BOB Project 2020-05

UNDERWATER ARCHAEOLOGY SURVEY OF PERTINACITY BARGE FLEETING AREA HARRIS COUNTY, TEXAS

Prepared for:

Schneider Engineering and Consulting, Inc.
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Principal Investigator:
Robert Gearhart

3 October 2020

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Texas Antiquities Permit No. 9507
Army Corps of Engineers Permit Application SWG-2020-00309

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Abstract

BOB Hydrographics, LLC (BOB) conducted an underwater archaeological survey for a proposed barge fleeting area on Buffalo Bayou in Harris County, Texas. Pertinacity Harbor and Marine Services, LLC funded this study. Schneider Engineering and Consulting, Inc. of Galveston, Texas subcontracted with BOB to conduct this archaeological assessment. The survey spans portions of State Mineral Lease Tracts B and B-1 downstream from the East Beltway 8 Bridge in Pasadena. The proposed fleeting area (the PROJECT) measures 400 x 2,000 feet and encompasses 18.4 acres. Water depths in the PROJECT range from less than -0.5 feet to -20 feet below Mean Lower Low Water. Dredging is proposed to provide a uniform depth of -12 feet. Mooring will be provided by spud barges spaced at regular intervals. Field investigations included a geophysical survey, performed under Texas Antiquities Permit 9507, from August 12 to 14, 2020. The purpose of the survey was to locate potential archaeological sites that could be affected by dredging. The survey plan encompassed 34.8 acres, including the PROJECT and a Texas Historical Commission buffer, extending 50 meters beyond the PROJECT, or less where limited by the shoreline. Magnetometer survey was completed over 24 acres, and side-scan sonar survey covered 40 acres. Portions of the planned survey could not be completed due to shoals and to a small number of barges that could not be moved. An archaeological assessment was conducted of all data acquired from the survey. No artifacts were collected during this survey. A desktop review of the cultural background determined that 8 underwater archaeological investigations and 2 historic wrecks have been reported within 3 miles of the PROJECT. Analysis of geophysical survey results from the survey did not discover any targets potentially eligible for the State Antiquities Landmark or for the National Register of Historic Places; therefore, BOB recommends clearance of the proposed undertaking from further cultural resource requirements. 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 underwater 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

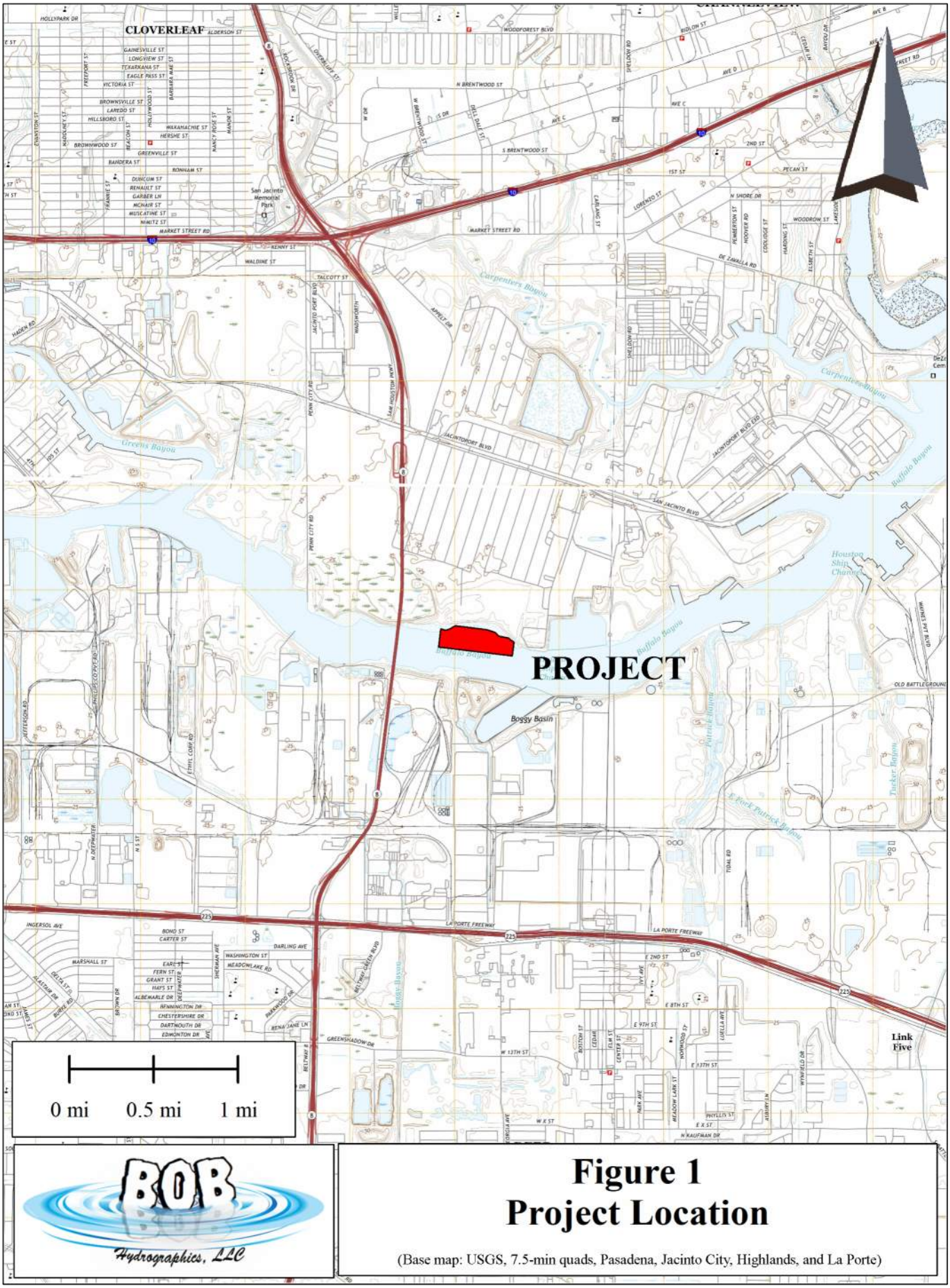
BOB Hydrographics, LLC (BOB) conducted an underwater archaeological survey for a proposed barge fleeting area on Buffalo Bayou in Harris County, Texas (Figure 1). Pertinacity Harbor and Marine Services, LLC funded this study. Schneider Engineering and Consulting, Inc. of Galveston, Texas subcontracted with BOB to conduct this archaeological assessment. The proposed fleeting area (the PROJECT) measures 400 x 2,000 feet and encompasses 18.4 acres. Dredging is proposed to provide a uniform depth of -12 feet. Mooring will be provided by spud barges spaced at regular intervals.

The survey spans portions of State Mineral Lease Tracts B and B-1 downstream from the East Beltway 8 Bridge in Pasadena. The purpose of the survey was to locate potential archaeological sites that could be affected by dredging. Water depths in the PROJECT range from less than -0.5 feet to -20 feet below Mean Lower Low Water (MLLW). The survey plan encompassed 34.8 acres, including the PROJECT and a Texas Historical Commission (THC) buffer, extending 50 meters beyond the PROJECT, or less where limited by the shoreline. Magnetometer survey was completed for 24 acres, and side-scan sonar survey covered 40 acres. Portions of the planned survey could not be completed due to shoals and to a small number of barges that could not be moved. Survey was completed, with the magnetometer, over all but 13.5 acres of the planned area and, with the sonar, over all but 8.7 acres.

Geophysical survey was completed under Texas Antiquities Permit 9507, from August 12 to 14, 2020. Field personnel included Robert Gearhart and Ed Baxter, RPA. Robert Gearhart analyzed the data and prepared this report. The purpose of this study was to assess the archaeological potential of the PROJECT; however, no artifacts were collected during this survey. A desktop review of the cultural background determined that 8 underwater archaeological investigations and 2 historic wrecks have been reported within 3 miles of the PROJECT.

An archaeological assessment was conducted of all geophysical data acquired by the survey, including areas located beyond the PROJECT boundary. Analysis of geophysical survey results did not discover any targets potentially eligible for the National Register of Historic Places (NRHP) or as a State Antiquities Landmark. BOB recommends clearance of the proposed undertaking from further cultural resource requirements. The results reported in this document will support Pertinacity Harbor and Marine Services' application for a United States Army Corps of Engineers (USACE) Permit, SWG-2020-00309.

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 complies also 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 PROJECT is publicly owned; therefore, Texas Antiquities Permit 7874 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 underwater archaeological studies conducted under Texas Antiquities Permits.



BOB Hydrographics, LLC

Figure 1
Project Location

(Base map: USGS, 7.5-min quads, Pasadena, Jacinto City, Highlands, and La Porte)

This report is organized into six sections that provide context for interpreting the survey results and includes maps of magnetic contours and side-scan sonar imagery. Section II relies upon a combination of published literature and data collected by this survey to summarize the physical environment of the PROJECT. Section III describes the relevant cultural background within a 3-mile radius of the PROJECT, including maritime history and shoreline developments, previous archaeological investigations, and the potential for intact archaeological sites in the area. Section IV summarizes methods for conducting the geophysical survey and for processing and analyzing the data. Section V presents an archaeological assessment of the geophysical data and provides recommendations specific to those findings. Bibliographic references cited in the text are included as Section VI.

II. Physical Environment

Buffalo Bayou is a natural tributary of the San Jacinto River. The bayou provided navigable water depths during Houston's earliest days with minimal need for improvement until the size of ships necessitated a deeper channel. The development of Houston as a major commercial hub, combined with rapid growth of the petrochemical industry, has led to major changes in the physical landscape of Buffalo Bayou. Figure 2 shows present conditions at the PROJECT. Bathymetry is referenced to the MLLW datum and overlain on a 2015 aerial photograph. Bathymetry for the PROJECT was acquired under a separate contract by Chris Ransome & Associates, Inc. in 2019 and was reused with permission. The THC approved use of their bathymetry as a variance to Antiquities Permit 9507.

Water depths in the PROJECT range from less than -0.5 feet to -20 feet MLLW. Historic shorelines from 1919, 1955, and 1967 are overlain on the bathymetry to illustrate the degree of change that has occurred during the past century. The maps selected for digitization of shorelines were geo-referenced for the Texas Department of Transportation by Foster, et al. (2006).

Land surfaces in this area have subsided substantially over the past century, due to withdrawal of groundwater in the Houston metropolitan area. A study by the United States Geological Survey (USGS) documented 7.5 feet of subsidence in the survey area vicinity from 1943-1973 (Gabyrsch and Bonnet 1977: 10-14). Their study relied largely on data from the National Geodetic Survey leveling program. An additional 0.8 feet of subsidence may have occurred from 1906-1943, although their data for that period is less abundant.

Elevations charted in 1919 and 1955 (figures 3 and 4) were compared with PROJECT bathymetry and with the 2015 shoreline position, the latter taken as a rough approximation of 0 feet MLLW. The results confirm that the survey area has subsided substantially, possibly in the range of 8-10 feet, since 1919, consistent with the findings of Gabyrsch and Bonnet (1977). That picture is complicated, however, by the placement of material dredged from Buffalo Bayou during the mid-20th century. A 1952 aerial photograph shows recently dredged material filling once low-lying, marshy areas north of the PROJECT (Figure 5). This material was pumped from Buffalo Bayou as the waterway was widened and deepened during the early-20th century (Hoyt, et al. 1998). The northern shoreline crossed through the PROJECT as recently as 1955 (Figure 4), but today only the northern corners of the PROJECT touch upon land.

