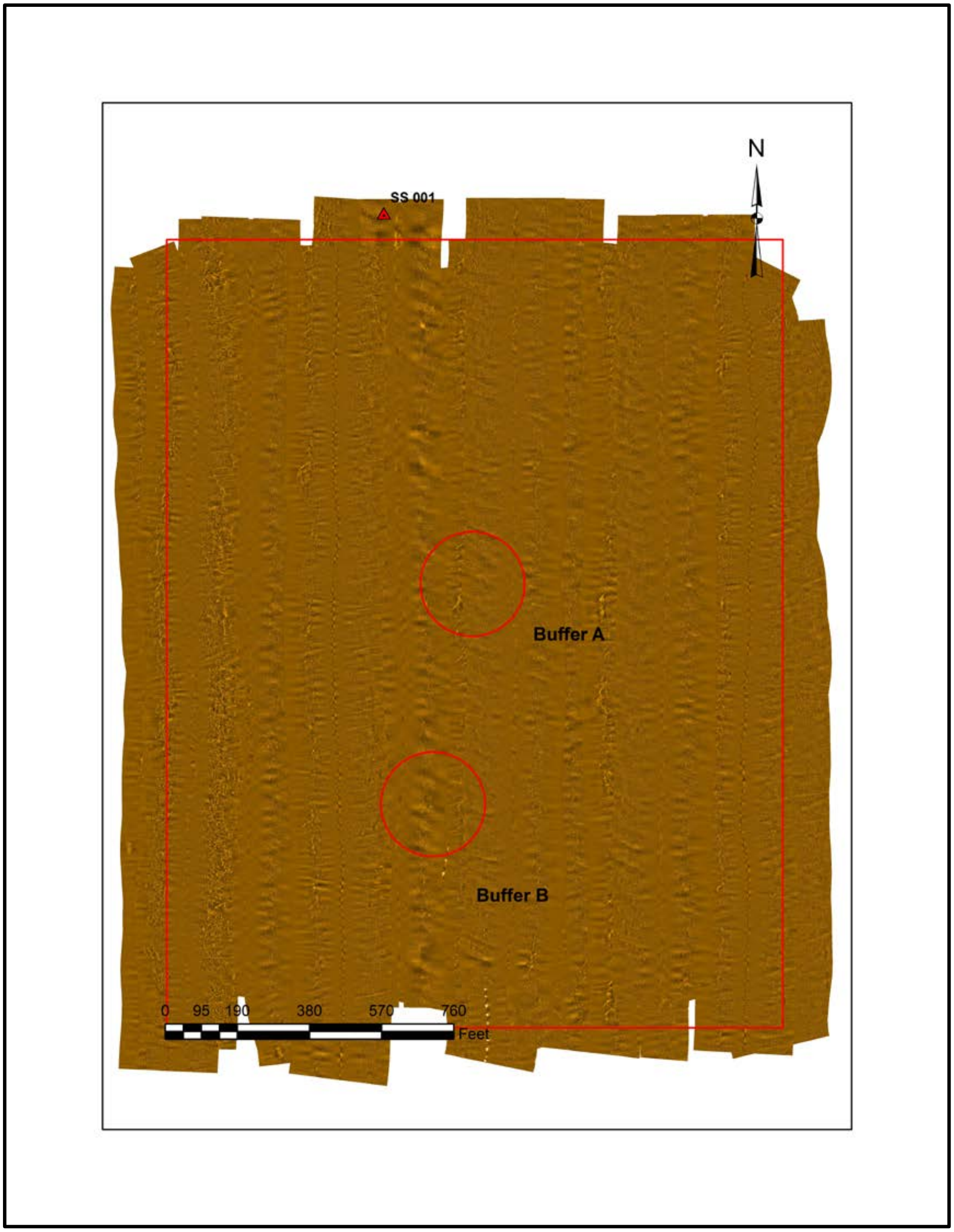

Figure 94. SS P1 S sonar coverage mosaic with sonar target.

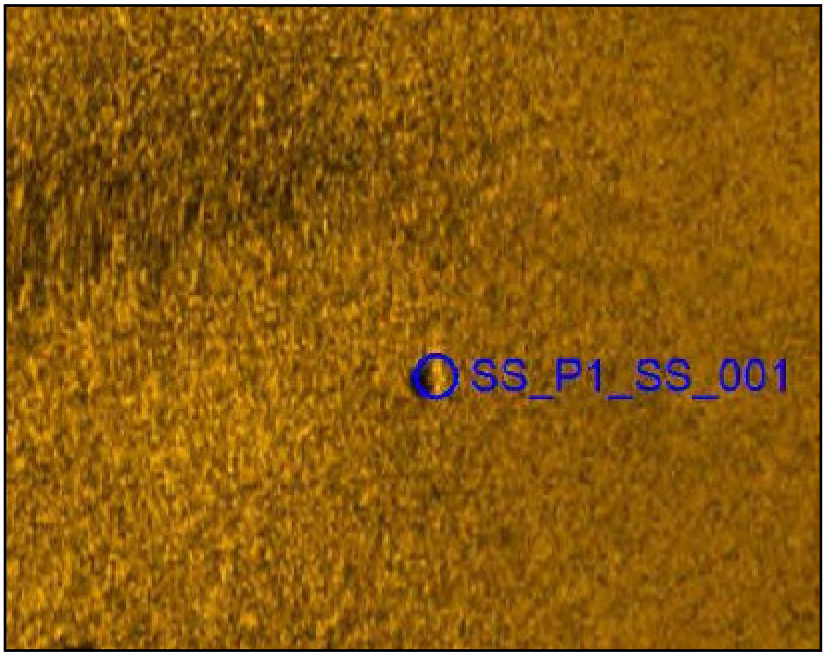

Figure 95. SS P1 S small object sonar target.

Although the entire SS P1 S area lies within a site previously permitted for sand recovery, magnetic anomalies within two buffers are recommended for avoidance or additional investigation. Previous surveys detected material at the current buffer sites and both sites were recommended for avoidance. Data suggests that the source of the magnetic anomalies was in situ prior to previous dredging operations and recommended avoidance was successful. Because previous dredging did not disturb material generating the signatures, the buffered magnetic anomalies remain recommended for avoidance buffer protection and are recommended for additional investigation.

One SS P1 S magnetic anomaly (017-2) has high-intensity signature characteristics that could be associated with vessel tackle and/or machinery. The intensity and duration of the signature could also mask more subtle magnetic anomalies associated with wooden structural remains. That magnetic anomaly is identified within Buffer A (Figure 96). Two magnetic anomalies (019-1 and 021-1) collectively have signature characteristics that could be associated with small vessel remains and are identified by Buffer B (Figure 97).

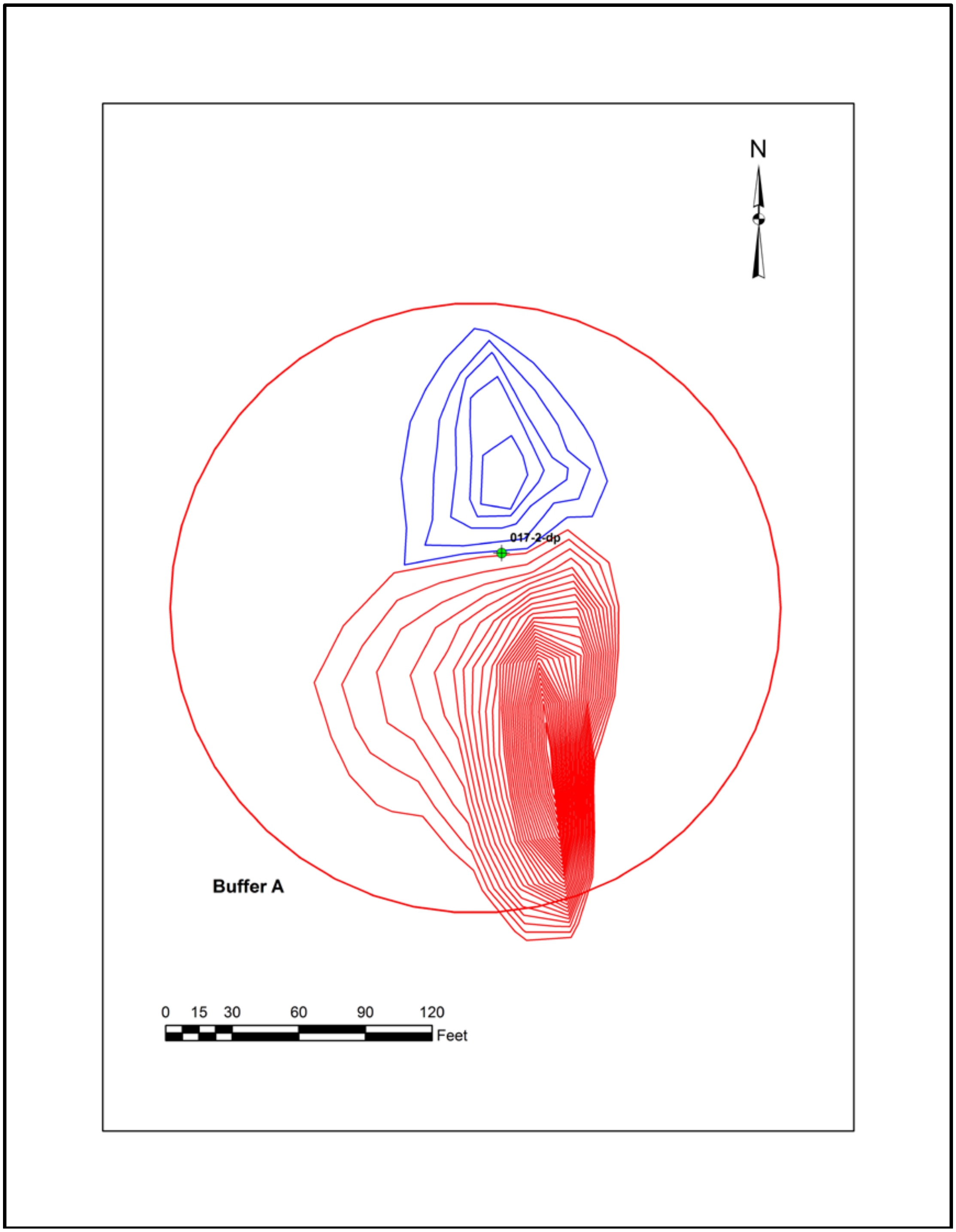

Figure 96. SS P1 S Buffer A magnetic anomaly and contours.

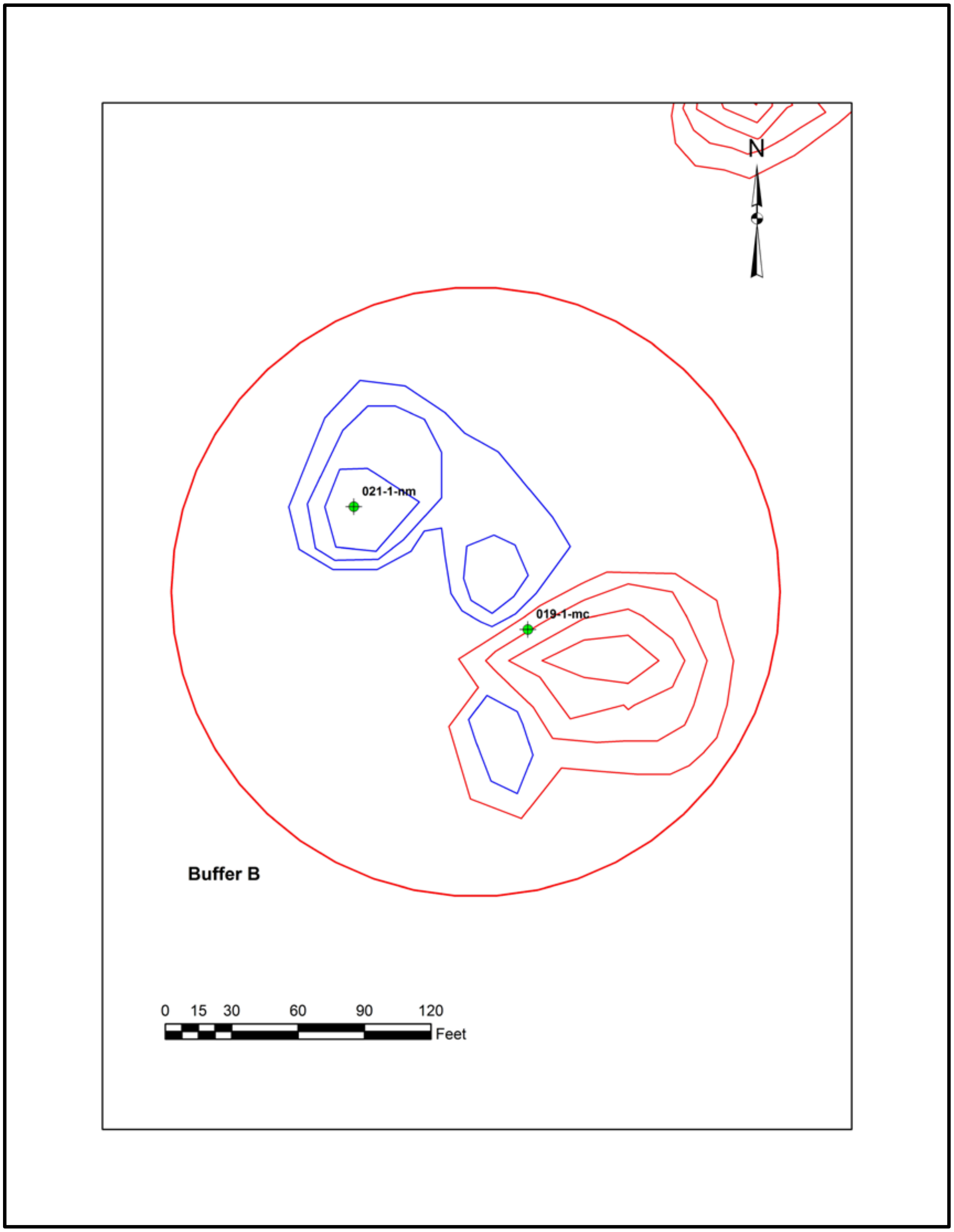

Figure 97. SS P1 S Buffer B magnetic anomalies and contours.

The remaining eight magnetic anomalies all appear to represent small objects such as traps, small anchors or machinery, and/or short sections of pipe, chain, wire, or cable. Magnetic anomalies within Buffer A and Buffer B have signature characteristics and/or spatial associations that suggest a potential for association with vessel remains or other submerged cultural resources. High sensitivity buffers remain recommended because previous dredging was successfully designed to avoid both buffer areas. No buffered magnetic anomalies in SS P1 S were selected for investigation by archaeological divers in conjunction with this project. However, in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the buffer sites cannot be avoided, both buffer areas should be priorities for future archaeological diver investigation. That investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.2.3. Primary Area 2

Ship Shoal Primary Area 2 (SS P2) was selected for remote sensing, due to previously identified anomalies that could be associated with historical vessel remains or other potentially significant submerged cultural resources (Figure 98). In addition, SS P2 is located adjacent to previously permitted borrow area South Pelto SP-C (see Table 2). That borrow site could be reutilized or perhaps expanded.

SS P2 was surveyed on September 10, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS P2 identified 12 magnetic anomalies (Figure 99, Volume III: Appendix R). No sonar targets or sub-bottom features were identified in the acoustic data (Figure 100).

Four magnetic anomalies (012-2, 013-1, 014-1, and 015-1) in survey area SS P2 form a cluster that was considered to have a potential for association with small vessel remains (Figure 101). Those anomalies were identified for archaeological diver investigation.

One vibracore was collected in SS P2: SSVC-14-04. It indicated sand with increasing silt from top to bottom and no recovery below 13.2 feet. The sandy material ranged in grain size from 0.14 to 0.16 mm. Future work on modeling potential borrow area affects to surrounding cultural resources should focus on the top 13.2 feet as future dredging events for beach nourishment projects will be focused on the top layers.

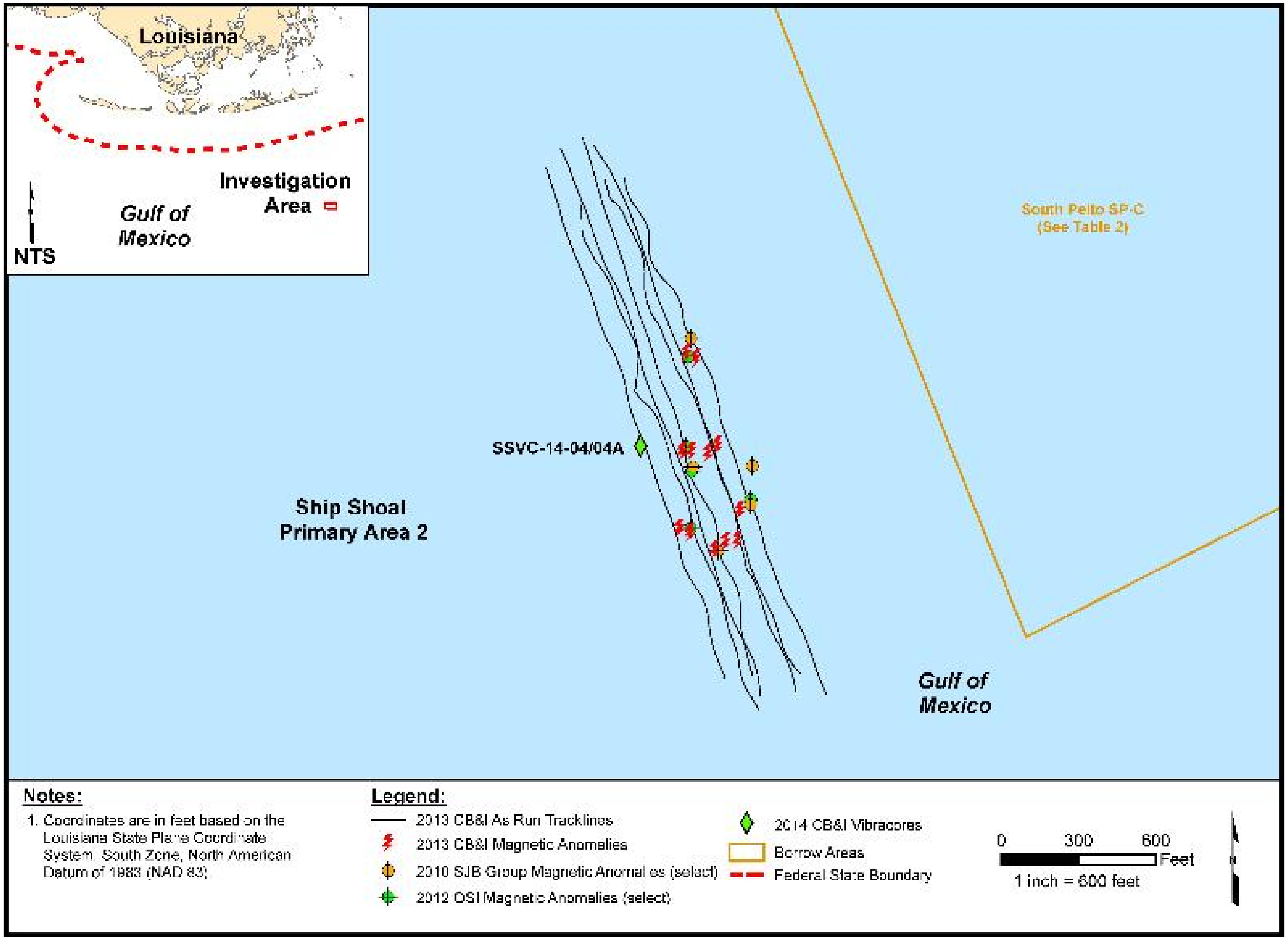

Figure 98. Magnetic anomalies identified in Ship Shoal Primary Area 2.

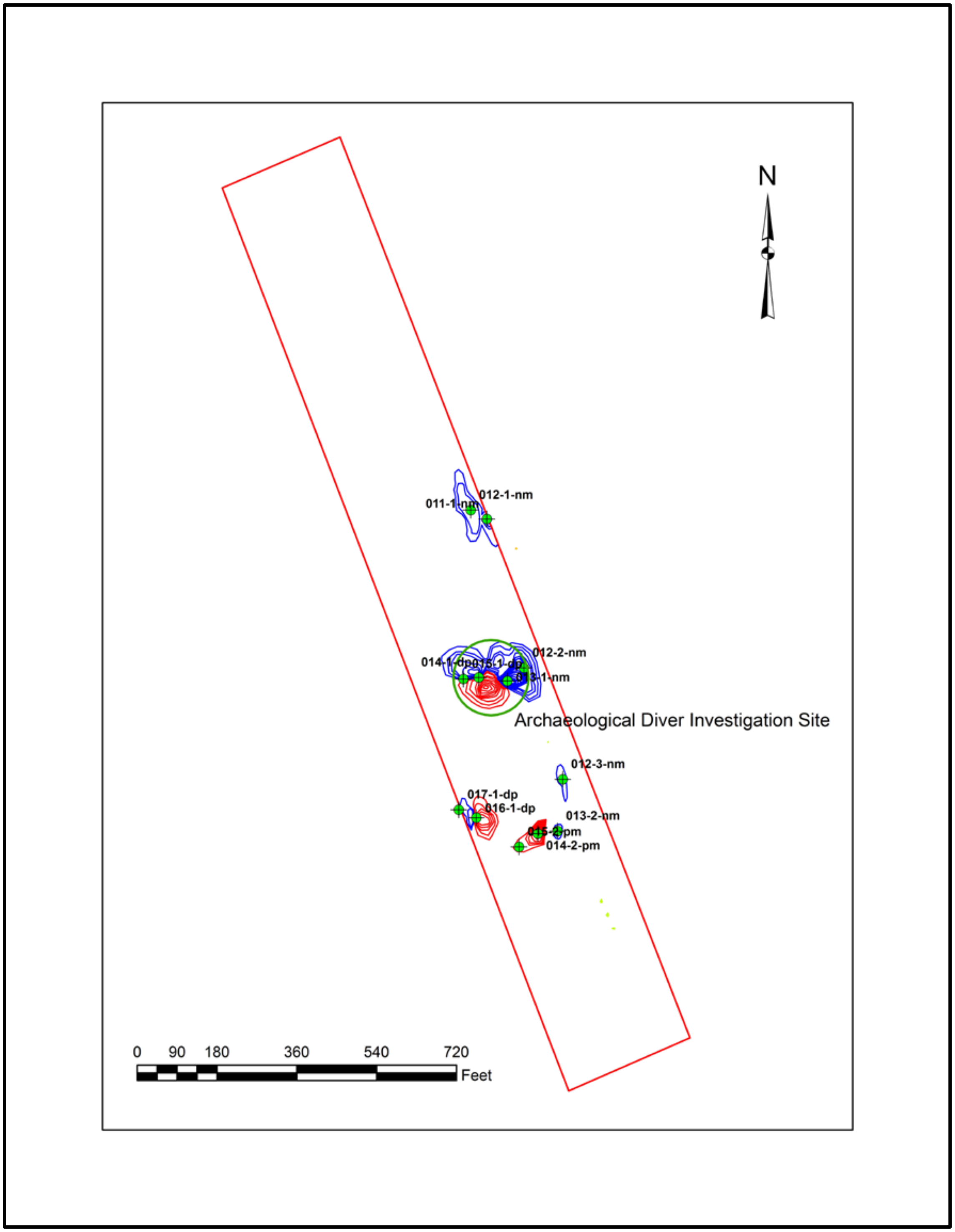

Figure 99. SS P2 magnetic anomalies, contours, and archaeological diver investigation site.

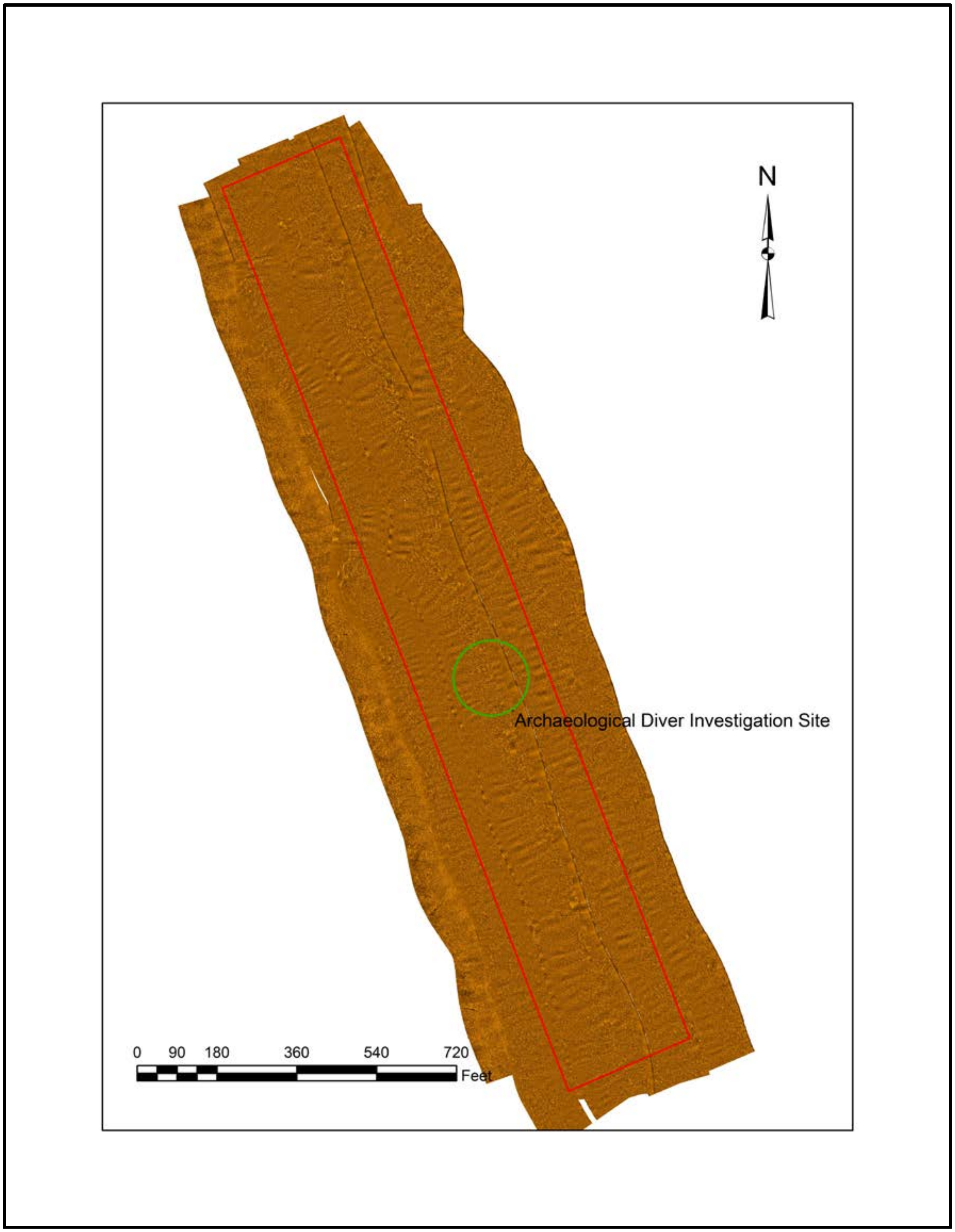

Figure 100. SS P2 sonar coverage mosaic.

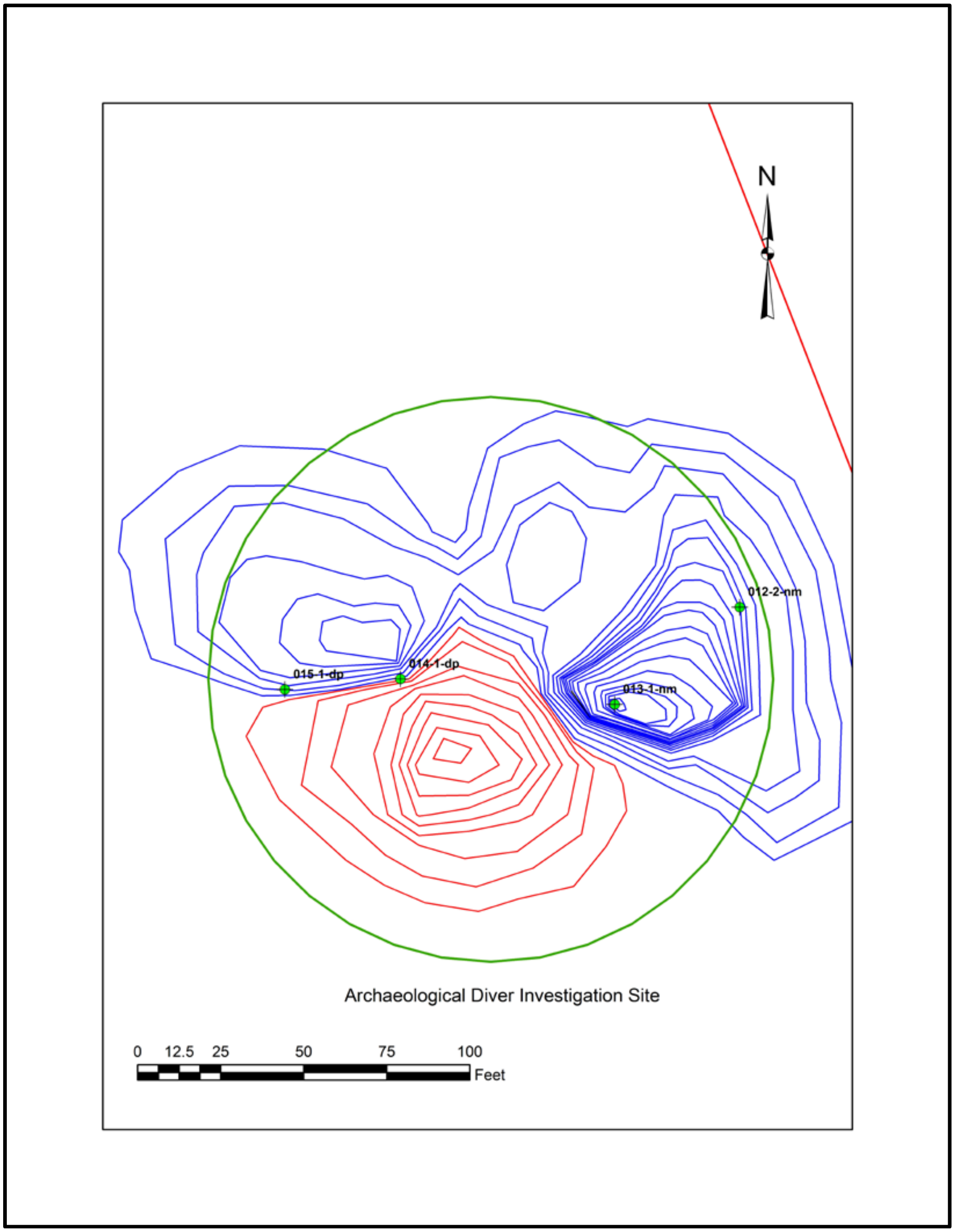

Figure 101. SS P2 magnetic anomalies and contours in area identified for archaeological diver investigation.

The diver investigation was attempted on August 20, 2014. High currents and rough seas prevented refining the location of material generating the magnetic anomalies using a hand-held magnetometer and hydraulic probing. On August 22, 2014 conditions were more conducive. The site was relocated and archaeological divers refined the location of material generating magnetic anomalies 013-1, 014-1, and 015-1 using the hand-held magnetometer. Using a hydraulic probe the area was systematically investigated in concentric circles. Material located by probing was identified as modern iron and/or steel plate. One piece of plate was partially exposed and contained a modern welded seam.

The remaining eight magnetic anomalies all appear to represent small and moderate size objects such as traps, small anchors or machinery, and/or short sections of pipe, chain, wire, or cable. However, there could be an association with the iron plate debris identified by probing or previous dredge related activity in the borrow site to the east. No additional investigation of the magnetic anomaly cluster inspected by archaeological divers or the remaining eight magnetic anomalies is recommended.

4.2.4. Primary Area 3

Ship Shoal Primary Area 3 (SS P3) was selected for remote sensing due to previously identified magnetic anomalies that could be associated with historical vessel remains or other potentially significant submerged cultural resources (Figure 102). In addition, SS P3 is located adjacent to previously permitted borrow area South Pelto SP-C (see Table 2). That borrow site could be reutilized or perhaps expanded.

SS P3 was surveyed on September 10, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS P3 identified 33 magnetic anomalies (Figure 103; Volume III: Appendix S). Only one sonar target was identified in the acoustic data (Figure 104; Volume III: Appendix T). That target (SS P3 001) was identified along the southern perimeter of the survey area (Figure 105). No sub-bottom features were associated with the magnetic anomaly clusters or single magnetic anomalies.

One vibracore was collected in SS P3: SSVC-14-05. It indicated fine-grained sand and no recovery below 6.9 feet. The sandy material ranged in grain size from 0.17 to 0.19 mm. Future work on modeling potential borrow area affects to surrounding cultural resources should focus on the top 7 feet as future dredging events for beach nourishment projects will be focused on the top layers.

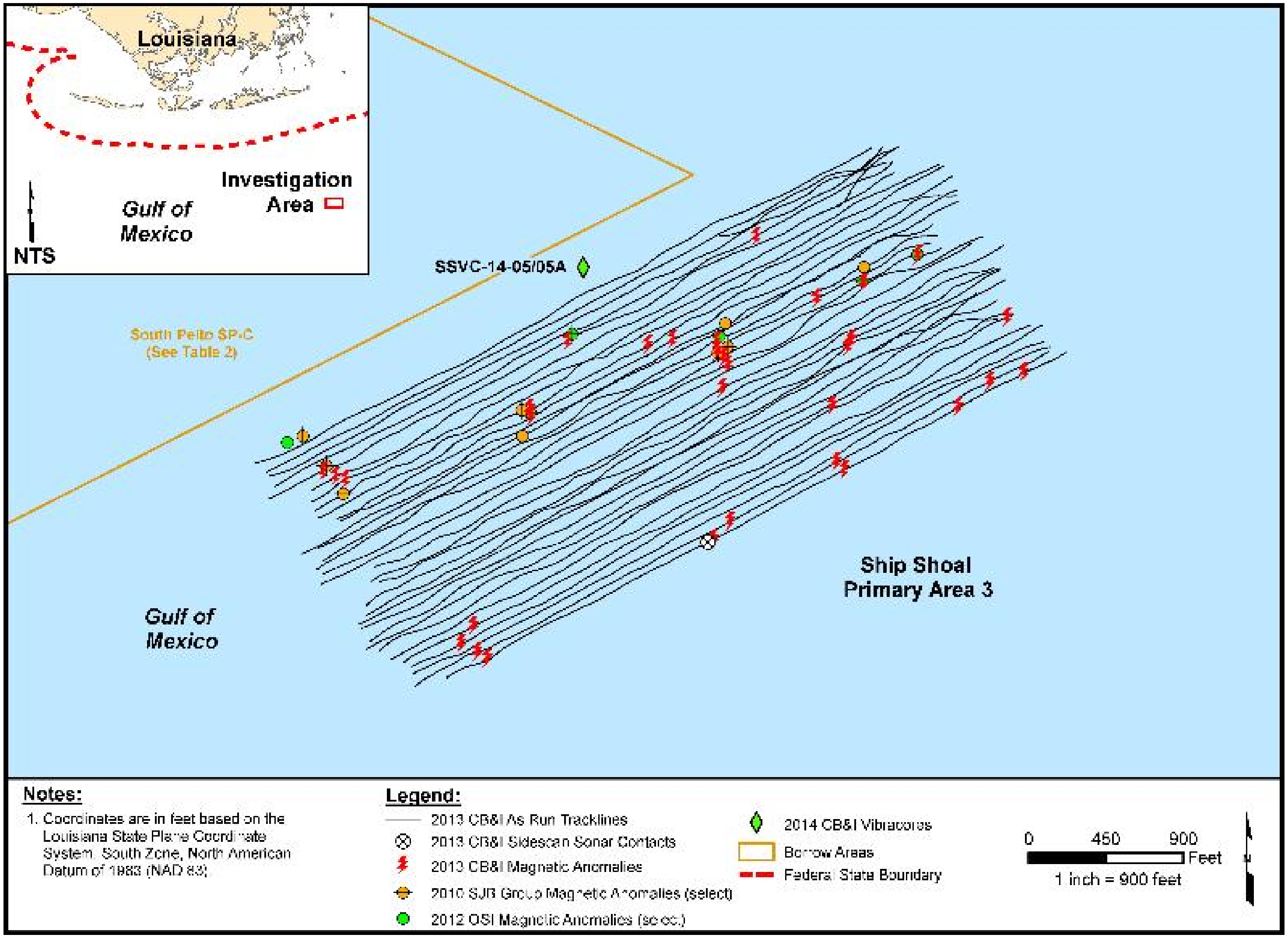

Figure 102: Magnetic anomalies and sonar target identified in Ship Shoal Primary Area 3.

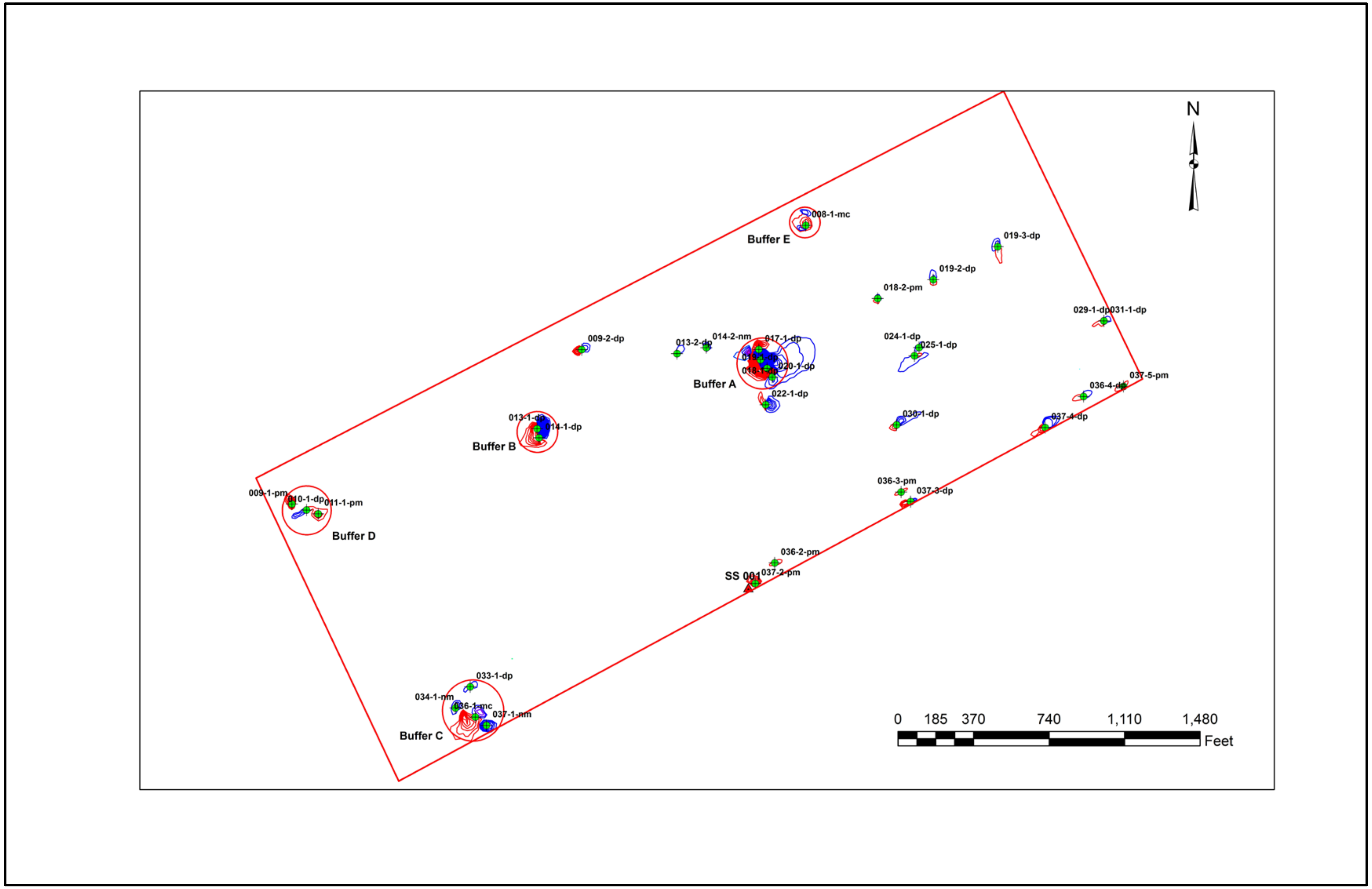

Figure 103. SS P3 magnetic anomalies, contours, and buffers.

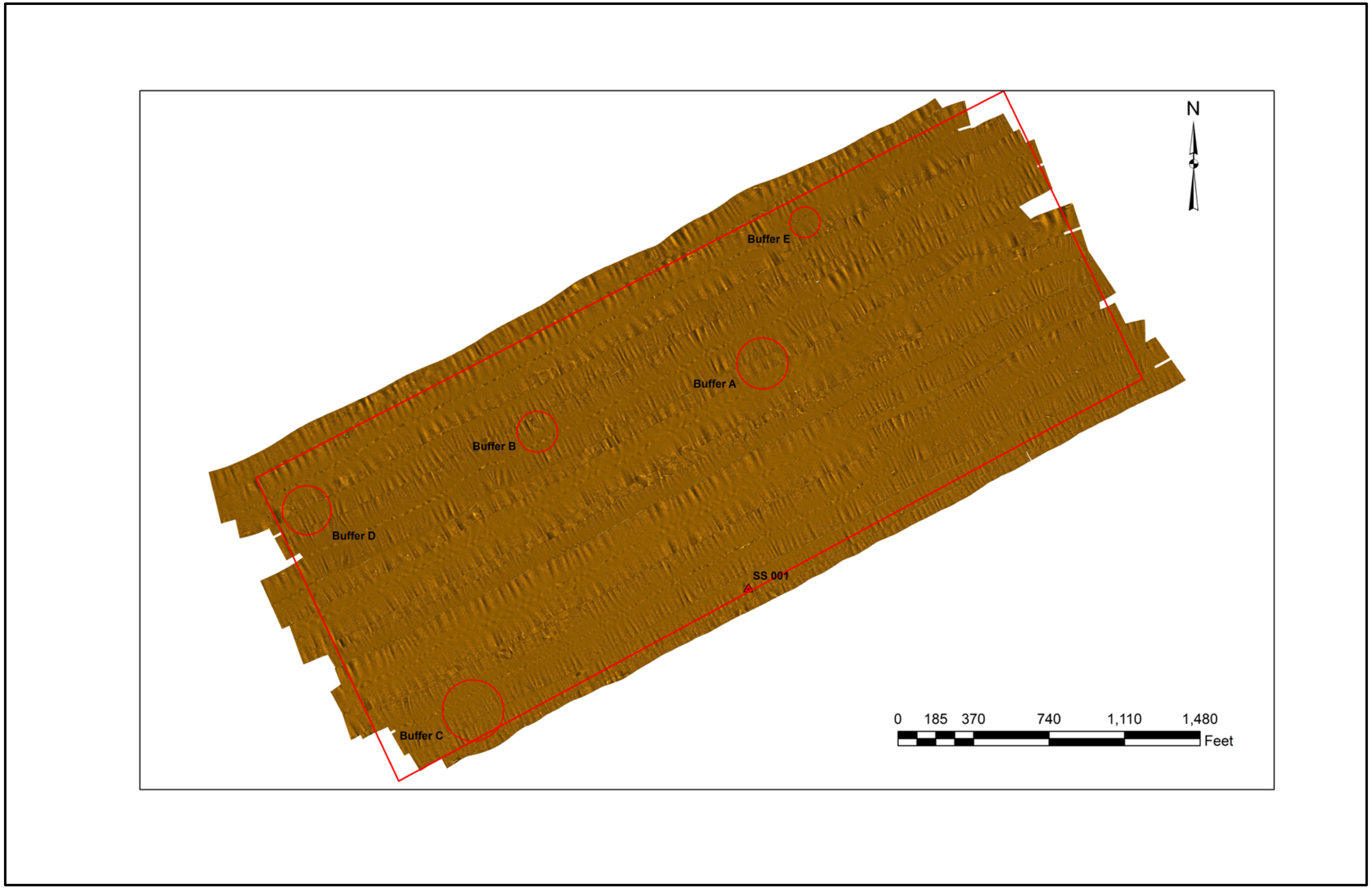

Figure 104. SS P3 sonar coverage mosaic with sonar target.

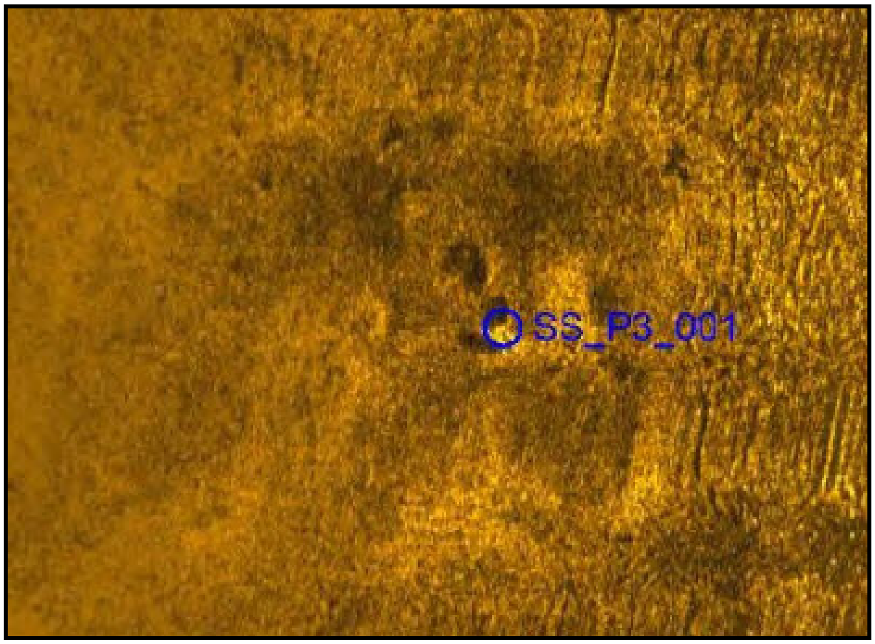

Figure 105. SS P3 sonar image of target SS P3 001.

Four clusters of magnetic anomalies and one single magnetic anomaly are considered to have individual or collective signature characteristics that may be associated with historical vessel remains or other submerged cultural resources. Four anomalies (017-1, 018-1, 019-1, and 020-1) form a cluster with a high potential association with shipwreck remains. Those four are identified as Buffer A (Figure 106). Two magnetic anomalies (013-1 and 014-1) form a cluster with high potential for association with small vessel remains. Those magnetic anomalies are identified as Buffer B (Figure 107).

Four additional magnetic anomalies (033-1, 034-1, 036-1, and 037-1) form a cluster with a high potential association with shipwreck remains. Those four are identified as Buffer C (Figure 108). Three magnetic anomalies (009-1, 010-1, and 011-1) form a cluster with a moderate potential association with shipwreck remains. Those three are identified as Buffer D (Figure 109). One additional magnetic anomaly (008-1) has a multicomponent signature with a moderate potential association with shipwreck remains. That magnetic anomaly is identified as Buffer E (Figure 110).

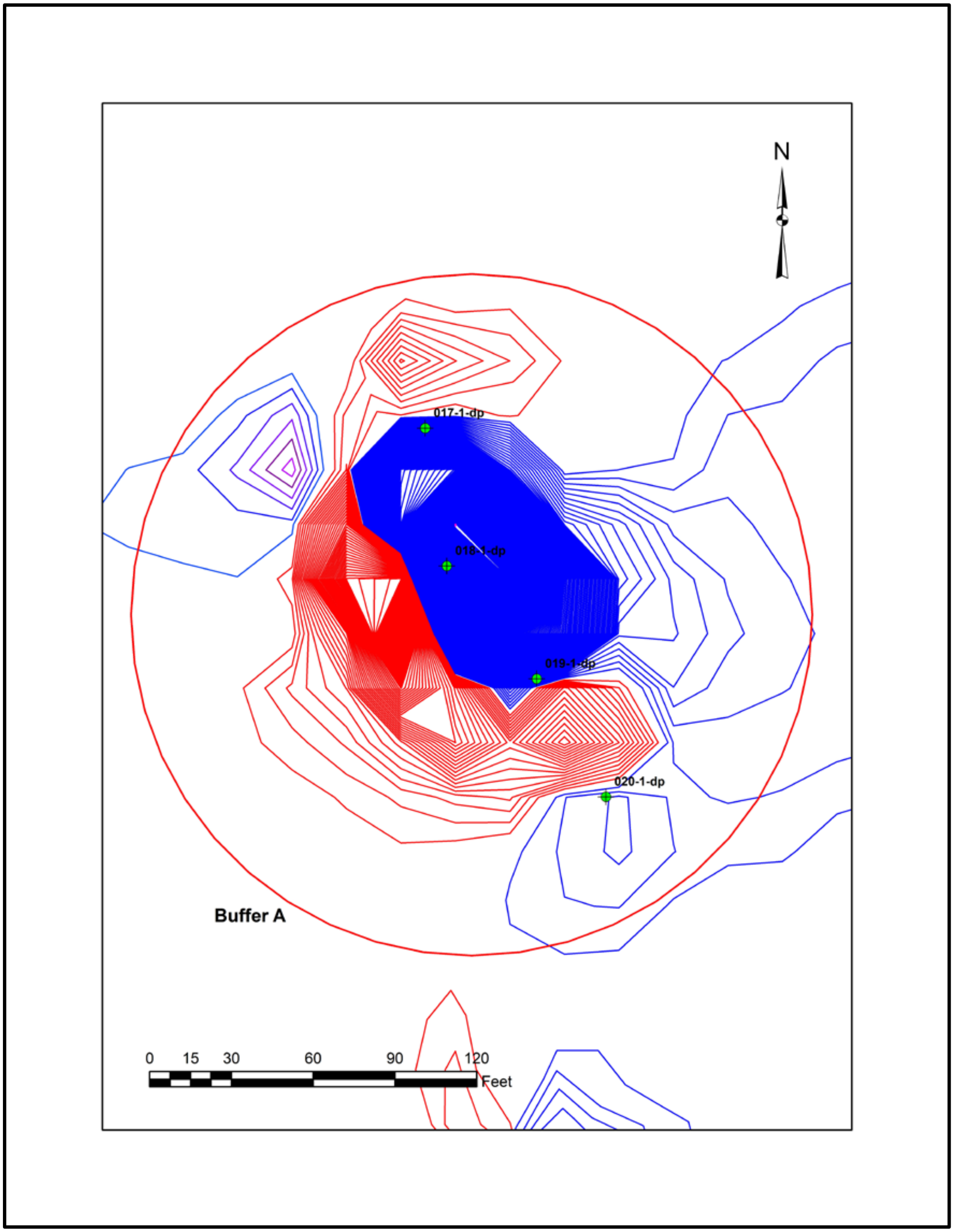

Figure 106. SS P3 Buffer A magnetic anomalies and contours.

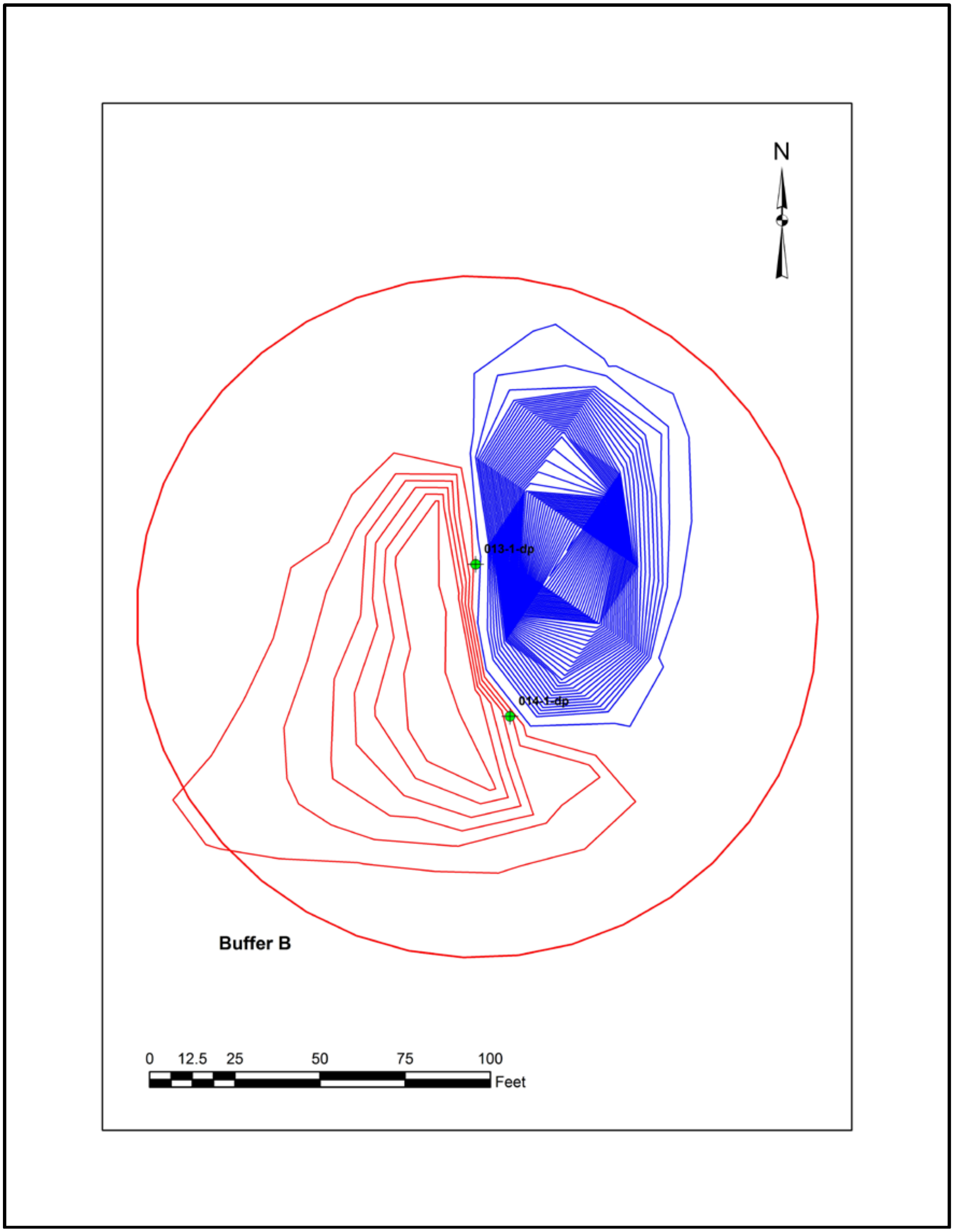

Figure 107. SS P3 Buffer B magnetic anomalies and contours.

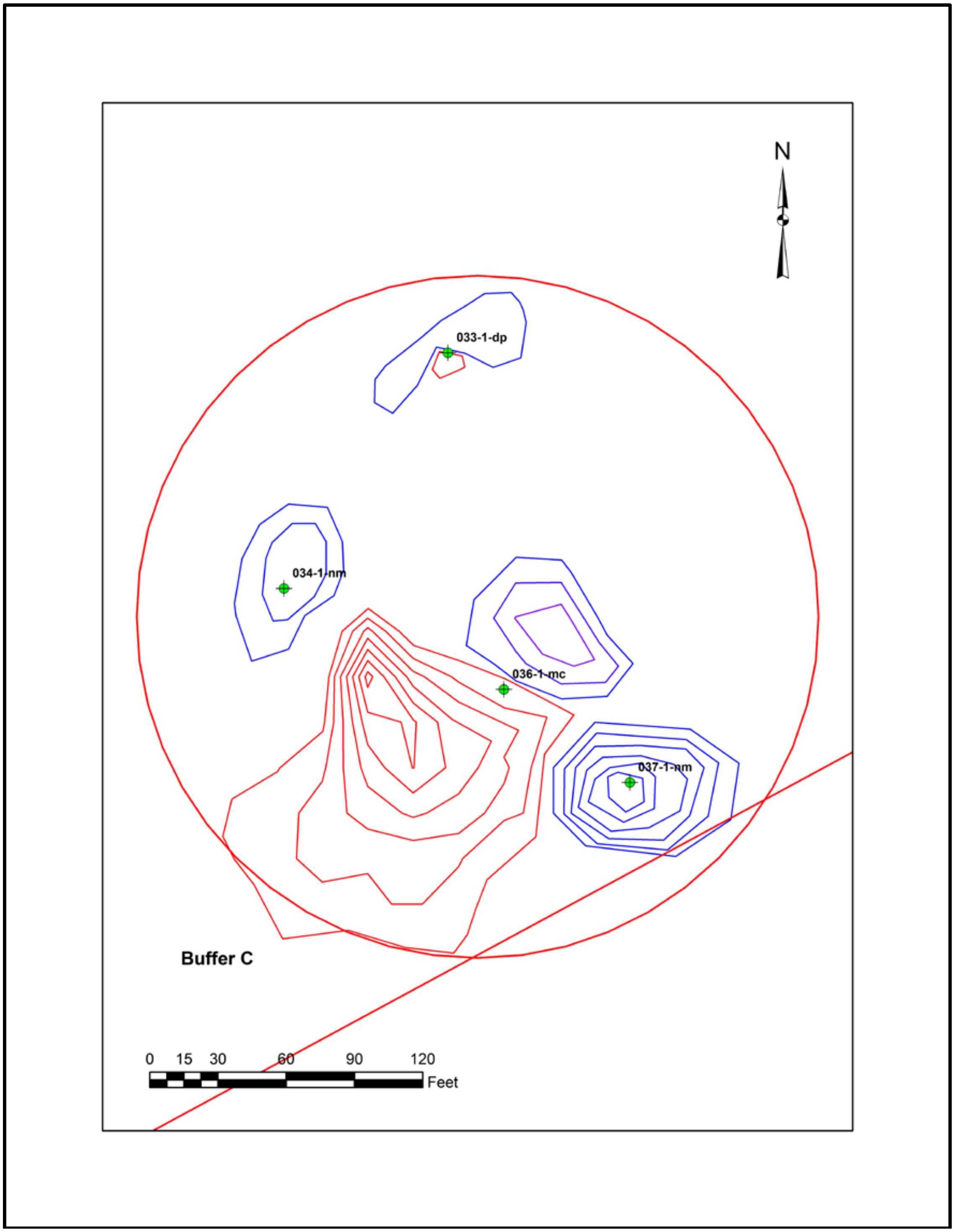

Figure 108. SS P3 Buffer C magnetic anomalies and contours.

