Appendix B

Marine Archaeology Survey of Proposed Placement Areas, Lavaca Bay, Calhoun County, Texas, April 2017

BOB Project 2017-01

MARINE ARCHAEOLOGY SURVEY OF PROPOSED PLACEMENT AREAS LAVACA BAY, CALHOUN COUNTY, TEXAS

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April 2017

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MARINE ARCHAEOLOGY SURVEY
OF PROPOSED PLACEMENT AREAS
LAVACA BAY, CALHOUN COUNTY, TEXAS

Texas Antiquities Permit No. 7897

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Abstract

BOB Hydrographics, LLC (BOB) conducted a geophysical survey and marine archaeological assessment of 3 proposed dredged material placement areas (PA) in Lavaca Bay, Texas. The survey, sponsored by Lloyd Engineering, Inc. on behalf of the United States Army Corps of Engineers, included a broader area for mapping oysters. The combined surveys span portions of State Mineral Lease Tracts 8, 9, 17, 18, 20, 21, 29, 30, 33, and 34 in Calhoun County. The archaeological area of potential effect (APE) includes the 3 PA's and a 50-meter buffer around their margins. Together these areas total 514 acres. A total of 1,005 acres was surveyed to archaeological standards due to a change of scope mid-way through the project. Water depths range from 3 to 8 feet below Mean Lower Low Water. The PA's would be used for placement of sediment dredged from the Matagorda Bay Ship Channel. Field investigations included a marine geophysical survey, performed under Texas Antiquities Permit 7897, on January 25-30, February 27-28, and March 9, 2017. An archaeological assessment was conducted of all data acquired from the survey. The purpose of the survey was to locate potential archaeological sites that would be affected by placement of dredged materials. No artifacts were collected during this survey. A desktop review of the cultural background determined that 8 marine archaeological investigations and at least 19 wrecks have been reported within 3 miles of the APE. Analysis of geophysical survey results from this survey discovered 6 targets potentially eligible for the State Antiquities Landmark or for the National Register of Historic Places. Anomalies 1-6 are recommended for avoidance. This study was completed in compliance with Section 106 of the National Historic Preservation Act (Public Law 89-665; 16 U.S.C. 470) and the Antiquities Code of Texas (Texas Natural Resource Code, Title 9, Chapter 191). The minimum reporting and survey requirements for marine archaeological studies conducted under a Texas Antiquities Permit are mandated by The Texas Administrative Code, Title 13, Part 2, Chapters 26 and 28, respectively.

I. Introduction

BOB Hydrographics, LLC (BOB) conducted a geophysical survey and marine archaeological assessment of 3 proposed dredged material placement areas (PA) in Lavaca Bay, Texas (Figure 1). The PA's would be used for placement of sediment dredged from the Matagorda Bay Ship Channel. Lloyd Engineering, Inc. contracted with BOB, on behalf of the project sponsor, the United States Army Corps of Engineers (USACE), to conduct this archaeological assessment. The archaeological area of potential effect (APE) covers 514 acres, including the 3 PA's and a 50-meter (m) buffer around their margins. A total of 1,005 acres was surveyed to archaeological standards due to a change of scope mid-way through the project. The combined surveys span portions of State Mineral Lease Tracts 8, 9, 17, 18, 20, 21, 29, 30, 33, and 34 in Calhoun County. Water depths range from 3 to 8 feet (ft) below Mean Lower Low Water (MLLW). Cultural resources investigations were required by the Texas Historical Commission (THC) because placement of dredged materials might affect historic cultural resources resting on or embedded in the seafloor.

Geophysical survey was completed on January 25-30, February 27-28, and March 9, 2017. The purpose of this study was to assess the archaeological potential of the APE; however, no artifacts were collected during the survey. An archaeological assessment was conducted of all geophysical data acquired by the survey, including areas located beyond the APE. Submerged archaeological sites, in this context, might be sunken or abandoned watercraft. Submerged historic remains may be eligible for nomination to the National Register of Historic Places (NRHP) or as State Antiquities Landmarks. A desktop review of the cultural background determined that 8 marine archaeological investigations and at least 19 wrecks have been reported within 3 miles of the APE. Analysis of geophysical survey results from this investigation discovered 6 targets potentially eligible for the State Antiquities Landmark or for the NRHP. Anomalies 1-6 are recommended for avoidance.

This study was completed in compliance with Section 106 of the National Historic Preservation Act (Public Law 89-665; 16 U.S.C. 470), requiring that the lead agency consider the effects of projects, receiving either permits or funding from the federal government, upon historic resources. This study also complies with the Antiquities Code of Texas (Texas Natural Resource Code, Title 9, Chapter 191), which provides for the protection of cultural resources on state lands. The APE's are publicly owned; therefore, Texas Antiquities Permit 7897 was obtained prior to beginning fieldwork. Title 13, Part 2, Chapters 26 and 28 of The Texas Administrative Code mandates the minimum reporting and survey requirements, respectively, for marine archaeological studies conducted under Texas Antiquities Permits.

This report is organized into six sections that provide context for interpreting the survey results. Section II relies upon a combination of published literature and data collected by this survey to summarize the physical environment of the APE. Section III summarizes the relevant cultural background within a 3-mile radius of the APE, including maritime history, previous archaeological investigations, and the potential for

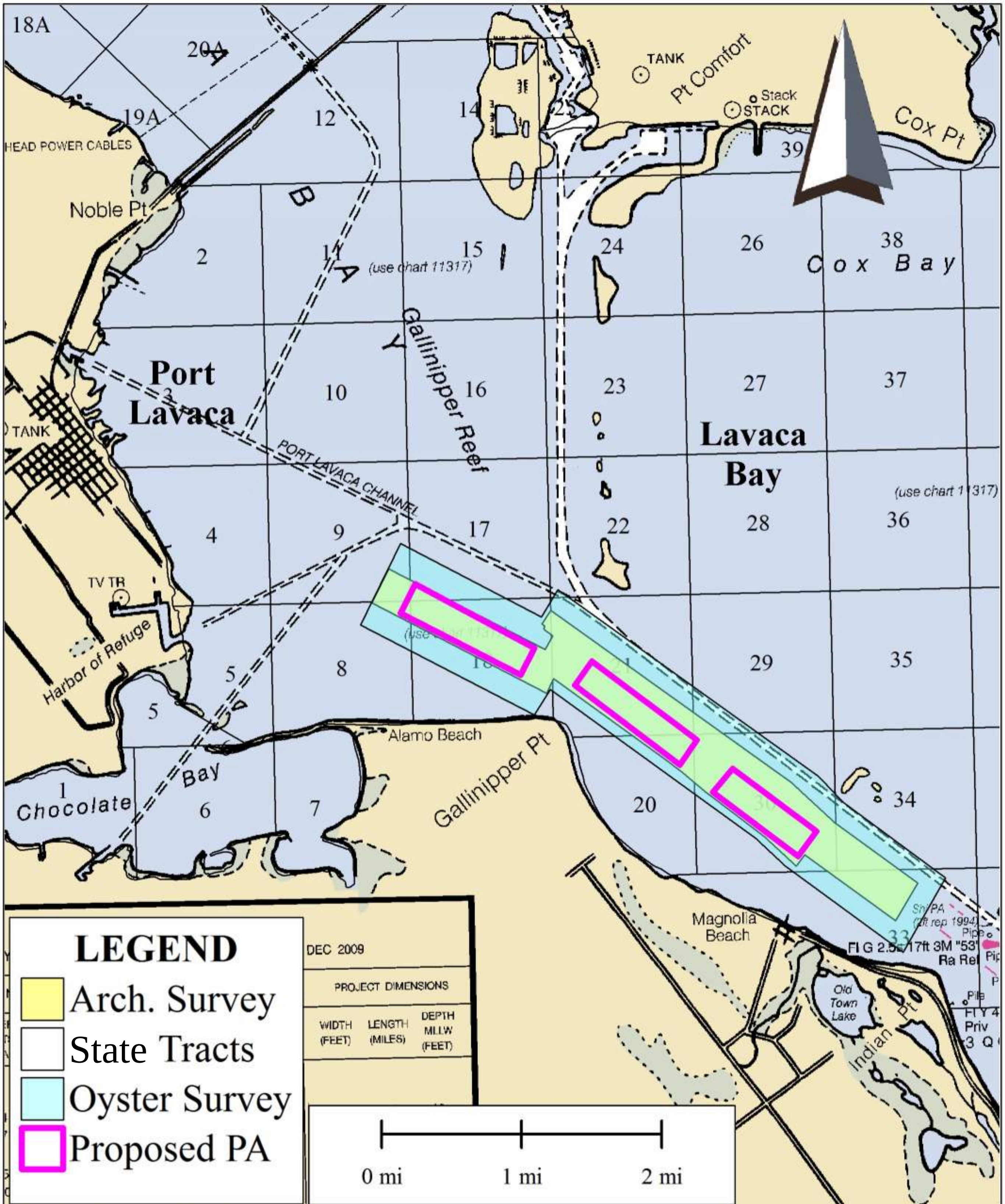


Figure 1
Project Location

(Base map:NOAA Chart 11316, 41st edition, 2007)

archaeological sites. Section IV summarizes methods for conducting the survey and for processing and analyzing the geophysical data. Section V presents an archaeological assessment of the geophysical data and provides recommendations specific to archaeological findings within the APE. Bibliographic references cited in the text are included as Section VI.

II. Physical Environment

Figures 2 and 3 capture the historic landscape of the APE in 1846, when Indianola and Lavaca were newly established ports, and in 1952, prior to deep-draft navigation and before the channel was cut through Matagorda Peninsula. The bathymetry shown for the APE in Figure 3 is from United States Coast and Geodetic Survey (USCGS) Chart 1284 and is expressed relative to the Mean Low Water (MLW) datum. The bathymetry of the APE from this survey is illustrated in Figure 4. Historic water depths in the mid-nineteenth-century were 7-8 ft (MLW) over most of the APE and 3-5 ft (MLW) over the reef extending from Gallinipper Point (USCGS 1888). Today the APE remains 3-8 ft deep (Figure 4; MLLW). The MLLW datum is less than 0.1 ft lower than the MLW datum in the APE, so depths are essentially unchanged.

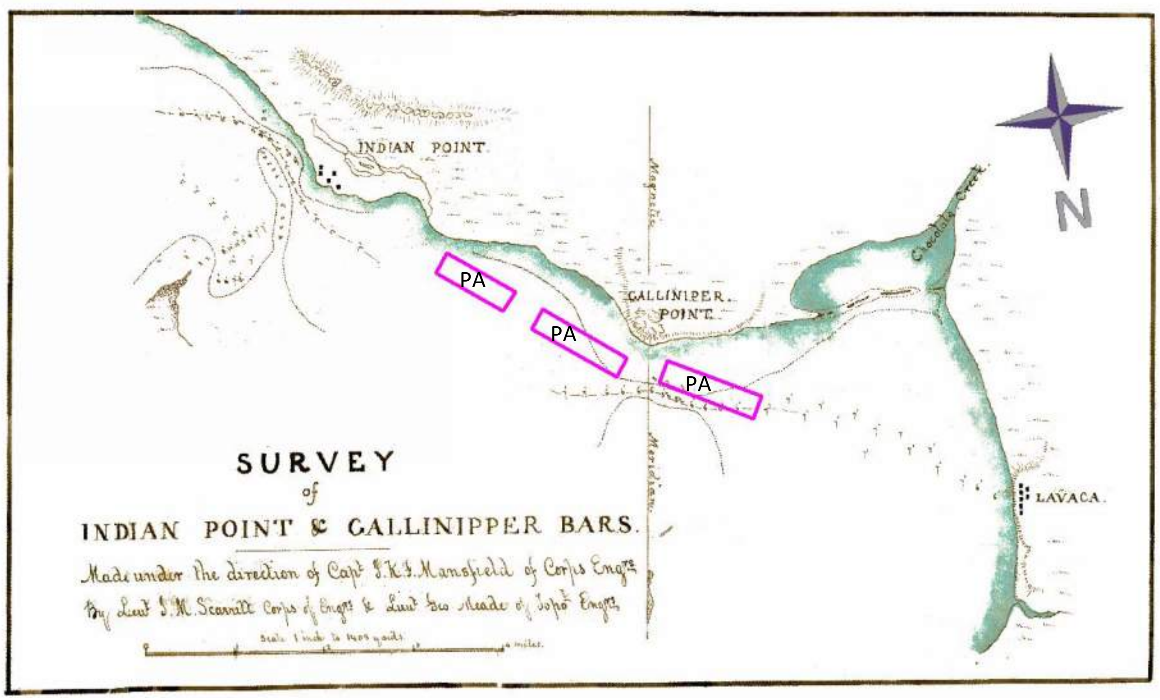


Figure 2: 1846 Survey of Indian Point & Gallinipper Bars (USACE 1846)

Oyster reefs at Gallinipper and Indian points are ancient features formed following retreat of the last continental glaciers. These shoals have been a hazard to navigation throughout history and represent a likely place for ships to run aground. Figure 2 shows the deepest natural passage through these reefs in 1846. Gallinipper Reef was described a century ago in a federal report on fisheries: “The eastern portion is covered by 4 feet or less of water, the reef rising rather abruptly 2 feet or more above the general level of the surrounding barren bottom. From the crest of this ridge it slopes westward to the general level of the bottom (United States Department of Commerce 1915: 21).”

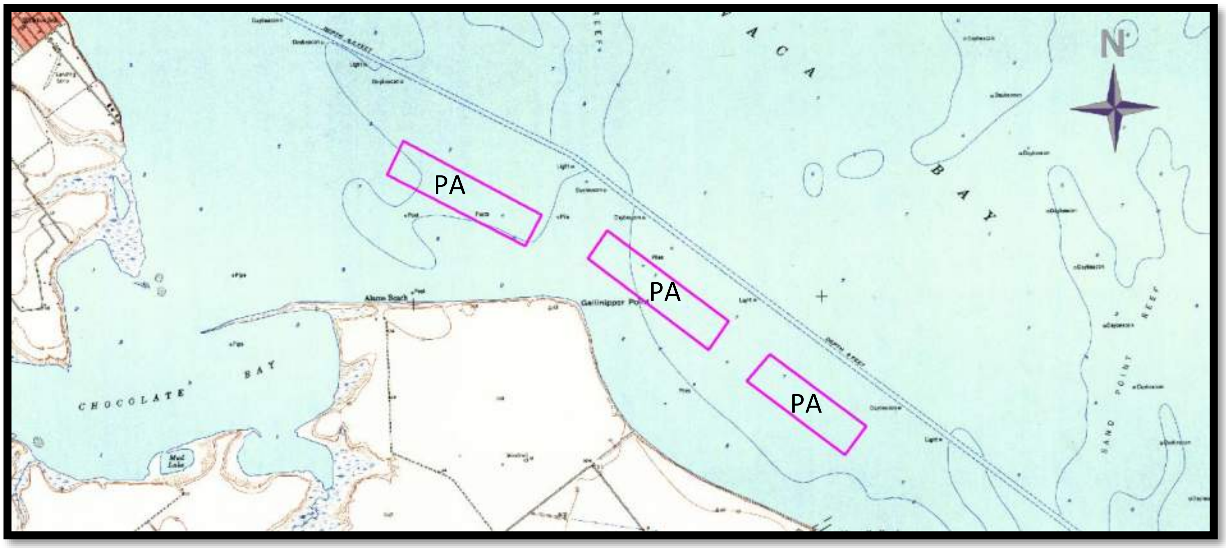


Figure 3: 1952 Port Lavaca East 7.5-min. Quadrangle (United States Geologic Survey 1952; MLW)

Part of the historic bar adjacent Gallinipper Point appears to have been deepened. A portion of the reef, charted historically as less than 6 ft deep, now is 8 ft deep (MLLW) and covered by a pattern of linear features resembling drag line scars. This area might have been deepened by dredging to mine dead oyster shells for use on roads and as fill material. Culbertson (2008: 5) states that dredging of dead shell occurred informally prior to 1907 and was formally authorized, with certain environmental restrictions, by the Texas Parks and Wildlife Commission in 1963. Shipwrecks located in such areas prior to dredging of shell would have been negatively affected and possible removed.

III. Cultural Background

Maritime History

Exploration of the Texas Coast began in 1519, when a Spaniard named Alonso Alvarez de Pineda led an expedition, on behalf of the governor of Jamaica, to map lands bordering the Gulf of Mexico. A Pineda map shows major inlets along the Texas Coast, one of which might be Pass Cavallo, the entrance to Matagorda Bay, although there is no proof that he entered the bay or explored its shores (Weddle 1985). Pineda demonstrated there is no shortcut to Asia through the Gulf of Mexico. His logs also helped to identify the fastest sailing route between Vera Cruz and Havana (Chipman 1992: 24-26). The Spanish silver fleet, sailing out of Vera Cruz, conducted steady trade with Havana for about 250 years, until 1790. Their ships typically followed either a northern route, paralleling the coast, or crossed the central Gulf of Mexico. Seasonal changes in wind and current patterns determined their choice of routes (Lugo-Fernandez et al. 2007). The northern route occasionally imperiled Spanish flotillas when storms pushed them toward the coast.

The first Europeans known to explore the Texas Coast were survivors from the shipwrecked Pánfilo de Narváez expedition of 1527. Cabeza de Vaca and 80 other Spaniards sailed on makeshift rafts to what many believe was Galveston Island. Those who survived the first winter were enslaved by Native Americans. Only

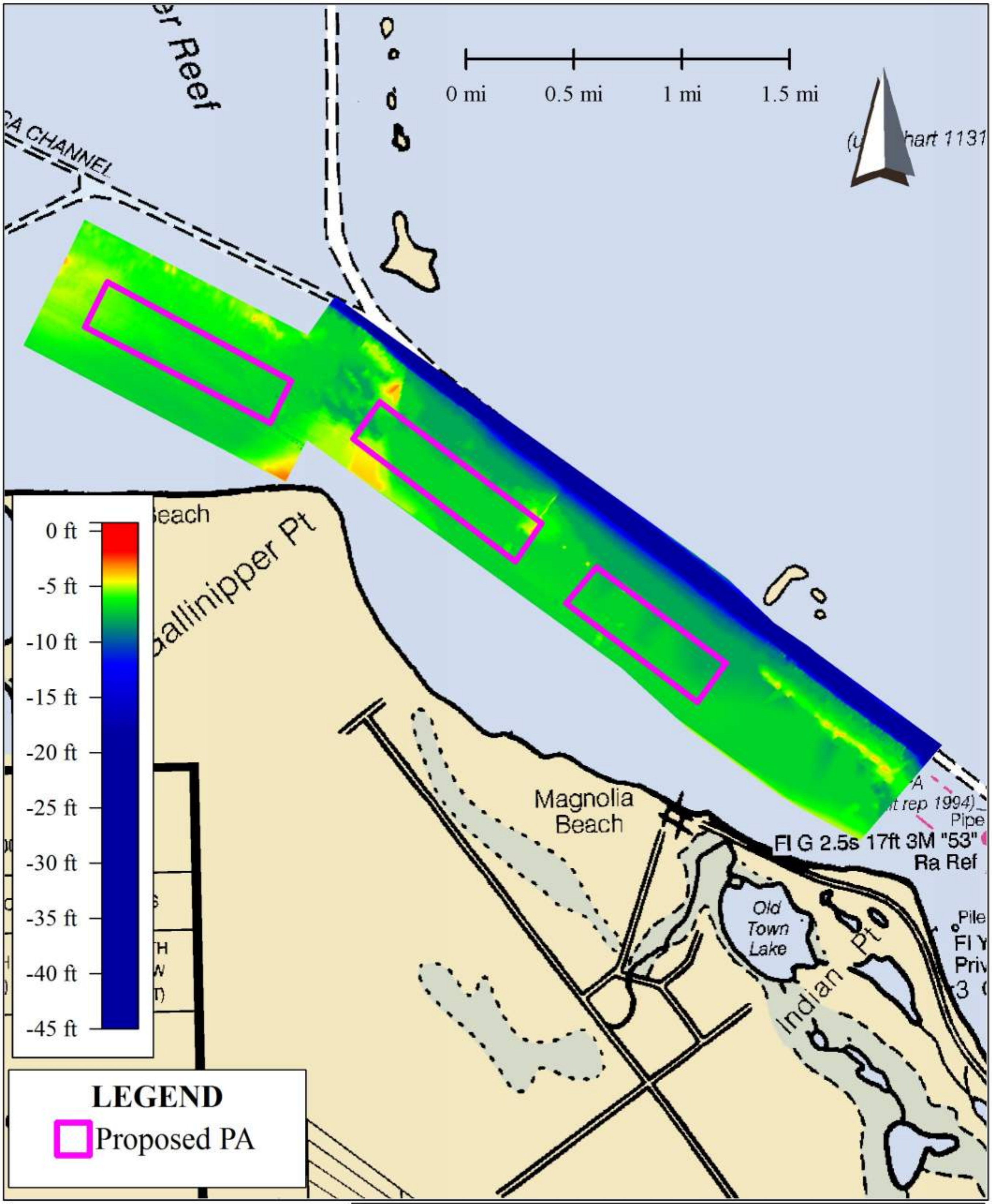


Figure 4
Bathymetry (MLLW)

(Base map:NOAA Chart 11316, 41st edition, 2007)

four men returned to tell their stories of wandering from tribe to tribe through what is now Texas and northern Mexico to the Pacific Coast, eventually reaching Mexico City after eight years. Cabeza de Vaca published his story in 1542 upon returning to Spain (e.g., Cabeza de Vaca 2013).