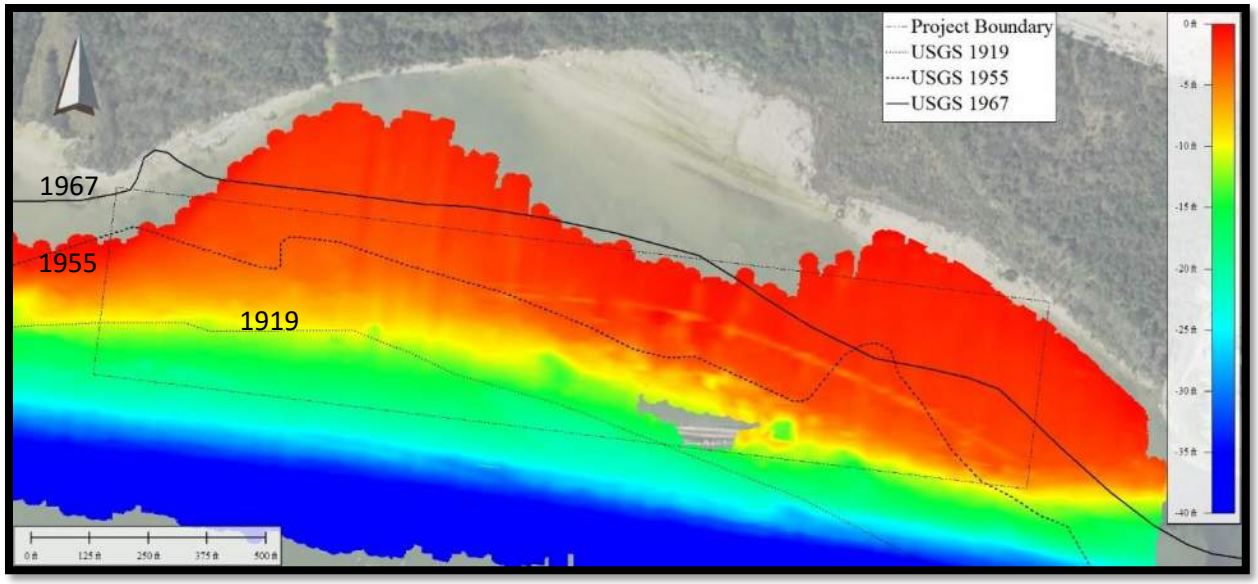


Figure 2: 2019 Bathymetry, MLLW
Acquired by Chris Ransome & Associates, Inc.; 2015 Aerial Base

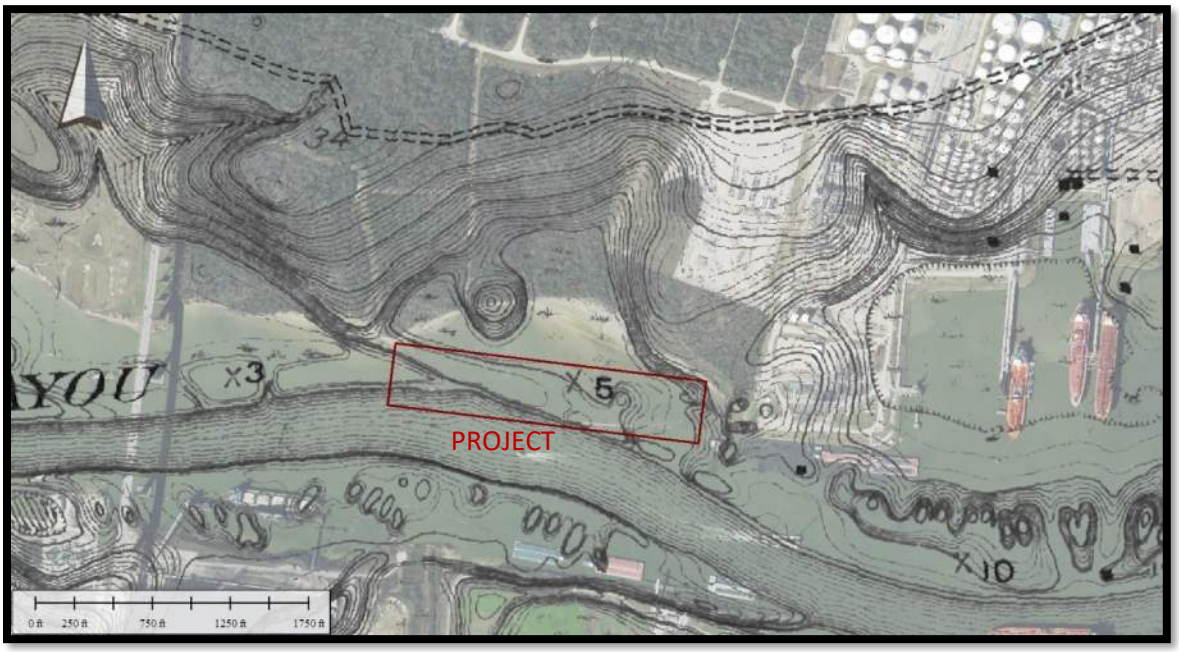


Figure 3: 1919 Topography on 2015 Aerial Base (USGS 1919)

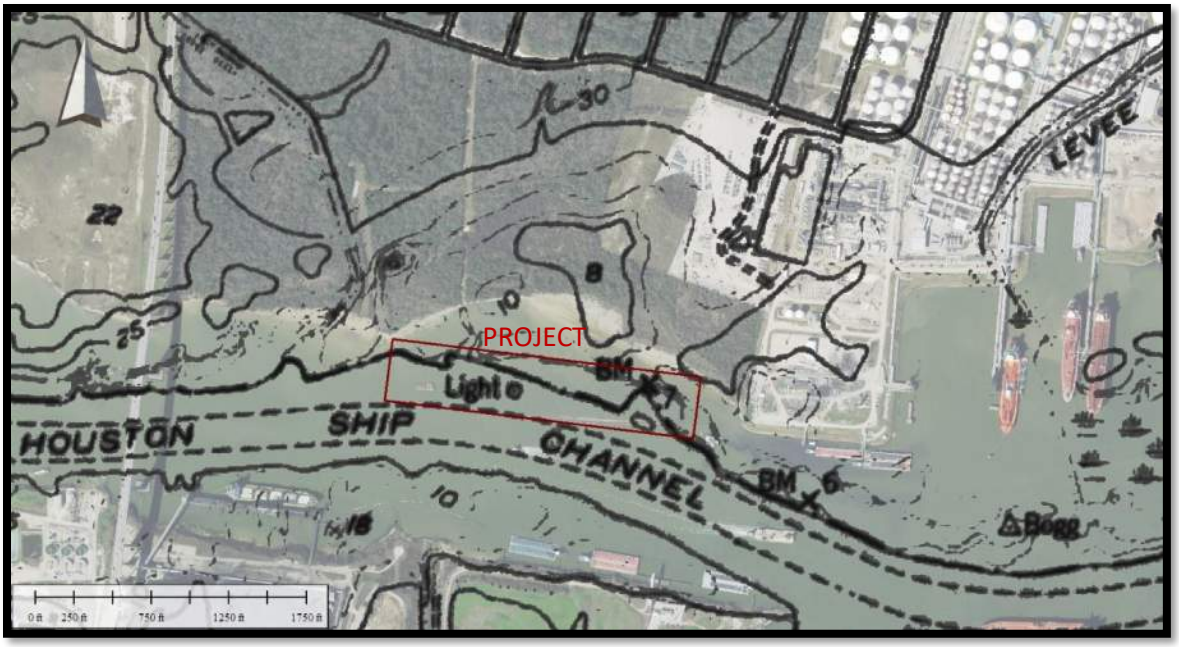


Figure 4: 1955 Topography on 2015 Aerial Base (USGS 1955)

Figure 5: 1952 Aerial Photograph (Google Earth)

III. Cultural Background

Land grants bordering the PROJECT were issued by Stephen F. Austin to the brothers Richard and Robert Vince on the northern shore of Buffalo Bayou in 1824 (General Land Office 1825, cited in Foster, et al. 2007). Thomas Earle settled on the southern shore, opposite the Vince brothers, in 1825. The Battle of San Jacinto, which defeated Santa Anna's Army during the Texas Revolution, was fought in April of 1836, about 3 miles downstream from the PROJECT. The battlefield is designated as an NRHP District. Houston was founded in August of that same year, on the banks of Buffalo Bayou, several miles upstream from the PROJECT.

Houston leaders soon recognized the need for navigational improvements along the winding length of Buffalo Bayou to attract commerce inland from Galveston. The Buffalo Bayou Ship Channel Company made the first attempt to improve a channel across Galveston Bay in 1869 by cutting a channel through Morgans Point to bypass Cloppers Bar. The project encountered financial difficulties and was forced to sell to Charles Morgan. The federal Rivers and Harbors Act of 1870 funded a survey for a ship channel extending across Galveston Bay to Buffalo Bayou (Alperin 1977). Buffalo Bayou was chosen because the Houston area was becoming a major railway hub. Houston was granted status as an official federal port of entry that same year.

Charles Morgan's company completed the canal through his namesake point and went on to dredge the first channel across Galveston Bay. The first deep-draft ship to pass through what is now the Houston Ship Channel was the Morgan Line steamer *Clinton* in 1876. The inland end of Morgan's 12-foot-deep channel was his marine and rail terminal at Clinton Island, a short distance upstream from the PROJECT. Since then the ship channel has been repeatedly deepened to accommodate ever larger vessels. Nevertheless, Buffalo Bayou through the PROJECT remained sparsely settled until the mid-twentieth century.

The northern bank of Buffalo Bayou, adjacent the PROJECT, has changed ownership several times since the original 1824 land grants to Richard and Robert Vince. Subsequent buyers included: James Spillman in 1839, J.W.S. West in 1853, Richard West in 1869, and S.H. West by 1907 (Foster et al. 2007: 15-16). The first evidence of shoreline development in the PROJECT appears on a map of Buffalo Bayou in 1871 (USACE 1871). The map shows two structures set back a short distance from the northern shore. One structure is on a parcel of land labeled "Mrs. Rachael Wests." The other is on an adjacent parcel, downstream from the first, labeled "Mr. Richard Wests." A five-year-old child, Lydia K. West (daughter of John H. West), was buried, between 1870 and 1875, less than half a mile north of the PROJECT, on the southern margin of the San Jacinto Ordnance Depot, Site 41HR424 (Foster, et al. 2007: 15). A single structure continues at the Richard West location on an 1897 chart (USACE 1897).