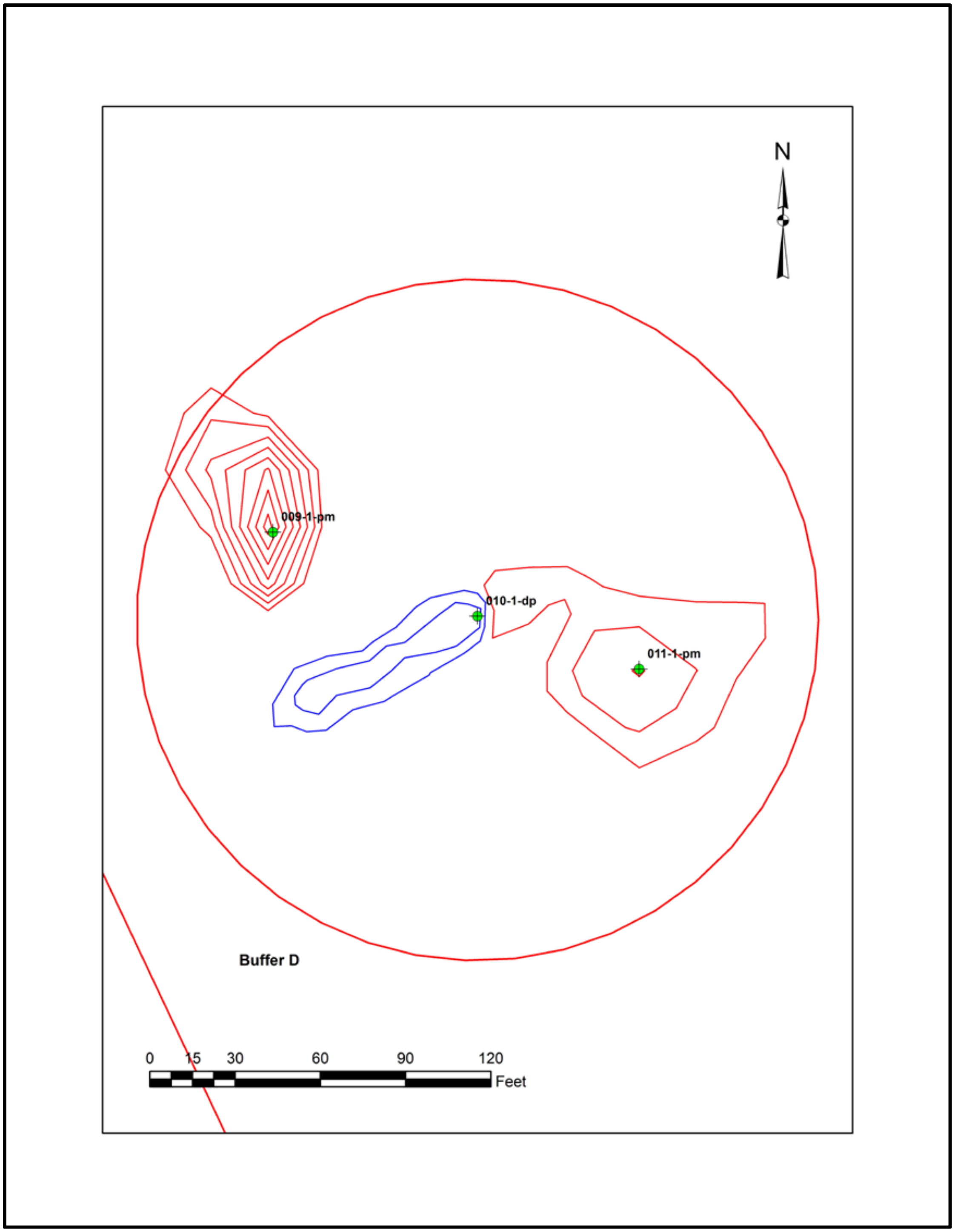

Figure 109. SS P3 Buffer D magnetic anomalies and contours.

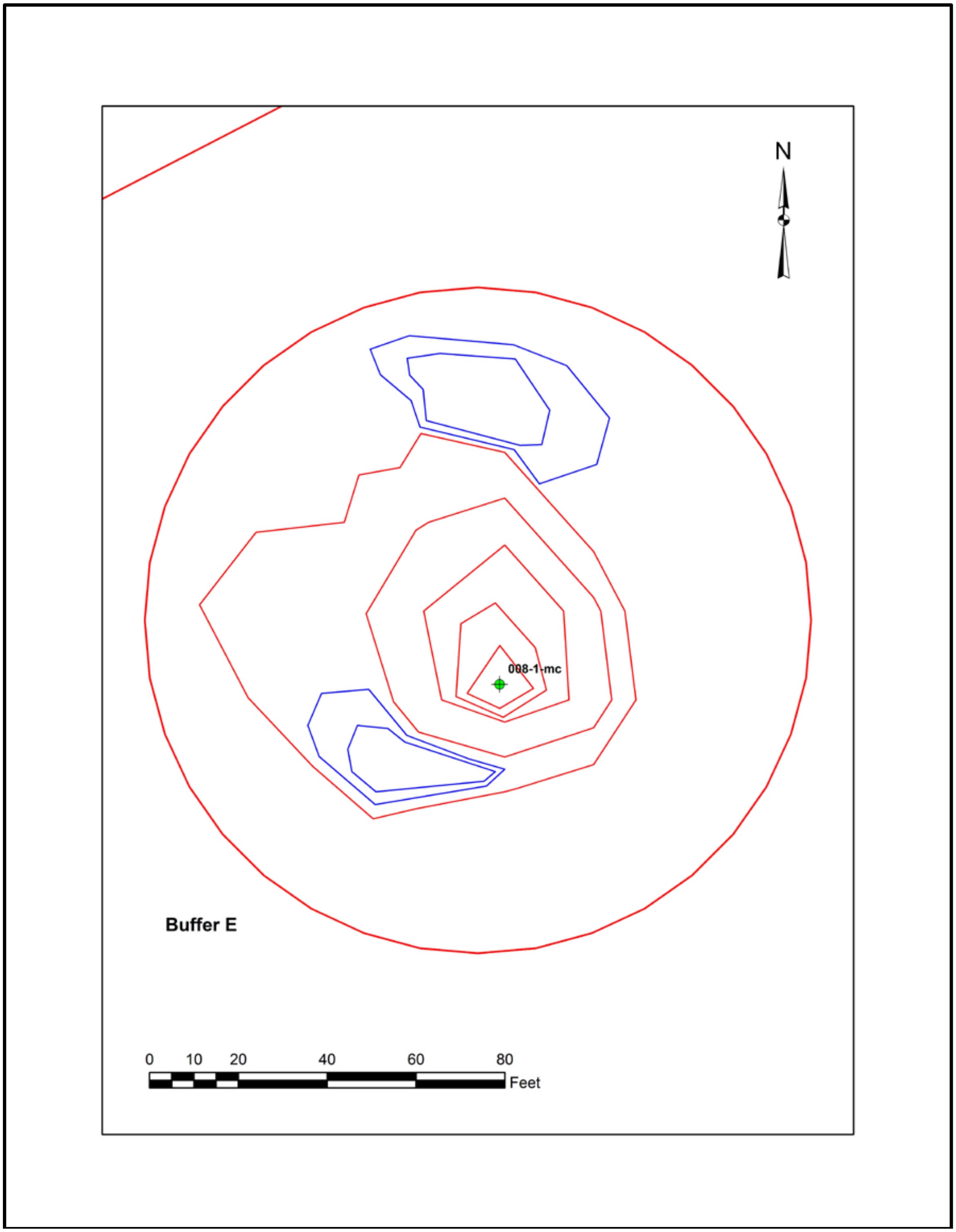

Figure 110. SS P3 Buffer E magnetic anomalies and contours.

Thirteen of the remaining magnetic anomalies have signatures indicative of small isolated ferrous objects. The final six magnetic anomalies have signatures indicative of moderate ferrous objects. Those magnetic anomalies do not appear to have more complex signatures generally associated with historical shipwreck remains. The single sonar image (SS P3 001) could be associated with one of the moderate anomalies. That magnetic anomaly (037-2) is suggestive of a moderate size object such as the acoustic target identified in the sonar data. Sub-bottom profiler data contained no features associated with the magnetic anomaly clusters or the single anomalies.

Magnetic anomalies within Buffers A, B, and C have signature characteristics and spatial associations that suggest a high potential for association with vessel remains or other submerged cultural resources. Magnetic anomalies in Buffers D and E appear to have signature characteristics and spatial associations that suggest a moderate potential for association with small vessel remains or other submerged cultural resources. None of the buffered anomaly clusters in SS P3 were selected for investigation by archaeological divers in conjunction with this project. However, all five buffer areas should be priorities for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.2.5. Secondary Area 1

Ship Shoal Secondary Area 1 (SS S1) was selected for remote sensing due to previously identified anomalies that could be associated with historic vessel remains or other potentially significant submerged cultural resources (Figure 111). SS S1 is not located in, or adjacent to, a previously permitted or proposed borrow area.

SS S1 was surveyed on September 9, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS S1 identified 27 magnetic anomalies (Figure 112; Volume III: Appendix U). No sonar targets and/or associated sub-bottom features were identified in the acoustic data (Figure 113).

Four magnetic anomalies (020-1, 021-1, 022-1, and 023-1) form a tight cluster with a high potential for association with shipwreck remains. Those four have been identified as Buffer A (Figure 114). Buffer B contains two magnetic anomalies (028-1 and 029-1). Those magnetic anomalies have a moderate potential for association with small vessel remains and are identified as Buffer B (Figure 115).

Eighteen magnetic anomalies represent a line of deteriorating pipe, cable, or chain. The final three magnetic anomalies (19-2, 24-2, and 27-1) have signature characteristics indicative of small and moderate single ferrous objects, not more complex signatures that are more reliably associated with shipwrecks or small vessel remains.

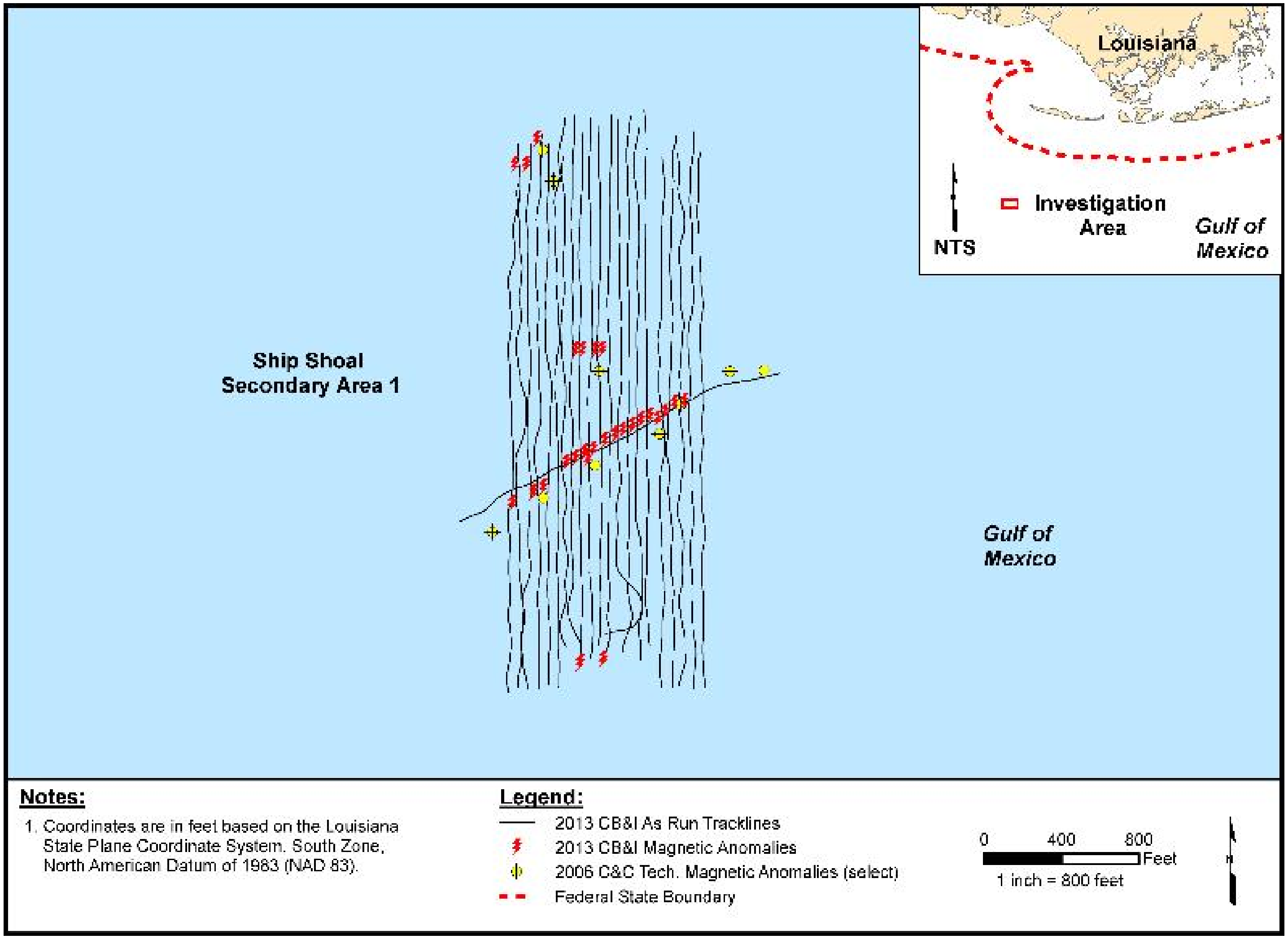

Figure 111. Magnetic anomalies identified in Ship Shoal Secondary Area 1.

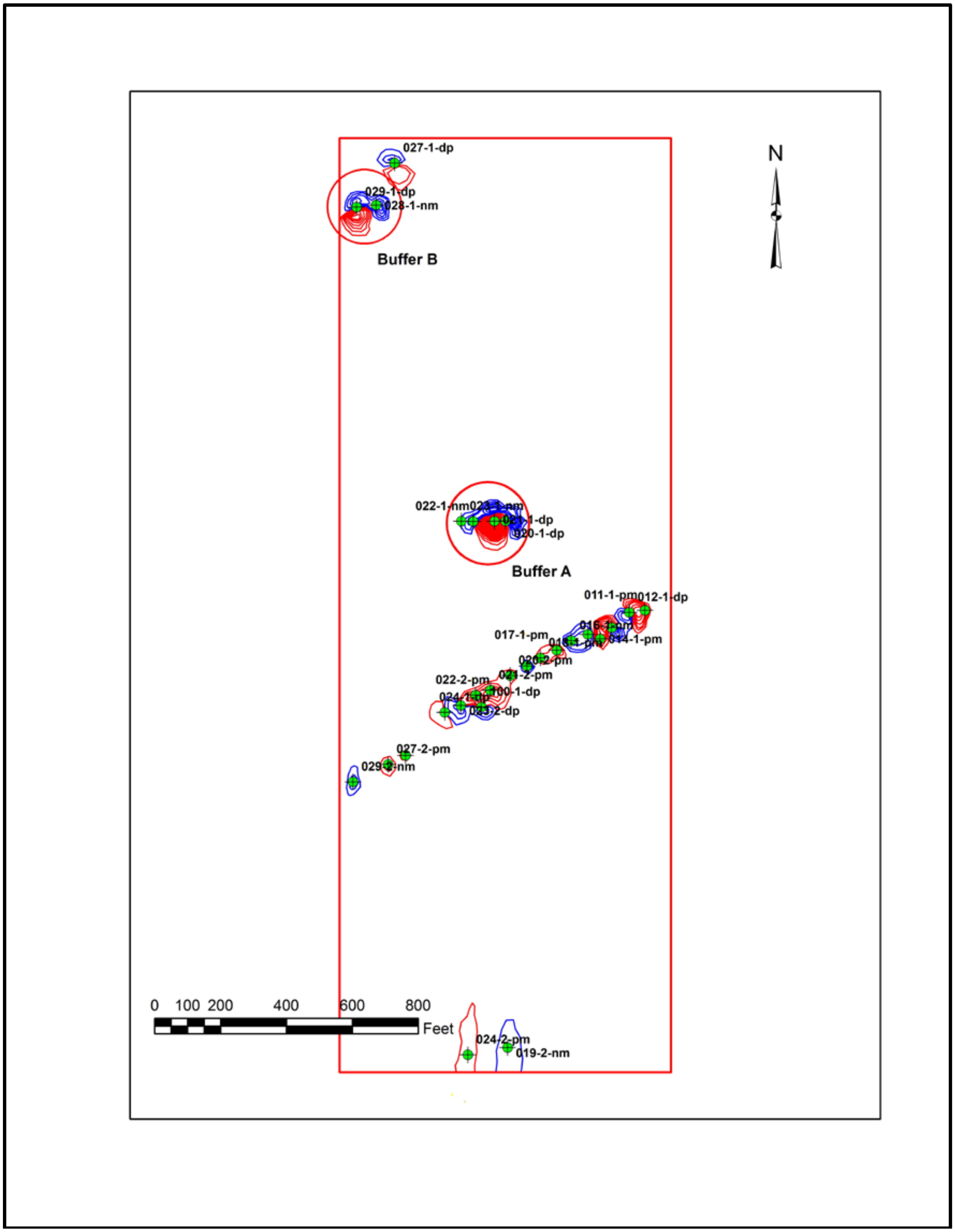

Figure 112. SS S1 magnetic anomalies, contours, and buffers.

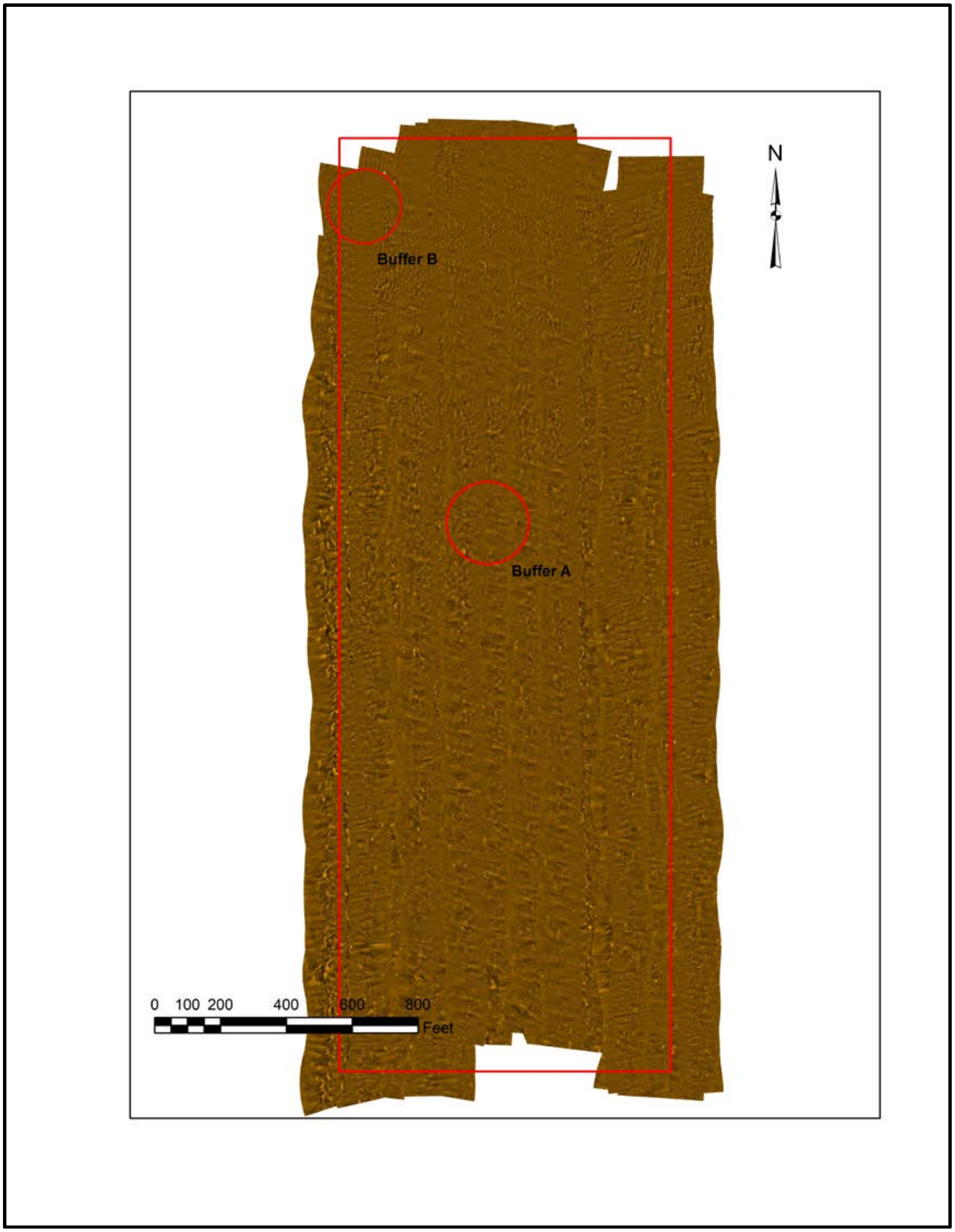

Figure 113. SS S1 sonar coverage mosaic.

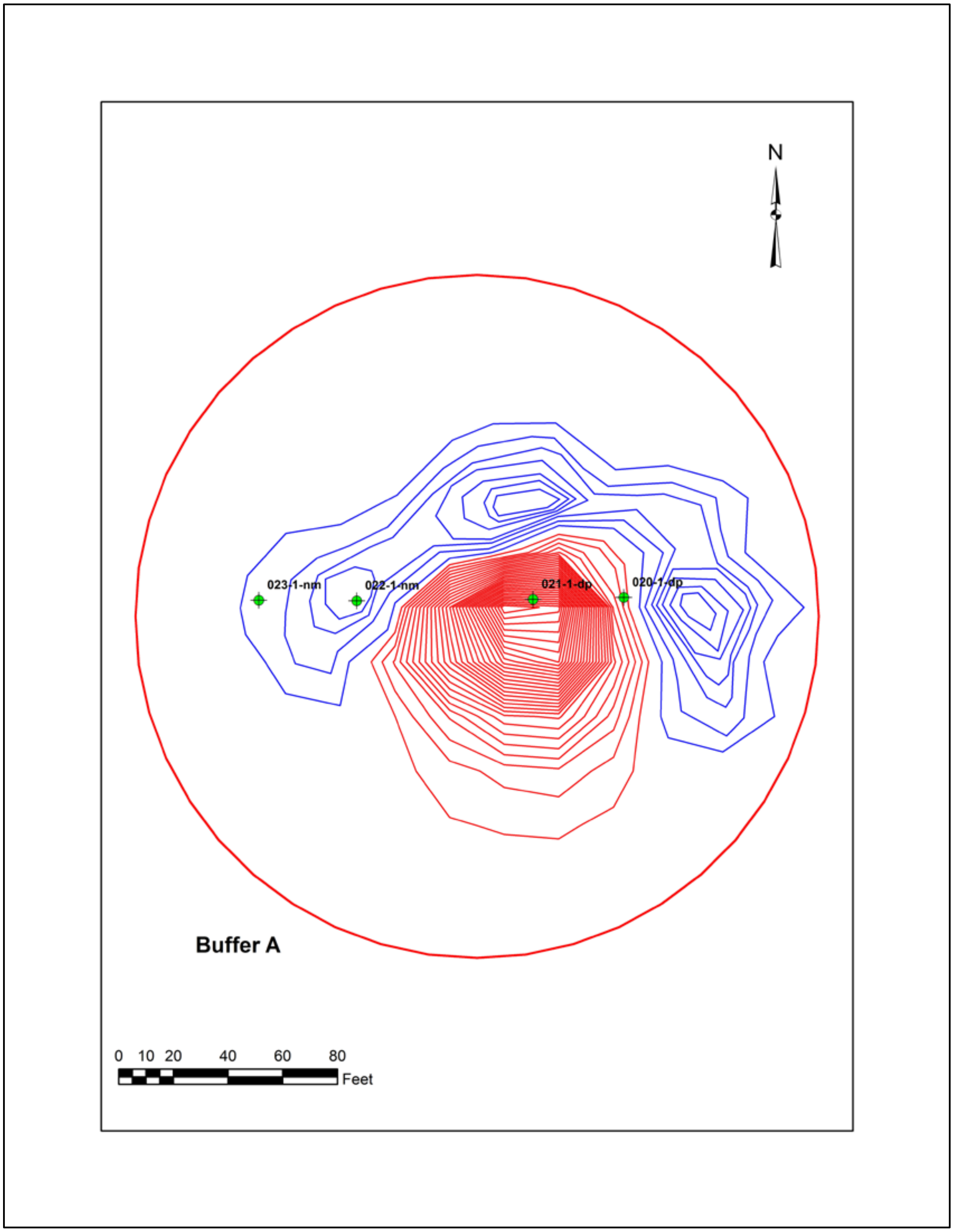

Figure 114. SS S1 Buffer A magnetic anomalies and contours.

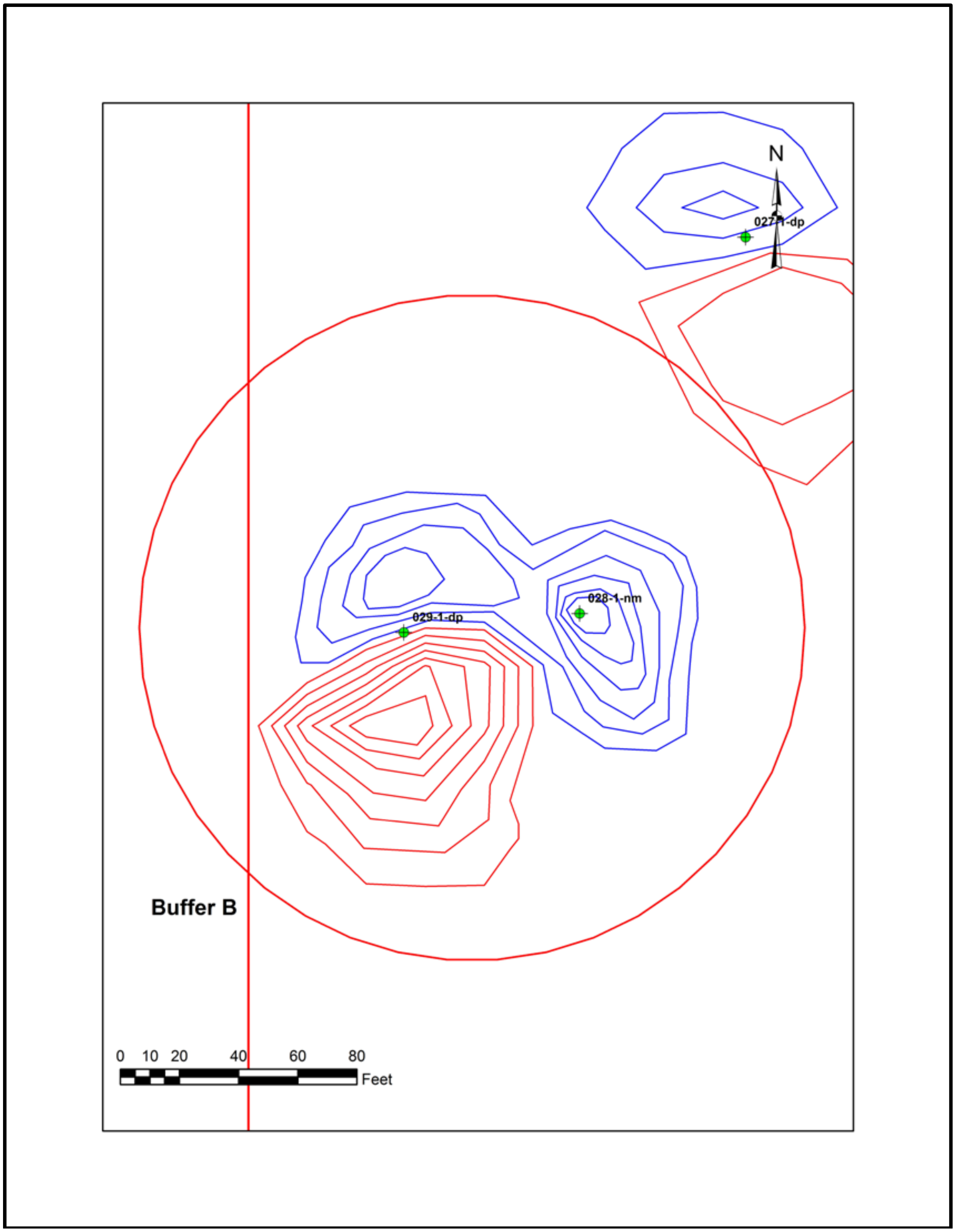

Figure 115. SS S1 Buffer B magnetic anomalies and contours.

No sonar targets were identified in the acoustic data and no features associated with the single magnetic anomalies or clusters in SS S1 were apparent in the sub-bottom data. Magnetic anomalies within Buffer A have signature characteristics and spatial associations that suggest a high potential for association with vessel remains or other submerged cultural resources. Magnetic anomalies in Buffer B appear to have signature characteristics and spatial associations that suggest at least a moderate potential for association with small vessel remains or other submerged cultural resources.

None of the buffered magnetic anomaly clusters in SS S1 were selected for diver investigation. However, both buffer areas should be priorities for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.2.6. Secondary Area 2

Ship Shoal Secondary Area 2 (SS S2) was selected for remote sensing due to previously identified anomalies and sonar targets that could be associated with historic vessel remains (Figure 116). It is not located in, or adjacent to, a previously permitted or proposed borrow area.

SS S2 was surveyed on September 9, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS S2 identified 31 magnetic anomalies (Figure 117; Volume III: Appendix V). Five sonar targets were identified in the acoustic data (Figure 118; Volume III: Appendix W).

Eighteen of the thirty-one magnetic anomalies (012-1, 013-1, 014-1, 015-1, 016-1, 017-1, 018A-1, 019A-1, 020-1, 021-1, 022-1, 023-3, 024-1, 025-1, 100-1, 101-1, 102-1, and 103-1) form a large linear cluster (Figure 119). Magnetic anomalies in the cluster are associated with four sonar targets. That site was selected for archaeological diver investigation as signatures clearly represent significant structure.

Two additional magnetic anomaly clusters are recommended for avoidance. Buffer A includes three magnetic anomalies (028-1, 029-1, and 030-2). That cluster of magnetic anomalies has a moderate potential for association with small vessel remains. Two additional magnetic anomalies (030-1 and 031-1) within Buffer B also have a moderate potential for association with small vessel remains (Figure 120).

Four of the five sonar targets identified in SS S2 (SS 001, SS 002, SS 003, and SS 005) are associated with vessel remains and debris generating the cluster of 18 magnetic anomalies (Figure 121 through Figure 124). The remaining sonar image (SS 004) illustrates a small object on the bottom surface in the northwestern corner of the survey area (Figure 125). That image illustrates a small single object not associated with any of the magnetic anomalies.

One vibracore was collected in SS S2: SSVC-14-07. It indicated clay with thin silty sand and silty clay layers. Unless this site is used for marsh nourishment, future modeling is not recommended; future nourishment projects will not likely use sediments surrounding SS S2.

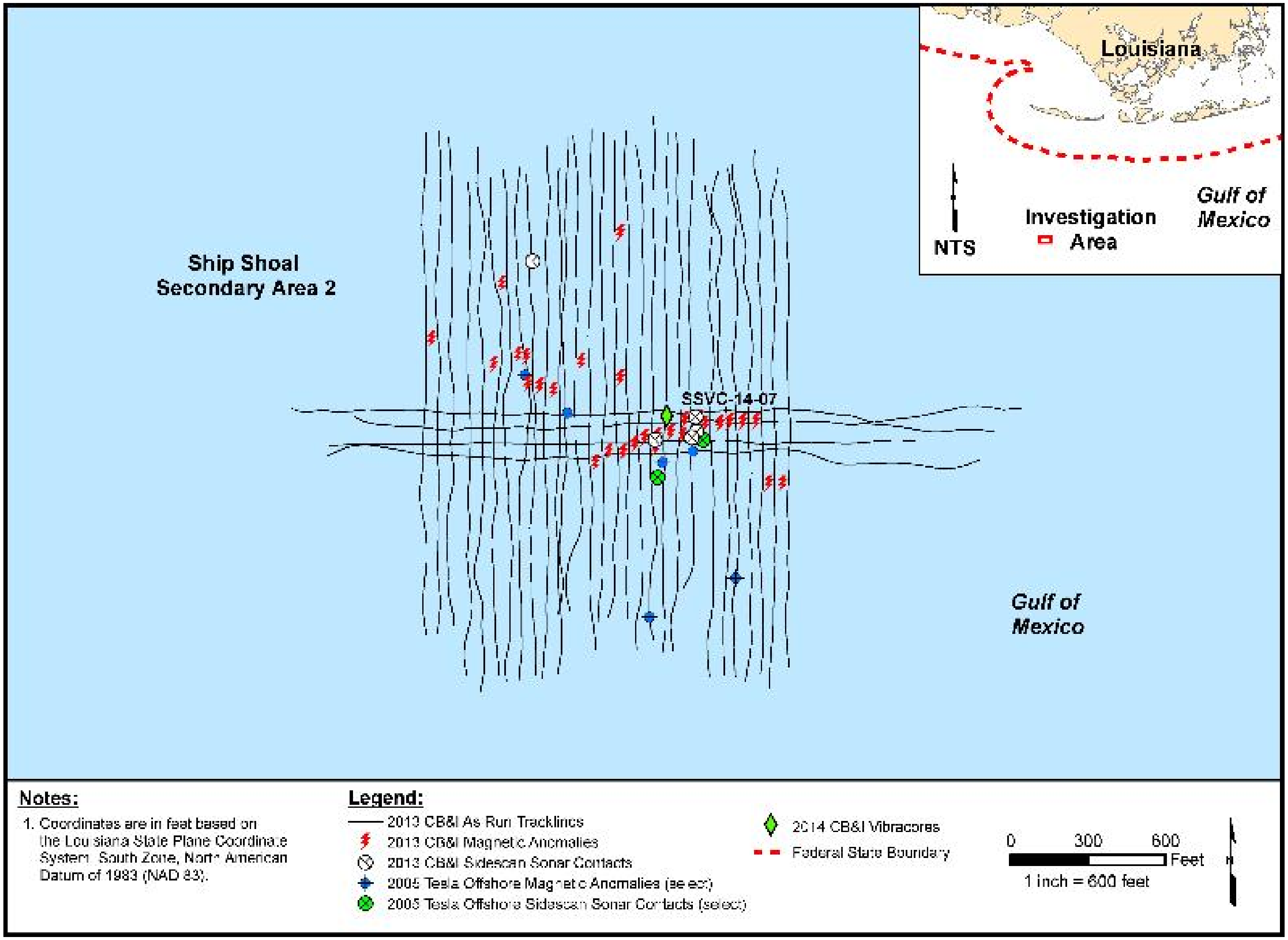

Figure 116. Magnetic anomalies and sonar targets identified in Ship Shoal Secondary Area 2.

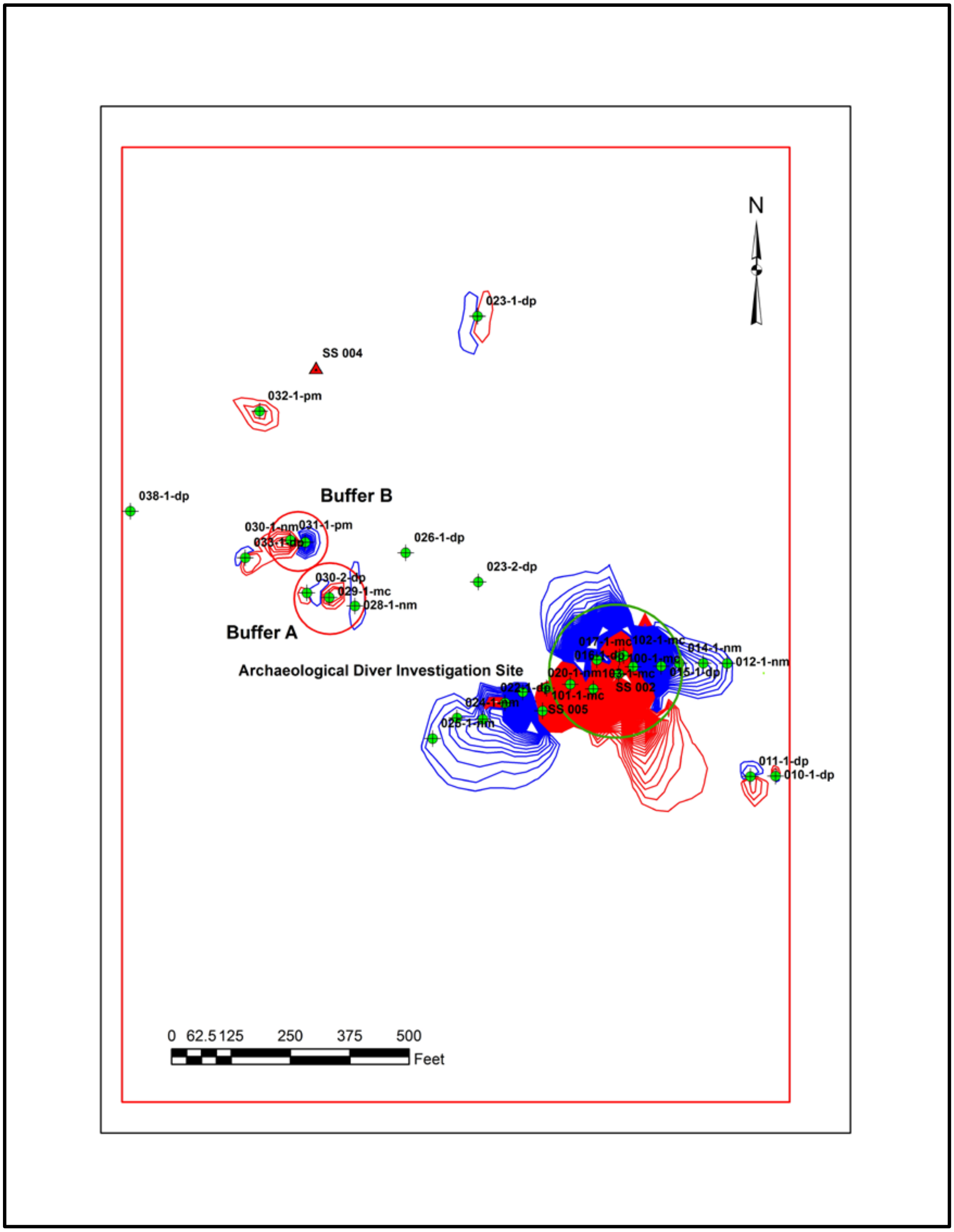

Figure 117. SS S2 magnetic anomalies, contours, and buffers.

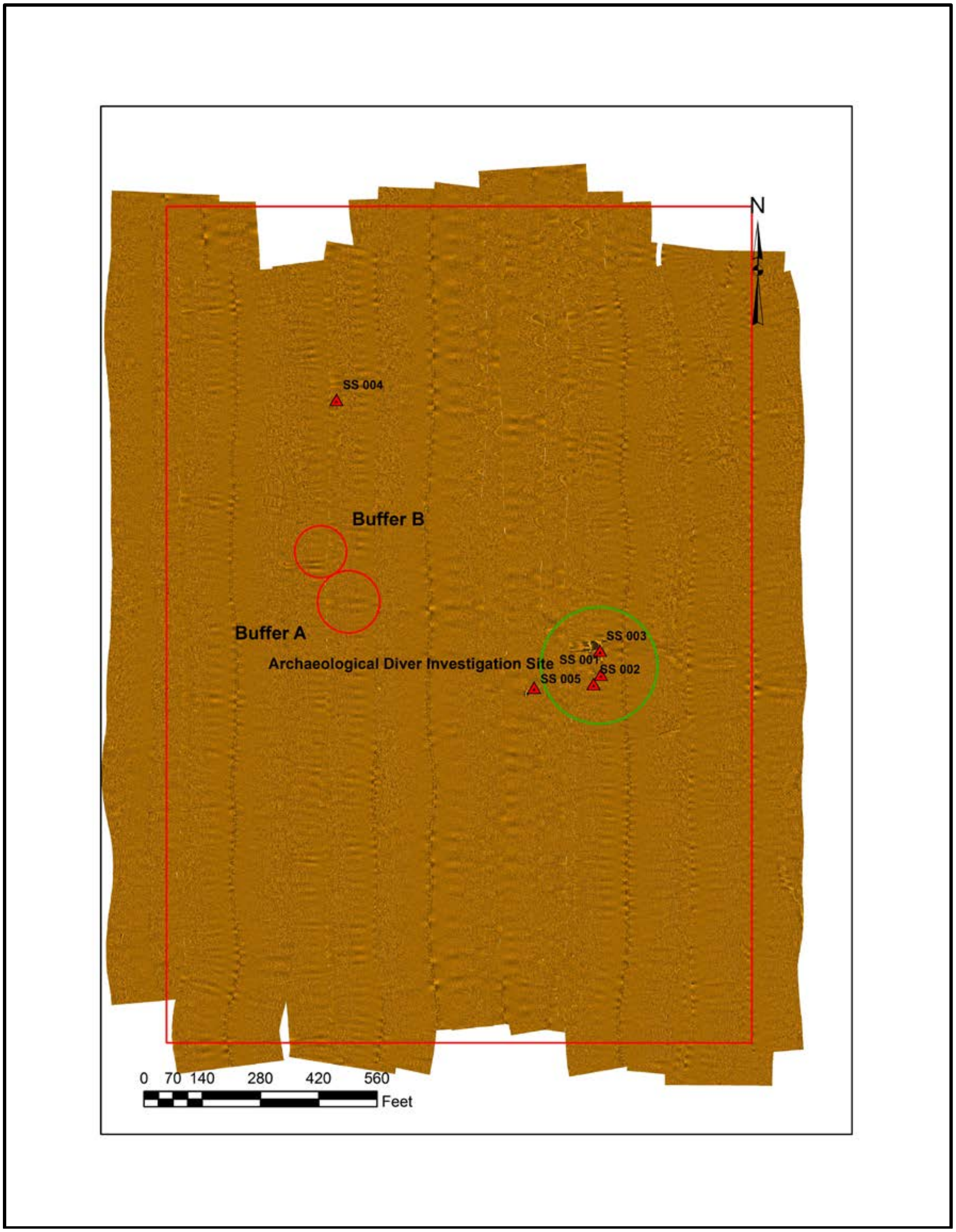

Figure 118. SS S2 sonar coverage mosaic with sonar targets.

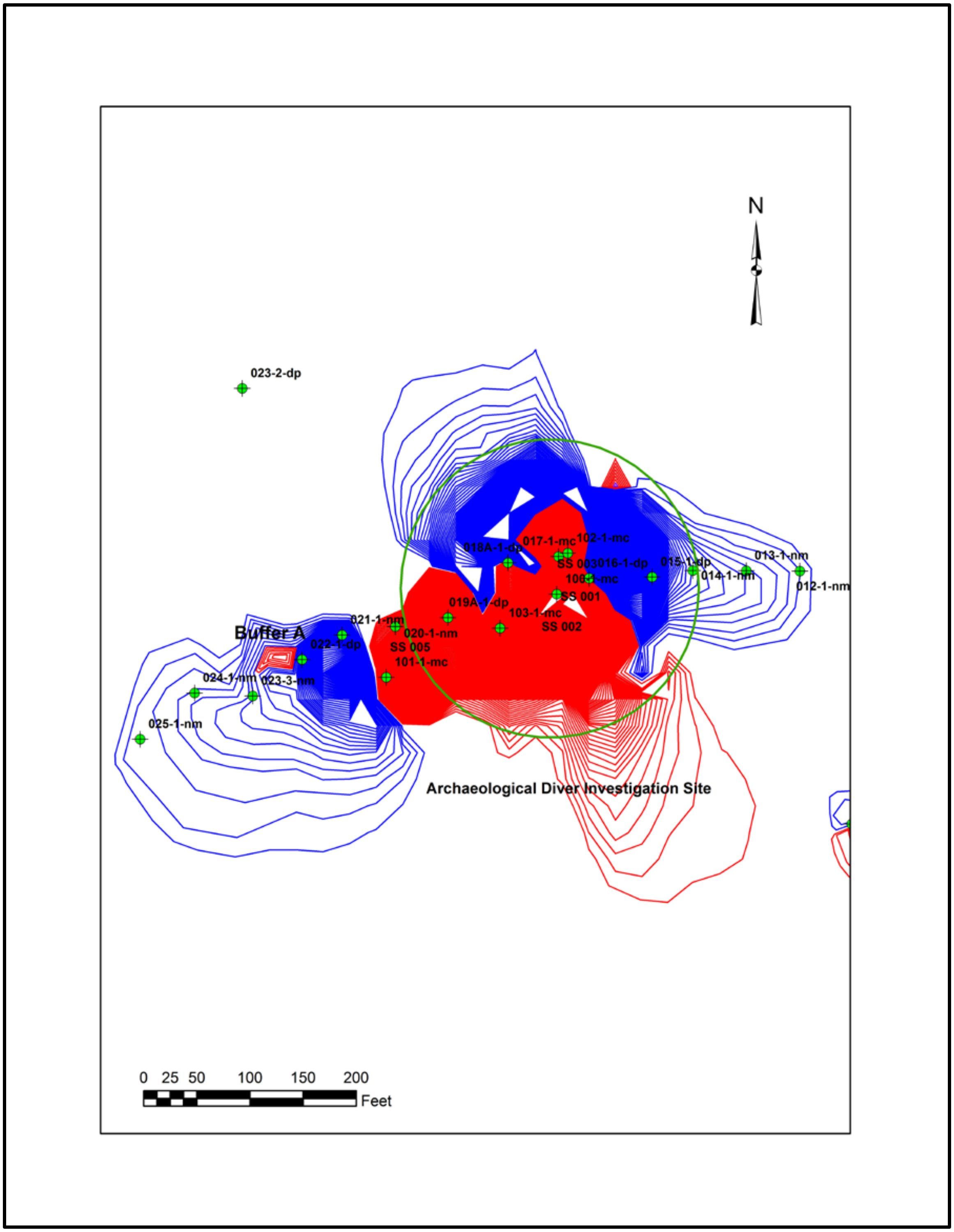

Figure 119. SS S2 magnetic anomalies, contours, and sonar targets in area identified for archaeological diver investigation.

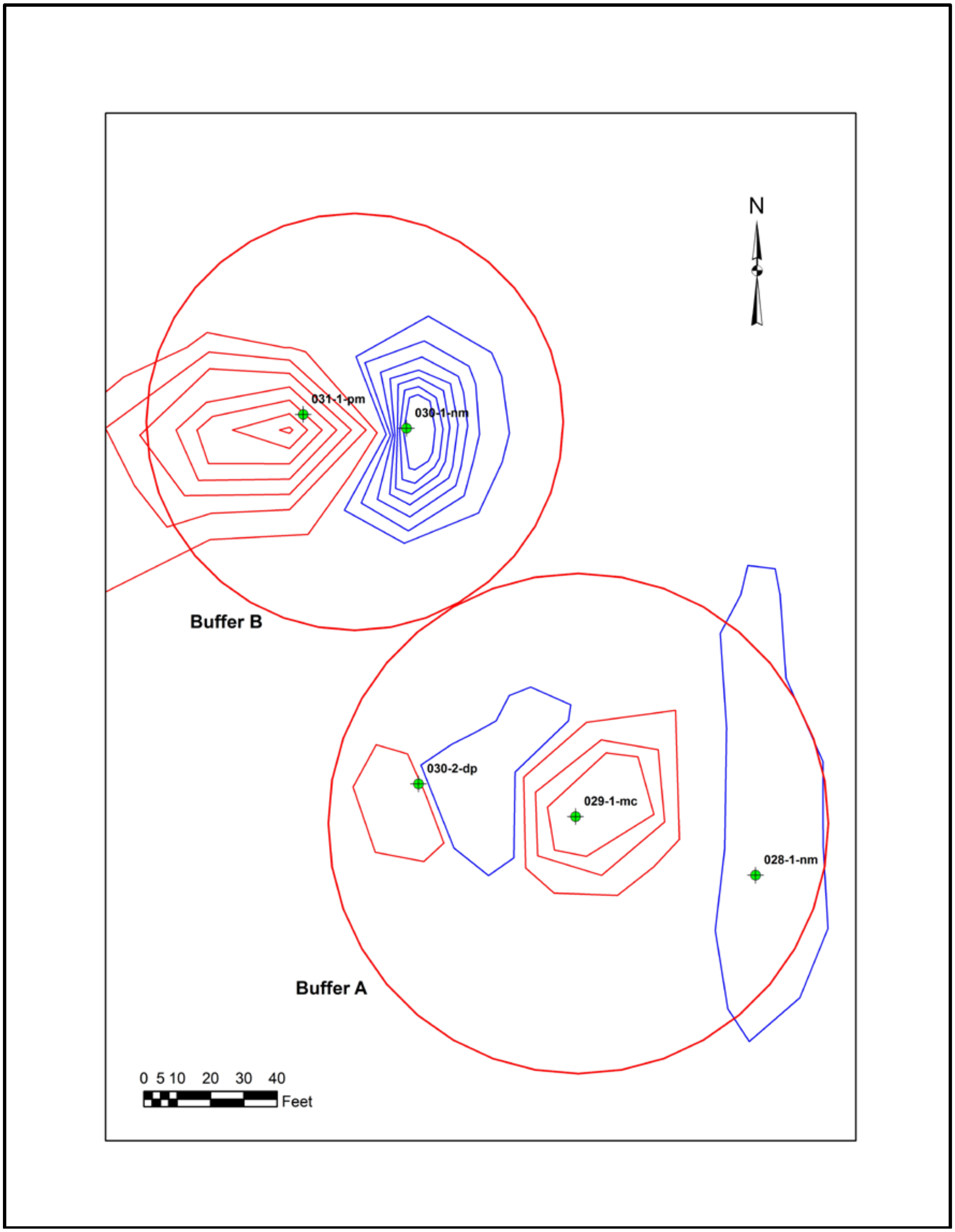

Figure 120. SS S2 Buffers A and B magnetic anomalies and contours.

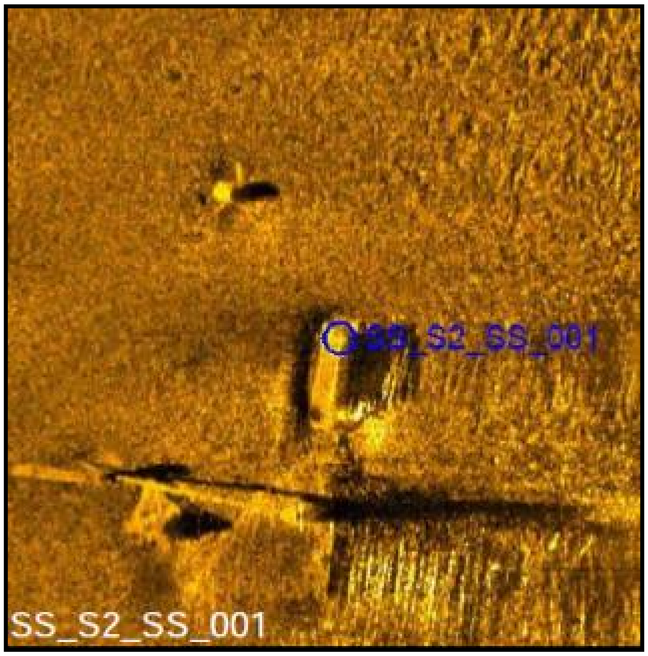

Figure 121. SS S2 sonar image SS 001 of vessel remains and debris.

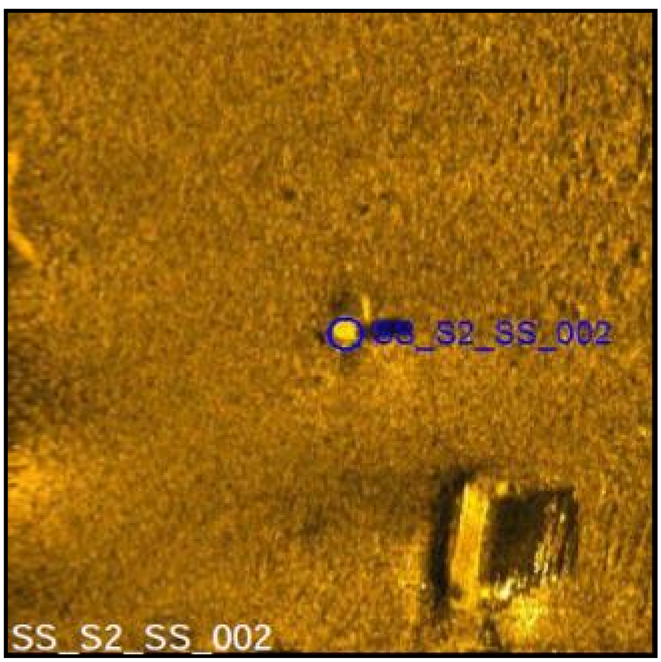

Figure 122. SS S2 sonar image SS 002 of vessel remains and debris.

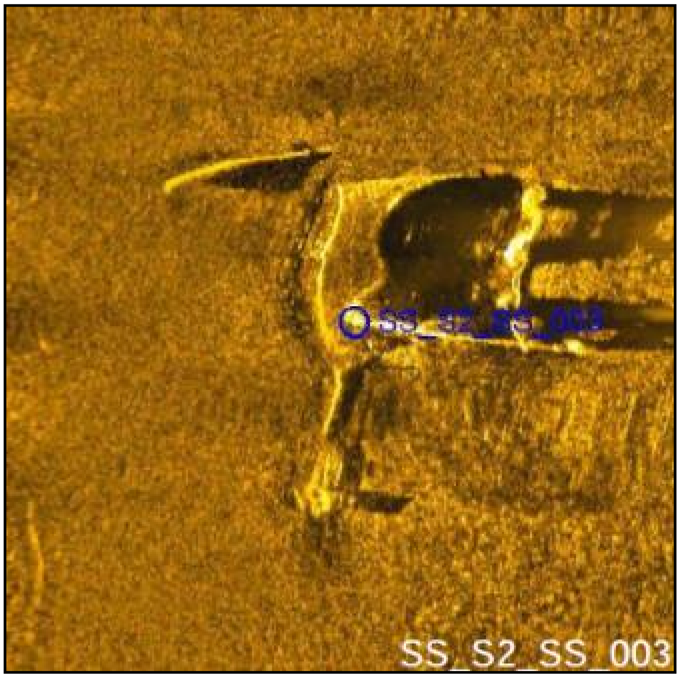

Figure 123. SS S2 sonar image SS 003 of vessel remains and debris.

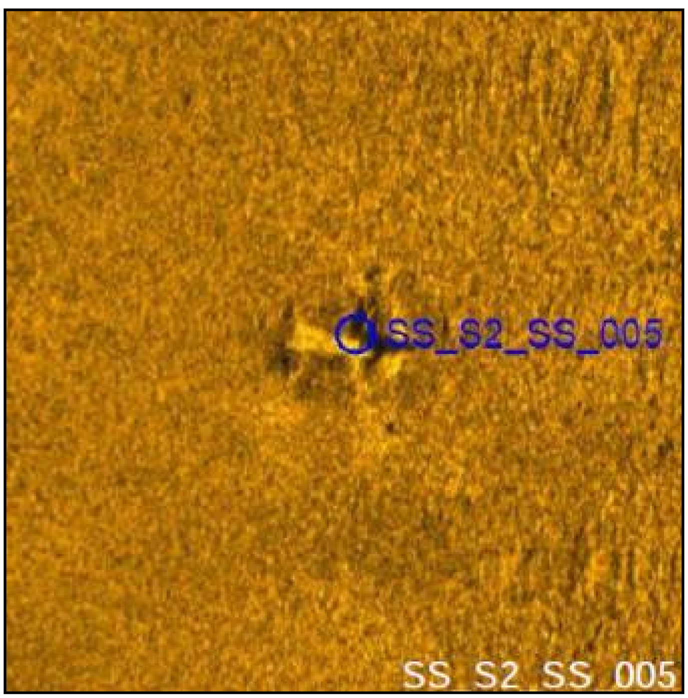

Figure 124. SS S2 sonar image SS 005 of vessel remains and debris.

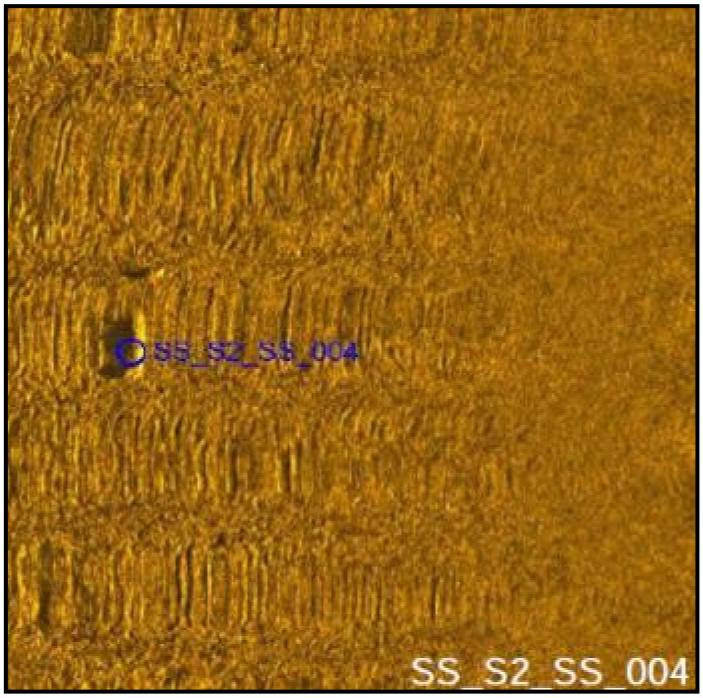

Figure 125. SS S2 sonar image SS 004 of bottom surface debris.

Archaeological diver investigation of the large cluster of magnetic anomalies and sonar images indicative of vessel remains was carried out on August 23, 2014. Examination of structural material exposed at the site identified the source as a modern spud barge (Figure 126). The vessel remains are partially buried with one corner exposed to the bottom of the hull. That corner is fitted with a tow post and a hydraulic pedestal crane. The boom extends diagonally across the hull and into the sediment behind a spud. The spud extends approximately 12 feet into the water column and is fitted with ratchets for securing and an eye on the top for lifting. A ventilator is located at the edge of the deck roughly opposite the location of the spud. The exposed end of the barge was originally fitted with a series of wood rub timbers but most have deteriorated. The ventilator side of the hull has extensive damage that could have occurred at the time of loss or subsequent to that event. A large section of what appears to be hull or deck structure lies off the corner of the barge with the pedestal crane.