In the same year of Cabeza de Vaca's publication, Europeans were exploring Matagorda Bay for the first time. Luis de Moscoso Alvarado led Hernando De Soto's expedition into the bay in 1542, having taken command upon De Soto's death (Chipman 1992:39-40; Weddle 1991:100). Shortly after Alvarado's visit, Guido de Lavazares is believed to have visited Matagorda Bay in 1558 (Chipman 1992:48-49 and Weddle 1991:100-103). There is no record of ships lost in the bay during this early period, and the Spanish seem to have ignored the Texas Coast for the next two centuries. While undocumented visits are possible during the ensuing years, Spain largely ignored the Texas Coast except when other countries encroached on their territory. Such was the case when René Robert Cavelier, Sieur de La Salle arrived in 1685 with 300 colonists.

La Salle attempted to establish a permanent colony, Fort St. Louis, upstream from Lavaca Bay on Garcitas Creek. Through a series of unfortunate events, the French colony at Fort St. Louis did not succeed. The expedition lost one of three ships upon their arrival. A second ship returned to France with a group of colonists. Then, while La Salle was attempting to find the Mississippi River with an overland expedition, their last ship, *La Belle*, grounded during a storm and was lost in Matagorda Bay. With no way to return to Europe, those remaining at Fort St. Louis eventually perished (Weddle 1991).

La Salle's engineer, Minet, was among those who returned to France, taking with him the first map of Matagorda Bay. Although Fort St. Louis failed, its existence renewed Spanish interest in the Texas Coast. Spain mounted several expeditions to search for the French settlement. Alonso de León finally discovered the abandoned remains of Fort St. Louis in 1689. Spain established La Bahía del Espíritu Santo on the former site of Fort St. Louis in 1721 but moved it inland to the Guadalupe River four years later (Weddle 1991).

General Luis Aury, former Mexican governor of Galveston Island by appointment of José Manuel Herrera, established a temporary settlement in Matagorda Bay after losing control of Galveston to Jean Lafitte (Davis 2005: 324, 337). Aury left Galveston Island for Matagorda in May 1817 when it became clear he could no longer hold power in Galveston. It has been speculated that Aury destroyed his fleet in Matagorda Bay after Xavier Mina was defeated at Soto de la Marina in June of that year (Taylor 1957:30–31). Borgens, et al. (2007: 27) suggests that Aury destroyed no more than five vessels there despite a claim by the Spanish governor of Texas, Antonio Martinez, that he had sailed into Matagorda Bay with 13 vessels. A letter written six months later to United States President James Monroe also refers to Aury's loss of vessels. "…Aury, having lost a number of his Vessels on the Mexican Coast, and unable to maintain his position, either at Galveston or Matagorda, sailed for this Place [Amelia Island, Florida]" (British Foreign Office 1837: 772; letter to President Monroe from Major James Bankhead and Captain J.D. Henley, 10 January 1818). The number of vessels destroyed and their locations remain a mystery.

Stephen F. Austin founded the town of Matagorda in 1822 at the mouth of the Colorado River on East Matagorda Bay. Austin lobbied the Mexican Government to settle Galveston to promote a cotton market with England, which likewise would benefit his colony at Matagorda. A Mexican port of customs was established in Galveston in 1825 (Cotham 1998:1; Francaviglia 1998:91, 95) followed quickly by a Matagorda custom house in 1831 (Guthrie 1988). Increased trade soon prompted formation of other communities along the shores of Matagorda Bay.

The town of Linnville formed in 1830 around John Linn's Landing at the entrance to upper Lavaca Bay. Linnville played a part in supplying the Texas Army during the Texas War for Independence (Guthrie 1988: 130, 148 and 155) and was designated the official port of entry for the Lavaca Customs District in 1839. Linnville was destroyed in 1840 by a Comanche raid, commemorated by a Texas Centennial Historical Marker. The marker reads: "Site of the Town of Linnville. An early Texas port named for John Joseph Linn, 1798-1885, pioneer merchant of Victoria who located his warehouse here in 1831. Around this a settlement grew up which was destroyed by Comanche Indians on August 8, 1840. Erected by the State of Texas, 1936." Linnville was soon replaced by the town of Lavaca, the busiest port on the bay during the Texas Republic Period (Maywald 2010).

The town of Indianola, located near the APE, had its beginnings in 1844 when Carl, Prince of Solms Braunfels, chose a site on Indian Point for landing German immigrants bound for the interior of Texas (Malsch 2010). By 1846 a deep-water port and a military depot were established to supply the army during the United States' war with Mexico. Indianola thrived for three decades, reaching a population of 5,000 people, and becoming the second busiest port in Texas, until severe hurricanes in 1875 and 1886 destroyed the town.

The destruction of Indianola removed Port Lavaca's main commercial rival. It became the county seat in 1886 and saw its rail link with Victoria reestablished in 1887. Imports and exports through Matagorda Bay declined as the railroads expanded during the 1880s. Port Lavaca shifted its commercial emphasis from cattle to seafood and tourism. The seafood industry dominated Port Lavaca's maritime economy through the Great Depression and up until the growth of raw material industries. By 1940 the population of Port Lavaca had grown to just over 2,000 people (Maywald 2010).

Natural gas and oil were discovered upstream from Lavaca Bay during the 1930s, which led to the authorization of the Channel to Red Bluff in 1945. Commercial shipping to and from destinations outside of Matagorda Bay began to rebound with the growth of the petro-chemical and aluminum industries during the 1940s (Maywald 2010). Congress authorized the first deep-draft channel through the bay in 1958 in response to the industrial growth. The Matagorda Ship Channel was dredged through Matagorda Peninsula in 1965 and was opened to traffic in 1966 (Alperin 1977).

Potential for Historic Shipwrecks

The earliest confirmed European navigation of Lavaca Bay occurred in 1685 when LaSalle established Fort St. Louis on Garcitas Creek upstream from the bay. He was followed, literally, in 1689 when Alonso de León led an expedition to search for LaSalle's settlement. Subsequent Spanish expeditions entered the bay in search of a suitable location for their own settlement. By 1781, they had settled on the former site of Fort St. Louis (Weddle 1991).

Shipwrecks reported within 3 miles of the APE are included in Table 1. Sources consulted for Table 1 include the THC Texas Archaeological Sites Atlas (THC Atlas); the National Oceanic and Atmospheric

Administration's (NOAA) Automated Wreck and Obstruction Information System (AWOIS) database; a shipwreck database compiled by PBS&J; and historic maps from the Texas Historical Overlay (Foster, et al. 2006). There also is potential for unreported wrecks in Lavaca Bay dating back to the time of early European navigation through the area.

Table 1: Wrecks Reported Within Three Miles of APE

Name of Vessel	THC No.	AWOIS No.	PBS&J No.	Description	Date Lost	Position Accuracy
Bildot	930	5363	1636	32-ft cabin cruiser	1960	High, 0.1 mile
Ben Hur			1096	gas screw	1917	Unknown
Commercial	1003				1851	1 mile
Edgar			1590	wooden schooner	c. 1886	Unknown
Fina V		2501	1653	65-ft fishing vessel	1976	High
General Bustamente			1588	wooden sloop	1830	Unknown
Mary Ethel		5313		39-ft wood fishing vessel, b. 1941	1980	Low
Nettie			1310	steel schooner	1916	Unknown
Swan			733	schooner	1846	Unknown
Thistle			1380	gas screw	1929	Unknown
Volunteer			1397	wooden gas screw	1919	Unknown
William & Mary	1001			merchant sailing ship	1851	Unknown
Unknown	929					0.1 mile
Unknown	1239			unknown	1976	Unknown
Unknown	1240				Pre-1966	0.5 mile
Unknown		5304		multiple steel barges	Pre-1980	High
Unknown		5317	1618	barge	1966	Low
Unknown		5331		barge (80x10 m)	1975	High
Unknown		5362	1634	34-ft fishing vessel	1974	Low
Unknown		5851		22-ft steel shrimp boat	1984	High
Unknown		8718		multiple barges	1991	High
Unknown		8719		unknown	1991	High
Unknown		8720		unknown	1991	High
Unknown		8721		unknown	1991	High
Unknown		8722		multiple wrecks; unknown	1991	High
Unknown		8723		unknown	1991	High

The THC Atlas contains reports of shipwrecks from historic records. The AWOIS database is maintained by NOAA to support the charting of coastal areas. AWOIS tends to report recent shipwrecks; however, historic wrecks are included. Positions for wrecks in AWOIS are usually more accurate than those from historic records, although positions pre-dating the era of satellite position systems can vary considerably from actual locations. A group of archaeologists, including this author, assembled the PBS&J database, in part, based on information gathered from charts, historical reports, THC files, and AWOIS. The PBS&J database focuses primarily on well-documented commercial wrecks postdating 1850. The THC Atlas was searched over a radius of 3 miles from each APE. The positions of most reported wrecks remain uncertain. Positions reported in historical accounts are often imprecise. Vessels reported as lost in Lavaca Bay may be included in Table 1 unless information exists to suggest a more precise position further than 3 miles from the APE.

At least 19 shipwrecks have been reported within a 3-mile radius of the APE (Table 1) by one or more of the sources listed above. Seven additional wrecks are reported from the Lavaca Bay area, some of which might be in or near the APE. Archaeologists have yet to locate any of the wrecks listed in Table 1.

Factors Affecting Vessel Loss

Factors contributing to the loss of watercraft vary depending on environment conditions. Historic government statistics, summarized by Gearhart, et al. (1990: Volume IV, 59-61), categorized vessel casualties, including most accidents and incidents resulting in injury or loss of property, and reported the value of losses incurred. A total loss was reported if the hull could not be saved. These statistics do not reflect the degree to which cargo and vessels were salvaged. Types of casualties included foundering, stranding, collision and other (fires, boiler explosions, injuries, mechanical failures, etc.).

Foundering was the primary mechanism of vessel loss in navigable waters. The *Annual List of Merchant Vessels of the United States* (United States Department of the Treasury 1906-1946) defined foundering as leaking or capsizing of vessels. Foundering accounted for about 6 percent of historic vessel losses. Despite its low rate of occurrence, recovery from foundering was less likely than from any other type of casualty. Fifty-four percent of all foundered vessels were reported as totally lost.

Stranding was the primary mechanism of loss in shoal waters and was, by far, the most common type of shipwreck during the historic period. Stranding (or grounding) accounted for 64 percent of total losses reported by the U.S. Lifesaving Service for the period 1876 through 1914 (Gearhart, et al. 1990: Volume IV, 59-61). Stranding occurred where the water was too shallow for navigation, including shorelines, harbor bars and reefs. Forty-six percent of stranding events resulted in a total loss (Gearhart 1990: Volume IV, 59-61). Stranding is the most likely source of shipping losses in the APE's.

Severe weather accounted for 55 percent of total losses reported by the U.S. Lifesaving Service from 1876 through 1914. Almost half of all losses from foundering were caused by weather, compared with two thirds of losses from stranding. Mariners had short warning of approaching storms prior to modern weather forecasting. The central Texas Coast can experience hazardous weather conditions throughout much of the year. Hurricane season lasts from late June through October. Hurricane-force winds can devastate ships caught unprepared. During the winter, severe cold fronts affect the Texas Coast. These

"Northers" may have winds exceeding 50 miles per hour, generating dangerous waves, and can last 24–36 hours (McGowen 1976:19–23, 94).

Factors Affecting Vessel Preservation

Preservation of sunken watercraft depends mainly upon their composition and the extent of their burial in the seafloor. Vessels may become partially buried soon after sinking due to the combined effects of storm-induced current scour, liquefaction of sediments, and the ship's weight pressing down on a waterlogged substrate. Ships made of metal are equally susceptible to burial as wooden hulls, but metal hulls remain exposed much longer than wooden ones in saline waters along the Texas Coast. Exposed wooden components tend to disintegrate quickly where wood-boring organisms thrive. Biological organisms and water saturation weaken the wood, which is then more easily disarticulated and laid flat or removed by fishing trawlers and storm waves. Burial promotes long-term preservation of wood by creating an oxygen-deprived environment, which limits biological activity. Given a sufficient quantity of weakly-consolidated sediment, a significant portion of a hull might become preserved in this manner.

Iron corrodes five times faster in seawater than when buried on land. Iron artifacts tend to become concreted when calcium carbonate from the seawater cements adjacent materials, such as rock and sand, or even other artifacts, to the iron object. Prolonged oxidation can leach out most or all iron mineral, leaving only a carbonate mold of the original artifact (Hamilton 1998). Iron and steel hulls, nevertheless, can survive seawater exposure for well over a century.

Previous Investigations

Eight marine archaeological surveys and one desktop study have been completed within 3 miles of the APE (Table 2). Abstracts for most of these studies are available on the THC Atlas. Archaeological investigations have been sponsored primarily by the USACE and by the petroleum industry. A Texas Antiquities Permits was not issued for the earliest survey. None of these studies overlaps the APE.

The earliest archaeological survey in the area was conducted as a precursor to shell dredging by The Institute for Underwater Research, Inc. (Scurlock 1971). This work covered seven state mineral lease tracts northeast of the ship channel. The study recommended 16 geophysical targets as potential shipwrecks. One of these targets was confirmed as a modern wreck.

Coastal Environments, Inc. conducted geophysical survey along the Matagorda Ship Channel in 1988 on behalf of the USACE. Their survey covered over 11 miles of the channel, including 5.9 miles in the upper bay. This is the closest survey to the present APE, coming within 0.6 miles, and overlapped slightly with survey conducted to map oyster reefs as part of the current project. They reported 12 targets as potential shipwrecks. Five of those were investigated by divers but only one source was found, which proved to be modern debris (Pearson and Hudson 1990).

HRA Gray & Pape, LLC performed a cultural resource background study in 2005 on behalf of URS Corporation. Their study summarized historic potential within a half mile of the Matagorda Ship Channel in anticipation of plans by the Calhoun County Navigation District for widening and deepening. The study compiled a list of historic markers, archaeological sites, and shipwrecks based on the THC Atlas and the AWOIS database (Hughey 2005).

Table 2: Previous Investigations Within Three Miles of APE

Antiquities Permit	Principal Investigator	Report Title	Sponsor
THC Annual Antiquities Permit 2035	Steve Hoyt	Indianola Archeological Remote-Sensing Survey, Calhoun County, Texas.	NOAA Office of Ocean Exploration
6335	Michael Tuttle	Lavaca Bay LNG Project, Texas Antiquities Permit Number 6335 Update on Remote Sensing Data Analysis and Recommendation for In-Water Investigation, and Request for Comments under Section 106 of NHPA	Excelerate Liquefaction and Lavaca Bay Pipeline
4616	Stephen James	Submerged Cultural Resources Remote Sensing Survey, Proposed Flowline and Wellhead in ST 65, Matagorda Bay, Calhoun County, Texas.	Sterling Exploration and Production
4328	Jenna Enright	Marine Geophysical Survey for Historic Properties for Proposed State Tract 37 Well No. 4 and Proposed Pipeline in State Tracts 36 and 37, Cox Bay, Calhoun County, Texas	Neumin Production Company
4080	Amy Borgens	Marine Geophysical Survey for Historic Properties, Matagorda Ship Channel and Potential Placement Areas, Matagorda Ship Channel Improvement Project, Matagorda and Lavaca Bays, Texas	URS Corporation
4079	Amy Borgens	Archaeological Investigations Related to Calhoun County Navigation District's Proposed Turning Basin and Marine Improvements and Associated Placement Areas, Lavaca Bay, Calhoun County, Texas	URS Corporation
None; desktop study	James Hughey	A Cultural Resources Assessment Study: The Potential Impact to Cultural Resources Within Property Proposed for Improvements to the Matagorda Ship Channel and Associated Dredge Locations in Matagorda and Calhoun Counties	URS Corporation
0938	Charles Pearson	Magnetometer Survey of the Matagorda Ship Channel: Matagorda Peninsula to Point Comfort, Calhoun and Matagorda Counties, Texas	USACE
None	Dan Scurlock	Archeological Survey for Shipwreck Sites in Northwestern Matagorda Bay, June 1-12, 1971	unknown

In 2006, PBS&J conducted an archaeological assessment of geophysical data acquired by NCS Subsea, Inc. The assessment was performed under Texas Antiquities Permit 4079 on behalf of URS Corporation and the Calhoun County Navigation District. The survey encompassed 828 acres, including a proposed turning basin at Point Comfort and three associated dredge placement areas. Their study found no evidence for potential shipwreck sites (Borgens and Gearhart 2006).

Later that same year URS Corporation hired PBS&J to conduct extensive geophysical surveys along both sides of the Matagorda Ship Channel, including proposed placement areas north and east of the channel. The Calhoun County Navigation District proposed to double the existing width of the Matagorda Ship Channel and to deepen the channel by 8 ft. PBS&J's survey was completed in 2006 under Texas Antiquities Permit 4080 (Borgens et al. 2007). The combined surveys encompassed 7,786 acres. Their archaeological assessment recommended avoidance of 39 potentially significant magnetic anomalies.

In 2006, PBS&J conducted a geophysical survey and archaeological assessment of 117 acres for a proposed well pad and flow line on behalf of Neumin Production Company. One magnetic anomaly was flagged as potentially significant. Close-order survey and further research determined the anomaly is associated with an abandoned petroleum well, so archaeological clearance was recommended for the project (Enright and Gearhart 2007).

In 2006 and 2007, the THC conducted a remote-sensing survey and diving in Matagorda Bay near the historic site of Indianola. A grant from NOAA's Office of Ocean Exploration funded the investigation. The THC's research tentatively identified remains of Charles Morgan's 1852 steamship *Perseverance*, believed shown as wreckage in a lithograph of Indianola based on an 1860 painting by Helmuth Holtz.

In 2007, Panamerican Consultants, Inc. surveyed 40 acres for a proposed well pad and flowline corridor on behalf of C.H. Fenstermaker & Associates, Inc. and the project sponsor, Sterling Exploration and Production Company. No geophysical anomalies were recommended for avoidance by their archaeological assessment (James and Faught 2007).

A remote-sensing data analysis was conducted in 2013 by HRA Gray & Pape on behalf of Excelerate Liquefaction and Lavaca Bay Pipeline (Tuttle 2013). The study was performed under Texas Antiquities Permit Number 6335 in support of a proposed Liquid Natural Gas project in Lavaca Bay. The sponsors have postponed the project, and only an interim report has been submitted.

IV. Research Design

Survey Methods

The geophysical survey reported here was conducted for two purposes, locating potential archaeological sites and mapping shell reefs. Portions of the survey reported outside of the archaeological survey areas were conducted only for mapping shell reefs thus were not subject to the same survey requirements. Nevertheless, data acquired outside of archaeological survey areas is included in this assessment report. Any potential cultural resources observed in that data would be reported in this document. Geophysical survey of the archaeological APE was designed to meet or exceed the following minimum standards of the THC for archaeological survey of state-owned submerged lands (Texas Administrative Code, Title 13, Part 2, Chapter 28, Rule 28.6): 1) the survey must be conducted under a Texas Antiquities Permit issued by the THC; 2) the survey line interval cannot exceed 20 m (30 m when greater than 3 nautical miles offshore); 3) bottom-disturbing activities must be avoided within 50 m of potentially significant targets (150 m when more than 3 nautical miles offshore); 3) the survey area must extend beyond the limits of bottom-disturbing activities by the width of the avoidance margin; 4) survey instrumentation must include a marine magnetometer, a high-resolution side-scan sonar, and a recording fathometer all of which must record data digitally to electronic storage media; 5) survey instrumentation should be interfaced with a positioning system having accuracy comparable or better than a differential global positioning system (GPS) receiver; 6) the magnetometer must be towed within 6 m of the marine bed and should sample at least once per second; 7) the side-scan sonar should operate at a minimum frequency of 300 kiloHertz (kHz); 8) the positioning system should sample at least once per second; and 9) no artifact collection is permitted.

The APE was modified during the project; thus, the survey was conducted in two separate field sessions using different boats, equipment, and personnel. Session 1 was completed January 25-30, 2017 by BOB with assistance in the field from Edward Baxter Consulting. Session 2, interrupted by weather, was completed February 27-28 and March 9, 2017 by Tim Seward and Miles Becker of Hydrographic Consultants, Ltd. The Principal Investigator was present in the field for all of Session 1 and for greater than the mandated 25-percent of Session 2.

Session 1 was surveyed from a 25-foot hydrographic survey vessel. Geographic positions were acquired using a Hemisphere VS131 differential GPS. Bathymetry data were acquired using a Teledyne-Odom CVM recording fathometer equipped with a 200-kHz transducer. Lead-line soundings were used to calibrate the fathometer. A Geometrics 882 magnetometer was towed on the sea surface 50 ft aft of the survey boat. Side-scan sonar data was acquired using a 600-kHz Edgetech 4125 system towed from the survey vessel's port side. Sonar imagery was recorded using Edgetech's Discover acquisition software. Geographic positions were embedded into the digital sonar data as it was recorded. Chesapeake SonarWiz software was used to combine sonar data from each transect into a composite sonar mosaic.