The nearest early community, Penn City, was located on the north bank of Buffalo Bayou about a mile upstream from the PROJECT (USGS 1919). In 1909, three Houston business men, Jachmia Daugherty,

Clarence Waller and J.S. Welch, formed the Penn City Land Company with the idea of establishing an industrial town on the banks of Buffalo Bayou (Pearson, et al. 2015: 2-7). A large residential subdivision was planned (Harris County Map Volume 2:72; cited in Foster, et al. 2007: 17). Financing was raised from a holding company in Pennsylvania, hence the name "Penn City" (Hardy and Roberts 1910: 967; cited in Pearson, et al. 2015: 2-7). The Houston Bank and Trust filed a plat of Penn City in 1918 under the name Houston Terminals (reproduced in Foster, et al. 2007: Figure A-5) showing ambitious plans for a substantial community.

The community of Penn City, including a ferry across Buffalo Bayou and a Penn City School, persisted as landmarks on USGS maps through 1925; however, Penn City never approached the size imagined by its developers. A 1926 "Map of the Houston Ship Channel, Showing All Industries, Railways, Public and Private Docks," prepared by the Houston Chamber of Commerce, lacks industrial development along either shore (Foster, et al. 2006). A 1930 aerial photograph (illustrated in Foster, et al. 2007: Figure A-7) demonstrates that the platted community was never constructed. Penn City probably only grew to a few scattered homes.

The United States (U.S.) Army constructed the San Jacinto Ordnance Depot in 1941, about a third of a mile north of the PROJECT. Two-hundred and two concrete "igloo" magazines were built on a grid covering nearly 5,000 acres to store ammunition during World War II. Munitions were shipped to and from the facility by water and landed at a dock about a mile upstream from the PROJECT. The depot was sold by the government to private industry in 1959. The depot was documented as a historic site (41HR424) in 2007 in anticipation of using 557 acres to construct the proposed Beltway 8 Dredged Material Placement Area for material to be dredged from the Houston Ship Channel (Foster, et al. 2007).

Previous Underwater Investigations

Eight underwater archaeological surveys have been completed within 3 miles of the PROJECT. In 1991, Espey, Huston & Associates (EH&A) surveyed a corridor adjacent each side of the Houston Ship Channel for the USACE, Galveston District (Hoyt 1992). Their survey (Antiquities Permit 1128) covered over 40 linear miles of ship channel from Bolivar Roads to the East Beltway 8 Bridge near Houston, plus 3.6 miles of the Galveston Ship Channel. EH&A's survey overlapped the channel side of the present study; however, their 44-meter transect interval was more than double that required by the THC today. EH&A mapped over 3,400 magnetic anomalies and 570 sonar targets with the goal of finding shipwrecks and other historic sites that might be affected by future channel improvements. Ground-truthing by archaeological divers was recommended at 18 localities, based on their survey interpretations. Their nearest recommended target was Locality 1, roughly 3 miles downstream from the present survey.

A year later, EH&A completed a companion, archival research study of the same area (Foster, et al. 1993). That supplement to Hoyt's (1992) study delineated areas of potential archaeological and historical sites within and adjacent the ship channel based on historic records. Their research summarized 103 previously recorded archaeological, historical, and shipwreck sites and identified over 600 other potential historic sites within 1 mile of the channel. They made recommendations regarding high-priority sites and portions of the study area warranting further research and compiled a database of over 500 reported shipwrecks.

EH&A conducted diver investigations of 23 locations, on behalf of the Galveston District, under Antiquities Permit 1194 (Hoyt and Schmidt 1993). Dive targets were selected based on their earlier survey (Hoyt 1992). Modern debris was the source of many anomalies. Three localities were recommended for further testing to assess their potential for NRHP eligibility, including one with a scatter of hand-formed "common" bricks (ca. 1860-1890) and two others potentially associated with commerce on Hog Island predating the 1940s. Locality 1, located 3 miles downstream from the present study, was the dive target nearest to the present study area.

In 1994, EH&A completed a cultural resource study for the Galveston District, under Antiquities Permit 1424 (Hoyt, et al. 1998). Their study included specific areas scattered along the entire length of the Houston-Galveston Navigation Channels. The project included archival research, close-order magnetometer survey of selected areas, radiometric dating of a human mandible fragment found on the beach of Pelican Island, and diving on 10 offshore targets. Research identified 242 potential historic sites. Recommendations were made for future field examination of specific locations based on the correlation of magnetic anomalies with archival sites, including: the old Lynchburg town plat, the San Jacinto town plat, Hog Island, the Bayport Channel area, Red Fish Bar, and the Galveston Jetties. The research and survey, nearest to the present study, was between Carpenter Bayou and Lynchburg.

In 2009, Panamerican Consultants, Inc. conducted a remote sensing survey (Antiquities Permit 5400) of the proposed Ship Dock #4, for the Houston Fuel Oil Terminal Company (James and Murray 2009). Their study, located at the confluence of Buffalo and Carpenter Bayous, discovered 13 magnetic anomalies and 20 side-scan sonar targets, including cables and a partially exposed pipeline. The sources for all but two anomalies were visible on the surface. The two unidentified anomalies were attributed to a pipeline. No further work was recommended.

Atkins completed an underwater archaeological survey (Antiquities Permit 6495) on the south side of Buffalo Bayou between the East Beltway 8 Bridge and the San Jacinto River for Vopak Terminal Deer Park, Inc. (Tubby 2013). Their project searched for submerged archaeological sites in an area proposed for construction of docks and other shoreline facilities. No significant targets were discovered, and the project was recommended for cultural resource clearance.

Moore Archeological Consulting, Inc. completed an underwater archaeological survey and diving project (Antiquities Permit 7300) along the northern shore of Buffalo Bayou upstream from the East Beltway 8 Bridge (Pearson, et al. 2015). Their study recorded two sunken barges, designated as archaeological sites 41HR1168 and 41HR1169, which are located just outside of the PROJECT. The THC concurred with their recommendation that neither site is eligible for the NRHP.

In 2017, BOB conducted a submerged cultural resource survey (Antiquities Permit 7874) for Magellan Terminals Holdings, LP of Tulsa, Oklahoma. A total of 59 acres were surveyed for a proposed marine terminal and turning basin on Buffalo Bayou. Zephyr Environmental Corporation subcontracted with BOB to conduct this archaeological assessment. The survey overlapped portions of an earlier study by Moore

Archeological Consulting, Inc. (Pearson, et al. 2015). Analysis of geophysical survey results did not discover any targets potentially eligible for the NRHP. BOB recommended clearance of the proposed undertaking from further cultural resource requirements.

During August 2016, Gray & Pape, Inc. conducted an underwater cultural resources survey (Antiquities Permit 7716) in Buffalo Bayou for Benchmark Ecological Services, Inc. The survey covered 37.5 acres along the north bank of Buffalo Bayou, immediately downstream from Greens Bayou. Numerous magnetic anomalies were caused by debris placed along the shoreline to control erosion. Seventeen side-scan sonar contacts were discovered. No magnetic anomalies or sonar targets were interpreted as significant cultural materials, and no further archaeological investigations were recommended.

Potential for Submerged Archaeological Sites

Submerged archaeological sites may be eligible for nomination to the NRHP or as State Antiquities Landmarks. Archaeological sites, in this context, might be sunken or abandoned watercraft or shoreline sites that have become submerged. Undocumented shipwrecks are likely rare in heavily controlled and protected waters, such as Buffalo Bayou; however, aged and/or decommissioned watercraft often were abandoned or intentionally scuttled in backwater sloughs or along undeveloped shorelines, where they would not have been considered a hazard to navigation at the time.

Drowned Terrestrial Sites

Several archaeological investigations have been completed on the northern bank of Buffalo Bayou near the PROJECT; however, their geographic limits are not plotted in the THC Archaeological Sites Atlas (Atlas). No physical evidence of historic sites or industrial development has been documented by archaeologists on the northern shore of the PROJECT. Aerial images on Google Earth show snapshots of the PROJECT since 1944. No structures are visible on aerial photography adjacent the PROJECT.

One Late Prehistoric shell midden, 41HR140, was reported nearby during the 1960s by W.L. McClure of Houston (Atlas). The site was discovered in sandy soil, on the first terrace above Buffalo Bayou, 10 feet above and 50 feet back from the stream. Artifacts collected from the site included sand-tempered ceramics, flint chips, and *Rangia* shell. McClure reported that “very little of the area is undisturbed.” The site might have been disturbed by machine traffic associated with placement of dredged materials as apparent in a 1952 aerial photograph (Figure 5).

Site 41HR140 was revisited by Paul McGuff and Mike Thomas in 1973. They described it as a thin remnant of a shell midden in poor condition. At the time of their visit, artifacts were observed on clay loam soil, 100 feet west of a pipeline. The absence of sandy soil, as reported by McClure, was noted in their site form. McGuff and Thomas plotted the site on 1967 USGS topography (Figure 6).

Within ten years of their visit, an updated topographic map indicated that the site location was marshy, tidal ground (USGS 1983), about 10 feet lower in elevation than when discovered. Gabyrsch and Bonnet (1977: 12) estimate subsidence of 3 feet from 1964-1973, alone. Presumably subsidence continued through 1983. The loss of sandy soil by 1973 suggests that erosion of the surface might have occurred simultaneously with subsidence.

Moore Archaeological Consulting reported a 1990 cultural resources survey of 328 acres for the Jacintoport Industrial Complex in support of an application for USACE Permit 19164. That study included surface survey, shovel testing, and research of historic land use. Moore (1990) made an unsuccessful attempt to relocate 41HR140, 17 years after McGuff and Thomas had visited the site.

The position of 41HR140 now appears to be straddled by two pipelines (Figure 6; cleared rights-of-way show on 2015 aerial photography). The site location likely was exposed to wave erosion from the wakes of passing ships by, at least, 1983 when USGS topography places it in the tidal zone. There is no expectation of intact stratigraphy at the site today.

Image removed to protect sensitive cultural information.

Figure 6: Site 41HR140 on USGS 1967 Pasadena Quadrangle; 2015 Aerial Photo Base

Two structures were mapped, in 1871, along the north bank of Buffalo Bayou (Figure 7) on adjacent properties, owned by "Mr. Richard West" (Hoyt, et al. 1998: Site 76-201) and "Mrs. Rachael West" (*ibid.* 1998: Site 76-202). The easternmost of those structures correlates closely with another shown in 1897 (Figure 8). The former locations of both structures plot in or near the PROJECT (Figure 7); however, the shoreline has retreated northward 500-600 feet since 1871, eroding both locations into Buffalo Bayou (Figure 2). Foster, et al. (2007: 16) agree that both sites were destroyed by straightening and widening of the ship channel during the early-20th century, as reported in Hoyt, et al. (1998; 31-32). The degree of subsidence of formerly exposed land in the PROJECT, and its subsequent erosion by ship wakes, supports the conclusions of Hoyt, et al. and Foster, et al. that both sites have been destroyed.

Image removed to protect sensitive cultural information.

Figure 7: 1871 Historic Structures (USACE 1871)

Image removed to protect sensitive cultural information.

Figure 8: 1897 Historic Structures (USACE 1897)

Shipwrecks

BOB researched potential shipwrecks within 3 miles of the PROJECT (Table 1). Sources consulted for this research included the THC Atlas; the National Oceanic and Atmospheric Administration's 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). It is important to note that the

position of most wrecks has not been ascertained. Historical accounts of wrecks are often inexact and may contain errors. Precise locations of most reported wrecks are unknown. Shipwrecks for which no position estimate is available, but which might have been lost in the vicinity, may be included in Table 1.

