



# Operations Plan and Environmental Assessment

Proposed 3-D Seismic Program on  
Brazoria National Wildlife Refuge  
Brazoria County, Texas



## Document Information

Prepared for Samson Exploration, LLC  
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3-D Seismic Program on Brazoria National Wildlife Refuge  
Brazoria County, Texas  
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## Acronyms

ATV	All-terrain vehicle
CFR	Code of Federal Regulations
COE	United States Army Corps of Engineers
Complex	Texas Mid-coast National Wildlife Refuge Complex
EA	Environmental Assessment
FWS	United States Fish and Wildlife Service

GPS	Global positioning system
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
PPV	Peak particle velocity
Refuge	Brazoria National Wildlife Refuge
Samson	Samson Exploration, LLC
SHPO	State Historic Preservation Office
SUP	Special use permit
TARL	Texas Archeological Research Laboratory
TCCC	Texas Coastal Coordination Council
TCEQ	Texas Commission on Environmental Quality
TCMP	Texas Coastal Management Program
TGLO	Texas General Land Office
THC	Texas Historical Commission
TPWD	Texas Parks and Wildlife Department
TXNDD	Texas Natural Diversity Database
UTV	Utility vehicle

## **1.0 PURPOSE AND NEED FOR ACTION**

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The Federal action being contemplated within this Environmental Assessment (EA) is the issuance of a Special Use Permit (SUP) by the U.S. Fish and Wildlife Service (FWS), Department of Interior, issued to Samson Exploration, LLC, a subsidiary of Samson Energy Company, LLC, to access surface lands of Brazoria National Wildlife Refuge to conduct a 3-D seismic survey.

### **1.1 Proposed 3-D Seismic Survey**

Samson Exploration, LLC (Samson) is proposing to conduct a 3-D seismic survey within Brazoria National Wildlife Refuge (Refuge) in 2014 or 2015. The Project Area encompasses all of the Refuge (Figures 1.1-1 and 1.1-2). The seismic program will be conducted under the supervision of Samson through a third-party seismic contractor.

The proposed Project will be a state-of-the-art 3-D seismic survey which will provide a high-resolution image of the subsurface geological features. Data gathered from this survey will allow Samson to effectively evaluate the geological features that may potentially contain hydrocarbon reserves underlying the Refuge, while keeping the disruption of the Refuge at an absolute minimum. The 3-D survey will eliminate the need for numerous smaller 2-D projects, minimize the drilling of dry holes, and avoid unnecessary development/exploration wells. Long-term plans can be designed for prudent development. This will result in fewer and less severe long-term cumulative and direct impacts on Brazoria National Wildlife Refuge (NWR).

Briefly, the seismic survey will be acquired by drilling a series of shotholes at 110 feet in, unless proximity to sensitive resources requires adjustment. The shotholes will then be loaded with biodegradable explosives and fired one at a time; the charge size will be 11 pounds, unless proximity to sensitive resources requires adjustment. The resultant reflected energy signal will be received with geophones/hydrophones or receivers placed in a grid at approximately 220-foot intervals along parallel lines separated by 1,760 feet. This depth and charge sizes were determined by testing of varying shot hole depths and charge sizes within the Greens Lake Project boundary east of the Refuge. This proprietary testing confirmed that the shot hole depth of 110 feet and charge size of 11 pounds are necessary to allow the imaging of the deeper depths of formations that Samson is targeting with the 3-D seismic survey. Samson used the same depth and charge size during a previous 3-D seismic survey conducted in 2012, which included the Anahuac Refuge system. The Project will be conducted from east to west through the Refuge and is proposed for the time period of March 15 to October 15, 2014 or 2015. The period from March 15 through April 15 will be used for mobilization and set-up of equipment; drilling will not begin until April 15. The Texas Parks and Wildlife Department (TPWD) has



requested Samson move from east to west through the Project Area to avoid impacts on finfish in bays during the months of April and May.

In addition, the proposed schedule will ensure that:

- The program is finished before the majority of migratory waterfowl return from northern latitudes and begin using the area for foraging and resting; and
- The amount of time spent on the Refuge is minimized and traffic is reduced on receiver and shot lines.

Logistical support, living quarters, and food services for the 125 to 250 persons working on the overall seismic project will primarily be supplied from the vicinity of Angleton, Lake Jackson, and Freeport. A subset of those personnel will be assigned to working on the Refuge.

A complete description of the proposed seismic survey, including equipment, methods of operation, and schedule, is included in Section 2.0.

## **1.2 Purpose of the Operations Plan/Environmental Assessment and Legal Framework**

Before entering any tract within the Refuge, Samson will obtain the right to enter that tract from one of its subsurface owners. Recognizing the public issues that affect such a program, Samson has agreed to submit a plan of operations and perform work for the entire Project within Brazoria NWR under a SUP. Stipulations of the SUP are being developed through this ongoing planning process and according to FWS policies. Development of the Operations Plan and EA should provide the best opportunity for public notice, public comment, and conflict resolution. In this way, the rights and interests of the general public who use the Refuge or share concerns and interest in the Refuge and its resources will be addressed and impacts on these resources minimized.

## **1.3 Proposed Project Area**

The Project Area for the proposed 3-D seismic survey is presented in Figures 1.1-1 and 1.1-2. The Project Area covers 719 square miles (460,160 acres) of which approximately 67 square miles (42,693 acres) are within Brazoria NWR. Signs regarding survey operations will be posted at all access roads and boat ramps into the Refuge.

## **2.0 DESCRIPTION OF THE PROPOSED ACTION**

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### **2.1 Lease Agreement Authorization**

Samson will comply with applicable sections of federal regulations in the Code of Federal Regulations 50 Code of Federal Regulations (CFR) dealing with minerals management on federal wildlife refuges. Specifically, this seismic survey has been developed to satisfy the following provisions:

**50 CFR 29.32** “Mineral rights reserved and excepted” governing mineral operations on Refuges states “Persons holding mineral rights in wildlife Refuge lands... (1) shall, to the extent practical, conduct all exploration, development, and production operations in such a manner as to prevent damage, erosion, pollution, or contamination to the lands, waters, facilities, and vegetation of the area. (2) So far as is practicable, such operations must also be conducted without interference with the operation of the Refuge or disturbance to the wildlife thereon. (3) Physical occupancy of the area must be kept to the minimum space compatible with the conduct of efficient mineral operations... (4) Upon the cessation of operations, the area shall be restored as nearly as possible to its condition prior to the commencement of operations...”

### **2.2 Location of Proposed Operations**

The proposed seismic operation will occur within and surrounding Brazoria NWR. The Project Area includes the entire Refuge (see Figures 1.1-1 and 1.1-2) in Brazoria County, Texas.

### **2.3 Equipment**

Seismographic equipment developed for transition zone environments will be used in the proposed survey. This equipment includes: lightweight equipment for drilling shotholes; recording equipment; global positioning system (GPS) based navigation systems; and a helicopter for transport of equipment and personnel. The energy source for the seismic survey will be biodegradable explosives, the size of which will be 11 pounds as determined during peak particle velocity (PPV) testing outside the Refuge, unless proximity to sensitive resources requires adjustment.

Vegetative cover, hydrologic conditions, and wetland habitat types within the Project Area will dictate the use of equipment used to complete the seismic survey. Prior to entering an area, the conditions will be evaluated by Samson in conjunction with the environmental monitors and the Refuge Manager to determine which equipment to use and how to best access the sites. In general:

- For submerged lands and shallow water conditions, airboats will be required for transportation of personnel and drilling equipment.
- For emergent wetland operations, to minimize rutting, lightweight aluminum tracked vehicles or airboats will be used.
- For upland operations, terra-tired vehicles may be used where necessary for drilling, deploying, and retrieving receivers. Surveyors and the line troubleshooter will use all-terrain or utility vehicles (ATVs or UTVs) or walk whenever possible.

For submerged land and shallow water, most personnel transportation and light equipment transportation, including recording equipment, will be done in airboats. Whenever possible, servicing of receiver lines will be carried out on foot. Existing natural and man-made travel lanes (roads, trails, ditches, bayous) will be used when possible to minimize passes along lines. A helicopter equipped with a long-line will be used to transport recording equipment as often as possible with the approval of the Refuge Manager. Samson's seismic contractor will use shothole-drilling rigs mounted on airboats, lightweight tracked vehicles, and terra-tired vehicles for the entire survey.

Additional crew vehicles will consist of utility trucks or vans for operations, logistics, and transportation to and from the crew accommodation site(s). Only the airboats and tracked vehicles will enter wetland areas. All other support vehicles will be restricted to designated roads. If access is required by a support vehicle to an area away from a designated roadway, it will only be approved by the environmental monitors and the Refuge Manager on a case-by-case basis.

Following is a generic list of equipment that can be expected to be used by the designated seismic contractor for the proposed Project:

- Highland rigs, such as terra-tired vehicles
  - Two to three for drilling crew
- Airboats, pontoons, or lightweight aluminum tracked vehicle (marsh buggy) drills in wetland areas and bays
  - One for survey crew, one for drilling crew, one for recording crew
- Marsh master with a water tank
  - One, as needed during the Project
- Trucks, ATVs, and UTVs

- Two for survey crew, two for recording crew
- Marsh masters
  - One for survey crew, one for drilling crew, one for recording crew
- Helicopters for recording crew
  - One for overall Project support

The number of each type of equipment used by each crew may change depending on site-specific conditions, weather conditions, or other unforeseen circumstances. Changes in the type of equipment used will be approved by the Refuge Manager and environmental monitors prior to use in a specific area. Table 2.3-1 summarizes the specifications of drilling equipment and Appendix 1 includes photographs of drilling equipment.

**Table 2.3-1 Specifications of Drilling Equipment Proposed for Use in Areas Managed by FWS**

Equipment Type	Weight (pounds)	Height (feet)	Width (feet)	Length (feet)	Depth (feet)	Drill Type	Suitable Habitats
Lightweight aluminum tracked vehicle (marsh buggy) drill	20,000	11	14	24	10 – 150	Flush	Sensitive habitats including wetlands
Aluminum pontoon drill	12,000	8	11.5	30	10 – 120	Flush	Open Water (e.g., open lakes, shallow bays)
Airboat drill	8,000	11	14	22	10 – 180	Flush	Shallow water areas, including some wetlands
Highland ARDCO drill with TERRA tires	18,000	10.8	8	24.9	10 – 120	Auger	Open or sparsely wooded dry areas

## 2.4 Schedule

The complete proposed seismic survey program will require approximately 180 to 240 days of field work, from commencement of land survey to completion of the recording phase. The Project activities conducted on the Refuge are proposed to be carried out within the work window of March 15 to October 15. In the event of unforeseen circumstances, such as inclement weather, or equipment malfunctions/repairs, the Project may continue as late as November 15, with approval from the Refuge Manager. Surveying for cultural resources, roads, buildings, pipelines, and wells, flagging, and land surveying can begin prior to other field work on March



15 in certain areas as approved by the Refuge Manager. Shothole drilling can begin April 15. Seismic recording is anticipated to begin 5 to 7 weeks after drilling has begun. The survey is proposed to start at the eastern limit of the seismic grid within the Refuge and move to the west; this survey schedule has been requested by TPWD to minimize impacts on the bay systems.

## **2.5 Typical Method of Operations**

Samson's designated seismic company will be acquiring the 3-D seismic data for the proposed Project. The seismic contractor will use equipment that is well-suited for seismic surveying in coastal marshes and wetlands. The staff at Samson understand they have a duty to minimize their effect on the resources of the Refuge to the extent practical and to keep their occupancy to a minimum that is compatible with a safe and efficient operation. Samson is committed to using airboats, tracked vehicles, terra-tired vehicles, and helicopters in the sensitive environments located within the Project boundaries inside the Refuge.