Session 2 was completed from a 20-foot hydrographic survey vessel. Geographic positions were acquired using a Trimble SPS461 dual-antennal GPS. Bathymetry data were acquired using a Teledyne-Odom Hydrotrac recording fathometer equipped with a 200-kHz transducer. A Geometrics 882 magnetometer was towed on the sea surface 50 ft aft of the survey boat. Side-scan was acquired using a DSME S150 sonar operating at a frequency of 400 kHz and recorded with Oceanic Imaging Consultants (OIC) Geodas software. A mosaic was created using OIC Clean Sweep software.

All data, except sonar, was logged in Hypack navigation software. Horizontal position estimates for each sensor were recorded in real time. Positions are based on the Universal Transverse Mercator (UTM) Coordinate System (Zone 14 North, meters). Sonar data for archaeological portions of the survey were recorded along 25-m-wide (82-ft) swaths overlapping with data from adjacent vessel tracks. Sonar data for oyster-only portions of the survey were recorded along swaths of either 25 m (82 ft) or 50 m (164 ft) along lines spaced 40 m (131 ft) apart.

The purpose of the survey was to map geophysical anomalies that might have historical significance. In the context of submerged lands, historical significance typically, although not necessarily, refers to association with historic shipwrecks. The primary instrument for locating potential shipwrecks in buried contexts is the magnetometer. Exposed shipwrecks are visible in side-scan sonar imagery; however, historic wrecks in Texas bays are more often buried. Vessels predating World War II tend to be constructed of wood, which quickly deteriorates when exposed to wood-loving organisms common to warm saline environments. Nevertheless, buried wooden hulls can retain a high level of artifact preservation and historic integrity. Wrecks exposed above the mudline for more than a few years tend to be constructed of materials other than wood.

Low-frequency fluctuations in magnetic data, caused, for example, by diurnal passage of the sun or by geologic gradients, were removed prior to contouring using a filter algorithm. The algorithm treats short-term fluctuations, exceeding a selected threshold amplitude, as anomalous values. The result is a dataset in which abnormally high and low magnetic amplitudes (anomalies) are centered around zero (representing the ambient level). All amplitude shifts smaller than the threshold value are reduced to zero and are treated as ambient background. This process removes low frequency data, leaving potentially significant anomalies intact, and allows a visual representation of anomaly polarity.

Magnetometer data illustrated in this report have been thinned to a 1-second interval between data points. Diurnally-corrected magnetometer data was contoured using Blue Marble's Global Mapper® software (Version 17.2) at a 5-nanoTesla (nT) contour interval. Magnetic amplitudes between +5 nT and –5 nT are considered insignificant. Contour maps omit the 0-nT contour level to prevent a cluttered appearance. Positive amplitude is indicated by red contours, and negative amplitude is drawn as blue contours.

Interpretation of Magnetometer Data

Most magnetic anomalies in marine environments are caused by relatively small pieces of ferromagnetic debris, which tends to concentrate near high-traffic areas, marine disposal areas, industrial developments, petroleum wells, and pipelines. The frequency of ferromagnetic debris far outnumbers shipwrecks, necessitating some means for distinguishing between the two when conducting archaeological assessments. The method used here is based primarily upon a study by Gearhart (2011) that compared shipwreck and debris anomalies. Gearhart has analyzed magnetic data from a large and diverse collection of anomaly sources, including 39 verified shipwrecks and many debris sources with the goal of characterizing differences between these two categories of magnetic sources. Shipwrecks in his dataset represent a broad spectrum of material compositions, construction styles, ages, and archaeological contexts. Their hulls include construction from wood, iron, steel, and concrete. Their propulsion systems range from sail to steam-driven paddlewheels and propellers, and from oil and diesel screws to towed or pushed barges. They range in age from the mid-16th to the mid-20th century. They have been found in diverse depositional environments including harbor entrances, surf zones, beaches, marsh, oyster reefs, open bay waters, and the Gulf of Mexico. And this assortment of watercraft found their way to the seafloor in various ways including stranding on beaches, foundering at sea, by fire, by explosions (both accidental and intentional), and by abandonment. Some were partially demolished or salvaged after wrecking. Others remain largely untouched since the day they sank. Yet despite their many differences, they share common characteristics, which form the basis for this interpretative method.

Complexity

Archaeologists frequently have characterized shipwreck anomalies as appearing “multicomponent” or “complex”, because shipwreck anomalies are observed to exhibit multiple dipoles, as well as unpaired monopoles. Such observations, however, can be affected by sampling bias. In other words, a single anomaly might look quite different depending on how many points are sampled and where those points occur. Some observations of complexity in wreck anomalies might have been influenced by the fact that early surveys typically were not contoured. Magnetometer technology also might have contributed to the perception of complexity. Proton precession systems tended to produce false noise spikes in the presence of high magnetic gradients, which easily could be interpreted as anomaly complexity.

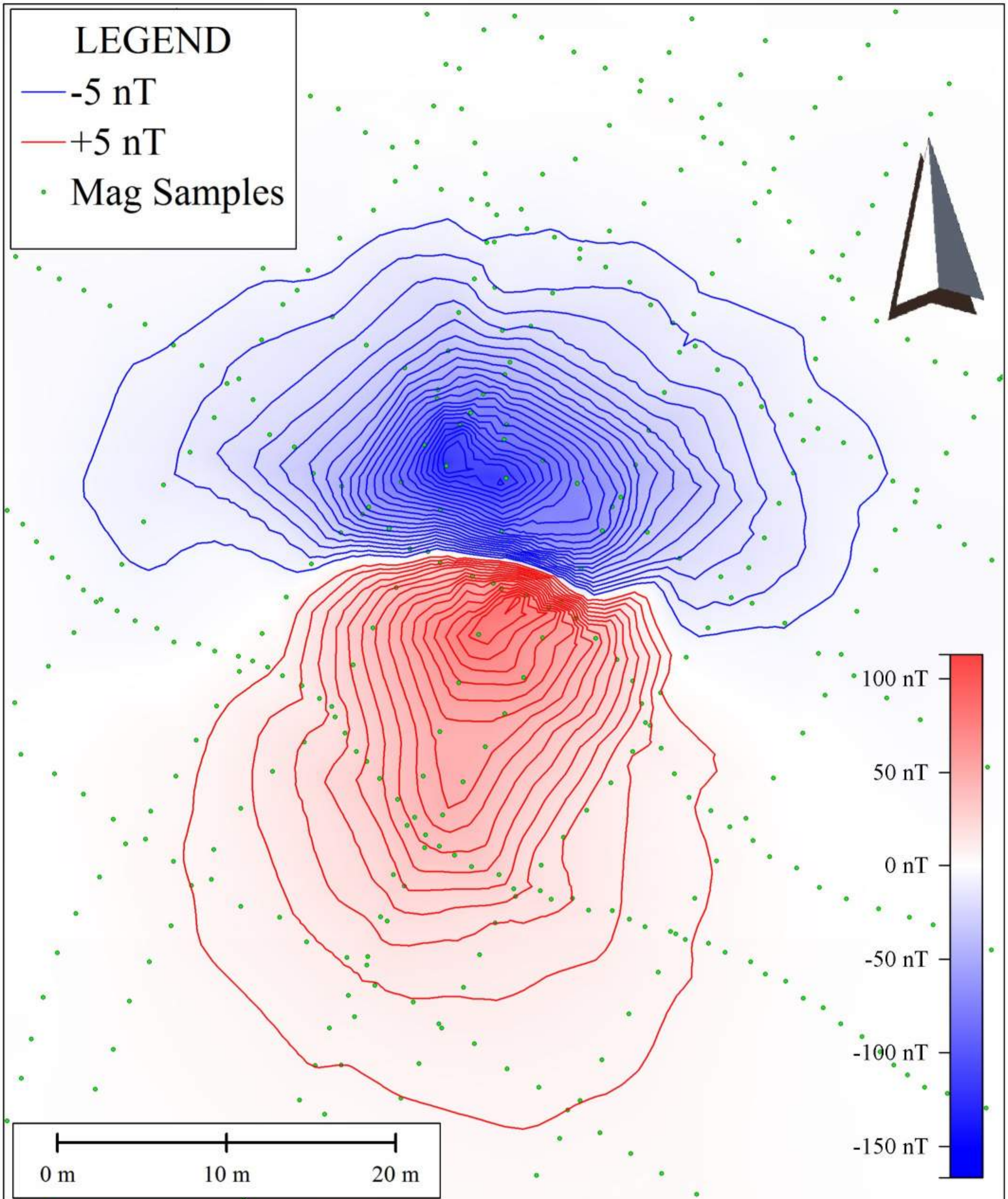
Garrison, et al. (1989: II, 223) summarized several common methods for prioritizing anomalies with a focus on complexity. Shipwreck anomalies were characterized as having: multiple peaks of differing magnitudes spread over an area greater than 10,000 square meters (2.5 acres); gentle gradients; and a linear association with anomalies on adjacent transects. A typical debris anomaly was characterized as having a single peak covering an area of less than 10,000 square meters, a steep gradient, and no alignment of anomalies on adjacent lines.

Horizontal Dimensions

Anomaly width, or duration as preferred by some, is a common and valid measure used by archaeologists for discriminating potential shipwreck anomalies from those believed more likely caused by debris. For example, Linden and Pearson (2014) would consider an anomaly significant if it has amplitude of at least 50 nT and a width of 65 ft or more. The horizontal dimensions of shipwreck and debris anomalies overlap considerably, especially when considering wrecks with wooden hulls, thus width alone is not particularly useful for discriminating between the two. There is a 15-fold difference in width between the smallest wood-hulled sailing ship and the largest steel tanker, so large wrecks tend to be obvious. Unfortunately, small, wooden watercraft, even many steamboats, tend to have anomalies no wider than many debris anomalies.

Small, wooden, and generally historic, shipwrecks are the most difficult sites to detect precisely because their anomalies overlap in size with many debris anomalies. Site 41CL92 (Figure 5) has the smallest verified wreck anomaly known to this author. Divers confirmed the site, measuring 23 x 52 ft (7 x 15.9 m), as an early 19th-century sailing vessel containing a large collection of concreted artifacts, iron bar stock, and pig iron ballast (Borgens 2004). The 41CL92 anomaly measures 155 x 176 ft (47.2 x 53.6 m) to the 5-nT contour, 3.0 to 3.4 times the maximum width of the site. The archaeological site covers only about 4 percent of the anomaly’s area. The smallest wreck in Gearhart’s anomaly dataset, Mag-13, is a buried wooden hull measuring roughly 13 x 35 ft, based on diver probes (Gearhart 2016: 46). The Mag-13 anomaly measures 164 x 197 ft (50 x 60 m), which is 4.7 to 5.6 times the length of the hull.

Based on the models provided by the 41CL92 and Mag-13 anomalies, the minimum horizontal dimension of a significant anomaly should be wider, by a factor of at least 3, than the smallest, historic, wooden vessel likely to have navigated an area. The smallest likely size of historic watercraft can be determined



BOB Hydrographics, LLC

Figure 5
Example of a Verified Shipwreck Anomaly
Site 41CL92

through research. For example, the average size of wooden sailing vessels registered in the Port of New Orleans during the period 1804-1820 was 71 x 21 ft (21.6 x 6.4 m) (based on Works Progress Administration [1941] as summarized in Ford et al. 2008: 54-71). The smallest vessel registered in New Orleans during the same period was the schooner *Tickler*, which measured only 29 x 10 ft (Works Progress Administration 1941: 127). It seems reasonable, based on comparison with 41CL92, that a wooden vessel as small as *Tickler* could have an anomaly measuring no more than 87 ft across, three times its hull length.

Small shipwreck anomalies cannot be distinguished from debris anomalies based on size alone. All wooden-sailing-ship anomalies and all but one wooden-steamboat anomaly known to this author are smaller than 10,000 square meters, Garrison, et al.'s (1989: II, 223) minimum suggested size for typical shipwreck anomalies. Site 41CL92, for example, covers an area of only 1,580 square meters (0.4 acres) out to the 5-nT contour.

Amplitude

Anomaly amplitude correlates poorly with horizontal dimensions of a magnetic source, because amplitude depends greatly upon the mass of the source and the distance between the magnetometer and the source. Small sources can produce large amplitude when measured at close range. Shipwreck anomalies from Gearhart (2011) have average peak-to-peak amplitudes of 270 nT for wood-hulled sailing vessels (n=6); 5,020 nT for wood-hulled machine-powered vessels (n=7); and 10,386 nT for iron- and steel-hulled vessels (n=12). Magnetic debris can produce amplitudes virtually anywhere within that same range, thus amplitude is of little use for differentiating shipwrecks from debris.

Orientation

Shipwreck anomalies (e.g., Figure 5) consistently share a common orientation with respect to earth's magnetic field, despite the great diversity of wrecks described above. All wreck anomalies observed by this author, to date, are oriented with their primary negative pole north of their positive pole. This is expected to be the case for all wrecks, as well as all other complex anomaly sources, in mid-latitudes of the northern hemisphere; however, the orientation of anomalies over simple debris sources is not limited.

Shipwrecks, and other complex sources, have anomalies closely aligned to the direction of magnetic north. This phenomenon is believed due to the random orientations of many individual magnetic components that make up each complex source, including shipwrecks. The magnetic field of each component interacts with that of its neighbors. The overlapping portions of fields that oppose one another in direction tend to cancel, while lines of force that run in the same general direction reinforce each other. Since a small portion of each field is aligned with (induced by) earth's local field, the net result of all these interactions is that more reinforcement occurs in the direction of magnetic north than in any other direction, resulting in a north-aligned anomaly. A simple debris source, on the other hand, is a solitary object on the seabed. By definition, there are no nearby sources affecting its magnetic field, thus the alignment of its anomaly is determined not by earth's magnetic field direction but by the object's orientation on the seabed. Hence debris anomalies can be oriented along any point of the compass.

Orientation can differentiate magnetic anomalies caused by most simple debris sources from anomalies caused by complex sources, including shipwrecks, and has potential to eliminate close to 80 percent of debris anomalies from further archaeological concern. Roughly 20 percent of simple debris sources have northerly orientations like those observed over complex sources. Absent a sonar target, there is no reliable method known, short of physically probing an anomaly, to differentiate that 20 percent of debris having northerly orientations from complex sources, including potential buried shipwrecks.

Anomalies can be eliminated from consideration as potential shipwrecks by demonstrating that their orientations differ substantially from the direction of magnetic north. It seems extremely unlikely that a shipwreck could have a magnetic anomaly that is not aligned closely with magnetic north, as this would require a large percentage of the wreck's many ferromagnetic components, by chance, to have the same magnetic moment. On the other hand, the anomaly of a simple debris source should align with earth's magnetic field only when its magnetic moment, as determined by the source's orientation on the seafloor, closely aligns with magnetic north.

The interpretation of magnetic anomalies based on orientation requires comparing unidentified magnetic anomalies, contoured at a 5-nT interval, to the anomaly of a small, verified wreck anomaly, such as 41CL92, shown in Figure 5. One must ensure that the reference anomaly is contoured, oriented and scaled using the same parameters as the survey data to which it is compared. Anomalies having a polar orientation like 41CL92 should be considered possible shipwrecks unless contradicted by other information, such as reliable evidence of an abandoned petroleum well nearby, as anomalies over steel well casings often closely resemble shipwreck anomalies.

V. Results

An archaeological assessment of the geophysical data is tabulated in Appendix A (not for public disclosure). Sonar and magnetometer data is illustrated for the entire survey in Appendix B (not for public disclosure). Survey transects are included in Appendix B, overlain on the pre-planned lines. Transects were spaced 20 m apart in archaeological survey areas, as required by THC guidelines. Additional data were gathered over selected areas along wandering transects to assist in evaluating their historic potential. No significant side-scan sonar targets were identified from the survey.

Seven magnetic anomalies, designated Anomaly 1 through Anomaly 7 (figures 6-12), resemble examples recorded over verified shipwrecks (Gearhart 2011). The sources of anomalies 1-6 remain unidentified and presumably buried, since none are associated with sonar targets. The possible association of anomalies 1-6 with historic shipwrecks cannot be ruled out based on the geophysical data at hand. In the absence of further information, their sources must be considered potentially eligible for inclusion on the NRHP.

Anomaly 7 correlates with a plugged gas well operated by Humble Oil and Refining Company (American Petroleum Institute Number 05700355). The well was drilled in 1952 and plugged in 1972. Information regarding petroleum infrastructure was obtained from the Railroad Commission of Texas' Public GIS Viewer. The position of this well was scaled into the Railroad Commission's GIS system from a printed map, which explains the discrepancy with its anomaly location (Figure 12). The well position is confirmed at Anomaly 7 by a 150 x 300-ft oyster reef, visible on sonar, consistent with typical well pads.