Table 1: Wrecks Reported Within Three Miles of the PROJECT

Name of Vessel	PBS&J No.	THC No.	AWOIS No.	Rig	Hull	Date Built	Date Lost	Nature	Locality
Unknown (Site 41HR1169)	231	1363	-	barge	-	-	pre-1955	unknown	Charted 1 mile upstream from PROJECT in 1955
Unknown (Site 41HR1168)	-	2433	-	barge	-	-	pre-1955	unknown	Charted 0.9 miles upstream from PROJECT in 1955

The Atlas database contains shipwrecks reported from historic records. The AWOIS list focuses on shipwrecks and other navigational hazards along the coastal U.S. The PBS&J database was originally compiled by EH&A under a contract with the USACE, Galveston District, based on National Archives sources listed in Foster, et al. (1993: 91-94). A group of archaeologists, including this author, added to that database over subsequent years as ownership of EH&A changed. The PBS&J database focuses primarily on well-documented commercial wrecks postdating 1850.

Two barges have been recorded as archaeological sites, 41HR1168 and 41HR1169, about 1 mile upstream from the PROJECT. The Atlas correlates those sites with THC Wrecks 2433 and 1363, respectively. Both wrecks predate publication of the 1955 edition of the USGS Pasadena topographic quadrangle map, on which they first appear. The sites were recorded by Pearson, et al. (2015) and revisited by Gearhart 2017.

Factors Affecting Vessel

Historic navigation through Buffalo Bayou began by at least the early nineteenth century. The main factors likely to influence the loss of vessels in the PROJECT are industrial accidents, mostly related to petrochemical materials carried on Buffalo Bayou; collisions and strandings, due to high traffic and seasonal foggy conditions; and intentional abandonment. Stranding is the most common type of shipwreck, accounting for 64 percent of total losses reported by the U.S. Lifesaving Service from 1876 through 1914 (Gearhart, et al. 1990: Volume IV, 59-61). Weather caused two-thirds of stranding events. Most stranding events occur along unprotected shorelines, or in the case of Buffalo Bayou, on the margins of the navigation channel.

Intentional abandonment was a common method, prior to modern environmental regulations, to dispose of watercraft at the end of their useful lives. Any area with sufficient water depth to accommodate a vessel without creating a hazard to navigation might have been used for this purpose. This includes the undeveloped shoreline adjacent the PROJECT, although the age of submerged areas there would preclude abandonment of vessels prior to the early-20th century.

The most significant environmental factor contributing to shipwrecks is severe weather, which accounted for 55 percent of total losses reported by the U.S. Lifesaving Service from 1876 through 1914. 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. Each winter sees 15 to 20 northers, or rapidly moving polar fronts, lasting 24–36 hours, pass over the coast of Texas. Northers may have 50-mile-per-hour winds and generate intense waves (McGowen 1976:19–23, 94).

Factors Affecting Vessel Preservation

Preservation of sunken watercraft depends mainly upon the composition of their hull and the degree to which they become and remain buried. Vessels may become partially buried soon after sinking due to scour and liquefaction of sediments during storms combined with the effects of their weight. 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 as 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 2010). Iron and steel hulls, nevertheless, can survive seawater exposure for well over a century.

IV. Research Design

Survey Methods

The purpose of the survey was to map geophysical anomalies that might indicate the presence of historically-significant, sunken or abandoned watercraft. Gulf Coast wrecks that survive exposure above the seafloor for more than a few years tend to be constructed of materials other than wood and are most easily recognized in side-scan sonar imagery. Vessels predating World War II tend to be constructed of wood (Gearhart 2011a), which preserves well when buried, but quickly deteriorates where exposed in the water column to wood-loving organisms, common to warm saline environments along the Gulf Coast. The primary instrument for locating submerged watercraft in buried contexts is the magnetometer.

Geophysical investigations were 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 meters (30 meters when greater than 3 nautical miles offshore); 3) bottom-disturbing activities must be avoided within 50 meters of potentially significant targets (150 meters 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 (excluded from this survey under a one-time permit variance) 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 meters 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.

Geophysical survey was completed from August 12 to 14, 2020 by Robert Gearhart (the archaeological Principal Investigator) with assistance from Ed Baxter, RPA. The Principal Investigator was solely responsible for archaeological data analysis and report preparation. The survey was conducted from BOB's 20-ft survey boat. A Hemisphere VS330, dual GPS-heading system provided sub-meter geographic positions. A Geometrics 882 magnetometer was towed on the surface 50.0 feet behind the survey vessel. Vector data, including sensor positions and magnetometer, were logged by Hypack navigation software.

Side-scan sonar data was acquired using an Edgetech 4125P system, operating at frequencies of 400 and 900 kHz, and recording to a range of 25 meters, except for two lines, recorded at 50 meters, in deep water near the ship channel. The sonar was towed near the surface, from the port side of the boat. Side-scan sonar data was logged in Edgetech's Discover software. Geographic positions were embedded in the digital sonar data as it was recorded. Chesapeake SonarWiz software was used to combine the 900-kHz sonar data from each transect into a composite sonar mosaic.

Primary survey transects were spaced 20 meters apart. The survey plan encompasses 34.8 acres, including the PROJECT and a THC buffer, extending 50 meters beyond the PROJECT, or less where limited by the shoreline. Magnetometer survey was completed over 24 acres. Side-scan sonar survey covered a larger

area, 40 acres, owing to its extended swath of data along the survey margins. Portions of the planned survey could not be completed due to shoals and to a small number of barges that could not be moved. Survey was completed, with the magnetometer, over all but 13.5 acres of the planned area and, with the sonar, over all but 8.7 acres.

Single-beam bathymetry data were acquired in 2019 under a separate contract by Chris Ransome and Associates, Inc., using a Teledyne Odom Hydrotrak II, single-beam echosounder, operating at 200 kHz. RTK GPS positioning was used for the bathymetric survey.

Interpretation of Magnetometer Data

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 (typically 0.5 nanoTesla [nT]) 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 near 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 1.5-meter interval between data points (about 0.8 seconds per sample). Diurnally-corrected magnetometer data was contoured using Blue Marble's Global Mapper® software (Version 17.2) at a 5-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.

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. Ferromagnetic debris far outnumbers shipwrecks, necessitating some means of distinguishing between the two when conducting archaeological assessments. Archaeologists have interpreted magnetic anomalies using a variety of criteria over the decades since marine geophysical surveys have been used for cultural resource investigations. Various factors, including amplitude, complexity and horizontal dimensions, have been considered important when trying to distinguish shipwreck anomalies from debris (non-shipwreck) anomalies. The interpretation method used by this author considers an additional factor, orientation, as an aid to segregating potential shipwreck anomalies from debris anomalies. Each of these factors is described in more detail below. The role of side-scan sonar in aiding interpretation is also considered.

The interpretative method described below is based primarily upon a study by Gearhart (2011b) comparing magnetic data from a large and diverse collection of anomaly sources, including 29 verified shipwrecks and many debris sources, with the goal of characterizing significant differences between shipwreck and debris anomalies. To date, this collection of magnetic anomalies has been expanded to include 42 verified shipwrecks (Gearhart 2011b, 2016, 2018, and 2019). A subset of 22 shipwreck

anomalies are illustrated in Figure 9, and summarized in Table 2, for comparison with the results of this survey.

Shipwrecks included in this sample 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.

Role of Sonar Imagery

Anomaly sources exposed at the seafloor can be detected by side-scan sonar, which may, on occasion, be useful for determining their identity. For example, a straight, narrow, linear sonar target might be interpreted as a pipe. A pipe interpretation becomes more likely if that target is situated along the central axis of a magnetic dipole. On the other hand, if that same sonar target is not associated with a magnetic anomaly, one might interpret, instead, a tree or anchor scour. More often than not, sonar targets are unreliable indicators of magnetic source identity, but sonar occasionally provides unambiguous verification. Sonar also can aid magnetic interpretations because of what it does not show. For example, a magnetic anomaly without a corresponding sonar target, in warm, saline waters, is not likely associated with a shipwreck having either a metallic hull or a machine-powered propulsion system, except in areas of high sediment accretion.

Shipwrecks with metal hulls are usually exposed on the seafloor, thus tend to be fairly obvious on a sonar image. Gearhart (2011a) reported that 100 percent of shipwrecks (n=74) discovered by BOEM-regulated geophysical surveys in shallow, Gulf of Mexico waters (less than 600 feet deep) appear on side-scan sonar imagery. About one third of that number are confirmed to have metal hulls. The rest are presumed to be metallic, simply because their ship-shaped structures are preserved in the water column. By comparison, only 7 wood-hulled wrecks were known to BOEM from the same area up to that time, but none of those were discovered by geophysical surveys, despite the fact that wood-hulled wrecks in the U.S., pre-dating World War II, are 13 times more abundant than metal-hulled wrecks (Gearhart 2011a).

Wrecks of wood-hulled sailing ships, in Gulf Coast bays and adjacent coastal waters, are often buried, thus they typically have no sonar target. Shipwrecks with wooden hulls and machine-powered propulsion systems might appear on sonar or might not. Lower portions of the wooden hull itself would tend to bury, but steam machinery is large and may remain exposed above the seafloor. Gas- and diesel-powered machinery tends to be smaller thus might be more easily buried than steam machinery.

Table 2: Magnetic Anomalies of 22 Verified Shipwrecks

Shipwreck (Figure 9)	Min. Ampl. (nT)	Max. Ampl. (nT)	Date Lost, Hull Material, Propulsion, Dimensions (feet), Notes
41AS119	-3,867	6,155	unknown, iron?, steam?, 138x33
41CL100	-1,904	4,259	1856?, wood, steam, unknown; divers confirmed presence of boilers; suspect Morgan steamer *Perseverance*; Hoyt (2005)
41GV143	-6,197	9,050	1865, wood, steam, 182x23
Mag 13	-312	1,216	unknown,wood,sail?,est35x13; found by probing,buried 2-10 feet
Mag 24	-28	31	unknown, wood, sail?, est. 65x15; found by probing, buried 14 feet; low amplitude due in part to 35-foot sensor-source distance
41NU291	-1,333	3,358	1845, wood, steam, 125x18
41CH372	-3,258	4,838	c. 1970, steel, diesel, 83x18
41CL92	-113	78	e.19th-c., wood, sail, est. 50-70 long
Mat 1	-158	108	e.19th-c., wood, sail, est. 50-70 long
Sonar 1	-1,817	55,394	unknown, steel?, diesel?, 70x24
Sonar 8	-817	1,006	unknown, steel?, barge, 77x28
Sonar 2	-1,670	13,902	unknown, steel?, diesel?, 86x18
Sonar 7	-1,646	10,223	unknown, steel?, diesel?, 114x32
Sonar 4	-1,974	4,025	unknown, steel?, diesel?, 81x14
Sonar 6	-1,768	8,782	unknown, steel?, diesel?, 47x20
41GV68	-2,425	3,170	1863, iron, steam, 210x34
41NU252	-403	653	1876, iron, steam, 234x33
BOEM 1614	-2,698	2,562	unknown, steel, barge, 89x30
41NU292	-3148	3253	1920, wood, 282x46
BOEM 773	-4,691	10,264	1954, steel, barge, 240x50
41GV177	-7,947	9,031	1875, iron, steam, 242
BOEM 323	-4,328	5,888	unknown, steel, diesel, 220x30

Amplitude

Anomaly amplitude depends greatly upon the mass of the source and its distance from the magnetometer sensor. Small sources can produce large amplitude when measured at close range. Shipwreck anomalies from Gearhart (2011b) have average peak-to-peak amplitudes of 270 nT (range: 191-376 nT) for wood-hulled sailing vessels (n=7); 5,020 nT (range: 663-15,247 nT) for wood-hulled, machine-powered vessels (n=7); and 10,386 nT (range: 688-36,050 nT) for iron/steel-hulled vessels (n=12). Anomalies from verified, wood-hulled sailing vessels in Gearhart (2011b) have lower peak-to-peak amplitude than anomalies associated with either machine-powered or iron/steel-hulled vessels; however, amplitudes from machine-powered and iron/steel-hulled vessels overlap one another. Magnetic debris can produce amplitudes virtually anywhere within the range of shipwreck anomalies, thus amplitude, alone, is of little use for differentiating shipwrecks from debris. Nevertheless, amplitude may aid in anomaly interpretation when considered in combination with other factors. For example, a buried anomaly source with amplitude greatly exceeding the range of verified, wood-hulled shipwrecks might be more likely caused by debris, since high-amplitude shipwreck anomalies, those with iron/steel hulls or machinery, are more likely exposed on the seafloor.