The seismic survey will require a continuous effort throughout the schedule period by a sequence of three crews: the survey crew; the drilling crew; and the recording/clean-up crew. Throughout the Project, environmental monitors will be present to observe the activities of each crew. A kick-off orientation will be held with all key personnel at the start of the Project to facilitate a meeting between key personnel and the Refuge Manager. Samson will hire a contractor to provide all environmental monitors; resumes will be provided to FWS for approval by the Refuge Manager. The environmental monitors will report to a third-party contractor that will act as a liaison between FWS and the monitors. The third-party liaison will provide updates to both FWS and Samson and will be responsible for managing all of the environmental monitors. The number of environmental monitors on-site at any given time will vary, depending on the ability of the monitors to access each crew. If, for example, the time it takes to travel between two crews is too great, an additional monitor may be required. One environmental monitor will be present on each drill. The decision on how many additional environmental monitors are required will be made by the third-party liaison and approved by the Refuge Manager. As equipment is removed from an area, a complete evaluation of the conditions of the area will be made by the designated seismic operations contractor and environmental monitor.

### **2.5.1 Survey Work**

The initial phase of the Project will be the land survey. The survey crews will mark shot and receiver lines with survey lathes, cane poles, and flagging. Locating source and receiver points will be accomplished using GPS, inertial, and/or conventional survey methods. In areas of heavy canopy cover, a combined GPS/Electronic Distance Measuring system will be used so that no trees are affected. Cane poles, lathes and flagging will be removed as soon as shotholes have

been recorded and once receiver locations are picked up. The estimated number of personnel for the survey work will be approximately four people.

### **2.5.2 Shothole Drilling**

The shothole drilling crew will consist of approximately six to seven personnel with three drills mounted on airboats or tracked vehicles and will follow the survey crew. The proposed source lines will be oriented north to south and spaced 1,760 feet apart with source points positioned at 220-foot intervals along each line (Figure 2.6-1). Shotholes, approximately 4 inches in diameter, will be drilled to a design depth as determined by the PPV tests to be completed outside the Refuge; depths will be 110 feet, unless proximity to sensitive resources requires adjustment.

Off-road travel will be limited to the minimum required to efficiently complete the drilling, which will minimize disturbance of the land surface and associated vegetation.

Lightweight aluminum tracked vehicles will be used for drilling in emergent wetlands. The critical zone for vehicular access is in these areas of saturated soils, especially where vegetation is lacking. The environmental monitors will be involved in identifying these zones and ensuring the proper vehicle is used. The goal is to minimize rutting or gouging of exposed hydric soils as much as possible.

In shallow water areas, airboat drills will be used to drill the shotholes. The zone of change-over between the airboat drills and the tracked vehicle drills will need to be determined on a site-specific basis, as directed by the environmental monitors.

In each area, every effort will be made to make only one pass along each source line during the drilling process. To reduce the number of bad shotholes, each blasting cap will be tested before and after each hole is loaded with the charge. However, if a crew is required to re-drill a shothole that would necessitate an additional pass, approval will first be obtained from the environmental monitor. Shothole capwire will be buried where needed in upland areas with a small bar magnet attached to the capwire leads. The magnets will be recovered and reused, and will aid in locating shotholes with the use of a metal detector. In wetland and open water areas, shothole capwire will be tied to cane poles.

### **2.5.3 Water Sources and Hauling Water**

Water is typically required in the drilling of most shotholes on land. The amount of water required for each shothole is site-specific and will be determined during the course of operations, as it is dependent on the depth of the drill hole and soil texture. Water sources for shothole drilling will be approved by the Refuge Manager and may be subject to Texas Commission on Environmental Quality (TCEQ) permits. Upland drill sites are anticipated to use water brought in from outside sources or, where approved by the Refuge Manager, from irrigation ditches,

bayous, and similar water courses. The equipment used to bring in water from outside sources would be the same type of equipment being used by a particular crew in a particular area that has been approved by the Refuge Manager and/or environmental monitor.

### 2.5.4 Backfilling and Plugging Shotholes

In areas of standing water, cuttings produced from shothole drilling will naturally cave back in to the hole. In upland areas, the cuttings will be used to backfill the hole. All shotholes will be plugged with bentonite (natural clay) plugs in accordance with standard industry practices and agency regulations for the prevention of commingling of surface and groundwater. All cuttings at dry and wet sites that are not used as backfill for the source hole will be spread on site so that no mounds remain and the area is restored to pre-Project contours.

### 2.5.5 Safety and Setbacks

The crew will have at least one Health, Safety, and Environmental representative on-site during the seismic survey. Samson considers safety and environmental issues of the utmost importance and will use contractors committed to operating in a safe and environmentally sensitive manner.

Table 2.6-1 indicates the energy source operating distances that are commonly used and accepted by the geophysical industry.

Ground vibration monitoring will be conducted within the Project Area during operations. Offset distances will be adjusted accordingly and additional setbacks may be established by the Refuge Manager for the protection of sensitive resources.

**Table 2.6-1 Safe Operating Distance Chart**

Object	Explosives Energy Source Charge Size		
	< 5 pounds	6-10 pounds	> 11 pounds
Pipeline less than 6 inches diameter	100 feet	140 feet	190 feet
Pipeline 6-12 inches diameter	150 feet	215 feet	280 feet
Pipeline greater than 12 inches diameter	200 feet	290 feet	380 feet
Telephone line	40 feet	56 feet	76 feet
Railroad track or main paved highway	150 feet	215 feet	280 feet
Electric power line (shothole not to exceed 200 feet in depth)	Two times the shothole depth		
Refuge water well, water control structure, building, underground cistern, and other sensitive structures	300 feet	430 feet	560 feet

## **2.5.6 Seismic Recording Equipment Layout, Recording and Pick-up**

The recording crew will set up staging areas in approved locations from where all operations shall be coordinated. These locations will be dry highland locations in order to allow movement of trucks and trailers. The staging areas will be outside the Refuge boundaries; no staging areas will be placed within Brazoria NWR. Equipment that will be located at the staging areas for the duration of recording operations includes, but is not limited to: a coordinator's trailer, battery charging truck, equipment maintenance trailer, highboy transport trailers, and helicopter fuel trailer. Data acquisition will be managed from the main instrumentation truck, which will be located at various road-accessible sites around the survey area.

Recording equipment will be transported by airboat, other boat, marsh master, and helicopter. A helicopter will be used wherever necessary to protect sensitive areas. The recording equipment to be transported to the lines will include geophones/hydrophones, cables, data recording boxes, and batteries (set directly on the ground or floated in open water). The helicopters will lower cache bags containing the equipment along the receiver lines, and crews on the ground will deploy the equipment along the lines. Batteries for the recording equipment are non-halogenated and constructed from flame-retardant materials, as well as shock/vibration resistant to meet demanding, outdoor applications in sensitive environments.

Once the equipment is deployed to complete a recording swath (the corridor between two parallel and adjacent receiver lines), the recording crew will proceed with detonating shotholes. Crew members will travel between source point locations, connect a shooting pack to each electronic detonating wire (cap), and detonate each charge individually. The resulting reflected energy wave will be measured by the geophones/hydrophones and recorded. Recording crews will travel on foot for recording swaths on land, and will travel on airboats or lightweight aluminum tracked vehicles for wet areas.

Recording crews will travel through the Project Area along receiver lines at least twice during operations to accomplish layout and removal of equipment. Additional trips may be required in any given area to repair and/or replace equipment and to download data from recording equipment.

Once the recording operations are complete, the field electronics, trash, and flagging will be picked up by the recording crews and packed back in cache bags. The cache bags will be removed by crews, helicopter, or lightweight tracked vehicles, as approved by the Refuge Manager.



### **2.5.7 Staging and Storage**

Additional storage areas may be needed for the storage of seismic equipment including, but not limited to, a powder magazine for storage of explosives and a trailer for storage of bentonite. These storage areas will not be located on Brazoria NWR.

## 3.0 DESCRIPTION OF ALTERNATIVES

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### 3.1 No Action Alternative

Under the No Action Alternative, FWS would not issue a SUP for the proposed 3-D seismic survey. The National Environmental Policy Act (NEPA) and the Council for Environmental Quality regulations on the implementation of NEPA require consideration and analysis of the No Action Alternative. Since FWS is considering taking a new action (issuance of a SUP for a 3-D seismic survey program), the NEPA No Action Alternative is FWS not acting at all. Therefore, the No Action Alternative addresses not issuing a SUP for the proposed Project.

The No Action Alternative would occur under the following described set of circumstances. FWS would propose a SUP with stipulations to Samson. If Samson refused to accept the SUP and agree to conduct operations pursuant to the stipulations, FWS would not issue a SUP. At that point, Samson could abandon its proposed Project or could elect to proceed with the Project, relying on the underlying mineral interest owners' state property right to make reasonable and necessary use of the surface to explore for and develop its mineral interests. If Samson ultimately did proceed with Project operations without a SUP, FWS would continue to enforce all applicable state and federal statutes and regulations.

It can be reasonably anticipated that several operational aspects of the proposed seismic survey on Brazoria NWR without the issuance of a SUP by FWS would differ from a project that is governed by the general provisions and specific stipulations contained in a SUP. For example, operational aspects of a 3-D seismic survey program conducted without the issuance of a SUP that differ from a project governed by a SUP could include:

- Not restricting the number of vehicle passes along a single shot or receiver line to reduce impacts on wetlands;
- Conducting operations outside of the seasonal timeframes specified by FWS, which could be during the periods of highest migratory bird use and result in greater overall disturbance impacts on migratory birds and other wildlife; and/or
- Not requiring lightweight aluminum tracked vehicles to be used where it is too dry for airboats.

In addition to those listed above, it can be reasonably expected that many other operational procedures which are restricted or modified by the stipulations of a FWS SUP governing all aspects of a 3-D seismic survey would likely be conducted in a manner which would result in



greater environmental impacts. These impacts will be evaluated under this No Action Alternative.

### **3.2 Proposed Action Alternative**

Under the Proposed Action Alternative, FWS would issue a SUP to Samson governing all aspects of the 3-D seismic survey activities. SUPs contain a full range of stipulations and regulations aimed at protecting natural and cultural resources on Refuges, and minimizing conflicts with public uses and other FWS management activities. The provisions and stipulations of the SUP for the proposed Project are fully described in Section 5.0 of this EA. Through the issuance of a SUP and its subsequent implementation to ensure strict adherence to its provisions and stipulations by Samson, FWS is actively managing the proposed activity to provide maximum protections of natural and cultural resources and public safety on Brazoria NWR. This is the Proposed Action.

By agreeing to conduct the proposed Project within Brazoria NWR under all provisions of the SUP, Samson is agreeing to conduct all operations within the Refuge under stipulations aimed at protecting natural and cultural resources and minimizing conflicts with other uses of the Refuge, including public recreation, environmental education, and scientific research. Under the Proposed Action, the overall environmental impacts of the proposed Project will be reduced.

In addition to the SUP provisions and stipulations, FWS would enforce all applicable state and federal statutes and regulations.

## 4.0 DESCRIPTION OF THE ENVIRONMENT

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### 4.1 Geology and Soils

#### 4.1.1 Geology

Brazoria NWR is located in the Gulf Coastal Plain Physiographic Province (Gulf Coastal Plain); in Texas, the Gulf Coastal Plain begins approximately 200 miles from the coast and slopes gently toward the Gulf of Mexico. Three sub-provinces, Coastal Prairies, Interior Coastal Plains, and the Blackland Prairies, further divide the Gulf Coastal Plain (BEG 1996). The Refuge is located entirely within the Coastal Prairies sub-province and the topography is nearly flat.

Brazoria NWR is underlain by alluvium Holocene clay, silt, and sand as well as the Beaumont Formation of the Pleistocene, which is also composed mostly of clay, silt, and sand. The Beaumont Formation is clay, mud, and clayey sand and silt ranging from low to moderate permeability and drainage (Geologic Atlas of Texas 1982).