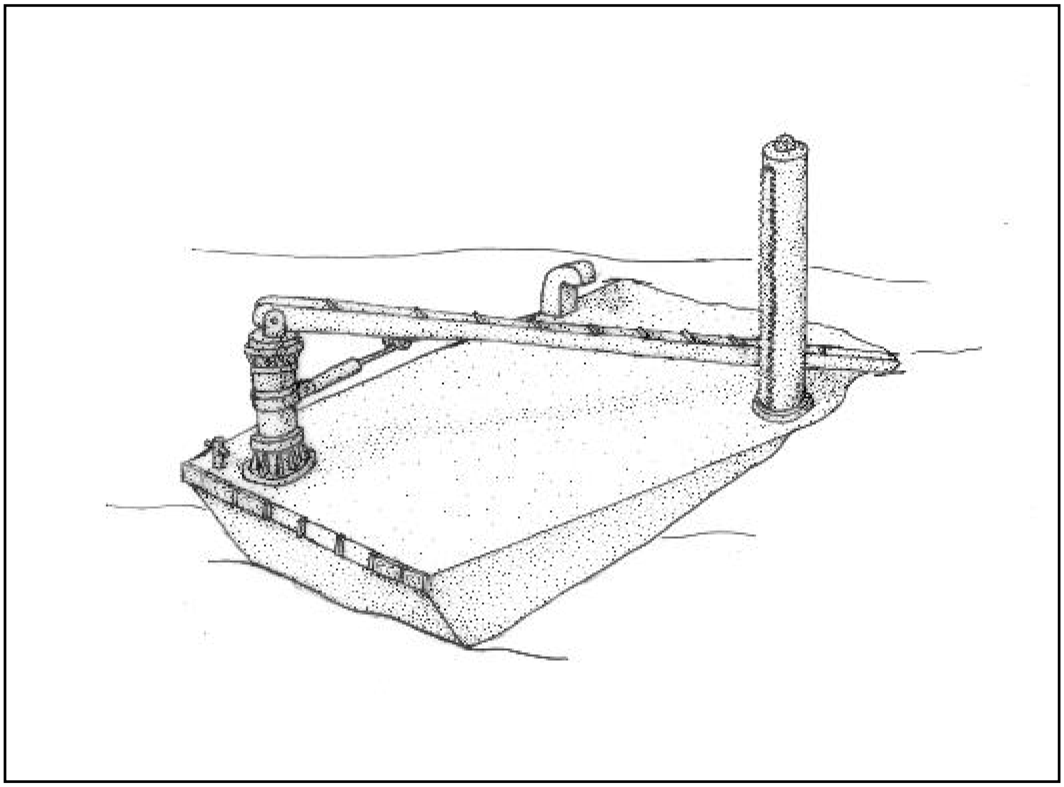

Figure 126. Drawing illustrating exposed details of spud barge within SS S2.

Remains of the spud barge are clearly modern and have no apparent design or construction features or association with persons or events that meet eligibility criteria for inclusion on the NRHP. However, in the event that dredging is permitted in the SS S2 area, the vessel would be a good candidate site for studying the impacts of sand removal on vessel remains and buffers designed to afford protection for the site.

4.2.7. Secondary Area 3

Ship Shoal Secondary Area 3 (SS S3) was selected for remote sensing due to previously identified anomalies that could be associated with historic vessel remains (Figure 127). The Ship Shoal Secondary Area 3 site is also the location of a NOAA charted shipwreck (Figure 128). Ship Shoal Secondary Area 3 is located immediately adjacent to the previously permitted borrow area South Pelto SP-B (see Table 2). That borrow site could be reutilized periodically.

SS S3 was surveyed on September 10, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS S3 identified 23 magnetic anomalies (Figure 129; Volume III: Appendix X). Four sonar targets and one sub-bottom feature were identified in the acoustic data (Figure 130; Volume III: Appendix Y).

Fourteen of the twenty-three magnetic anomalies (013-1, 014-1, 015-1, 016-1, 017-1, 020-1, 021-2, 022-1, 023-1, 100-1, 100-2, 101-1, 103-1, and 105-1) form a large linear cluster (Figure 131). Magnetic anomalies in the cluster are associated with four sonar targets and one sub-bottom feature. That site was selected for archaeological diver investigation.

The remaining magnetic anomalies (015-2, 020-2, 021-1, 024-1, 024-2, 024-3, 024-4, 025-1, and 025-2) have signature characteristics that reliably represent small objects and not shipwreck remains. Given the amount of damage to the vessel and the scatter of associated material many of those anomalies could be associated modern debris.

Sonar image SS S3 SS 001 associated with the wreck site at SS S3 confirmed the presence of exposed vessel structure. The image clearly identifies a section of relatively intact hull that appears is associated with the forward hull structure and bow (Figure 132). Sonar image SS S3 SS 004 illustrates the aft end of the forward hull structure and debris associated with the heavily damaged aft sections of the vessel (Figure 133).

Three vibracores were collected in SS S3: SSVC-14-02, SSVC-14-03 and SSVC-14-08. The vibracores indicated fine-grained sandy material and no recovery below 9.5 feet. The sandy material ranged in grain size from 0.16 to 0.45 mm. Future work on modeling potential borrow area affects to surrounding cultural resources should focus on the top 10 feet as future dredging events for beach nourishment projects will be focused on the top layers.

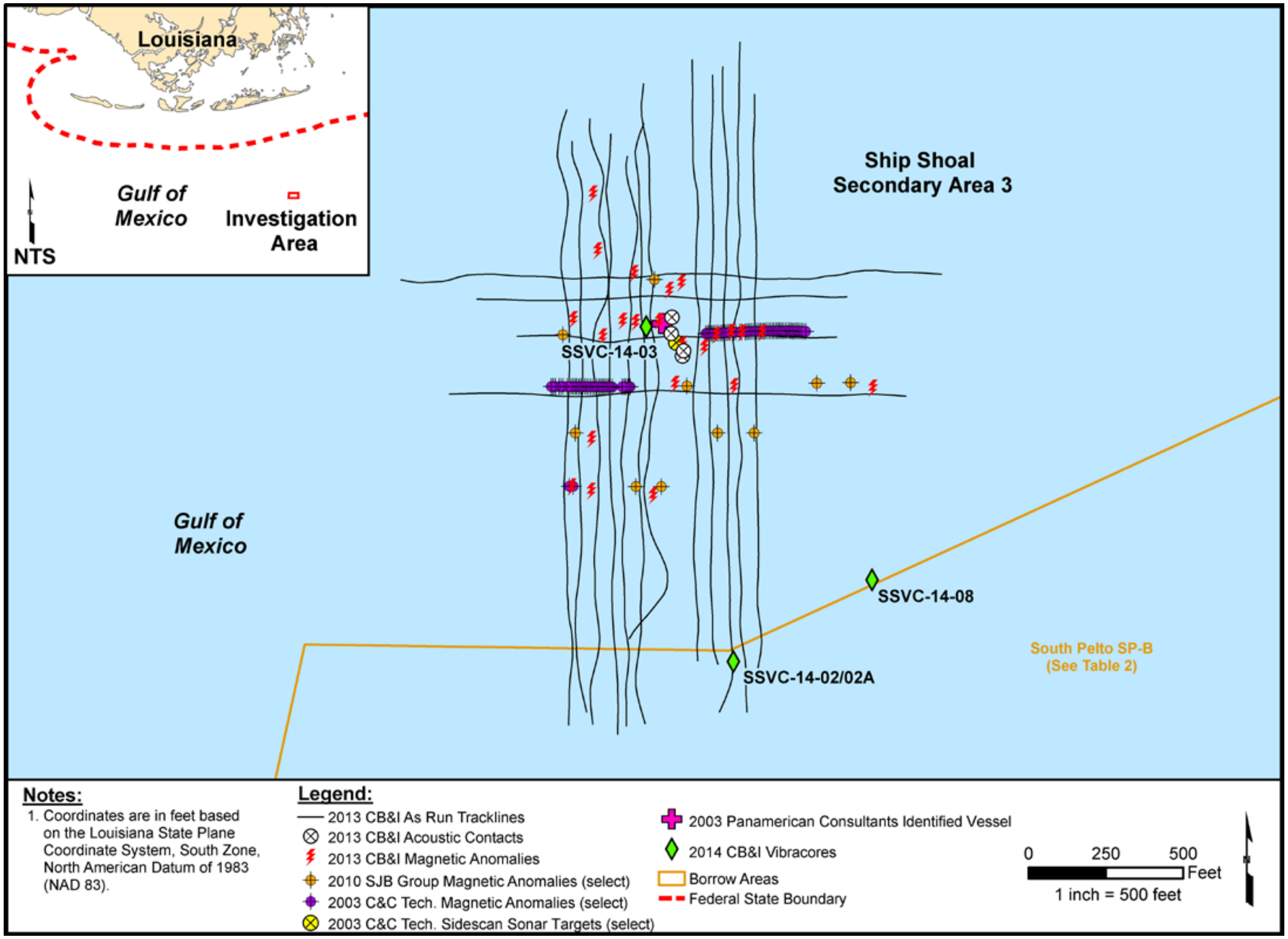

Figure 127. Magnetic anomalies and acoustic targets identified in Ship Shoal Secondary Area 3.

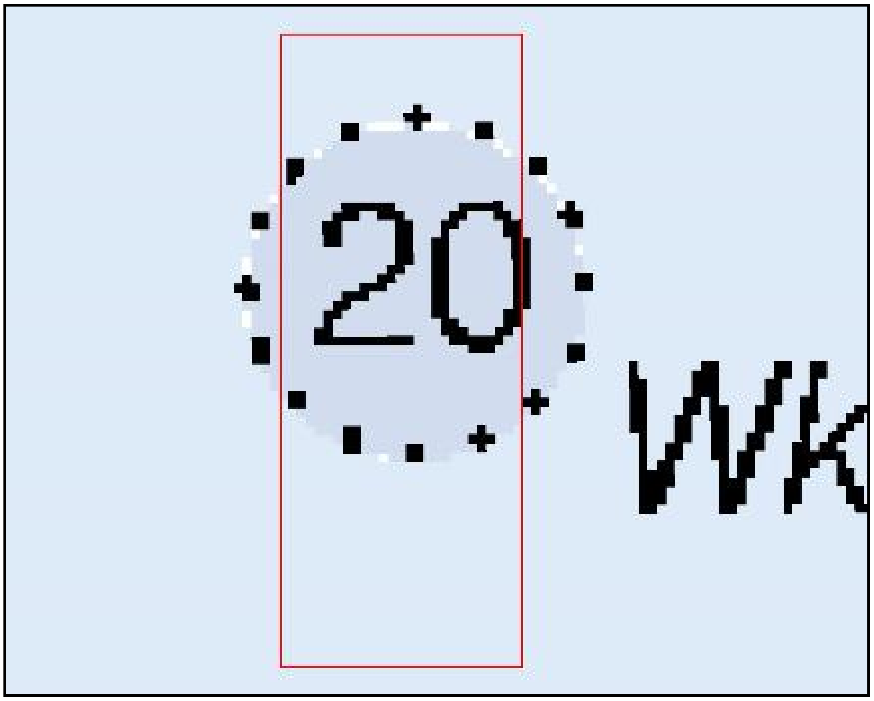

Figure 128. SS S3 survey area shown on NOAA Chart 11357-1 with shipwreck.

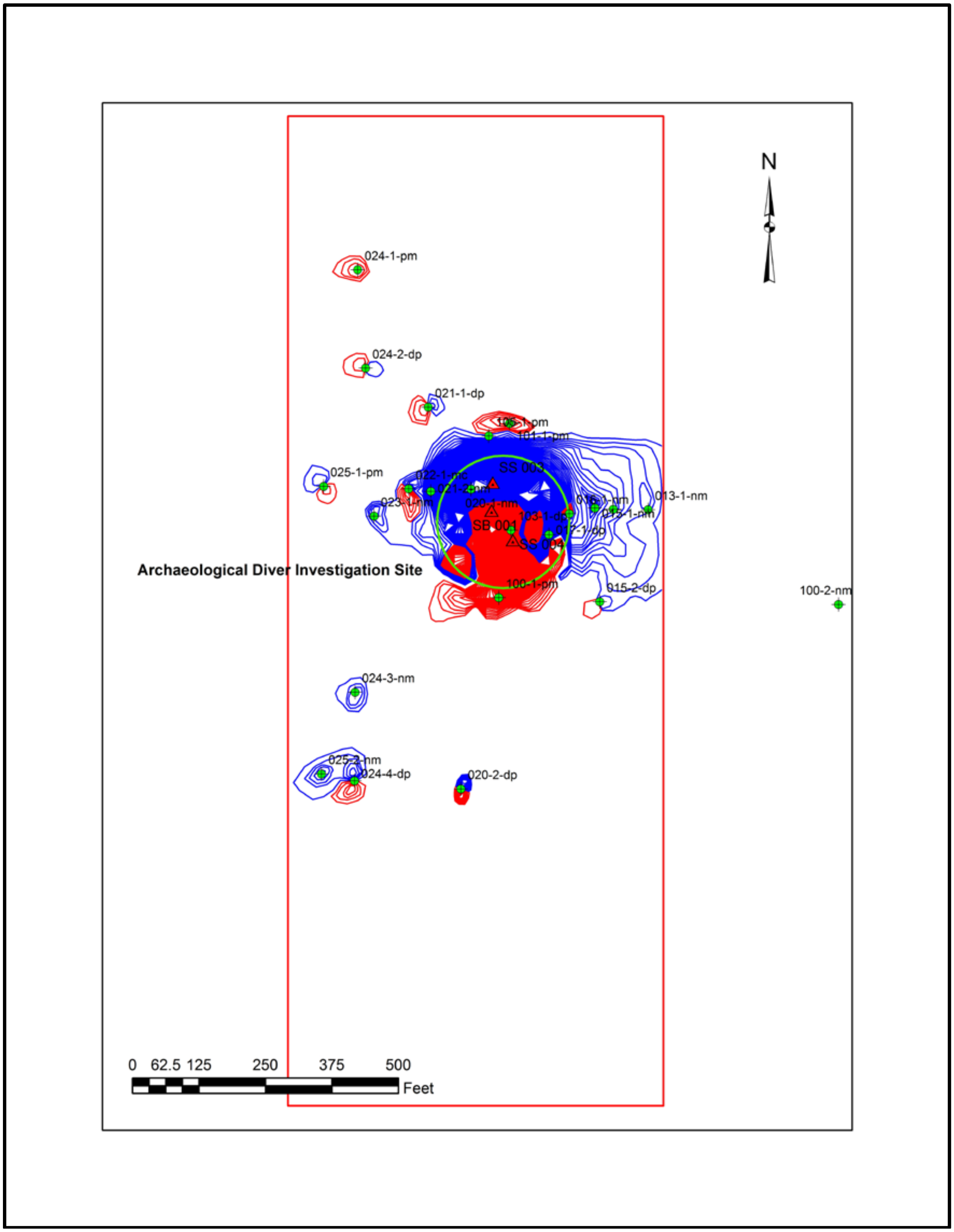

Figure 129. SS S3 magnetic anomalies and contours.

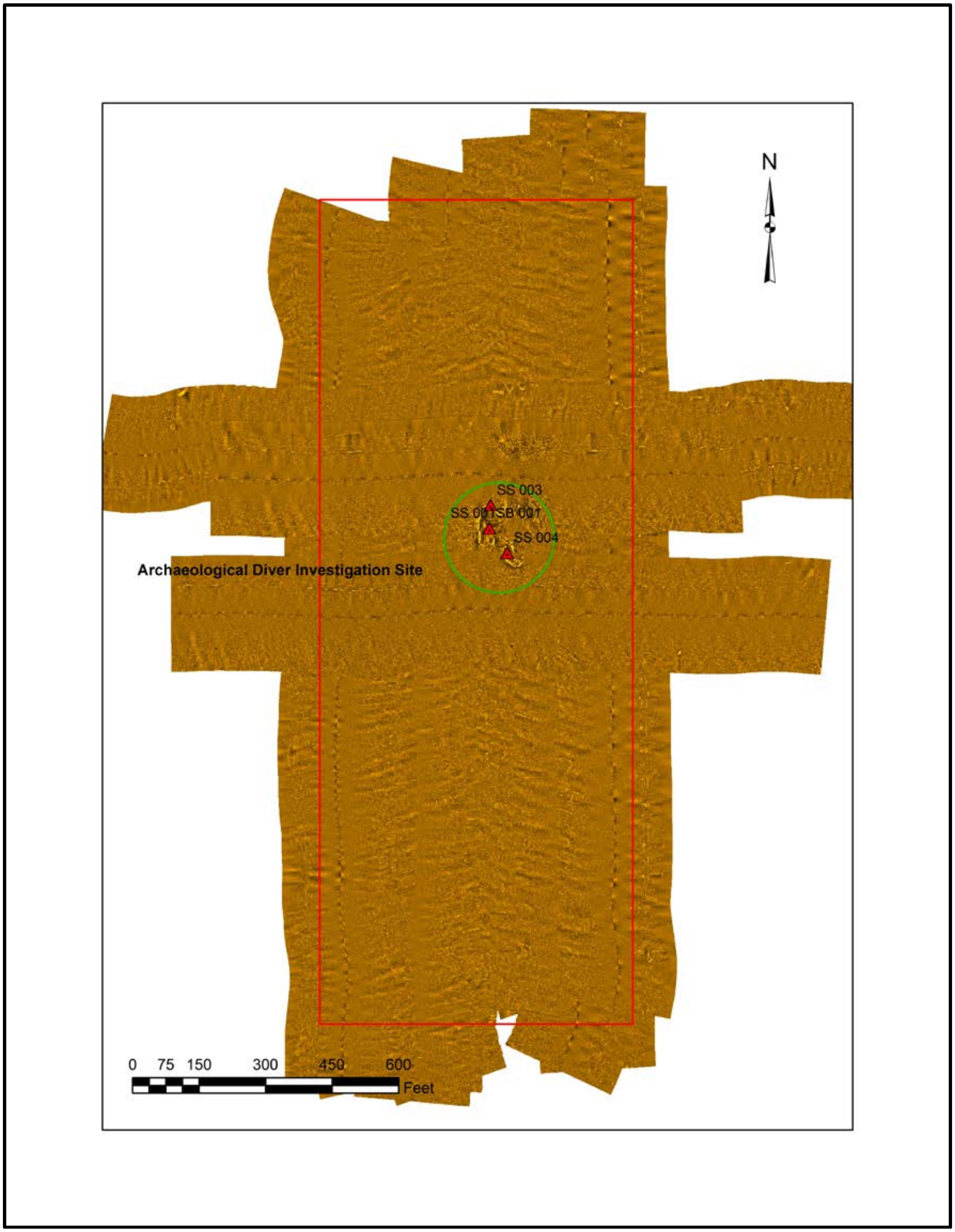

Figure 130. SS S3 sonar coverage mosaic and acoustic targets.

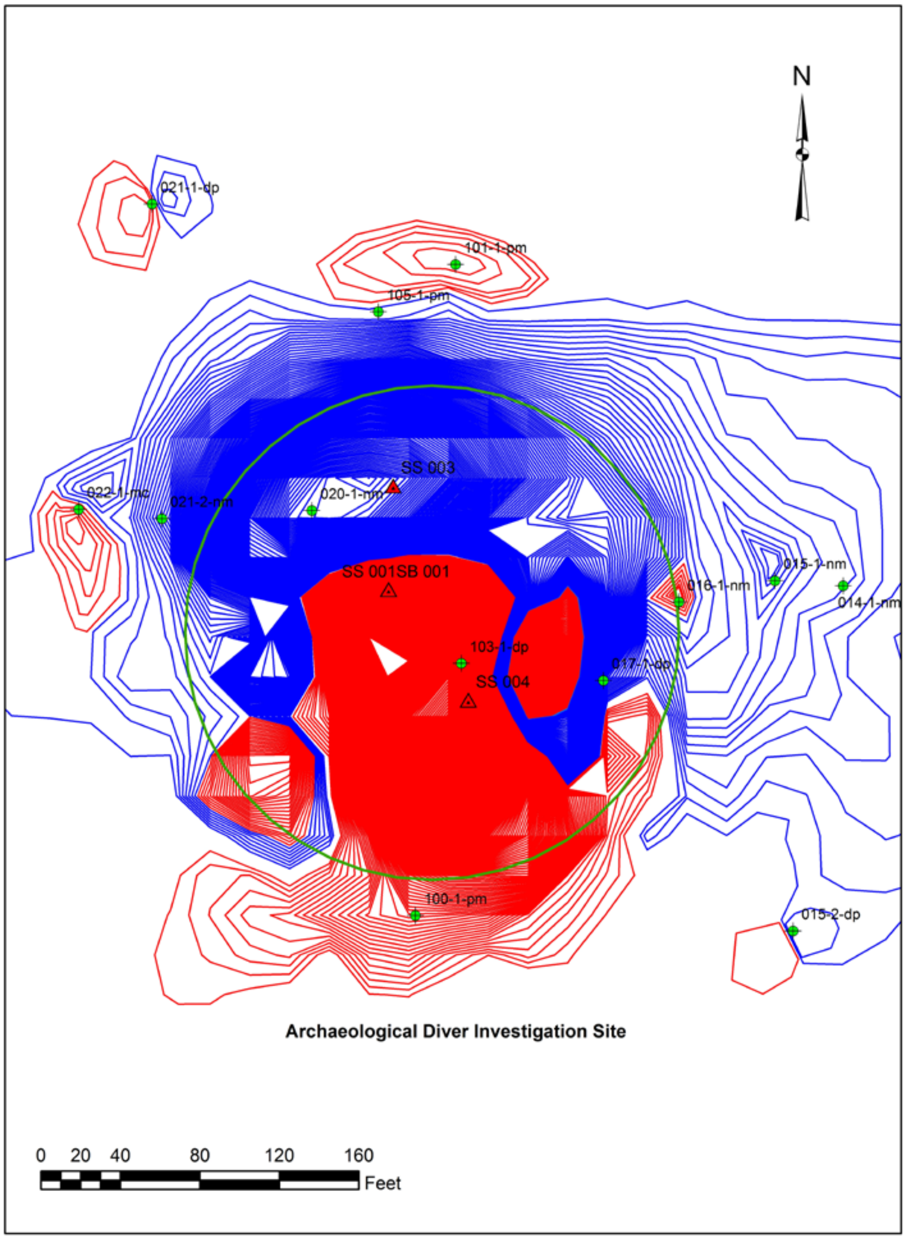

Figure 131. SS S3 archaeological diver investigation site magnetic anomalies, contours, and acoustic targets.

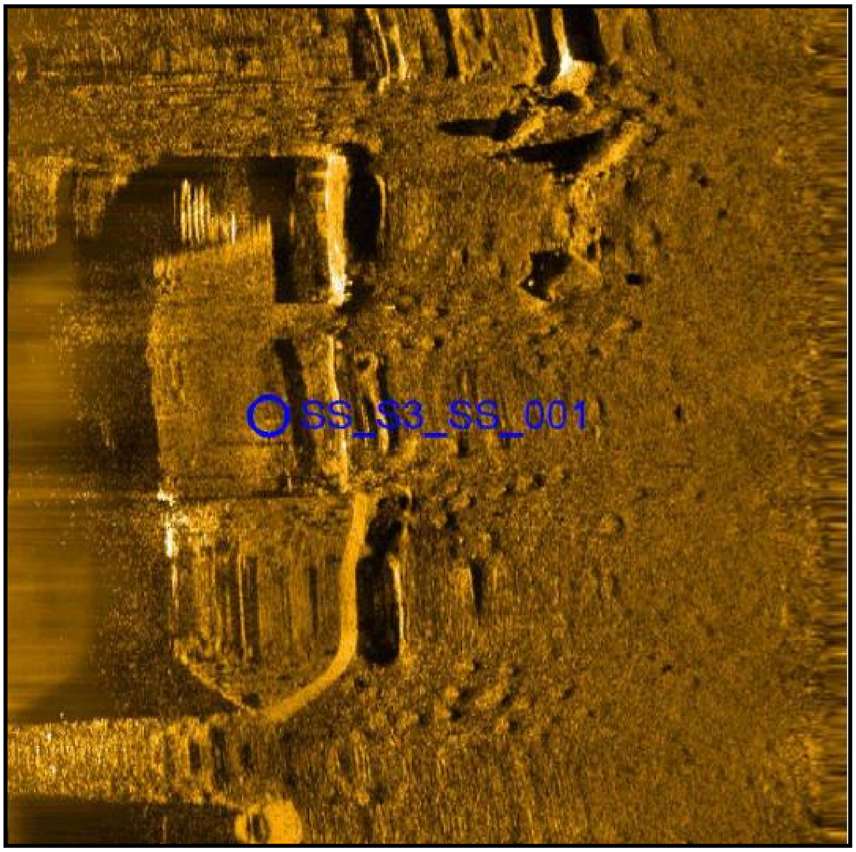

Figure 132. Sonar image SS S3 SS 001 documenting intact forward hull structure and the bow with a sunken buoy located forward of the bow.

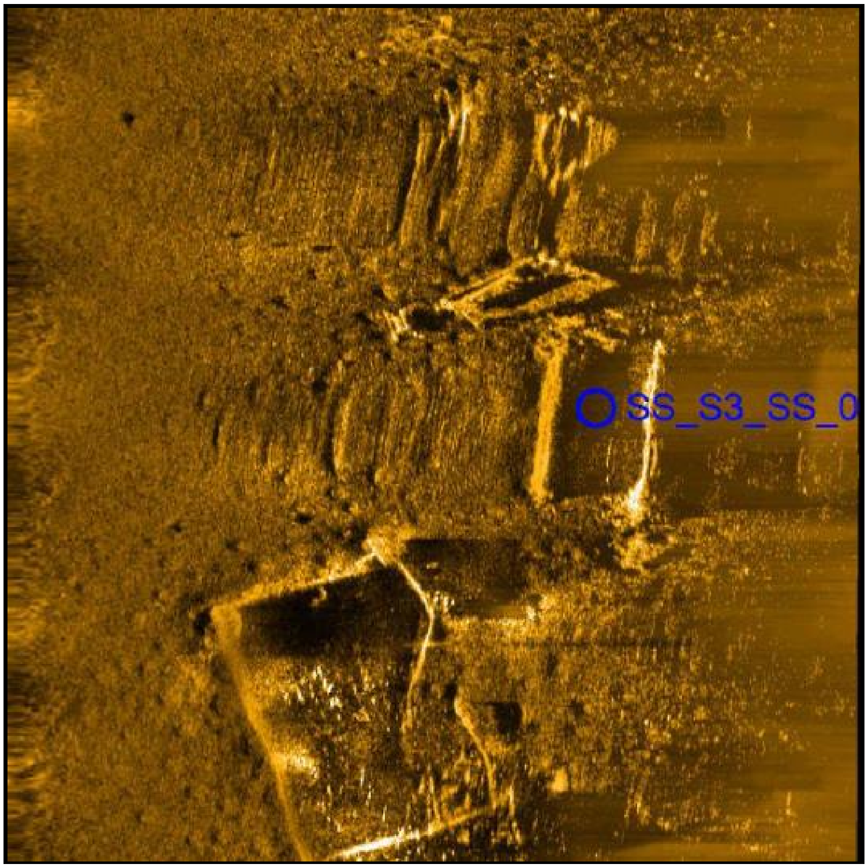

Figure 133. Sonar image SS S3 SS 004 documenting sections of aft hull structure.

Sub-bottom profiler data indicated an additional hull structure was buried at the charted wreck site (Figure 134). No sub-bottom features were associated with magnetic anomalies not generated by the charted wreck remains. An archaeological diver investigation of the SS S3 charted wreck site carried out on August 21, 2014 confirmed that the remains are those of a modern vessel. No evidence of propulsion machinery was observed. Exposed structural evidence suggests that the vessel was constructed as a welded steel barge fitted to transport oil, fuel, or other liquids (Figure 135).

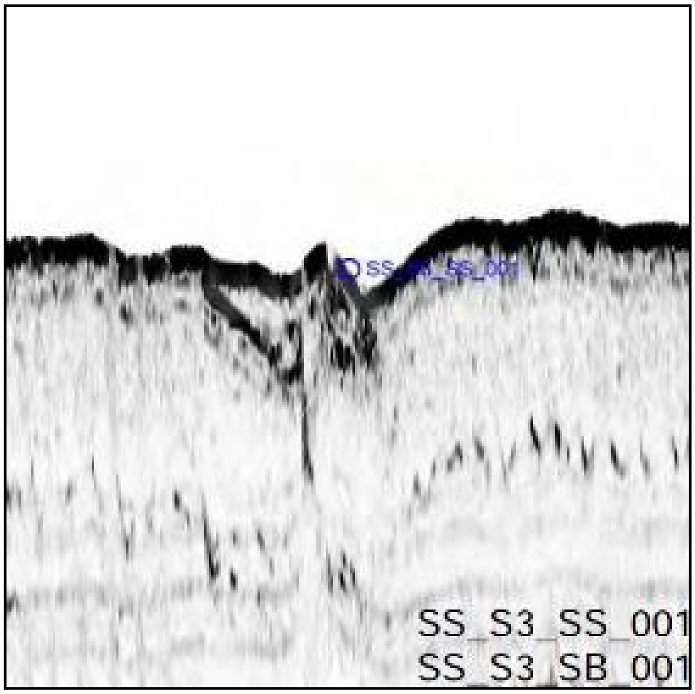

Figure 134. SS S3 sub-bottom profiler image of buried hull structure.

The foredeck is not entirely intact. It measures approximately 31 feet from the stern to the forward bulkhead of a compartment that measures 42 feet in length. At the forward bulkhead the beam measures 30 feet. Decking over the compartment has collapsed and the port side has collapsed into the hull. Approximately 55 feet of hull structure is exposed on the starboard side before it disappears into the sediment. All visible plate seams on the hull are welded.

About 40 feet from the point where the starboard side of the hull is covered in sediment there is a concentration of structural debris. That debris includes large sections of additional hull structure and a pile of debris that includes wire rope, pipe and angle iron. At least one length of pipe approximately 10 inches in diameter and 20 feet long was fitted with a flange approximately 14 inches in diameter. A section of hull and deck adjacent to the pipe contained angle iron frames and a pipe gunwale. A series of valves were located on a length of pipe attached to the hull under the deck remains. A cast iron bollard and similarly constructed cleat were also present along with a section of two-inch hawser tied off on or fouled around three valves.

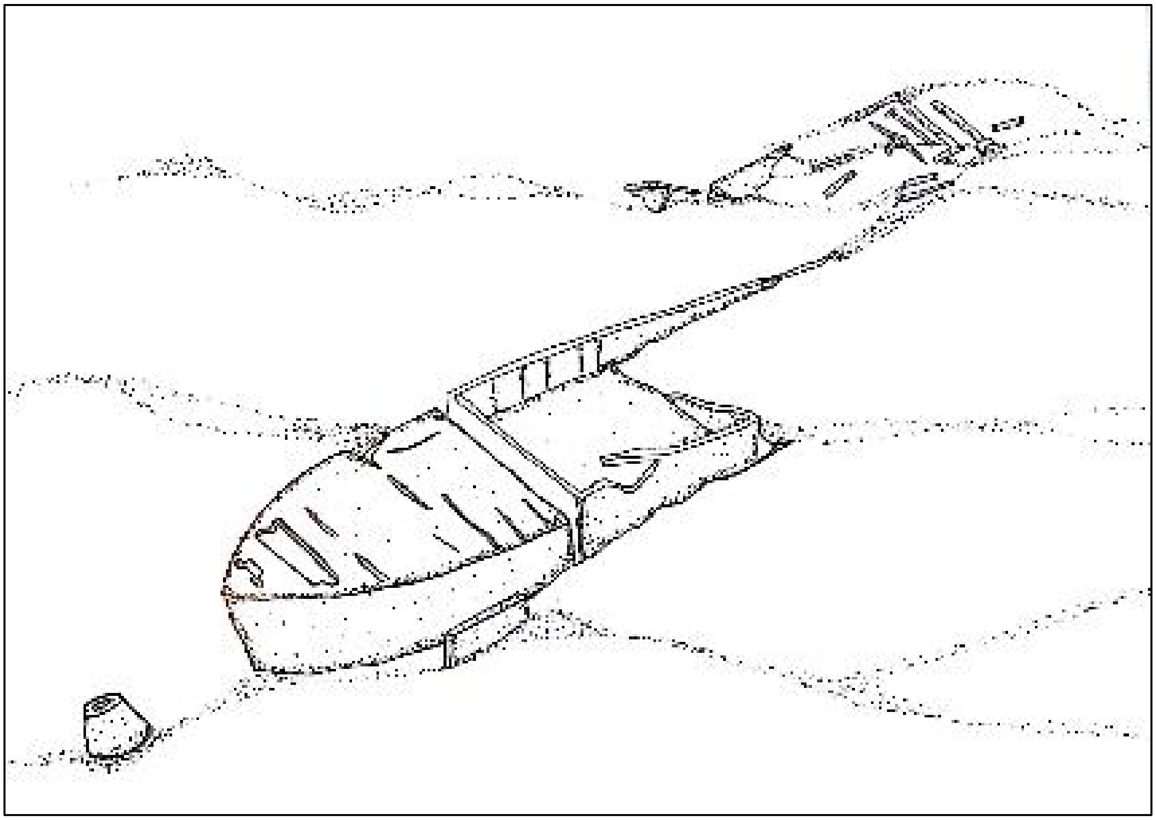

Figure 135. Drawing of the SS S3 vessel remains and debris.

Remains of the vessel are clearly modern and have no apparent design or construction features or association with persons or events that meet eligibility criteria for inclusion on the NRHP. Based on information collected to date, the vessel is assessed as not potentially eligible for NRHP listing. However, the wreck represents another excellent candidate for identifying and monitoring the impacts of dredging in the adjacent South Pelto borrow areas.

4.2.8. Secondary Area 4

Ship Shoal Secondary Area 4 (SS S4) was selected for remote sensing due to previously identified and buffered anomalies and a charted obstruction that could be associated with historical vessel remains or other potentially significant submerged cultural resources (Figure 136). The charted obstruction was located on NOAA Chart 11357-1 (Figure 137). SS S4 is not located in, or immediately adjacent to, any previously permitted or proposed borrow areas. However, South Pelto SP-C lies southwest of the survey area. That borrow area could be reutilized periodically.

SS S4 was surveyed on September 11, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS S4 identified 51 magnetic anomalies (Figure 138; Volume III: Appendix Z). Four sonar targets were identified in the acoustic data (Figure 139; Volume III: Appendix AA).

Two clusters of magnetic anomalies have collective signature characteristics that have a high potential for association with vessel remains. Eight magnetic anomalies (021-1, 022-2, 023-2, 025-1, 026-2, 026a-2, 26-3, and 100-1) form a cluster with a high potential for association with shipwreck remains. Those eight are identified as Buffer A and are located in geographical association with the charted obstruction (Figure 140).

Objects generating two sonar images (SS S4 SS 001 and SS S4 SS 002) are located in the immediate vicinity of that charted obstruction and magnetic anomalies in Buffer A (Figure 141; Figure 142). Six magnetic anomalies (009-1, 010-1, 011-1, 012-2, 012-3, and 013-3) form a cluster with a high potential for association with shipwreck remains. Those six are identified as Buffer B (Figure 143). Objects generating two sonar images (SS S4 SS 003 and SS S4 SS 004) are located in association with the magnetic anomalies in Buffer B (Figure 144; Figure 145).

The remaining 19 magnetic anomalies have signature characteristics and a spatial configuration indicative of a long linear object (Figure 146). Candidates for the sources of those magnetic anomalies include deteriorated pipeline, wire rope or cable, and possibly anchor chain. Material generating those signatures could be associated with material generating the magnetic anomalies and sonar targets that were included in Buffer A.

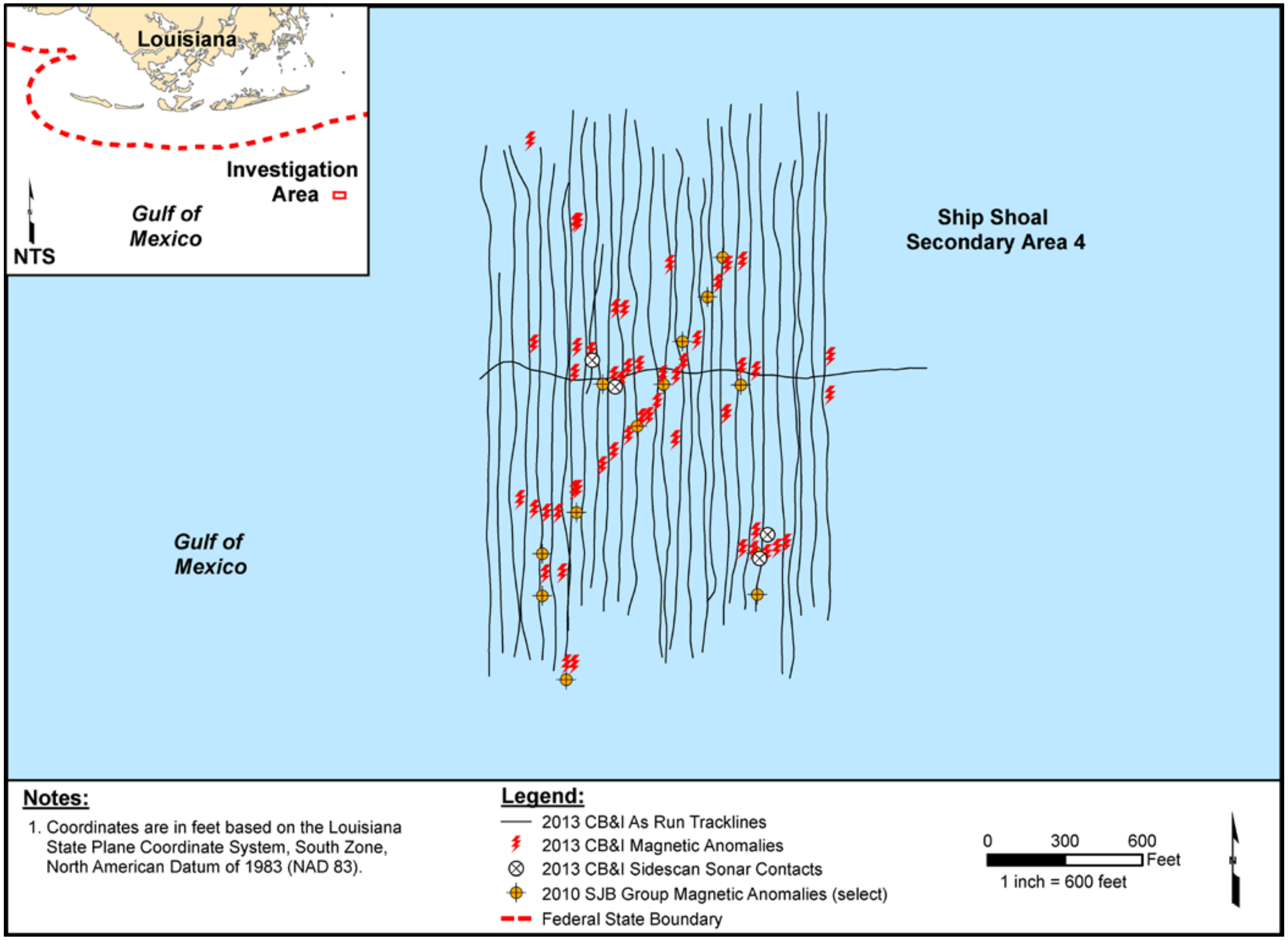

Figure 136: Magnetic anomalies and sonar targets identified in Ship Shoal Secondary Area 4.

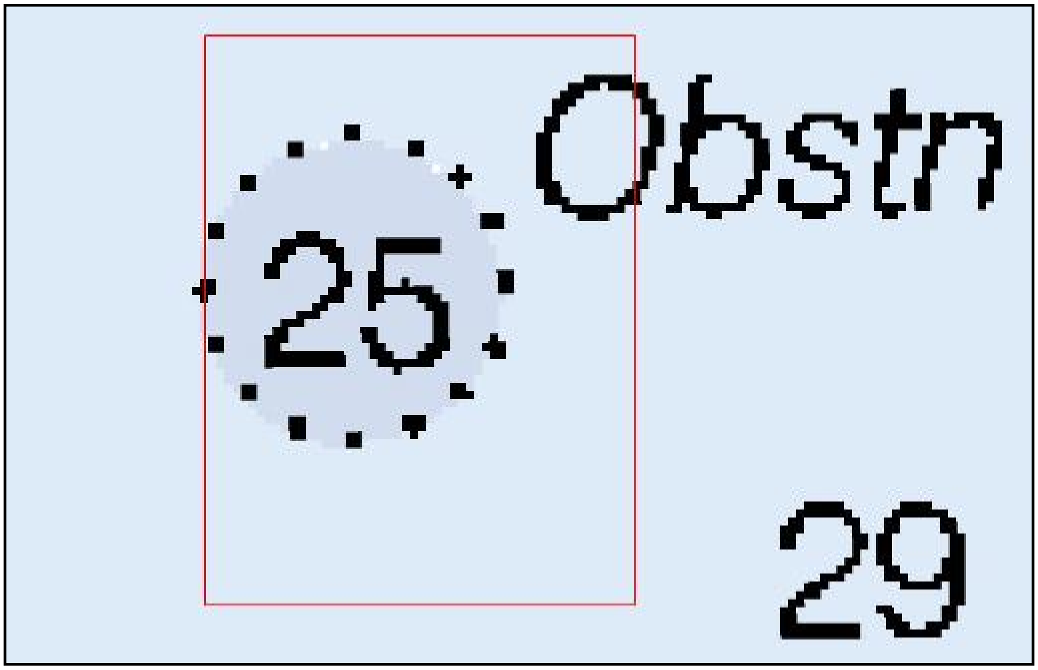

Figure 137. NOAA Chart 11357-1 with "Obstn" in survey area SS S4.

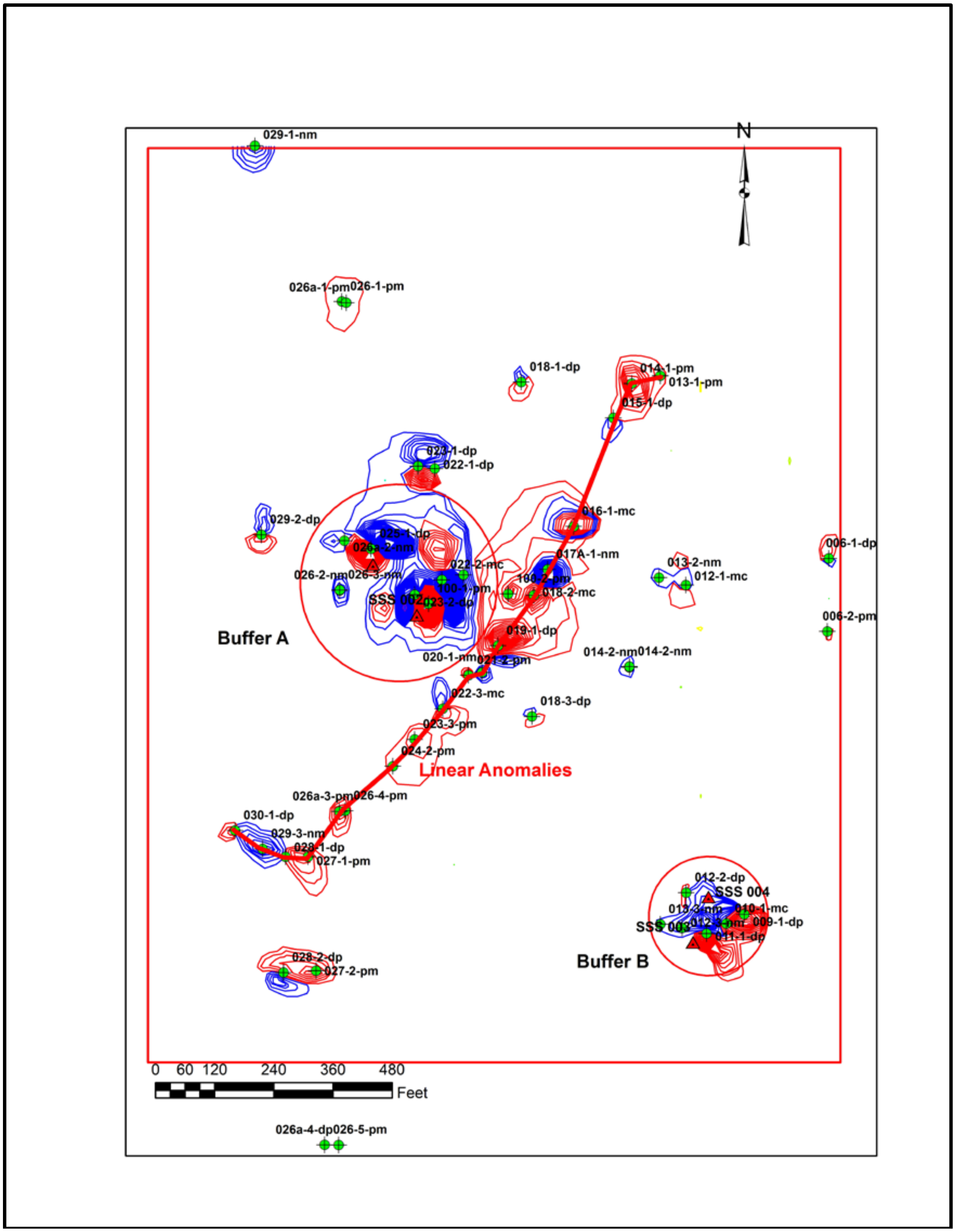

Figure 138. SS S4 magnetic anomalies, contours, and buffers.

Figure 139. SS S4 sonar coverage mosaic with sonar targets.

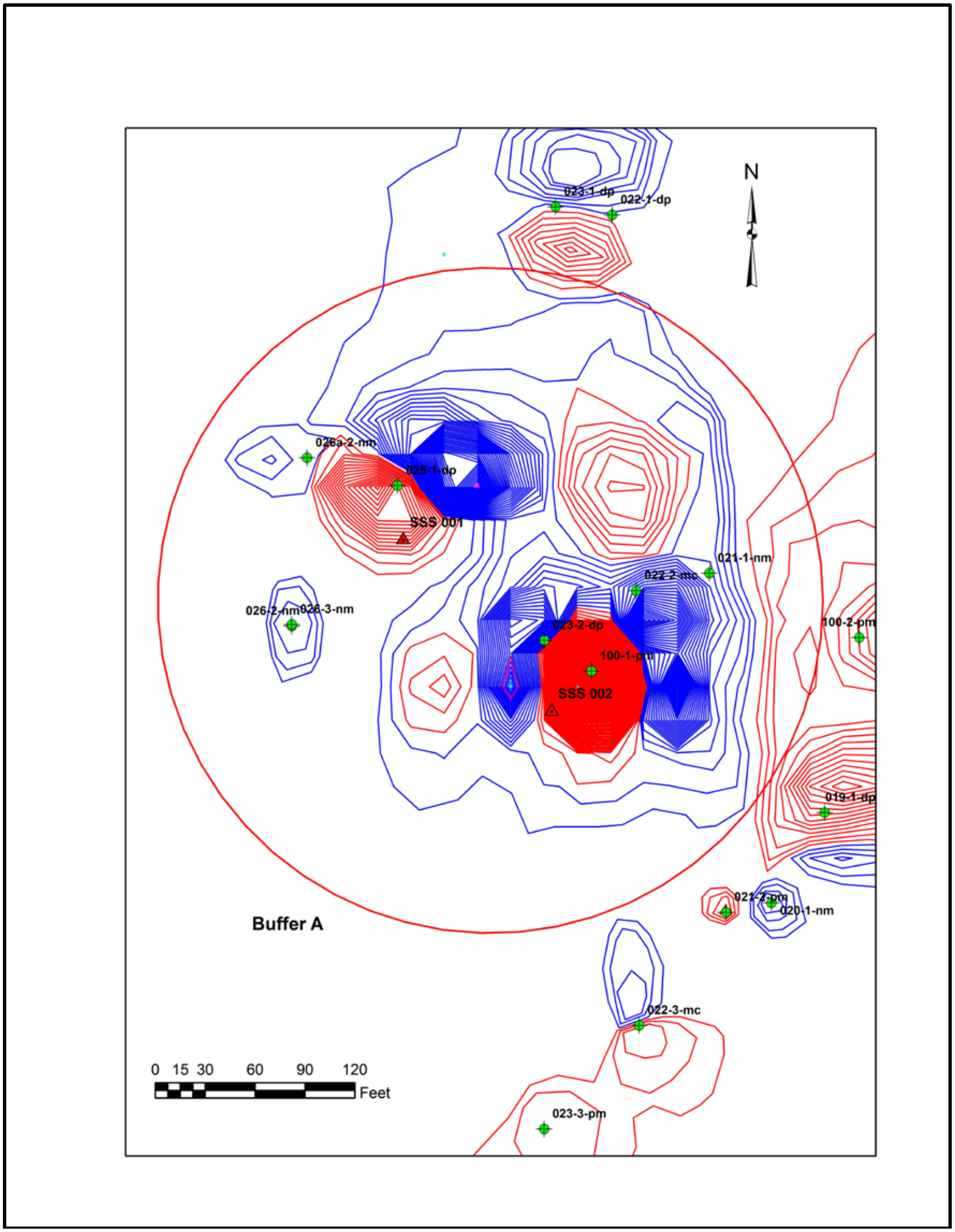

Figure 140. SS S4 Buffer A magnetic anomalies and contours.

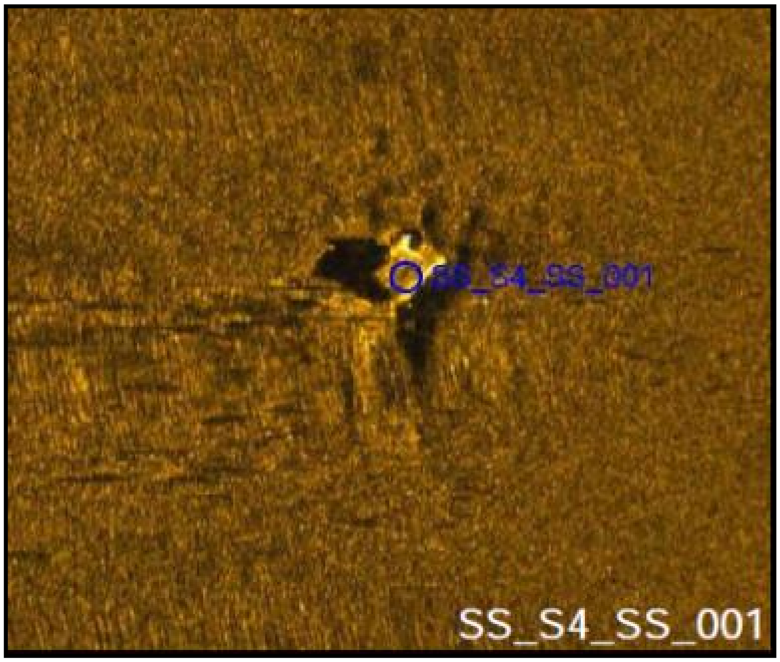

Figure 141. Sonar image SS 001 showing rectangular object on the bottom surface in Buffer A.

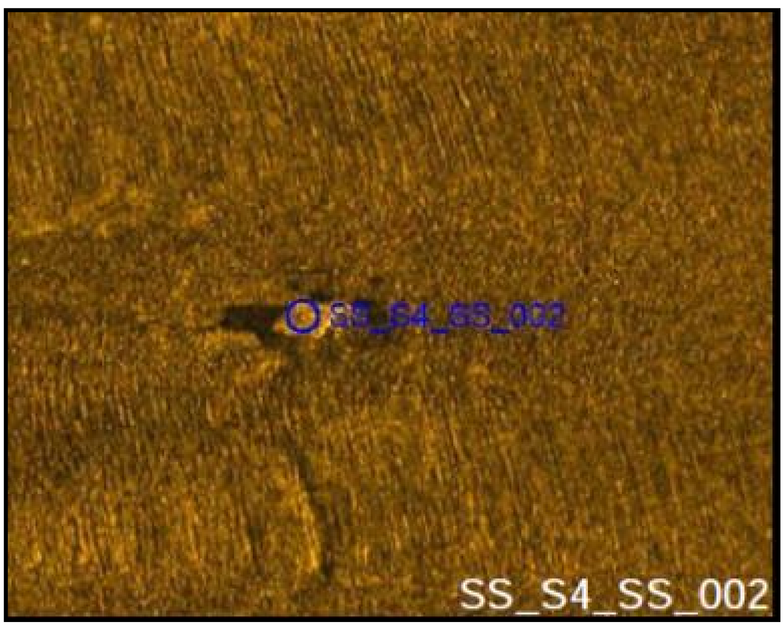

Figure 142. Sonar image SS 002 showing rectangular object on the bottom surface in Buffer A.

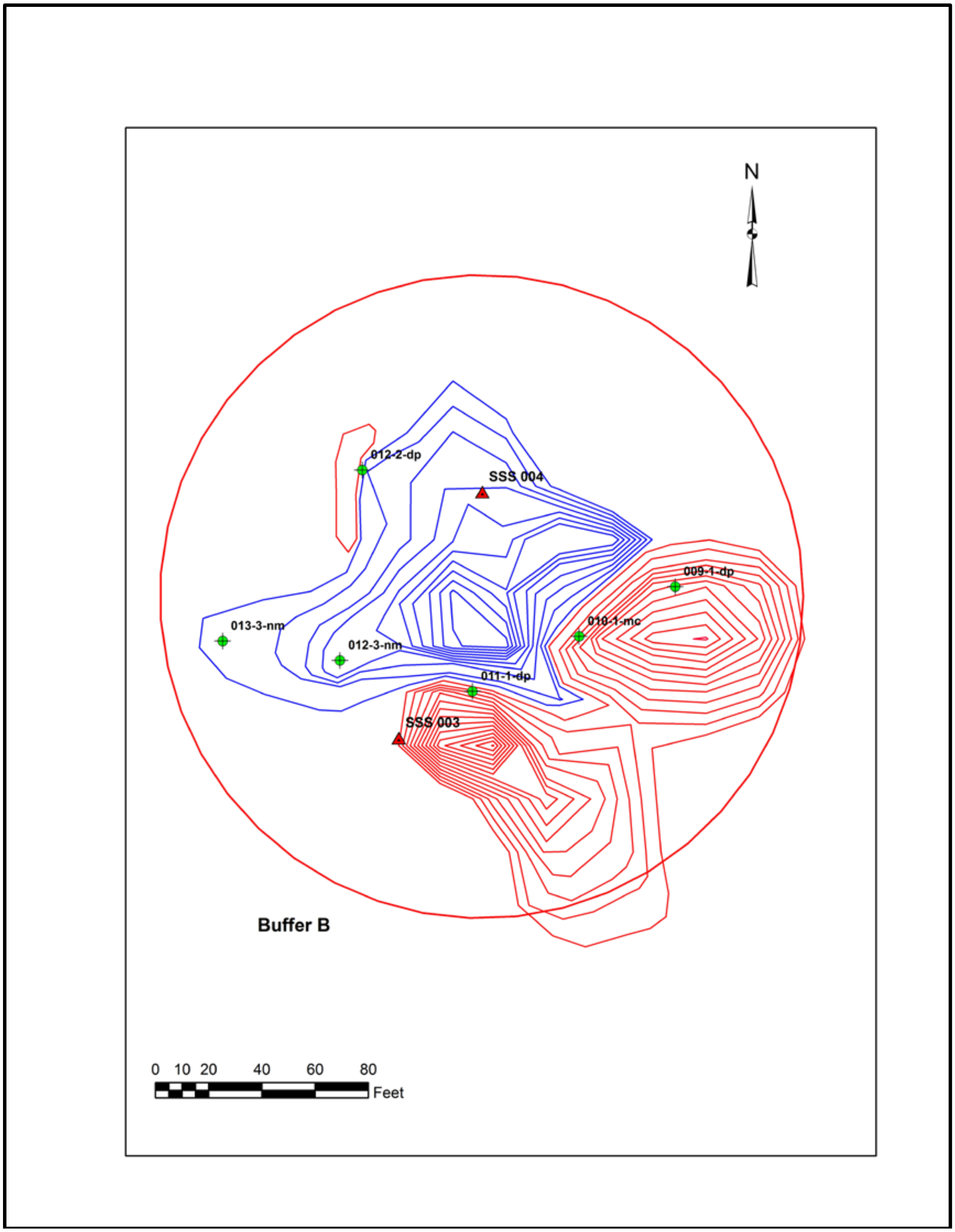

Figure 143. SS S4 Buffer B magnetic anomalies and contours.

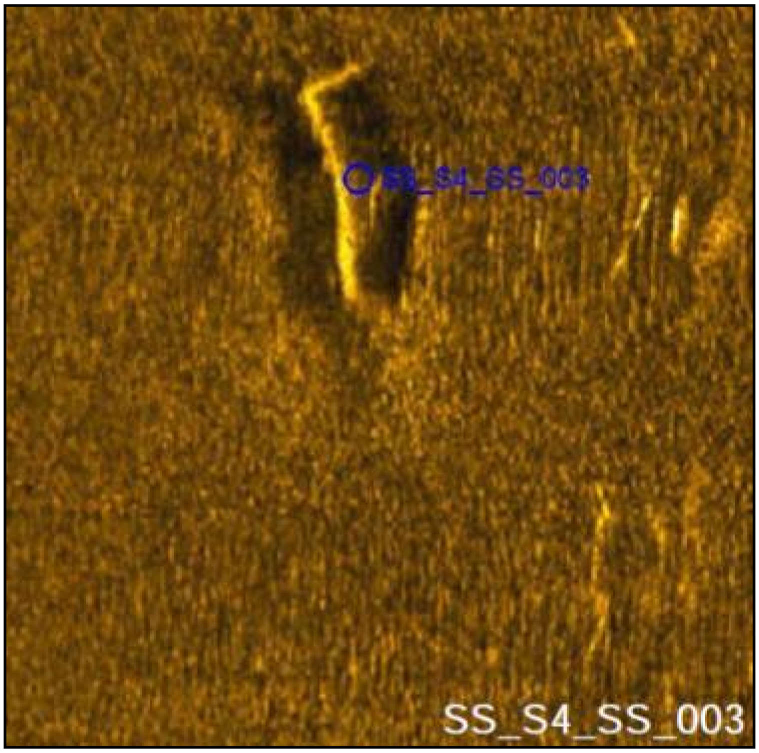

Figure 144. Sonar image SS 003 showing rectangular object on the bottom surface in Buffer B.