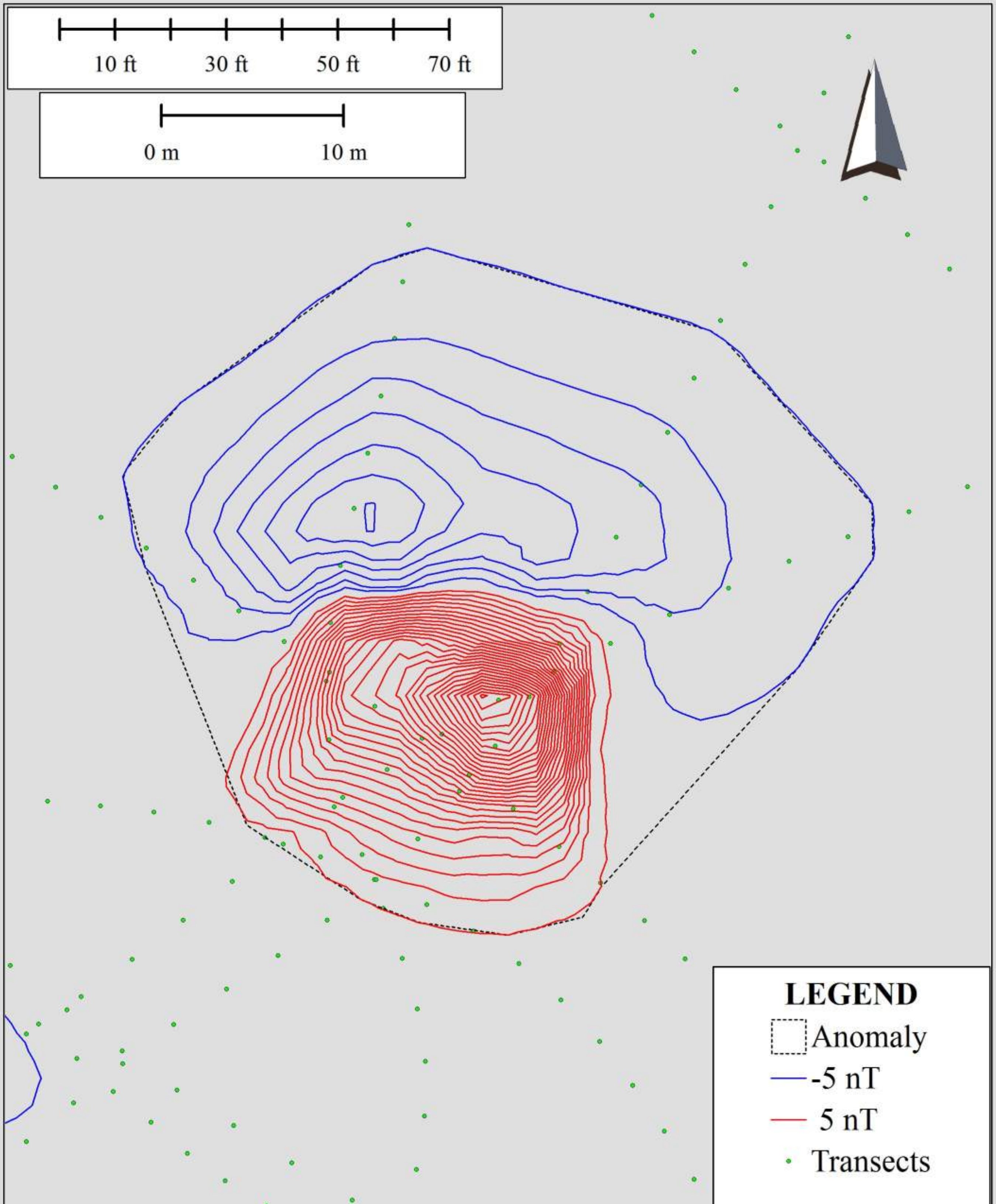


Figure 6
Anomaly 1

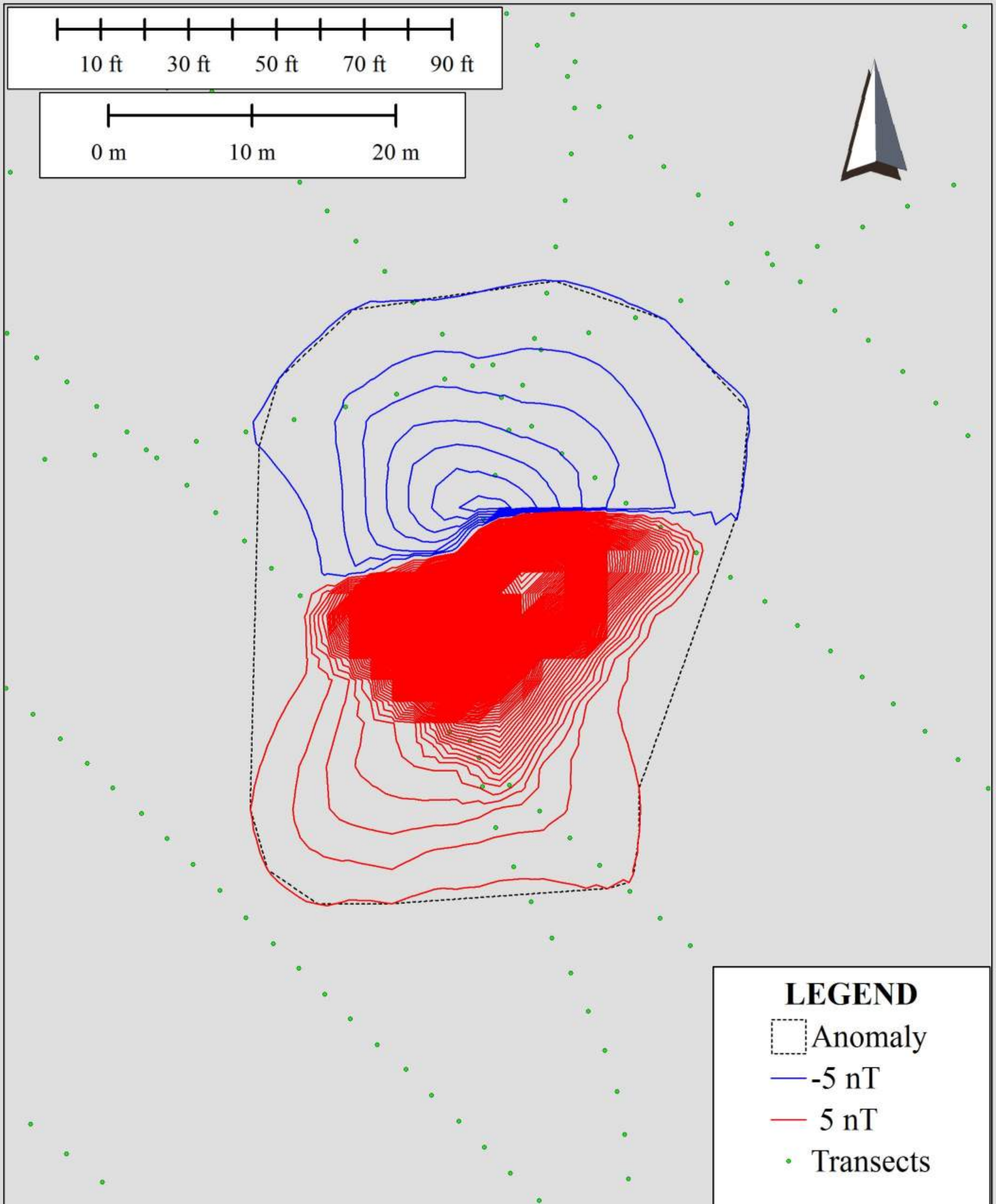


Figure 7
Anomaly 2

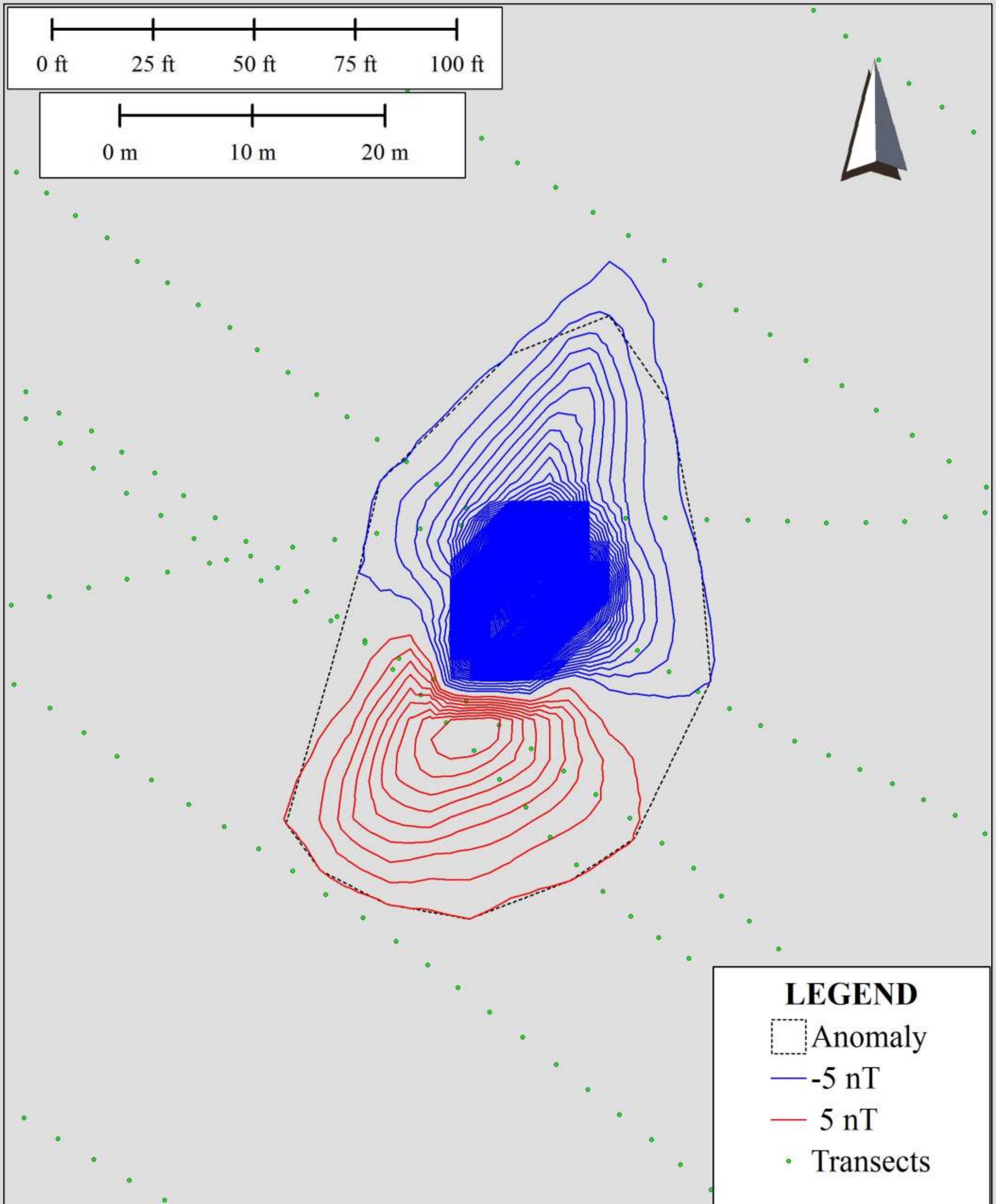


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Figure 8
Anomaly 3

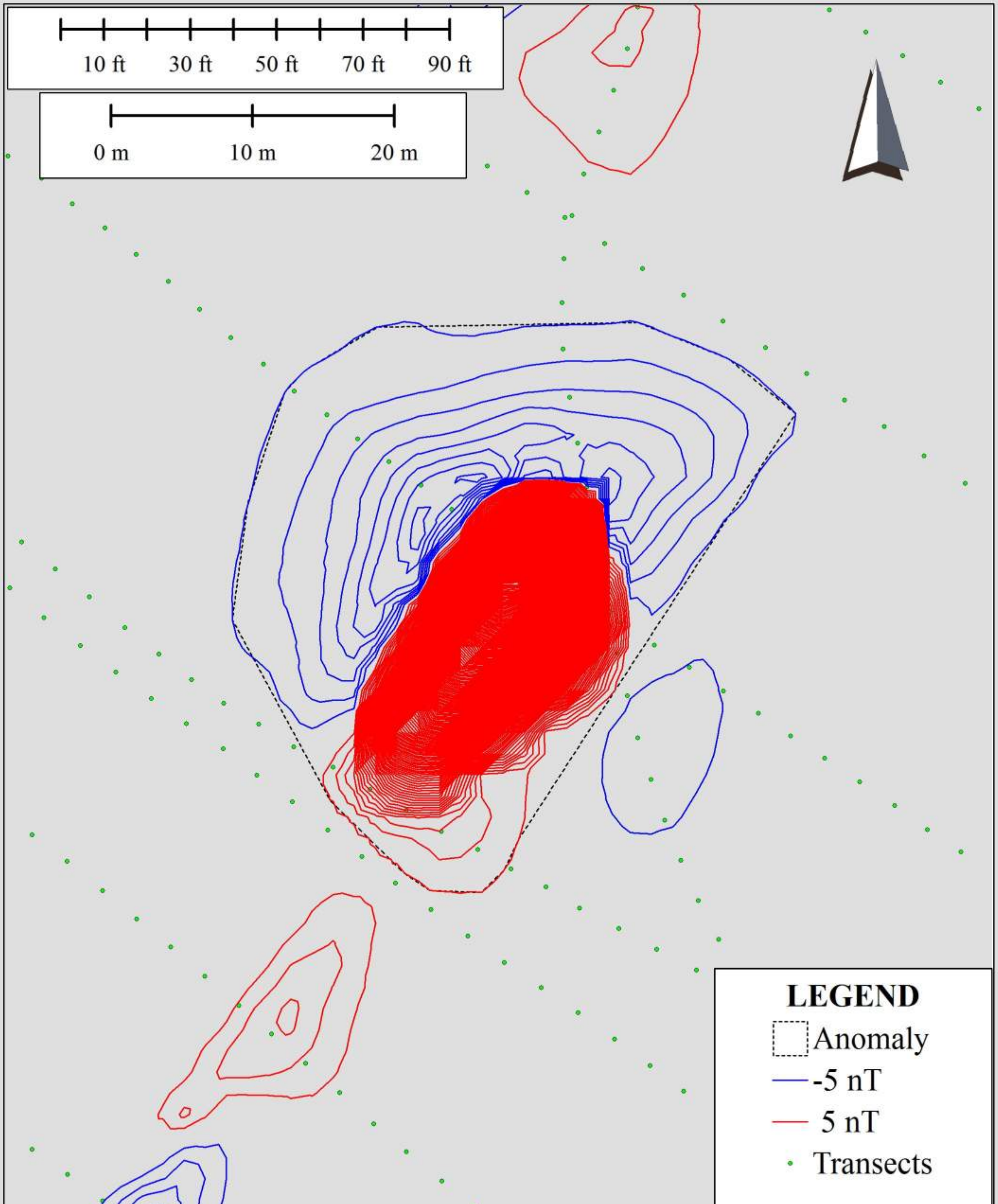
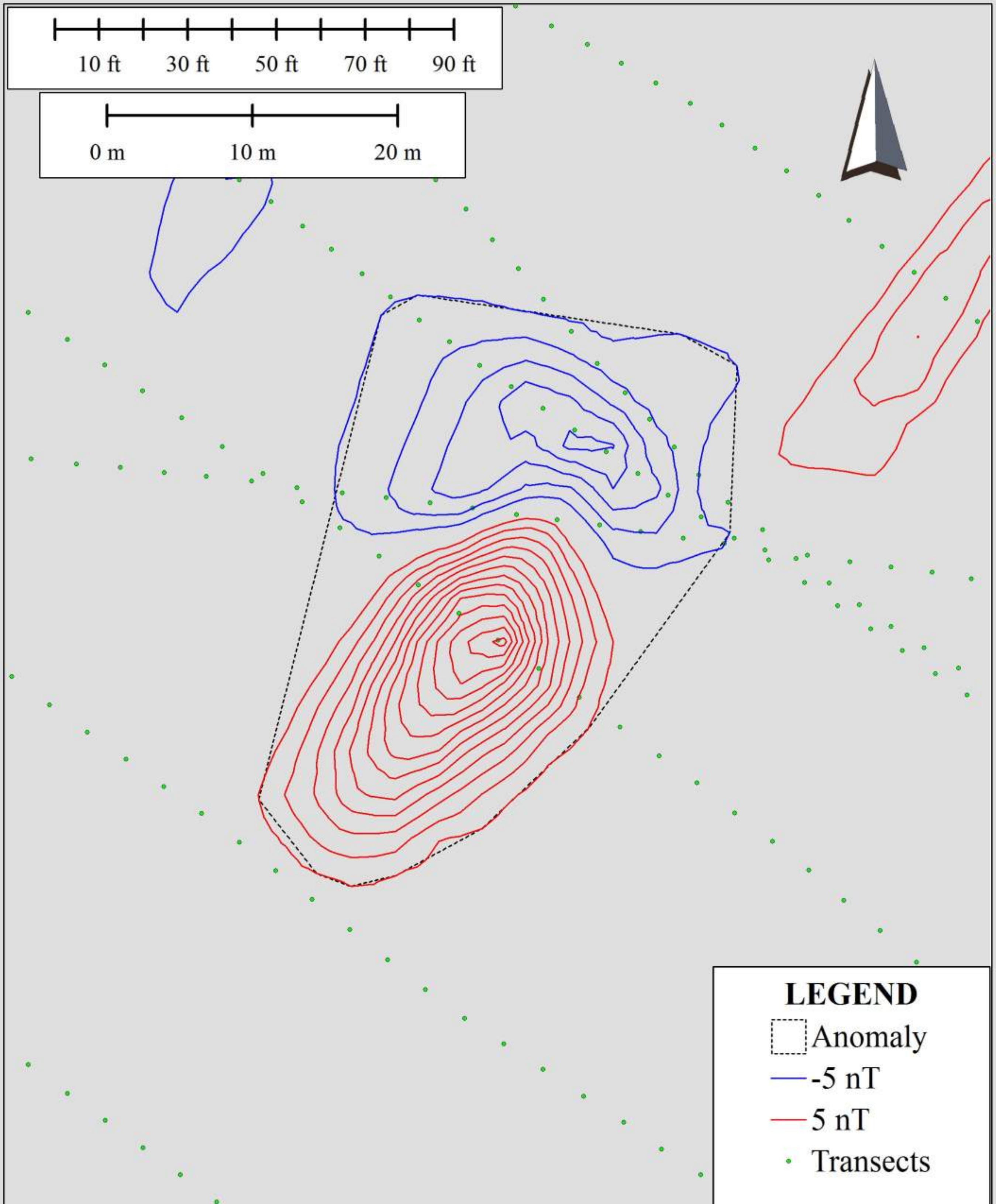
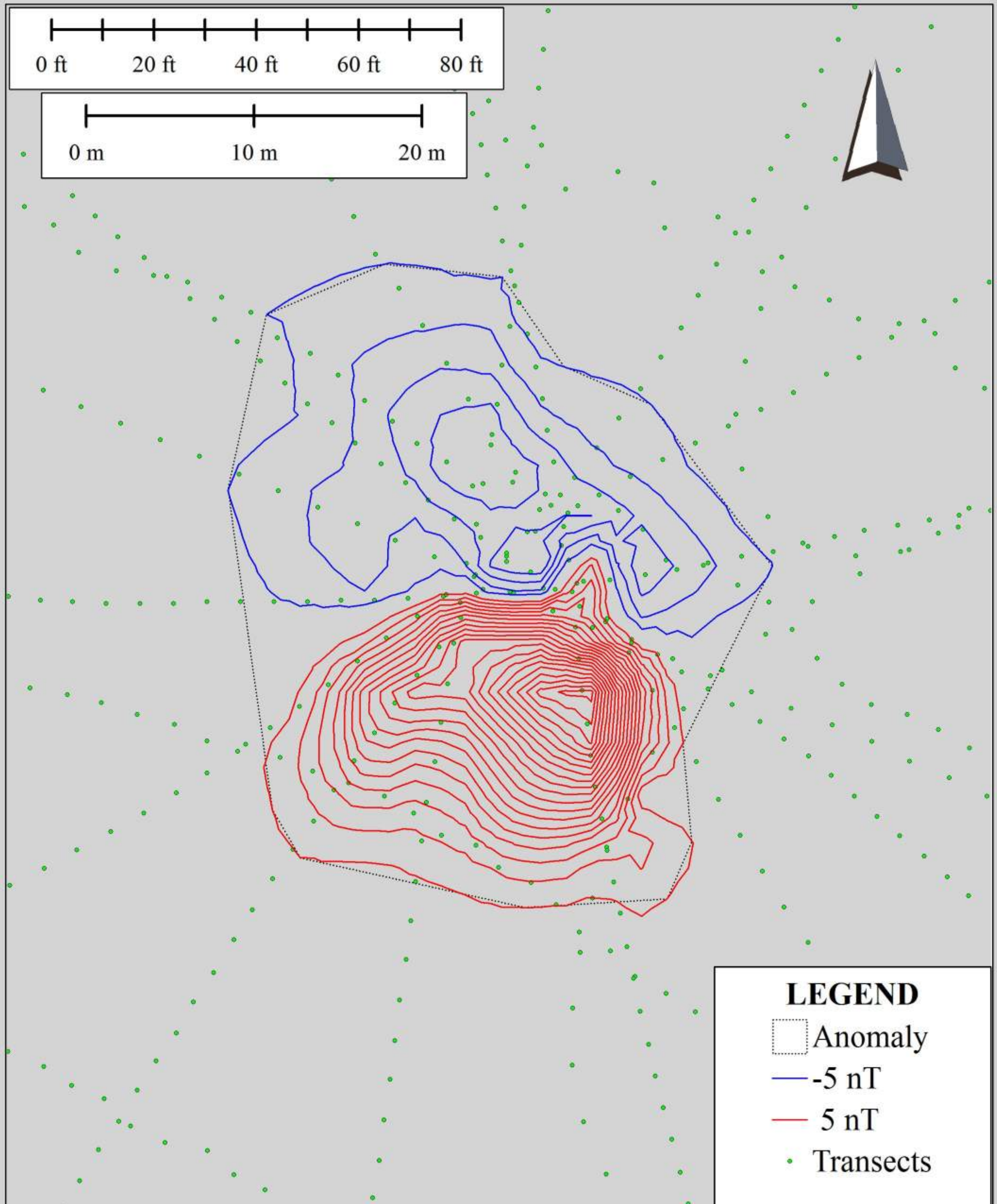


Figure 9
Anomaly 4



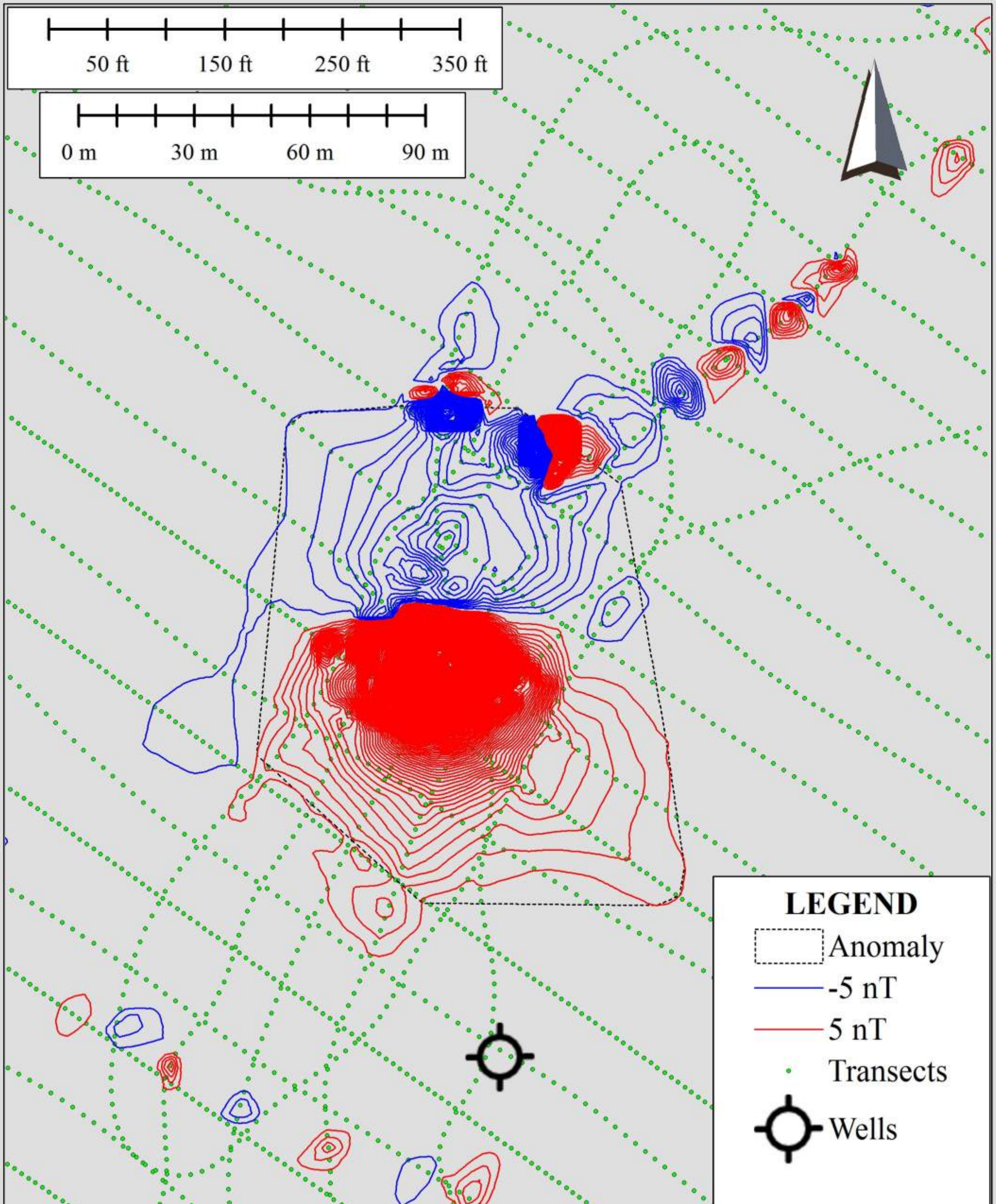
Bob Hydrographics, LLC

Figure 10
Anomaly 5



Hydrographics, LLC

Figure 11
Anomaly 6



BOB Hydrographics, LLC

Figure 12
Anomaly 7

Two other well locations, both reported as dry holes, are charted by the Railroad Commission within the area surveyed for this project (Appendix B). One of these locations, in State Lease Tract 21, is associated with a large magnetic anomaly, indicating that the well was completed. The other well, in Tract 8, has no anomaly associated, indicating that steel casing is not buried in the seafloor. The Railroad Commission reports five pipelines crossing the APE. All 5 correlate approximately with linear anomalies detected by this survey. The Railroad Commission charts two pipelines that closely parallel one another near the southernmost linear anomaly shown in Appendix B.