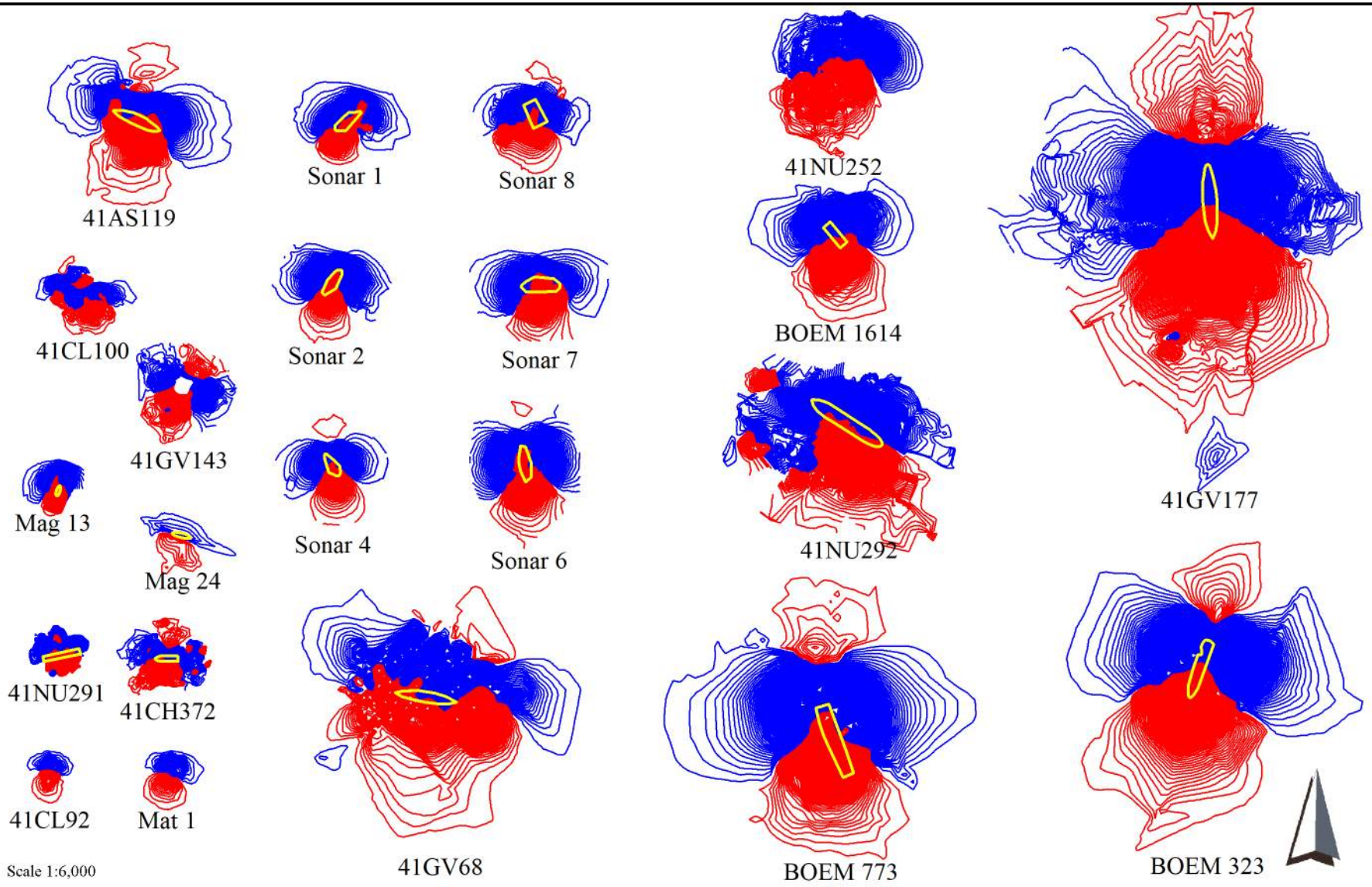


Figure 9

Magnetic Anomalies of 22 Verified Shipwrecks

Complexity

Archaeologists frequently have described shipwreck anomalies as appearing "multicomponent" or "complex", while anomalies having simple, monopolar or dipolar shapes often were attributed to debris. 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.

Some early observations of complexity in wreck anomalies pre-dated computer contouring software. One or more peaks were observed on each transect crossing a single anomaly, but the spatial relationships between those peaks were not apparent. This problem was compounded by the lower accuracy of positioning systems prior to GPS. Thus, even a simple dipole might appear more complex than it really was. Earlier 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 could be interpreted as complex patterns of amplitude peaks where none existed.

The collection of anomalies from verified shipwrecks reported by Gearhart (2011b and 2016) indicate, contrary to earlier models, that shipwreck anomalies (in mid-northern latitudes) tend to be dominated by a single main dipole, oriented approximately in line with magnetic north (Figure 9, for example; also see "Orientation" below). In fact, most debris anomalies also tend toward simple, dipolar shapes, though often not aligned with magnetic north. The concept of complexity is insufficient, by itself, to differentiate shipwrecks from debris anomalies; although, this fact does not lessen the need to correct any remaining misconceptions that shipwreck anomalies are typically complex and debris anomalies are not. The truth is more complicated than that simple dichotomy.

Many wreck anomalies also have secondary amplitude peaks, in addition to their main, north-south-aligned dipole. Secondary peaks can be caused in two ways. The combined mass of the wreck either induces secondary peaks, or they are directly associated with individual ferromagnetic sources in a debris field. Secondary peaks have substantially lower amplitudes and cover smaller areas than the main dipole peaks in all examples known to this author. The main dipole of each wreck in this sample, has a negative peak of area comparable to the size of its positive peak. Monopoles, or primary dipoles with substantially smaller (in area) negative peaks than positive peaks, do not occur in this sample of wreck anomalies.

Secondary peaks can be induced by the magnetic field lines emanating from wreckage. In mid-northern latitudes, a smaller peak sometimes occurs immediately north or south of, and in line with, the main dipole (e.g., peaks labelled "A" in Figures 10, 11, and 12). Amplitude peaks of this nature are not necessarily located over an anomaly source and may not indicate the presence of widely-scattered wreckage. Rather they seem to be induced by a source of relatively high mass, such as a ferrous hull. In such cases, magnetic lines-of-force can loop so far to the north and/or south of a source that, respectively, they reinforce or diminish (i.e., are anomalous to) earth's field. The result is a small positive peak to the north and, occasionally, a smaller negative peak to the south of the main dipole. They will always have polarity

opposite the adjoining peak of the main dipole. Such peaks are fairly symmetrical about an anomaly's north-south axis and will not overlap its main dipole. The inflection point between an induced secondary peak and the main dipole occurs where the anomaly's lines of magnetic force are perpendicular to earth's lines of force (Figure 11).

Other secondary peaks may be directly caused by relatively large, individual magnetic sources within or near a hull or debris field. If such a mass is sufficiently large, its anomaly might not be completely cancelled by neighboring sources, allowing it to stand out. A similar effect may be observed if a magnetometer passes sufficiently close to a complex source, such as a shipwreck, so that some large-mass sources, are individually expressed against the background of the main dipole field. Such debris-centric, secondary peaks should have random orientations and positions, with respect to the main dipole, since they are directly caused by randomly-positioned objects within a debris field. They may overlie and disrupt the symmetry of the primary north-south dipole (e.g., peaks labelled "B" in Figures 10 and 12).

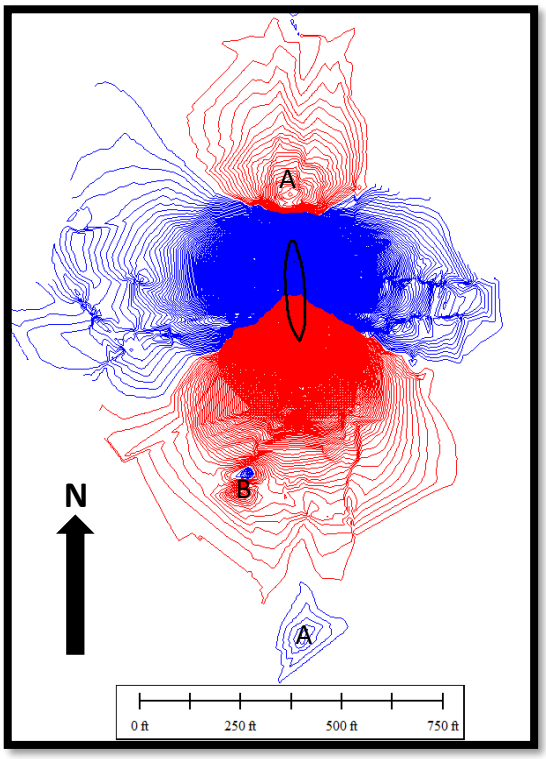


Figure 10: City of Waco Anomaly (iron hull)

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 feet 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 anomaly 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 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 (Figures 9 and 13), for example, covers an area of only 1,580 square meters (0.4 acres) out to the 5-nT contour. Small, wooden, and generally historic, shipwrecks are the most difficult sites to detect precisely because their anomalies overlap in size with many debris anomalies.

The smallest wreck, although not the smallest anomaly, in Gearhart's anomaly dataset, Mag-13 (Figures 9 and 14), is a wooden hull buried 2-10 feet below the seafloor. The hull measures roughly 35 x 13 feet, based on diver probes (Gearhart 2016). The Mag-13 anomaly measures 197 x 164 feet (60 x 50 meters) across. Site 41CL92 (Figure 13), although having larger site dimensions, has the smallest verified wreck anomaly known to this author, measuring 176 x 155 feet (53.6 x 47.2 meters) to the 5-nT contour. Divers identified Site 41CL92 as an early 19th-century sailing vessel containing a large collection of concreted artifacts, iron bar stock, and pig iron ballast but with no hull remaining (Borgens 2004). Its debris field measures 52 x 23 feet (15.9 x 7 meters) across.