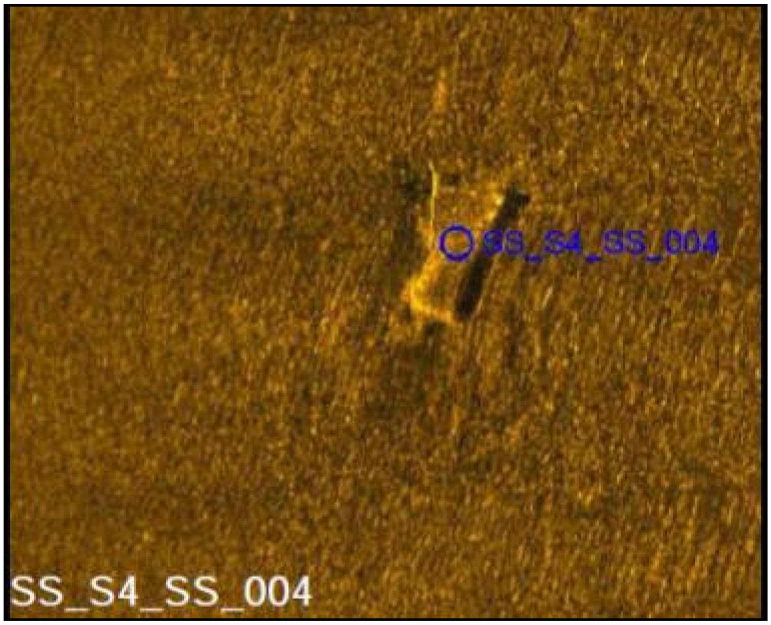

Figure 145. Sonar image SS 004 showing rectangular object on the bottom surface in Buffer B.

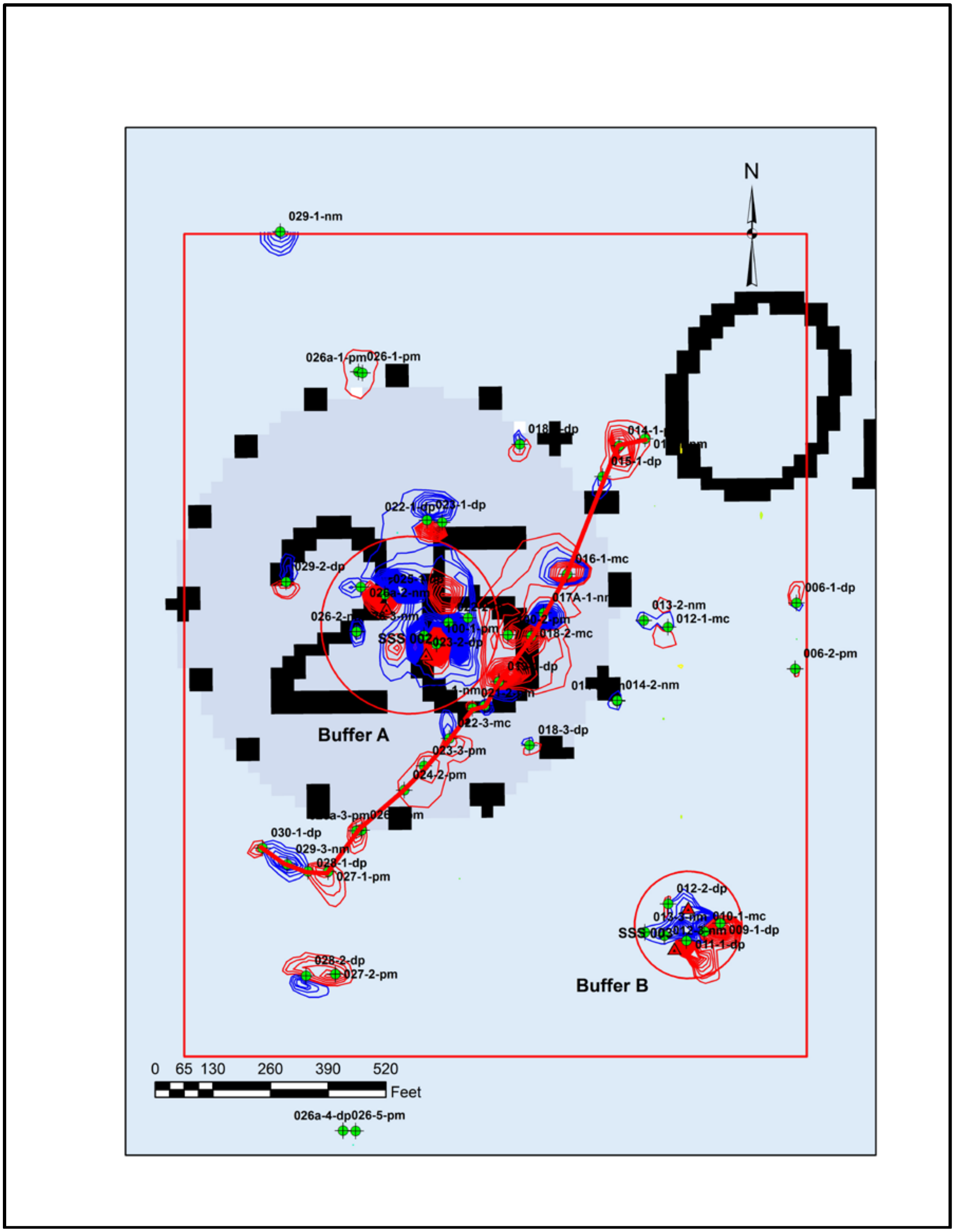

Figure 146. Linear magnetic anomaly configuration suggesting pipeline, cable, or anchor chain.

Of the eighteen remaining magnetic anomalies, five have signature characteristics of moderate size ferrous objects, and thirteen have signature characteristics of small ferrous objects. Those anomalies do not have more complex signatures or spatial associations that are more reliably associated with shipwrecks or small vessel remains. In all likelihood material generating those anomalies represents small anchors, sections of small pipe, cable, wire rope or chain, fish traps, or other modern debris.

None of the buffered magnetic anomaly clusters in SS S4 were selected for investigation by archaeological divers in conjunction with this project. However, both buffer areas should be priorities for future archaeological diver investigation in the event that dredging or other bottom disturbing activity in the vicinity is authorized and the site cannot be avoided. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.2.9. Secondary Area 5

Ship Shoal Secondary Area 5 (SS S5) was identified for reconnaissance level remote sensing out of convenience due to its location in the vicinity of other survey areas (Figure 147). The site was selected due to its association with the reported and mapped location of the World War II tanker *David McKelvy* in the BOEM shipwreck database. Six lines of data were collected at 600-foot (183 m) line spacing. SS S5 is not located in or immediately adjacent to any previously permitted or proposed sand source borrow areas. However, South Pelto SP-C lies west of the survey area. That borrow area could be reutilized periodically.

SS S5 was surveyed on September 11, 2013. Line-by-line analysis of the magnetic and acoustic data associated with SS S5 identified six magnetic anomalies (Figure 148; Volume III: Appendix BB). No sonar targets or sub-bottom features were identified in the acoustic data.

The six magnetic anomalies identified in the SS S5 survey area included one generated by moderate size material (002-2) and five generated by smaller material (002-1, 004-1, 006-1, 008-1, and 011-1). Due to the reconnaissance-level lane spacing, magnetic anomaly assessment could not be enhanced with close adjacent line data. Likewise, contouring the data was not considered worthwhile or productive. Sonar data was also limited due to the reconnaissance-level line spacing. Consequently, the sonar mosaic represents only data from the six lines (Figure 149). No sonar targets or sub-bottom features were identified in those data.

Based on data generated by the reconnaissance survey of SS S5, no evidence of potentially significant submerged cultural resources was apparent. The scatter of magnetic anomalies identified in the area does suggest that the presence of additional cultural material is highly likely. In the event that SS S5 is included in or adjacent to future sand source borrow areas, additional remote sensing is recommended. Additional investigation should be carried out at survey line spacing no greater than 100 feet (30 m).

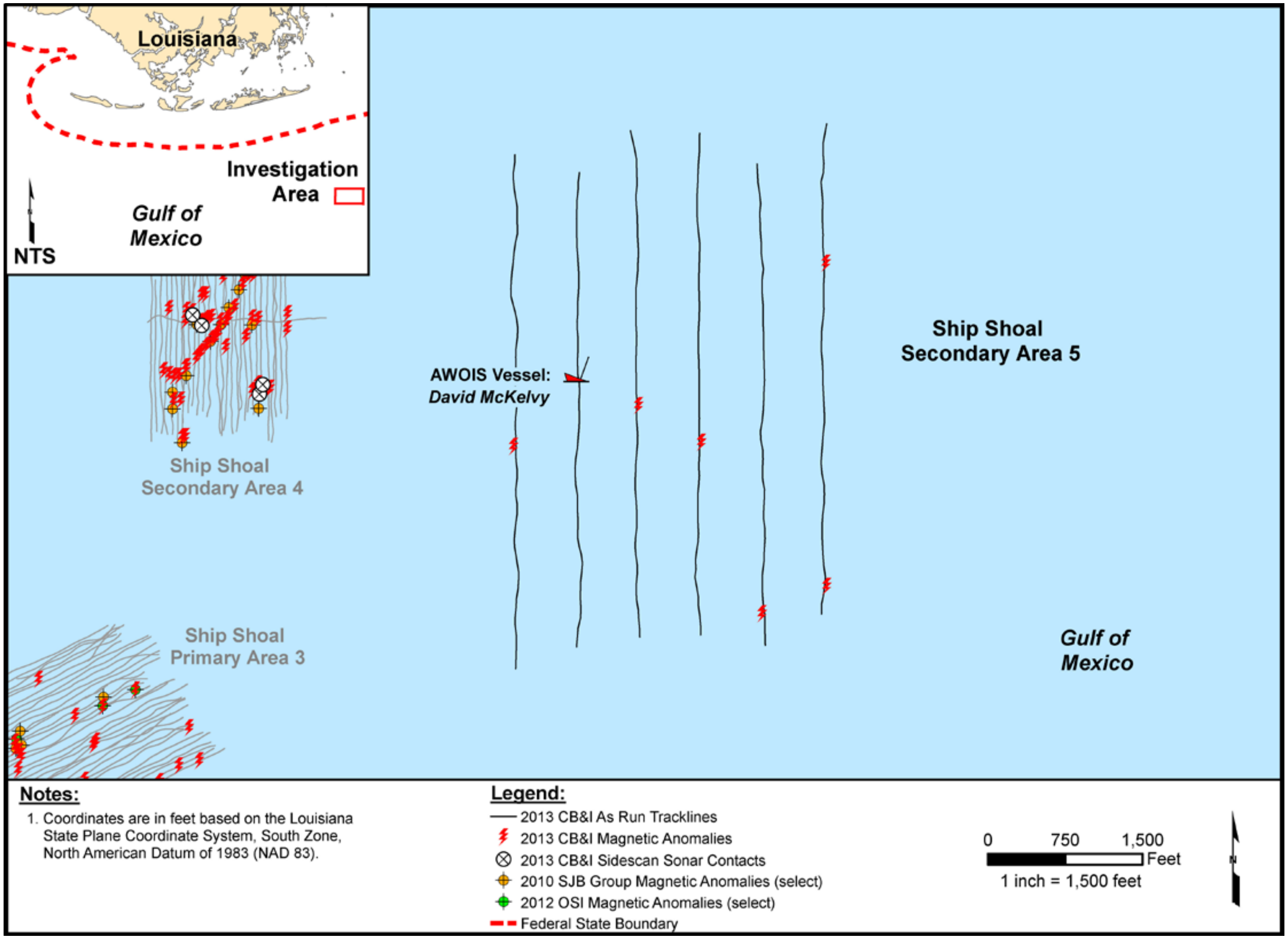

Figure 147: Magnetic anomalies identified in Ship Shoal Secondary Area 5.

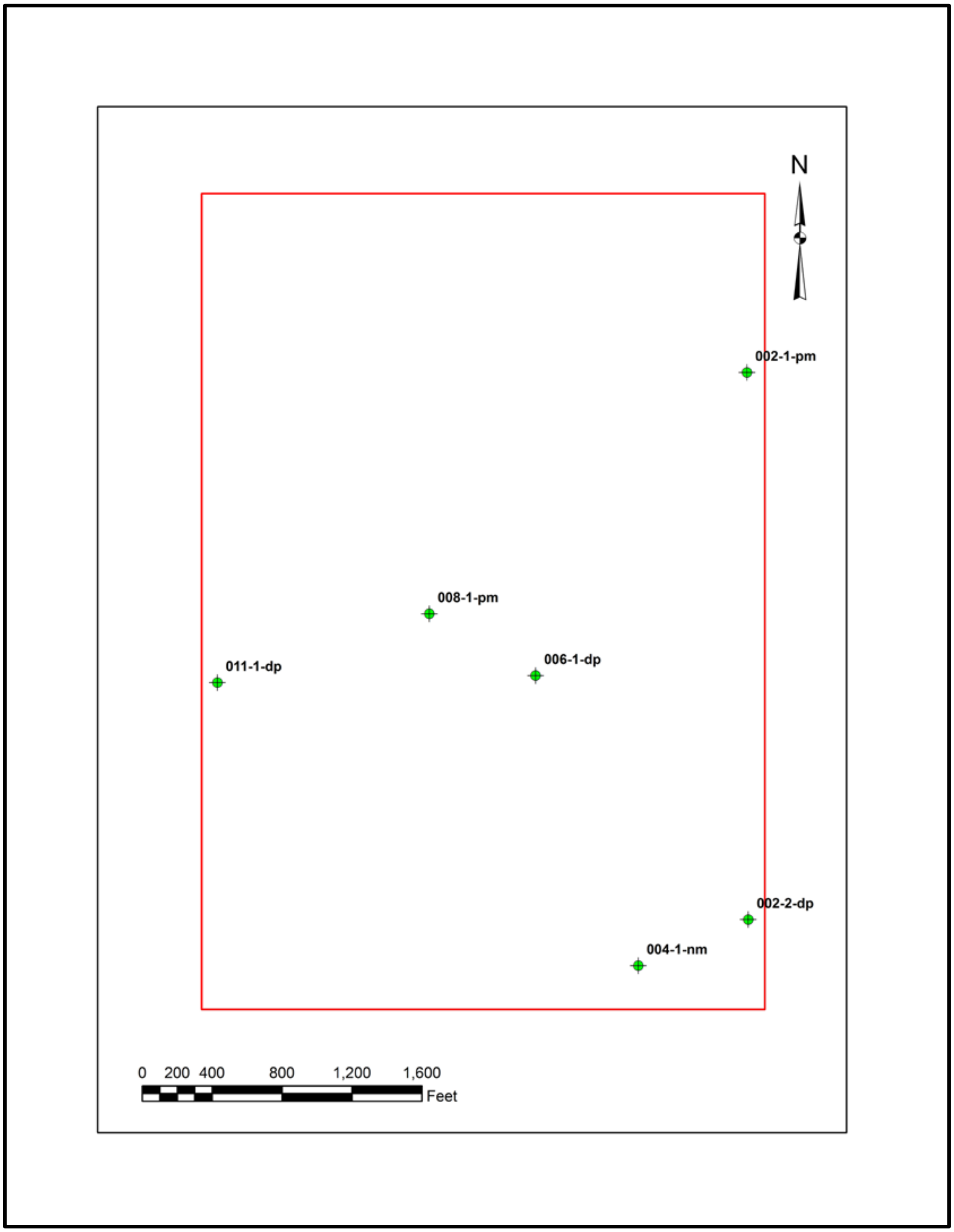

Figure 148. SS S5 magnetic anomaly scatter identified during reconnaissance level survey.

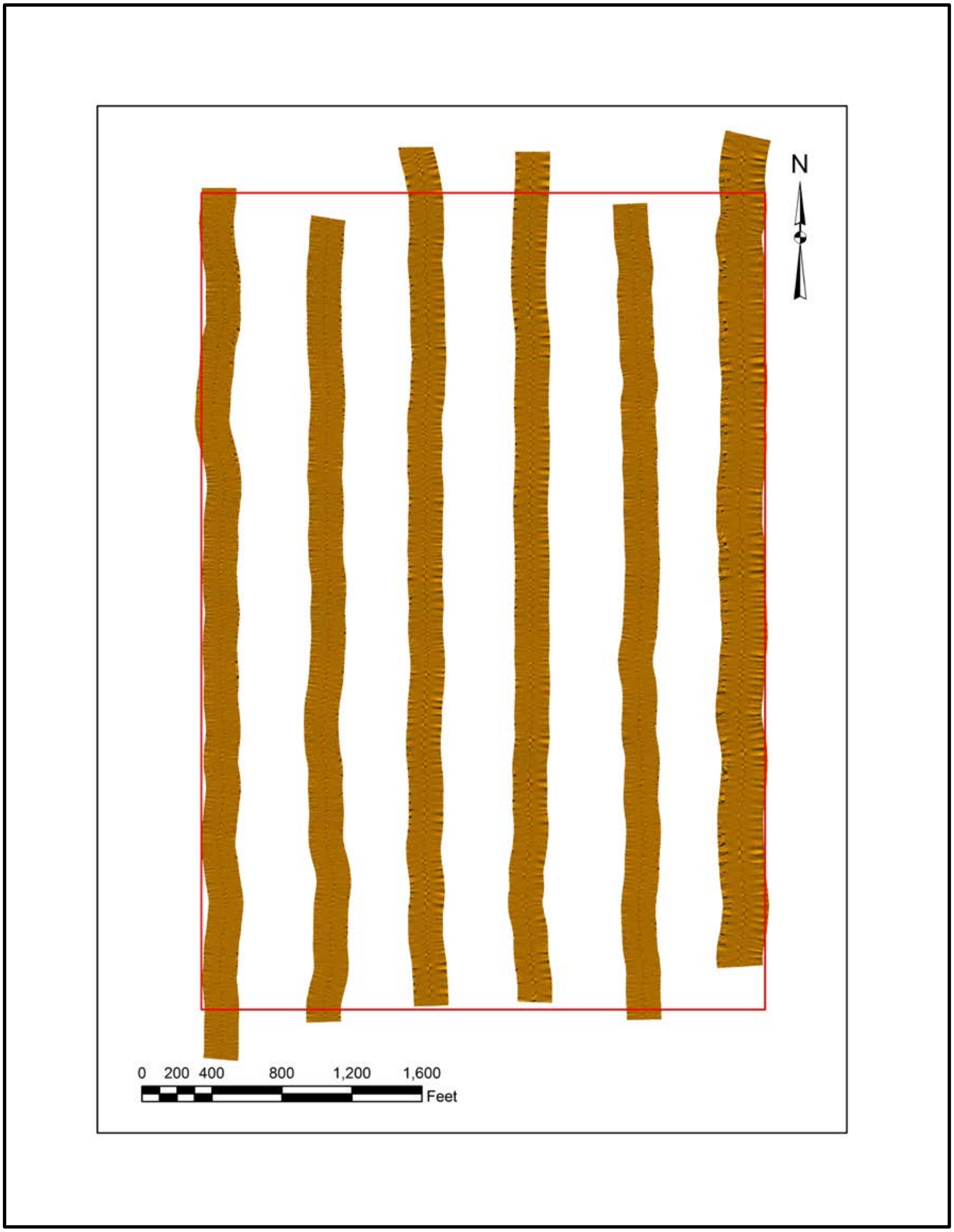

Figure 149. SS S5 sonar mosaic data generated on six lines of reconnaissance level survey data.

4.3. Hewes Point

4.3.1. Secondary Area 1

Hewes Point Secondary Area 1 (HP S1) was selected for remote sensing due to coordinates provided to BOEM and reportedly identifying the location of the Chandeleur ballast pile site investigated in 1989 (Garrison et al. 1989b; Figure 150, Figure 151). HP S1 was surveyed on September 13 and 14, 2013.

Line-by-line analysis of the magnetic and acoustic data generated during the HP S1 survey identified 51 magnetic anomalies (Figure 152; Volume III: Appendix CC). One sonar target was identified in the acoustic data (Figure 153; Volume III: Appendix DD). Thirty-four magnetic anomalies are located in three clusters that have collective signature characteristics with a high potential for association with vessel remains. Twelve magnetic anomalies (017-1, 019-1, 020-1, 021-1, 022-1, 023-1, 024-1, 025-1, 026-1, 027-1, 028-1, and 101-1) form a large cluster with a high potential for association with shipwreck remains or other submerged cultural resources. Those 12 are identified as Buffer A (Figure 154).

Fifteen anomalies (031-1, 033-1, 033-2, 035-1, 035-2, 036-1, 036-2, 036-3, 037-2, 037-3, 037-4, 038-2, 039-2, 040-2 and 100-1) also have a high potential association with shipwreck remains or other submerged cultural resources. Those 15 are identified as Buffer B (Figure 155). Buffer C (Figure 156) contains an additional seven magnetic anomalies (037-1, 038-1, 039-1, 040-1, 041-1, 043-1, and 102-1). Those magnetic anomalies have an equally high potential for association with shipwreck remains or other submerged cultural resources.

The single sonar target (HP S1 SS 001) has no association with any of the magnetic anomalies identified during the survey. The image is suggestive of a ballast pile, but it more likely represents a school of fish because it does not appear at the same location in any of the adjacent lines of data (Figure 157).

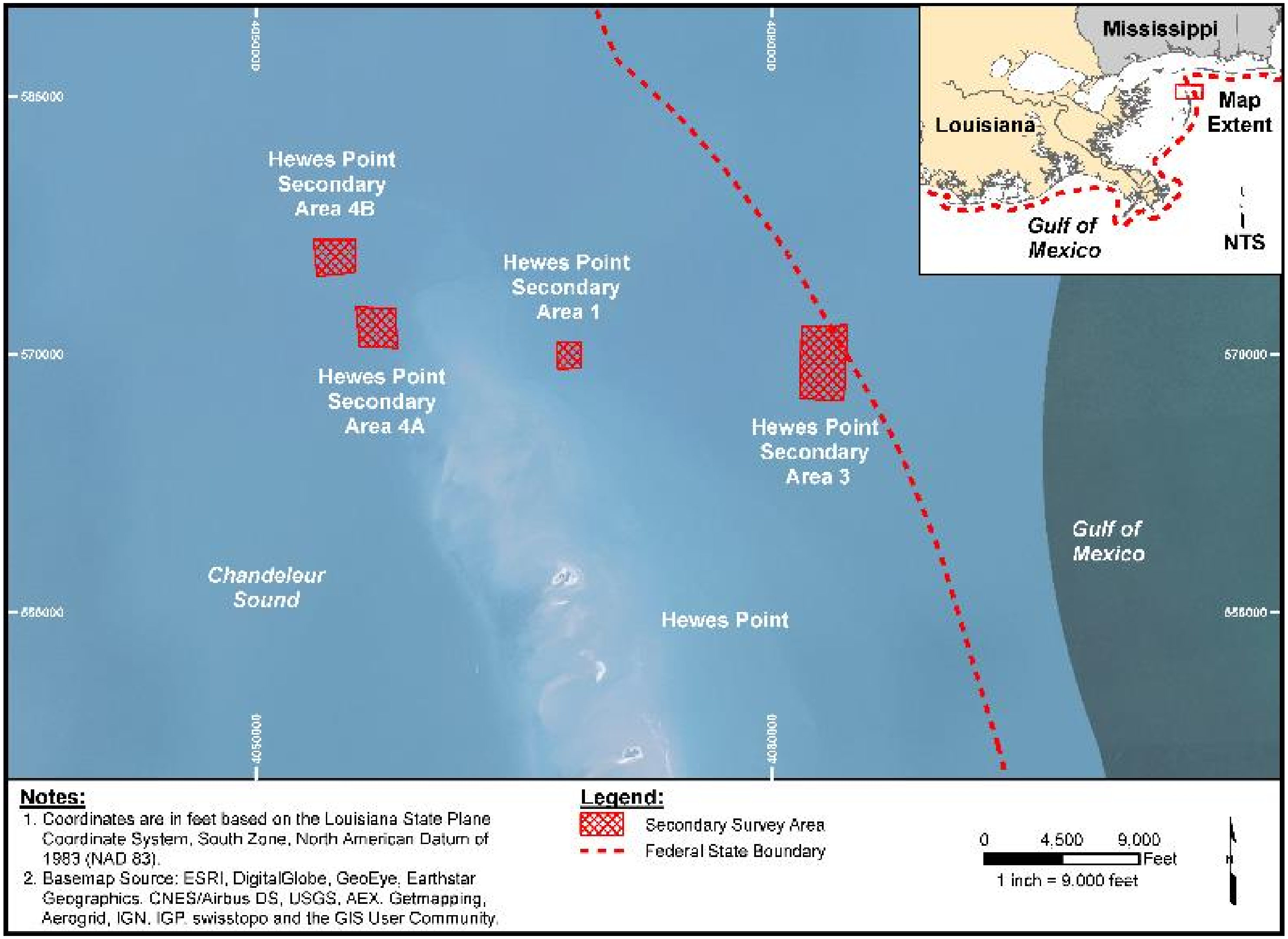

Figure 150: Hewes Point study area.

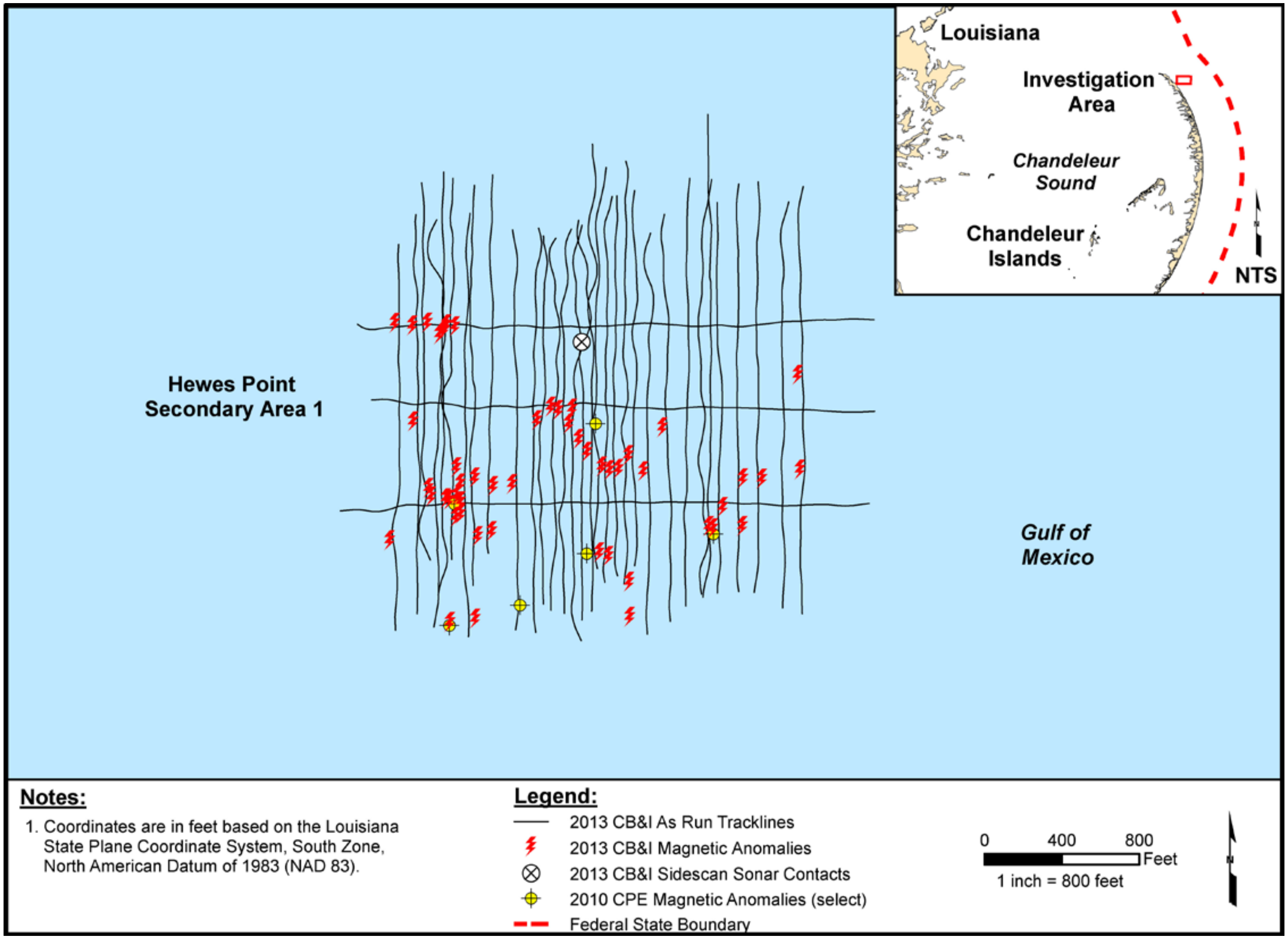

Figure 151: Magnetic anomalies and sonar targets identified in Hewes Point Secondary Area 1.

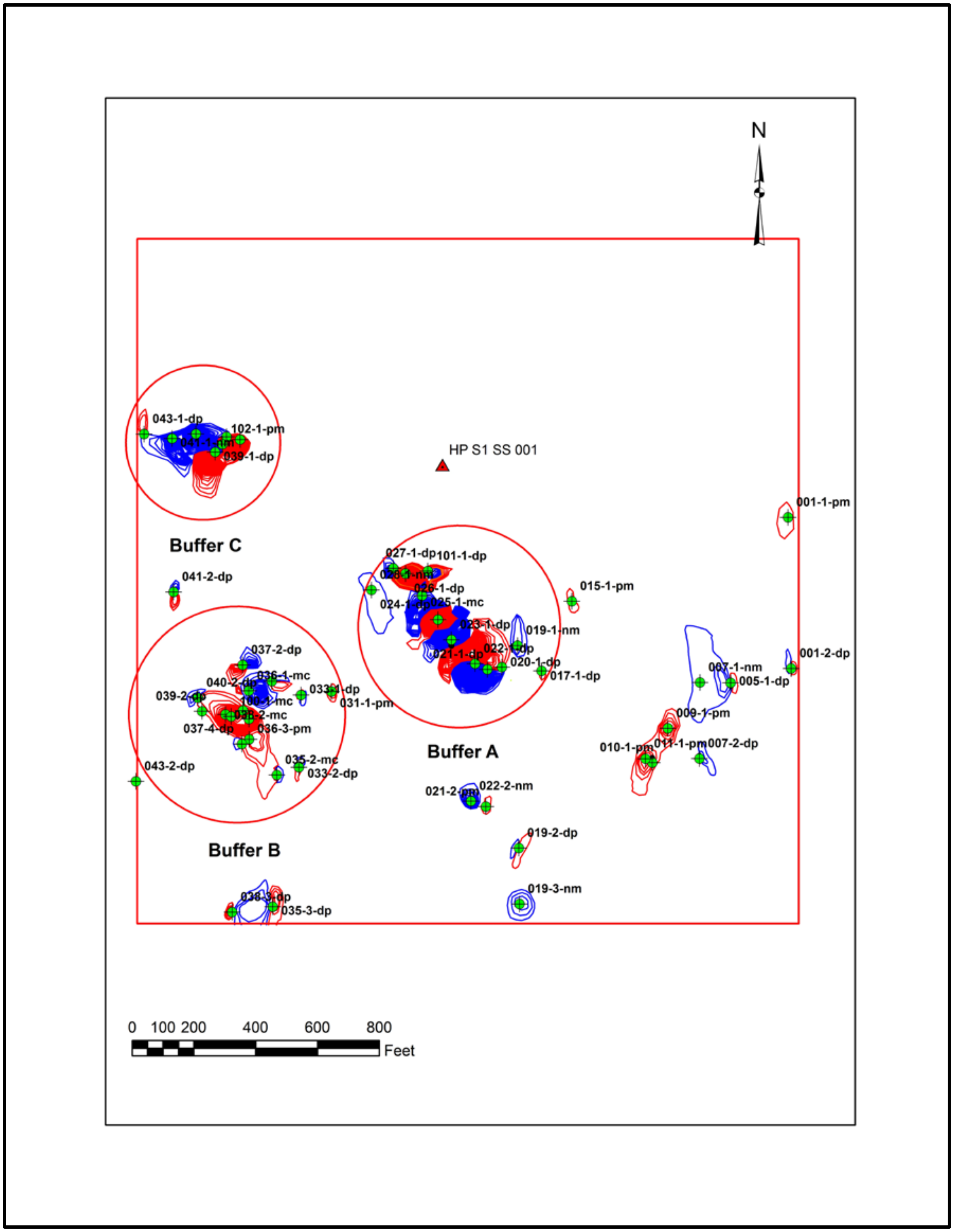

Figure 152. HP S1 magnetic anomalies, contours, and buffers.

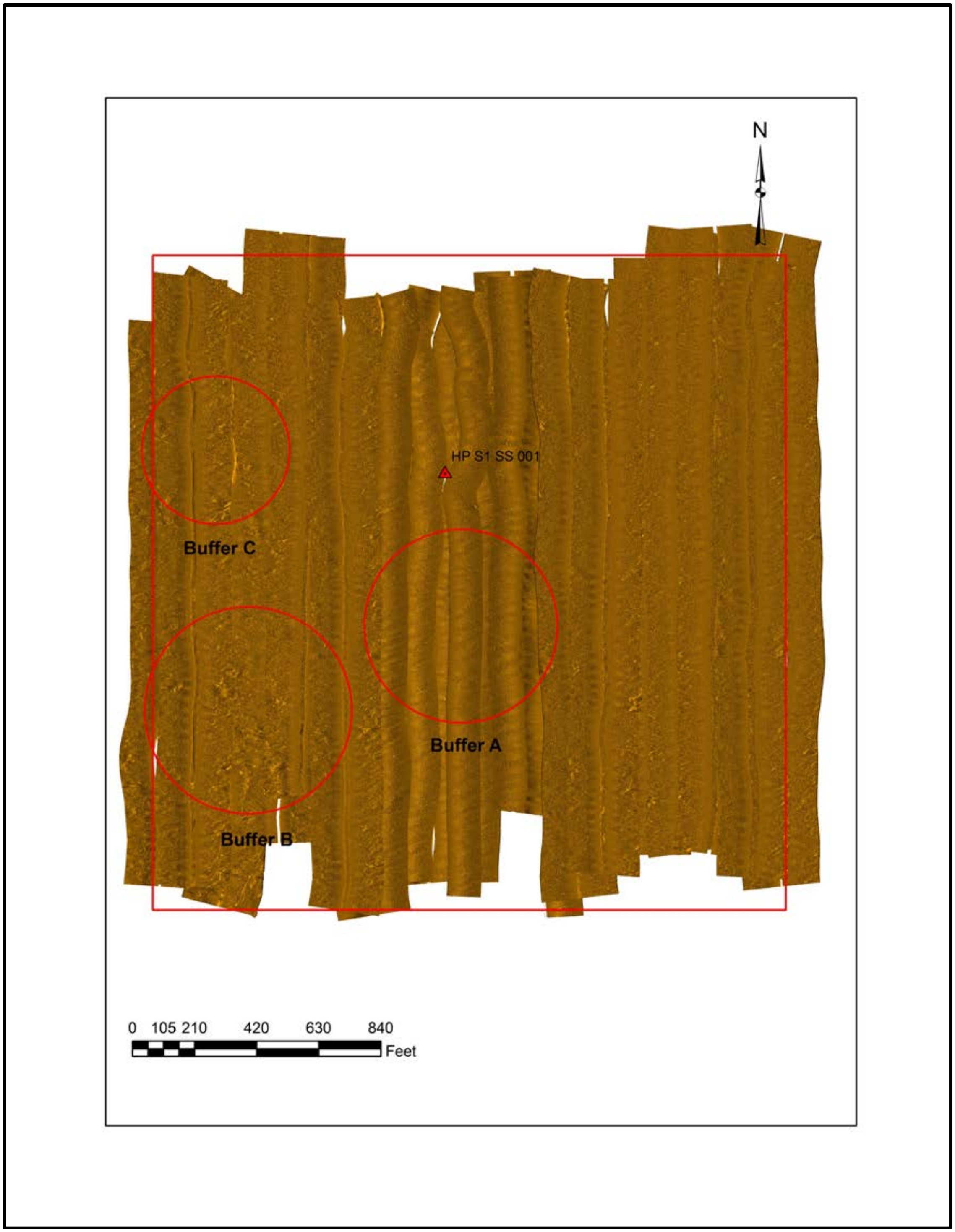

Figure 153. HP S1 sonar coverage mosaic with sonar target.

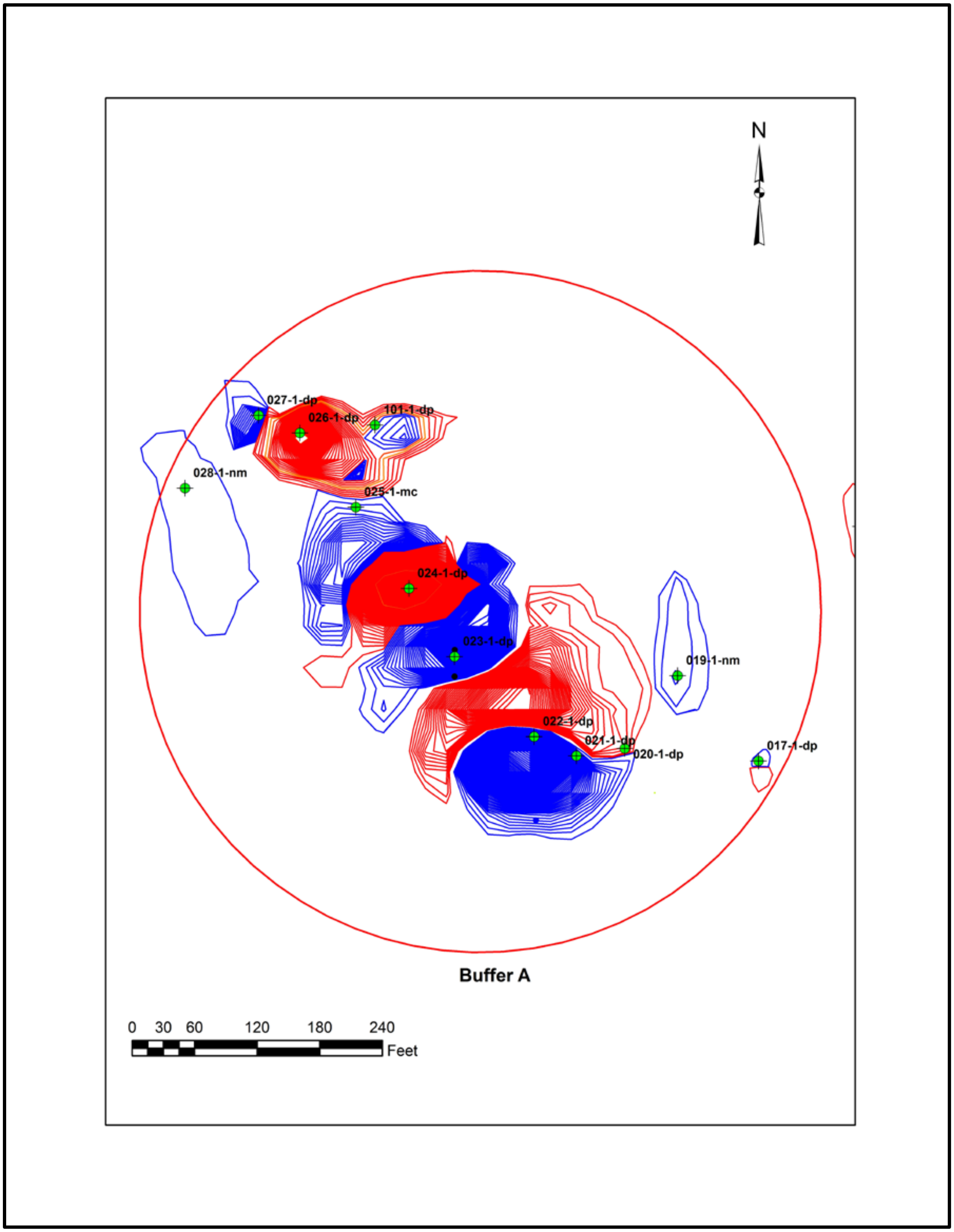

Figure 154. HP S1 Buffer A magnetic anomalies and contours.

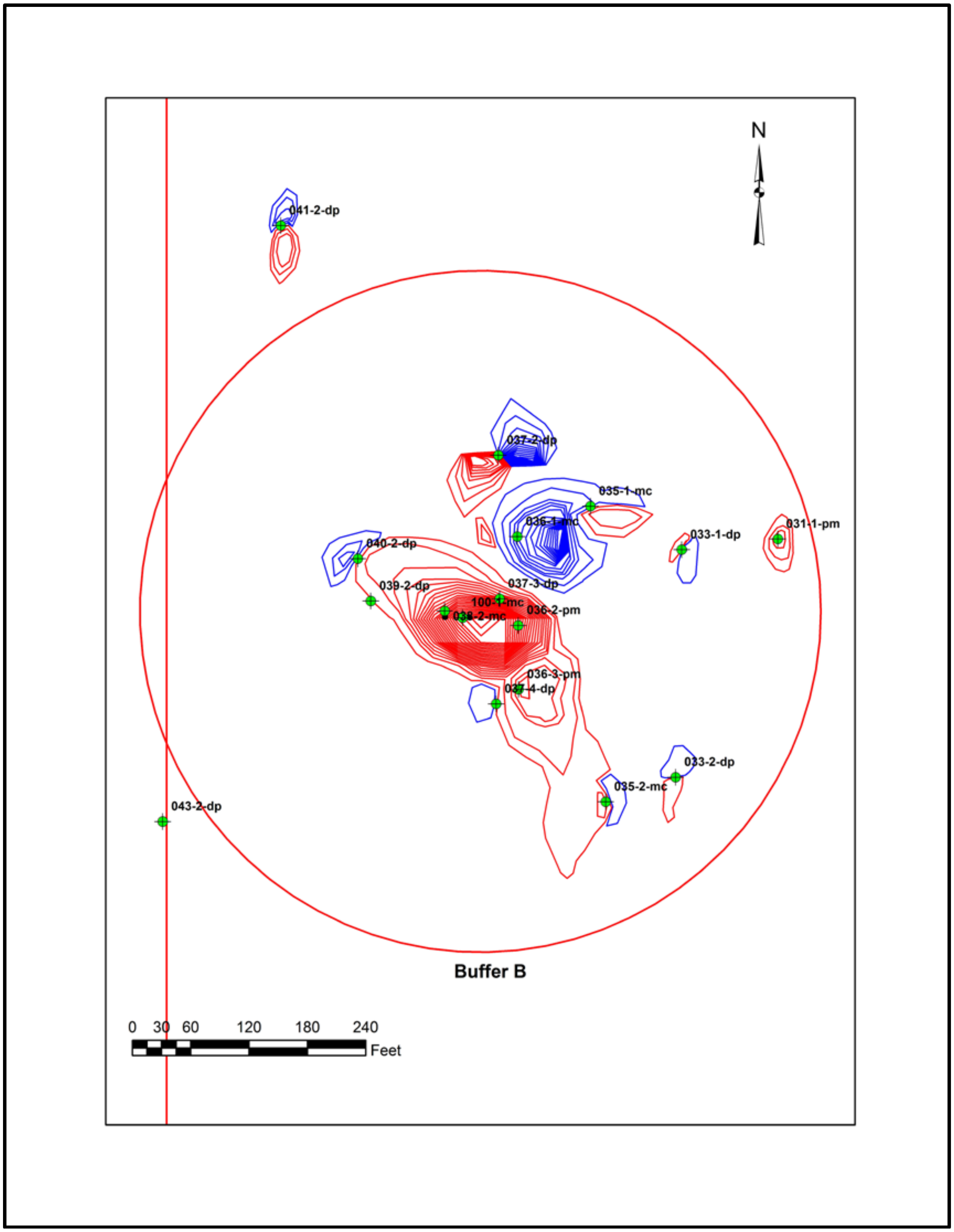

Figure 155. HP S1 Buffer B magnetic anomalies and contours.

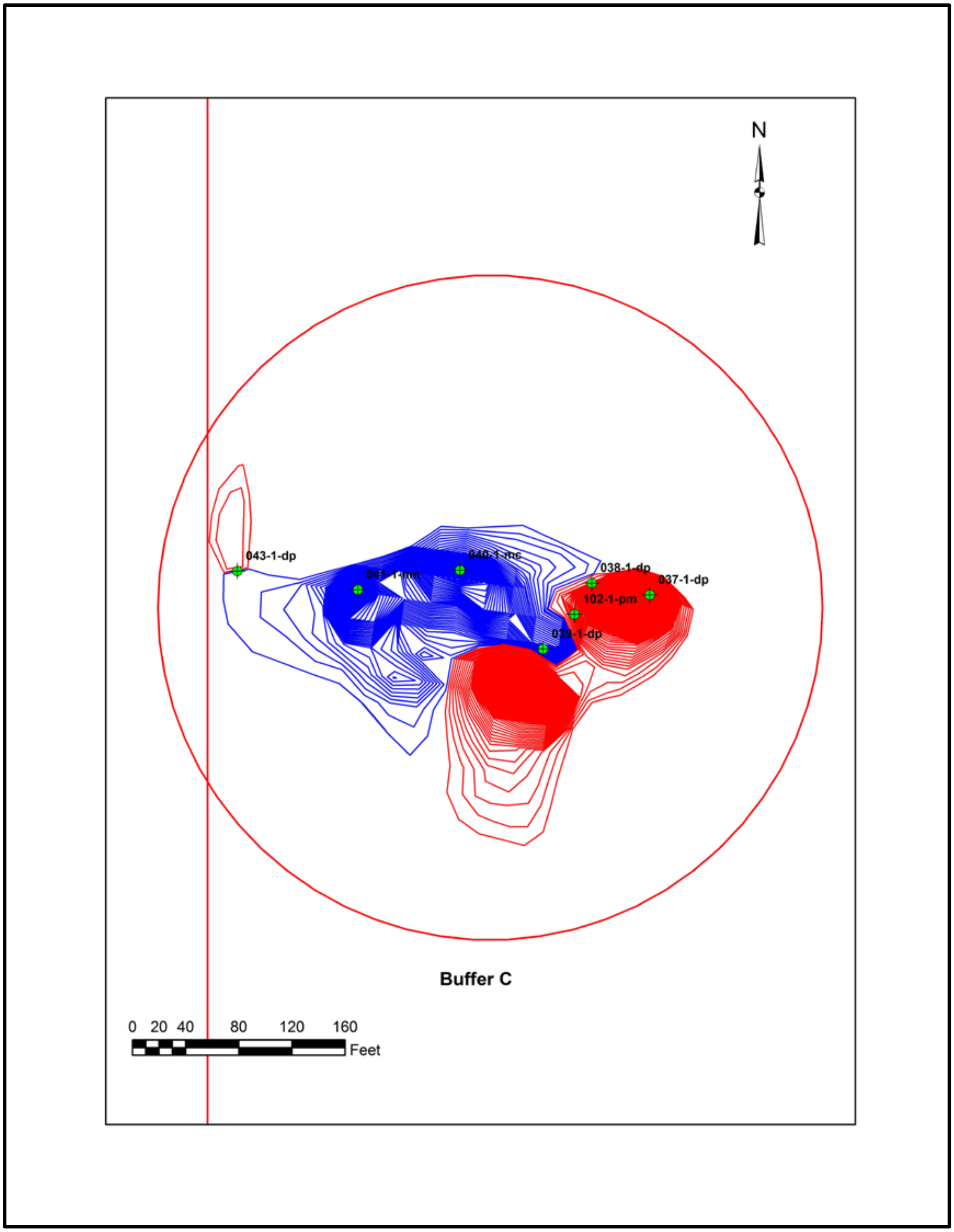

Figure 156. HP S1 Buffer C magnetic anomalies and contours.

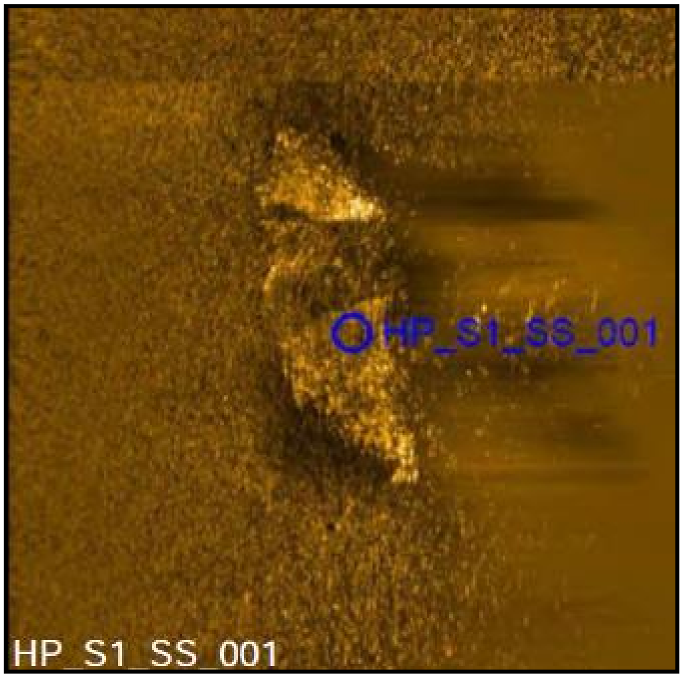

Figure 157. Sonar target HP S1 SS 001 possibly representing a school of fish.

Although the potential for association with vessel remains appears high for all of the buffered magnetic anomalies, archaeological diver investigation was not carried out in HP S1. The remaining 17 magnetic anomalies are not considered to have signature characteristics or clustering that suggests a high potential association with shipwreck remains or other potentially significant submerged cultural resources. Of the seventeen, six have signature characteristics of moderate size ferrous objects and eleven have signature characteristics of small ferrous objects. Those magnetic anomalies appear to be generated by material associated with oil and gas activity, fish traps, small anchors, or other modern debris.

None of the buffered magnetic anomaly clusters in HP S1 were selected for investigation by archaeological divers. However, all of the buffer areas should be priorities for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

4.3.2. Secondary Area 3

The Hewes Point Secondary Area 3 (HP S3) is located approximately five miles east of the light tower off the northern end of the Chandeleur Islands (Figure 158). HP S3 was selected for remote sensing primarily due to the possible association with the subject ballast pile and cannon site investigated in 1989. Coordinates for the ballast pile and cannon site provided by Dr. Ervan Garrison were used as the center point of the HP S3 remote-sensing investigation (Figure 159). HP S3 was surveyed on September 12 and 13, 2013. Primary survey lines were run north/south (NS), and a series of secondary lines at the northwest corner were run east–west (EW) to investigate the magnetic anomalies identified on the primary survey lines.

Line-by-line analysis of the magnetic data generated during the primary HP S3 NS survey identified four magnetic anomalies (Figure 160; Volume III: Appendix EE). Nine anomalies were identified in the magnetic data from the secondary HP S3 EW survey (Figure 161; Volume III: Appendix EE). All HP S3 magnetic anomalies were concentrated in the vicinity of the northwest corner of the primary survey area.

Thirteen sonar targets were identified in the primary (NS) and secondary (EW) acoustic data (Figure 162; Volume III: Appendix FF). With the exception of SSS 006, SSS 012, and SSS 013, all appear to be small or linear objects and none are associated with magnetic anomalies.

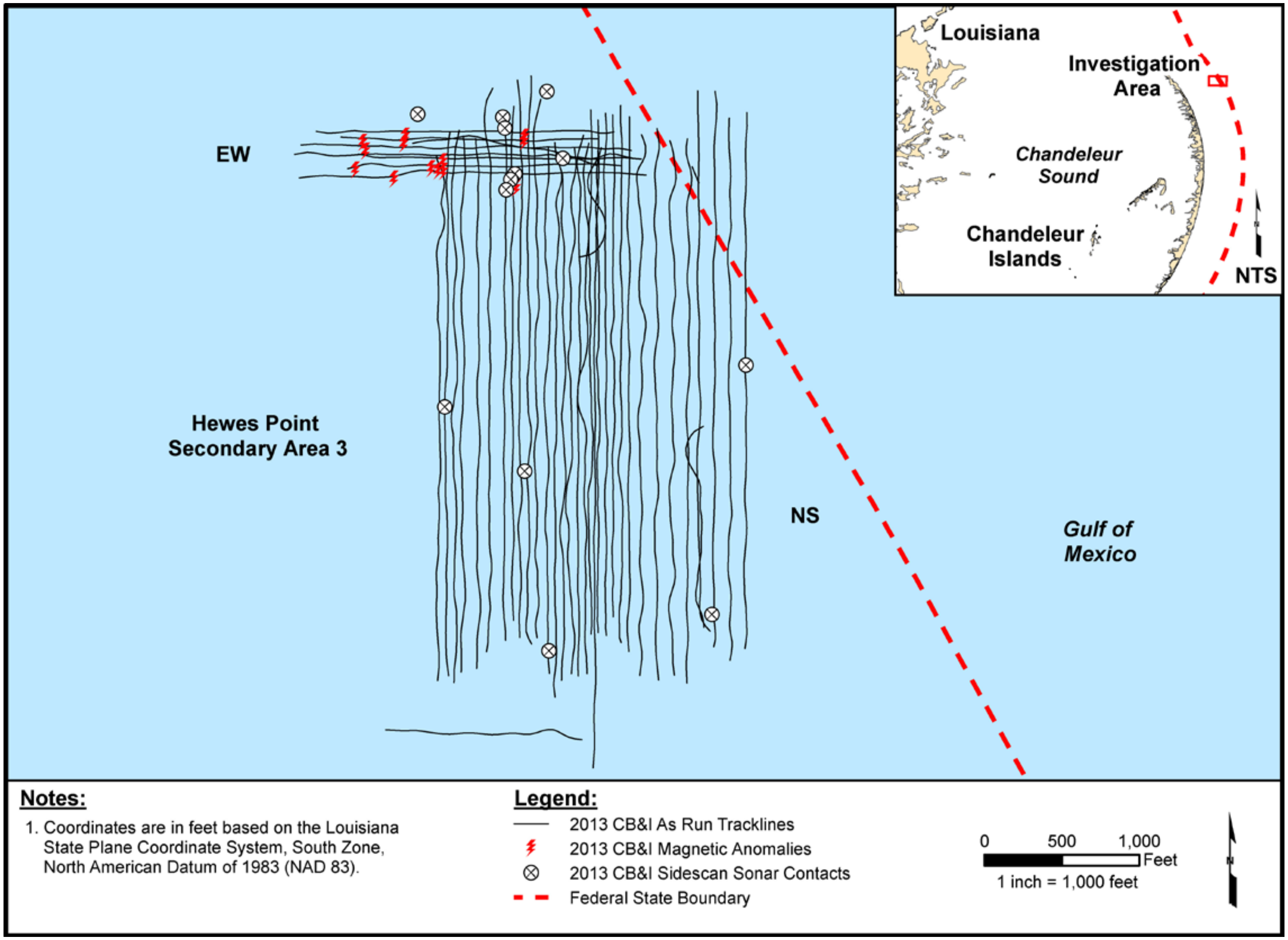

Figure 158: Magnetic anomalies and sonar targets identified in Hewes Point Secondary Area 3 NS and EW.

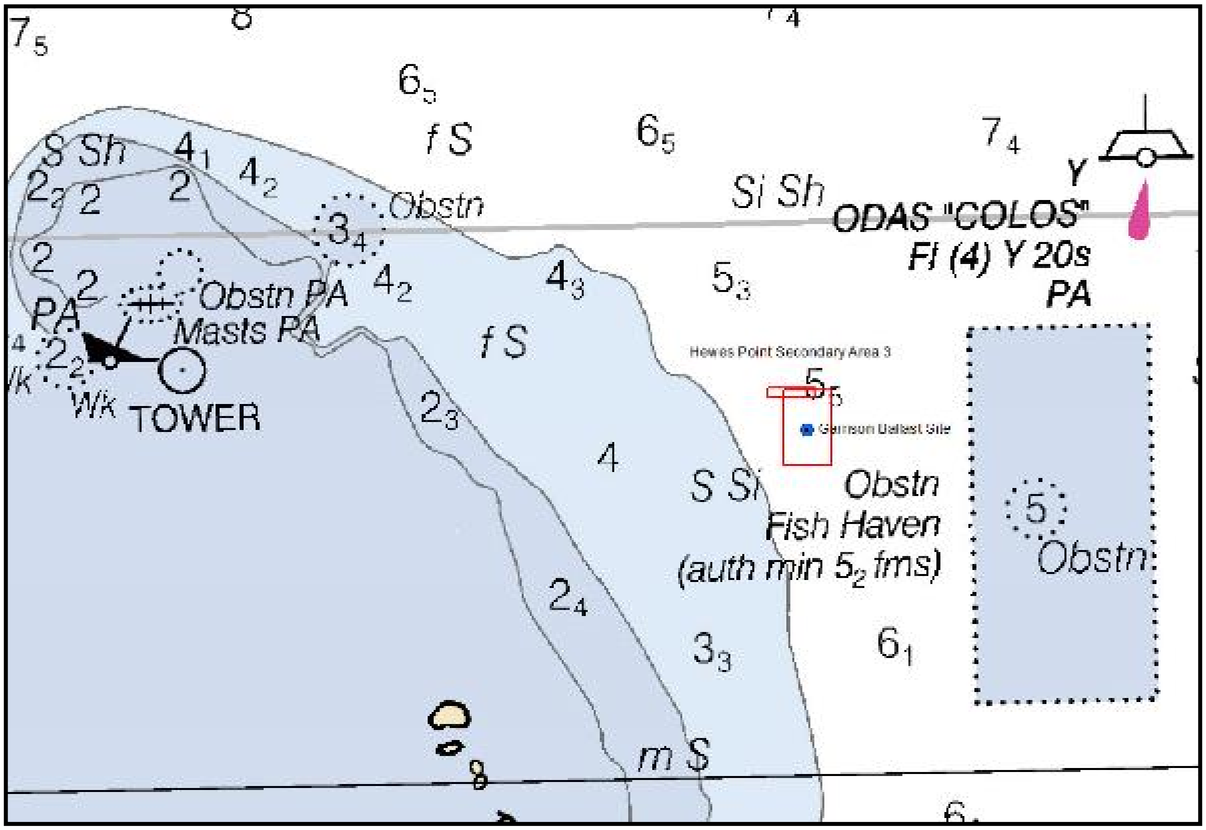

Figure 159. HP S3 and reported Garrison Ballast Site.