#### 4.1.2 Soils

Both deep, non-saline soils and deep, saline soils are found within Brazoria NWR (USDA 1981). The major deep, non-saline soils that occur within Brazoria NWR include the Aris, Asa, Bernard, Edna, Lake Charles, and Pledger series. In general, the deep, non-saline soil series are somewhat poorly drained to poorly drained and have very slowly permeable subsoil; however the Asa soil series is loamy and well drained. The major, deep, saline soils that occur within the Refuge include the Francitas, Harris, Narta, Surfside, Velasco, and Veston series. The soils of the deep, saline soils are primarily sandy in areas adjacent to the Gulf of Mexico and affected by salts from the Gulf of Mexico. Also included within the Project Area are Beaumont, Follet, Ijam, Leton, Morey, Tatlum, and Tracosa soil series, which are coastal, poorly drained silt loams and clay. Soils within the Project Area can be found in Figure 4.1-1.

Brazoria NWR is part of the Galveston Bay Estuarine System. This bay-estuary-lagoon system receives modern sediments derived from several sources including suspended-load and bed-load materials of rivers and streams; erosional products from bay-margin shores; gulf sediments transported through tidal passes and across barrier islands through wash-over channels; sediments transported across the barriers by eolian processes; non-terrestrial biogenic materials, composed primarily of oyster shells, but including the tests or “skeletons” of other benthic invertebrates; and dredge spoils placed on submerged lands along the channels and near shell-dredging. Erosion, transportation, and deposition of sediments are directly related to active processes and corresponding levels of wave and current energy that occur in the bay system. Erosion of bay shorelines is largely determined by prevailing and dominant wind directions,

fetch, orientation of the bay shoreline, and textural composition of the shore (Paine & Morton 1986).

## **4.2 Climate and Hydrology**

### **4.2.1 Climate**

Generally, the climate in Brazoria County is mild and humid. Temperature and moisture is largely influenced by solar insolation and air mass movements from the Gulf of Mexico; these factors interact to create a climate of dry, hot summers, wet springs and falls, and dry, mild winters. Average temperatures generally range from the low 90's in summer (highs) to the mid 40's in winter (lows); average annual rainfall at the Refuge is approximately 50 inches, with rainfall usually distributed uniformly throughout the year.

Hurricanes and floods are common in the region. The most severe storms typically occur when tropical disturbances move inland from the Gulf of Mexico during late summer and early autumn. A typical hurricane in this area would produce water levels at approximately 10.7 feet above mean sea level. Storm level probability data indicate that it can be expected that the entire Refuge be covered by a high tide approximately once every 10 years.

### **4.2.2 Hydrology**

Brazoria NWR consists of five types of surface water systems in the Refuge drainage network. These types include: fresh, intermediate, brackish, and saline marshes; small temporal freshwater ponds scattered throughout the Refuge; bayous and irrigation ditches; brackish to freshwater lakes and reservoirs; and the Gulf Intracoastal Waterway. Generally, water flows from the north to the south across the Refuge. Major sources of freshwater include Austin and Bastrop Bayous, Otter Slough, precipitation, and surface runoff. Austin Bayou on the western border of the Refuge flows south to Bastrop Bayou and Bastrop Bay. Big Slough, which runs through the Refuge, has a connection to Bastrop Bay. Multiple drainage ditches, maintained by the county, drain lands north of the refuge but have associated levees that may be utilized by the refuge to create seasonal freshwater wetlands. The Refuge manages 23 fields/ponds for moist soil and freshwater habitats. Moist soil units along the Big Slough include Gut Pond, Gator Nest Pond, Olney Pond, Teal Pond, Crosstrails Pond, and Roger's Pond. Additional moist soil units include Butterfly, Mottled Duck Marsh, Canvasback Pond, Walker Pond, and multiple impoundments along Otter Slough.

Saltwater intrusion, occurring in the southern portion of the Refuge, has historically been prevented by the Gulf-Margin Normal fault lines; however, these fault lines are sensitive to compression. Over the years, during oil and gas extraction activities, the fault lines have been compressed, which has resulted in subsidence over the fault lines. This has accelerated saltwater

intrusion into the Slop Bowl area of the Refuge (the southwestern corner) and caused degradation of saltwater marsh habitat in that area. The Slop Bowl area is the most degraded and most sensitive area of the Refuge due to the loss of marsh over time.

Portions of Brazoria NWR have been used for ranching and rice farming; channelization associated with rice farming has altered the hydrology. A series of irrigation ditches are located in the northern portion of the Refuge between FM 2004 and Hoskins Mound, and between Austin Bayou and Chocolate Bay.

### **4.3 Vegetation**

Predominant habitat types within Brazoria NWR include coastal prairie, freshwater marsh, saline prairie, estuarine marsh, open water, mud flats, and disturbed land. Figures 4.3-1 and 4.3-2 show the habitats present within the Refuge, and details regarding habitats are provided below (FWS 2012). In addition to the habitats described in this section, there are four plant species of concern that environmental monitors will be familiar with and that Samson will avoid disturbing where practicable. Coastal gay-feather (*Liatris bracteata*) may be found off Alligator marsh road and in the Bermuda Triangle Units with little bluestem (*Andropogon scoparius*) and in saline prairie transition zones in the Chocolate Bayou unit with Gulf cordgrass (*Spartina spartinae*). Three-flower broomweed (*Thurovia triflora*) is found in a limited range, often as a co-dominant with shoregrass (*Monanthochloe littoralis*), on sparsely vegetated areas of saline prairie south of Cox Lake and on the northwest side of the Chocolate Bayou unit. An undetermined species of yucca (*Yucca sp.*) is found in Chocolate Bayou unit and along the auto tour loop in upper saline prairie. Sundew (*Drosera annua*) is found on Mima mounds, swales and along vegetated ditches, generally on the north slope of those features. It is an early growing annual and is usually seeded out by May. The environmental monitors will work with Refuge personnel to become comfortable with identifying the species in the field ahead of the work crews.

#### **4.3.1 Coastal Prairie**

Coastal prairie dominates the northern and western portions of Brazoria NWR, or those areas that are furthest landward from the coast. The ridge-and-swale microtopography of coastal prairies allows for a matrix of upland and wetland vegetation communities. TPWD identifies three rare plant communities (associations) that occur on the Refuge. Alfisol Coastal Prairie (endemic), Vertisol Coastal Prairie (endemic), and Wet Coastal Prairie/Marsh are all designated with a critically imperiled (G1) conservation status. Coastal prairie habitats are composed of herbaceous species, and require regular fire for maintenance and to prevent invasion of woody shrubs and trees. Texas coastal prairie uplands are dominated by switchgrass (*Panicum virgatum*), little bluestem, and brown-seed paspalum (*Paspalum plicatulum*) (FWS 2012). Wildlife that use coastal prairie habitat include white-tailed deer, bobwhite quail and wintering

grassland birds such as LeConte's sparrow. Additionally, mottled ducks use coastal prairie on Brazoria NWR as nesting habitat (FWS 2012).

#### **4.3.2 Freshwater Marsh**

Freshwater marsh habitat is primarily found in the northern portions of Brazoria NWR, adjacent to coastal prairie and old field habitat. These wetlands are located within depressions that form within the ridge-and-swale topography of coastal prairies, and are dependent on rainwater runoff and percolation (FWS 2012). Additionally, seasonal freshwater wetlands managed for emergent vegetation have been created within the Brazoria NWR by raising levees, diverting surface water from drainage ditches, and catching natural run-off. Freshwater wetland plant communities are dominated by bulrushes (*Scirpus spp.*), cattails (*Typha spp.*), common reed (*Phragmites australis*), and rice cutgrass (*Leersia oryzoides*) (FWS 2012). Areas with shallow ponds may include floating and submerged aquatic vegetation. Within the Refuge, freshwater wetlands provide molting and brood habitat for the mottled duck, as well as fresh drinking water and habitat for wildlife. Freshwater wetland ponds support wintering waterfowl and provide shallow freshwater resources for wading birds and shorebirds.

#### **4.3.3 Saline Prairie**

Saline prairie is found at the transition between coastal prairie and salt marsh habitats at higher elevations than salt marshes. These areas are periodically inundated by saline waters; periodic fires and saline flooding are required to maintain saline prairie habitat and to prevent the intrusion of woody species. Dominant plant species in saline prairie include gulf cordgrass, sea ox-eye daisy (*Borrchia frutescens*), and shoregrass (FWS 2012). This habitat is easily invaded by eastern baccharis (*Baccharis halimifolia*) Wildlife that use saline prairie include resident and migratory birds such as Henslow's sparrow, mottled ducks, dickcissels, and rails (FWS 2012).

#### **4.3.4 Saline Marsh**

Saline marshes are located in the southern and eastern portions of Brazoria NWR, nearest to open water bays. Resident species (e.g., secretive marsh birds, wading birds, Gulf saltmarsh snake) and migratory species (e.g., wintering waterfowl) use saline marshes as habitat and feeding grounds. Saline marsh vegetation is adapted to inundation of saline water, clay soils, and desiccating winds.

##### **4.3.4.1 High Salt Marsh**

High salt marsh is located landward of low salt marsh and is often adjacent to saline prairie habitat in tidally influenced areas. Herbaceous and shrub-scrub vegetation prevalent in high salt marsh includes saltmeadow cordgrass (*Spartina patens*), saltgrass (*Distichlis spicata*), sea ox-eye daisy, and high-tide bush (*Iva frutescens*) (FWS 2012).

#### **4.3.4.2 Low Salt Marsh**

Low salt marsh is found in Brazoria NWR at bay shores, near lakes, and near the Gulf Intracoastal Waterway in areas of tidal influence. Dominant vegetation in low salt marsh habitat includes smooth cordgrass (*Spartina alterniflora*), saltgrass, and saltmarsh bulrush (*Scirpus robustus*) (FWS 2012).

#### **4.3.5 Open Water**

Open water habitat within Brazoria NWR includes standing water associated with fresh and saltwater marsh, fresh and saltwater ponds, and bayous. In saltwater areas, seagrasses dominate the vegetation and provide food and shelter to saltwater invertebrates and fish, including shrimp, blue crab, and juvenile game fish. Waterbirds also use open water habitat.

Waterbodies within Brazoria NWR are described in detail in Section 4.2.

#### **4.3.6 Mud Flats**

Mud flats are characterized by sparse, scattered emergent vegetation (or no vegetation) and saturated soil conditions adjacent to marsh habitat. Shorebirds, gulls, and aquatic wildlife use tidal mudflats as a feeding ground.

#### **4.3.7 Disturbed Land**

Disturbed land within Brazoria NWR includes cultivated land and spoil areas. Agricultural lands are located in the northern portion of the Refuge; farming is allowed within Brazoria NWR to benefit wildlife, and the most prevalent crop in Brazoria County is rice (FWS 2012).

Areas of spoil are primarily located adjacent to open water along the Gulf Intracoastal Waterway, where dredging maintenance is required.

### **4.4 Wildlife**

The Texas Mid-coast National Wildlife Refuge Complex (Complex) is composed of Brazoria, San Bernard, and Big Boggy NWRs. Wildlife resources are typically assessed for the entire Complex, rather than for individual refuges since these three refuges form an interrelated complex of coastal wetland and coastal prairie habitats for wildlife. The purpose of Brazoria NWR is to provide a sanctuary for migratory birds, and provide management, conservation, and protection of fish and wildlife resources (FWS 2012).

#### 4.4.1 Terrestrial Species

The Complex hosts a diversity of migratory and resident wildlife that use marsh, open water, and prairie habitats along the Texas Gulf Coast. Prominent terrestrial species documented on the Complex include birds, mammals, reptiles, and amphibians.

##### 4.4.1.1 Birds

A total of 350 bird species are documented to occur within Brazoria County and are likely to occur on the Mid-coast refuges; 44 of these species are known to nest in the Complex (FWS 2013; FWS 2013c). Nesting birds at the Refuge include ten species of bitterns and herons, white ibis, roseate spoonbill, white-tailed kite, three species of rail, black skimmer, and the scissor-tailed flycatcher.