Recommendations

Six magnetic anomalies, designated Anomaly 1 through Anomaly 6 (figures 6-11; also Appendix B), are recommended for avoidance by seafloor disturbances based on their resemblance to anomalies typically recorded over verified shipwrecks (Gearhart 2011). If a historic wreck exists at any of these locations, it could meet criteria for State Antiquities Landmark or NRHP eligibility. BOB recommends cultural resource clearance for all other portions of the archaeological survey, outside of those six anomaly avoidance buffers.

Avoidance buffers are mandated by The Texas Administrative Code, Title 13, Part 2, Chapter 26. The buffer for inland waters is set at 50 m (164 ft) beyond significant target boundaries, in the case of anomalies meaning the 5-nT contour. Seafloor disturbances include, but are not limited to, dredging, anchoring, use of barge spuds, and compaction of the substrate by heavy overburden. If the THC concurs with these findings, then disturbance of the seafloor must be avoided within the mandated 50-m (164-ft) buffer around and including anomalies 1-6, unless the presence of historic shipwrecks can be disproved.

If shipwreck remains, or other potentially historic materials, are discovered anywhere in the APE during construction, work should be halted within 50 m (164 ft) of the find until the THC can provide guidance concerning the discovery.

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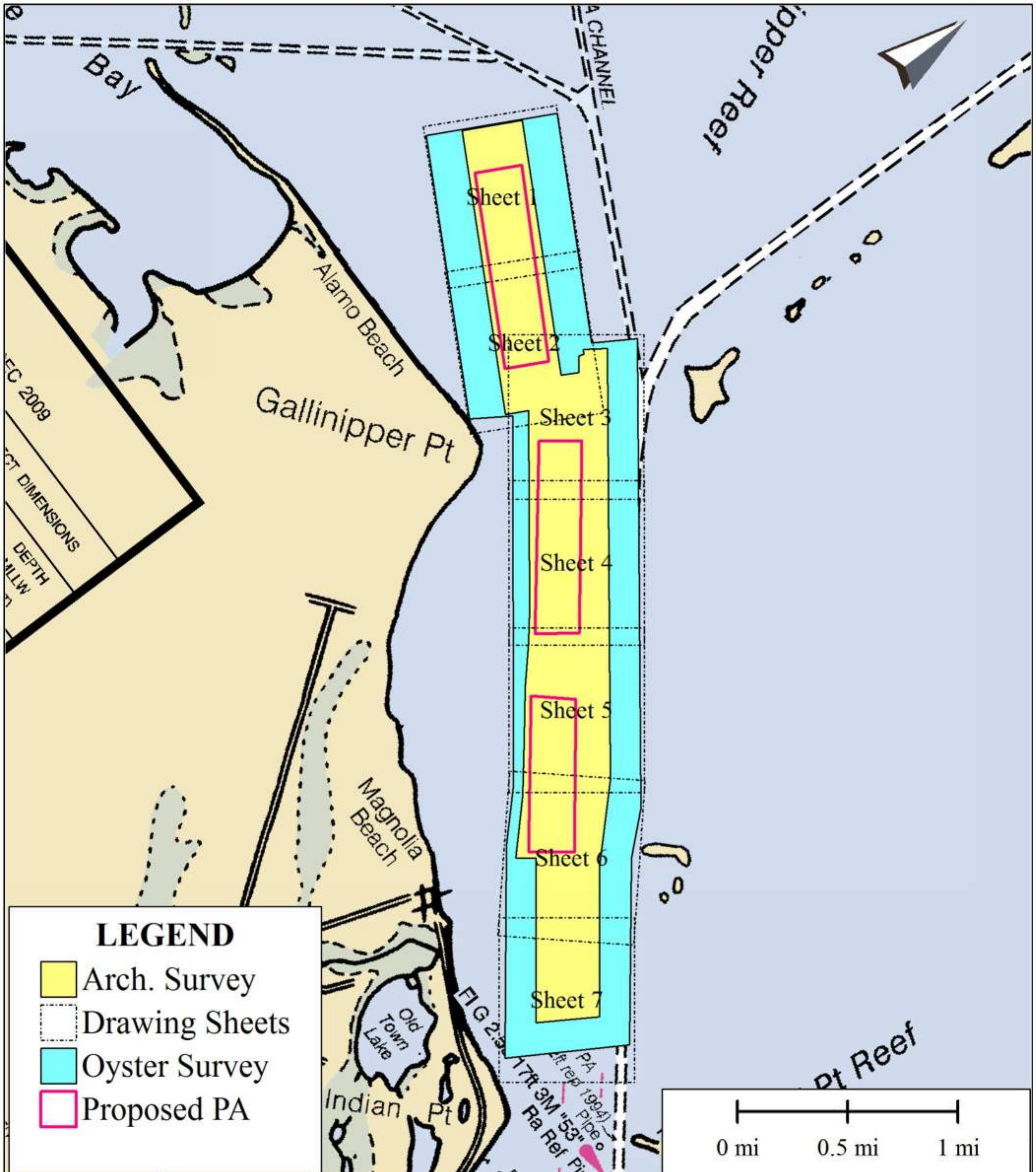
Appendix A: Geophysical Targets Recommended for Avoidance (Not for Public Disclosure)

Table A-1: Geophysical Targets Recommended for Avoidance (Not for Public Disclosure)

Target ID	Mag (nT)	Sonar	Depth (ft,MLLW)	State Mineral Lease Tract	Width (ft)	Center Easting (UTM 14N, m,WGS84)	Center Northing (UTM 14N, m,WGS84)
Anomaly 1	+171/-43	no	8.3	34	124x136	741,199	3,163,036
Anomaly 2	+912/-42	no	8.0	30	110x140	740,932	3,163,166
Anomaly 3	+58/-733	no	5.0	21	90x155	739,412	3,164,170
Anomaly 4	+886/-57	no	7.4	21	100x138	739,088	3,164,411
Anomaly 5	+72/-33	no	5.4	21	90x145	738,300	3,164,943
Anomaly 6	+120/-29	no	7.0	18	108x128	737,427	3,165,134

Appendix B: Geophysical Survey Results (Not for Public Disclosure)



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Appendix B Map Index

(Base map:NOAA Chart 11316, 41st edition, 2007)

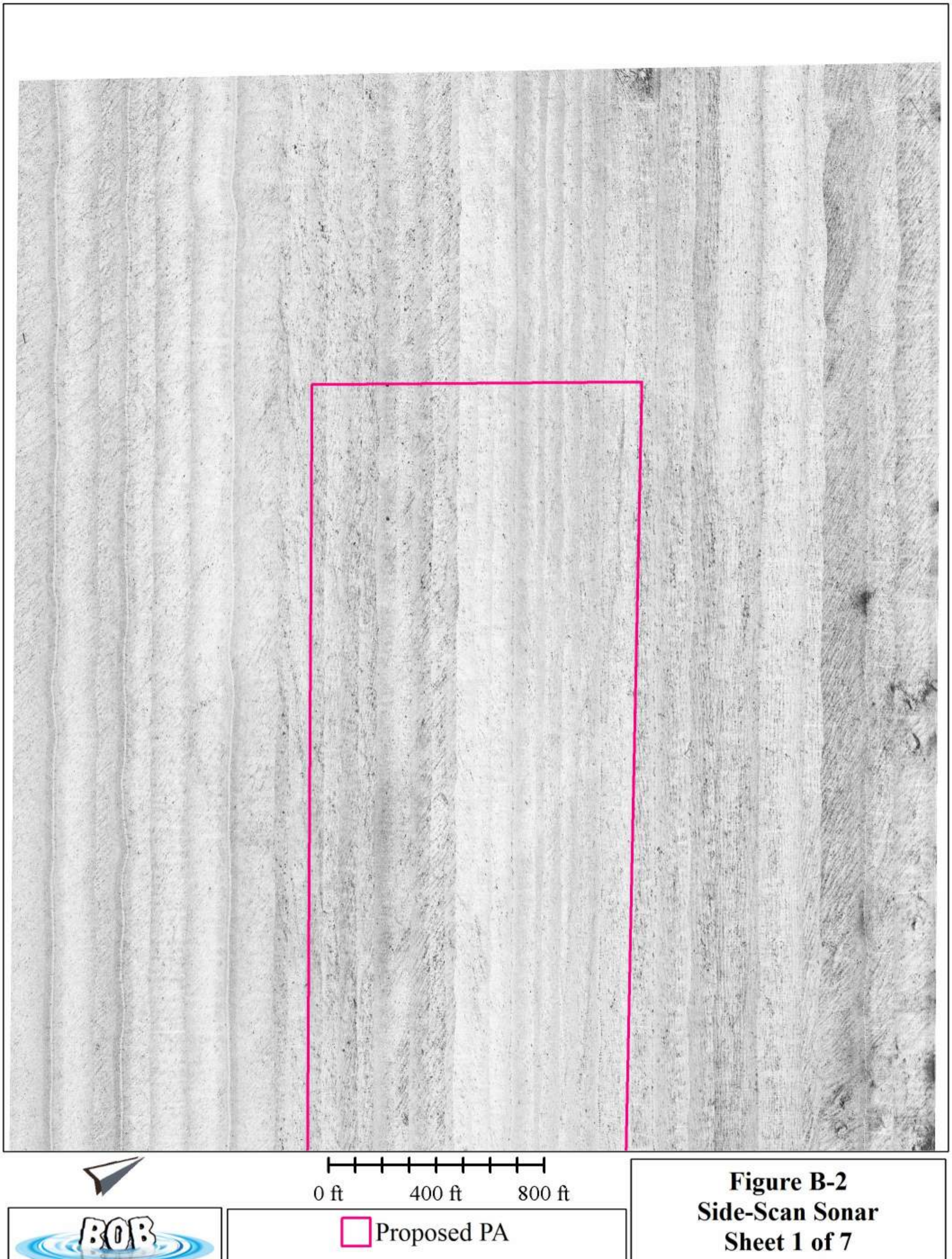
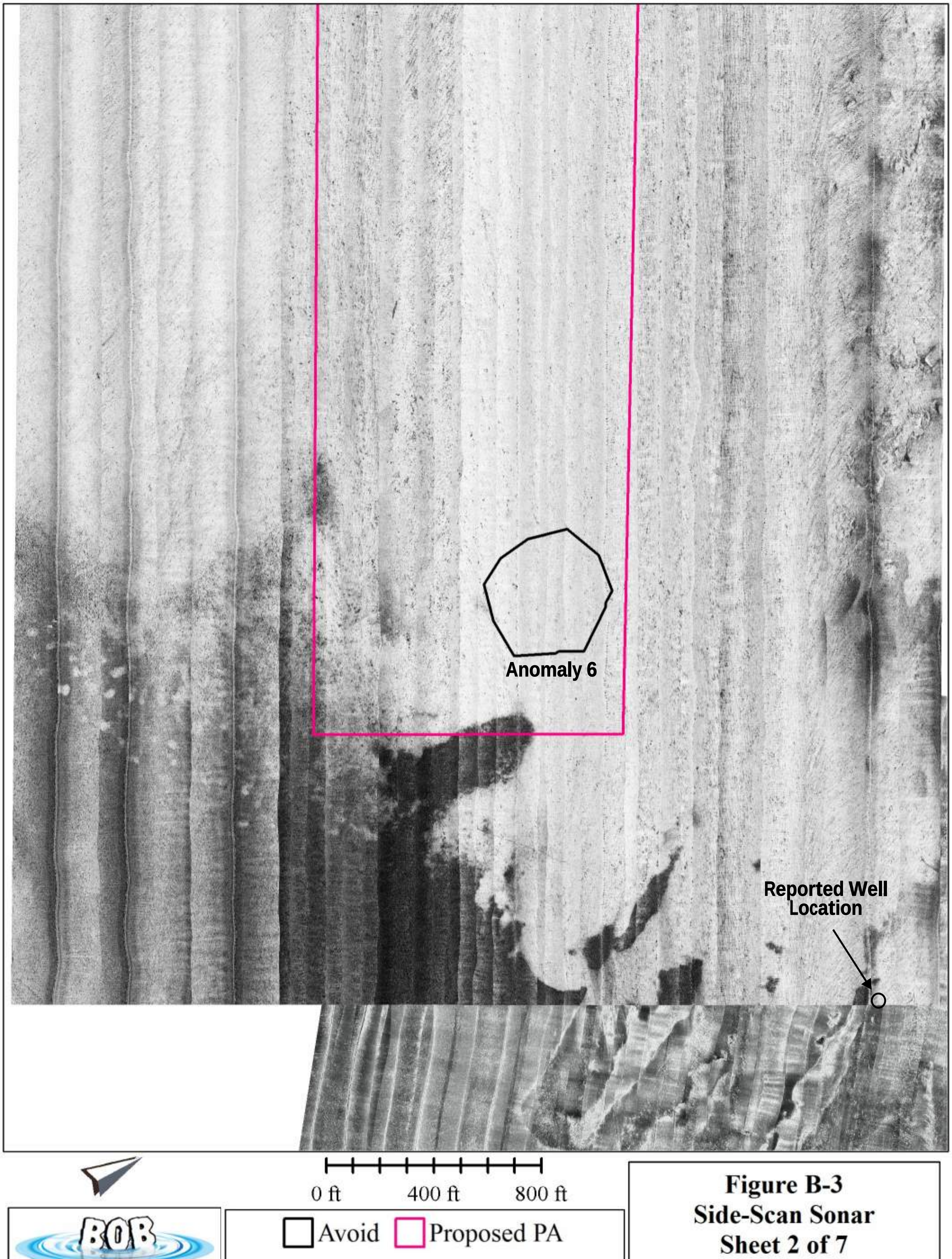


Figure B-2
Side-Scan Sonar
Sheet 1 of 7



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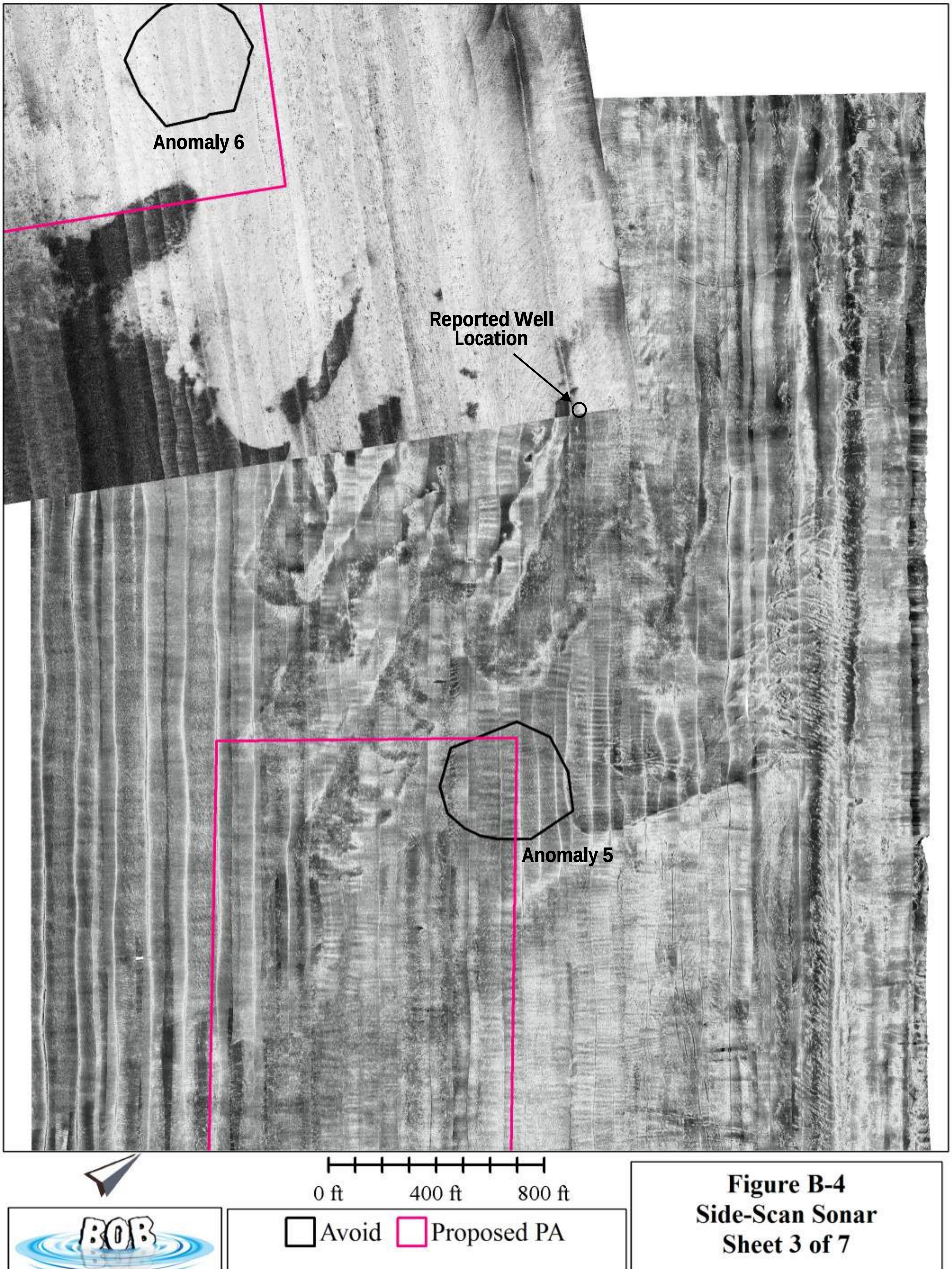
Side-Scan Sonar
Sheet 2 of 7



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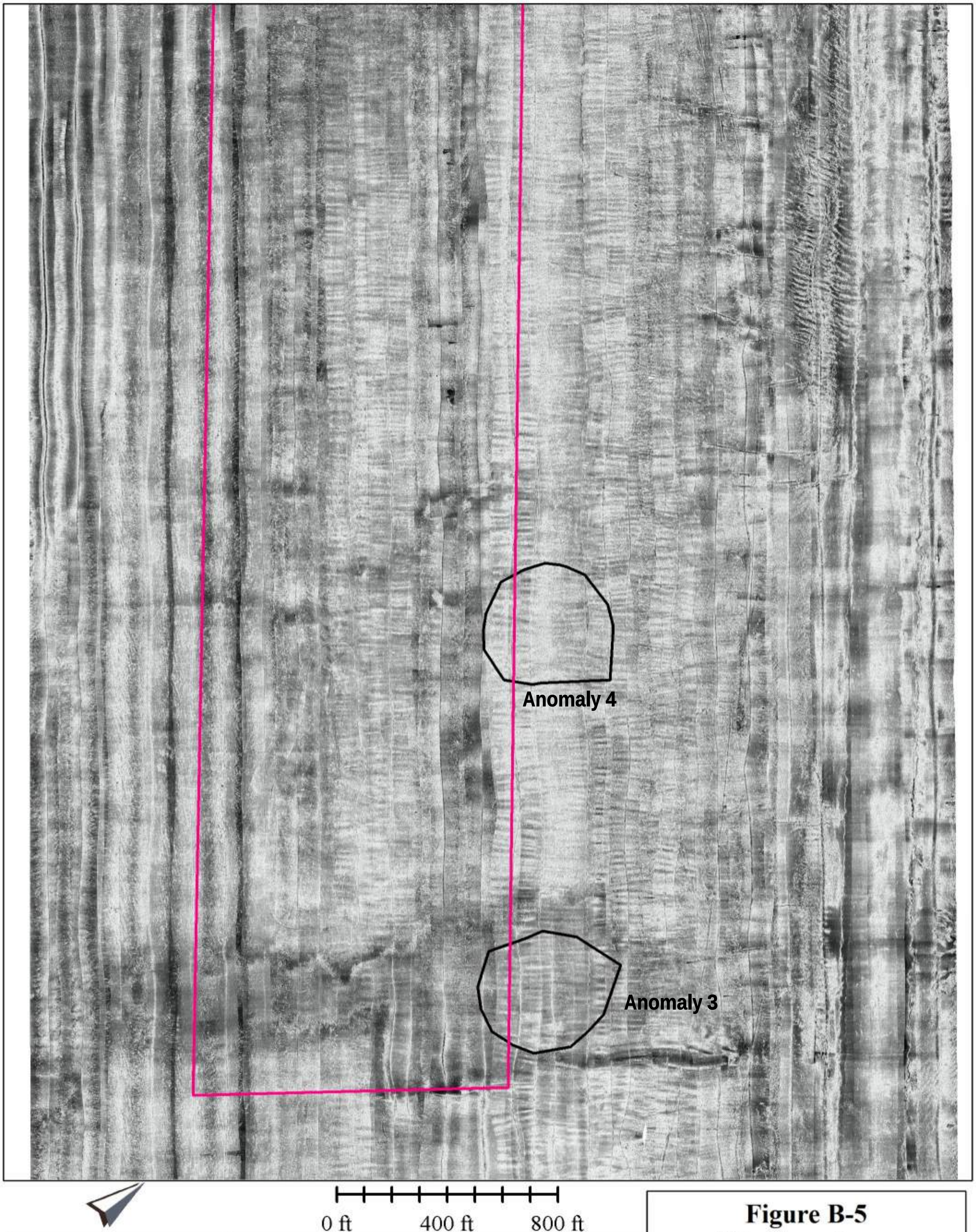
Sheet 3 of 7