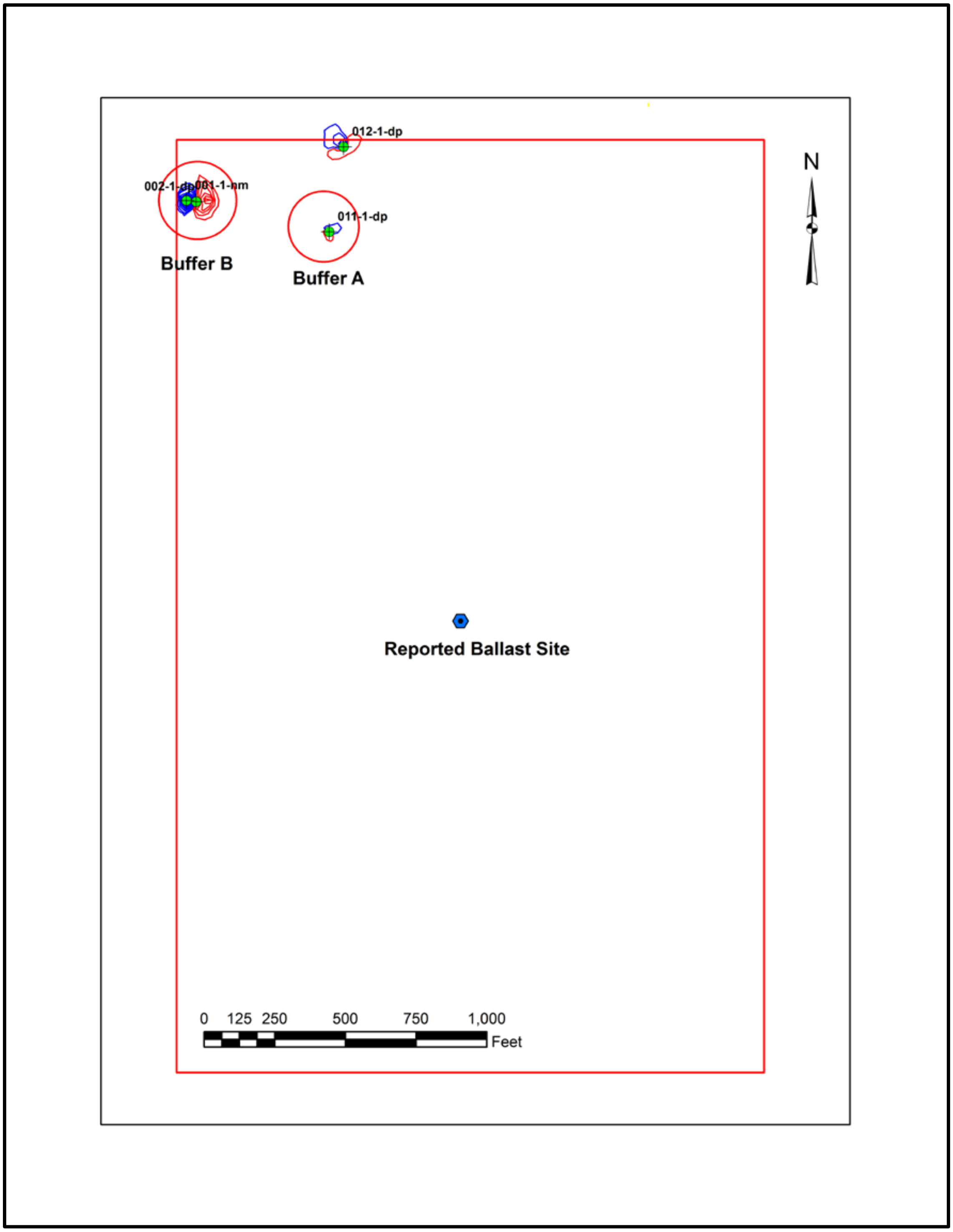

Figure 160. HP S3 NS magnetic anomalies, contours, and buffers.

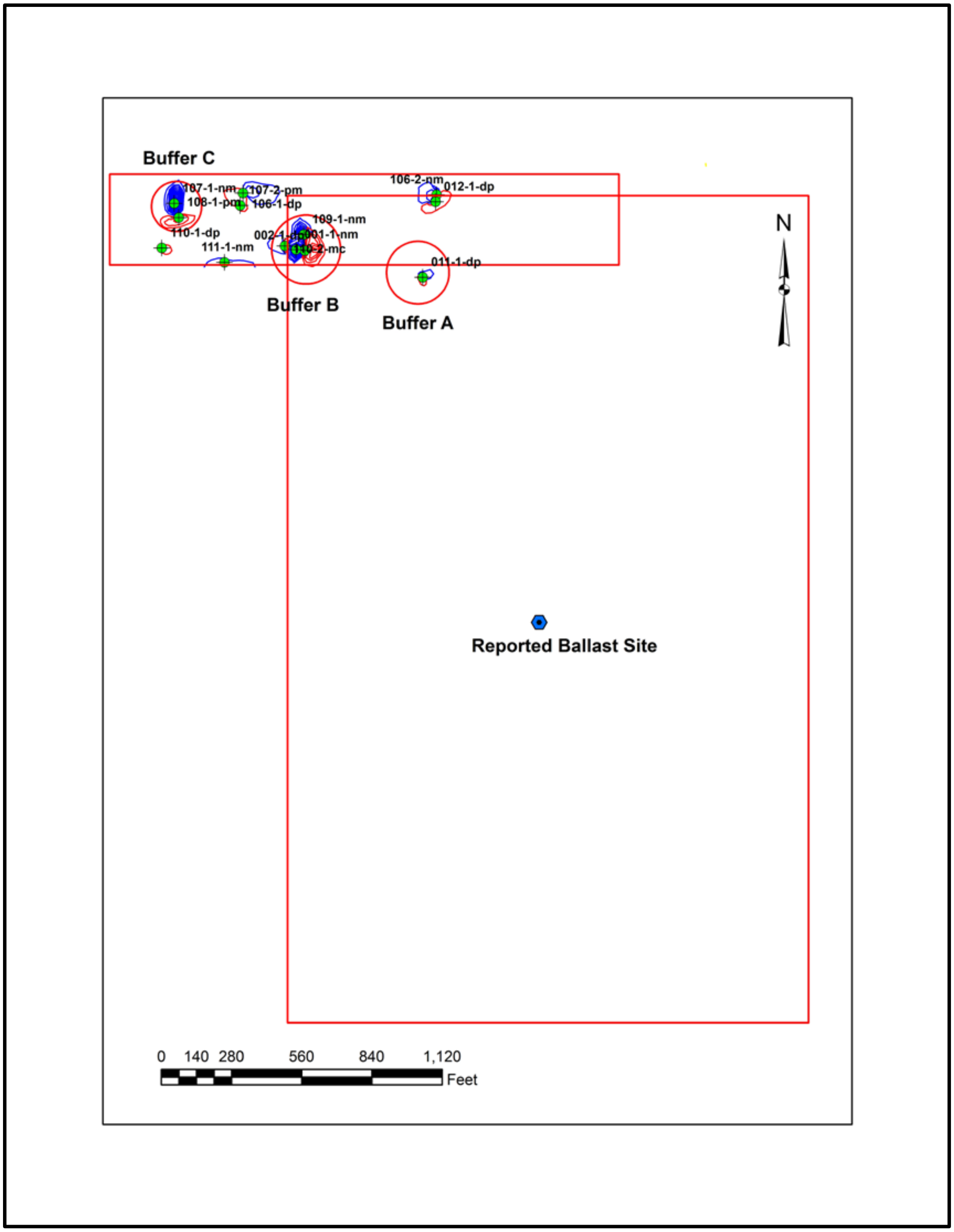

Figure 161. HP S3 EW magnetic anomalies, contours, and buffers.

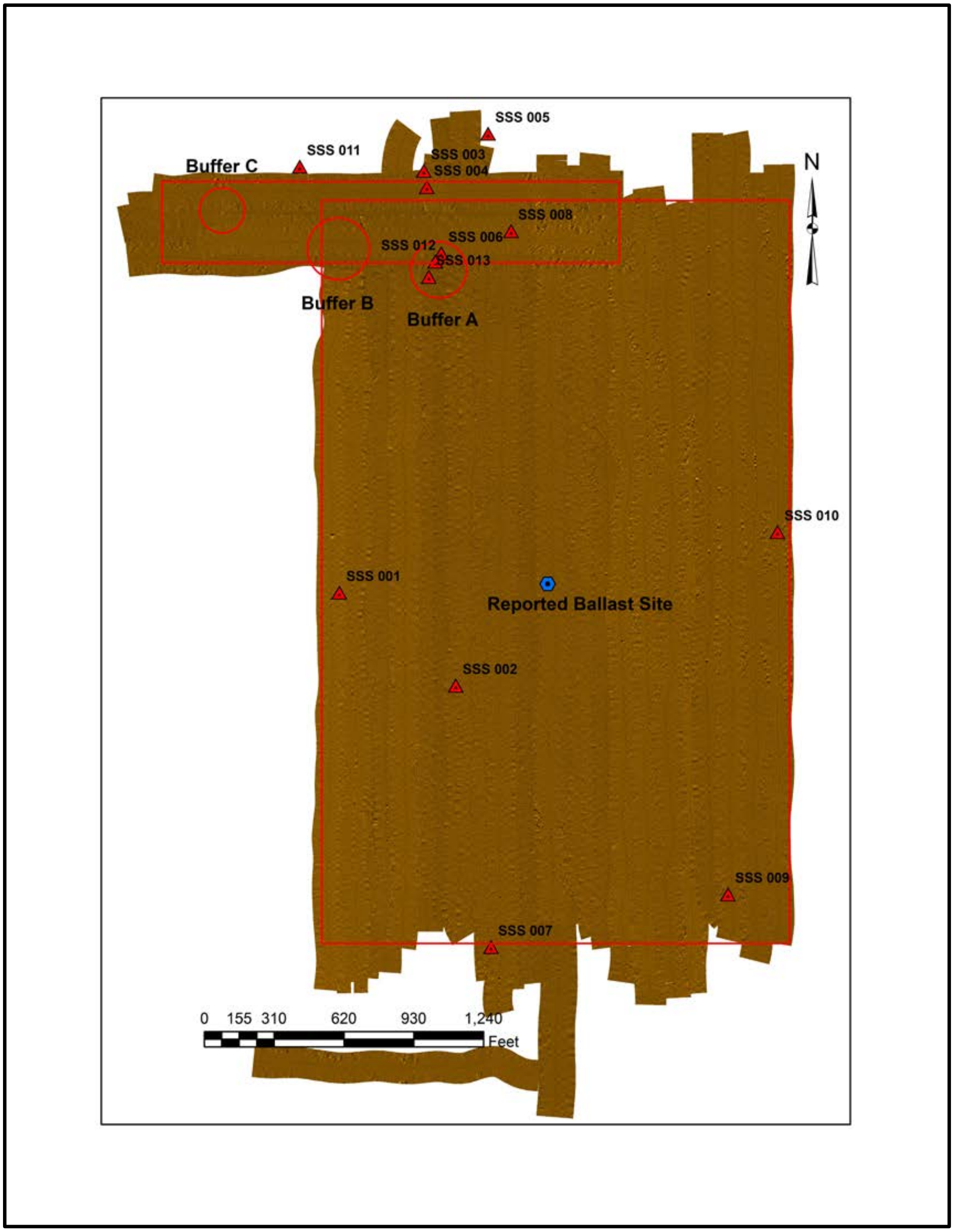

Figure 162. HP S3 sonar coverage mosaic with sonar targets.

One magnetic anomaly (011-1) is in close proximity to three sonar targets (SSS 006, SSS 012 and SSS 013) that could represent a ballast scatter (Figure 163). That magnetic anomaly and the three sonar targets are considered to have a high potential association with shipwreck remains and are included in Buffer A (Figure 164).

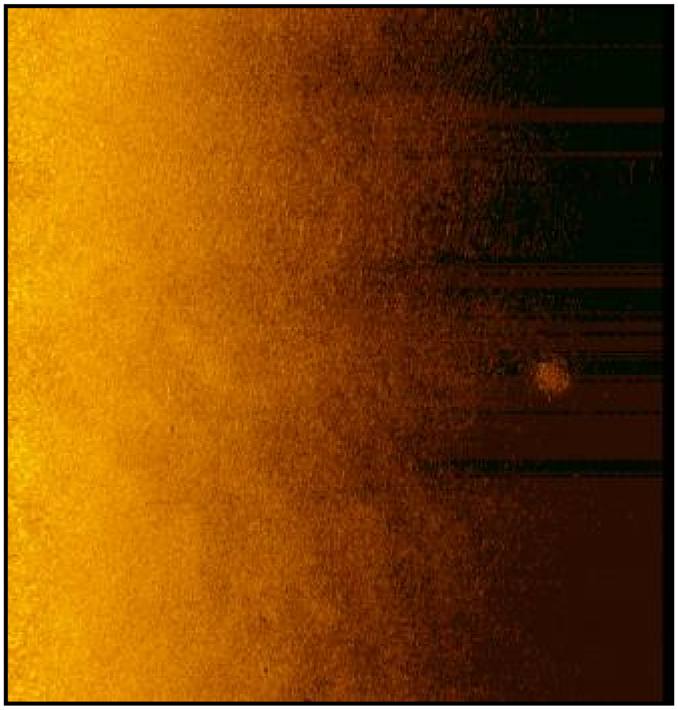

Figure 163. Sonar target SSS 012 possibly representing ballast scatter.

Two magnetic anomalies (001-1 and 002-1) have collective signature characteristics considered to have a high potential association with shipwreck vessel remains. Those two magnetic anomalies lie within Buffer B (Figure 165).

A third buffer contains two secondary survey magnetic anomalies (107-1 and 108-1) that appear to have a moderate potential for association with shipwreck remains. Those magnetic anomalies are included in Buffer C (Figure 166).

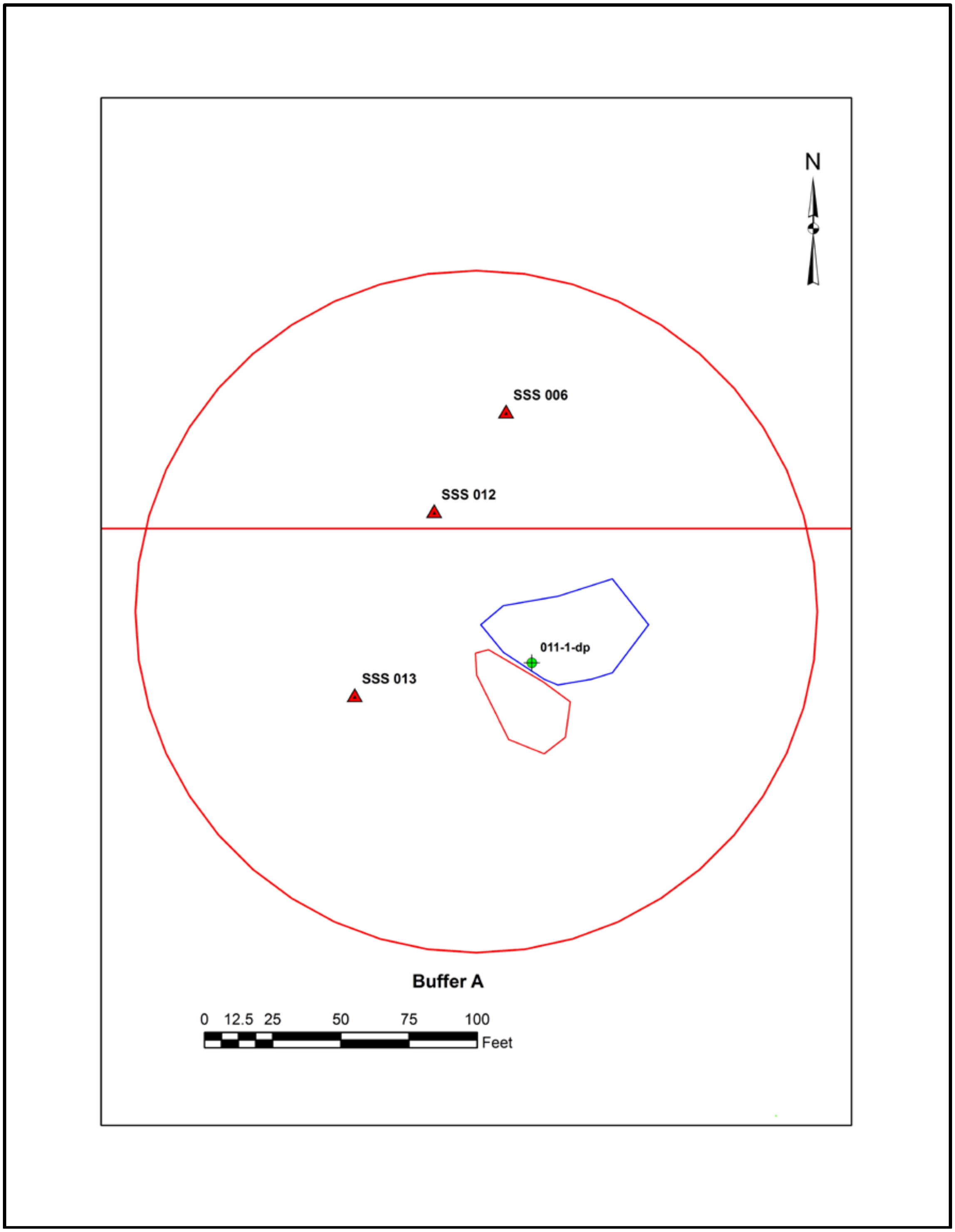

Figure 164. HP S3 magnetic anomaly, contours, and sonar targets within Buffer A.

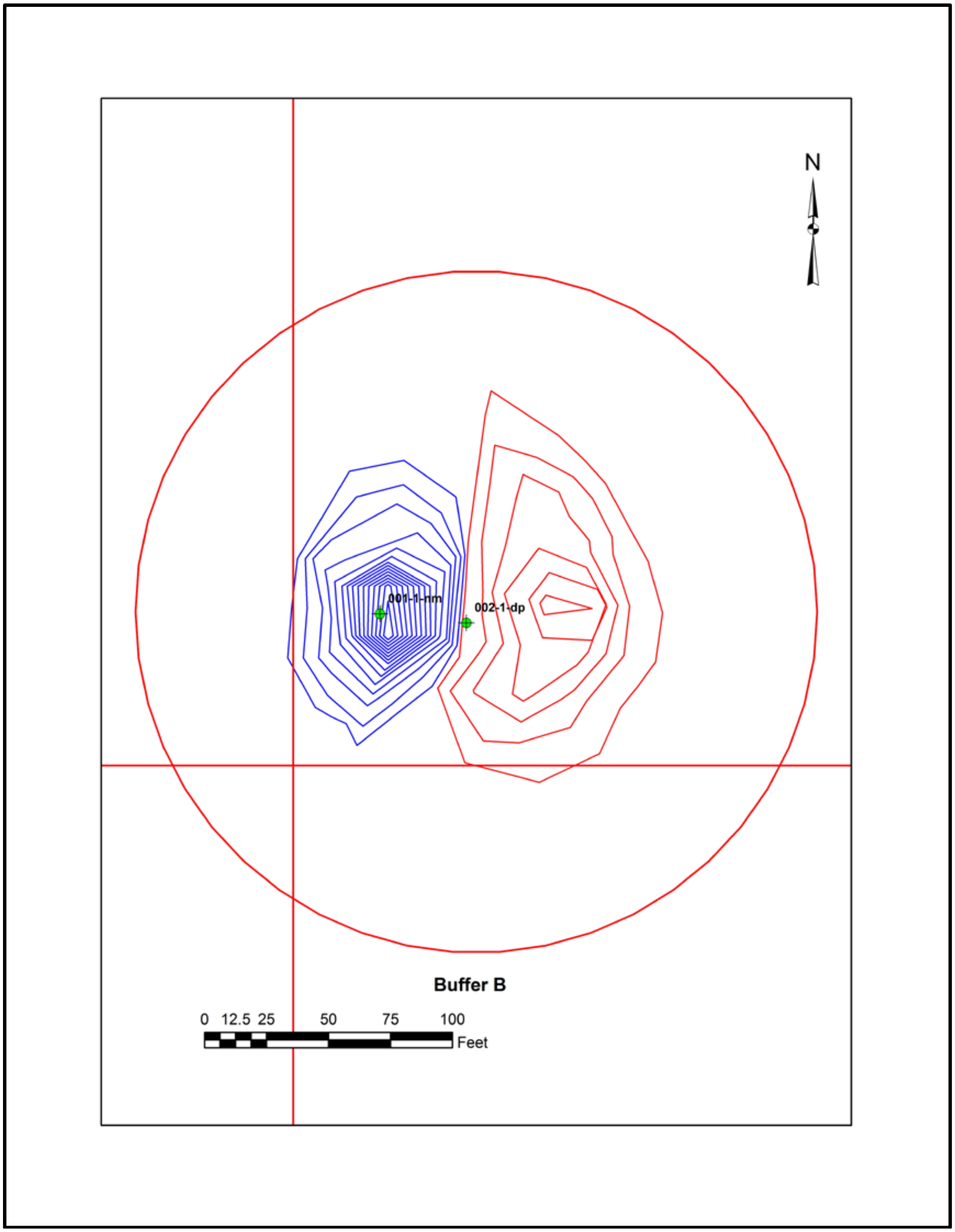

Figure 165. HP S3 magnetic anomalies and contours within Buffer B.

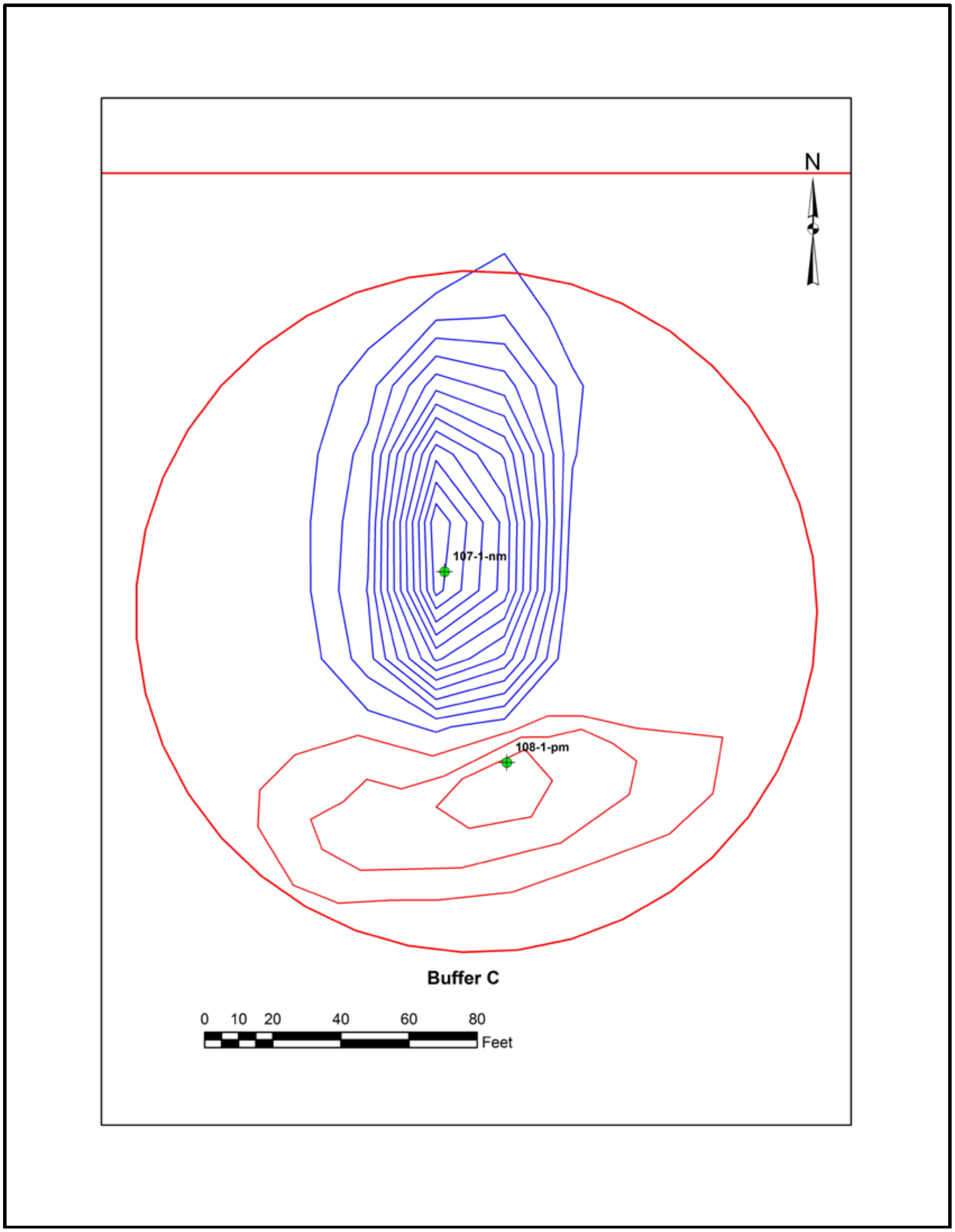

Figure 166. HP S3 magnetic anomalies and contours within Buffer C.

With the exception of the three sonar targets (SSS 006, SSS 012, and SSS 013) geographically associated with magnetic anomaly 011-1, the remaining sonar targets are not associated with magnetic anomalies. All represent small objects exposed on the bottom surface, such as fish traps, logs or timbers, and other similar debris.

The magnetic anomalies and sonar targets identified in the HP S3 primary and secondary survey data are not associated with the Chandeleur Ballast Site. The Chandeleur Ballast Site was later relocated 3.5 miles south-southwest of the reported location in HP S3 (see Chapter 4.5). However, there is a distinct possibility that they could represent other shipwreck or small vessel remains. Although the potential for association with vessel remains appears high for all of the buffered magnetic anomalies, archaeological diver investigation was not carried out in HP S3 in conjunction with this project.

All three buffers areas should be priorities for future archaeological diver investigation in the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided. Archaeological diver investigation should be designed to identify material generating the signatures and to assess its significance in terms of NRHP eligibility.

The five unbuffered magnetic anomalies have signature characteristics of moderate and small objects. Those magnetic anomalies do not have more complex signatures or spatial associations that are more reliably associated with shipwrecks or small vessel remains. In all likelihood, material generating those magnetic anomalies represents small anchors, sections of small pipe, cable, wire rope or chain, fish traps, or other modern debris. No additional investigation of those sites is recommended unless material in adjacent buffers proves to be historically and archaeologically significant.

4.3.3. Secondary Area 4B

The Hewes Point Secondary Area 4B (HP S4B) is located approximately 0.65 miles north-northwest of the light tower off the northern end of the Chandeleur Islands (Figure 167). HP S4B was selected for remote sensing primarily due to a possible association with the ballast pile and cannon site investigated in 1989 and a charted shipwreck on NOAA Chart 11366-1 (Figure 168). In addition, HP S4B was located within the previously permitted borrow area CH-C (see Table 2). HP S4B was surveyed on September 14, 2013.

Line-by-line analysis of the magnetic data generated during the HP S4B survey identified 18 magnetic anomalies (Figure 169; Volume III: Appendix GG). One sonar target was identified in the acoustic data (Figure 170; Volume III: Appendix HH).

One of the anomalies identified in the HP S4B survey data (006-2) was clearly associated with sonar image HP S4 SSS 001 (Figure 171). Two additional magnetic anomalies (004-2 and 008-2) were in all likelihood associated with material generating Anomaly 006-2 and the HP S4 SSS 001 sonar target. The magnetic anomalies and the sonar target were identified by Buffer A (Figure 172). Although buffered, an archaeological diver investigation of exposed material at the site confirmed it was associated with modern vessel remains. It also confirmed that the remains were those of a wooden shrimp trawler.

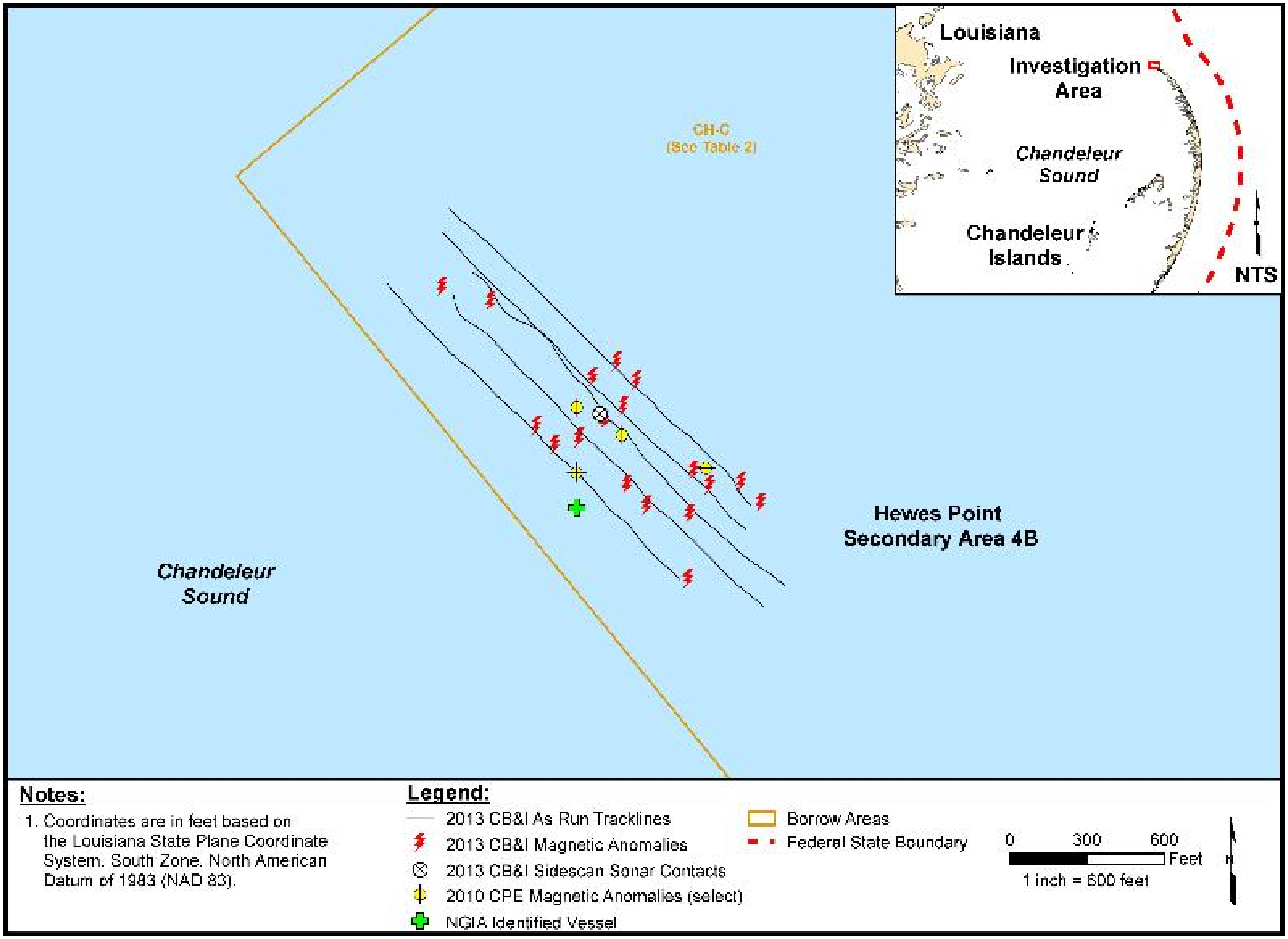

Figure 167: Magnetic anomalies and sonar target identified in Hewes Point Secondary Area 4B.

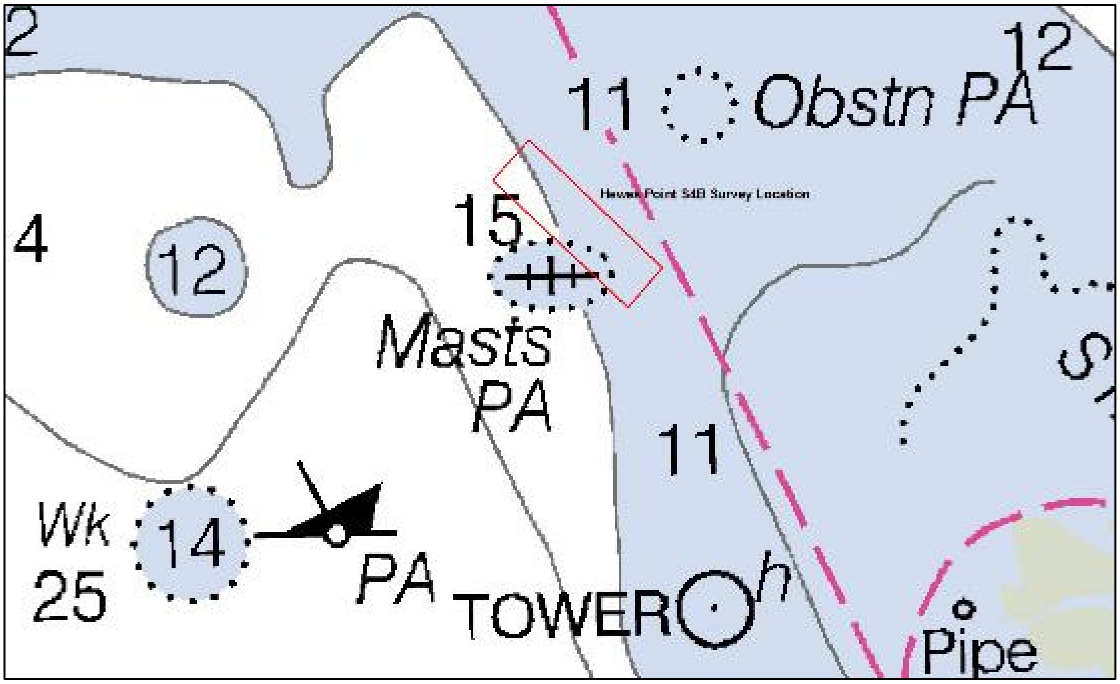

Figure 168. HP S4B survey location and NOAA Chart 11366-1 plotted shipwreck.

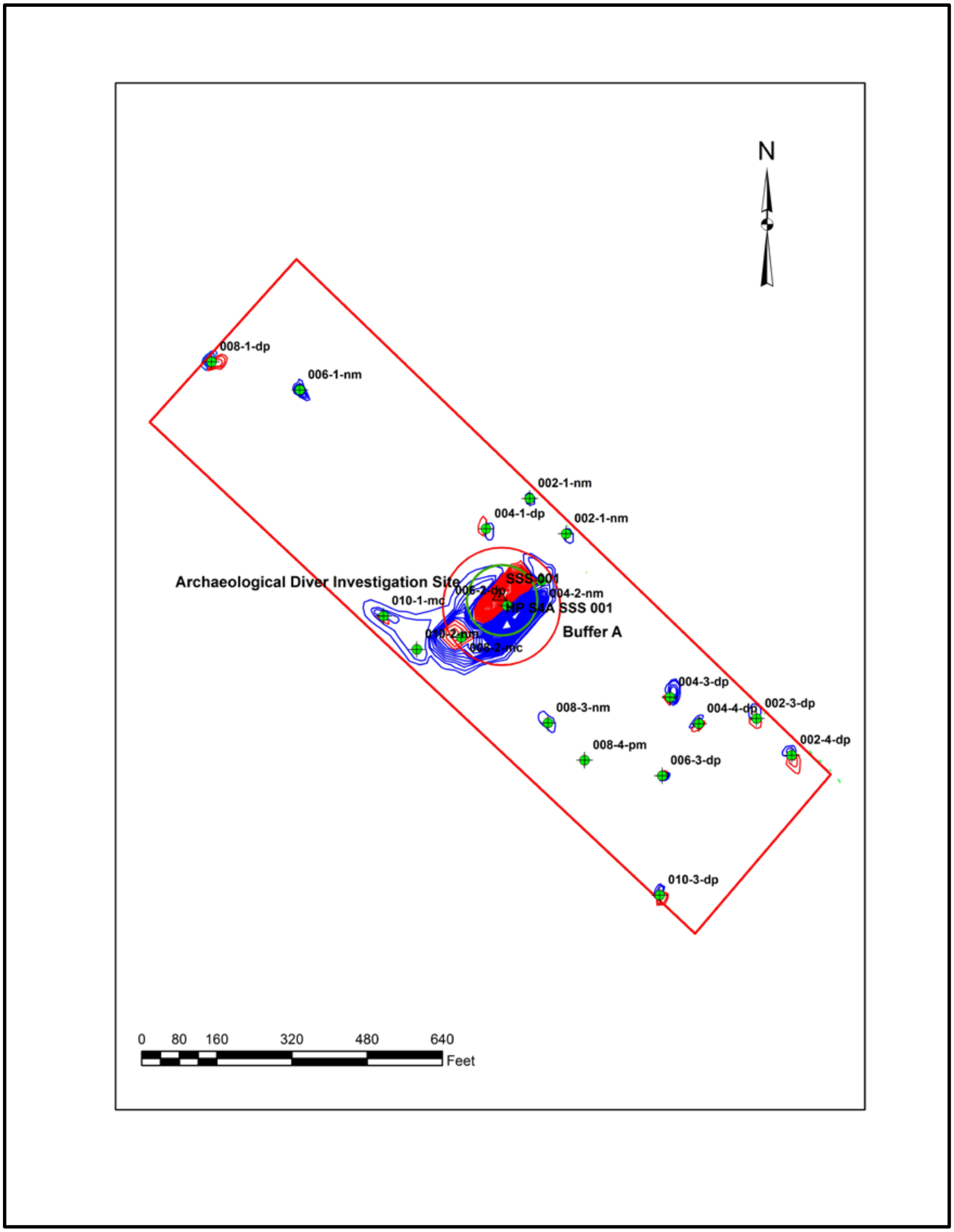

Figure 169. HP S4B magnetic anomalies, contours, and Buffer A.

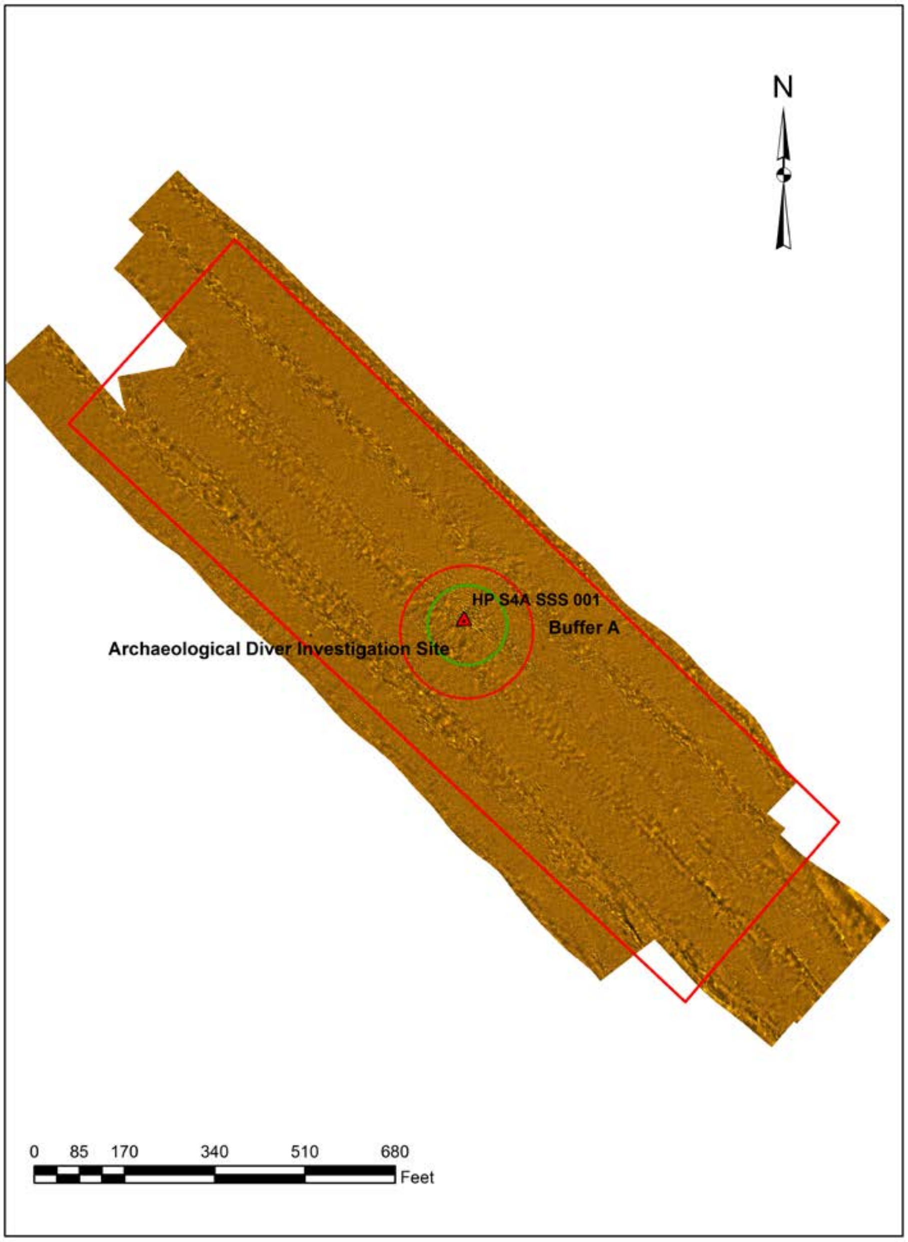

Figure 170. HP S4B sonar coverage mosaic with sonar target.

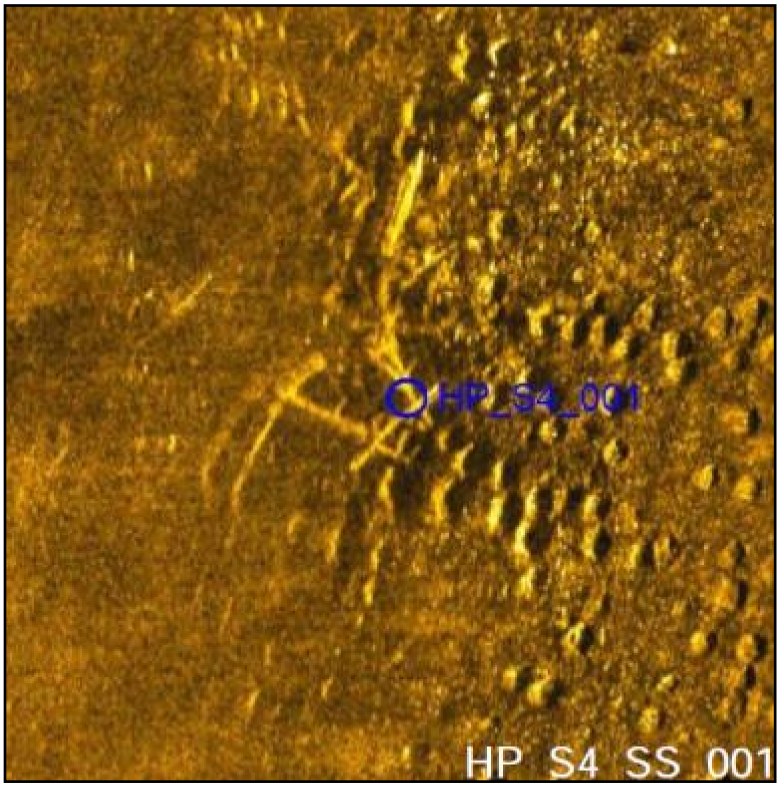

Figure 171. Sonar target SS 001 of material exposed on the bottom surface at HP S4B.

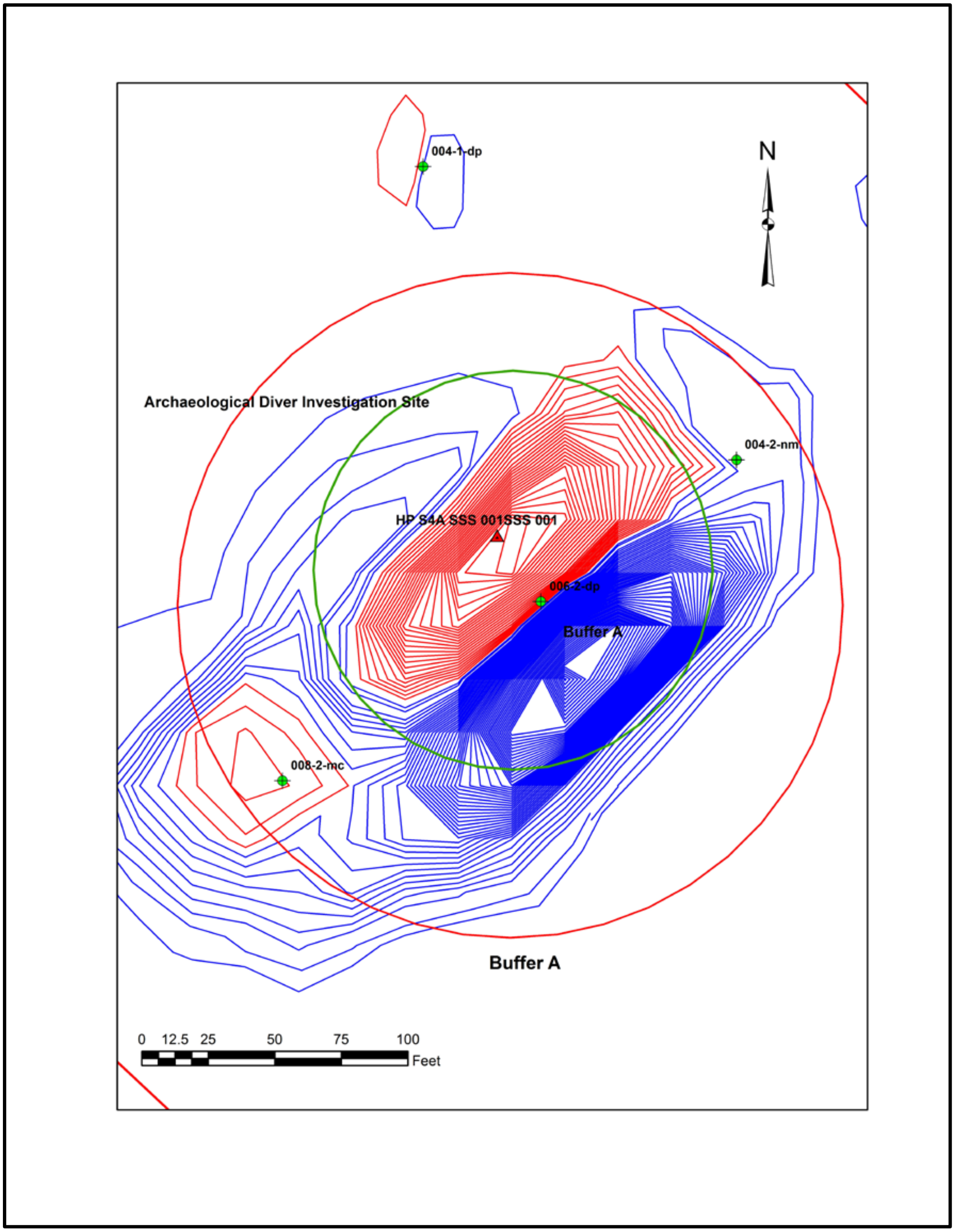

Figure 172. HP S4B magnetic anomalies, contours, and sonar target within Buffer A.

Archaeological diver investigation at the site was carried out on September 14, 2016. The majority of exposed vessel structure was identified as welded pipe masts, booms, and wire rope (Figure 173). Machinery appeared to be the engine bed and associated generators with intact pulley belts (Figure 174) and the starter motor (Figure 175). Although unable to recall its name, Biloxi fishing Captain Kenny Barhanovich recalled the loss of a trawler in the vicinity during a 1960s storm (Kenny Barhanovich, pers. comm., September 18, 2016).

The wreck is not recommended for avoidance or additional investigation, although the site might be a candidate for assessing dredging impacts if sand recovery associated with borrow area CH-C (see Table 2) is carried out in the immediate vicinity.

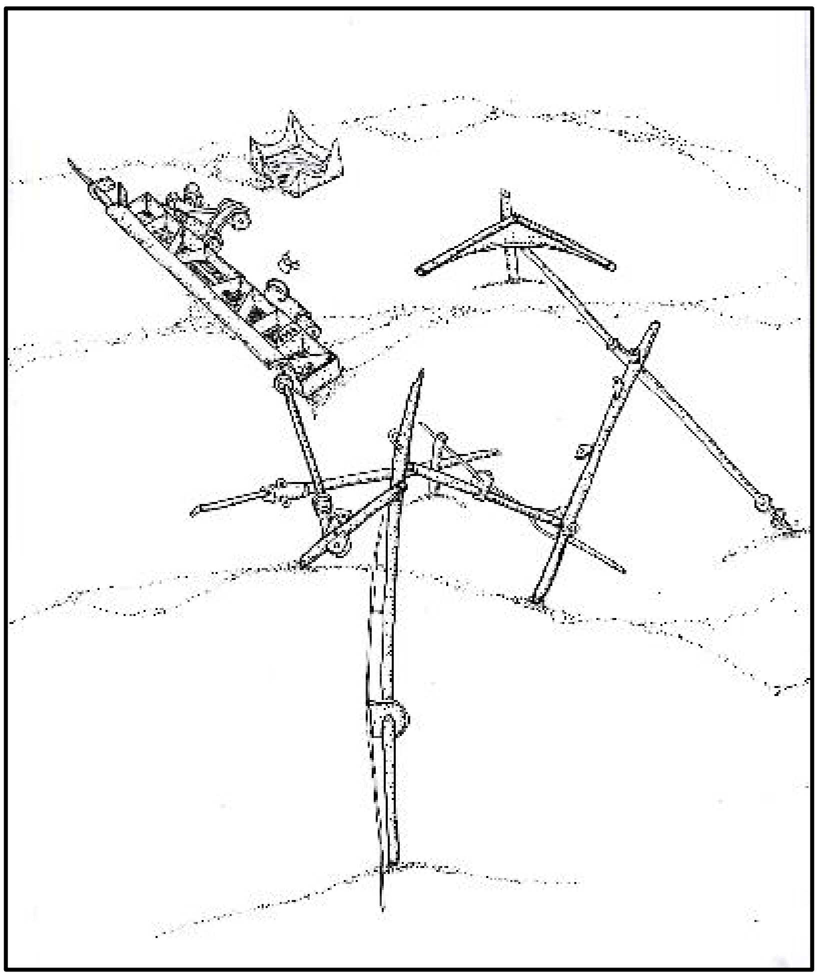

Figure 173. Exposed machinery and rigging at HP S4B trawler site.

Figure 174. Engine bed with attached generators at HP S4B trawler site.

Figure 175. Engine bed with attached starter motor at HP S4B trawler site.

The remaining magnetic anomalies are generally representative of small objects and with three exceptions (004-3, 008-1, and 010-2) are rated low for potential association with submerged cultural resources. That rating is due to the extensive amount of debris associated with the wrecked trawler. The three moderate-size anomalies are rated higher as there are both documented terrestrial structures and small vessels lost at Hewes Point in association with private and government facilities. In the event that borrow sites in the vicinity are used, a more thorough remote-sensing investigation should be carried out to better assess the potential for adverse impacts to unidentified submerged cultural resources.

4.3.4. Secondary Area 4A

The Hewes Point Secondary Area 4A (HP S4A) is located immediately east of the light tower off the northern end of the Chandeleur Islands (Figure 176; Figure 177). HP S4A was selected for remote sensing primarily due to the possible association of bottom surface debris with ballast or similar material possibly associated with the previous Hewes Point lighthouse, associated structures, or vessel remains. In addition, HP S4A was located near the previously permitted borrow area CH-C (see Table 2). HP S4A was surveyed on September 14, 2013.

Line-by-line analysis of the magnetic data generated during the HP S4A survey identified 20 magnetic anomalies (Figure 178; Volume III: Appendix II). Analysis of the acoustic data identified two scatters of debris on the bottom surface. Two sonar targets and one sub-bottom feature were identified in the acoustic data (Figure 179; Volume III: Appendix JJ).

Fourteen of the twenty magnetic anomalies (009-2, 009-3, 009-4, 009A-2, 011-1, 011-2, 013-2, 013-3, 013-4, 013-5, 015-2, 015-3, 015-4, and 015-5) form a broad scatter over the center of the survey area. Those fourteen magnetic anomalies are included in Buffer A and are in the same vicinity of the two sonar targets, SS 002 and SS 003 (Figure 180).

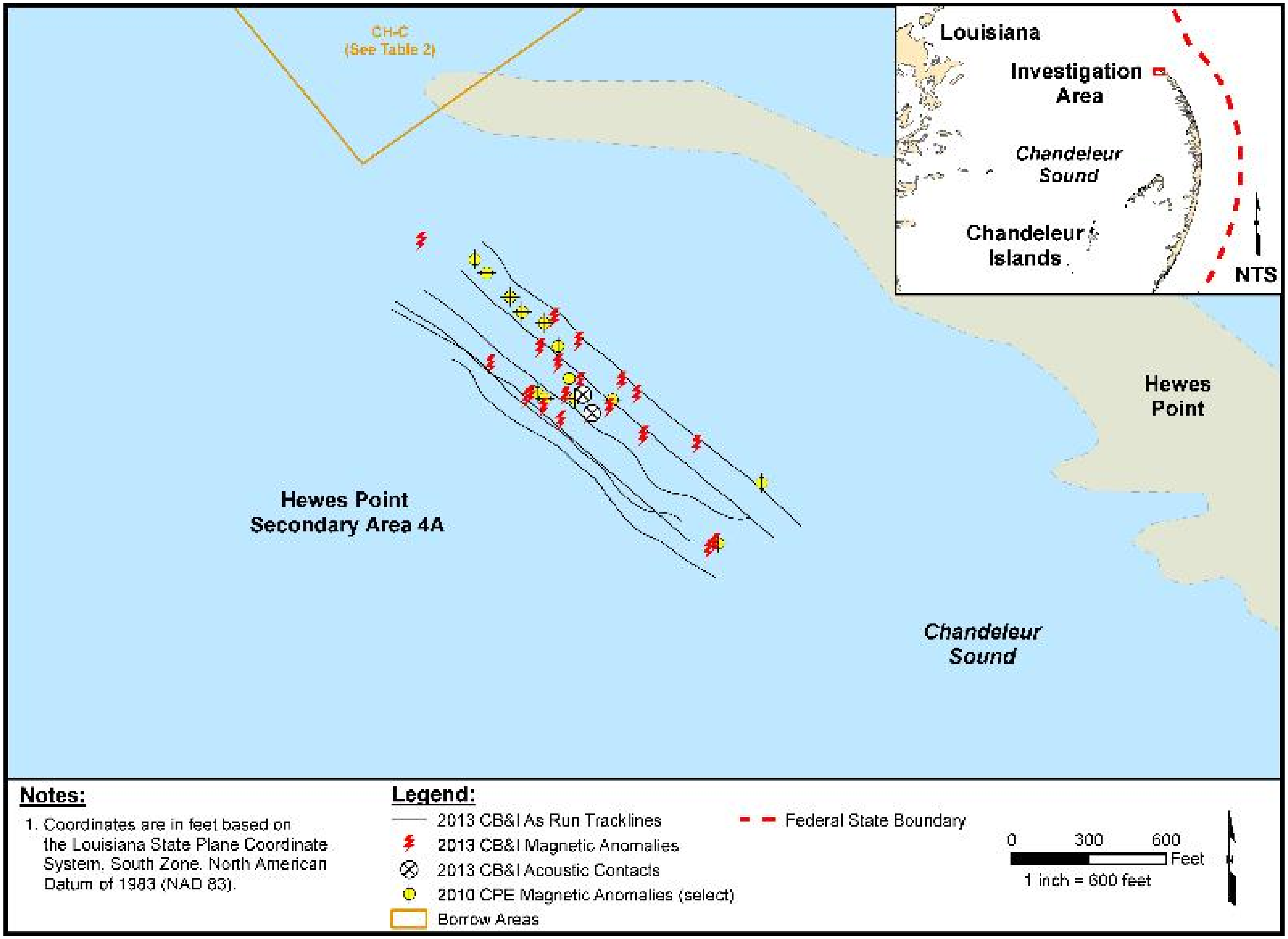

Figure 176: Magnetic anomalies and acoustic targets identified in Hewes Point Secondary Area 4A.

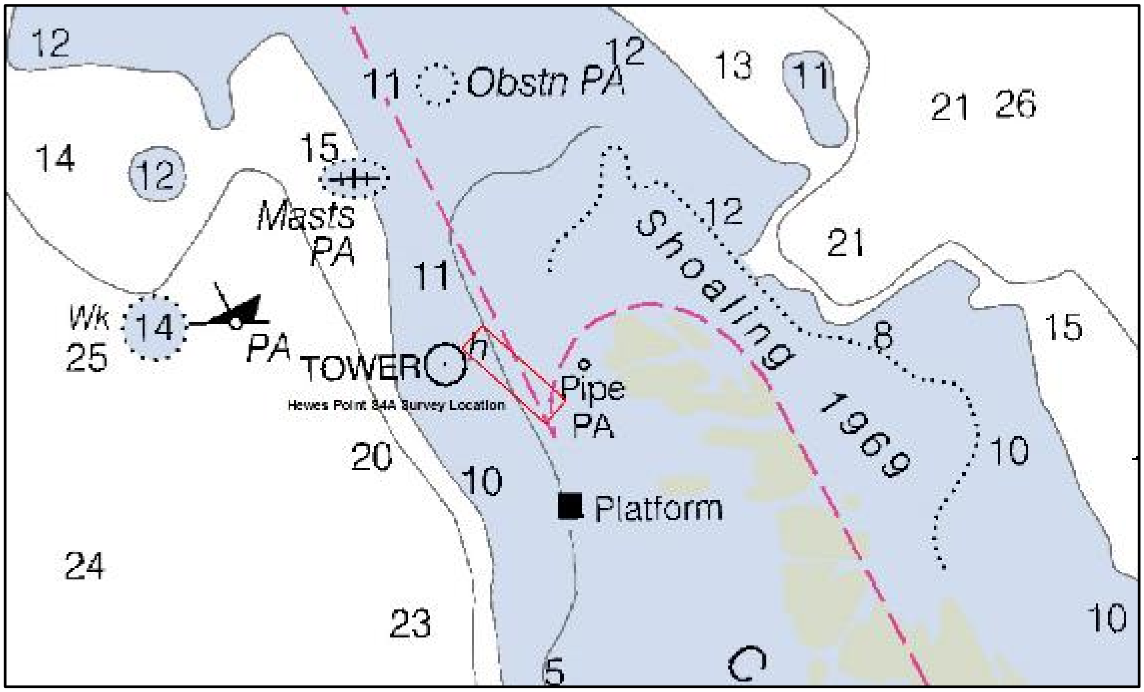

Figure 177. HP S4A survey location.