The Refuge is located within the Central Flyway, and provides a stopover for more than 50 neotropical migrant species and wintering habitat to waterfowl that winter on the Texas coast (FWS 2013, FWS 2012). In the fall, birds migrate south along the Central Flyway from the Great Plains to the Texas Gulf Coast; neotropical migrant species continue south past the Gulf Coast to winter in Central and South America. In the spring, the migratory route is reversed as birds return to summer nesting grounds. Common species observed on the Refuge include waterfowl, shorebirds, waterbirds, raptors, and perching birds (Table 4.4-1).

**Table 4.4-1 Common Birds in the Texas Mid-coast National Wildlife Refuge Complex**

Species Group	Species Common Name	Species Group	Species Common Name
Grebes	Pied-billed grebe	Pigeons and Doves	Mourning dove
Pelicans	Brown pelican		Eurasian collared dove
	American white pelican	Goatsuckers	Common nighthawk
Cormorants	Double-crested cormorant	Hummingbirds	Ruby-throated hummingbird
Bitterns and Herons	Great blue heron	Woodpeckers	Downy woodpecker
	Great egret		Red Bellied Woodpecker
	Snowy egret	Tyrant Flycatchers	Eastern phoebe
	Little blue heron		Scissor-tailed flycatcher
	Tricolored (Louisiana) heron	Swifts	Chimney swift
	Cattle egret	Swallows	Purple martin
	Green heron	Jays, Magpies, and Crows	Blue jay
	Green Heron		American crow

**Table 4.4-1 Common Birds in the Texas Mid-coast National Wildlife Refuge Complex**

Species Group	Species Common Name	Species Group	Species Common Name
Swans, Geese, and Ducks	Snow goose	Chickadees and Titmice	Carolina chickadee
	Green-winged teal		Tufted titmouse
	Blue-winged teal	Wrens	Carolina wren
	Northern shoveler		Sedge wren
	Gadwall	Kinglets and Gnatcatchers	Ruby-crowned kinglet
	American widgeon	Thrushes	American robin
Kites, Eagles, and Hawks	Northern harrier	Mockingbirds and Thrashers	Northern mockingbird
	Red-shouldered hawk		Brown thrasher
	Red-tailed hawk	Pipits	Sprague's pipit
Caracaras and Falcons	American kestrel	Shrikes	Loggerhead shrike
American Vultures	Black vulture	Starlings	European starling
	Turkey Vulture	Vireos	White-eyed vireo
Pheasants, Turkeys, and Quail	Northern bobwhite	Wood-warblers	Yellow warbler
Rails, Gallinules, and Coots	Clapper rail		Yellow-rumped warbler
	American coot		Black-and-white warbler
Plovers and Oystercatchers	Killdeer		Common yellowthroat
		Sandpipers and Phalaropes	Black-necked stilt
American avocet	Indigo bunting		
Willet	Painted bunting		
Long-billed dowitcher	Sparrows		Savannah sparrow
Sanderling			House sparrow
Gulls and Terns	Laughing gull	Blackbirds and Orioles	Eastern meadowlark
	Ring-billed gull		Great-tailed grackle
	Herring gull		Boat-tailed grackle
	Forster's tern		Common grackle
	Least tern		Brown-headed cowbird

Source: FWS 2013c

Thirty-one species of waterfowl use the Complex. Most of the waterfowl that occur in the Complex are present in the winter months (November thru January); these species use the freshwater and saline wetland and open water habitats along the Texas Gulf Coast as a wintering ground. Waterfowl species that are not migratory and use Brazoria NWR during spring and summer months include fulvous whistling duck, black-bellied whistling duck, and mottled duck (FWS 2007, FWS 2012).

More than 100,000 shorebirds of more than 30 species occur within the Complex each year, and the Complex is designated as a Site of International Importance by the Western Hemisphere Shorebird Reserve Network (FWS 2012). In late April and early May, migratory shorebird use of the wetlands within the Complex peaks (FWS 2007).

Colonial waterbirds, including gulls, terns, skimmers and wading birds, nest in large colony groups in several locations within the Complex. The Wolf Lake area in Brazoria NWR is a management priority for nesting colonial waterbirds (FWS 2007).

Twelve raptor species use the Complex, with five species that may nest on the Brazoria Refuge including crested caracara, northern harrier, white-tailed kite, white-tailed hawk and red-tailed hawk as well as great-horned owl. Approximately 90 species of perching birds, including woodpeckers, mockingbirds and thrashers, thrushes, sparrows, and warblers are also found in the Complex (FWS 2012).

#### **4.4.1.2 Mammals**

Habitat for 52 species of mammals is present on the Complex (FWS 2012). Common mammalian species include the armadillo (*Dasyopus novemcintus*), coyote (*Canis latrans*), opossum (*Didelphis virginiana*), white-tailed deer (*Odocoileus virginianus*), bobcat (*Lynx rufus*) raccoon (*Procyon lotor*), and striped skunk (*Mephitis mephitis*). Other species that occur in the Complex include the river otter (*Lutra canadensis*), long-tailed weasel (*Mustela frenata*), cougar (*Puma concolor*), and Eastern spotted skunk (*Spilogale putoris*) (FWS 2012).

#### **4.4.1.3 Reptiles and Amphibians**

The Gulf Coast habitats within the Refuge are suitable for and within the range of 67 species of reptiles and 24 species of amphibians. Reptiles include the American alligator (*Alligator mississippiensis*), snapping turtle (*Chelydra serpentine*), box turtle (*Terrapene spp.*), red-eared slider (*Trachemys scripta elegans*), soft-shell turtle (*Apalone spp.*), rat snake (*Elaphe obsoleta*), and western cottonmouth (*Agkistrodon piscivorous leucostoma*) (FWS 2012). Amphibians include the bullfrog (*Rana catesbeiana*), green tree frog (*Hyla cinerea*), Gulf Coast toad (*Bufo valliceps*), and southern leopard frog (*Rana sphenoccephala*) (FWS 2012).

#### 4.4.2 Aquatic Species

Five bays are located adjacent to the Refuge; from north to south along the coast they are Chocolate Bay, West Bay, Bastrop Bay, Christmas Bay, and Drum Bay. Christmas Bay contains areas of seagrass beds, and oyster colonies are documented within and adjacent to the Refuge in West, Bastrop, and Christmas Bays (TXNDD 2012; TGLO 2012). Aquatic species that inhabit these coastal Texas bays include several fish species [e.g., red drum (*Sciaenops ocellatus*), black drum (*Pogonias chromis*), Gulf menhaden (*Brevoortia patronus*), Atlantic croaker (*Micropogonias undulates*), pinfish (*Lagodon rhomboids*), and spotted seatrout (*Cynoscion nebulosus*)]; shellfish [e.g., blue crab (*Callinectes sapidus*), shrimp species, and American oyster (*Crassostrea virginica*)], and bottlenose dolphins (*Tursiops truncatus*) (GLO 2012). Fish and other aquatic species that use the Refuge include species that are known to be dependent on marsh vegetation and species that use coastal marshes seasonally (FWS 2012).

#### 4.5 Threatened and Endangered Species and Species of Concern

Table 4.5-1 lists the federally and state listed threatened and endangered species which occur in Brazoria County, Texas, as well as species of concern within the Complex (FWS 2013, FWS 2013a, TPWD 2013). The potential for occurrence is based on both the federal and state species lists by county.

For the purpose of this EA, only the species listed as priority species of concern (those with documented population declines that may be subject to future coastal habitat loss) for the Complex are discussed (FWS 2012). Documented occurrences of rare species are shown in Figure 4.5-1; the only priority species of concern with an occurrence documented in the Texas Natural Diversity Database (TXNDD), which tracks state and federally listed and rare species, is the Texas diamondback terrapin (TXNDD 2012).

**Table 4.5-1 State and Federally Listed Species and Species of Concern that Occur in Brazoria County**

Species Common and Scientific Name	Federal Listing Status	State Listing Status	Refuge Priority Species of Concern
<b>Birds</b>			
American oystercatcher ( <i>Haematopus palliatus</i> )			Yes
American peregrine falcon ( <i>Falco peregrinus anatum</i> )	DL	T	
Bald eagle ( <i>Haliaeetus leucocephalus</i> )	DL	T	Yes
Black rail ( <i>Rallus jamaicensis</i> )			Yes
Black skimmer ( <i>Rhynchops niger</i> )			Yes

**Table 4.5-1 State and Federally Listed Species and Species of Concern that Occur in Brazoria County**

Species Common and Scientific Name	Federal Listing Status	State Listing Status	Refuge Priority Species of Concern
Brown pelican ( <i>Pelecanus occidentalis</i> )	DL		Yes
Dickcissel ( <i>Spiza americana</i> )			Yes
Eskimo curlew ( <i>Numenius borealis</i> )	E	E	
Henslow's sparrow ( <i>Ammodramus henslowii</i> )			Yes
LeConte's sparrow ( <i>Ammodramus leconteii</i> )			Yes
Loggerhead shrike ( <i>Lanius ludovicianus</i> )			Yes
Mottled duck ( <i>Anas fulvigua</i> )			Yes
Northern bobwhite ( <i>Colinus virginianus</i> )			Yes
Painted bunting ( <i>Passerina ciris</i> )			Yes
Piping plover ( <i>Charadrius melodus</i> )	T	T	Yes
Red knot ( <i>Calidris canutus</i> )	C		Yes
Reddish egret ( <i>Egretta rufescens</i> )		T	Yes
Seaside sparrow ( <i>Ammodramus maritimus</i> )			Yes
Sprague's pipit ( <i>Anthus spraguui</i> )	C		
Snowy plover ( <i>Charadrius nivosus</i> )			Yes
Sooty tern ( <i>Sterna fuscata</i> )		T	
Swainson's warbler ( <i>Limnithyplis swainsonii</i> )			Yes
Swallow-tail kite ( <i>Elanoides forficatus</i> )			Yes
White-faced ibis ( <i>Plegadis chihi</i> )		T	Yes
White-tailed hawk ( <i>Buteo albicaudatus</i> )		T	Yes
Whooping crane ( <i>Grus americana</i> )	E	E	
Wilson's plover ( <i>Charadrius wilsonia</i> )			Yes
Wood stork ( <i>Mycteria americana</i> )		T	
Yellow rail ( <i>Coturnicops noveboracensis</i> )			Yes
<b>Fishes</b>			
Sharpnose shiner ( <i>Notropis oxyrhynchus</i> )	C		
Smalltooth sawfish ( <i>Pristis pectinata</i> )	E	E	
<b>Mammals</b>			
Jaguarundi ( <i>Herpailurus yaguarondi</i> )	E	E	

**Table 4.5-1 State and Federally Listed Species and Species of Concern that Occur in Brazoria County**

Species Common and Scientific Name	Federal Listing Status	State Listing Status	Refuge Priority Species of Concern
Louisiana black bear ( <i>Ursus americanus luteolus</i> )	T	T	
Ocelot ( <i>Leopardus pardalis</i> )	E	E	
Red wolf ( <i>Canis rufus</i> )	E	E	
West Indian manatee ( <i>Trichechus manatus</i> )	E	E	
<b>Mollusks</b>			
False spike mussel ( <i>Quadrula mitchelli</i> )		T	
Smooth pimpleback ( <i>Quadrula houstonensis</i> )	C	T	
Texas fawnsfoot ( <i>Truncilla macrodon</i> )	C	T	
<b>Reptiles</b>			
Alligator snapping turtle ( <i>Macrolemys temminckii</i> )		T	
Atlantic hawksbill sea turtle ( <i>Eretmochelys imbricata</i> )*	E	E	
Texas diamondbacked terrapin ( <i>Malaclemys terrapin littoralis</i> )			Yes
Green sea turtle ( <i>Chelonia mydas</i> )*	T	T	
Kemp's ridley sea turtle ( <i>Lepidochelys kempii</i> )*	E	E	Yes
Leatherback sea turtle ( <i>Dermochelys coriacea</i> )*	E	E	
Loggerhead sea turtle ( <i>Caretta caretta</i> )*	T	T	
Gulf saltmarsh snake ( <i>Nerodia clarkii</i> )			Yes
Texas horned lizard ( <i>Phrynosoma cornutum</i> )		T	
Timber/canebrake rattlesnake ( <i>Crotalus horridus</i> )		T	Yes

E – Endangered, T – Threatened, C – Candidate, DL – Delisted

\*The National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) has jurisdiction over this species in marine waters. No marine waters occur within Brazoria NWR.