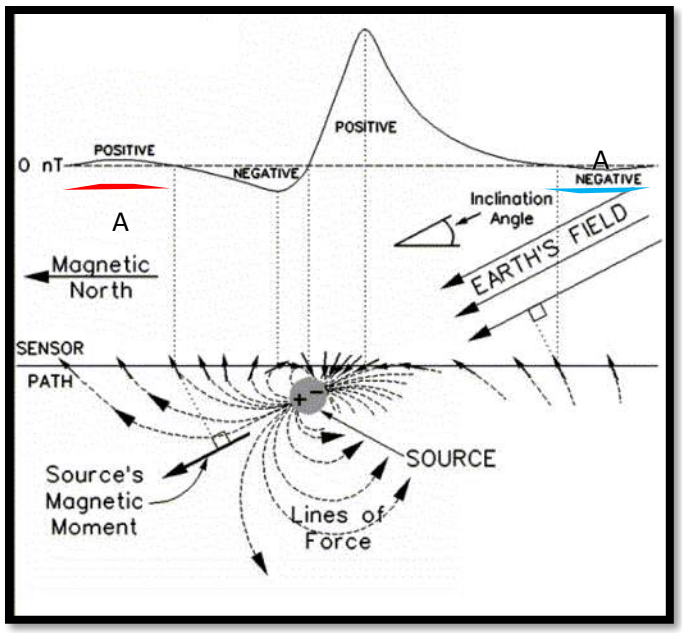


Figure 11: Induced Magnetic Anomaly

The 41CL92 anomaly is smaller than the Mag-13 anomaly, even though the 41CL92 site dimensions are larger. Its smaller magnetic footprint might be due to its disarticulated nature, whereas the Mag-13 site appears to have an intact hull. The higher entropy of a disarticulated wreck, in theory, should result in a lower peak amplitude and a smaller magnetic footprint, all other things being equal, than if the same wreck were an intact hull. Unfortunately, the original hull dimensions of 41CL92 are unknown. Although it represents the smallest anomaly known to date for a disarticulated wooden wreck, smaller examples likely exist. A realistic lower limit for the dimensions of a significant anomaly remains open for debate; however, a working estimate is suggested below.

The smallest likely size of historic commercial watercraft in the Gulf Coast trade can be determined 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 feet (21.6 x 6.4 meters) (based on Work Projects 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 feet (8.8 x 3.0 meters) (Work Projects Administration 1941: 127), roughly 81 percent the size of the Mag-13 hull.

It seems reasonable that an intact wooden vessel of *Tickler's* dimensions (81 percent of the Mag-13 hull size) might have an anomaly measuring about 81 percent as wide as the Mag-13 anomaly. Based on that assumption, the *Tickler* anomaly hypothetically could measure 160 x 133 feet (48.8 x 40.5 meters) across, or an average diameter of 147 feet wide. The 41CL92 anomaly, the smallest verified wreck anomaly known to this author, measures 92 percent smaller than the Mag-13 wreck anomaly, possibly because the site is disarticulated. To be conservative, the hypothetical anomaly size for a disarticulated wreck of *Tickler's* dimensions, likewise, has been adjusted downward by 92 percent, yielding an estimate of 147 x 122 feet

(44.8 x 37.2 meters), or an average diameter of 135 feet (41.1 meters). This author, therefore, will consider dipoles potentially significant if they align with magnetic north and have a minimum horizontal dimension of at least 135 feet (41.1 meters), 81 percent smaller than the 41CL92 anomaly (Figures 9 and 13).

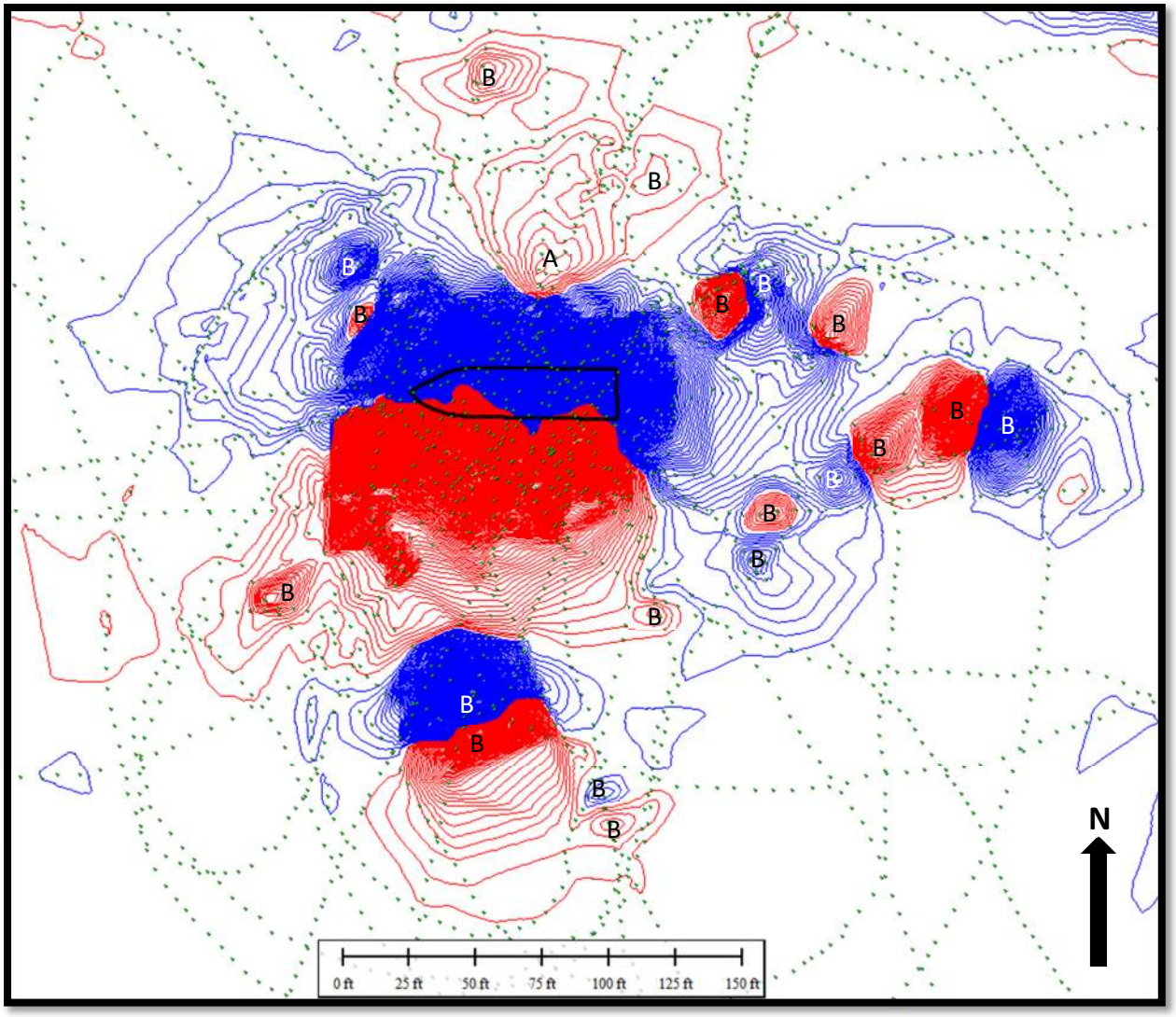


Figure 12: 41CH372 Anomaly (steel hull), 5-nT contour interval

Orientation

Shipwreck anomalies (e.g., Figure 9) consistently share a common orientation, in the horizontal plane, with respect to earth's magnetic field, despite the great diversity of wrecks described above. All 42 wreck anomalies observed by this author, to date, are oriented with their primary negative pole situated north of their positive pole. The horizontal orientation (magnetic declination) of 29 dipoles over verified shipwrecks, reported in Gearhart (2011b), agrees on average within +/- 10 degrees (east or west) of the local direction of magnetic north. Declination is 0 degrees when a dipole's negative pole is due north (magnetic) of its positive pole (in mid-northern latitudes). The maximum reported difference between a wreck anomaly's declination and the direction of magnetic north is 26 degrees for Site 41GV143, the *Denbigh* blockade runner (Figure 9). Similar northerly orientation is expected of all wrecks, and all other

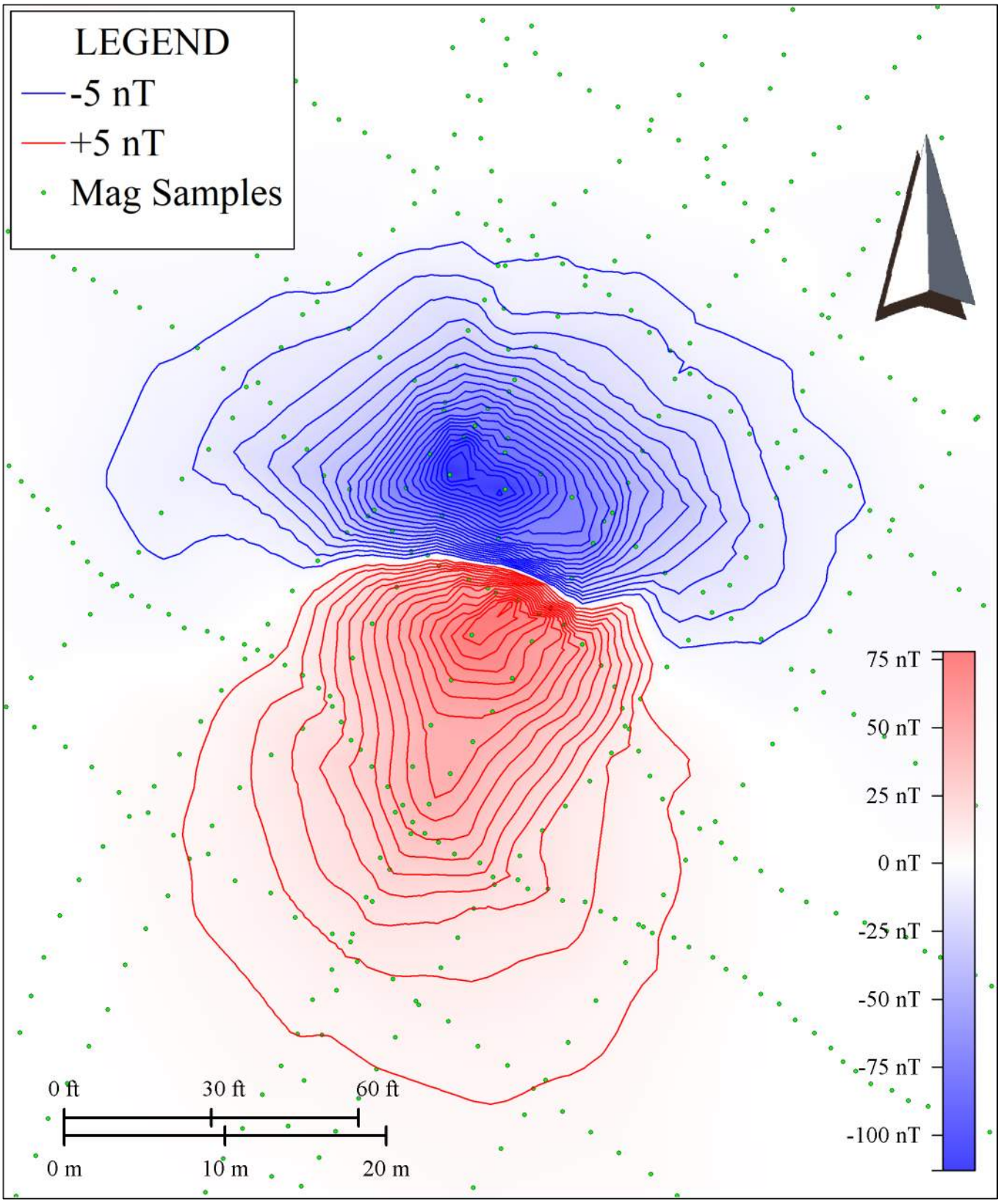


Figure 13

Smallest Example of a Verified Shipwreck Anomaly, Site 41CL92

complex anomaly sources, in mid-latitudes of the northern hemisphere. The magnetic declinations of anomalies over simple debris sources, in contrast to complex sources, are determined primarily by source orientation rather than by earth's magnetic field direction.