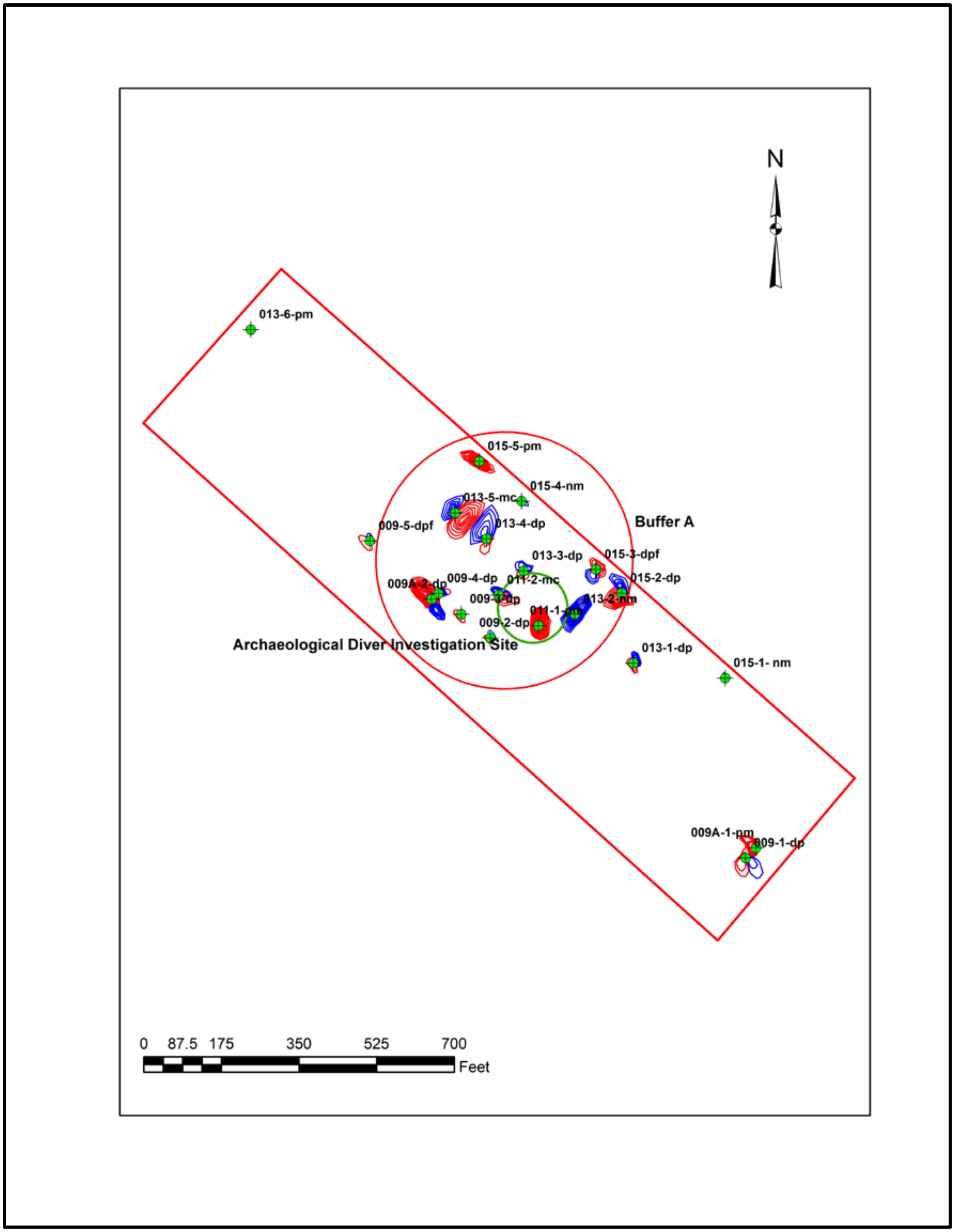

Figure 178. HP S4A magnetic anomalies, contours and Buffer A.

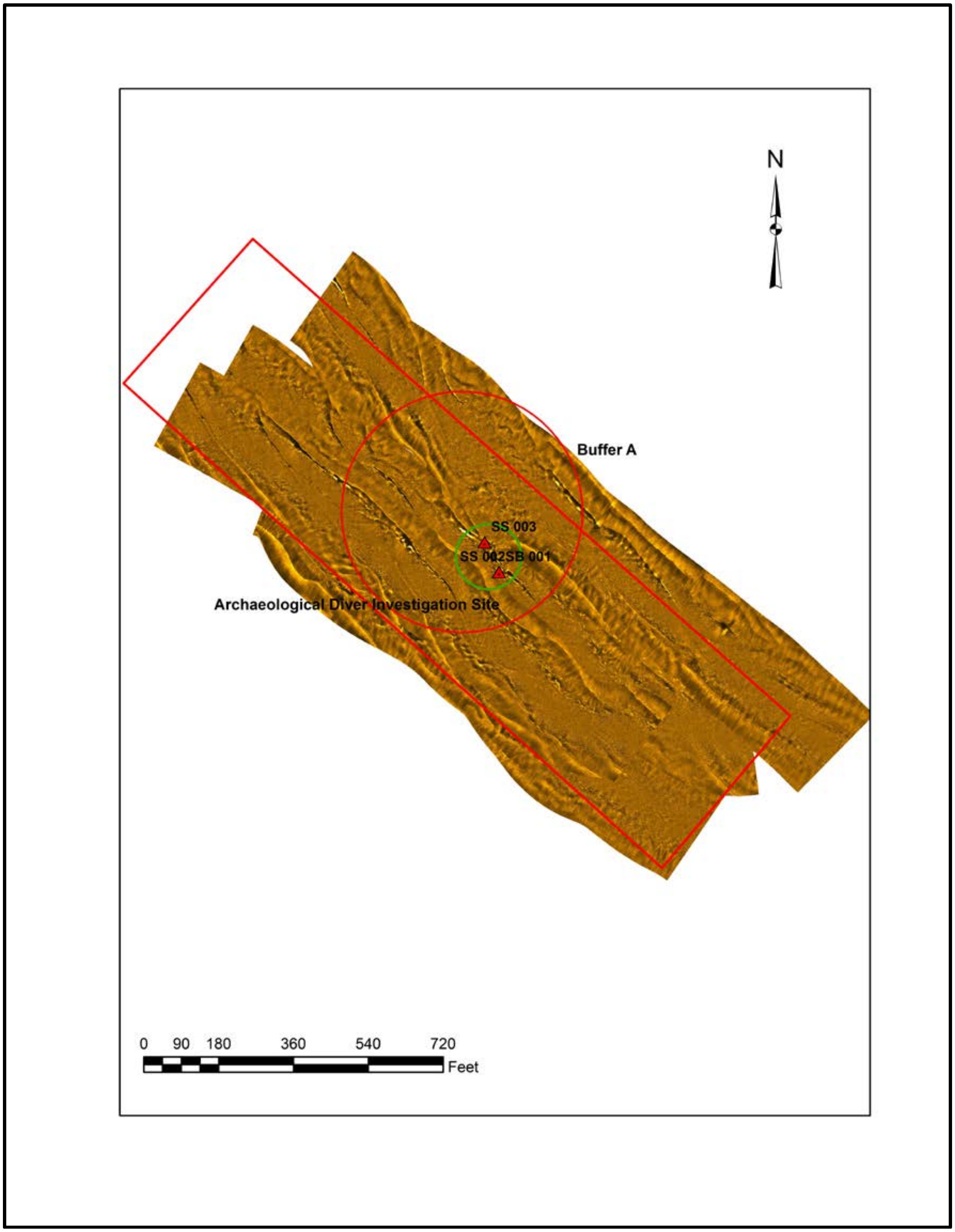

Figure 179. HP S4A sonar coverage mosaic with acoustic targets.

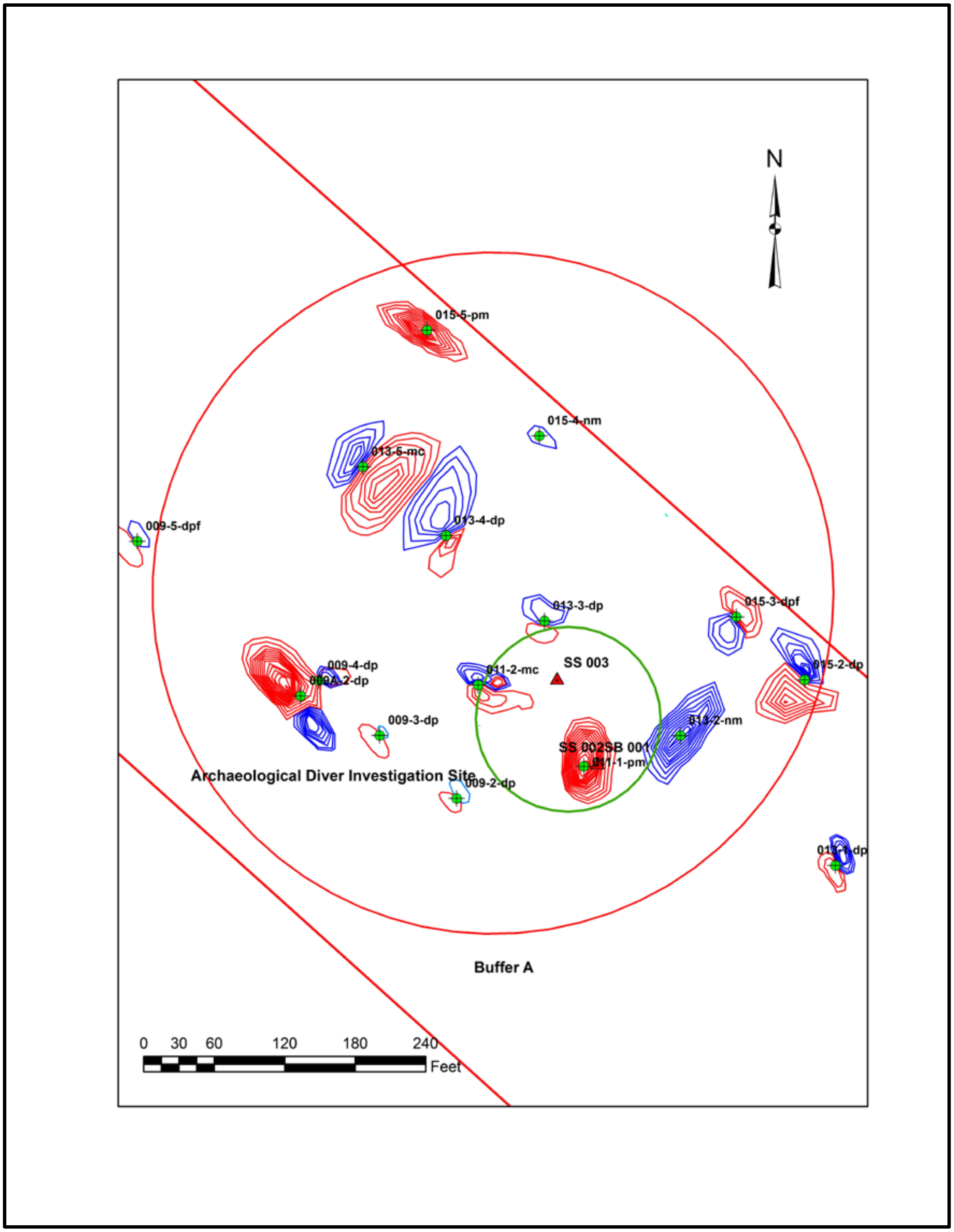

Figure 180. HP S4A magnetic anomalies, contours, acoustic targets, and archaeological diver investigation site within Buffer A.

With the exception of two magnetic anomalies (009-5 and 015-1) that represent very small single objects, the remainder (009-1, 009A-1, 013-1, and 013-6) have a moderate potential for association with submerged cultural resources. That determination is based on historical documentation of the private and government facilities and associated vessels that were periodically destroyed on Hewes Point by weather events.

Analysis of the acoustic data identified two sonar targets and one sub-bottom feature within two clusters of bottom surface debris in the vicinity of the magnetic anomalies (Figure 181; Figure 182). Sub-bottom profiler data in the vicinity of the cluster sites produced no additional insight into the nature of the targets and anomalies (Figure 183).

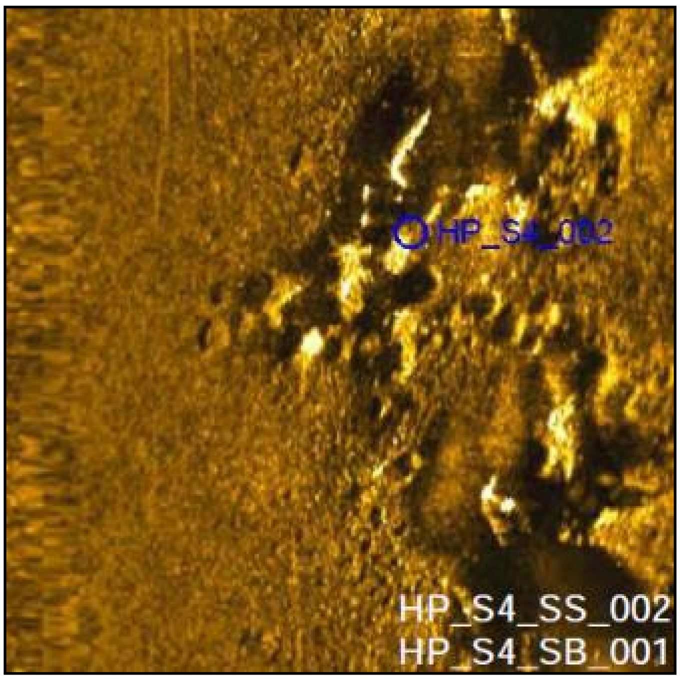

Figure 181. HP S4A sonar target SS 002.

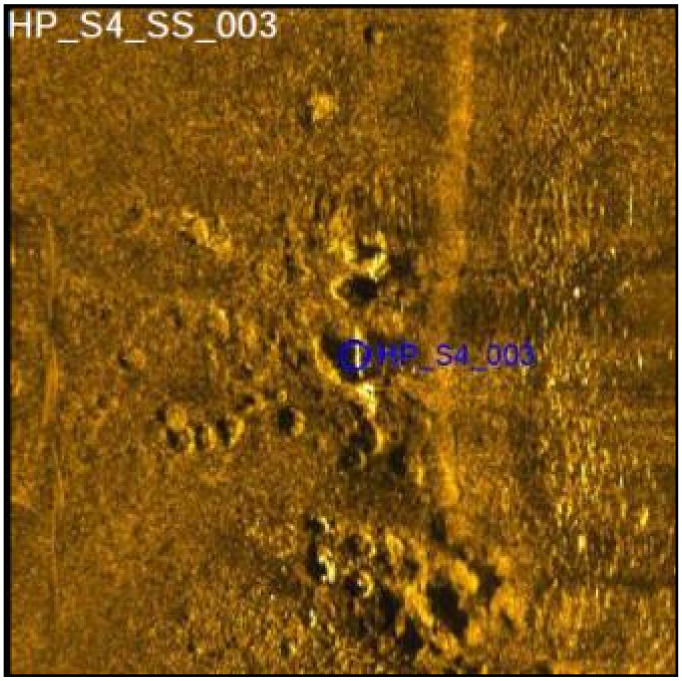

Figure 182. HP S4A sonar target SS 003.

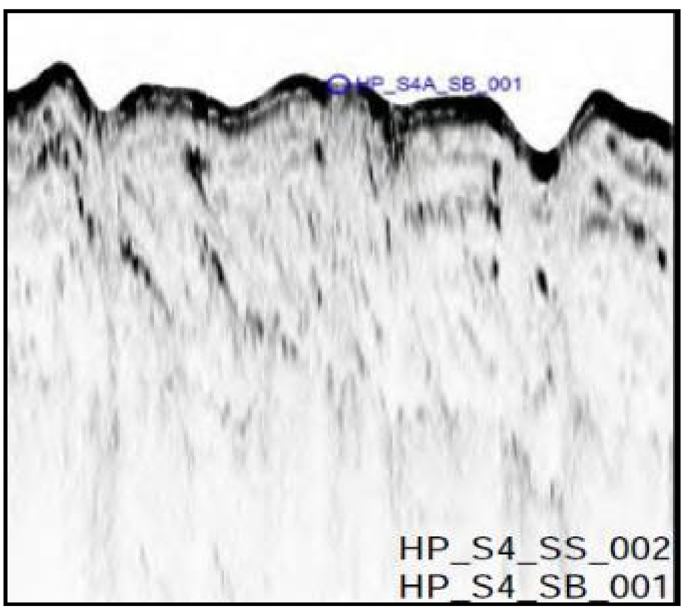

Figure 183. HP S4A sub-bottom image SB 001.

An archaeological diver investigation at the site was carried out on September 14, 2016. Material exposed on the bottom surface was considerably less than that documented in the 2013 sonar images. As much as three feet of sediment consisting of silt and mud appears to have migrated into the area during that period. The most predominant exposed feature investigated by divers proved to be fragments of a structure. A jet probe was used to improve very limited visibility and expose enough of the structure to confirm that it was composed of large brick or cut stone concreted together with mortar. The bricks or stones measured roughly sixteen inches in length and six inches in width. The subject feature appears to represent a terrestrial structure such as a lighthouse base, chimney foundation, or cistern.

The remaining magnetic anomalies, although generally representative of small objects, are rated moderate for potential association with submerged cultural resources. That rating is due to the extensive amount of documented terrestrial structure and vessels lost in association with private and government facilities on Hewes Point.

The potential for association with vessel and/or terrestrial structural remains appears high for all of the buffered anomalies. Archaeological diver investigation carried out in HP S4A confirmed that significant features could survive at the site. In the event that dredging or other bottom-disturbing activity in the vicinity is authorized and the site cannot be avoided, future archaeological investigation is highly recommended. An additional investigation should be designed to identify material generating additional signatures and to assess its significance in terms of NRHP eligibility.

4.4. St. Bernard Shoal

4.4.1. Primary Areas 1 and 2

St. Bernard Shoal Primary Area 1 (SBS P1) and St. Bernard Shoal Primary Area 2 (SBS P2) were selected for remote sensing due to previously identified and buffered anomalies (Figure 184; Figure 185). A substantial portion of SBS P1 is located within the previously permitted borrow area SB-D (see Table 2). A less substantial portion of SBS P2 is located within the previously permitted borrow area SB-E (see Table 2). Both areas were surveyed at the same time due to their immediately adjacent locations. That survey was carried out on September 14 and 15, 2013.

Line-by-line analysis of the magnetic and acoustic data generated during the survey identified 13 magnetic anomalies (Figure 186; Volume III: Appendix KK). One sonar target and one associated sub-bottom feature were identified in the acoustic data (Figure 187; Volume III: Appendix LL).

Two clusters of SBS P1/SBS P2 magnetic anomalies have collective signature characteristics that have a high potential for association with vessel remains. Eight magnetic anomalies (008-2, 009-1, 010-1, 011-1, 012-1, 013-1, 014-1, and 101-1) form a cluster with a high potential for association with shipwreck remains (Figure 188). Those anomalies are identified as Buffer A.

Three additional magnetic anomalies have collective signature characteristics with a high potential for association with vessel remains. Those anomalies (006-1, 007-1, and 008-1) form a cluster identified as Buffer B (Figure 189). Sonar Target SS 001 (Figure 190) and sub-bottom feature SB 001 (Figure 191) are not associated with any magnetic anomalies and appear to represent a partially buried geological feature. The featured image, SB 001, illustrates sediment-filled relict landforms.

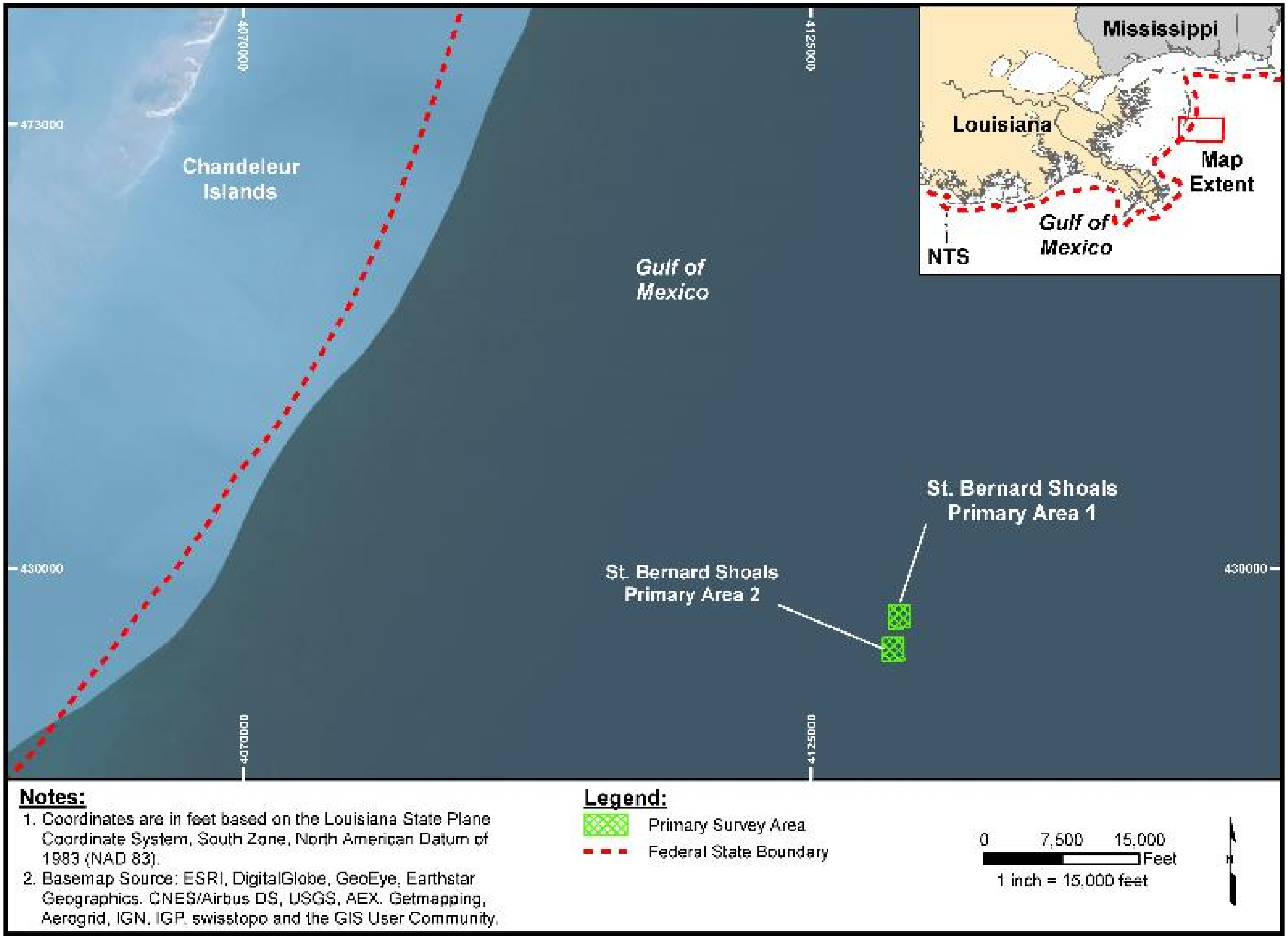

Figure 184: St. Bernard Shoals study area.

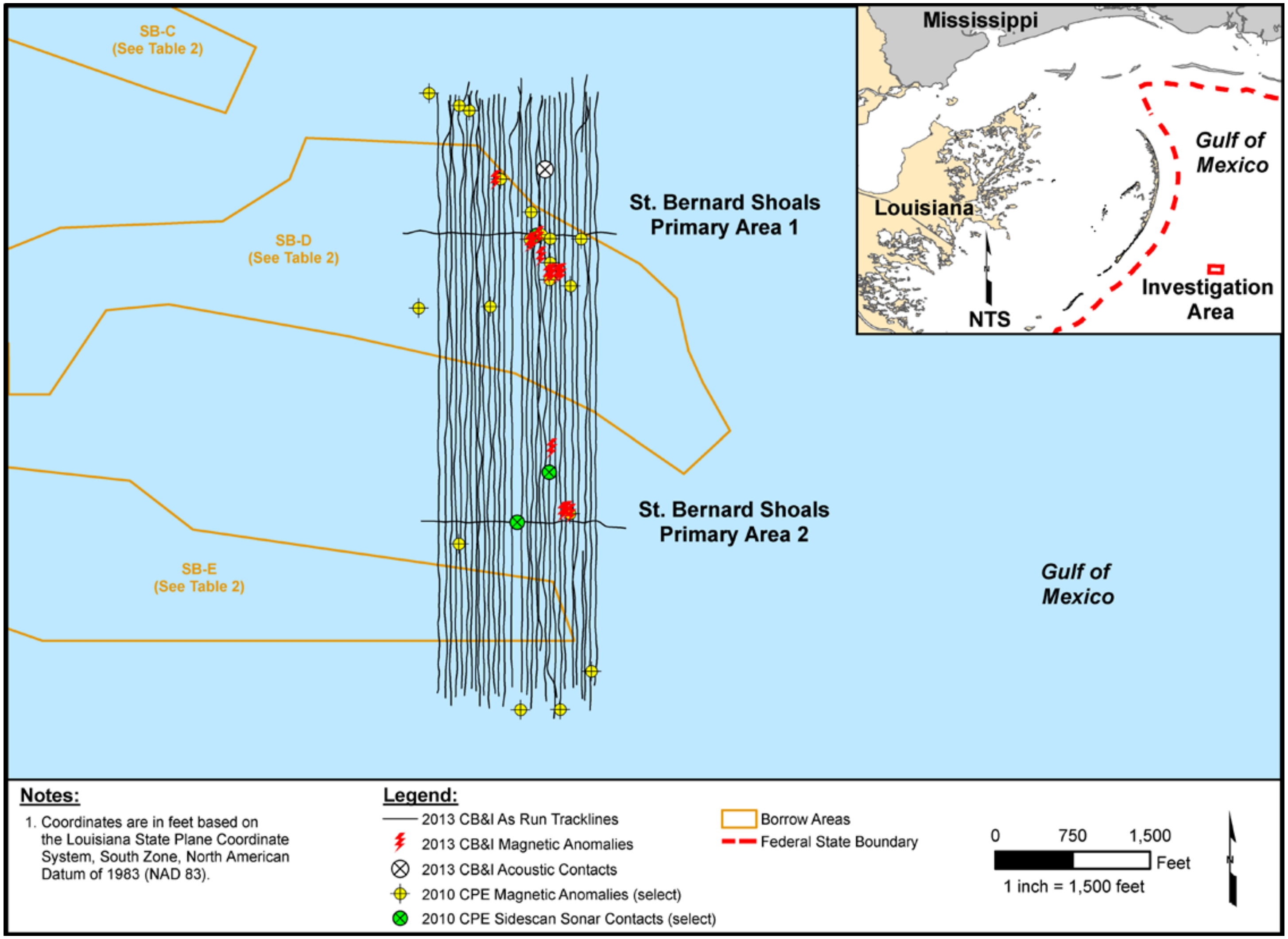

Figure 185: Magnetic anomalies and acoustic targets identified in St. Bernard Shoals Primary Areas 1 and 2.

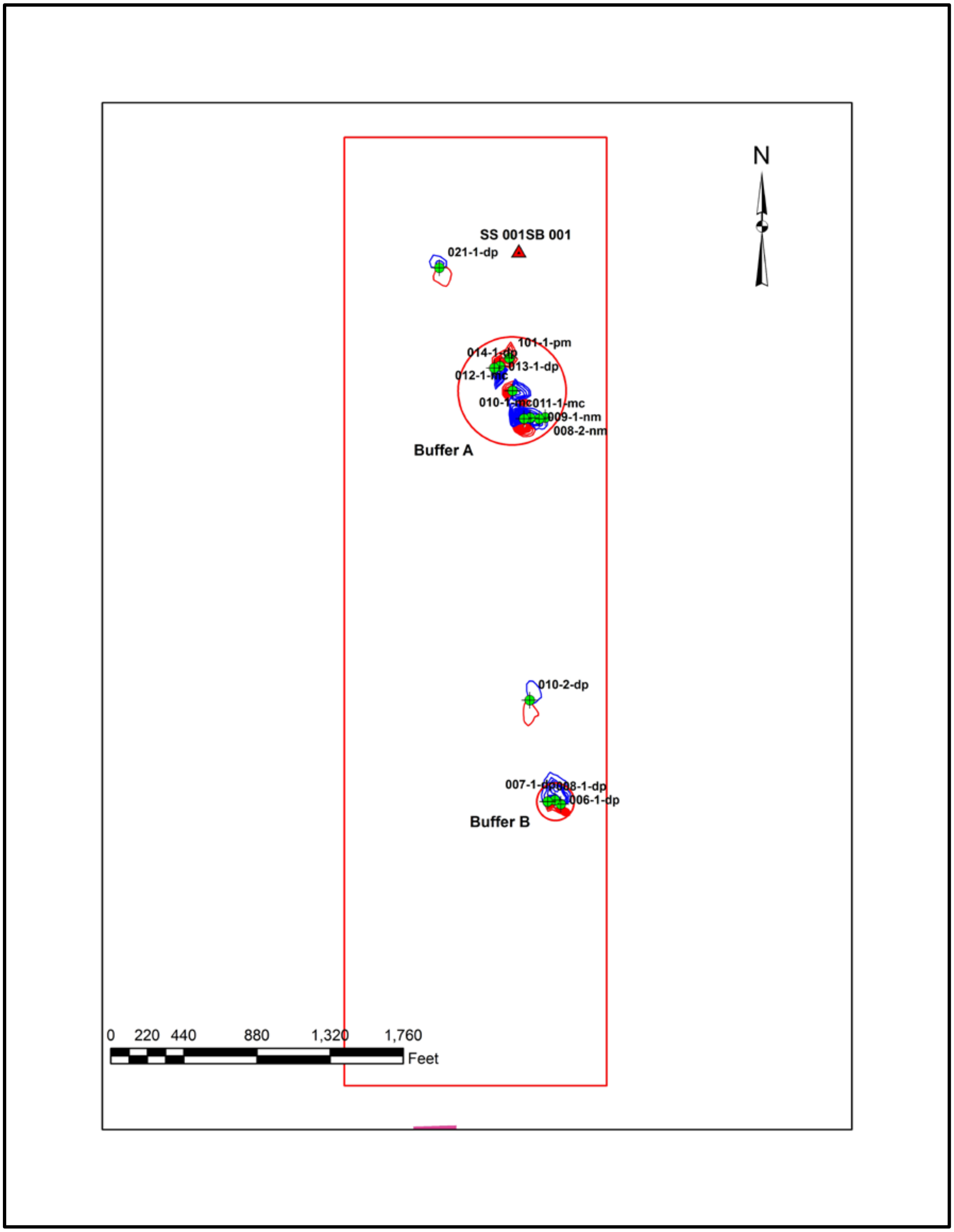

Figure 186. SBS P1/SBS P2 magnetic anomalies, contours, and buffers.

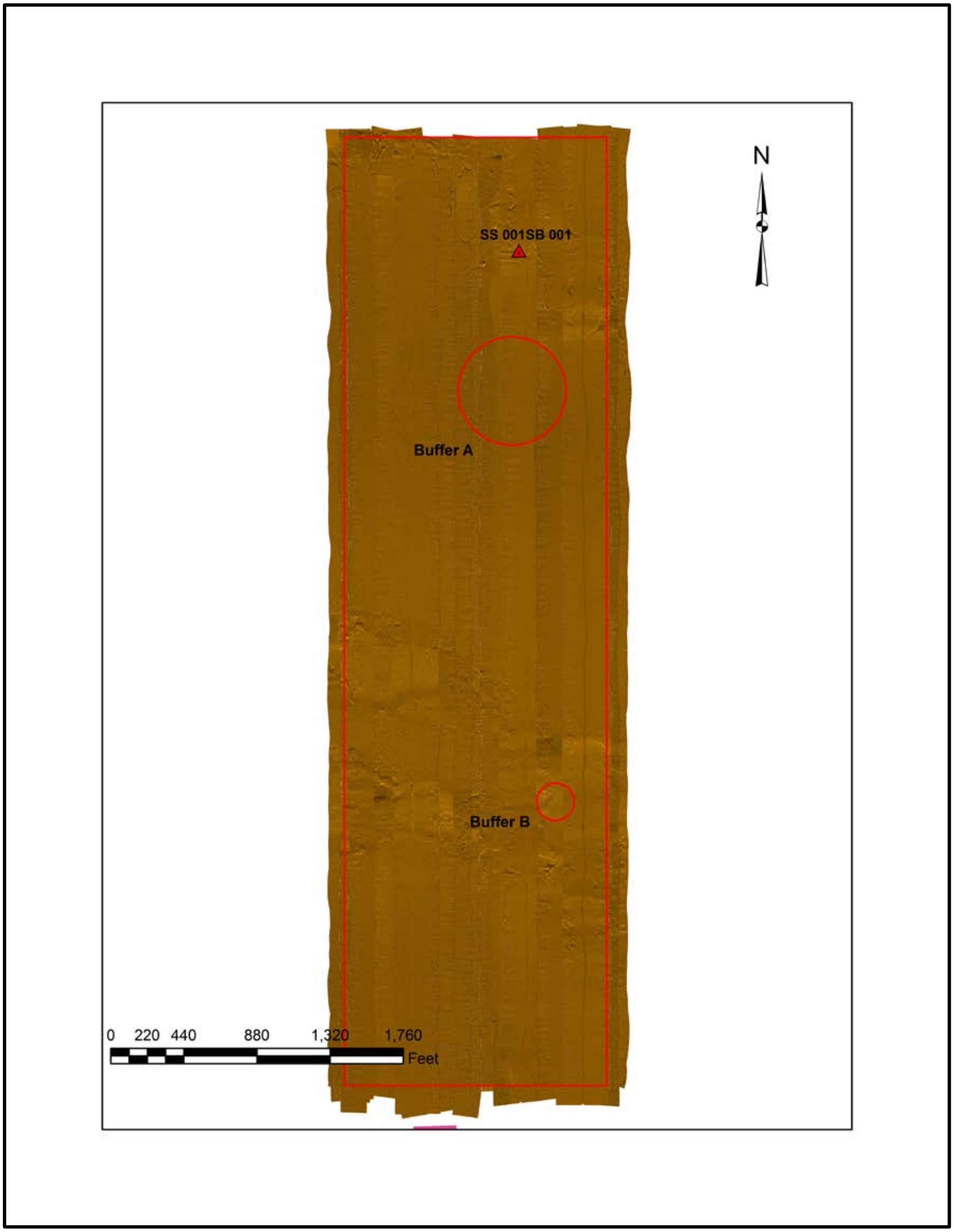

Figure 187. SBS P1/SBS P2 sonar coverage mosaic with acoustic targets.

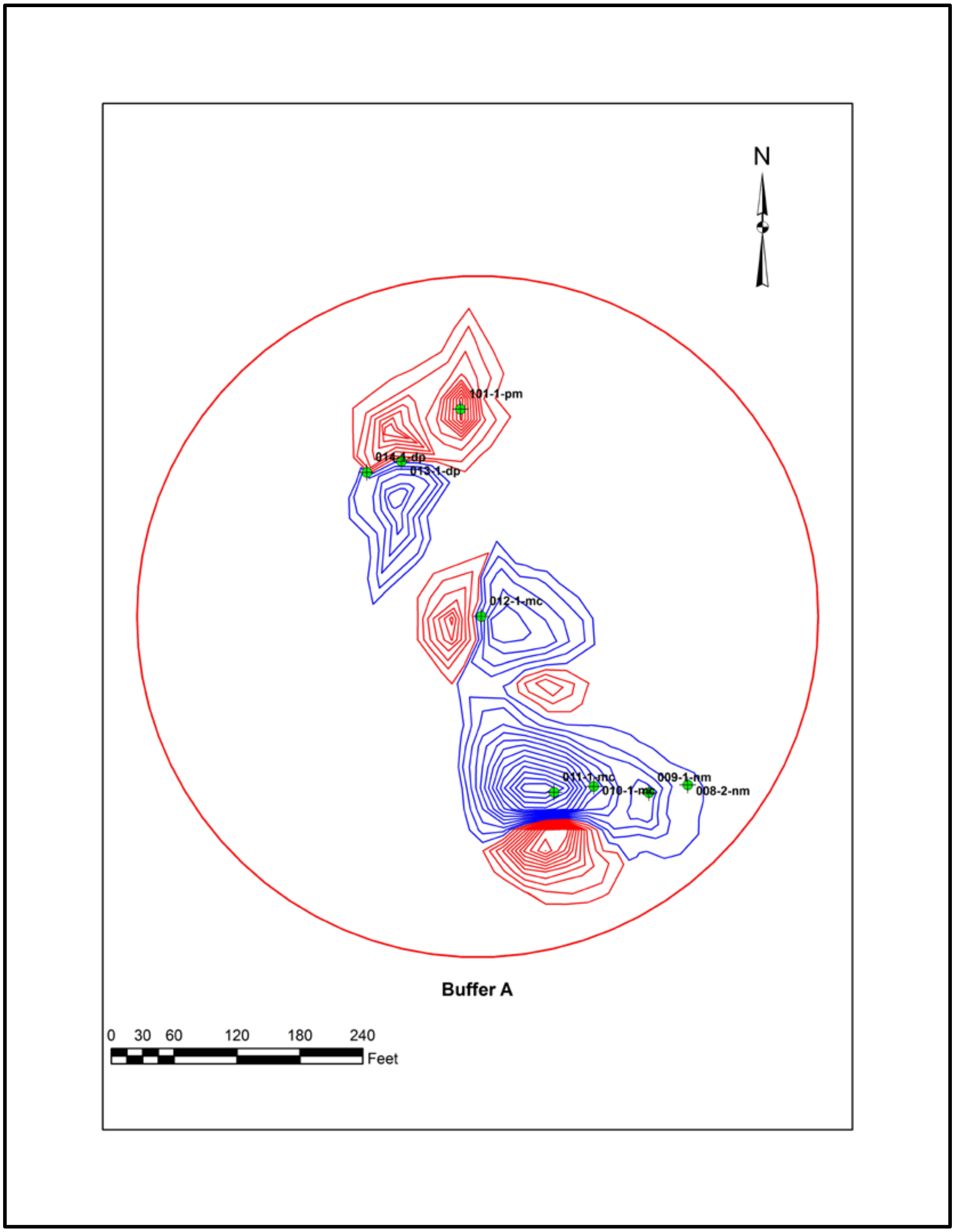

Figure 188. SBS P1/SBS P2 magnetic anomalies and contours within Buffer A.

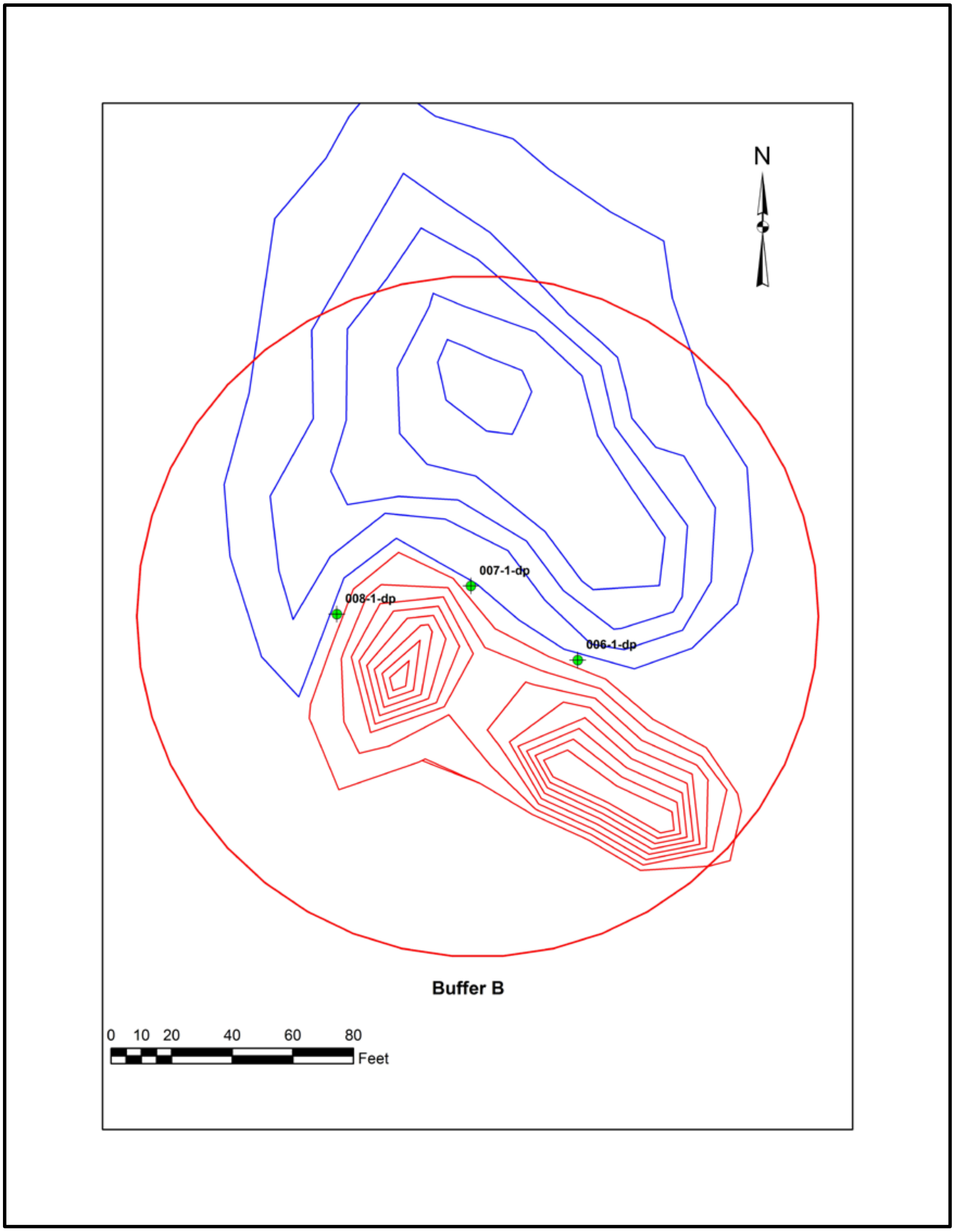

Figure 189. SBS P1/SBS P2 magnetic anomalies and contours within Buffer B.

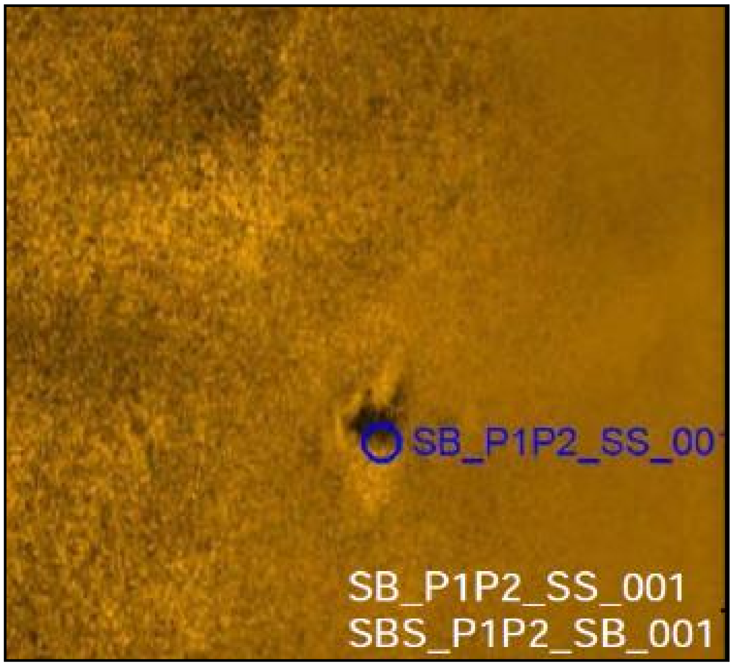

Figure 190. SBS P1/SBS P2 sonar target SS 001.

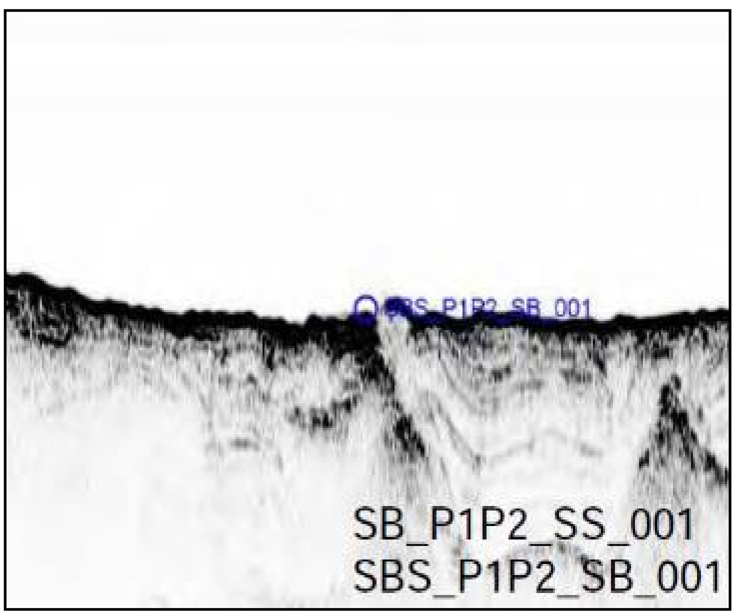

Figure 191. SBS P1/SBS P2 sub-bottom image SB 001.

The remaining two magnetic anomalies (010-2 and 021-1) in the SBS P1/SBS P2 survey area appear to represent single objects. Their signatures do not have more complex characteristics or clustering that is more commonly associated with shipwreck signatures. Magnetic anomaly 021-1 is located within a borrow area previously permitted and dredged. This consideration could significantly increase the chance that the source of that anomaly is modern dredging-related debris.

There is a distinct possibility that magnetic anomalies and sonar targets identified in the SBS P1/SBS P2 survey data could represent vessel remains. Though the magnetic anomalies in Buffer B lie outside two previously permitted borrow areas, Buffer A lies entirely within a previously permitted site. That suggests that the source of Buffer A anomalies could also be associated with dredging-related debris. An archaeological diver investigation was not carried out at either of the buffer sites in conjunction with this project.

In the event that dredging or other bottom-disturbing activity in the vicinity is authorized and Buffer A and Buffer B cannot be avoided, future archaeological investigation is recommended. Additional investigation should be designed to identify material generating additional signatures and to assess its significance in terms of NRHP eligibility.

The St. Bernard Shoal area anomalies were not identified as priority sites for archaeological diver investigation during the current project as those borrow areas were not considered to be immediate candidates for dredging.

4.5. Chandeleur Islands

4.5.1. Ballast and Cannon Site

The relocation of the eighteenth-century ballast pile site investigated by the Texas A&M Research Foundation in conjunction with, and sponsored by, the MMS in 1989 was a high priority due to the significance of the site and its proximity to potential borrow areas (Garrison et al. 1989). Captain Kenny Barhanovich identified the ballast pile in early 1988. Fish schooling over the ballast pile initially attracted Captain Barhanovich and the site became a productive location for fishermen aboard his charter vessel, *Miss Hospitality*. After diving identified the habitat as a ballast pile with associated cannons, Captain Barhanovich and Mr. Derrick Groves reported their discovery and news reached MMS archaeologists (Barhanovich, pers. comm., September 18, 2016).

Under the direction of Dr. Ervan Garrison, the team consisting of C. P. “Chuck” Giammona, James “Jim” Jobling, E. N. “Eri” Weinstein, Anthony R. “Tony” Tripp, and Gary A. Wolff organized an investigation of the site first identified by Captain Barhanovich. The “Eighteenth Century Ballast Pile Site” provided the “first opportunity to obtain scientifically acquired data on a possible historic shipwreck in the east-central MMS planning areas” (Garrison et al. 1989a:1).

Investigation of the ballast pile site would test what Garrison identified in a previous study as “Task I (shipwreck potential) and Task II (instrumental characterization) models” (Garrison et al. 1989a:1). To generate data to test those hypotheses, Garrison and his team adopted a methodology based on;

1. A magnetic and side-scan sonar survey of the site,
2. Groundtruthing and reconnaissance level survey of the site, and,
3. Mapping and recovery of a small suite of identifiable and chronologically datable material from the site (Garrison et al. 1989a:3-2).

The remote-sensing survey was directed by Bill Crow and generated acoustic images of the ballast pile and magnetic signatures of the site developed on the basis of varying survey line spacing. A Del Norte microwave-positioning system was provided and operated by Rob Floyd to collect positioning data (Garrison et al. 1989a:3-2). Project specific grids were established to identify survey lines for vessel navigation and data collection (Figure 192).

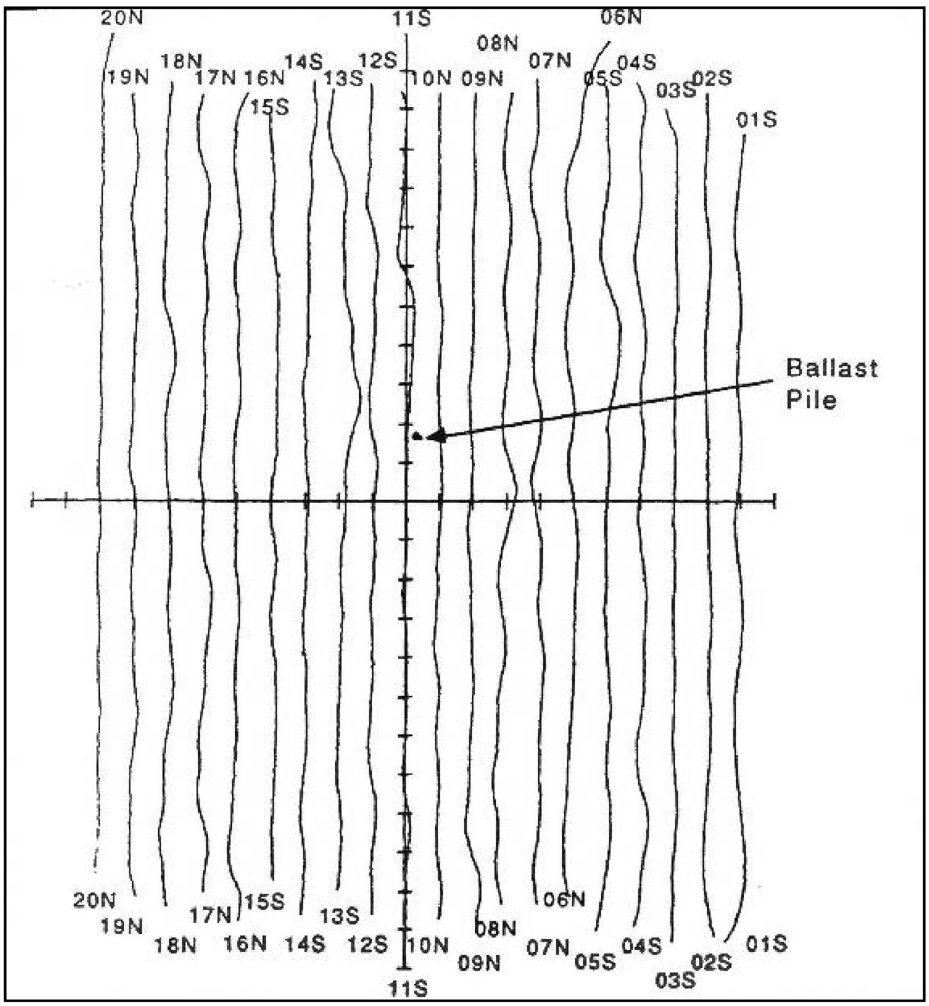

Figure 192. As-run vessel tracks on survey lines established using microwave ranging system.

Contouring the magnetic data from 100-meter and 50-meter survey lines failed to provide a significant indication of the ballast pile and associated cannons (Garrison et al. 1989a:6-13). However, contouring the data collected on 10-meter survey lines clearly characterized the ballast site as a 68-gamma dipolar signature. The data also identified two additional dipolar signatures; a 78-gamma dipole northwest of the ballast pile and a 100-gamma dipole southeast of the ballast pile (Figure 193).

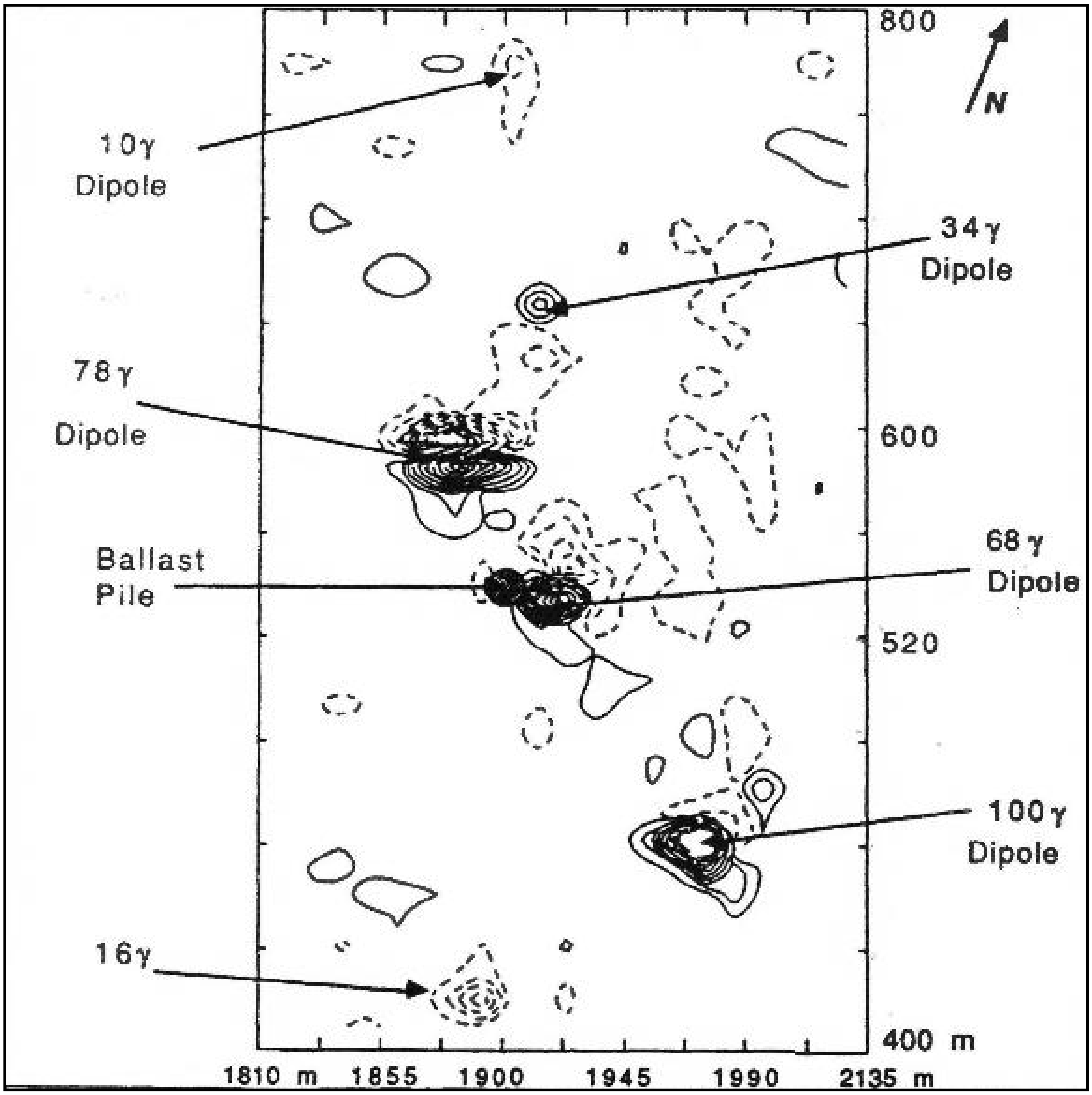

Figure 193. Magnetic signature of ballast and cannon site, and geographically associated magnetic anomalies.

Groundtruthing by diver investigation confirmed a ballast pile approximately 44 feet in length, 33 feet in width, and 3 feet in height. Six iron cannons were scattered on top of the ballast (Figure 194). Test excavations at the site generated a collection of ballast stones, red clay tile fragments, iron concretions, lead pipe and patches, and fragments of ceramics that included lead glazed earthenware and salt glazed stoneware. Analysis of the ceramic samples suggested a date around the second quarter of the 18th century (Garrison et al. 1989a:7–11).

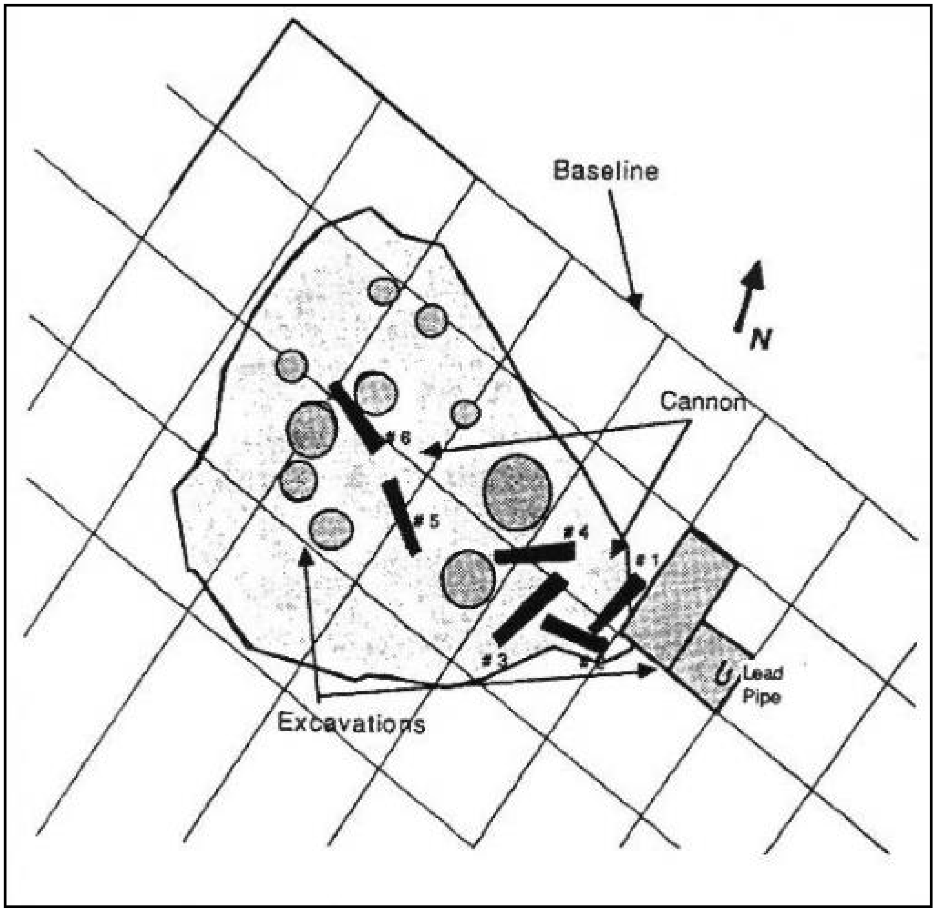

Figure 194. Site plan from 1989 investigation showing location of the cannons and test excavations.