Source: TPWD 2013, FWS 2013a, FWS 2012

## 4.5.1 Birds

### 4.5.1.1 American Oystercatcher

The American oystercatcher is a shorebird that is present year-round along the Texas Gulf Coast. This species eats bivalve mollusks, including oysters, as well as other marine invertebrates

(Alsop 2001). American oystercatchers nest on dry, flat beaches and habitats adjacent to bays. Within Brazoria NWR, American oystercatchers nest in Chocolate, Bastrop, and Drum Bays (FWS 2012).

#### **4.5.1.2 Bald Eagle**

Bald eagles are primarily found near rivers and large lakes, and nest in tall trees or on cliffs near water. They are opportunistic predators that hunt live prey, including fish and waterfowl, or pirate food from other birds (TPWD 2013). Bald eagles from two nests are known to use the Brazoria NWR as feeding habitat.

The bald eagle population in Texas is state listed as threatened and is divided into two groups: breeding birds and nonbreeding or wintering birds. Breeding populations occur in the eastern half of the state and along coastal counties from Rockport to Houston (TPWD 2013a). Nonbreeding populations are located primarily in the Panhandle, Central, and East Texas. In Texas, the bald eagle nests in a variety of species of tall trees (primarily loblolly pine in East Texas) from October to July and breeds primarily in the eastern half of the state (TPWD 2013a). Peak egg-laying occurs in December. A bald eagle occurrence was recorded in 2005 in the TXNDD at the end of a Refuge-managed road that extends out of the western boundary of the Refuge.

#### **4.5.1.3 Black Rail**

The black rail is a secretive marsh bird that remains under vegetative cover in salt and freshwater marshes, wet prairies and at pond borders. This species nests in habitat dominated by sedges, rushes, and grasses in coastal marshes (FWS 2012). Black rails feed on seeds, insects, and small crustaceans (Alsop 2001). This species is a year-round resident that nests at the Complex and is sensitive to human disturbance.

#### **4.5.1.4 Black Skimmer**

This colonial waterbird nests in small ground colonies on coastal beaches and in salt marsh habitat. The black skimmer feeds on small fish and crustaceans by skimming prey from the surface of open waters (Alsop 2001). Black skimmers loaf on beaches during the day and forage in the evening. A black skimmer colony is located near Wolf Lake on Brazoria NWR (FWS 2012).

#### **4.5.1.5 Brown Pelican**

The brown pelican is found in coastal and nearshore areas along the Texas Gulf Coast, as well as in pelagic areas. Brown pelicans are present year-round along the Texas Gulf Coast. This

species nests and roosts in colonies on islands and spoil banks (TPWD 2013). Brown pelicans eat fish, which they capture by plunge-diving into the water.

#### **4.5.1.6 Dickcissel**

This grassland species nests in prairies and fields with dense vegetation, and is present at the Complex during the nesting season from March through September (FWS 2012). Nests are located either on the ground or low in woody vegetation. Dickcissels forage for insects, seeds, and grains on the ground (Alsop 2001).

#### **4.5.1.7 Henslow's Sparrow**

Henslow's sparrow is solitary and winters on the Texas Gulf Coast in upland prairie habitat dominated by bunch grasses, with some woody species (TPWD 2013). This species feeds by foraging for insects and seeds on the ground (Alsop 2001). Henslow's sparrow is present in the Complex from October to March or April (FWS 2012).

#### **4.5.1.8 LeConte's Sparrow**

LeConte's sparrow is a solitary, secretive grassland species that winters on the Texas Gulf Coast in prairie wetland habitat. On wintering grounds, this species feeds by foraging for seeds on the ground (Alsop 2001). LeConte's sparrow is present in the Complex from October to March or April (FWS 2012).

#### **4.5.1.9 Loggerhead Shrike**

The loggerhead shrike is a grassland and scrub species that is present in Texas year-round. This species hunts prey, which includes insects, small rodents, reptiles and amphibians, by aerial pursuit, and often caches prey by suspending it from thorns (Alsop 2001). The loggerhead shrike inhabits grassland and scrub with scattered trees, and nests in trees or tall bushes.

#### **4.5.1.10 Mottled Duck**

The mottled duck is non-migratory and is present in the Complex year-round. This species inhabits freshwater and brackish marshes, where it nests and molts. This species nests in dense marsh vegetation near open water (Alsop 2001). Broods of mottled duck peak between April and June, and adults molt between June and September at the Complex (FWS 2007). The mottled duck primarily feeds on invertebrates, but also consumes vegetation. Disturbance during the nesting season could result in reduced nest success through nest destruction, abandonment or increased susceptibility to nest predation. While molting, flightless birds are more susceptible to disturbance and predation. Northern Bobwhite

This year-round resident inhabits fields, grasslands and farmlands, including coastal and salty prairies within the Complex (FWS 2012, Alsop 2001). This species roosts, nests and forages for worms, insects, spiders, and seeds on the ground.

#### **4.5.1.11 Painted Bunting**

This species is present at the Complex during the nesting season from March through September (FWS 2012). Nests are low in dense, woody vegetation, and habitat includes scrub, saltmarshes and coastal prairies (FWS 2012, Alsop 2001). The painted bunting forages for insects and seeds on the ground and in low trees and shrubs (Alsop 2001). This species is sensitive to human disturbance.

#### **4.5.1.12 Piping Plover**

The piping plover is a small shorebird and a winter migrant along the Texas Gulf Coast and is federally and state listed as threatened for Brazoria County. Piping plover habitat includes beaches and bayside mud or salt flats (TPWD 2013). Piping plovers are present along the Texas Gulf Coast between July and mid-May, and designated critical habitat for this species is located in sandy beaches along the Texas Gulf Coast. The nearest piping plover critical habitat to Brazoria NWR is located on Galveston Island; no critical habitat is designated within Brazoria NWR (Figure 4.5-1).

#### **4.5.1.13 Red Knot**

This shorebird migrates from breeding grounds in the arctic to wintering grounds on the Texas Gulf Coast and farther south, and is present on the Complex from September through April. Some individuals remain on the Complex year-round (FWS 2012). The red knot inhabits beaches and tidal flats where it feeds on mollusks, crustaceans and insects by probing the sediment (Alsop 2001). The red knot is currently a candidate for federal listing under the purview of FWS.

#### **4.5.1.14 Reddish egret**

The reddish egret is state listed as threatened. It inhabits salt and brackish marshes, ponds, and mud flats along the Texas Gulf Coast year-round. Reddish egrets nest in colonies on dry coastal islands on the ground in Texas and on platforms or in trees in other parts of their range (Alsop 2001). They feed on aquatic invertebrates and small fish and are known to feed within the Refuge.

#### **4.5.1.15 Seaside Sparrow**

The seaside sparrow is a resident secretive marsh bird that inhabits salt marshes along the Texas Gulf Coast year-round. Seaside sparrows eat insects, small crustaceans, snails, and seeds that they forage on the ground and while wading in shallow water (Alsop 2001). This species nests in clumps of grass or marsh reeds along the Texas Gulf Coast.

#### **4.5.1.16 Snowy Plover**

This species winters on the Texas Gulf Coast, though individuals remain year-round and occasionally nest. The snowy plover inhabits beaches, sand dunes, and tidal flats where it feeds by gleaning invertebrates and crustaceans (Alsop 2001, TPWD 2013). This species is sensitive to human disturbance.

#### **4.5.1.17 Swainson's Warbler**

Swainson's warbler inhabits bottomland hardwood forest with dense understory vegetation. Within the Complex, bottomland hardwood forest habitat is primarily found within San Bernard NWR and is not prevalent in Brazoria NWR. This neotropical migrant species nests in deciduous forests in North America and winters in South America. Swainson's warbler forages for insects and spiders on the ground in dense undergrowth (Alsop 2001).

#### **4.5.1.18 Swallow-tailed Kite**

Habitat for the swallow-tailed kite includes forested regions and marshes along rivers, lakes, and ponds. Within the Complex, bottomland hardwood forest habitat is primarily found within San Bernard NWR and is not prevalent in Brazoria NWR. Swallow-tailed kites usually nest high in tall pine, cypress, or various deciduous trees in clearings or on the forest woodland edge (TPWD 2013). This species is sensitive to human disturbance.

#### **4.5.1.19 White-faced Ibis**

The white-faced ibis is state listed as threatened for Brazoria County. White-faced ibis habitat includes freshwater marshes, sloughs, and irrigated rice fields. These ibis nest in marshes, low trees, and on the ground in bulrushes or reeds, or on floating mats (TPWD 2013). This species feeds on invertebrates and fish by probing the sediment with its bill. The white-faced ibis was previously documented to nest within the Complex, but is not currently known to do so (FWS 2012).

#### **4.5.1.20 White-tailed Hawk**

Near the coast, white-tailed hawk habitat includes prairies, live-oak scrub, and cordgrass flats; inland habitat includes prairies, mixed savanna-chaparral, and mesquite and oak savannah

(TPWD 2013). The white-tailed hawk is state listed as threatened and is a year-round resident that nests at the Complex. This species is sensitive to human disturbance and may abandon a nest due to human disturbance (FWS 2012). White-tailed hawks primarily feed on small mammals.

#### **4.5.1.21 Wilson's Plover**

This species primarily uses the Texas Gulf Coast as breeding grounds from May to September, though some individuals remain year-round (FWS 2012). Wilson's plover inhabits beaches and mud flats where it feeds on small crustaceans, mollusks and insects (Alsop 2001). This species nests on the ground above the high-tide line and is sensitive to human disturbance.

#### **4.5.1.22 Yellow Rail**

The yellow rail is a secretive marsh bird that inhabits the dense grasses of salt and freshwater marshes and prairies (Alsop 2001, FWS 2012). Yellow rails feed on seeds, insects, snails, and vegetation (Alsop 2001). This species is a migrant that winters along the Texas Gulf Coast and in the Complex. This species is sensitive to human disturbance.

### **4.5.2 Reptiles**

#### **4.5.2.1 Diamondback terrapin**

The Texas diamondback terrapin inhabits brackish and saline waters along the Texas Gulf Coast, including marshes, estuaries, and tidal creeks (FWS 2013b, TPWD 2013b). This species feeds on crustaceans, bivalves, fish, and insects. The diamondback terrapin is documented at the northern extent of Brazoria NWR near Chocolate Bay (Figure 4.5-1) and in Wolf Lake (FWS 2013).

#### **4.5.2.2 Gulf saltmarsh snake**

The nocturnal Gulf saltmarsh snake inhabits brackish and saline marshes, estuaries, and tidal flats, where it feeds on small fish, crustaceans, and other invertebrates (TPWD 2013c). Within Brazoria NWR, this species occurs in the coastal prairie, salty prairie, and salt and freshwater marshes (FWS 2013). Gulf saltmarsh snakes mate in the early spring and birth live young in July and August (TPWD 2013c).

#### **4.5.2.3 Kemp's ridley sea turtle**

Habitat for the Kemp's ridley sea turtle includes marine waters and bays of the Atlantic Ocean and Gulf of Mexico, where it feeds on marine invertebrates and fish (TPWD 2013d). This species nests on sandy beaches from May through July (FWS 2012). Kemp's ridley sea turtles



are found in the Bays near the Brazoria NWR, and nests on beaches in San Bernard NWR (FWS 2012).

#### **4.5.2.4 Timber/canebrake rattlesnake**

Timber/canebrake rattlesnake habitat includes upland pine and deciduous woodlands, riparian zones, moist bottomland forests, and swamps near permanent water sources. This species prefers areas with dense ground cover, such as grapevines or palmetto, and may seek refuge in tree stumps, logs, and branches (TPWD 2013, 2013e). The timber/canebrake rattlesnake is state listed as threatened in Brazoria County. Within the Complex, bottomland hardwood forest habitat is primarily found within San Bernard NWR and is not prevalent in Brazoria NWR.