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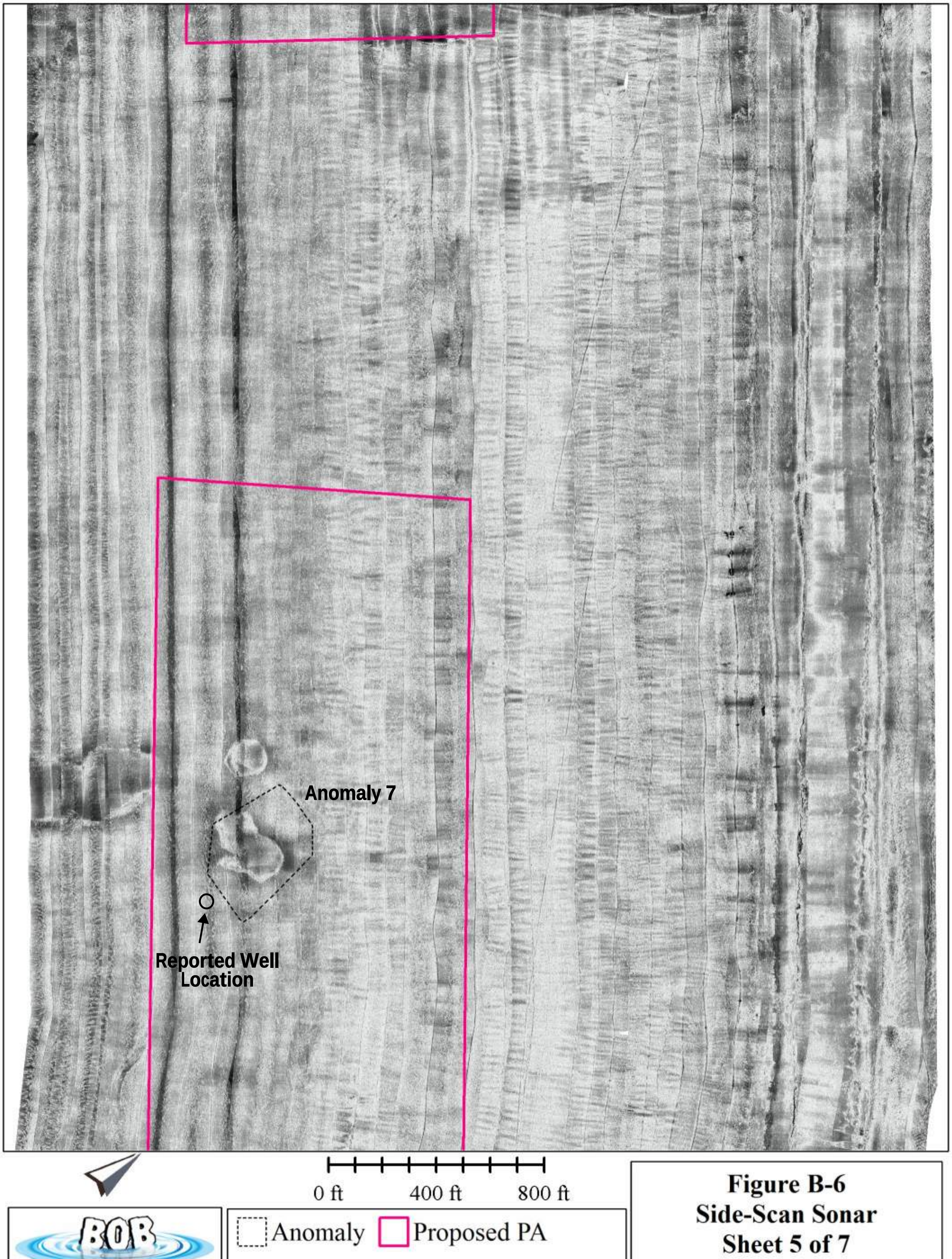
Sheet 4 of 7



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Sheet 5 of 7

Figure B-7
Side-Scan Sonar
Sheet 6 of 7

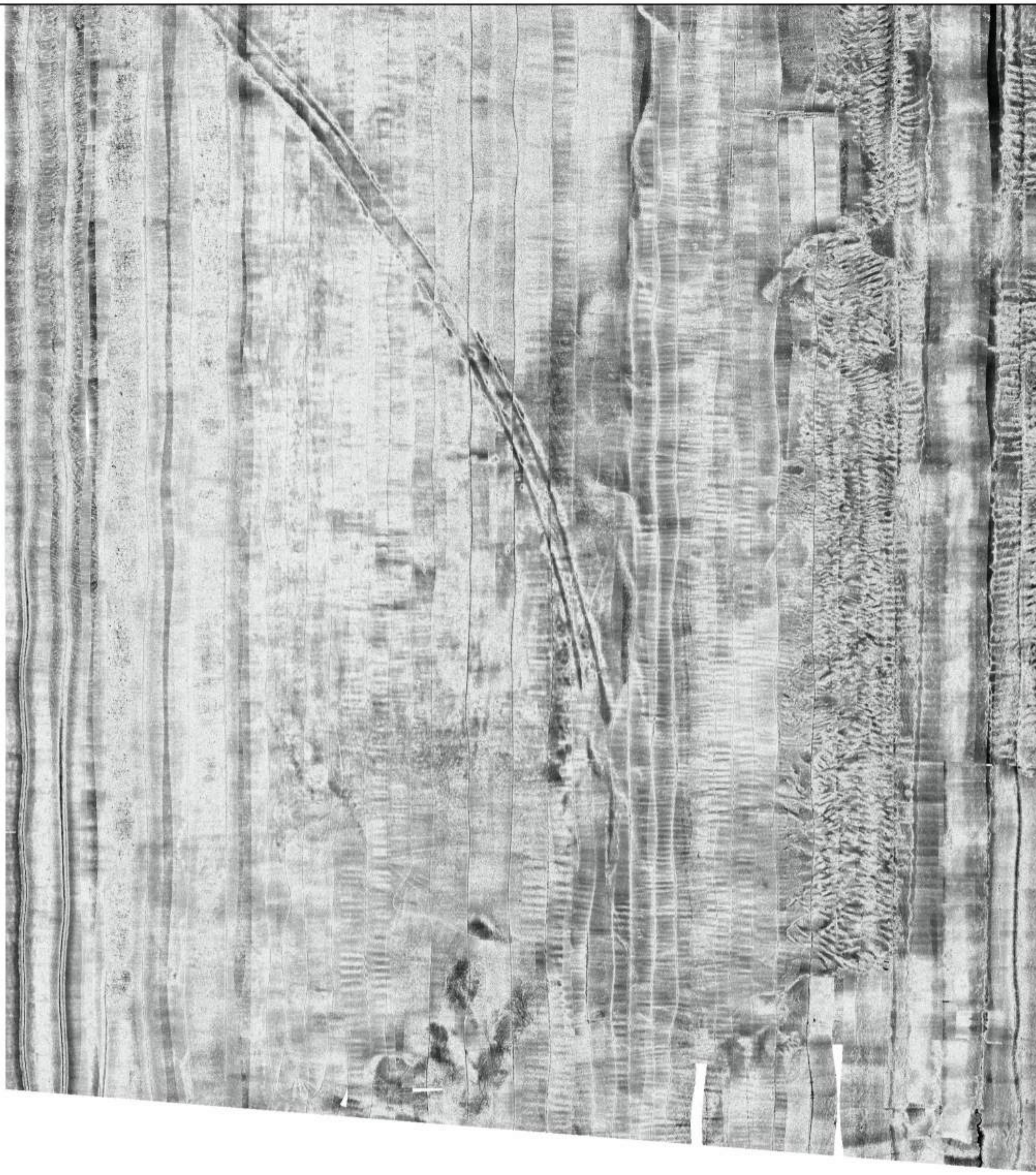

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Figure B-8
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Sheet 7 of 7

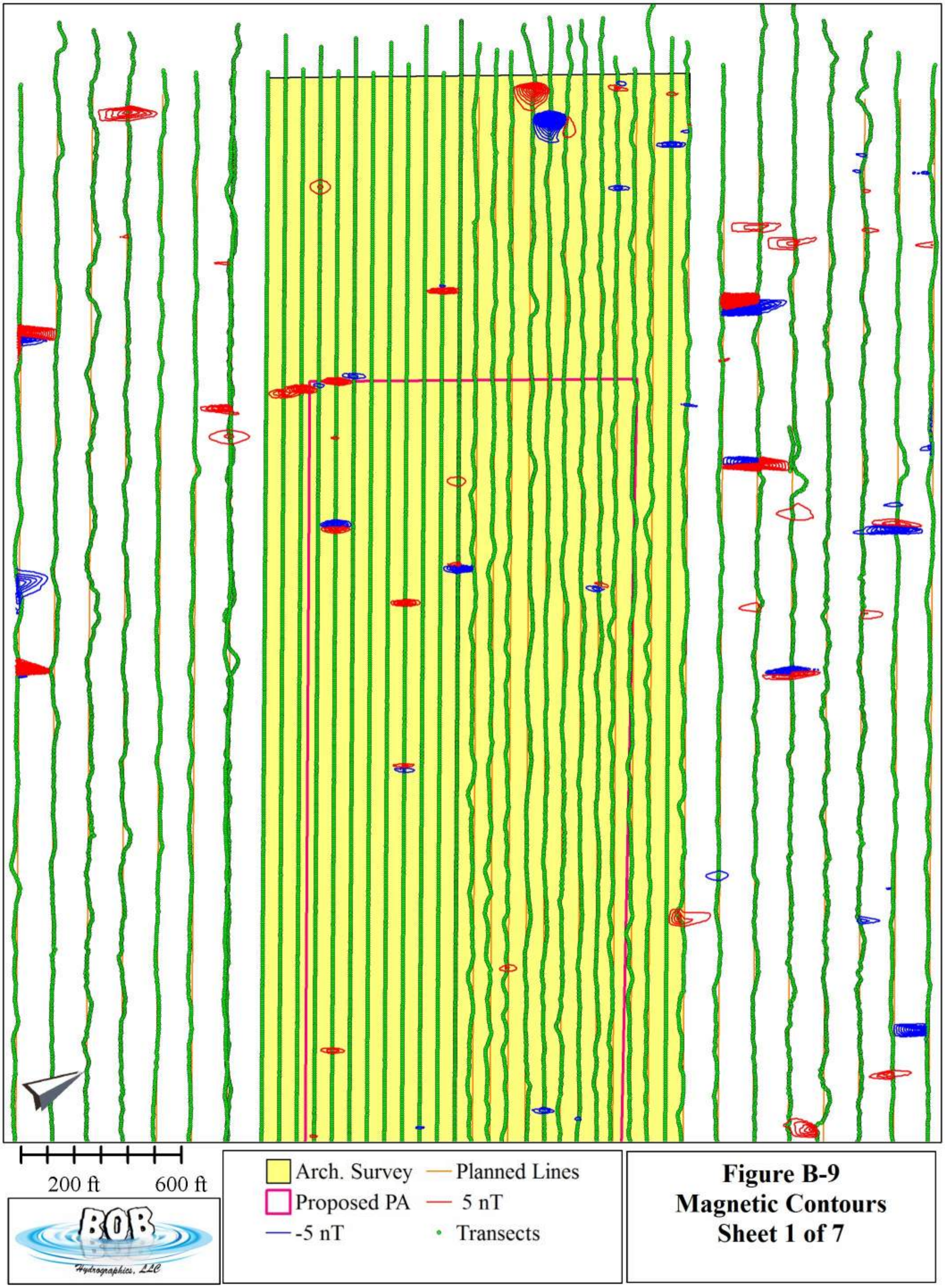
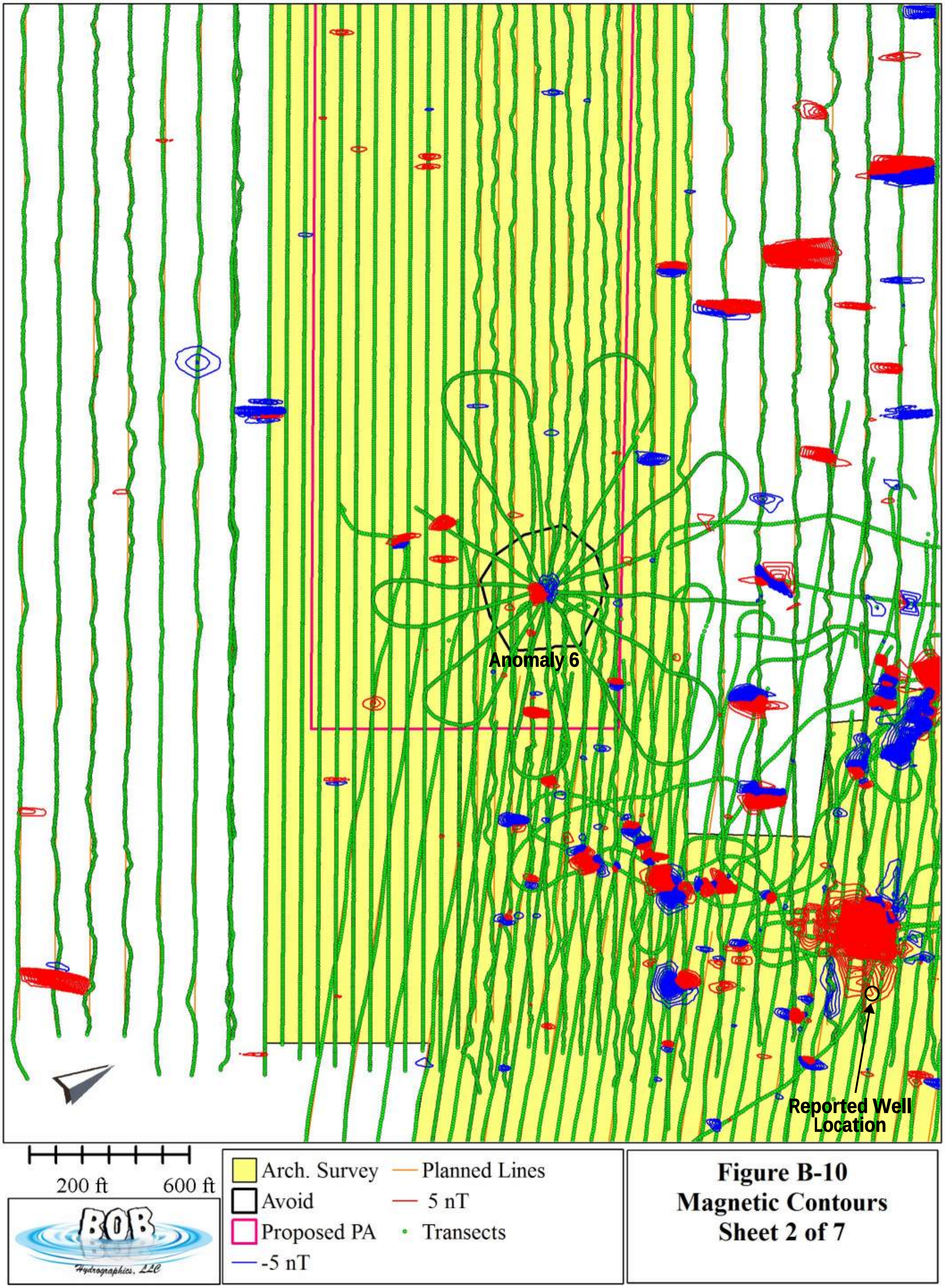


Figure B-9
Magnetic Contours
Sheet 1 of 7



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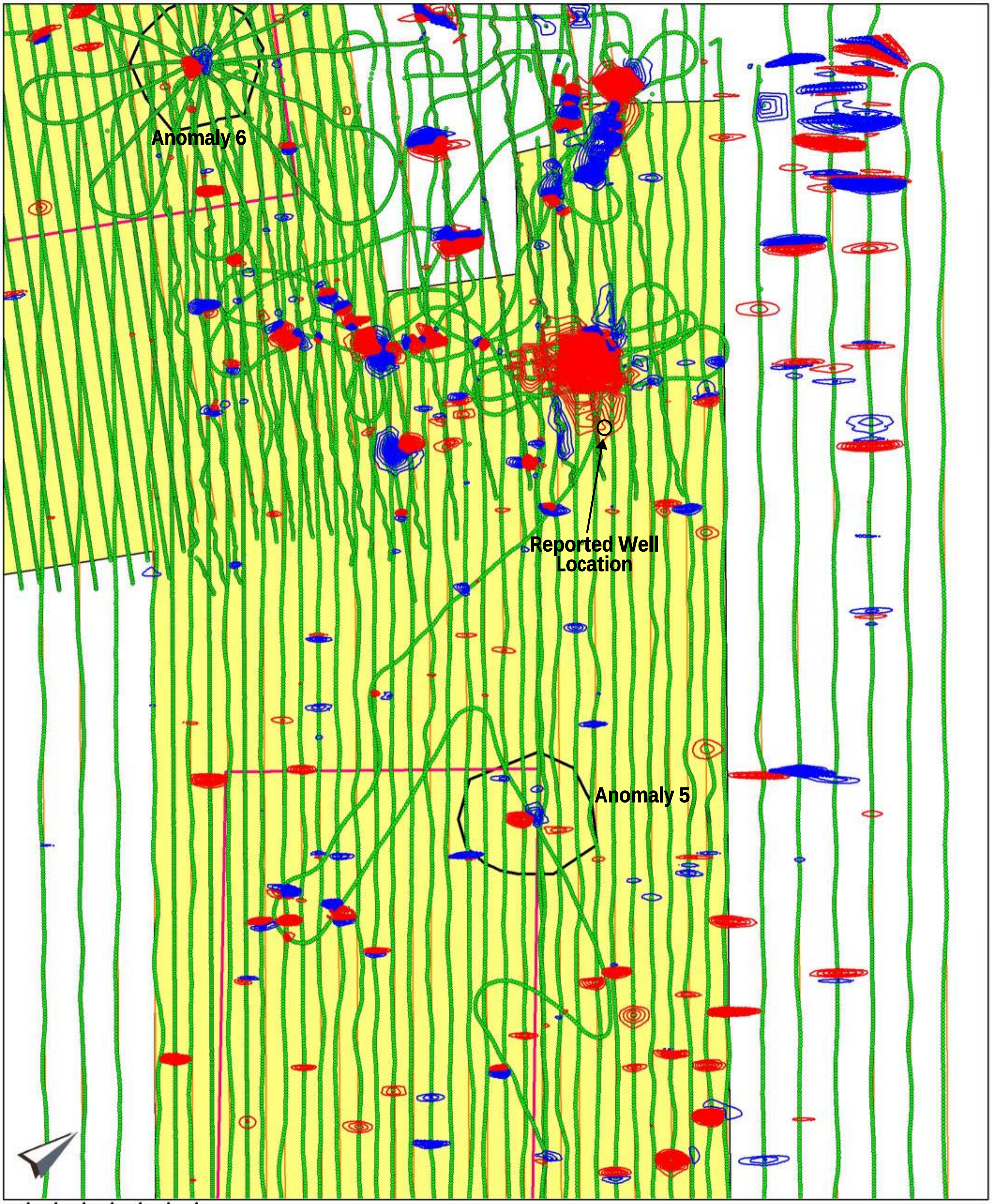
Magnetic Contours
Sheet 2 of 7