All of the cannons were cast iron and either three or four-pounders based on their bore diameters. The right trunnion on cannons #2, #3, and #6 contained the maker's mark IEC confirming Swedish manufacture by Ehrencreutz. Similar IEC marked cannons were recovered from the shipwreck site identified as *Queen Anne's Revenge* lost off the North Carolina coast in 1718 (Figure 195). The presence of the fleur-de-lis symbol suggests the cannons may have been produced for, captured by, or in use aboard a French vessel.

The cannons' size, manufacturer's marks, and design aligned with a date around the first quarter of the 18th century. Two cannons, #4 and #6, were recovered and transported to Texas A&M University for cleaning and conservation (Figure 196). Zinc anodes were attached to the remaining cannons by stainless steel hose clamps to test the effectiveness of in-situ conservation (Garrison et al. 1989a:4-9).

Figure 195. Comparison of *Queen Anne's Revenge* cannon (top) with one of the Chandeleur site's cannons recovered in 1989.

(Enhanced image courtesy Nathan Henry, North Carolina Underwater Archaeology Branch.)

Figure 196. Cannon recovered in 1989 from Chandeleur ballast pile.

(Courtesy Jim Jobling, Texas A&M University Conservation Research Laboratory.)

Although surviving copies of the Garrison et al. (1989b) report are very detailed, none have geographical coordinates for the "Ballast Pile Site," the sonar imagery, the magnetic data contours, or the locations of test excavations and recovered cannons. All extant copies were redacted to protect the site location. Unfortunately, all documents with coordinates and records associated with the field investigation that contained geographical information disappeared as time passed in conjunction with personnel changes.

To relocate the site, considerable effort went into searching for records and interviewing personnel involved in the 1989 investigation. Information received from Dr. Garrison included latitude–longitude coordinates for the site, and these were converted to Louisiana South, NAD 83, U.S. Survey Foot, State Plane coordinates. When included in a GIS project, set up to manage data related to relocating the site, it was apparent that the location was too far offshore of the Chandeleur Islands and in water much deeper than the 7 meters (23 feet) reported by Garrison. The 1989 report located the site "1.5 km east" (0.8 nautical miles) and "approximately five nautical miles (9 km) south of the northern tip of the island chain" in Garrison et al. (1989b) (Figure 197). In addition, data generated by a remote-sensing survey of the site (HP S3) identified no corroborating data in the vicinity of the coordinates.

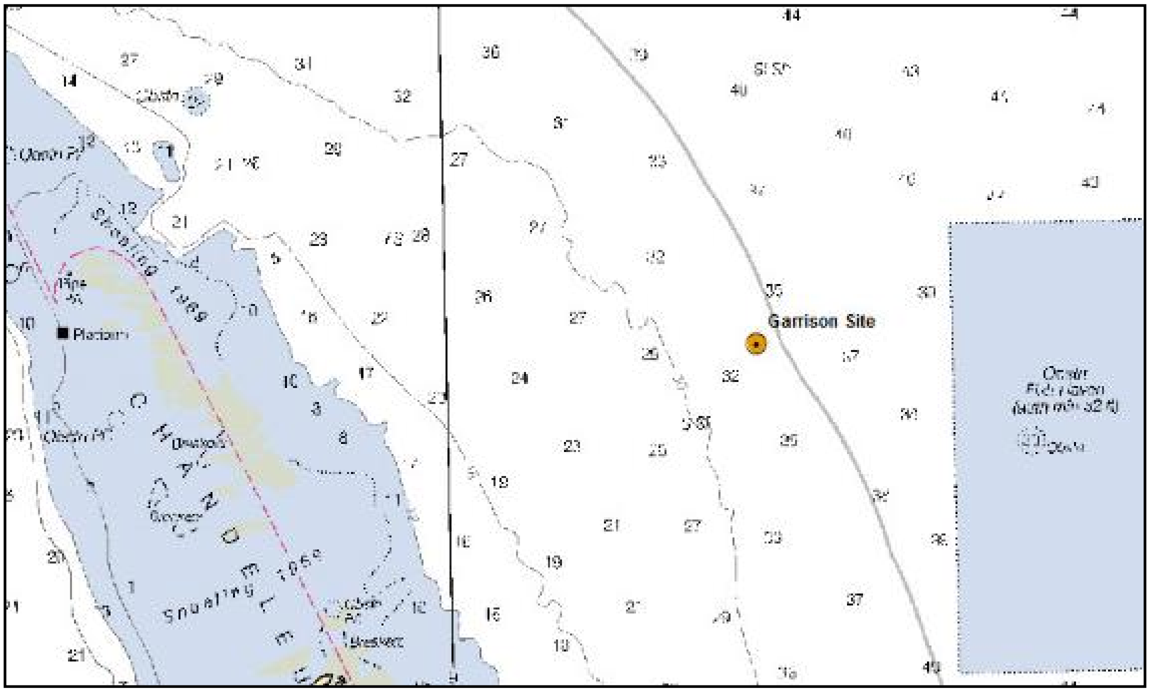

Figure 197. Location of reported "Ballast Pile Site" coordinates provided by Garrison.

Contact with Jim Jobling at the American Institute for Nautical Archaeology conservation laboratory at Texas A&M University produced additional insight into the water depth, distance offshore, and his 1989 efforts to attach zinc anodes to the cannons. Jobling contacted Gary Wolff, Dr. Eri Weinstein, and Tony Tripp to convey the authors' request for site location information. Fortunately, Tripp shared several LORAN C time/distance (TD) coordinates from field material in his possession. The new coordinates were converted to Louisiana South State Plane, NAD 83, U.S. Survey Foot coordinates and included in the project GIS.

Although converting LORAN C TD coordinates to Louisiana South, NAD 83, U.S. Survey Foot, State Plane could contain a geographical error factor as much as ¼ mile, Tripp's location was much more realistic and fell within an acceptable triangulation factor for data collected using a Del Norte microwave-positioning system. The charted location of the converted LORAN coordinates also fell closely within the water depths, distance offshore and distance from Hewes Point identified in the 1989 report text (Garrison et al.: 1989b: v, 6.1, 6.5, 7.23 and 7.26). Tripp also had LORAN C coordinates for the north microwave transmitter and a distance to the south microwave transmitter. In an effort to reduce the size and refine the location of the modern survey area, several conversion programs were used to convert 1989 LORAN C coordinates.

Once a "best guess" site was defined, a survey area border was identified. The Primary survey area was scaled and oriented to produce a "best fit" with the same 50 meter (164 ft.) line spacing used in the preliminary survey area investigated by the Texas A&M University Foundation team under Crow's supervision. A survey border and lines were created in Hypack® survey software in an effort to replicate the 1989 survey. The new survey area was investigated using a cesium vapor magnetometer and the BOEM high-resolution sidescan sonar on September 8, 2016 (Figure 198).

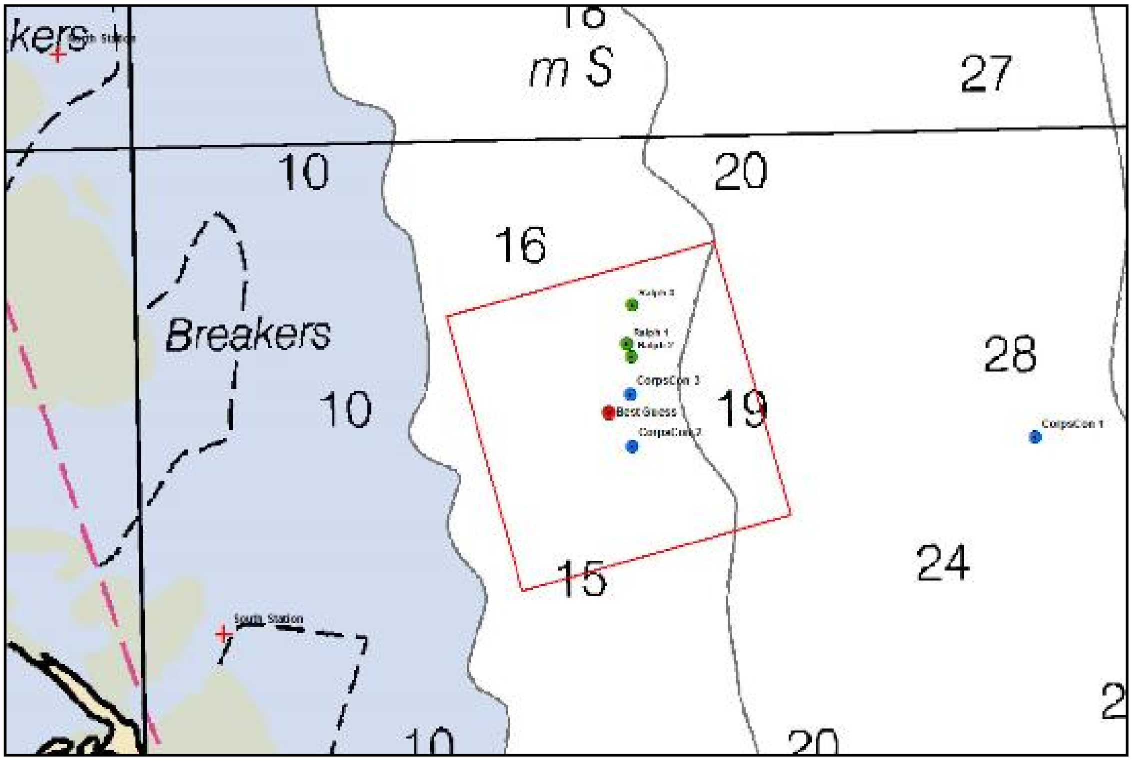

Figure 198: "Best guess" center-point location for survey area with border designed to replicate 1989 area surveyed at 50 meters (164 ft.).

On-board analysis of the magnetometer data identified seven magnetic anomalies (Figure 199; Volume III: Appendix MM). Sonar data from the Primary survey area identified no targets and produced no additional insight into the source of the magnetic anomalies.

In the field, offset lines were set up in Hypack® to collect additional data in an area where only one potentially significant magnetic anomaly was detected (Primary Offset survey area). Data from those lines identified two additional magnetic anomalies (Volume III: Appendix MM). Both were geographically associated with the magnetic anomaly identified during the Primary line survey earlier in the day (Figure 200). Sonar data from the Primary Offset survey area lines identified no targets and produced no additional insight into the source of the magnetic anomalies.

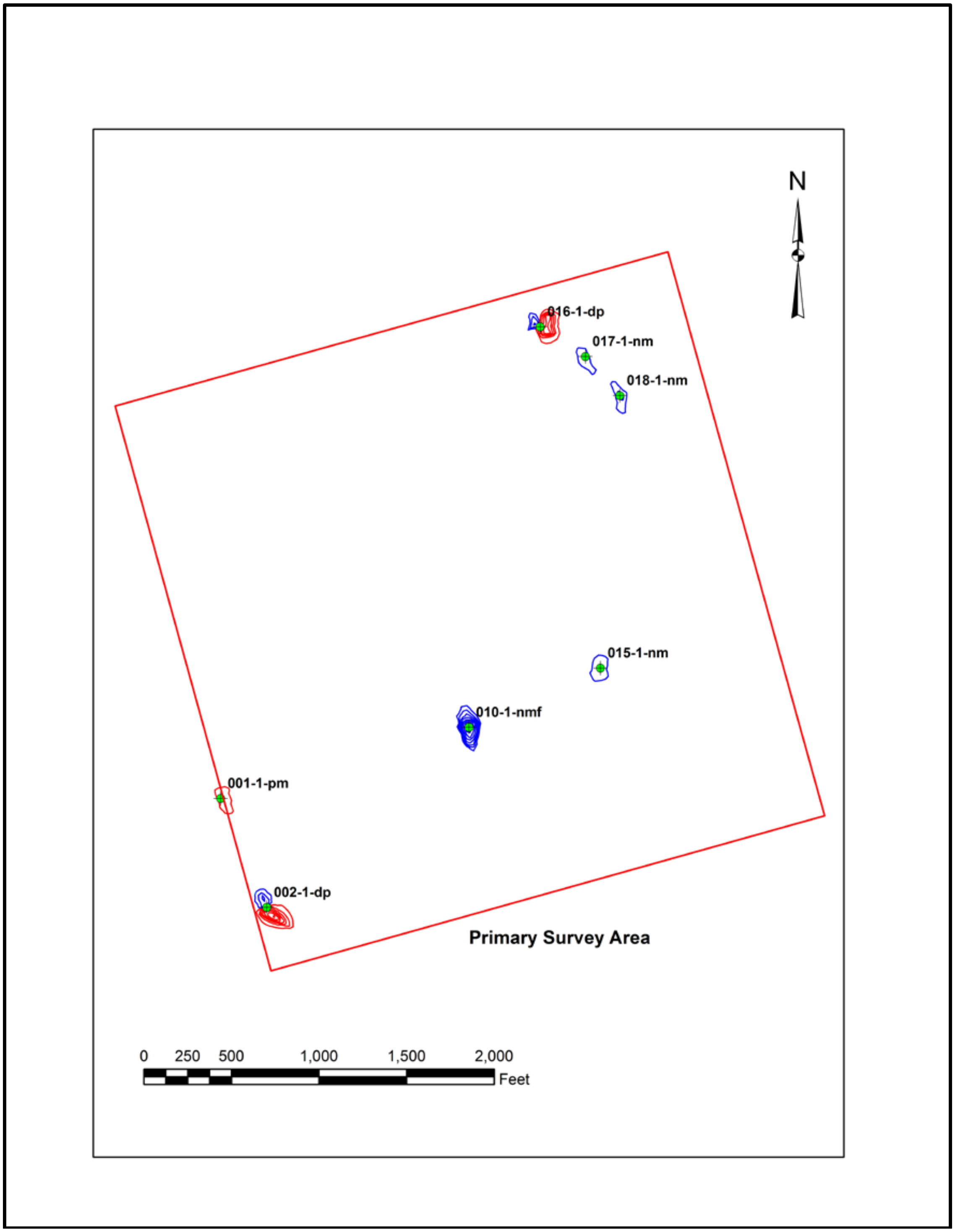

Figure 199. Primary survey area magnetic anomalies and contours.

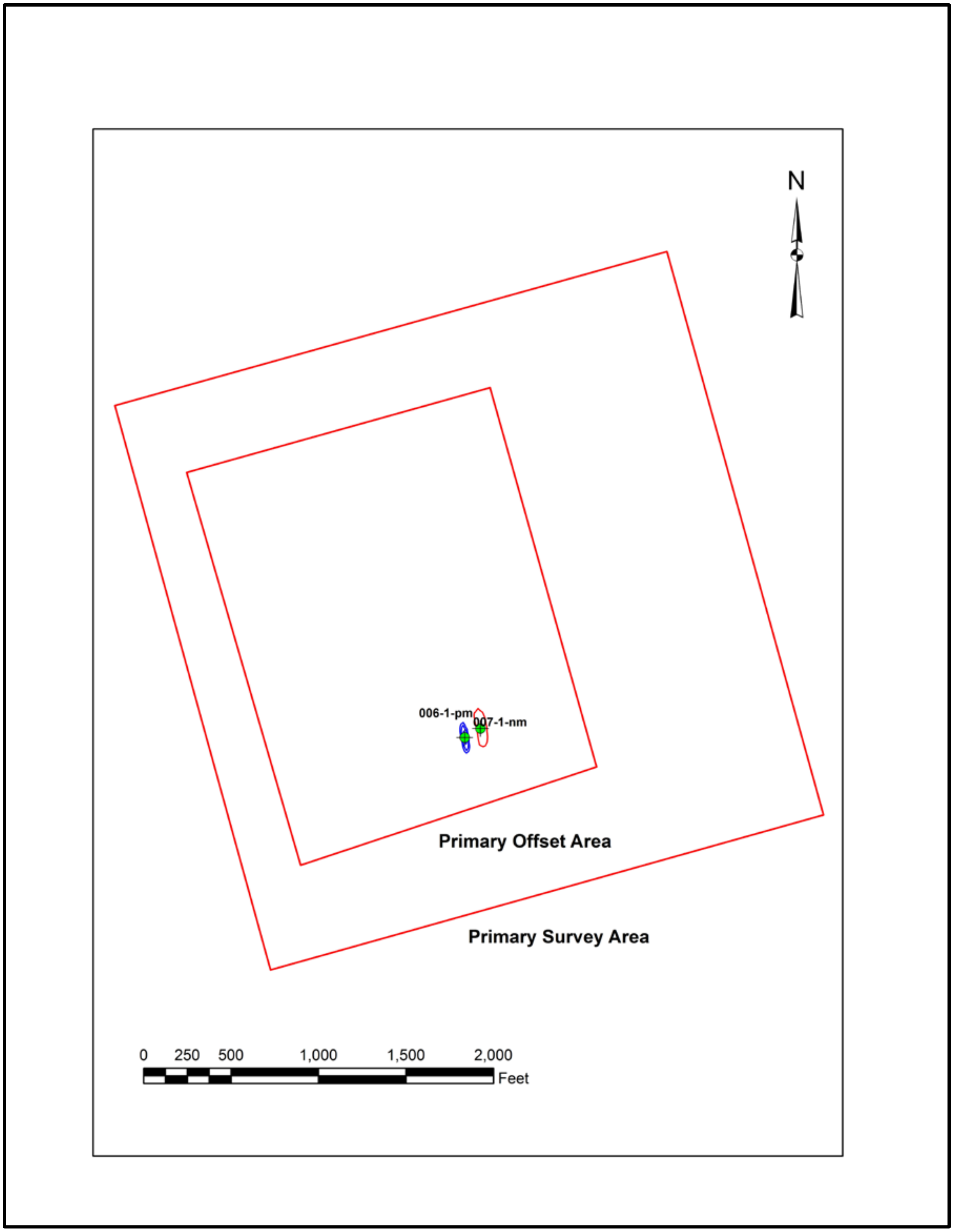

Figure 200. Primary Offset survey area magnetic anomalies and contours.

After reviewing the data, two secondary areas were identified for a more intensive remote-sensing investigation on September 9, 2016. The Secondary North survey area was established to focus on three magnetic anomalies identified during the Primary line survey. Likewise, the Secondary South survey area was established to focus on three magnetic anomalies identified during the Primary and Primary Offset line surveys (Figure 201).

The Secondary South survey area was investigated on tracklines established on 50-foot (15 m) line spacing. Magnetic data generated on the more intensive 50-foot (15 m) line spacing identified five additional anomalies (Volume III: Appendix MM). Three of the five magnetic anomalies increased the cluster of Primary line anomalies to six. That enhanced the potential association with vessel remains and justified collection of additional magnetometer data (Figure 202). Analysis of the sonar data associated with the Secondary South survey area identified no targets and produced no additional insight into the source of the magnetic anomalies.

The Secondary North survey area was also investigated on tracklines established on 50-foot (15 m) line spacing. Magnetic data generated on the more intensive 50-foot (15 m) line spacing identified eight additional anomalies (Volume III: Appendix MM). All of the Secondary North survey area anomalies proved to be geographically associated with the three magnetic anomalies identified during the Primary line survey. The three clusters and their spatial orientation significantly enhanced the potential for association with 10-meter (33 ft.) magnetic data and the ballast pile location reported by Garrison in 1989. That correlation and the potential for association of the clusters with shipwreck remains justified collection of additional magnetometer data (Figure 203).

Analysis of the sonar data associated with the Secondary North survey area identified six small object targets (Figure 204; Volume III: Appendix NN). Five of the six sonar targets have no association with magnetic anomalies in the area. One sonar target, SSS 009, is geographically associated with magnetic anomaly 017-1 identified during the Primary line survey, and anomalies 08-1 and 09-1 identified during the survey of the Secondary North area (Figure 205).

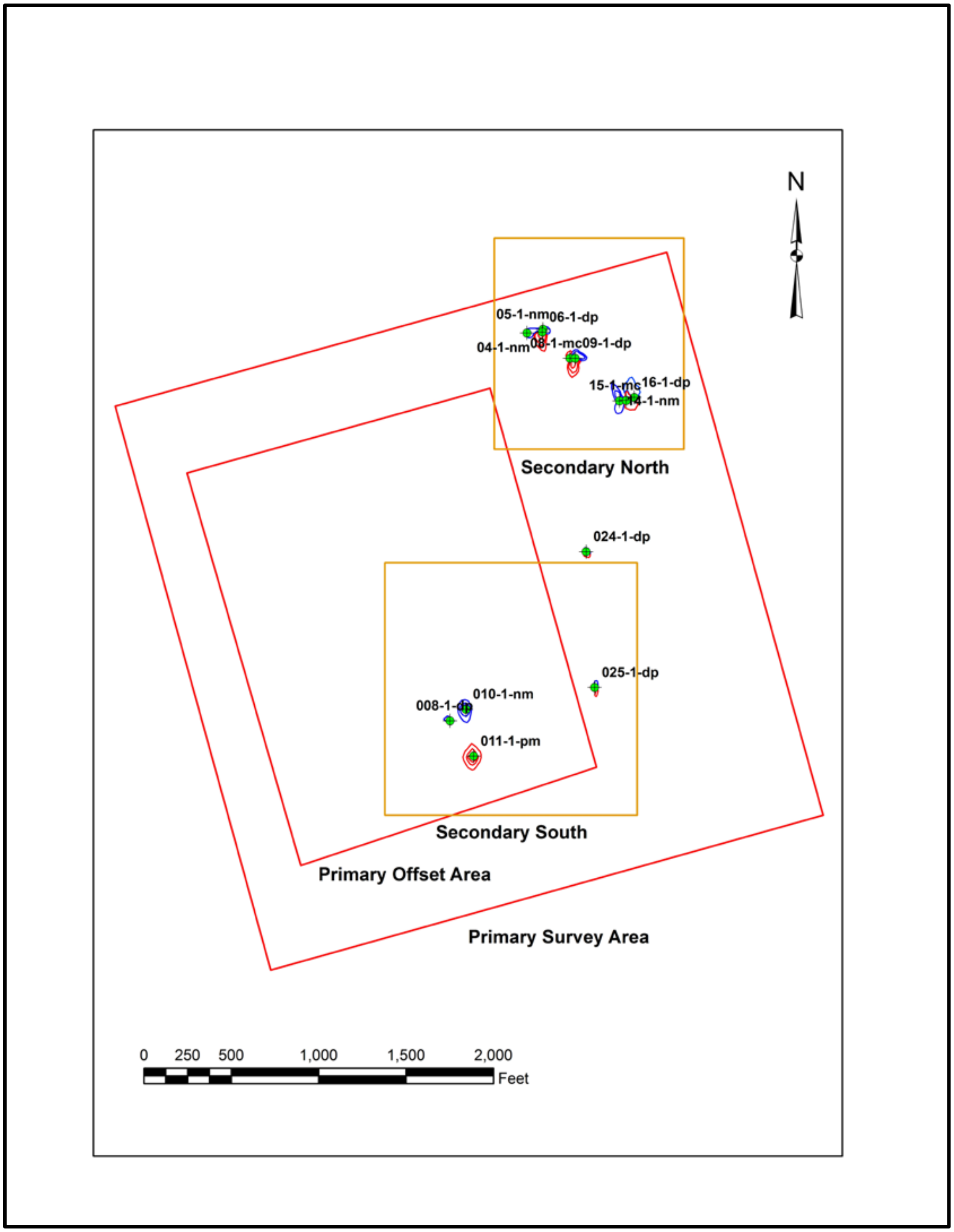

Figure 201. Secondary North and Secondary South survey area magnetic anomalies and contours.

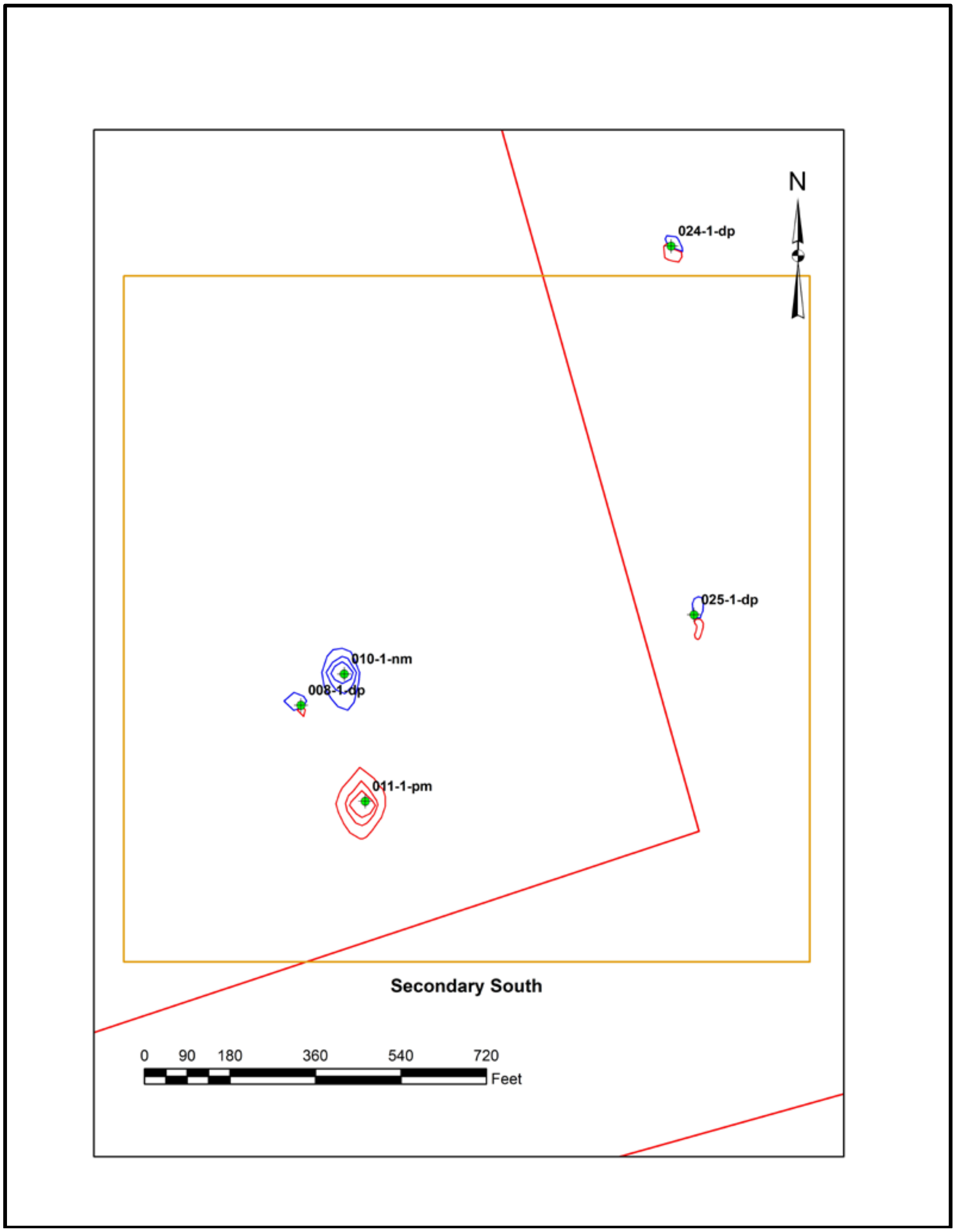

Figure 202. Secondary South survey area magnetic anomalies and contours.

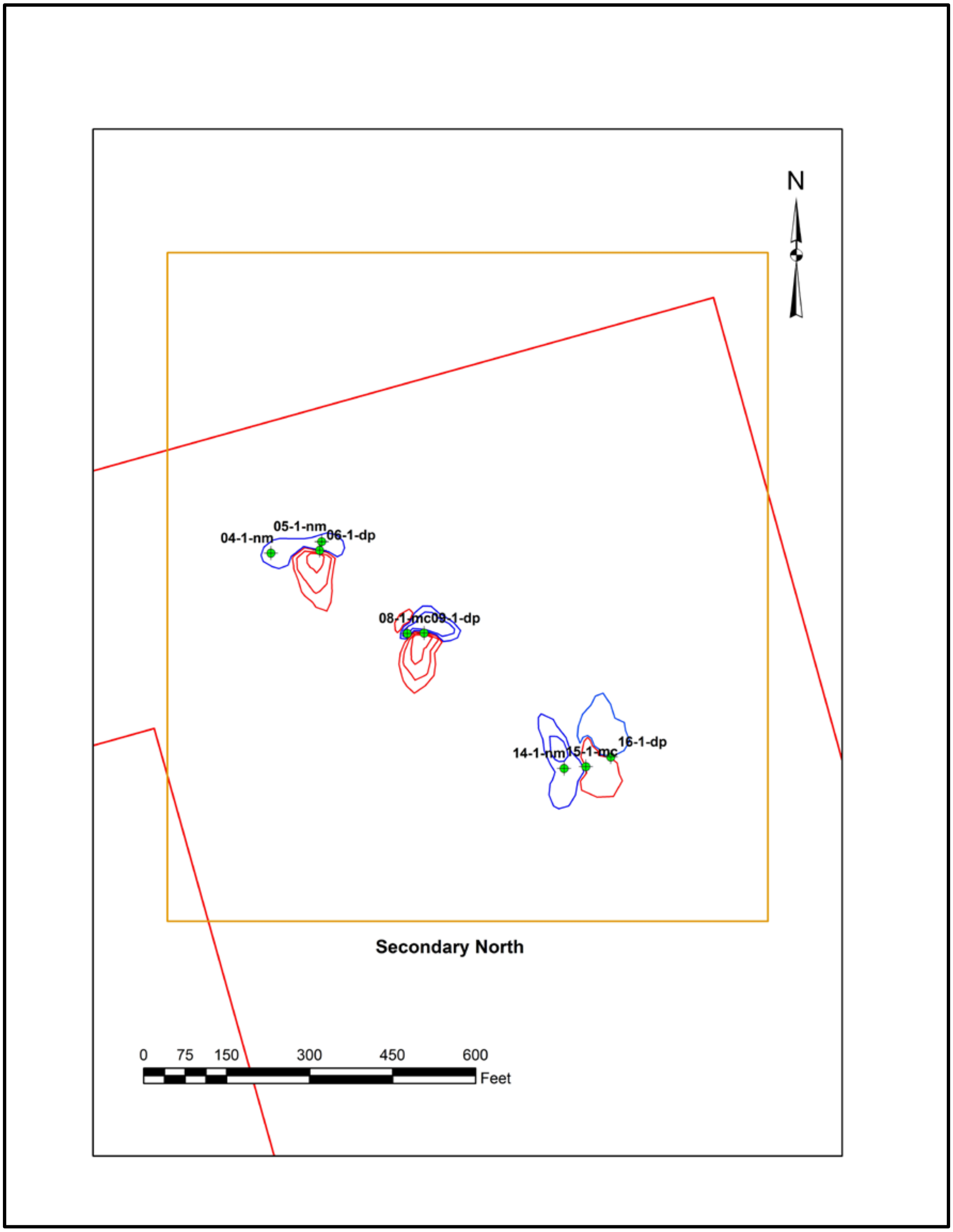

Figure 203. Secondary North survey area magnetic anomalies and contours.

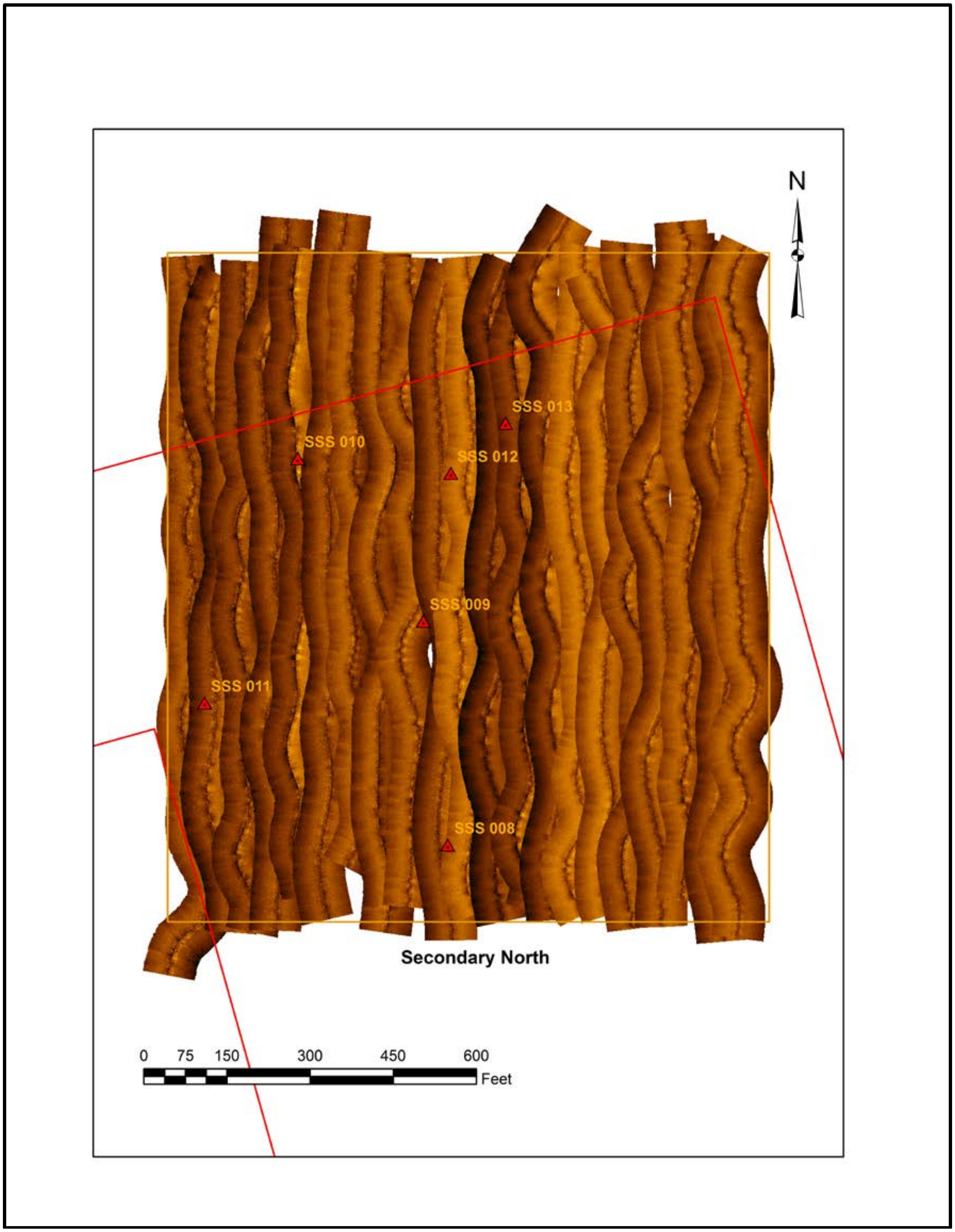

Figure 204. Secondary North sonar coverage mosaic with sonar targets.

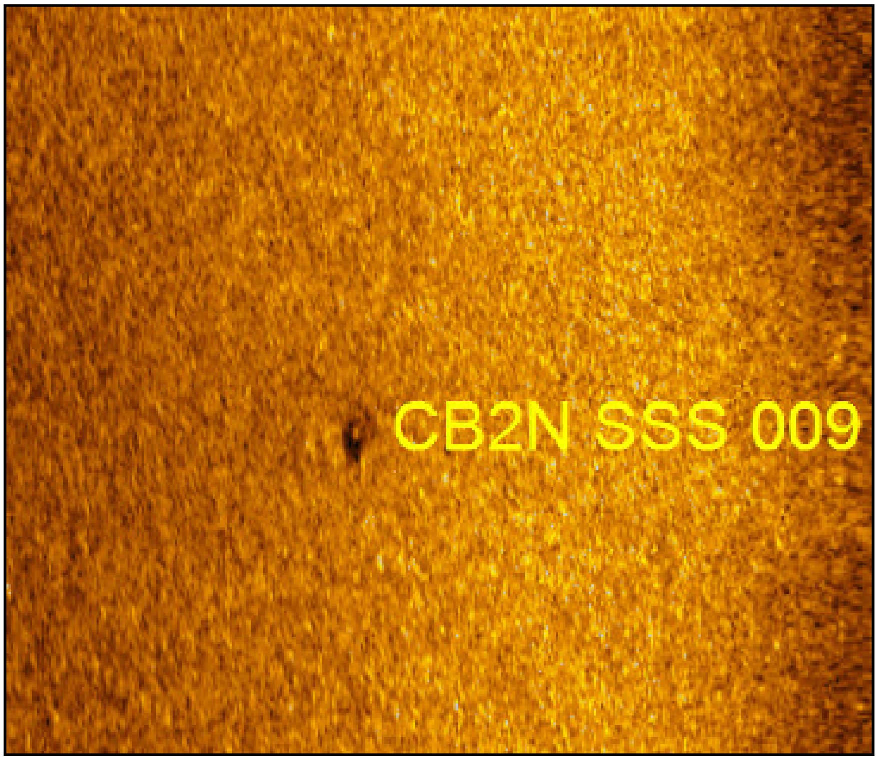

Figure 205. Small object in the vicinity of magnetic anomalies in the center of the Secondary North survey area.

Although the concentration of magnetic anomalies in the Secondary South survey area did not appear to have a geographical distribution similar to anything reported by Garrison et al. (1989b), the scatter could represent vessel remains. To further refine the magnetic data associated with the cluster, additional 50-foot survey lines were run diagonally through two tertiary survey areas, labeled as the Tertiary North and Tertiary South survey areas (Figure 206). Analysis of the Tertiary South data confirmed two previously identified magnetic anomalies, but identified no new signatures (Figure 207; Volume III: Appendix MM). Analysis of the sonar data associated with the Tertiary South survey area identified no sonar targets.

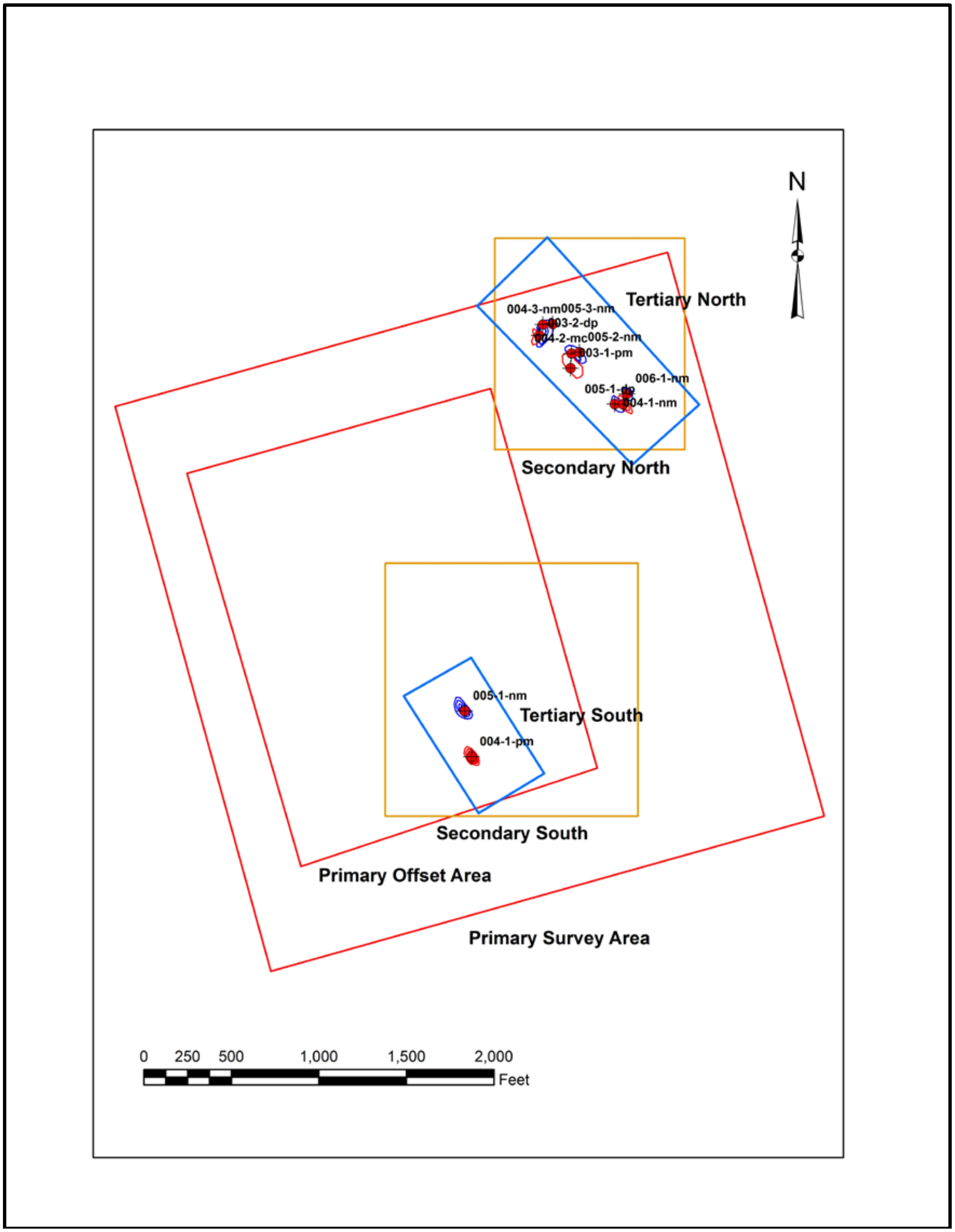

Figure 206. Tertiary North and Tertiary South survey areas.

(Defined by blue border.)

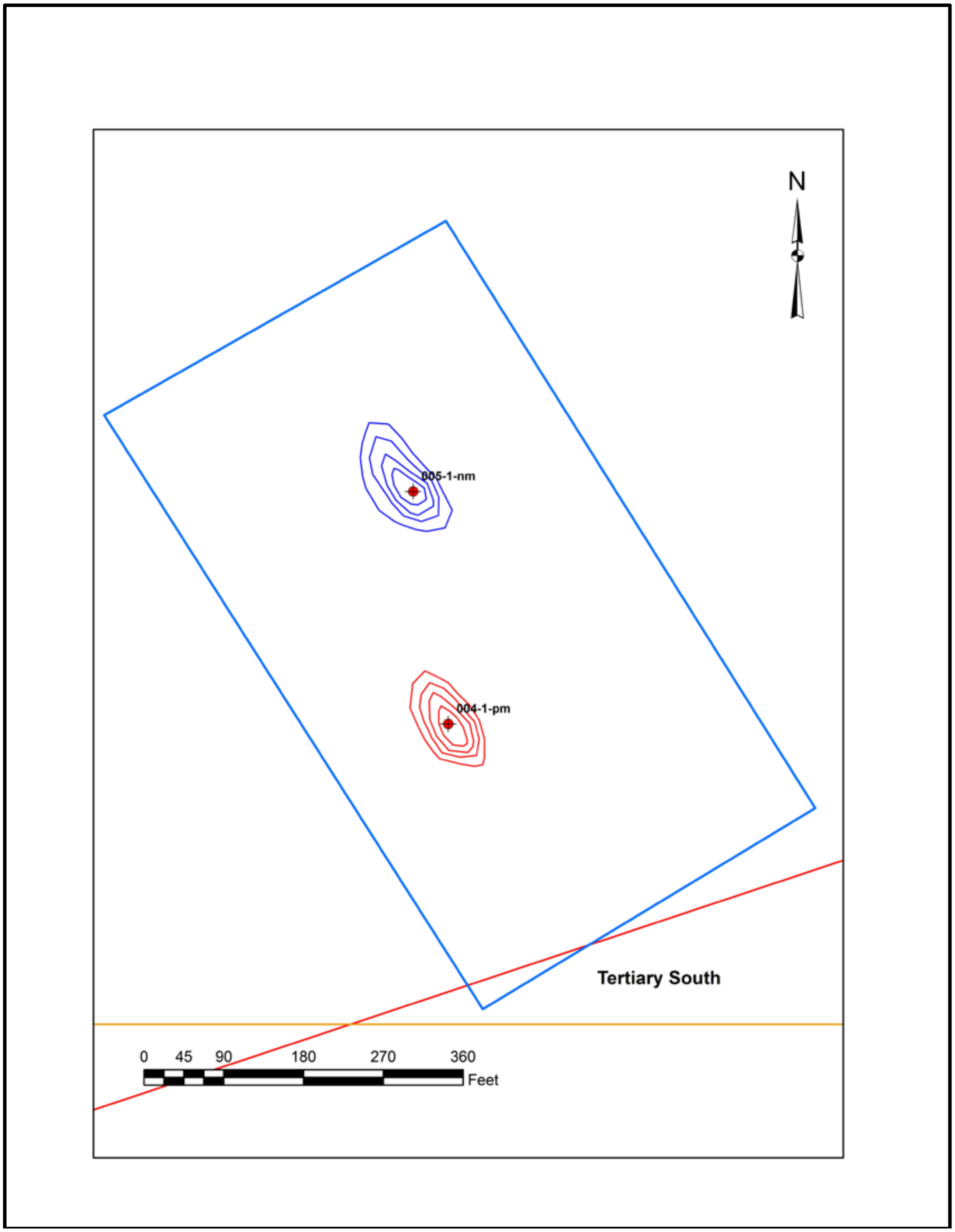

Figure 207. Tertiary South survey area magnetic anomalies and contours.

Unlike the concentration of magnetic anomalies in areas to the south, the pattern of magnetic anomalies in the Secondary North survey area did appear to have a geographical distribution similar to the 15-meter (49 ft.) contoured data pattern reported by Garrison et al. (1989b). As that anomaly pattern suggested a potential association with the "Ballast Pile Site," additional lines were investigated. To further refine the magnetic data in the Secondary North survey area, additional 50-foot (15 m) survey lines were run diagonally through this Tertiary North survey area.

Analysis of the data identified nine magnetic anomalies (Volume III: Appendix MM). The Tertiary North survey area magnetic anomalies corresponded with previously identified anomaly clusters. Three anomalies were located in association with each Secondary North survey area cluster and the three anomalies identified in the northeast corner of the Primary survey area (Figure 208).

Analysis of the sonar data associated with the Tertiary North survey confirmed three of the previously identified sonar targets (SSS 008, SSS 009, and SSS 010). No new sonar targets were located, and one of the previously identified sonar targets (SSS 011) was not confirmed (Figure 209).

A comparison of the 2016 magnetic data with that reported by Garrison et al. (1989b) showed that the only signatures suggesting a potential association were the three concentrations identified in the Tertiary North survey area (Figure 210). These three magnetic anomaly clusters (North Priority, Center Priority, and South Priority) were considered high-priority for diver investigations.

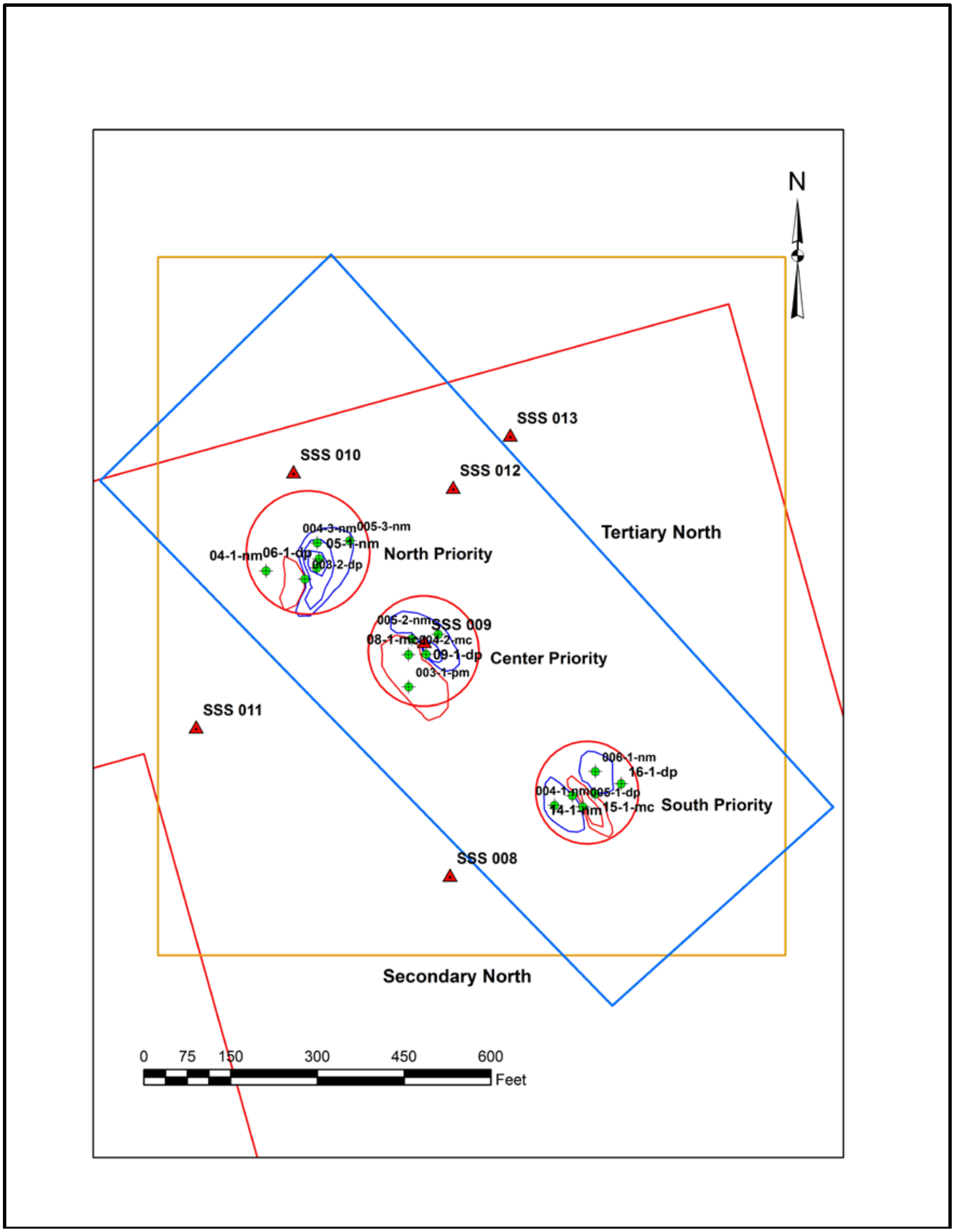

Figure 208. Tertiary North survey area magnetic anomalies and contours.

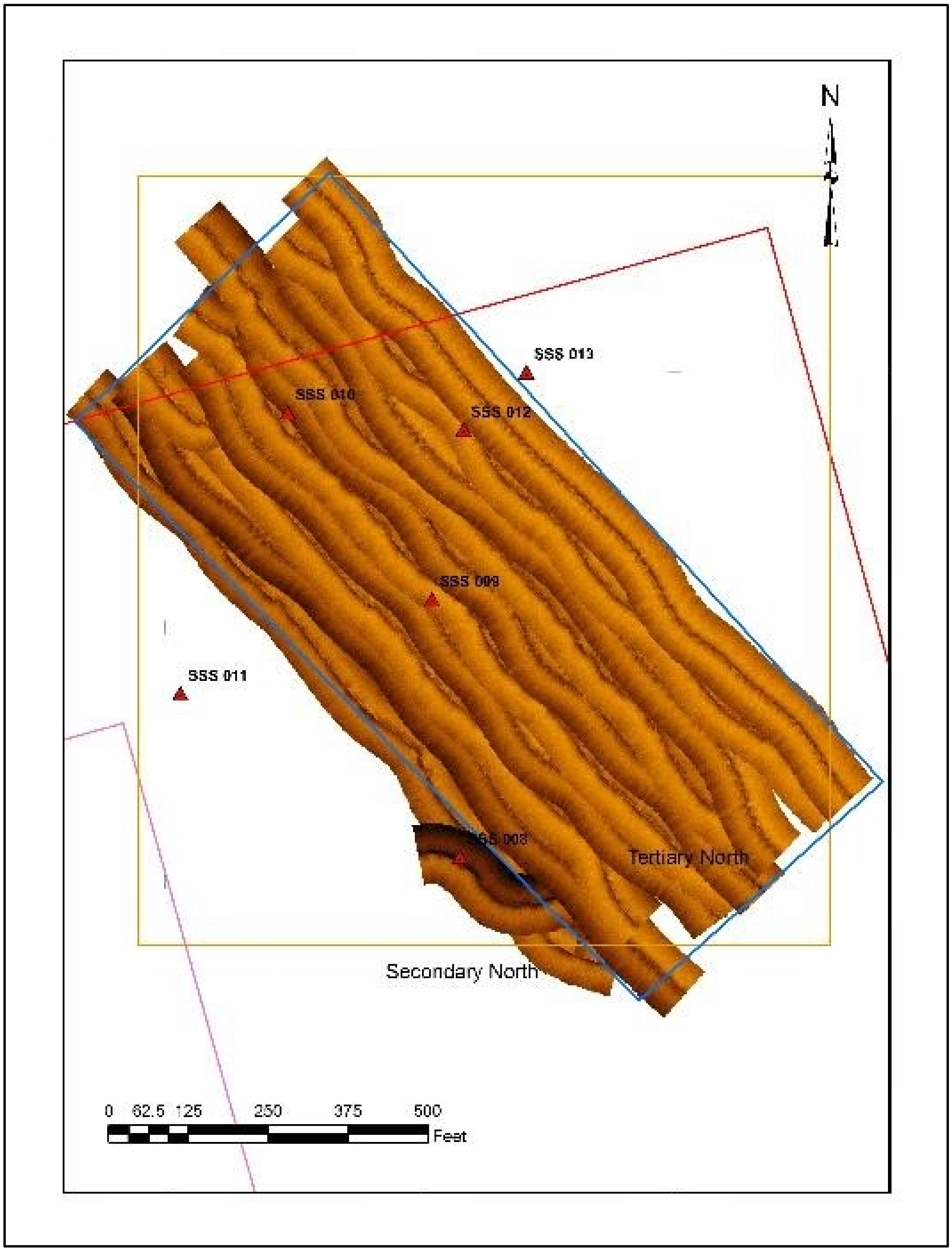

Figure 209. Tertiary North survey area sonar coverage mosaic with sonar targets.

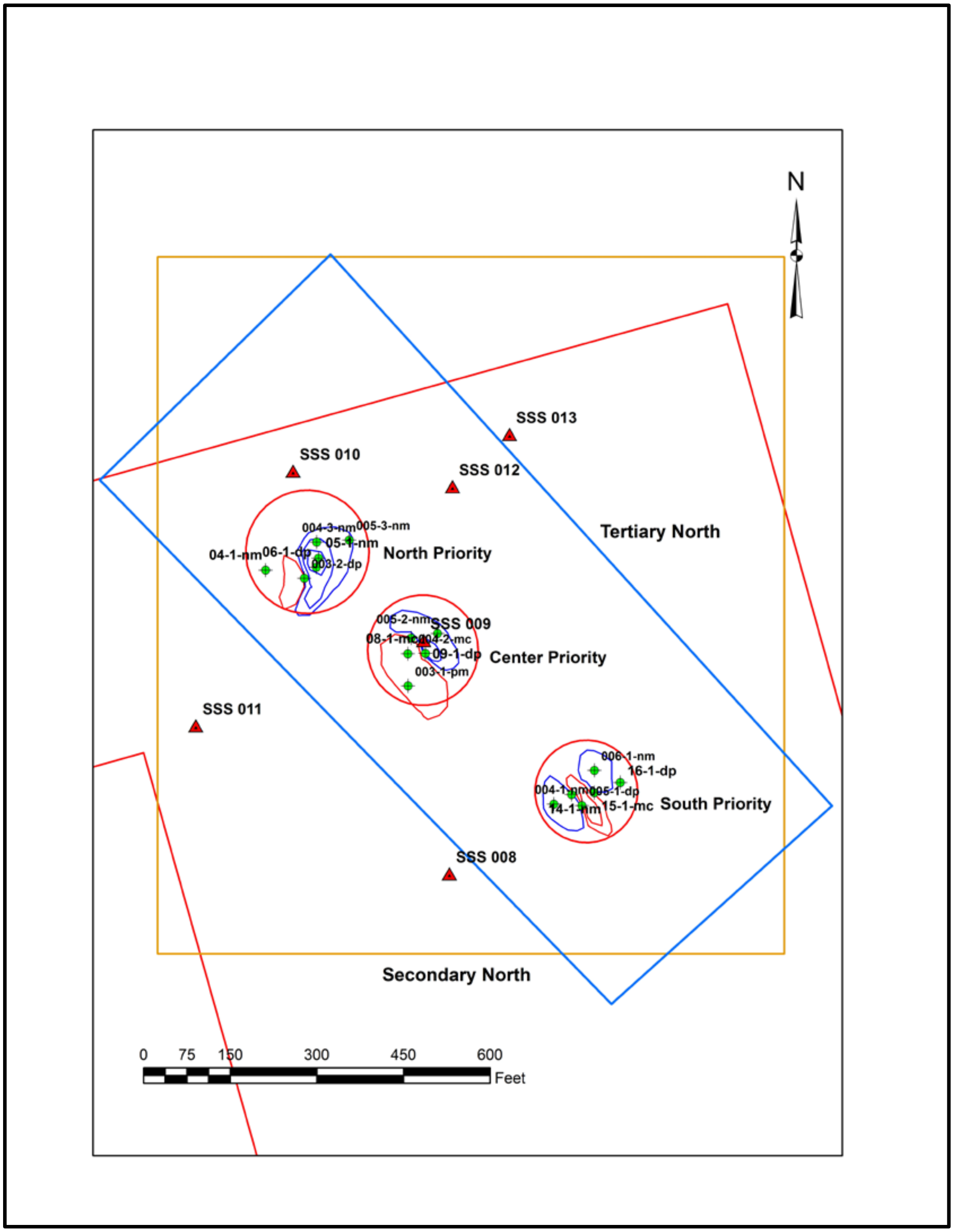

Figure 210. Tertiary North survey area high-priority magnetic anomaly clusters.