## **4.6 Historical and Archeological Resources**

Samson's contractor (Cardno ENTRIX) performed a desktop review of cultural resources within and immediately adjacent to Brazoria NWR. The Texas Archeological Research Laboratory (TARL) was contacted and a search of the Texas Historical Commission's (THC) Archeological Sites Atlas was conducted. These sources provide information regarding previously conducted archeological surveys, previously recorded archeological sites, historic structures, National Register of Historic Places (NRHP) properties, State Archeological Landmarks, Official Texas Historic Markers, Registered Texas Historic Landmarks, cemeteries, local neighborhood surveys, and shipwrecks.

The search revealed the presence of seven previously recorded archeological sites within the Refuge boundaries and an additional five archeological sites recorded within 200 meters of the Refuge boundaries. All seven sites identified within the Refuge are recorded as short-term prehistoric campsites or food processing stations, and all have been recommended as ineligible for the NRHP. The five sites adjacent to the Refuge boundaries include three prehistoric shell middens and two early to mid-twentieth century shipwrecks partially buried by dredged material (spoil). The three shell middens each yielded only *Rangia* shell with no accompanying artifacts, although one midden was recommended for additional survey or testing prior to disturbance. Both shipwrecks were only surface inspected and testing was recommended prior to disturbance to determine the age and nature of the vessels.

Site location information is protected by the National Historic Preservation Act of 1966 (as amended), Title III §304 and by the Texas Antiquities Code §191.004, and is not intended for public distribution. All information regarding the location of cultural or historic resources should be kept confidential. Location information for this particular Project Area can be seen in Figure 4.6-1.

## 4.7 Land Use, Aesthetics, Socioeconomic, and Recreational Resources

### 4.7.1 Land Use and Aesthetic Resources

As stated previously, Brazoria NWR is part of the Texas Mid-coast National Wildlife Refuge Complex and was established in 1966 with a total of 6,398 acres. Since then, land acquisitions, easements, and gift donations have brought the total acreage of Brazoria NWR to 44,414 acres. Land use within the Project area is comprised of open water, developed land, barren land, deciduous forest, shrub/scrub, herbaceous areas, hay/pasture, cultivated crops, woody wetlands, and emergent wetlands. See table 4.7-1 for acreages associated with the different land uses and land cover types. Data provided in Table 4.7-1 are derived from the National Land Cover Database. Land use and land cover types are defined in the National Land Cover Database at a lower resolution and in broader habitat categories than the habitat types documented on the Refuge (Section 4.3, Figures 4.3-1 and 4.3-2) and therefore cannot be used to determine soil saturation or constrain vehicle use within the Refuge. Further detail regarding the vegetative cover types in Brazoria NWR is included in Section 4.3 (Vegetation).

**Table 4.7-1 Land Uses and Land Cover Types Within Brazoria NWR**

Land Use or Land Cover Type	Acres
Open water	5,129
Developed, open space	118
Developed, low intensity	19
Developed, medium intensity	1
Barren land	767
Deciduous forest	7
Shrub/scrub	63
Herbaceous	268
Hay/pasture	4
Cultivated crops	491
Woody wetlands	3,152
Emergent herbaceous wetlands	36,297

Source: National Land Cover Database (Homer et al. 2007).

Aesthetic resources refer to the composite of those features that influence the visual appeal of an area for residents or visitors, including physical terrain, hydrological features, vegetation, and anthropogenic features.

#### **4.7.2 Socioeconomic Resources**

The proposed Project would occur across the entirety of Brazoria NWR, located in Brazoria County, Texas. Based on 2010 U.S. Census Bureau data, the estimated population in Brazoria County was 313,166, an increase of approximately 24 percent since the 2000 census. Population density in Brazoria County is approximately 230.7 persons per square mile. The largest population center in Brazoria County is Pearland, with a population of 91,252. The cities of Lake Jackson and Freeport are the closest cities to Brazoria NWR, both located approximately 15 miles southwest of the Refuge.

As of the 2010 census, the labor force in Brazoria County was 151,670, with an estimated 5.7 percent of the labor force unemployed. The major employment industries in the county include education and other social services, manufacturing, retail trade, and construction. The 2010 estimated median household income in Brazoria County was \$67,018.

#### **4.7.3 Recreation Resources**

Brazoria NWR provides recreational opportunities, including scenic and wildlife observation; approximately 34,000 visitors visit Brazoria NWR each year. Brazoria NWR is open year-round. Visitors can travel to parts of the Refuge via designated auto routes, established foot trails, and by boat on the Nicks, Salt, and Lost Lakes by way of the Gulf Intracoastal Waterway or Bastrop Bayou. The Brazoria NWR Discovery Center includes a visitor center and space for educational events. Seasonal events, including tours, exhibits, and nature walks, also take place at the Refuge.

Two public waterfowl hunting areas exist at Brazoria NWR. The Christmas Point Public Waterfowl Hunting Area encompasses approximately 4,000 acres and is located southwest of the Gulf Intracoastal Waterway. The area may only be accessed by boat. The Middle Bayou Public Waterfowl Hunting Area encompasses approximately 1,500 acres and is located south of County Road 227. Hunting is permitted during early teal season, which occurs in September; for the 2013 season, early teal season is tentatively scheduled for 16 days in September. Hunting hours during early teal season are from early morning until 12:30 PM. Regular season waterfowl hunting is permitted only for ducks, geese, and coots from late November through mid-January. Sport fishing is permitted in three designated areas accessible by vehicle and foot year-round. Sport fishing is also permitted by boat on Salt, Nicks, and Lost Lakes and Bastrop Bayou. Hunters and fishers must follow the regulations set forth by Brazoria NWR regarding use of the area.

## 5.0 PROPOSED ENVIRONMENTAL STIPULATIONS AND OPERATIONAL COMMITMENTS

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Best management and operational procedures will be followed throughout the seismic survey to control, reduce, and correct adverse impacts. These management procedures will provide the Refuge Manager with high-quality information throughout the course of the seismic survey and allow the Refuge Manager to modify the course of the survey to protect Refuge resources, if necessary.

Samson has agreed that the Refuge Manager and environmental monitors will retain the right to stop work in any situation that endangers a listed threatened or endangered species or its habitat, causes significant harm to Refuge resources, threatens cultural or historic resources, or endangers public safety. Any sightings of cultural features or artifacts, or threatened or endangered species by any personnel on-site will be immediately reported to the Refuge Manager.

As per regulations specified in 50 CFR 29.32 regarding oil and gas exploration activities on FWS lands, the following stipulations apply:

- Samson and its designated seismic contractor, to the greatest extent practicable, conduct all exploration in such a manner as to minimize damage, erosion, pollution, or contamination to the lands, waters, facilities, and vegetation of the area;
- So far as is practicable, seismic operations must be conducted without interference with the operation of the Refuge or disturbance to the wildlife thereon;
- The physical occupancy of the area must be kept to the minimum space compatible with the conduct of efficient mineral operations; and
- Upon the cessation of operations, the area must be restored as nearly as possible to its condition prior to the commencement of seismic operations.

Third-party environmental monitors will be hired at Samson's expense to ensure compliance with Refuge regulations and special conditions of the SUP. Samson will contract the company to provide the monitors, as mutually agreed upon with the Refuge Manager prior to the hiring of environmental monitors. Samson will provide the resumes of the contract company's selected environmental monitors to FWS for final approval. The monitors will be supervised by a designated third-party liaison, who will report to both Samson and the Refuge Manager. The environmental monitors will be provided a radio and cell phone for communications with crews. Monitors will also have access to airboats and airboat operators when work is being conducted in wet areas, and will have access to ATVs for work in other areas.

Samson is responsible for any damage caused by the seismic contractor or any other sub-contractor during the seismic survey, and for restoring the area as near as practicable to its original condition prior to the commencement of seismic operations.

## **5.1 Operational Methods to Implement Commitments**

- **Training Program:** Training of field personnel assigned to working within Brazoria NWR will be conducted prior to commencing seismic activities. Training will include these environmental stipulations and operational commitments, as well as environmental awareness training. Environmental awareness training will include providing pictures and descriptions of all threatened and endangered species, and species of concern. In particular, the mottled duck will be thoroughly reviewed. Training will be repeated periodically throughout the Project to account for turnover in personnel.
- Field personnel will record GPS coordinates of any species of concern observed during the Project and turn them in to Refuge management.
- **Monitoring Program:** One environmental monitor will be present with each crew type (survey, drilling, and recording) at all times. One monitor will rove between crews of the same type throughout the Project Area; additional monitors will be on duty when determined necessary by the Refuge Manager or the third-party liaison. Daily operations logs will be kept by the environmental monitors and the seismic survey project manager. These logs will document all daily activities, as well as any environmental impacts, such as rutting or damage to levees. Daily updated logs will be made available to the Refuge Manager and seismic contractor each morning and a final composite log will be given to the Refuge Manager and seismic contractor upon completion of the Project.
- An Environmental Orientation meeting will be held at the beginning of the Project. Attendance by all key seismic field employees and the environmental monitors will be required. FWS will designate representatives to attend and participate in this orientation.
- Daily tailgate safety and environmental meetings will be conducted by each crew to review safety and environmental concerns and operating procedures. These will provide an additional forum for the environmental monitors or the Refuge Manager to address concerns and provide an opportunity for any and all field personnel to ask questions or address issues.
- In the event of adverse weather conditions, the Refuge Manager may halt all seismic operations. Should work be delayed for this reason, the Refuge Manager is authorized to extend the period of operation up to an additional 30 days.

- Samson will pressure wash all vehicles prior to starting work at the Refuge to avoid introducing any foreign plants or materials. Boats and vehicles will be inspected by the environmental monitors prior to entering the Refuge.

## **5.2 Stipulations to Protect Cultural Resources**

- Samson will prepare an Avoidance Plan for the Project Area. This plan will be submitted to the THC and the U.S. Army Corps of Engineers' (COE) archaeologist for approval.
- Samson will offset source points at least 50 meters from any known or designated archaeological sites and cemeteries.
- Samson will offset source points from high probability areas unless an archaeological survey is conducted in these areas and any site located as a result of the survey is avoided.
- The Refuge Manager and the environmental monitors will have stop work authority for any activity that may threaten a cultural artifact or feature and, if necessary, Samson can avoid the particular threatened area and continue operations outside of this area.

## **5.3 Stipulations to Protect Birds, Wildlife, and Vegetation**

- Samson will offset source and receiver points at least 1,000 feet from active rookeries during the nesting season (February 15 through September 1).
- Samson will offset source and receiver points 1000 feet from any known locations of threatened or endangered species in accordance with agency requirements.
- Samson will offset lanes of travel, source and receiver locations at least 300 feet from mottled duck nests. Environmental monitors will mark potential nests, identified by a bird flushing from grassland habitat during nesting season, at four corners at least 300 feet from the flush site, identify the potential nest location by GPS and report the potential nest location to the third-party liaison as an avoidance area. No attempt to locate the nest will be made.
- Samson will offset lanes of travel, source and receiver locations at least 200 feet from alligator nests. Environmental monitors will mark nests on four corners as least 200 feet from the nest, identified by GPS and reported to the third-party liaison as an avoidance area.
- Samson will make least impact equipment selections based on habitat type and substrate conditions. In particular, Samson will use airboats where possible in the Slop Bowl area

in the southwest portion of the Refuge and lightweight aluminum tracked vehicles (marsh buggies) where airboat use is not possible in the Slop Bowl.