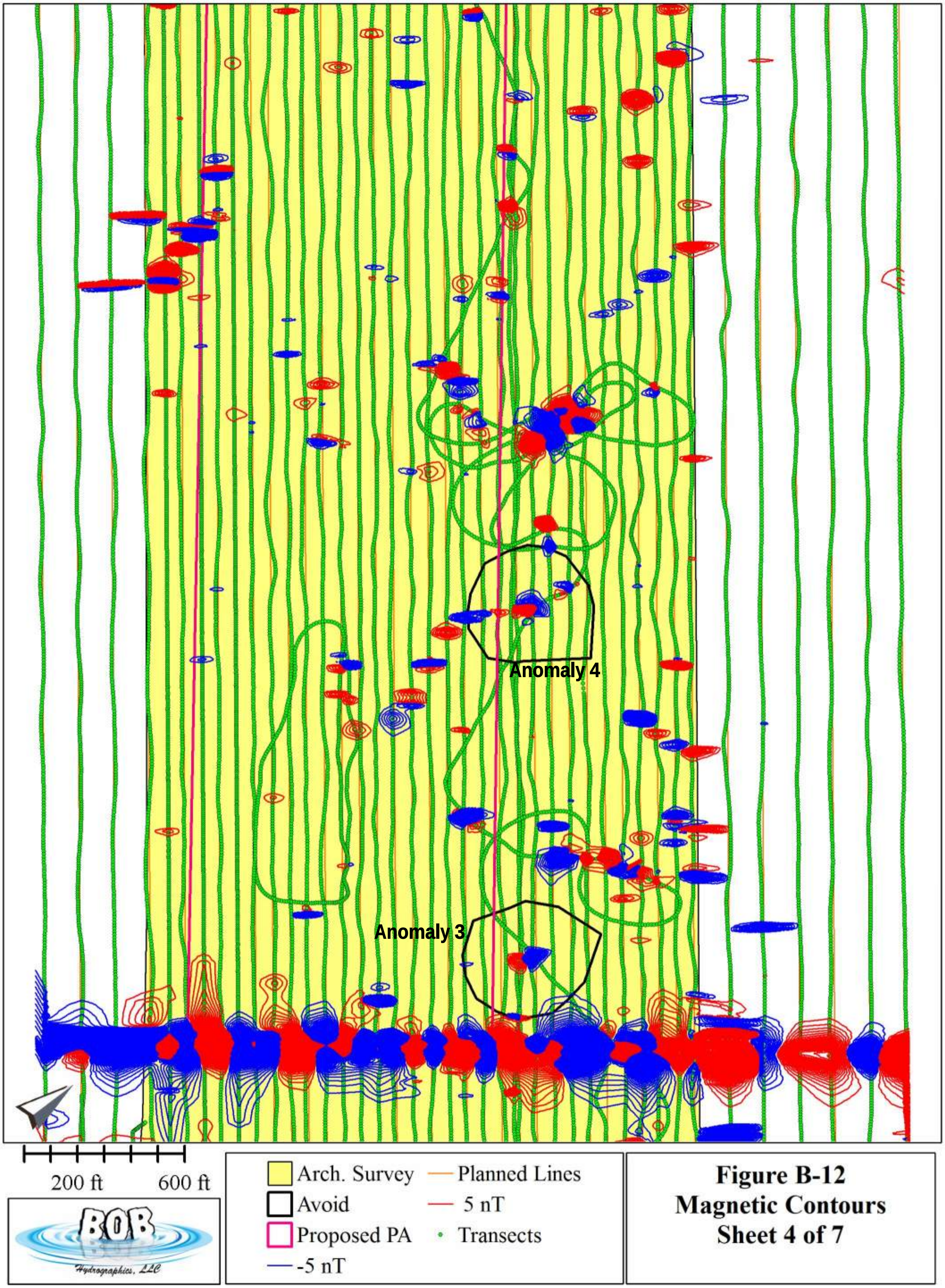


200 ft 600 ft

BOB Hydrographics, LLC

Arch. Survey
Avoid
Proposed PA
-5 nT
Planned Lines
5 nT
Transects

Figure B-11
Magnetic Contours
Sheet 3 of 7



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Sheet 4 of 7

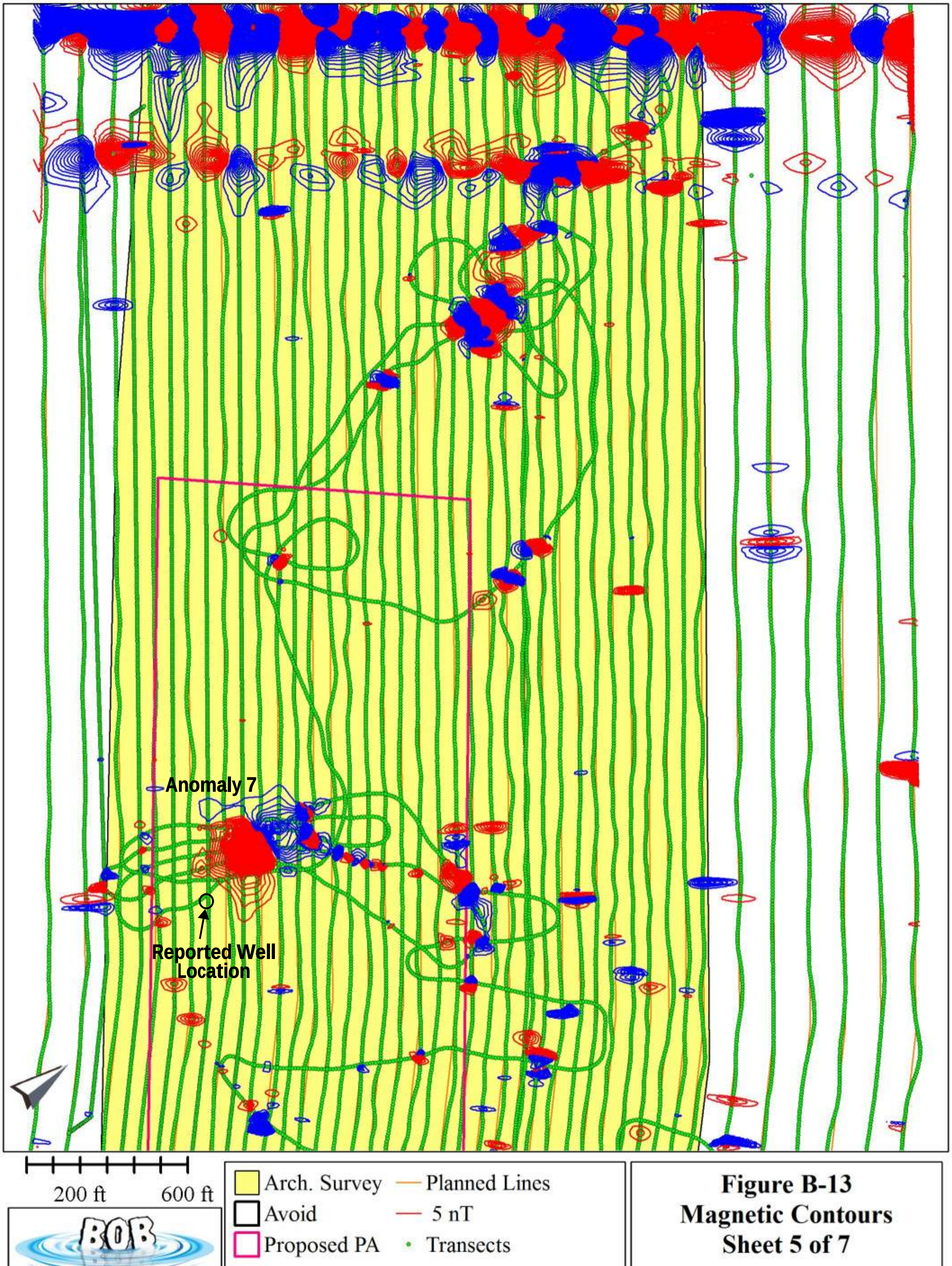


Figure B-13
Magnetic Contours
Sheet 5 of 7

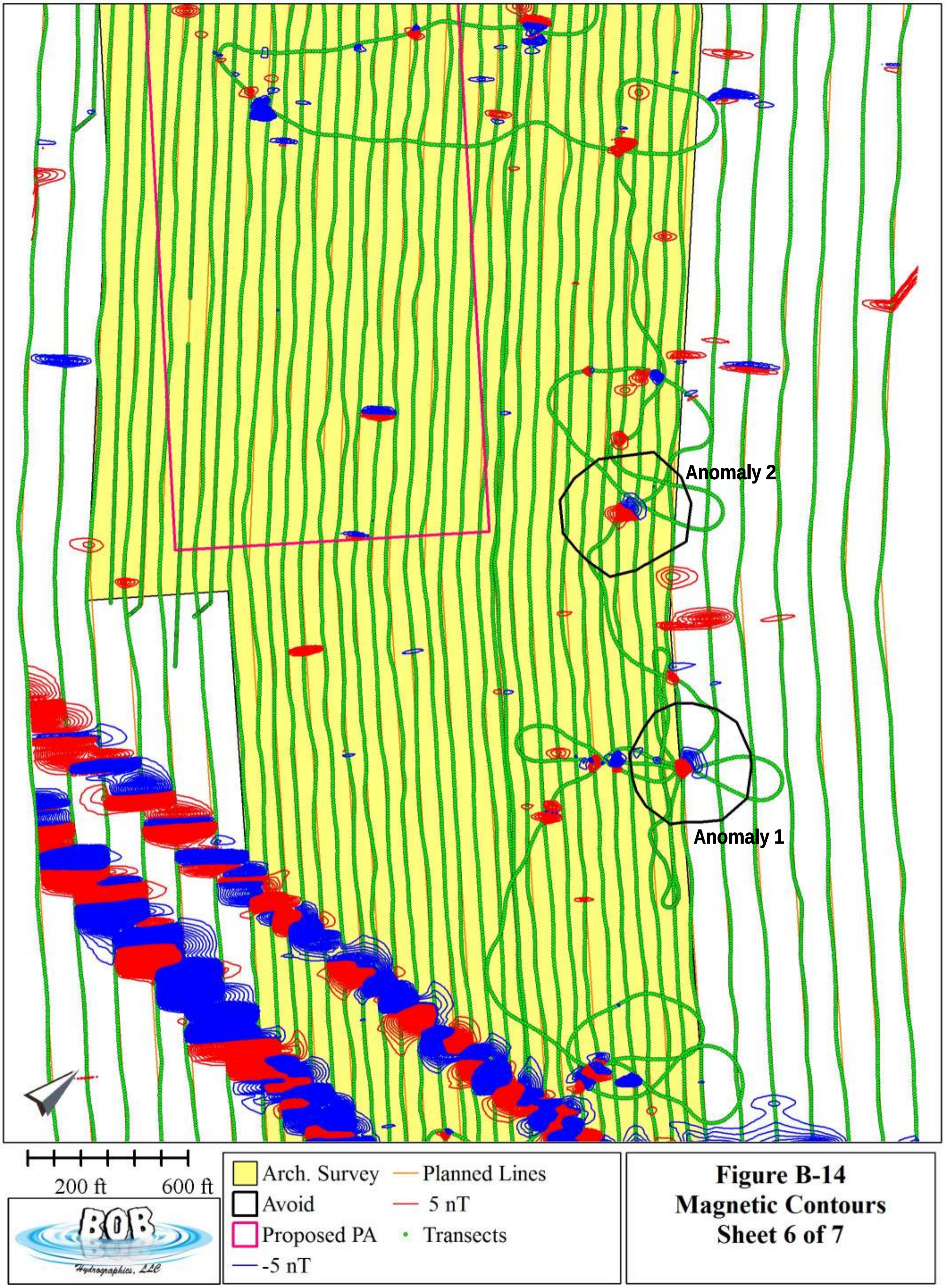
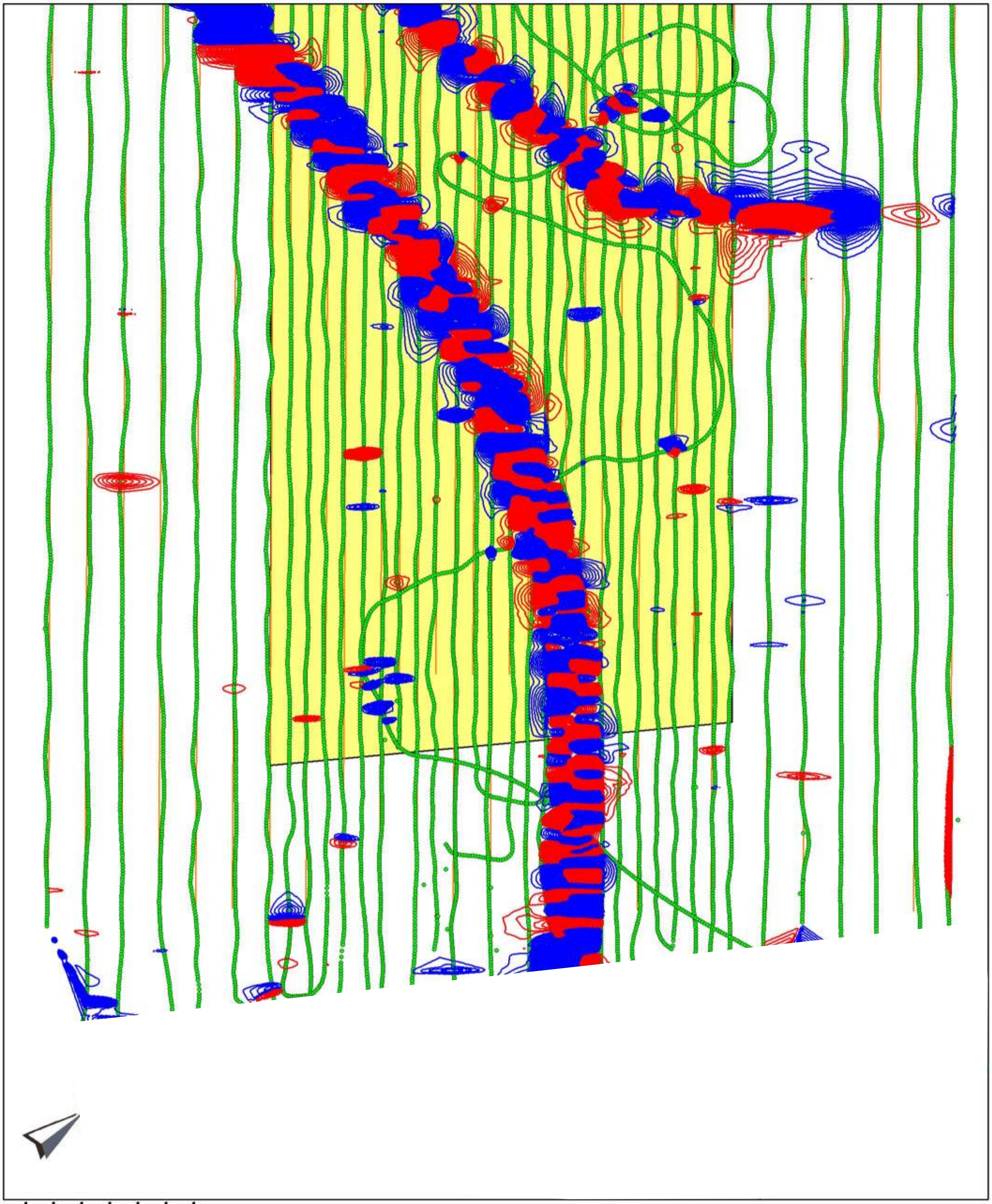


Figure B-14
Magnetic Contours
Sheet 6 of 7



200 ft 600 ft

Arch. Survey — 5 nT
— -5 nT • Transects
— Planned Lines

BOB Hydrographics, LLC

Figure B-15
Magnetic Contours
Sheet 7 of 7

Appendix C: Texas Antiquities Permit 7897 and THC Concurrence Letter (final only)

January 23, 2017

Robert Gearhart
BOB Hydrographics, LLC
1315 Fall Creek Loop
Cedar Park, TX 78613-5820

Re: Project review under the Antiquities Code of Texas
Underwater Archeology Survey of Proposed Placement Areas, Calhoun County, Texas
Texas Antiquities Permit Application **#7897**

Dear Colleague:

Thank you for your Antiquities Permit Application for the above referenced project. This letter presents the final copy of the permit from the Executive Director of the Texas Historical Commission (THC), the state agency responsible for administering the Antiquities Code of Texas.

Please keep this copy for your records. The Antiquities Permit investigations requires the production and submittal of one printed copy of the final report, a completed abstract form submitted via our online system, two copies of the tagged PDF final report on CD (one with site location information & one without), and verification that any artifacts recovered and records produced during the investigations are curated at the repository listed in the permit. The abstract form maybe submitted via the THC website (www.thc.state.tx.us) or use url: http://xapps.thc.state.tx.us/Abstract/login.aspx Additionally, you must send the THC shapefiles showing the boundaries of the project area *and* the areas actually surveyed via email to archeological_projects@thc.texas.gov.

If you have any questions concerning this permit or if we can be of further assistance, please contact Lillie Thompson at 512/463-1858. The reviewer for this project is Amy Borgens, 512/463-6096.

Sincerely,

William A. Martin

for
Mark Wolfe
Executive Director

MW/lft

Enclosures

Cc: Lisa Finn, COE-Galv.
Anne Idsal, GLO

State of Texas

TEXAS ANTIQUITIES COMMITTEE

***ARCHEOLOGY PERMIT #* 7897**

This permit is issued by the Texas Historical Commission, hereafter referred to as the Commission, represented herein by and through its duly authorized and empowered representatives. The Commission, under authority of the Texas Natural Resources Code, Title 9, Chapter 191, and subject to the conditions hereinafter set forth, grants this permit for:

Underwater Survey

To be performed on a potential or designated landmark or other public land known as:

Title: ***Underwater Archeology Survey of Proposed Placement Areas***

County: ***Calhoun***

Location: ***South side of Matagorda Ship Channel between Indian Point and Gallinipper Point***

Owned or Controlled by: (hereafter known as the Permittee):

Texas General Land Office

1700 North Congress Avenue, Suite 935
Austin, TX 78701

Sponsored by (hereafter known as the Sponsor

Corps of Engineers, Galveston District

2000 Fort Point Road
Galveston, TX 77550

The Principal Investigator/Investigation Firm representing the Owner or Sponsor is:

Robert Gearhart

BOB Hydrographics, LLC

1315 Fall Creek Loop

Cedar Park, TX 78613-5820

This permit is to be in effect for a period of:

1 Years and 0 Months

and Will Expire on:

01/09/2018

During the preservation, analysis, and preparation of a final report or until further notice by the Commission, artifacts, field notes, and other data gathered during the investigation will be kept temporarily at:

Texas Archeological Research Lab.

Upon completion of the final permit report, the same artifacts, field notes, and other data will be placed in a permanent curatorial repository at:

Texas Archeological Research Lab.

Scope of Work under this permit shall consist of:

Underwater survey (may include remote sensing survey and diver ground-truthing). For details, see scope of work submitted with permit application.

ARCHEOLOGY PERMIT # 7897

This permit is granted on the following terms and conditions:

1) This project must be carried out in such a manner that the maximum amount of historic, scientific, archeological, and educational information will be recovered and preserved and must include the scientific, techniques for recovery, recording, preservation and analysis commonly used in archeological investigations. All survey level investigations must follow the state survey standards and the THC survey requirements established with the projects sponsor(s).
2) The Principal Investigator/Investigation Firm, serving for the Owner/Permittee and/or the Project Sponsor, is responsible for insuring that specimens, samples, artifacts, materials and records that are collected as a result of this permit are appropriately cleaned, and cataloged for curation. These tasks will be accomplished at no charge to the Commission, and all specimens, artifacts, materials, samples, and original field notes, maps, drawings, and photographs resulting from the investigations remain the property of the State of Texas, or its political subdivision, and must be curated at a certified repository. Verification of curation by the repository is also required, and duplicate copies of any requested records shall be furnished to the Commission before any permit will be considered complete.
3) The Principal Investigator/Investigation Firm serving for the Owner/Permittee, and/or the Project Sponsor is responsible for the publication of results of the investigations in a thorough technical report containing relevant descriptions, maps, documents, drawings, and photographs. A draft copy of the report must be submitted to the Commission for review and approval. Any changes to the draft report requested by the Commission must be made or addressed in the report, or under separate written response to the Commission. Once a draft has been approved by the Commission, one (1) printed, unbound copy of the final report containing at least one map with the plotted location of any and all sites recorded and two copies of the report in tagged PDF format on an archival quality CD or DVD shall be furnished to the commission. One copy must include the plotted location of any and all sites recorded and the other should not include the site location data. A paper copy and an electronic copy of the completed Abstracts in Texas Contract Archeology Summary Form must also be submitted with the final report to the Commission. (Printed copies of forms are available from the Commission or also online at www.thc.state.tx.us.)
4) If the Owner/Permittee, Project Sponsor or Principal Investigator/Investigation Firm fails to comply with any of the Commission's Rules of Practice and Procedure or with any of the specific terms of this permit, or fails to properly conduct or complete this project within the allotted time, the permit will fall into default status. A notification of Default status shall be sent to the Principal Investigator/Investigation Firm, and the Principal Investigator will not be eligible to be issued any new permits until such time that the conditions of this permit are complete or, if applicable, extended.
5) The Owner/Permittee, Project Sponsor, and Principal Investigator/Investigation Firm, in the conduct of the activities hereby authorizes, must comply with all laws, ordinances and regulations of the State of Texas and of its political subdivisions including, but not limited to, the Antiquities Code of Texas; they must conduct the investigation in such a manner as to afford protection to the rights of any and all lessees or easement holders or other persons having an interest in the property and they must return the property to its original condition insofar as possible, to leave it in a state which will not create hazard to life nor contribute to the deterioration of the site or adjacent lands by natural forces.
6) Any duly authorized and empowered representative of the Commission may, at any time, visit the site to inspect the fieldwork as well as the field records, materials, and specimens being recovered.
7) For reasons of site security associated with historical resources, the Project Sponsor (if not the Owner/Permittee), Principal Investigator, Owner, and Investigation Firm shall not issue any press releases, or divulge to the news media, either directly or indirectly, information regarding the specific location of, or other information that might endanger those resources, or their associated artifacts without first consulting with the Commission, and the State agency or political subdivision of the State that owns or controls the land where the resource has been discovered.
8) This permit may not be assigned by the Principal Investigator/Investigation Firm, Owner/Permittee, or Project Sponsor in whole, or in part to any other individual, organization, or corporation not specifically mentioned in this permit without the written consent of the Commission.
9) Hold Harmless: The Owner/Permittee hereby expressly releases the State and agrees that Owner/Permittee will hold harmless, indemnify, and defend (including reasonable attorney's fees and cost of litigation) the State, its officers, agents, and employees in their official and/or individual capacities from every liability, loss, or claim for damages to persons or property, direct or indirect of whatsoever nature arising out of, or in any way connected with, any of the activities covered under this permit.The provisions of this paragraph are solely for the benefit of the State and the Texas Historical Commission and are not intended to create or grant any rights, contractual or otherwise, to any other person or entity.
10) Addendum: The Owner/Permittee, Project Sponsor and Principal Investigator/Investigation Firm must abide by any addenda hereto attached.