Though no 2016 magnetic signatures reflected the intensities recorded in 1989, the pattern and geographical orientation of the clusters was considered significant enough to merit archaeological diver investigation. On September 10, 2016, the North Priority anomaly cluster was relocated and buoyed. Nothing was apparent on the bottom surface, so a handheld proton precession magnetometer was used to identify the most appropriate area to probe. Using a hydraulic probe, researchers identified a heavy metal object occupying an area approximately 2 feet by 5 feet 7 feet below the bottom surface. Using the object as a central point, researchers probed circles every 5 feet for a distance of 25 to 30 feet. No additional metal or ballast were identified at the site.

Due to weather conditions, archaeological diver investigation of the remaining Tertiary North survey area anomaly clusters was not undertaken until September 16, 2016. On that date, the focus of investigation was the Center Priority anomaly cluster. That cluster correlated well with both the 1989 scatter pattern and the magnetic anomaly complex associated with the ballast pile. The site was relocated and buoyed. As nothing was apparent on the bottom surface, the underwater magnetometer was again used to identify the most productive area for probing.

Probing immediately identified ballast, metal objects, and wood that occupied an area approximately 40 feet in diameter. Sediment covering that material consisted of a shallow layer of silty sand approximately 6 inches deep over sandy mud. Using a short probe within that area, the configuration of a linear object similar to a cannon was identified about 3 feet below the surface. The location was buoyed before inclement weather brought the day's investigation to a halt.

On September 17, all attempts to resume diver investigation were halted by foul weather and sea states. On the final day of field operations, September 18, 2016, weather moderated and the site was relocated. Using the buoy as a reference, an induction dredge was used to excavate sufficient overburden to expose a small iron cannon lying on the ballast (Figure 211). When excavation cleared the trunnion, a stainless-steel hose clamp was found. Archaeologist Jim Jobling attached this hose clamp during 1989 as he secured a zinc anode to the cannon (Figure 212). Jobling's hose clamp confirmed that the ballast pile and cannon were indeed the eighteenth century ballast pile site located by Captain Barhanovich in 1988, and investigated by Dr. Garrison and his crew in 1989 (Figure 213).

One sample of the ballast was recovered for identification (Figure 214). The sample was broken into several pieces for analysis and examination of a break face (Figure 215). Initial identification provided by Dr. Peter Clift (Louisiana State University, Department of Geology and Geophysics) indicates that the sample is a plutonic granodiorite (Clift, 2017). Additional analysis conducted by Clift indicates that the geographical origin of the ballast stone can possibly be traced to the lower Rio Grande River in the vicinity of the Texas coast (Clift, 2018a) or possibly the Houston, Texas vicinity (Clift, 2018b).

Figure 211. Excavating on the Center Priority magnetic anomaly cluster with an induction dredge.

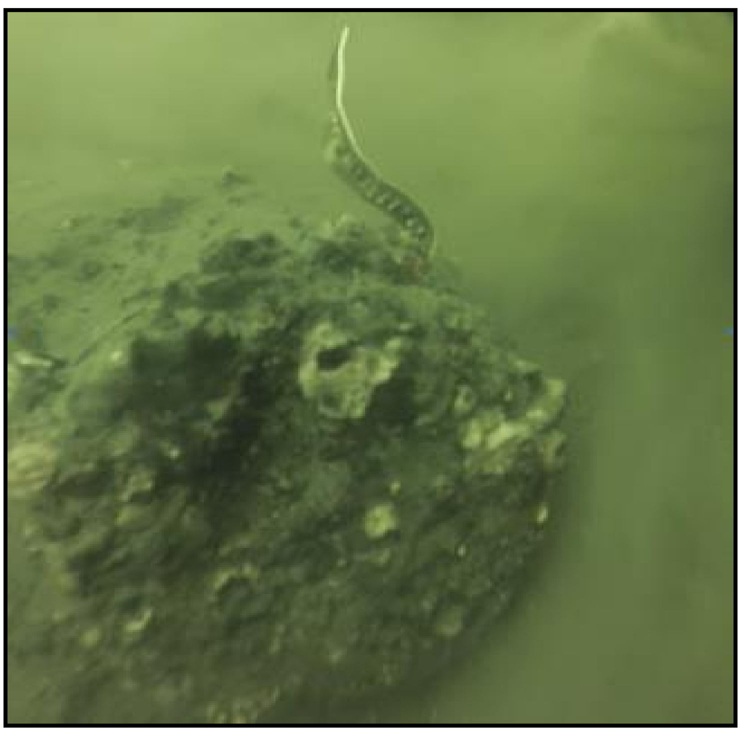

Figure 212. Stainless-steel hose clamp placed on trunnion by Jobling during the 1989 investigation.

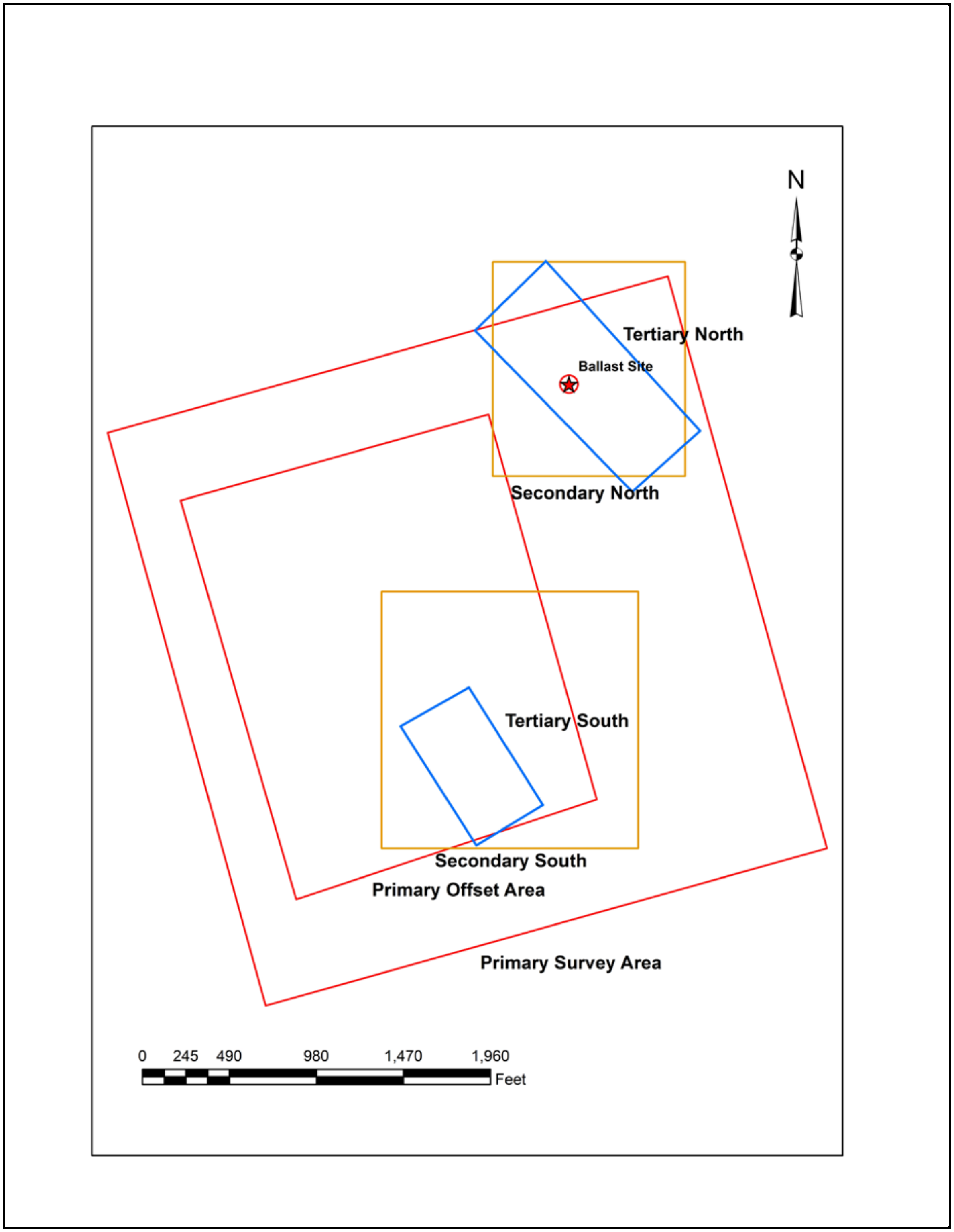

Figure 213: Ballast and cannon site illustrated within the Chandeleur survey areas.

Figure 214. Ballast sample collected during September 2016 from the Chandeleur site.

Figure 215. Break face illustrating plutonic granodiorite composition of subject ballast stone.

Although wood was encountered while probing at one location near the edge of the ballast pile, 1989 excavations to "sterile sand" (Garrison et al. 1989b) produced no evidence of hull structure. The ballast and cannons were determined to represent a dump site. That conclusion appears somewhat less likely based on current evidence. Recent data from the 1718 *Queen Anne's Revenge* wreck site in North Carolina represents a similar horizontal and vertical distribution of ballast and cannons. There, marginal hull remains are located beneath an elongated oval ballast pile and most of the associated cannons lie on top of or within the ballast. In addition to the similar configuration of the ballast pile, several cannons from the North Carolina wreck are identified by the same IEC foundry initials on the trunnions (Morris, 2017; Henry, 2017). That indicates that the Chandeleur site cannons could similarly date from the first quarter of the 18^{th} century and are much older than previously thought. Only additional investigation at the Chandeleur site will resolve the wreck or dump-site question.

5. Conclusions and Recommendations

5.1. Impact Assessment

At the 12 sites investigated by archaeological divers in 2014 and 2016, only 8 were in the vicinity of proposed or previously permitted dredging operations. At those 8 sites no dredging related impacts were observed. That was, in no small part, due to the limited geographical extent of investigation at each site. All of the sites investigated by archaeological divers were focused on very specific targets. Those targets were associated with magnetic anomalies with a high potential association with vessel remains or sonar images of exposed cultural material. In addition, visibility was always very limited. Perhaps the most significant constraint was the lack of specific baseline data necessary for comparison.

The only two locations where significant differences in the bottom surface environment were observed were off the Chandeleur Islands. The scatter of debris at HP S4A recorded by sonar in 2013 was almost completely covered by new sediment. That was also the case at the ballast pile site east of the Chandeleur Islands. The entire site was exposed in 1989 (Garrison 1989b). By 2016, archaeological divers observed that as much as 3 feet of sediment covered both the ballast and the associated cannons.

During Hurricane Katrina in 2005, the Chandeleur Islands lost over eighty percent of their surface area (Lavoie et al., 2010). Following the 2010 *Deepwater Horizon* oil spill, a sand berm was constructed along the northern Chandeleurs “as a protective, oil-spill response measure” (FitzGerald et al., 2015:5). The northern section of berm, identified as E-4, was built in “open water on a submerged platform of the northern Chandeleur system’ (FitzGerald et al., 2015:5). As tropical storms and cyclones have had a documented adverse impact on the Chandeleur Islands, (FitzGerald et al., 2017) it is possible that cyclones Colin (June 2016) and Hermine (August 2016) could have been responsible for redeposition of that material. The migration of material from the Chandeleurs during Katrina, the deposition of sediment associated with construction of the E-4 berm and the redeposition of that material by Colin and Hermine could be contributing factors in the amount of increased sediment at both sites. Unfortunately, without specific high resolution pre- and post-hurricane and berm construction bathymetric data in those areas it is impossible to confirm the speculated migration of material.

Under the best circumstances, determining the impacts of dredging on submerged cultural resources at or near significant sand extraction areas is a complex issue. Many variables are involved in defining and assessing potential impacts upon submerged cultural resources. Perhaps the most critical is the capacity to generate, preserve and recall comparative data. Without baseline data and repetitively collected comparative data sets, accurate identification and assessment of site-specific change cannot be effective. In addition, data parameters must be broad enough to take natural as well as human-made changes into account. A detailed study titled “Archaeological Damage from Offshore Dredging: Recommendations for Pre-Operational Surveys and Mitigation During Dredging to Avoid Adverse Impacts” published by MMS in February 2004 addresses many of those issues (Research Planning, Tidewater Atlantic Research and Baird & Associates 2004).

An initial and critical consideration is the nature of the cultural resource. The spectrum of those offshore cultural resources can, in the most general terms, be defined as prehistoric or historic. Within those general contextual terms there are a variety of site definitions that weigh heavily on defining and assessing impacts associated with dredging.

5.1.1. Prehistoric Site Impact Assessment

The presence, nature, and methods of discovery and investigation of prehistoric sites on the North American continental shelf has received considerable attention over the past four decades. Increased activity associated with the development and recovery and use of offshore resources such as oil, gas and more recently sediment deposits has focused increased attention on submerged cultural resources on the continental shelf. Recovery and use of offshore sand has become a critical issue in identifying, investigating and preserving prehistoric sites in accordance with federal legislation. Much of the associated published material is referenced in the 2004 MMS report (Research Planning, Tidewater Atlantic Research and Baird & Associates 2004).

Inundated prehistoric sites could be the most fragile and sensitive to the impacts of dredging. Except under what we might consider today to be unusual environmental circumstances associated with the inundation process, continental shelf prehistoric sites could have a compromised integrity (Murphy 1990). The speed of inundation is considered to be a significant factor. The longer sites are exposed on the shoreline or in nearshore environments the more likely extensive resorting can occur. Storm events where winds, seas, and currents are extremely high can impact the sub-bottom environment at depths of more than 30 meters (98 ft.). However, investigations associated with relict features of the Sabine River provide an indication that the impacts of nature and the inundation process may not be universally adverse (Pearson et.al., 1986).

In association with older Paleo-Indian sites, the archaeological record may well be marginal even before the impacts of inundation. Under the right circumstances, later Archaic and Woodland sites could preserve a more complex archaeological record. Where prehistoric sites are stabilized intact below terrestrial deposits or in association with inundated features, such as lagoons and embayments, preservation could be exceptional. Like terrestrial sites, inundated prehistoric sites are theoretically more likely to be discovered in association with relict landforms such as the confluence of streams and rivers, embayments, lagoon complexes, and sources of food and shelter. The use of terrestrial analogs to identify inundated prehistoric sites on the Continental Shelf has been the subject of numerous publications including Bullen et al., 1968, Dragoo, 1976, Gardner 1980, Cockrell, 1980; Gagliano et al., 1982; Science Applications, Inc., 1981; Belknap, 1983; Bonnichsen et al., 1987; Pearson et al., 1989; Waters, 1992; Faught, 2003; Faught 2014; and Evans et al., 2014).

Unfortunately, one of the most fundamental issues in identifying and assessing impacts associated with dredging is the dearth of hard data on the presence, nature, and condition of inundated prehistoric sites in, or in the proximity of, borrow sites. Where relict landforms with a high potential for association with inundated prehistoric sites are identified in the seismic records, the avoidance option is almost always exercised. In addition, confirmation of prehistoric resources in association with those features is not sufficiently reliable to risk the considerable expense of archaeological investigation.

It is readily apparent that inundated prehistoric sites are present on the continental shelf. It is also apparent that the methods and technology currently used to identify those sites will have to be refined. Today, sidescan sonars and sub-bottom profilers provide the most useful means to identify features related to a prehistoric site. Those instruments have a high and reliable capacity to detect large features such as shell middens, sink holes, and relict landforms that facilitate the preservation of prehistoric sites; however, these datasets cannot resolve actual archaeological remains (Evans and Keith, 2011; Faught 2014). Advances in remote-sensing technology may eventually improve site-specific detection.

To date, core samples associated with relict landforms in the Sabine Pass area have produced physical evidence suggestive of a high potential for prehistoric site preservation under certain circumstances. In 1982, Sherwood Gagliano and his colleagues identified the spectrum of physical evidence that might survive inundation and serve as markers for association with prehistoric habitation (Gagliano et al. 1982). Funded by MMS, Charles Pearson and associates used analysis criteria identified in the subject cutting-edge 1982 study regarding settlement patterns associated with terrestrial features to identify offshore relict landform locations for core sampling (Pearson et al., 1986).

Analysis of material extracted from cores collected at three Sabine Pass lease block locations (Sabine Pass Block 3, Sabine Pass Block 6, and Sabine Pass Block 9) led Pearson and his team to several conclusions. Their study methodology was found to be a productive approach for generating the data necessary to focus a search for, and to collect preliminary data from, inundated prehistoric sites. Data confirmed the intact survival of pre-transgressive landforms in the offshore Sabine River valley (Pearson et al. 1986).

Until remote-sensing technology improves, it is worthwhile to formulate strategies to test potentially significant relict landform features for cultural material where feasible rather than continuing to avoid all potential sites. Many of the known relict landform features on the OCS have been located as a consequence of remote-sensing surveys carried out in conjunction with projects designed to identify and permit suitable borrow site sediment. Inevitably, those potentially significant features are recommended for avoidance. One strategy that will test the preservation potential of these features is to work with dredging operations to “groundtruth” and document the association of prehistoric material with these relict landform features (Faught 2014). Coring and analysis of dredge material from areas with potential for association with prehistoric habitation was one of the recommendations of the 1986 MMS-funded study (Pearson, et al., 1986:226).

Today (2018), horizontal and vertical control of modern dredging operations can be very sophisticated and accurate. Methods of accurately identifying prehistoric materials and determining associations with sediment deposit-associated landforms are possible. Using GIS and sophisticated dredging software to store, analyze, and project geophysical data, archaeologists and submerged cultural resource managers can identify areas with prehistoric potential for research or protection. That level of stratigraphic definition and dredging control would permit feature-specific dredge sampling designed to test the application of terrestrial analogs to the continental shelf environment. With sufficient data, sophisticated computer modeling programs can be used to develop three-dimensional, geo-referenced models of relict landforms that could be associated with prehistoric archaeological sites (Research Planning, Tidewater Atlantic Research and Baird & Associates 2004). This method is currently used to identify the parameters of deposits of beach nourishment sand so that dredging activity will not produce undesirable material. The horizontal and vertical extent of dredge cuts are programmed into a three-dimensional computer model of the deposit and geographical coordinates are fed into the dredge navigation and excavation systems (Kniesley, 2004; Andrews, 2004). Seismic data from the cultural resource and shallow hazard investigation were combined with data from the geotechnical sand search investigation to refine the borrow area design around material suitable for beach nourishment. The combination of data produced a much more accurate definition of relict landforms and permitted dredging to be limited to the stratigraphic layers that contain the desirable material (Research Planning, Tidewater Atlantic Research and Baird & Associates 2004).

By correlating the location of dredge activity with potentially significant relict landforms and systematic testing of the sediment recovered from that location, highly useful information could be obtained. Those data could confirm a relict landform association with human habitation and facilitate identifying more sophisticated means of pre-disturbance resource identification, and develop effective methodologies for archaeological recovery of prehistoric cultural material and associated data.

That combination of high definition dredge control and monitoring of material was recommended by Tidewater Atlantic Research for a beach nourishment project at the Jefferson County, Texas, McFaddin Beach Site. There, Clovis material is hypothesized to be migrating to the beach from offshore features in the vicinity of a borrow site. At McFaddin Beach, dredged material was to be systematically examined to identify prehistoric artifacts and identify the source of that material using high definition dredge logs (Tidewater Atlantic Research 2017).

5.1.2. Historic Site Impact Assessment

The vast majority of historically significant submerged cultural resources in the offshore OCS environment are vessel remains. Known shipwrecks in the GOM date from early European exploration in the 16^{th} century. A number of research projects document GOM maritime history, patterns of navigation, and associated vessel losses. An early example includes the federally funded four-volume study entitled “Cultural Resources Evaluation of the Northern Gulf of Mexico Continental Shelf” (Coastal Environments 1977).

Garrison, Giammona, Kelly, Tripp, and Wolff (1989a) examined remote-sensing survey anomalies and their association with distribution patterns of historic shipwrecks in the northern GOM. With an objective to assess then-contemporary remote-sensing technologies and instruments as well as existing models of historic shipwreck distributions, Pearson, James, Krivor, Darragi, and Cunningham (2003) carried out a study designed to refine and revise the high probability model for shipwrecks on the GOM outer continental shelf. Shipwreck databases maintained by BOEM and the AWOIS database maintained by NOAA provide additional insight into the volume and distribution of GOM shipwrecks.

The types and numbers of lost vessels increases dramatically through more than four centuries. The spectrum of lost vessel types, wrecking sequences, and associated site formation processes have a significant bearing on the potential impacts of dredging activity. Earlier and smaller vessel remains are more likely to be heavily impacted by dredging that undermines the stability of the sedimentary matrix surrounding the site. Larger and more heavily built vessels appear to be less subject to the same destructive forces under consideration. Modern vessels of iron and steel seem to be more resistant to environmental impacts from dredging than their wooden counterparts.

However, like prehistoric sites, storm events during which winds, seas, and currents are extremely high can impact shipwreck environments at depths well below 30 meters. Also, like the traditional approach for avoiding relict landforms with a potential for association with prehistoric submerged cultural resources, remote-sensing signatures indicative or suggestive of shipwreck resources are generally avoided by buffering. Traditionally, buffered sites are investigated when avoidance is clearly not an option. Where sites are buffered and avoided, post-dredging impact assessments are rare and when carried out they are generally very short-term events.

Where historical submerged cultural resources are concerned, hard data is also necessary to support identifying and predicting dredging impacts on vessel remains in or immediately adjacent to borrow sites. Any solution to the issue will require a systematic program of hard data acquisition and analysis. To be effective, data will have to be systematically collected over a time span sufficient to document changes in, and impacts from, the natural environment and manmade changes in the physical environment.

Clearly, the gamut of necessary data will have to include definition of the impacts of nature such as weather, sea states, and currents. Definition of, and changes in, sediments will also be important factors in data collection. The impacts of dredging will have to be assessed within the context of the pre-disturbance nature of selected sites. Once an on-site data baseline is established, dredging impacts on changes in the physical environment, such as sea state characteristics and currents, can be documented. Dredging impact on the sediments that are a critical factor in site preservation can be defined and scientifically monitored.

Any program designed to accomplish these goals and objectives should be based on collecting data from several sites which, in general terms, reflect the variety of historical shipwreck remains and the spectrum of potential sand source environments. For example, shipwreck types could include a small-18th-century vessel such as a sloop or schooner, a larger mid-19th-century vessel such as a barque, brig, schooner, ship or steamer, and a modern early 20th-century vessel such as an iron or steel hull ship or steamer. Where possible, those vessels should be located in areas that reflect water depths and sediment profiles where dredging projects will be carried out.

To establish a baseline, each site should be archaeologically documented to a level sufficient to identify post-dredging and environmental site impacts. In addition, the pre-disturbance site should be documented to characterize significant environmental conditions such as weather, sea states, and currents. With baseline archaeological and environmental data, post-dredging changes could be determined through time and the impacts on each resource quantified. Those data would permit more accurate modeling designed to support impact assessment on other sites and help determine criteria for resource protection.

Such a comprehensive program of data collection and assessment would require considerable planning, be time consuming, and require a significant commitment of financial resources. An interim approach might be to utilize one or more of the sites identified and investigated during this project to facilitate defining research parameters and refine data collection methodology. Three sites investigated during this project would appear to offer sufficient data to initiate the repetitive studies necessary for reliable predictive modeling.

Shipwreck remains at SB P3, SS S2, and SS S3 represent modern vessels with no apparent qualifications for inclusion on the NRHP. Using the small vessel in SB P3 and the larger vessel in SS S3 would provide data from two geographically separated environments and two distinctly different wreck-site configurations. The small vessel in SB P3 has been protected from dredging impacts by a large buffer, and the larger vessel in SS S3 lies well outside the previously-used borrow area to the south. Exposed structure and the seafloor surface at both sites could be defined in considerable detail using currently available remote sensing and archaeological diver mapping.

Multi-beam technology combined with RTK positioning and software developed by the University of St. Andrews, Archaeological Diving Unit Survey (ADUS) has been very effectively used to generate highly detailed and geo-referenced 3D imagery of shipwreck remains (Dean et al. 2007). That cutting-edge system was used to record the remains of the CSS *Georgia* (Figure 216) in the Savannah River below Savannah, Georgia (Panamerican Consultants and Tidewater Atlantic Research 2007).

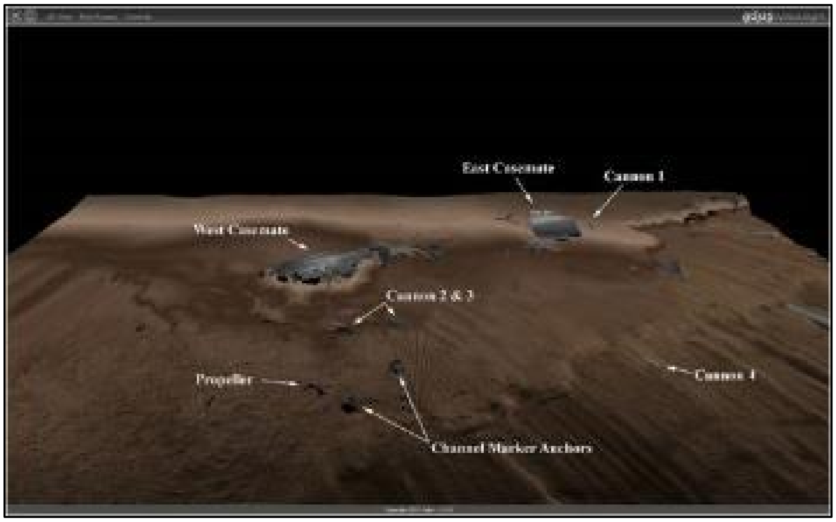

Figure 216: ADUS 3-D Image of CSS Georgia Site.

(Courtesy USACE Savannah District.)

Sector-scanning sonar has also been used on shipwrecks to generate similar highly detailed geo-referenced 3D imagery. The newest [2016] system was successfully used to record the remains of the Anglo-Confederate blockade-runner *Agnes E. Fry* (Figure 217) lost off the North Carolina coast during the American Civil War (Morris, et al. 2016).

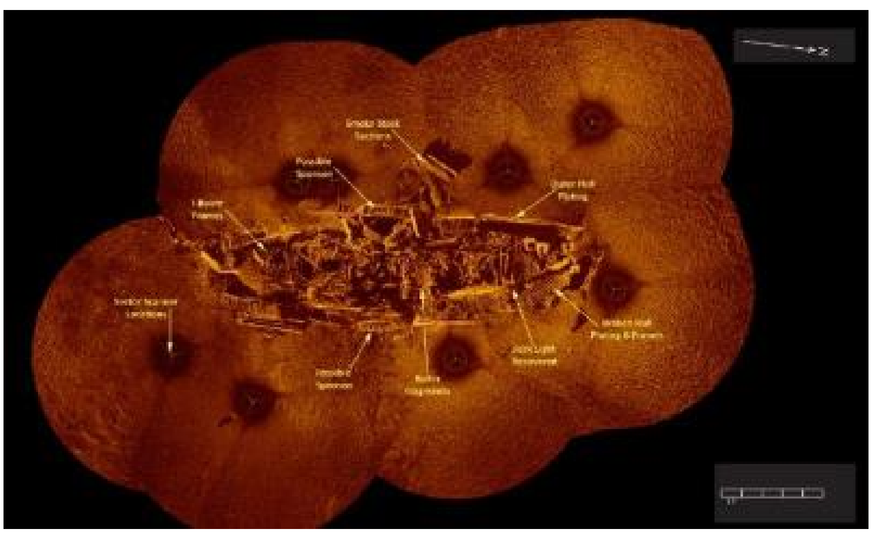

Figure 217: Sector scan image of Agnes E. Fry.

(Courtesy of Nautilus Marine Group, Portunes, Arbor Land Surveying, Charlotte North Carolina Fire Department and North Carolina Underwater Archaeology Branch.)

Data generated by the ADUS documentation of the CSS *Georgia* site was used as a baseline for systematic data and material recovery at the site. Using the ADUS georeferenced site plan, an electronic grid was created in Hypack® survey software (Figure 218).

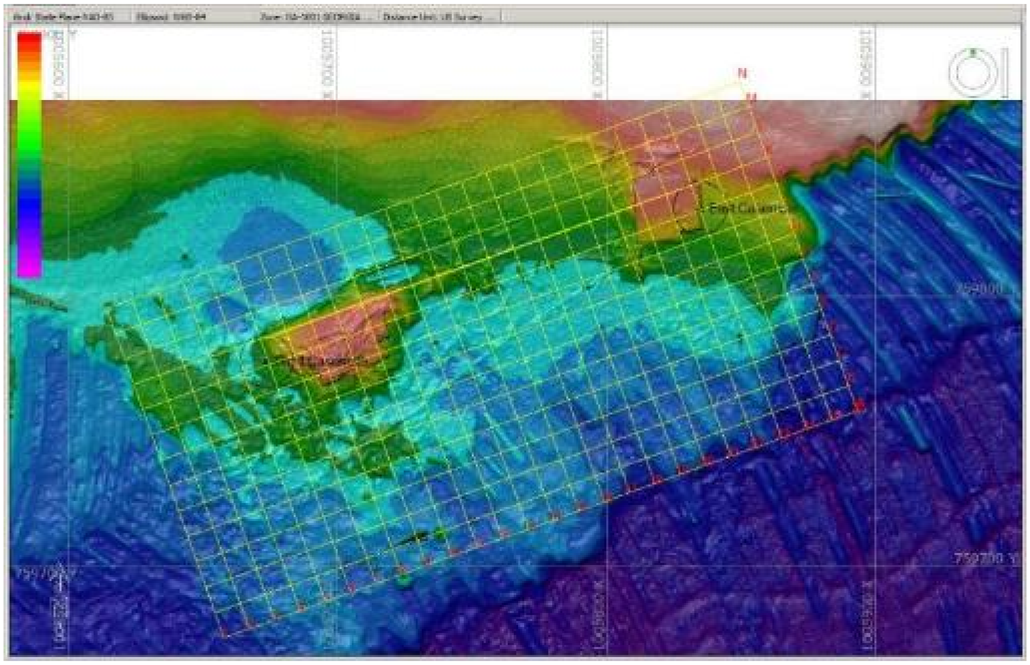

Figure 218: ADUS survey digital site map with georeferenced grid constructed in Hypack®.

An ultra-short baseline tracking system tied to the computer generated site plan and grid by RTK was used to guide archaeological divers mapping and recovering artifacts in the near-zero visibility of the site (Figure 219). Once on-site activity shifted to mechanized recovery the USB system was used to accurately control systematic clamshell and grapple material recovery from each of the electronic grid squares (Figure 220). Highly accurate positioning for both archaeological divers and mechanized recovery equipment was controlled from a computer surface station (Figure 221).

Figure 219: Archaeological diver with USBL transponder attached to tank.

Figure 220: Mechanized recovery grapple with USBL transducer attached.

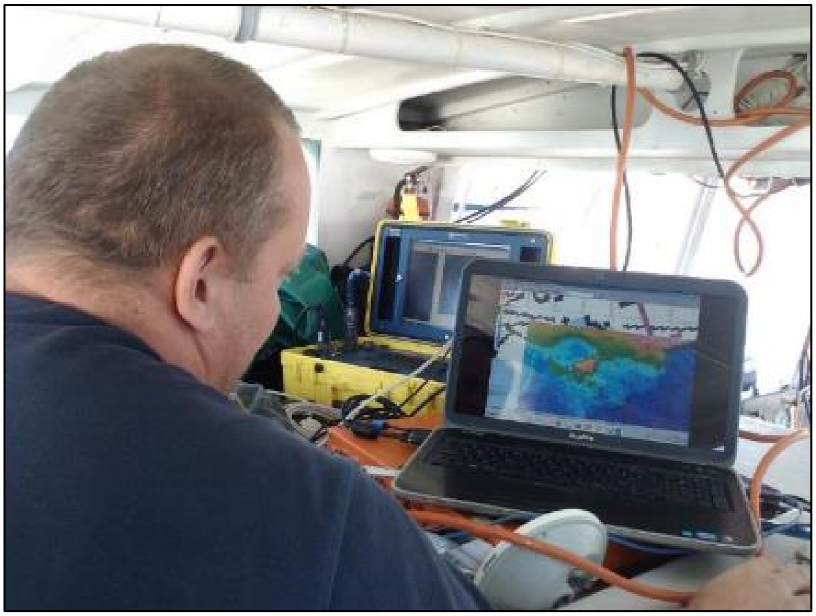

Figure 221: Surface station computer for controlling diver and mechanized recovery equipment.

Using existing technology makes it cleart that data concerning the potential association between relict landforms and prehistoric habitation can be effectively tested during dredging operations. Georectified three-dimensional computer representations of relict features can be developed from seismic data using Hypack®. Using RTK controlled dredging operations and material monitoring the origin of recovered prehistoric cultural material can be established with a high degree of accuracy. With hard data concerning the association between relict landforms and prehistoric sites available, methods for coordinating mechanical overburden removal and archaeological investigation can be developed.

For historic period sites such as shipwrecks, existing technology can be effectively used to generate, analyze, store, and recall baseline and comparative data. High-resolution multi-beam imaging is capable of producing the highly accurate three dimensional georectified digital site maps necessary to establish a baseline. Where visibility permits, underwater photogrammetry can be used in conjunction with computer programs to document exposed cultural material and generate three-dimensional images. Where visibility is limited, sector scanning sonar and USBL diver controlled positioning can be used to generate enhanced baseline and comparative data.

Using these techniques on the small vessel in SB P3 and the larger vessel in SS S3 could facilitate developing a standardized methodology and support experiments to better identify and define change associated with both natural and human-made impacts. Using reliable baseline data, BOEM could repeat the remote-sensing surveys and archaeological diver inspections after dredging in the vicinity of the wreck sites. Repetitive investigations could be carried out on a seasonal schedule and/or following storm events that could significantly impact the wreck and the site environment. ADCPs and other instruments could be used to collect on-site environmental information on changes associated with dredging, seasonal weather, and storm events. With the use of software programs like GIS, digital data sets can be stored, recalled, and readily compared. Adopting a systematic program of site definition and monitoring on the small vessel in SB P3 and the larger vessel in SS S3 would provide data necessary for modeling and the experience necessary to refine data collection requirements, data collection equipment, and data collection techniques.

5.2. Cultural Resources Modeling

The objective of the cultural resources modeling was to develop a conceptual plan for modeling potential borrow area impacts to nearby cultural resources in the GOM. Literature and data were reviewed and evaluated to characterize the cultural resources and physical processes in the vicinity of Sabine Bank, Ship Shoal, and the St. Bernard Shoals necessary to develop the modeling plan.

Existing geophysical, geotechnical, and hydrodynamic (water level, wave, and current) data sets were identified for Sabine Bank, Ship Shoal, and St. Bernard Shoals. Evaluation of these data facilitated an improved understanding of local processes that drive sediment transport and the morphological response of dredged borrow areas. Ultimately, the physical processes involved in borrow area infilling and the impacts of this infilling were identified.

The literature and data compiled during this desktop study provided valuable information on the link between the impacts of dredging on cultural resources and on the environmental characteristics of the surrounding area. Tools and technical approaches necessary to model potential borrow area impacts to nearby cultural resources in the GOM were identified.

5.2.1. Location

Louisiana barrier islands form the first line of defense to protect sensitive wetlands from the direct impact of GOM waves, currents, and storm surge. The disintegration of this protective buffer has resulted in increased land loss rates, which are considered to be the highest in the nation (Penland et al., 2005). This extreme back-bay land loss further stresses the system as the increased tidal prism accelerates barrier island loss rates, which in-turn accelerate back-bay land loss rates, thus creating a feedback loop of coastal destruction. Federal and State agencies have taken action to develop and implement massive coastal projects to restore the region. However, a sufficient volume of sand is required to complete these mega-restoration projects. Several large shoals have been identified as potential sand sources to nourish adjacent barrier islands and beaches. These shoals, shown in Figure 222, included Sabine Bank, Ship Shoal, and St. Bernard Shoals.

Figure 222: Location of the major sediment banks offshore Louisiana

5.2.1.1. Sabine Bank

Sabine Bank is a transgressive shoal located approximately 20 miles south of Sabine Pass, which is the geophysical boundary that separates the Louisiana and Texas coasts. Covering an area of 148,000 acres, the shoal extends more than 20 miles along the coast and is nearly 4 miles wide at the eastern end and roughly a mile wide at the western end. Water depth at the shoal decreases to 30 feet on the western side and 15 feet on the eastern side. Due to the volume of available sand (2.4 billion cubic yards) and its proximity to target restoration areas, Sabine Bank has been used (Holly Beach Restoration, Cameron Shoreline Restoration) and is being considered for further use (Stone et al. 2011) as a sand source to nourish adjacent barrier islands and beaches.

5.2.1.2. Ship Shoal

Ship Shoal is the easternmost and largest of a group of inner-shelf shoals that have developed along the Louisiana continental shelf as a result of deltaic abandonment and marine transgression (Kulp et al. 2001). Ship Shoal is located approximately 10 miles southwest of Isles Dernieres, which are south-central Louisiana barrier islands south of Cocodrie and immediately west of Timbalier and Terrebonne Bays. With a length greater than 30 miles and a width varying from 2 to 7 miles, this asymmetric landward-skewed shoal covers an area of 76,000 acres. Water depths at the shoal are less than 10 feet on the western side and more than 25 feet on the eastern side. Due to the volume of available sand (2.3 billion cubic yards) and its proximity to target restoration areas, Ship Shoal has been used (Caminada Headland Restoration, Whiskey Island

Restoration) and is being considered for further use as a sand source to nourish adjacent barrier islands and beaches.

5.2.1.3. St. Bernard Shoals

The St. Bernard Shoals are located roughly 15 miles southeast of the Chandeleur Islands, Louisiana. Although the shoal complex covers more than 130,000 acres, the 61 individual shoals within the system range in size from 10 to 10,000 acres. Individual shoals rise more than 10 feet above the surrounding seafloor and sit on a well-defined northeast striking bathymetric platform that extends from the 50-foot to 65-foot isobath (Lavoie 2009). Due to the volume of available sand (260 million cubic yards) and its proximity to target restoration areas, St. Bernard Shoals is being considered for use (North Breton Island Restoration) as a sand source to nourish adjacent barrier islands and beaches.

5.2.2. Existing Data

Existing geophysical, geotechnical, and hydrodynamic (water levels, waves, and currents) data sets were identified for Sabine Bank, Ship Shoal, and St. Bernard Shoals. A summary of identified data sets is provided in the following sections.

5.2.2.1. Sabine Bank

A comprehensive field investigation, coupled with numerical modeling, has been completed for the Sabine Bank region (Stone et al. 2011). Bottom boundary layer physics, particularly wave and current induced shear stress and shear velocity, were analyzed using data collected on the crest and nearshore and offshore flanks of the shoal during spring 2004, winter 2006, and summer 2008. Data collected as a part of this study include bathymetry, water levels, waves, currents, suspended sediment concentration, temperature, and salinity. Surface samples and turbidity measurements were collected in summer 2008 to characterize bottom sediments and determine whether bottom boundary layer dynamics are influenced by sediment supply from outside Sabine Bank. Wave models were calibrated using this data and then implemented to evaluate sediment re-suspension intensity and transport for existing conditions and two dredging scenarios using bulk wave parameters. The MIKE 21 SW (DHI 2015a) model was implemented to examine wave transformation over the shoal and its modifications due to targeted sand mining, while the SWAN (Delft University of Technology 2016) model coupled with WAVEWATCH III (Tolman 2009) was implemented to quantify the hurricane generated wave fields along the Louisiana and Texas coast and implications due to partial removal of sand from the shoal (Stone et al. 2011). Additional hydrodynamic data (water levels, waves, and currents) were collected by CB&I at Sabine Bank between December 9, 2014 and January 21, 2015 in roughly 30 feet of water.

5.2.2.2. Ship Shoal

Numerous field measurements and numerical modeling studies have been completed for the Ship Shoal region (Kobashi 2009; Kobashi and Stone 2009; Pepper 2000; Pepper and Stone 2002, 2004; Stone and Xu 1996; Stone et al. 2004; Stone 2000; Nowlin et al 1998; Murray 1997). Bottom boundary layer physics, particularly wave and current induced shear stress and shear velocity, were analyzed using data collected on the crest and flanks of the shoal in 1998, 2000, 2006, and 2008. Data collected include bathymetry, water levels, waves, currents, sediment, suspended sediment concentration, temperature, and salinity. Wave and flow models calibrated using this data were implemented to evaluate hydrodynamics and resulting sediment transport for existing conditions and several dredging scenarios. Models used to examine the spatially varying hydrodynamics and sediment transport include MIKE 21 Spectral Wave (SW) (DHI 2015a) and MIKE 3 Hydrodynamic (HD) (DHI 2015b). Additional hydrodynamic data (water levels, waves, and currents) were collected by CB&I at Ship Shoal between December 9, 2014 and January 21, 2015 in roughly 35 feet of water.

5.2.2.3. St. Bernard Shoals

A model study was conducted for the Chandeleur Islands to simulate waves and sediment transport along a transgressive barrier island (Lavoie 2009). Storm wave propagation was estimated using the SWAN (Delft University of Technology 2016) model. Data measured at NDBC 42040 were used to generate the storm wave boundary conditions while data measured at NDBC 42007 were used to calibrate the wave model. Considering that tidal circulation in the vicinity of the Chandeleur Islands is not well known and little data exist to describe tidal range and velocities (Lavoie 2009), an existing validated numerical model (McCorquodale 2008) based on the Finite Volume Coastal Ocean Model (FVCOM) was used to extract regional and local tidal currents, tidal range, and transport trends resulting from fair weather and tidal motion. Using this information, the Advanced Circulation (ADCIRC) model (Luettich and Westerink 2004) was calibrated and then used to simulate flow patterns and water levels during storm events.

Following the *Deepwater Horizon* explosion and oil spill (and the above-mentioned study), hydrodynamic data (water levels, waves, and currents) were collected by the U.S. Geological Survey at four locations in the vicinity of the Chandeleur Islands between July 8, 2010 and November 8, 2010 (Dickhudt et al. 2010). These locations vary from roughly 20 miles immediately east of the island chain center, to 5 miles east of the northern and southern half of the island chain, to 1 mile west of the northern half of the island chain. During this same time period, offshore directional spectral wave data were collected at National Data Buoy Center Station 42040, which is located roughly 60 miles southeast of Breton Island near the 600-foot depth contour.

5.2.3. Physical Processes

Literature from a variety of sources was reviewed and data identified in Section 5.2.2. were evaluated to identify the physical processes that drive sediment transport and morphological response when dredging Louisiana outer continental shelf shoals. Physical processes to be considered when dredging shoals include pit and disposal area morphology, sediment transport, and nearshore processes, such as shoreline change (Nairn et al. 2007). Additional physical processes to be considered when dredging shallow shoals, especially when borrow areas are located near submerged cultural resources or infrastructure, include scour (Quinn 2006) and slope stability (Nairn et al. 2005).

At Louisiana offshore shoals, the most important contributions to long-term sediment transport are made by fairly large (in relation to depth) but not too infrequent, waves combined with tidal currents between mean neap and maximum spring tide (Soulsby 1997). Weak currents and low waves in relation to water depth give a small contribution, because their potential for sediment transport is low, although their frequency is high. Extreme conditions are also relatively unimportant, since their frequency is too low, although their transport potential is high.

Computation of wave fields generated by hurricanes Gustav and Ike showed that Sabine Bank acts as a submerged breakwater against hurricane-generated waves and effectively protects the coast from substantial erosion (Stone et al. 2011). Borrow area dredging has the potential to impact this protection and nearshore morphology as the change in bottom bathymetry may be sufficient to influence local wave and flow fields and resultant sand transport rates due to the modification of shoaling, refraction, and reflection patterns (Walstra et al. 2002; Benedet and List 2008; Benedet et al. 2013). Although wave modeling studies have shown that partial removal of shoal crests does not significantly modify the wave pattern or wave height variation along the coast, potential impacts resulting from programmatic dredging of multiple borrow areas within a shoal complex should be thoroughly investigated as complete shoal removal has been shown to substantially alter wave patterns and wave height variation (Stone et al. 2011).

Morphology is affected in the sense that locally the bed level is lowered substantially in the form of a borrow pit, which may influence the local flow and wave fields and hence the sand transport rates due to modification of shoaling, refraction, and reflection patterns (Van Rijn and Walstra 2002). The morphological response of a dredged borrow area includes erosion of side slopes and the deposition of this material and suspended sediment within the dredged borrow area due a reduction in the sand transport capacity. When the bed contains relatively large muddy and silty sediment fractions, cohesive forces become important (Van Rijn and Walstra 2002).

In the case of steep side slopes (1:5 and steeper) flow separation and reversal will occur introducing a complicated flow pattern. The flow in steep sided borrow areas can only be described using a detailed 3D model as the flow pattern is strongly dominated by the flow separation zone in the steep-sided borrow area (Van Rijn and Walstra 2002). The problem with 2DH and quasi-3D models is the assumption and/or application of logarithmic velocity profiles which leads to an underestimation of near-bed velocities and bed shear stresses and hence the transport gradients in the acceleration zone of the pit. As a result, scour of the bed would also be underestimated using 2DH and quasi-3D models (Van Rijn and Walstra 2002).

5.2.4. Modeling Plan

A conceptual plan for modeling and assessing potential borrow area impacts to nearby cultural resources and adjacent shorelines has been developed. Physical processes to be modeled include waves, currents, and sediment transport. A numerical modeling package, such as Delft3D (Deltares 2014), should be applied to simulate the complex interactions between offshore bathymetry, waves, tides, currents, sediment transport, and morphological change within the study area. Using data identified in Section 5.2.2, the numerical model should be set-up and calibrated using locally measured water level, wave, current, geophysical, and geotechnical data.

Numerical model development includes the creation of appropriate grids that contain and sufficiently resolve the borrow area and adjacent coastal (beaches, marshes, shorelines, shoals, etc.) and submerged (cultural resources, infrastructure, etc.) features to be evaluated, appropriately mapping geophysical and geotechnical data to the computational grid points, calibration of the wave, hydrodynamic and morphological models, and application of the calibrated model for the simulation and comparison of alternatives (i.e., production runs). A detailed description of each element and the procedure used to assess potential impacts due to borrow area dredging and the associated bathymetric change is provided in the following sections.

5.2.4.1. Computational Grid Development

Model grids should be constructed to include and sufficiently resolve the borrow area(s) and adjacent coastal (beaches, marshes, shorelines, etc.) and submerged (shoals, cultural resources, infrastructure, etc.) features to be evaluated. The grid resolution and coverage area should be correlated to the simulated physical processes and features to be studied. For example, multiple model grids may be necessary to simulate the relevant processes accordingly, including large-scale grids (with lower resolution) used to account for regional processes and detailed high-resolution grids used to represent local smaller-scale processes. Sufficient distance between the studied features and the model boundary should be maintained to avoid boundary related disturbances. After developing the model grids, geophysical data should be interpolated to the grid points to develop the bed level surfaces that are to be used in the simulations. Moreover, geotechnical data should be used to appropriately map sediments for use in sediment transport and morphological simulations.

5.2.4.2. Wave Modeling

Waves may be simulated using SWAN (Delft University of Technology 2016) or another appropriate advanced third-generation wave transformation model that incorporates relevant wave transformation processes, such as wind-wave generation and wind-growth, refraction, diffraction, bottom friction, shoaling, and wave breaking (depth-induced and white-capping). A time series of wave measurements collected in the vicinity of the study area should be used to calibrate the wave model. The model should be run in an iterative fashion to select the best forcing scheme, boundary conditions, and calibration parameters for accurately simulating waves in the study area. The wave model calibration should be sufficient to realistically simulate coastal processes (i.e., the calibrated wave model should be used as the basis for the flow and morphology calibrations) necessary for a comparative analysis (impact analysis) of various alternatives.

The calibrated wave model should be applied to better understand the complex wave patterns and associated causes and then used to assess potential impacts due to waves. The developed and calibrated wave model should be comprehensively used to evaluate alternative scenarios relative to a baseline scenario (e.g. existing conditions). Potential impacts to be assessed by completing a detailed wave modeling analysis include the following:

- Reduction in the shelter to a coast provided by offshore shoals,
- Changes in wave refraction over the dredged area leading to changes in wave height and direction adjacent to and at the coast,
- Changes in wave refraction over the dredged area leading to changes in wave height and direction over submerged features (cultural resource, infrastructure, shoals, etc.).

Wave and bottom boundary layer interactions at Sabine Bank were found to be strongly influenced by the passage of cold fronts and strong south-southeasterly winds (Stone et al. 2011). Although Ship Shoal and St. Bernard Shoals are located in different geographic regions, they are both exposed to a large uninterrupted south/southeast fetch. Moreover, it is also expected that the passage of tropical storms and hurricanes would strongly influence wave and bottom boundary layer interactions. Therefore, when defining model boundary conditions to evaluate potential wave impacts, selected events should include tropical storms and hurricanes, cold fronts, and strong south/southeasterly wind events.

5.2.4.3. Current Modeling

Currents may be simulated using Delft3D-FLOW (Deltares 2014) or another appropriate model that incorporates the most relevant hydrodynamic processes, including contributions due to waves, tides, winds, river discharges, and bottom friction. A detailed three-dimensional hydrodynamic model should be used for borrow pit modeling as the flow pattern is strongly dominated by the flow separation zone caused by steep borrow area side slopes (Van Rijn and Walstra 2002). A time series of current and water level measurements collected in the vicinity of the study area should be used to calibrate the hydrodynamic model. The model should be run in an iterative fashion to select the best forcing scheme, boundary conditions, and calibration parameters for accurately simulating currents and water levels in the study area. The hydrodynamic model calibration should be sufficient to realistically simulate coastal processes (i.e., the calibrated hydrodynamic model should be used as the basis for the morphology calibration) necessary for a comparative analysis (impact analysis) of various alternatives.

The calibrated hydrodynamic model should be applied to better understand complex hydrodynamics and associated causes and then used to assess potential impacts due to water levels and currents. The developed and calibrated hydrodynamic model should be comprehensively used to evaluate alternative scenarios relative to a baseline scenario (e.g., existing conditions). Potential impacts to be assessed by completing a detailed hydrodynamic modeling analysis include the following:

- Changes to tidal currents,
- Changes to currents adjacent to and at the coast,
- Changes to currents over submerged features (cultural resource, infrastructure, etc.). Considering potential impacts due to scour and slope stability on submerged features, three-dimensional current models should be used to properly simulate current profiles that may be influenced by the submerged feature or localized slope variation (i.e., borrow area side slope).

Along the Louisiana-Texas shelf, the dominant force that drives coastal currents is the prevailing wind, particularly during storms (Cochrane and Kelly 1986; Murray 1997). Although wave and tidal currents are generally low along the shelf, they should be properly modeled due to their influence on nearshore morphology. Considering wave and bottom boundary layer interactions at Sabine Bank were found to be strongly influenced by the passage of cold fronts and strong south-southeasterly winds (Stone et al. 2011), wave model boundary conditions should also be applied for the hydrodynamic model. When defining model boundary conditions to evaluate potential hydrodynamic impacts, selected events should include tropical storms and hurricanes, cold fronts, and strong south/southeasterly wind events. Moreover, the wave and hydrodynamic models should be coupled so that wave-driven currents are properly simulated.

5.2.4.4. Sediment Transport and Morphological Modeling

Sediment transport and morphological change may be simulated using Delft3D-FLOW (Deltares 2014) or another appropriate model that is able to compute sediment transport rates over time and space, based on wave and flow contributions, and from that determine space-varying bathymetric changes (i.e., erosion and deposition). A detailed three-dimensional model should be used for borrow pit modeling as the flow pattern, especially in the bottom boundary layer which influences sediment transport, is strongly dominated by the flow separation zone caused by steep borrow area side slopes (Van Rijn and Walstra 2002). Model bathymetry should be updated during the simulation so that it can be used for subsequent wave, flow, and sediment transport computations. This feedback loop should take place every model time step (on the order of 1 minute). The sediment transport and morphological model can then be applied to address the effects of multiple alternatives on sediment transport pathways and erosion and/or sedimentation trends (i.e., impacts to adjacent shorelines, sedimentation in the borrow area and navigation channels, scour adjacent to submerged features, etc.) relative to a baseline scenario (e.g., existing conditions).

Geotechnical and geophysical measurements collected in the vicinity of the project area should be used to configure and calibrate the sediment transport and morphological model. The model should be run in an iterative fashion to select the best forcing scheme, boundary conditions, and calibration parameters for accurately simulating sediment transport and morphological change in the study area; the model should also be calibrated to properly simulate borrow area infilling. The sediment transport and morphological model calibration should be sufficient to realistically simulate coastal processes necessary for a comparative analysis (impact analysis) of various alternatives.

Multiple model setups should be modeled to reflect the geotechnical measurements collected for this study. Sabine Bank indicated sandy layers lying unconformably on top of clay and clay overburden on top of sandy layers. The sandy layers at the top are limited to just over 11 feet thick for Sabine Bank Primary Area 3 (SB P3) and Sabine Bank Secondary Area 3 (SB S3). The modeling for SB P3 and SB S3 should focus on the top 11 feet as future beach nourishment projects will not borrow material below this elevation. For Sabine Bank Secondary Area 1 (SB S1), the geotechnical data indicated clay on top of sand. Future beach nourishment projects would have to remove the overburden to get to the approximately 10 feet of sand below 8 feet of overburden. The model would need to simulate how the overburden and the borrow area would perform over time, keeping in mind that the borrow area walls will be 8 feet of clay on top of 10 feet of sand. The Ship Shoal geotechnical data did not recover material below 13.2 feet. Future modeling efforts should focus on the top 13 feet as material below 13 feet are not likely to be beach compatible.

The calibrated sediment transport and morphological model should be applied to better understand the complex sediment transport patterns, morphological changes, and associated causes. The developed and calibrated sediment transport and morphological model should be comprehensively employed to evaluate alternative scenarios relative to a baseline scenario (e.g. existing conditions). Potential impacts to be assessed by completing a detailed sediment transport and morphologic modeling analysis include the following:

- Damage to beaches as a result of beach draw down (i.e., material lost from the beach to the dredged area),
- Interruption of sediment supply to the coast,
- Changes to sedimentary processes on the sand shoals,
- Changes to longshore transport and erosion/deposition patterns along the coast,
- Changes to longshore transport and erosion and/or deposition patterns over and adjacent to submerged features (cultural resource, infrastructure, shoals, etc.).

In addition to potential impacts, borrow area side slope stability and infilling rate/time should also be evaluated.

Considering that sedimentary processes occur on a much longer time scale, morphology should be simulated for several years. The morphological simulation time period should be defined after reviewing model results to ensure morphological comparisons answer questions under consideration. For example, if borrow area infilling is to be evaluated, morphological simulations may be carried out until a time where borrow area infilling rates can be properly estimated. If impacts to nearby submerged resources are to be evaluated, morphological simulations may extend until a time where morphological change between the baseline (i.e., no action scenario) and alternative scenario stabilizes, indicating that the net effects of the borrow area to nearby submerged resources is fully developed. If the morphological change between the baseline and alternative scenario does not stabilize after a two year simulation and longer simulation periods prove to be unfeasible in terms of computation time, the available model results (i.e., after the two-year simulations) should be analyzed and/or interpreted to delineate the degree and extent of the borrow area impacts on morphology. Uncertainties inherent to the use of modeling tools and attributed to the projection of model results to longer time frames should be incorporated into the conclusions.

5.2.5. Conclusion

Sufficient data is presently available to develop and calibrate a process-based wave, hydrodynamic, and morphological model, such as Delft3D, to simulate and evaluate the effects of dredging offshore shoals. Although data may be available to calibrate the morphological components of the model, this data is either available for the beach and nearshore area or non-altered areas of the offshore shoals. Following barrier island restoration projects, as-built data are typically collected for the project fill and borrow areas. Louisiana monitoring programs include surveys of the constructed fill areas, but do not include monitoring of the dredged borrow pits. Considering the recently-constructed restoration projects that included borrow areas in the offshore shoals (Cameron Shoreline Restoration, Caminada Headland Restoration, Whiskey

Island Restoration) and those that plan to use offshore shoal borrow areas (North Breton Island), a program should be developed and implemented to survey and monitor the borrow areas following construction. Collection of this borrow area monitoring data will improve the understanding of offshore shoal borrow area morphology development (i.e., infilling and adjacent scour). Furthermore, monitoring data can be used to better calibrate an offshore shoal borrow pit morphological model for use in evaluating impacts to cultural resources and infrastructure adjacent to, within, or near proposed borrow areas (similar to the procedure used by Walstra et al. 2002).

5.3 Recommended Research

From an archaeological perspective, all of the Sabine Bank and Ship Shoal sites examined in conjunction with this project were identified as either modern vessels or modern debris. Though none of those sites are historically or archaeologically significant, the vessel in SB P3 and the vessel in SS S3 could be considered to be appropriate candidates for designing and testing a program of site definition and monitoring to facilitate predicting and quantifying impacts to submerged cultural resources in, or immediately adjacent to, borrow sites. With that exception, no additional investigation is recommended for the Sabine Bank and Ship Shoal sites investigated by archaeological divers. Other magnetic anomalies and anomaly concentrations in the Sabine Bank and Ship Shoal sites are buffered and recommended for additional archaeological diver investigation or avoidance if dredging operations are permitted. Likewise, buffered magnetic anomalies and sonar targets in surveyed areas at St. Bernard and off Hewes Point are also recommended for additional archaeological diver investigation or avoidance if dredging operations are permitted in the immediate area.

Although the "Eighteenth-Century Ballast Pile Site" off the Chandeleur Islands is within the territorial waters of the State of Louisiana, additional investigation of that site is highly recommended. Archaeological investigation of the ballast pile is the only way to determine if the site represents a shipwreck or a ballast dump feature. Historical research confirms that the shallow waters off the Chandeleur Islands contain numerous shipwrecks and ballast dumps. Excavation of several trenches across the ballast pile should reveal evidence of hull structure. Excavations in 1989 were carried out below the ballast to sterile sand. However, sand could have been placed in the hull to minimize damage from the ballast cobble and stones. Any future excavations should be carried to the natural bottom unless hull structure is encountered. If surviving hull structure is encountered, the extent of it should be exposed, documented and recovered with ballast and sand.

Also, the magnetic anomaly clusters northwest and southeast of the ballast pile should be investigated. Probing at the northwest site identified a linear metal object that could be another cannon. Cannons remaining at the ballast site provide an attraction that could lead to unauthorized salvage. In addition to loss of the historic cannons, the surviving archaeological record could be damaged or destroyed. If archaeological investigation at the site is scheduled, the remaining cannons should be removed, conserved, documented, and curated. At this point, available evidence indicates the site could represent the remains of a small, late-first-quarter or early-second-quarter 18th-century vessel. As such, the wreck could be the oldest shipwreck yet discovered in the Mississippi River Delta region of the GOM.

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