- Lightweight equipment will be used for drilling in all areas. Use of terra-tired vehicles must be approved by the Refuge Manager and will only be used in upland areas with dry soils and generally vegetated habitats, where the potential for rutting is minimal.
- Samson will use the route of least resistance along source and receiver lines, including the use of existing roads where feasible, to the extent practicable, in order to minimize impacts on vegetation and soils.
- Samson will use open water areas for access to the extent practicable.
- Samson will use lightweight drilling equipment (airboats, airboat drills, marsh buggies, marsh buggy drills) in wetland areas to minimize impacts.
- Equipment used to haul water to drills will be consistent with the drilling vehicles used in any particular habitat. On-site determinations will be made by environmental monitors and/or FWS personnel at the time of drilling as to whether water will be hauled to the drills or will be obtained at the drilling sites. If holes are dug at the drilling sites, they will be promptly re-filled, leveled, and repaired as near as practicable to their original condition. Wherever practicable, water available at the drill sites will be used.
- Samson will minimize the number of passes along source and receiver lines to the greatest extent practicable.
- Samson will instruct equipment operators to offset paths of vehicles in wetland areas with each pass to minimize the likelihood of compaction and reduce recovery time for the vegetation. Lightweight aluminum tracked vehicles (marsh buggies) will be required to offset by a full path (no overlap), while airboats will be required to offset by half the boat width.
- All ruts produced by mobile equipment will be kept to a minimum and will be repaired, as nearly as possible, to conditions comparable to that prior to commencement of the seismic survey. The Refuge Manager will have input into the type of mitigation necessary to repair all rutting.
- Samson will re-contour and fill land-based shotholes to pre-Project conditions.
- Samson will use helicopters for support of recording operations on land to minimize impacts.

- Samson will provide third-party environmental monitors in accordance with FWS requirements to ensure compliance with the SUP.
- All seismic activities, aside from surveying, will be conducted between April 15 and October 15 to reduce impacts on migratory birds and can continue to November 15 under certain circumstances as approved by the Refuge Manager as outlined in Section 2.4.
- Seismic survey crews will be informed of the importance to minimize disturbance to immature and flightless birds and mottled ducks during their molting season. Environmental monitors will walk ahead of equipment to ensure nests or molting birds are not present. Likely molting habitats (freshwater ponds) or concentrations of wildlife as identified by the Refuge Manager or environmental monitors will be avoided with a 300 foot buffer.
- Samson will use lightweight equipment and extreme caution when crossing over fault lines in the southwest portion of the Refuge to minimize compression of the fault lines and subsequent saltwater intrusion.
- Killing or harassing any wildlife is prohibited; this includes snakes, turtles, frogs, feral hogs and any other wildlife. Only environmental monitors or Refuge personnel are authorized to remove venomous snakes from work areas. Feral hogs will likely flee the area ahead of crews. However they can become a potential wildlife hazard. Care should be taken if an aggressive animal is encountered.
- Spotlighting of wildlife by field personnel is prohibited.
- Fishing by field personnel while on duty is prohibited.
- The Refuge Manager and the environmental monitors will have stop work authority for any activity that threatens to harm a threatened or endangered species, or species of special concern, or may cause irreparable harm to Refuge resources.

#### **5.4 Stipulations to Minimize Interference with Public Use of the Refuge**

- Samson will avoid, to the extent practicable, conducting seismic activities in the public use area on the western side of the Refuge during spring and fall when visitation from school groups is high.
- Samson will provide adequate signage to inform the public of the seismic program at highly visible public access points. Signs advising the public regarding seismic activities

or signs addressing public safety will be approved by the Refuge Manager before being posted.

- In the event any roads, trails, parking areas, levees, or other infrastructure are damaged by the seismic survey, repairs will occur immediately, or as soon as practicable under the existing conditions.
- All cans, bottles, and other trash generated by the seismic crews will be removed from the Refuge daily or placed in designated trash receptacles. Trash receptacles must be emptied and trash removed from the Refuge daily.
- All equipment and debris incidental to the survey, such as flagging, wires, poles, etc., will be removed following the cessation of activities within each swath.
- Samson will not detonate source points within 200 feet of any Refuge visitor and/or member of the public. This is well over the industry-accepted safe distance for individuals from a source point. Crew members will ensure that there are no visitors in the vicinity of the source point being detonated.

## **5.5 Other Commitments or Stipulations**

- Samson will coordinate with the Refuge Manager on the schedule for disking of moist soil units in the northern portion of the Refuge to minimize interfering with management of these units.
- All water control structures, wells, and water gauges will be avoided.
- Samson will coordinate with the Refuge Manager on the schedule for prescribed burning to avoid interfering with management of the burn units.
- Samson will use best management practices when crossing over levees, such as crossing at 90 degree angles and not rutting during crossing.
- Possession of firearms is prohibited by all Project personnel.
- Damage to levees, ditches, or other waterway banks or shorelines will be minimized to the extent practicable by conducting drilling activities on one side of a waterway before proceeding to the other side to minimize crossings; using plywood, PVC pipes, or other materials at crossing locations; and avoiding lateral travel along banks and shorelines.

- All farmers conducting agricultural operations on the Refuge will be contacted and provided with information on the seismic survey and its impacts on their operations before any survey activities occur.
- Explosives will be stored in a secured location in accordance with Bureau of Alcohol, Tobacco, and Firearms regulations as approved by the Refuge Manager. No explosives will be stored on the Refuge.
- Work will be conducted during daylight hours within the Refuge, with the exception of troubleshooting operations as necessary.
- Boat launch sites, water crossings, and vehicle/boat travel lanes will be approved by the Refuge Manager following a coordinated field review with Samson.
- Areas, such as boat launches and access points, will be restored according to FWS specifications if disturbed by seismic activities.
- Samson will confine vehicle and equipment movement to the designated access routes at all times. While on-site, Samson and/or its contractors will confine all activities to the designated work areas.
- Samson will establish and identify to FWS a designated point of contact who will be available at all times while Samson is conducting seismic survey operations for communication and coordination with FWS.
- FWS and Samson will cooperatively develop a Contingency Plan to cover the potential occurrence of Project-related or other incidences of wildfire during the seismic survey. Survey crews will carry basic fire suppression equipment (shovels, fire extinguishers, etc.). Crews will report any occurrence of wildfire to the Refuge Manager immediately.
- The Brazoria NWR speed limit of 15-45 miles per hour will be strictly enforced. Lower speed limits may be posted at any time as deemed necessary by the Refuge Manager.
- FWS will not be liable for accidents or injuries caused by Samson's employees, contractors, or other assigns during the seismic survey.
- Field oil or fluid changes will be permitted on the Refuge in selected areas determined by the Refuge Manager. Any spilled oil will require prompt clean-up; therefore, oil sorbent pads will be required on-site at all times as a precautionary measure.
- Samson will provide the Refuge Manager with proof of sudden and accidental pollution insurance or post a bond prior to the initiation of the seismic survey.

- Samson will advise the Refuge Manager at least 72 hours in advance of the initial survey activities and shall coordinate all activities during the seismic survey on the Refuge with the Refuge Manager.
- All applicable Federal and State regulations, including all Refuge-specific regulations, whether or not they are specified in the SUP, will be enforced and adhered to by all seismic personnel at all times, except where explicitly exempted by the Refuge Manager. Seismic personnel will comply with all applicable ordinances, laws, decrees, statutes, rules, and regulations of all Federal and State entities.
- FWS can add to or modify stipulations of the SUP during the seismic survey should additional or modified stipulations be needed to protect Refuge resources or public safety.
- Samson will furnish locks for gate access by field crews.
- All key field personnel will carry a copy of the SUP with them at all times so that each crew is in possession of a copy of the SUP.

## 6.0 IMPACTS ASSESSMENT

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### 6.1 Geology and Soils

Brazoria NWR consists primarily of wetlands. Soil compaction and rutting are primary concerns, particularly in the Slop Bowl area in the southwestern portion of the Refuge. Any compaction or rutting will be temporary during Project operations only; however, impacts could be long-term, depending on the soil type, and compaction lines have been identified years after seismic surveys have been completed.

#### 6.1.1 No Action Alternative

Under this alternative, FWS would not issue a SUP for seismic surveys within the Refuge and impacts on geology and soils could be greater than the Proposed Action. Damage to sensitive soils and associated habitat could increase since Refuge management would not be consulted regarding access and work methods in sensitive habitats. Environmental monitors would not be present during operations to recommend the use of lightweight drilling equipment that could minimize impacts on geology and soils.

#### 6.1.2 Proposed Action Alternative

Under this alternative, FWS would issue a SUP for seismic surveys within the Refuge. Under the Proposed Action, Samson would coordinate with resource agencies to develop a plan of operations to minimize impacts on geology and soil resources.

Shotholes would be drilled at primarily 110 feet, unless proximity to sensitive resources requires adjustments, into underlying geologic features. The primary effect would be disturbance of topographic features at shothole locations. Shotholes would be backfilled with bentonite and restored as nearly as practicable to pre-existing conditions; therefore, significant changes to underlying geology that would affect topography or other surface conditions would not be expected.

During Project work, soil compaction, rutting, and/or soil mixing may result from the movement of heavy equipment. Both soil compaction and rutting could affect ground elevation that may impact hydrology and associated habitat by creating depressions where water would pond or high areas that may dry out unnaturally. Hydrologic impacts, specifically those which may cause saltwater intrusion or increased tidal energies, can, in extreme situations, result in the loss or degradation of marsh areas. Soil mixing, as a result of rutting or other disturbance, could also affect habitat features. Refer to Section 6.2 for details regarding potential impacts on the

hydrologic regime and Section 6.3 for details regarding impacts on habitat as a result of this Project.

Project personnel would minimize disturbance to soils through the use of lightweight aluminum tracked vehicles and airboats as well as terra-tired vehicles in upland areas. Samson would work with the environmental monitors to select the appropriate equipment based on site-specific conditions as discussed in Section 2.4.

Through issuance of the SUP, FWS would ensure that stipulations to protect the local geology and soils were put into place and would ensure restoration and/or mitigation of unavoidable damages.

## **6.2 Climate and Hydrology**

In addition to the potential impacts to hydrologic processes in marsh areas described above, as a result of soil compaction and rutting, the impacts of the proposed seismic survey on hydrology can be categorized as effects on quality of surface water (i.e. turbidity) and effects on quality of groundwater.

### **6.2.1 No Action Alternative – Hydrology**

Under this Alternative, it is expected that impacts on surface water and groundwater could be greater than the Proposed Action. The seismic survey would require moderate quantities of water for the drilling of the shotholes. Under the No Action Alternative, water for drilling in dry areas may come from unapproved locations, such as man-made teal ponds on the Refuge.

Groundwater may be negatively impacted under the No Action Alternative as well. Field oil and fluid changes may take place on the Refuge in unapproved locations. Oil and other fluids spilled may not be dealt with properly and potentially contaminate groundwater without Refuge management and environmental monitor consultation.

### **6.2.2 Proposed Action Alternative – Hydrology**

Under this Alternative, impacts on surface water and groundwater could be less than the No Action Alternative. Refuge management, along with environmental monitors, would ensure that water for drilling in upland and dry areas is brought in by low-ground pressure tracked vehicles from outside sources or, where approved, from irrigation ditches, bayous, and similar water courses. Groundwater impacts would be mitigated by requiring oil and fluid changes to occur on Refuge-selected locations. Any spills would be cleaned to standards which the Refuge deems appropriate.

## **6.3 Vegetation**

Impacts on vegetation from Project activities will primarily include disturbance by vehicular traffic and equipment accessing and working at each shothole location. Traffic and equipment accessing shothole locations will crush or clear some vegetation.

### **6.3.1 No Action Alternative**

Under this Alternative, FWS would not issue a SUP for seismic surveys within Brazoria NWR and impacts on vegetation could be greater than the Proposed Action. Damage to sensitive vegetation could increase, since Brazoria NWR management would not be consulted regarding access and work methods in sensitive habitats. Environmental monitors would not be present during operations to recommend the use of lightweight drilling equipment that could minimize impacts on vegetation.