Upon a finding that it is in the best interest of the State, this permit is issued on 01/19/2017.

Pat Mercado-Allinger

Pat Mercado-Allinger, for the
Texas Historical Commission

Appendix C

Matagorda Ship Channel Oyster Resources Survey, Upper Reach Placement Area Project, Calhoun County, Texas, June 2017

OYSTER RESOURCES SURVEY
MATAGORDA SHIP CHANNEL
UPPER REACH PLACEMENT AREA PROJECT
CALHOUN COUNTY, TEXAS

Prepared for:

U.S. Department of the Army
Corps of Engineers, Galveston District
2000 Fort Point Road
Galveston, Texas 77550

Prepared by:

Lloyd Engineering, Inc.
6565 West Loop Street, Suite 708
Bellaire, Texas 77401

June 2017

Table of Contents

<u>Tables</u>

<u>Appendices</u>

Acronyms and Abbreviations

Cº	degrees Celsius
CPUE	catch-per-unit-effort
GNSS	global navigation satellite system
LEI	Lloyd Engineering, Inc.
mg/l	milligrams per liter
MSC	Matagorda Ship Channel
NMFS	National Marine Fisheries Service
NTU	Nephelometric turbidity unit
oysters/ft^3	oysters per cubic foot
PA	placement area
psu	practical salinity unit
SA	Survey Area
SOL	SOL Engineering Services, LLC
SSS	side-scan sonar
su	standard unit
TPWD	Texas Parks and Wildlife Department
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

SOL Engineering, LLC (SOL) subcontracted Lloyd Engineering, Inc. (LEI) to conduct an oyster resources survey on behalf of the U.S. Army Corps of Engineers (USACE), Galveston District to evaluate the potential impacts associated with the utilization of dredged material placement areas (PA) located west of the Matagorda Ship Channel (MSC). LEI conducted surveys to determine the presence or absence of oyster resources within PA numbers 16A, 15A, and 14A. Additionally, surveys were conducted approximately 1,000 feet beyond the limits of each PA to determine potential avoidance measures of oyster resources via minor modifications to the limits of the described PA's. This report details the findings of the oyster resources survey conducted and includes exhibits depicting the extent of oyster resources and potential oyster resources within the project area.

The project area is positioned south of the MSC within the Lavaca Bay complex, located in Calhoun County, Texas. Survey Area 1 encompassed PA 16A and measures approximately 7,100 feet long and 3,200 feet wide (500 acres). Survey Area 2 encompassed PA 15A and measures approximately 7,000 feet long and 3,100 feet wide (480 acres). Survey Area 3 encompasses PA 14A and measures approximately 6,600 feet long and 3,200 feet wide (466 acres). Refer to Figure 1 for a vicinity map depicting the location of the project area.

LLOYD ENGINEERING, INC.

Legend

Survey Area

Placement Area

Coordinate System: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
False Easting: 1,968,500.0000
False Northing: 13,123,333.3333
Central Meridian: -99.0000
Standard Parallel 1: 28.3833
Standard Parallel 2: 30.2833
Latitude Of Origin: 27.8333
Units: Foot US

N

0 3,000 6,000 Feet

Figure 1

Vicinity Map
Oyster Resources Survey
Matagorda Ship Channel
Upper Reach Placement Area Project
U.S. Army Corps of Engineers

Calhoun County, Texas

Prepared By: J. Wiedeman	1 inch = 3,000 feet
	Date: Apr 17, 2017

American Oyster (*Crassostrea virginica*)

American oysters (*Crassostrea virginica*) are sessile, bi-valved mollusks that occur throughout the Gulf of Mexico in shallow bays, mud flats, and offshore sandy bars (Stanley and Sellers, 1986). Oysters grow well on a variety of substrates, ranging from rocky bottoms to some types of mud. The presence and growth of oysters are closely correlated with salinity and other abiotic variables.

Oysters spawn from March through November in the northern Gulf of Mexico (Bulter, 1954), and the peak of spawning season in Texas is between May and early June (Stanley and Sellers, 1986). Spawning is triggered mostly by temperature when it rises above 20 degrees Celsius (C^{o}) for normal spawn and above 25^{o}C for mass spawning (Pattillo, et al., 1997).

Eggs hatch six hours after fertilization, and oyster larvae remain in the water column as meroplankton for two to three weeks after hatching (Patillo, et al., 1997). As a reference, settling or attachment to substrate was first observed in Galveston Bay about two months after spawning when the larvae were approximately 0.2 millimeter in length (Hopkins, 1931).

Upon settling or attachment, the sessile juveniles are referred to as spat. Spat-fall on the Gulf Coast typically occurs from March to mid-November (Gunter, 1955; Hopkins, 1931). Juveniles begin to develop once larvae attach. In the Gulf, sexual maturity of oysters may occur as soon as four weeks after attachment (Menzel, 1955), but generally maturation occurs at 18 to 24 months of age (Quast, et al.,1988).

Growth rates of adult oysters can vary greatly depending on conditions. Some adult oysters have been documented to grow at a rate of 50 millimeters per year (Bulter, 1954). Gunter (1951) provides growth rates of 60 millimeters in the first year, 90 millimeters in the second year, and 115 millimeters in the third year. Based on these growth rates, it is possible for an oyster to reach harvestable size of 76.2 millimeters (3 inches) within two years.

During open season, anyone with a Texas Parks and Wildlife Department (TPWD) harvester's license may harvest oysters from areas open to harvesting and sell to dealers certified by the Texas Department of Health. The rest of the year, harvest occurs on private oyster leases, mainly in Galveston Bay, home to 60 to 70 percent of the oyster crop along the Texas coast.

Oyster season in Texas lasts from November 1 through April 30; however, the Texas Department of Health and Safety has the discretion to close the fishery if the water conditions become conducive to propagation of toxic bacteria making oysters unsafe for human consumption.

2.0 Methods

The oyster resources survey methodology was completed in two phases. Phase 1 involved the use of side-scan sonar (SSS) and single-beam bathymetry surveys to identify anomalies throughout the project area. Phase 2 included the verification and characterization of the identified anomalies to delineation any oyster resources or potential oyster resources located within the project area. The following sections describe the methods implemented in Phase 1 and Phase 2 of the oyster resources survey.

2.1 Phase 1

During Phase 1 of the oyster resources survey, Hydrographic Consultants Ltd. and BOB Hydrographics, LLC was contracted by LEI to perform a remote-sensing sonar survey within the project area. From January 25-30, February 27-28, and March 9, 2017, contractors used an Edgetech 4125 sonar towfish with Edgetech's Discovery data acquisition software to acquire high-resolution, geo-rectified imagery of the bay floor within the project area. The SSS was towed behind a survey boat along parallel transects spaced approximately 20 meters apart to ensure 100 percent coverage of the project area.

Sub-meter positioning of the survey boat was accomplished using a Trimble Geo 7X global navigation satellite system (GNSS). Hypack navigation software running on a laptop computer was used to guide the survey boat along the previously established transects. A geo-referenced digital drawing of the survey area was utilized as a real-time moving map display for the navigation software and raw sonar data was recorded by the Discovery software on a laptop computer.

Upon completion of the field data acquisition, a mosaic sonar image was created using Chesapeake SonarWiz software to form a composite image of the bay floor. The mosaic was exported as georeferenced tiff files and provided to LEI for analysis and use for verification and characterization efforts during Phase 2.

2.2 Phase 2

From March 8, 2017, LEI ecologist conducted oyster resources verifications within the designated survey areas. This survey was conducted according to the protocols used on previous oyster surveys accepted by the U.S. Fish and Wildlife Service (USFWS), TPWD, and the National Marine Fisheries Service (NMFS). LEI ecologist conducted the oyster resources survey under TPWD scientific collection permit (SPR-1016-263), as required for sampling oysters within Texas state waters.

The boundaries of the preliminary anomalies were refined by poling along the boundary of each anomaly and mapping changes to preliminary boundaries where required. During this process, field ecologists navigated to, and inspected, each identified anomaly using a 20-foot long aluminum sounding pole equipped with a density gauging point on one end and a 3-inch sounding disk on the other. Anomalies verified as consisting of oyster resources were characterized based on their composition as either scattered live oysters or consolidated oyster reefs. The areas classified and confirmed as consolidated oyster reefs exhibited distinct SSS signatures and were positioned within areas of increased elevations in relation to the surrounding bay bottom. Due to the shallow nature of the project area, the boundaries of some of the consolidated oyster reefs were verified via visual inspection.

To characterize the anomalies, an oyster dredge was towed nine times to get a representative sample of substrate anomalies. Each dredge tow was recorded using a Trimble Geo 7X GNSS unit. The oyster dredge used consists of a steel frame with a 0.25-inch wire mesh collection basket anchored behind a row of steel digging teeth. The dimensions of the oyster dredge were 0.79 feet long by 1.35 feet wide and 0.82 feet deep. The wire mesh basket also allowed for the collection of shell, shell hash, and associated reef species.

At the completion of each dredge tow, the dredge was retrieved and contents were photo-documented, described, and classified. When oysters were collected in the dredge, all whole, in-tact individuals were enumerated, measured to the nearest 0.01 inch, and classified according to size as spat ($\leq$ 0.98 inches), juvenile (0.99 – 1.06 inches), sub-adult (1.07 – 2.95 inches), or adult ($\geq$ 2.96 inches). Additionally, the percentages of live and dead individuals were determined by separating the live oysters from the dead and calculating a ratio of live/dead individuals to the total number of oysters collected. Oysters were considered live if they were fully in-tact and tightly closed. Oysters were considered dead if the shell was fully in-tact with the two valves connected at the umbo, but was slightly to completely open. Whole shells that were either connected by only a single valve or were broken or fragmented were not enumerated as individuals and were classified as oyster shell. Any shell or man-made hard substrate larger than 1.5 by 2.5 inches was considered potential oyster resources (per comm. Robinson, 2006).

Catch-per-unit-effort (CPUE) was calculated for each dredge tow by dividing the total numbers of live oysters collected by the volume (feet^3) of substrate sampled along each dredge transect. The volume of each dredge tow sample was determined by calculating the product of the length of the transect (feet), the width of the oyster dredge (1.35 feet), and the height of the oyster dredge (0.79 feet). These calculations provided an index of abundance for each oyster dredge transect. Below is the formula used in calculating CPUE for dredge tows:

$$\text{CPUE for Dredge Tows } = \frac{(\#\ Live\ Oysters\ Collected)}{Transect\ Length(ft) x\ 1.35\ ft\ x\ 0.79\ ft}$$

In order to quantify CPUE for oyster reefs that prohibited oyster dredge tows (due to shallow water), data from surrounding oyster reefs were averaged and used to represent these reefs. The mean CPUE for all transects in each PA were also calculated to represent oyster reefs in each survey area.

2.2.1 Water Quality Investigation

In situ standard water quality parameters were collected at the time of the field effort using a YSI 6920 V2 multi-parameter data sonde. Standard water quality parameters collected within the study area included temperature ºC, salinity practical salinity units (psu), dissolved oxygen milligrams per liter (mg/L) and percent saturation (%), turbidity Nephelometric turbidity units (NTU), and pH standard units (su). Data collection depths ranged from 1 – 3 feet below the surface of the water column, depending on the depth at the sampling location during the time of field surveys.

3.0 Results

The following sections describe the results and findings from Phase 1 and Phase 2 of the oyster resources survey conducted within the project area.

3.1 Phase 1

Results of the SSS identified several substrate anomaly signatures characteristic scattered live oysters and/or consolidated oyster reefs. SSS signatures indicate substrate within the survey boundaries vary between firm to moderately firm sand and soft to moderately firm mud. Refer to Appendix B for figures depicting the SSS imagery and the identified substrate anomalies.

3.2 Phase 2

Refer to Appendix A for site photographs showing the contents from each dredge transect, Appendix C for figures depicting the location of the identified oyster resources within the survey areas, and Appendix D for all data collected from each oyster dredged transect.

Survey Area 1

Within Survey Area 1, three areas totaling approximately 46.29 acres of scattered live oysters were identified (Table 1). Of those, approximately 0.66 acres of scattered live oysters were located within the limits PA 16A (Table 1). The remaining 45.63 acres of scattered live oysters are located outside of the designated PA, but within Survey Area 1. A total of two oyster dredged transects, DT-6 and DT-8, were towed within Survey Area 1 within strategically located positions to confirm the absence of live oysters within areas of minimal SSS signatures.

Within Survey Area 1, approximately 0 percent of the oysters collected were live and 100 percent were dead. The CPUE and overall mean CPUE of live oysters in Survey Area 1 was 0.0000 live oysters/ft^3 (Table 2).

Survey Area 2

Within Survey Area 2, three areas totaling approximately 102.35 acres of scattered live oysters and two areas totaling 3.71 acres of consolidated oyster reef were identified (Table 1). Of those, approximately 16.10 acres of scattered live oysters and 1.59 acres of oyster reef were located within the limits PA 15A (Table 1). The remaining 86.25 acres of scattered live oysters and 2.12 acres of oyster reef are located outside of the designated PA, but within Survey Area 2. A total of three oyster dredged transects were towed at representative locations within Survey Area 2.

Within Survey Area 2, approximately 55.69 percent of the oysters collected were live and 44.31 percent were dead. The CPUE of oysters in Survey Area 2 ranged from 0.1126 to 0.1291 live oysters per cubic foot (oysters/ft^3) with an overall mean CPUE of 0.1220 live oysters/ft^3 (Table 2).

Survey Area 3

Within Survey Area 3, five areas totaling approximately 9.58 acres of scattered live oysters and one area totaling 0.33 acre of consolidated oyster reef were identified (Table 1). Of those, approximately 1.28 acres of scattered live oysters were located within the limits PA 14A (Table 1). The remaining 8.30 acres of scattered live oysters and 0.33 acre of oyster reef are located outside of the designated PA, but within Survey Area 3. A total of three oyster dredged transects were towed at representative locations within Survey Area 3.

Within Survey Area 3, approximately 45.66 percent of the oysters collected were live and 54.34 percent were dead. The CPUE of oysters in Survey Area 3 ranged from 0.0485 to 0.1149 live oysters per cubic foot (oysters/ft^3) with an overall mean CPUE of 0.0801 live oysters/ft^3 (Table 2).

Table 1
Acreage of Oyster Resources Identified Within the Matagorda Ship Channel Project Area

Survey Area (SA)	Acreage of Scattered Live Oysters	Acreage of Oyster Reef	Placement Area (PA)	Acreage of Scattered Live Oysters	Acreage of Oyster Reef
SA 1	46.29	0.00	PA 16A	0.66	0.00
SA 2	102.35	3.71	PA 15A	16.10	1.59
SA 3	9.58	0.33	PA 14A	1.28	0.00
TOTALS	**158.22**	**4.04**	**TOTALS**	**18.04**	**1.59**

Table 2
Catch-per-Unit-Effort of Live Oysters Collected in Dredge Tows Within Survey Areas 1, 2, and 3

Survey Area	Dredge Town Number	CPUE (No. Live Oysters/ft^3)	Mean CPUE[1]
Survey Area 1	DT-08	0.0000	0.0000
	DT-06	0.0000	
Survey Area 2	DT-04	0.1244	0.1220
	DT-05	0.1129	
	DT-07	0.1291	
Survey Area 3	DT-01	0.0485	0.0801
	DT-02	0.1149	
	DT-03	0.0769	

1 Mean CPUE calculated using data from completed dredge tows

The majority of associated reef organisms observed during the surveys were competitors or obligate species. Hook mussels were the dominant reef associate at the time of the survey. However, several species of crabs and barnacles (*Balanus* spp.), as well as Rangia clams (*Rangia cuneata*) and fathead sleepers (*Dormitator maculatus*), were observed. Field ecologists observed very few predators (e.g., boring sponges) throughout the project area, and no oyster drills were observed.

3.2.1 Observed Water Quality

Standard water quality parameters collected at the time of the survey revealed salinities ranging from 16.8 to 18.5 (psu). Dissolved oxygen ranged from 9.74 to 12.03 mg/l with temperature ranges of 16.77 to

17.11°C. Turbidity ranged 44.4 to 56.1 (NTU). PH ranged from 6.34 to 7.73 (su). Refer to Appendix E for the standard water quality parameters data collected during field surveys.

4.0 Conclusions

LEI was contracted by USACE, Galveston District, to conduct an oyster resources survey to determine the presence or absence of oyster resources and potential for direct or indirect impacts as a result of the discharge of dredged material within PA 16A, 15A, and 14A. As a result, a combined total of 158.22 acres of oyster resources were identified within the Survey Areas, consisting of 46.29 acres in Survey Area 1, 106.06 acres in Survey Area 2, and 9.91 acres in Survey Area 3. The CPUE of oysters within the project area ranged from 0.000 to 0.1291 live oysters/ft^3 with an overall mean CPUE of 0.0674 live oysters/ft^3.

At the time of the survey, all water quality characteristics were indicative of normal conditions during the month of March. A majority of the oysters observed were spat (142 individuals) and sub-adult (120 individuals) size. Potential oyster resources that occurred in the project area were present under moderately soft to moderately firm mud. Based on the conditions observed during field investigations, sizable portions of area located within Survey Area 1 and Survey Area 3 consisted primarily of soft sediments and unfavorable conditions for the establishment of oyster resources.

5.0 References

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Appendix A

Site Photographs

Oyster Resources Survey
Matagorda Ship Channel Upper Reach Placement Area Project
Site Photographs

Photo 1: View of oysters from DT-01 within SA 3.

Photo 2: View of oysters from DT-02 within SA 3.

Photo 3: View of dead oyster from DT-02 within SA 3.

Photo 4: View of oysters from DT-03 within SA 3.

Photo 5: Vegetative growth on oyster from DT-03 within SA 3.

Photo 6: View of oysters from DT-04 within SA 2.

Photo 7: View of associated oyster species from DT-04 within SA 2.

Photo 8: View of oysters from DT-05 within SA 2.

Photo 9: View of oysters from DT-06 within SA 1.

Photo 10: View of dead oysters from DT-06 within SA 1.

Photo 11: View of oysters from DT-07 within SA 2.

Photo 12: View of oysters from DT-08 within SA 1.

Photo 13: View of dead oysters from DT-08 within SA 1.

Appendix B

Side-Scan Sonar Maps

LLOYD ENGINEERING, INC.

Coordinate System: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
False Easting: 1,968,500.0000
False Northing: 13,123,333.3333
Central Meridian: -99.0000
Standard Parallel 1: 28.3833
Standard Parallel 2: 30.2833
Latitude Of Origin: 27.8333
Units: Foot US

Legend

- Survey Area
- Placement Area
- Consolidated Oyster Reef
- Scattered Live Oysters

0 1,200 2,400 Feet

Figure 1

Side-Scan-Sonar Map: Survey Area 1
Oyster Resources Survey
Matagorda Ship Channel
Upper Reach Placement Area Project
U.S. Army Corps of Engineers

Calhoun County, Texas

Prepared By: J. Wiedeman	1 inch = 1,200 feet
	Date: Jun 05, 2017

LLOYD ENGINEERING, INC.

Coordinate System: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet
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Standard Parallel 1: 28.3833
Standard Parallel 2: 30.2833
Latitude Of Origin: 27.8333
Units: Foot US

N

0 1,200 2,400 Feet

Legend

- Survey Area
- Placement Area
- Consolidated Oyster Reef
- Scattered Live Oysters

Figure 2

Side-Scan-Sonar Map: Survey Area 2
Oyster Resources Survey
Matagorda Ship Channel
Upper Reach Placement Area Project
U.S. Army Corps of Engineers

Calhoun County, Texas

Prepared By: J. Wiedeman	1 inch = 1,200 feet
	Date: Jun 05, 2017

LLOYD ENGINEERING, INC.

Legend

- Survey Area
- Placement Area
- Consolidated Oyster Reef
- Scattered Live Oysters

Coordinate System: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
False Easting: 1,968,500.0000
False Northing: 13,123,333.3333
Central Meridian: -99.0000
Standard Parallel 1: 28.3833
Standard Parallel 2: 30.2833
Latitude Of Origin: 27.8333
Units: Foot US

0 1,200 2,400 Feet

Figure 3

Side-Scan-Sonar Map: Survey Area 3
Oyster Resources Survey
Matagorda Ship Channel
Upper Reach Placement Area Project
U.S. Army Corps of Engineers

Calhoun County, Texas

Prepared By: J. Wiedeman	1 inch = 1,200 feet
	Date: Jun 05, 2017