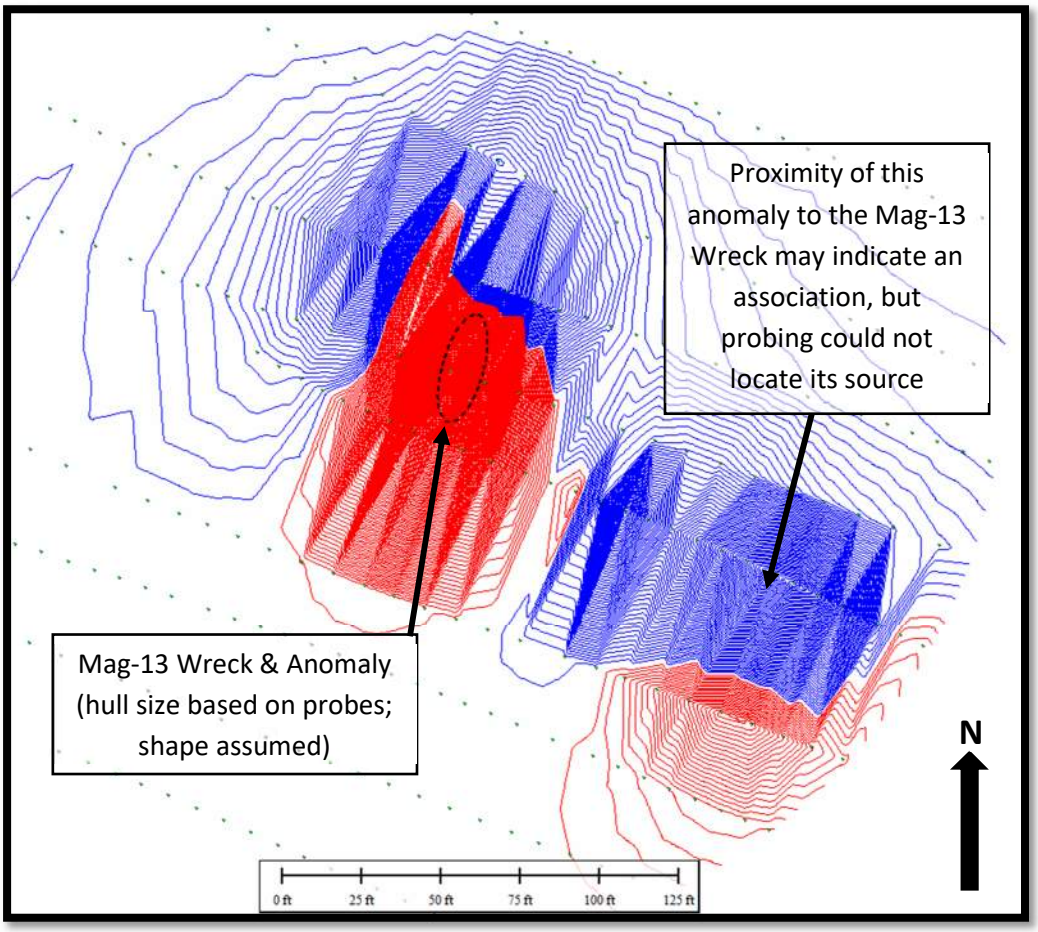


Figure 14: "Mag-13" Wreck Anomaly (wooden hull)
5-nT contour interval (Gearhart 2016: 46)

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 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 13. 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 similar to that of 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.

Significance Criteria

BOB's minimum criteria for archaeological assessment of magnetic anomalies (applicable in mid-latitudes of the northern hemisphere) requires that a significant anomaly, surveyed at 20-meter intervals, be consistent with the following conditions: a) it must have at least one dipole, oriented with its negative pole north of its positive pole; b) it should be at least 135 feet (41.1 meters) across (to the +/- 5-nT contour); and c) it should appear on a minimum of 2 transects. If survey lines are spaced at 10-meter intervals, a significant anomaly should meet all of the above conditions and d) should appear on at least 4 transects. An anomaly's shape usually is not obvious if data is from a single survey transect; thus, additional criteria have been designed to avoid missing significant targets. If survey lines are spaced at 30-meter intervals, a significant anomaly e) may be limited to a single transect; and f) may appear as a monopole, provided the transect follows a predominantly east-west heading. Exceptions may be made in either direction, at the Principal Investigator's discretion, based on mitigating circumstances or professional judgment. Resemblance to verified shipwreck anomalies, such as those reported by Gearhart (2011b, 2016) or illustrated in Figure 9, should be an important factor in such judgments when close-order survey has been conducted.

V. Results

Geophysical data are illustrated in figures 15 and 16. No significant geophysical targets were discovered by this survey. Survey coverage, including some inadvertent coverage outside of the THC buffer, totaled 24 acres for the magnetometer survey and 40 acres for the side-scan sonar survey. Portions of the 34.8-acre, planned survey area could not be completed due to shoals and to a small number of barges that could not be moved. Survey was completed, with the magnetometer, over all but 13.5 acres of the planned area and, with the sonar, over all but 8.7 acres. Parked barges prevented survey coverage of 1.1 acres by magnetometer and 0.5 acres by sonar. Shoals prevented survey coverage of 12.3 acres by magnetometer and 8.7 acres by sonar.

Magnetometer data was affected by the presence of numerous parked barges (Figure 17, red rectangle), thus the archaeological assessment primarily relied on side-scan sonar data. Prior to the survey, barges were moored, side-by-side, in approximately 30 rows, oriented perpendicular to the channel. The approximate extent of barges is shown in Figure 15. Four or five barges had spuds that were firmly planted into the riverbed. All other barges were moored to the spud barges.

The THC agreed, prior to the survey, that barges would be shuffled, a few at a time, during the survey to maximize data coverage. Two push boats worked throughout the survey, moving barges. As each set of 4 barge rows was temporarily moved, survey was completed in the gap where they had been parked. Then those barges were replaced, and the next 4 rows were moved and surveyed. The survey proceeded in this fashion, roughly from west to east. Spud barges could not be easily moved, and the THC agreed that they could be left in place during the survey. Nevertheless, magnetometer survey was required by the THC, since the number of barges, present when the survey began, could not be known in advance.

Information regarding petroleum infrastructure was checked on the Texas Railroad Commission's (TRC) Public GIS Viewer. No wells are reported in the survey area; however, as many as 10 pipelines may cross through the survey. Five pipelines appear to follow cleared rights-of-way on shore and to cross the western end of the PROJECT, along roughly north-south orientations (Figure 15). Five other pipelines are charted crossing the eastern end of the survey, east of the PROJECT boundary, along northeast-southwest headings. Pipeline locations cannot be confirmed from the magnetometer data, owing to the effect of nearby barges. Approximate locations, shown in Figure 15, are based on TRC maps.

Magnetic contours are illustrated in Figure 15. Geophysical survey transects are overlaid on pre-planned survey lines to show areas where shoals and barges prevented acquisition of magnetometer data. Tides were falling over the course of the survey day, so areas that were marginally accessible in the morning became too shallow to navigate later in the day. Only one crossing (east-west) transect could be completed north of the barges due to shoals. Most transects were necessarily oriented parallel to parked barges. Magnetometer transects that were surveyed along northerly headings were shortened on their northern ends, where the survey boat encountered shoals, because the sensor was towed 50 feet behind the boat. Unfortunately, BOB's minimum criteria for archaeological significance, described in Section IV above, cannot be applied to this data set, since barge anomalies and, to some extent, pipeline anomalies would obscure any underlying cultural features that might exist. None of the magnetic anomalies discovered by this survey are considered significant.

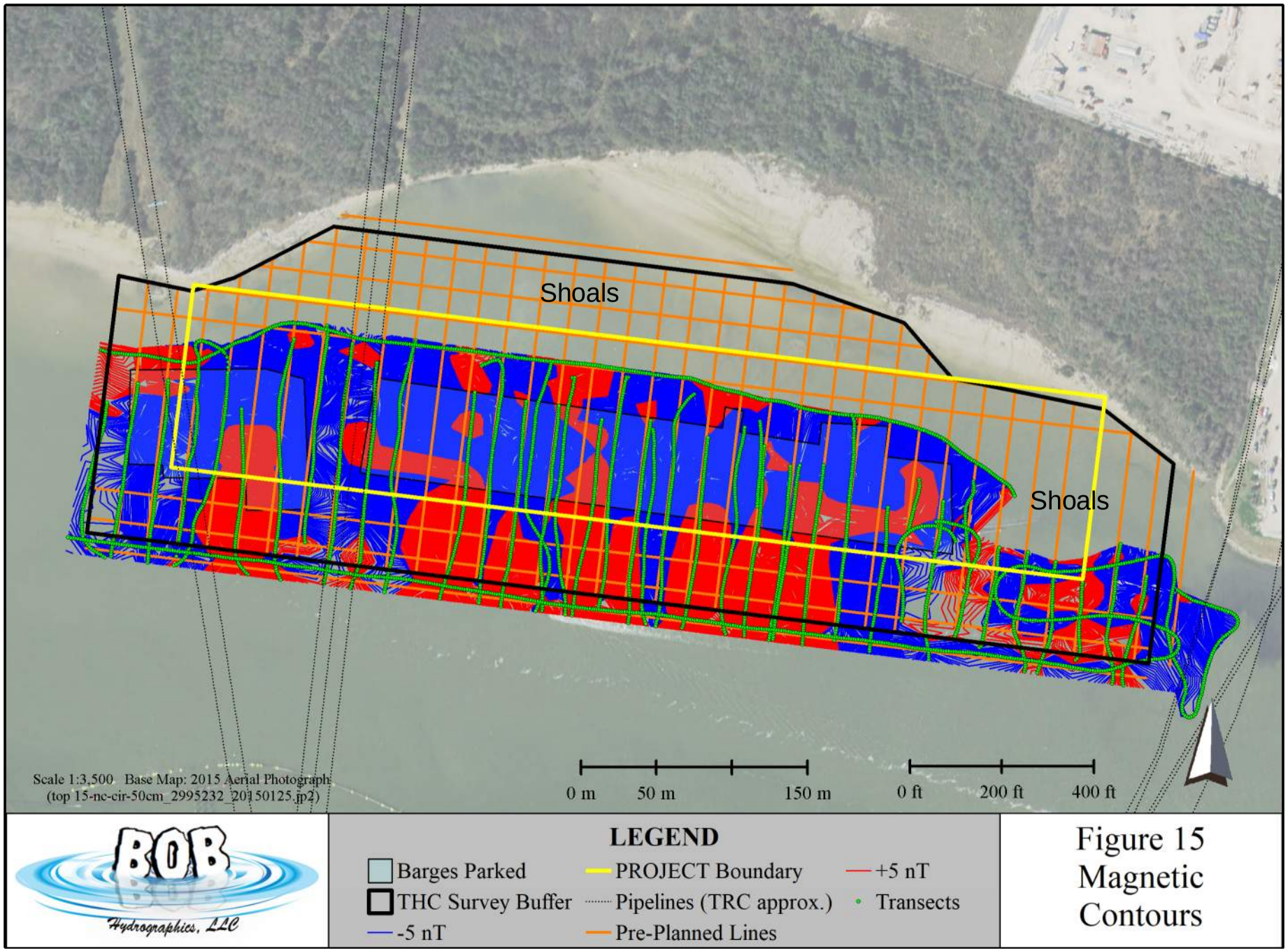
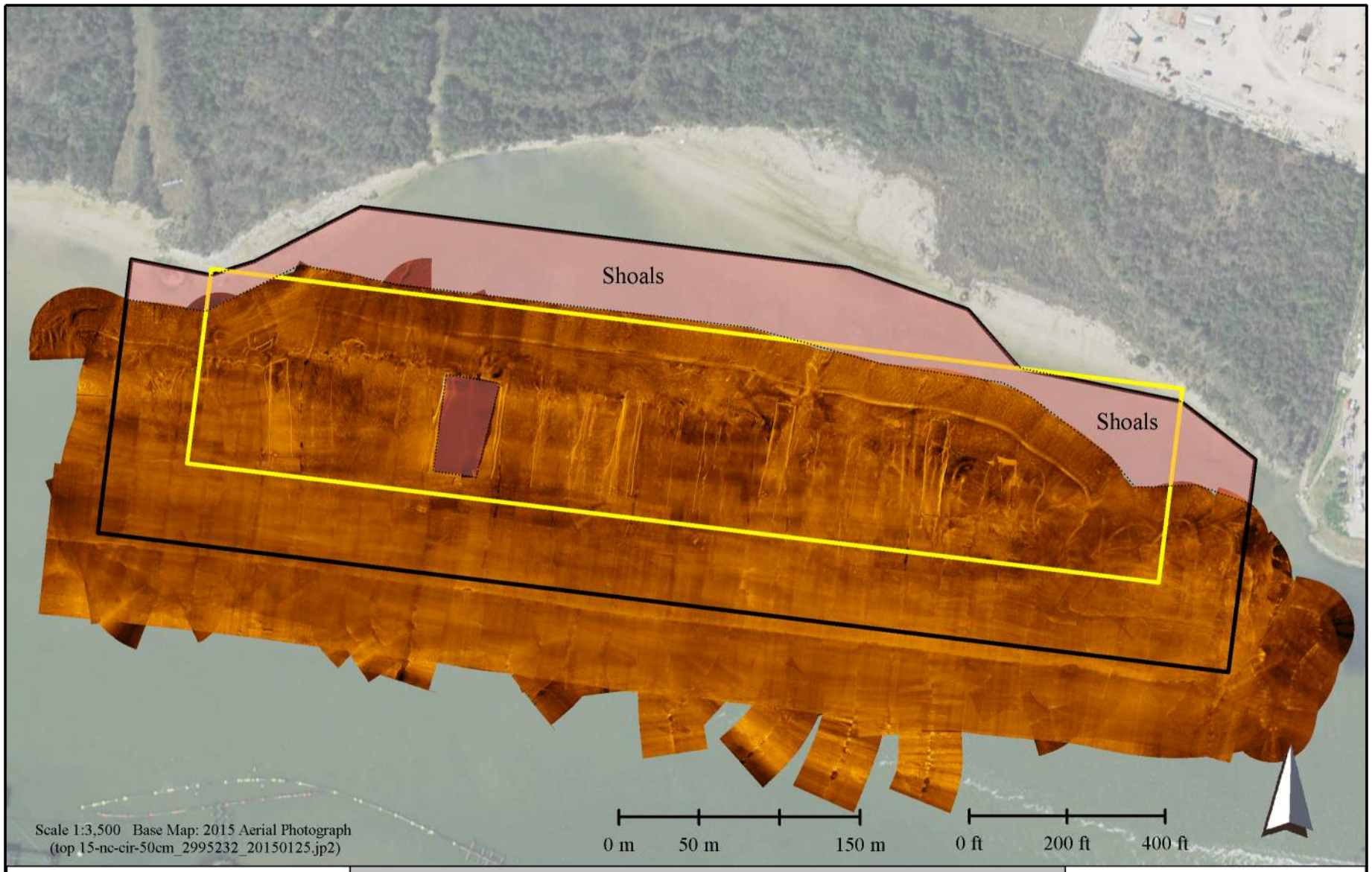


Figure 15
Magnetic
Contours



BOB Hydrographics, LLC

LEGEND

No Sonar | THC Survey Buffer | PROJECT Boundary

Figure 16
Side-Scan
Sonar Mosaic

Side-scan sonar data is illustrated as a mosaic image in Figure 16. No potential archaeological sites were discovered by the sonar survey, and no sonar targets correlate with specific magnetic anomalies. The edges of many barges appear as linear features in the sonar mosaic; however, the areas underlying those barges were covered by multiple, overlapping sonar swaths. The only area of the PROJECT that could not be imaged by sonar, due to the presence of barges, was 0.5 acres beneath a pair of adjacent spud barges that could not be moved.

Recommendations

No geophysical targets are recommended for avoidance and none are believed to meet criteria for State Antiquities Landmark or NRHP eligibility. BOB recommends cultural resource clearance for all portions of the archaeological survey. If shipwreck remains, or other potentially historic materials, are discovered anywhere in the survey area during construction, work should be halted within 50 meters (164 feet) of the find until the THC can provide guidance concerning the discovery.

Figure 17: Barges Parked in PROJECT Area (rectangle)

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Appendix A: Texas Antiquities Permit 9507 and THC Concurrence Letter

23-Jul-20

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

Re: Project review under the Antiquities Code of Texas
Final Report: Pertinacity Barge Fleeting Area SWG-2020-00309
Texas Antiquities Permit # 9507

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 the reviewer, Amy Borgens at (512) 463-9505.

Sincerely,

Laney Fisher:
Antiquities Permit Coordinator
(512) 463-5394

Enclosures

Cc :Port of Houston Authority
Pertinacity Harbor and Marine Services, LLC

State of Texas

TEXAS ANTIQUITIES COMMITTEE

ARCHEOLOGY PERMIT 9507

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: ***Pertinacity Barge Fleeting Area SWG-2020-00309***
County: ***Harris***
Location: ***Left (north) bank of Buffalo Bayou, 0.1-0.6 miles downstream from Beltway 8 Bridge***

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

Port of Houston Authority
111 East Loop North
Houston, Texas 77029

Sponsored by (hereafter known as the Sponsor

Pertinacity Harbor and Marine Services, LLC
14237 E. Sam Houston Pkwy N, Suite 200-232
Houston, Texas 77044

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:

06/30/2021

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:

BOB Hydrographics, LLC, Cedar Park, Texas

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

Center for Archaeological Studies

Scope of Work under this permit shall consist of:

Underwater Survey, see scope of work

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 06/30/2020.

Brad Jones,
Archeology Division Director

Mark Wolfe,
Executive Director

Gmail Robert Gearhart <bob.hydrographics@gmail.com>

Section 106 Submission

1 message

noreply@thc.state.tx.us <noreply@thc.state.tx.us> Fri, Oct 2, 2020 at 4:35 PM
To: bob.hydrographics@gmail.com, reviews@thc.state.tx.us

TEXAS HISTORICAL COMMISSION
real places telling real stories

Re: Project Review under Section 106 of the National Historic Preservation Act and/or the Antiquities Code of Texas
THC Tracking #202100641
Pertinacity Barge Fleeting Area
NA
Houston,TX

Dear Robert L Gearhart:
Thank you for your submittal regarding the above-referenced project. This response represents the comments of the State Historic Preservation Officer, the Executive Director of the Texas Historical Commission (THC), pursuant to review under Section 106 of the National Historic Preservation Act and the Antiquities Code of Texas.

The review staff, led by Amy Borgens, has completed its review and has made the following determinations based on the information submitted for review:

Archeology Comments

- No identified underwater archeological sites, historic shipwrecks, and/or significant remote-sensing targets present or affected. However, if buried cultural materials are encountered during project activities, work should cease in the immediate area; work can continue where no cultural materials are present. Please contact the THC's Archeology Division at 512-463-6096 to consult on further actions that may be necessary to protect the cultural remains.
- THC/SHPO concurs with information provided for the underwater project area.
- THC/SHPO has comments on the draft report submitted to this office for review.
- This draft report is acceptable. Please submit a final report: one restricted version with any site location information (if applicable), and one public version with all site location information redacted. To facilitate review and make project information and final reports available through the Texas Archeological Sites Atlas, we appreciate submitting abstracts online at http://xapps.thc.state.tx.us/Abstract and e-mailing survey area shapefiles to archeological_projects@thc.texas.gov if this has not already occurred. Please note that these steps are required for projects conducted under a Texas Antiquities Permit.

We have the following comments: On page 12 of the report, it is suggested that there are two errors in the THC Marine Archeology Shipwrecks Database that is presented in Atlas. Both observations are correct. There was a duplicate mis-plot of THC No. 1363. This has been deleted. Atlas does not show the source of the THC shipwrecks. THC No. 1981, Boots, was added to the Database from the 1992 Espey, Huston, and Associates report for Antiquities Permit No. 1128. The reference card describes the barge as lost at Morgan's Point, 200 ft. west of the ship channel. The EH&A source is listed as National Archives RG 26, No. 40, 1913/14, Document No. 686. This is the same wreck as that in the PBS&J Database and it has been replotted.

We look forward to further consultation with your office and hope to maintain a partnership that will foster effective historic preservation. Thank you for your cooperation in this review process, and for your efforts to preserve the irreplaceable heritage of Texas. If the project changes, or if new historic properties are found, please contact the review staff. If you have any questions concerning our review or if we can be of further assistance, please email the following reviewers: amy.borgens@thc.texas.gov.

This response has been sent through the electronic THC review and compliance system (eTRAC). Submitting your project via eTRAC eliminates mailing delays and allows you to check the status of the review, receive an electronic response, and generate reports on your submissions. For more information, visit http://thc.texas.gov/etrac-system.

Sincerely,

for Mark Wolfe, State Historic Preservation Officer
Executive Director, Texas Historical Commission

Please do not respond to this email.