### **6.3.2 Proposed Action Alternative**

Under this Alternative, FWS would issue a SUP for seismic surveys within the Refuge. Under the Proposed Action, Samson would coordinate with resource agencies to develop a plan of operations to minimize impacts on vegetation resources. Throughout the Project, environmental monitors would be present to watch the activities of each crew. Protective actions would include:

- Using least impact equipment selections based on habitat type and substrate conditions to minimize impacts on vegetation;
- Limiting off-road travel to the minimum required, including making only one pass along each source line during the drilling process where possible, to minimize impacts on vegetation;
- Using the route of least resistance along source and receiver lines, to the extent practicable, to minimize impacts on vegetation;
- Using airboats in areas of known or visible seagrass beds;
- Using lightweight drilling equipment (e.g., airboats, airboat drills, marsh buggies and marsh buggy drills) in wetland areas to minimize impacts; and
- Offsetting vehicle paths in wetland areas to minimize compaction and reduce recovery time of the vegetation.
- Additionally, Samson would be responsible for restoration of damaged habitats.

Through issuance of the SUP, FWS would ensure that stipulations to protect vegetation were put into place and would ensure restoration and/or mitigation of unavoidable damages.

## **6.4 Wildlife**

Impacts on wildlife resulting from the Proposed Action will be short-term and temporary. Project activities could result in disturbance and displacement of mobile species, which could leave the immediate vicinity of Project activities. Sufficient habitat is present at Brazoria NWR for displaced species to relocate during disturbance from Project activities. Small mammal, amphibian, and reptile populations may experience some short-term, localized loss of individuals during Project operations; however, a change at the population level is not expected.

### **6.4.1 No Action Alternative**

Under this Alternative, FWS would not issue a SUP for seismic surveys within Brazoria NWR. Under this Alternative, wildlife impacts could be greater than those under the Proposed Action. Samson would not be required to coordinate with FWS to develop an operations plan protective of sensitive resources. Without a SUP, Samson could conduct Project activities outside of schedule limitations that would be specified by FWS under a SUP, such as conducting operations during periods of migratory bird use or bird nesting seasons, and could result in increased disturbance impacts on wildlife.

### **6.4.2 Proposed Action Alternative**

Under this Alternative, FWS would issue a SUP for seismic surveys within Brazoria NWR. Under the Proposed Action, Samson would coordinate with resource agencies to develop a plan of operations to minimize impacts on wildlife resources. Project design features currently proposed by Samson include:

- Offsetting source and receiver points at least 1,000 feet from active rookeries during the bird nesting season (February 15 through September 1);
- Offsetting source points 400 feet from any known or designated oyster reefs unless an exception is approved; and
- Providing environmental monitors while working in areas containing tidal flats to ensure appropriate offsets from established rookeries.

The environmental monitors would be responsible for identifying the locations of ground-nesting birds, marking those areas with flagging, and ensuring that equipment and crews stay an appropriate distance from the locations, as set by the Refuge Manager. Qualified approved biologists would also be present during work in state waters to assess impacts on fish. These

biologists would observe the waters surrounding each source hole for the presence/absence of marine mammals, in addition to fish. If a marine mammal is observed, detonation of the source hole would be delayed until the animal leaves a defined exclusion zone. The use of these design features could minimize impacts on Refuge resources more effectively than the No Action Alternative.

## **6.5 Threatened and Endangered Species and Species of Concern**

No federally listed threatened or endangered species or species of concern are expected to be directly affected by Project activities. Project activities could result in negligible disturbance to state listed species (reddish egret and white-faced ibis) and/or species of concern if present in the immediate vicinity of the Project. Disturbance impacts will likely result in species avoidance of the active work area.

Species of concern that could be present during Project activities, which are scheduled to occur within the work window of March 15 to October 15, include the American oystercatcher, bald eagle, black rail, black skimmer, brown pelican, dickcissel, loggerhead shrike, mottled duck, northern bobwhite, painted bunting, reddish egret, seaside sparrow, white-faced ibis, white-tailed hawk, Wilson's plover, yellow rail, diamondback terrapin, and Gulf saltmarsh snake. No Action Alternative

Under this Alternative, FWS would not issue a SUP for seismic surveys within Brazoria NWR. Impacts on threatened and endangered species, and species of concern could be greater than those under the Proposed Action. Without a SUP, Samson would not consult with Brazoria NWR management for identification and avoidance of listed species and priority species of concern that may be present on Brazoria NWR.

### **6.5.1 Proposed Action Alternative**

Under this Alternative, FWS would issue a SUP for seismic surveys within the Refuge. Samson would coordinate with FWS to develop a plan of operations to minimize impacts on sensitive resources, including threatened and endangered species, and species of concern. Coordination with Brazoria NWR management could allow for identification and avoidance of listed species. Project design features that could reduce the potential for impact on a listed species or species of concern within Brazoria NWR include offsetting source and receiver points from any known locations of listed species.

## **6.6 Historical and Archeological Resources**

Most of the impact from the proposed seismic survey will be related to surface disturbance. This disturbance will be limited to airboat access, vehicular traffic, and seismic shotholes and receiver



lines. Subsurface disturbance from the drills will be limited to the approximately 4-inch hole drilled at each shothole location.

Within the Project boundaries in Brazoria NWR, there are currently no NRHP listed properties; however, 11 identified archeological sites are located within or very near the Project boundaries of the Refuge. This assessment is based on a search of the site files at TARL and the THC.

Samson will prepare an avoidance plan for the Project Area to be submitted to the THC and the COE's archeologist for approval. Samson will offset source points at least 50 meters from any known or designated archeological sites and cemeteries. Additionally, Samson will offset source points from high probability areas unless an archeological survey is conducted in these areas and any site located as a result of the survey is avoided. The Refuge Manager and the environmental monitors will have stop work authority for any activity that may threaten a cultural artifact or feature.

Because of the commitments made to the State Historic Preservation Officer (SHPO), all historical and archeological resources will be protected regardless of the issuance of a SUP. Therefore, there would be no difference in impacts on historical and archeological resources between the No Action Alternative and the Proposed Action Alternative.

Site location information is protected by the National Historic Preservation Act of 1966 (as amended), Title III §304 and by the Texas Antiquities Code §191.004, and is not intended for public distribution. All information regarding the location of cultural or historic resources should be kept confidential.

## **6.7 Land Use, Aesthetics, Socioeconomic, and Recreational Resources**

### **6.7.1 No Action Alternative**

Under this alternative, FWS would not issue a SUP for seismic surveys within the Refuge and impacts on land use, aesthetics, socioeconomic, and recreational resources could be greater than the Proposed Action. Damage to aesthetics and recreational resources could increase, since Refuge management would not be consulted regarding access and work methods in sensitive areas.

### **6.7.2 Proposed Action Alternative**

Under this alternative, FWS would issue a SUP for seismic surveys within the Refuge. Under the Proposed Action, Samson would coordinate with resource agencies to develop a plan of operations to minimize impacts to land use, aesthetics, socioeconomic, and recreational resources.

### **6.7.2.1 Land Use and Aesthetic Resources**

No permanent change in current land use is proposed; therefore, no permanent impacts would occur to land use as a result of the Project.

The proposed Project would have temporary effects on the aesthetic resources. The presence of equipment, vehicles, guide wires, and crews would disrupt the visual resources experienced by visitors. Additionally, the vegetation and ground surface would be disturbed at shothole locations and by tracked equipment, thus modifying existing visual resources related to vegetative cover. Upon Project completion, equipment and guide wires would be removed and shothole locations and vegetation would be allowed to revegetate naturally, or be restored as closely as practicable to pre-existing conditions. Therefore, no permanent impacts on aesthetic resources would occur as a result of the Project. Samson would be responsible for repairs relating to damage to any facilities within the Brazoria NWR, including roads.

### **6.7.2.2 Socioeconomic Resources**

The proposed Project will provide the communities closest to Brazoria NWR with short-term, positive economic benefits. These benefits will result from the purchase of lodging, food, fuel, supplies, and services in nearby cities by Project personnel. These impacts would be limited to the duration of the Project and are not expected to create a measurable impact on socioeconomics within the Project Area. Existing Samson or contract employees would be employed by this Project and would likely make up the bulk of the workforce; therefore, few to no temporary increases in employment in the local community would be expected.

### **6.7.2.3 Recreation Resources**

Presence of Project personnel at Brazoria NWR, including vehicular, boat, and air traffic, as well as the noise generated by drilling shotholes, would impact the recreational experience for visitors. In general, impacts would occur outside of the main public use areas; however Project work may occur within public use areas, including hiking, boating, and fishing areas. Public use areas would be temporarily closed during Project work to ensure the safety of both Project personnel and visitors in public use areas. Additionally, Project work may temporarily close areas used for the Brazoria NWR environmental education program or special events. . The presence of activity and noise from shothole drilling could result in localized disruptions to wildlife during Project work, but any disruptions would be temporary as work is completed. Samson would work with Brazoria NWR representatives to minimize interference with special events, educational opportunities, and other activities.

The proposed Project is scheduled for operation within Brazoria NWR in the approved timeframe of March 15 to October 15. Per the current Project schedule, Project work would be

complete by the beginning of regular hunting season in November; however, proposed activities would occur during early teal season in September. During early teal season, access to hunting areas would be restricted until designated hunting hours are closed at 12:30 PM to ensure the safety of both Project personnel and hunters.

If Project work were to take longer than expected and occur during hunting season, hunting areas would be temporarily closed to ensure the safety of both Project personnel and hunters. The presence of activity and noise from shothole drilling could result in localized disruption to waterfowl in areas that may not be closed to hunting activity. Based on the duration of the Project, Project work would not result in significant impacts on hunting.

## **6.8 Cumulative Impacts**

Cumulative impacts at the Brazoria NWR related to the Project include the effects of repetitive seismic surveys and ongoing oil and gas development.

The most recent seismic survey on the Brazoria NWR was conducted during 2008 (FWS 2012). Impacts from repeated seismic surveys include soil compaction or rutting; vegetation disturbance; localized mortality of small mammals, reptiles and amphibians; and temporary impacts on aesthetics. Repeated seismic surveys could result in long-term effects in sensitive habitats, including rutting and loss of wetland habitat due to vehicle travel, hydrologic impacts and the loss or degradation of marsh habitats.

Current oil and gas activities on the Brazoria NWR include natural gas wells in the Slop Bowl and exploration drilling around the Hoskins Mound inholding (FWS 2012). Impacts from oil and gas development include subsidence; wildlife disturbance and localized mortality; and habitat fragmentation due to infrastructure development (e.g., access roads). The Slop Bowl has been degraded by oil and gas developments (including pipelines), which caused subsidence and, therefore, altered wetland habitat.

### **6.8.1 No Action Alternative**

Under this alternative, FWS would not issue a SUP for seismic surveys within the Refuge and cumulative impacts on resources could be greater than the Proposed Action since Refuge management would not be consulted regarding access and work methods in sensitive areas.

### **6.8.2 Proposed Action Alternative**

Under this alternative, FWS would issue a SUP for seismic surveys within the Refuge. Under the Proposed Action, Samson would coordinate with resource agencies to develop a plan of operations to minimize cumulative impacts from repeated seismic operations and current oil and gas development.



Samson would implement the mitigation measures described in Sections 6.1-6.7 to minimize impacts to Brazoria NWR, and Samson would be responsible for restoring damaged habitat.

## 7.0 REGULATORY FRAMEWORK

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### 7.1 Texas Coastal Management Program

Coastal Zone Management Act of 1972: The Texas Coastal Management Program (TCMP) is administered by the Texas Coastal Coordination Council (TCCC) under the Texas General Land Office (TGLO). The Final Environmental Impact Statement for the TCMP was released in August 1996. The federal consistency requirement of the TCCC for the Project will be met through the Individual Permit process with COE.

### 7.2 Floodplain Management

Executive Order 11988, Floodplain Management: The Project is situated in a floodplain. The activities associated with the proposed Project must be located in the floodplain of Brazoria NWR to make the geophysical prospecting feasible. The Proposed Action will not induce increased flooding in developed areas and will not contribute to increased future flood damage.

### 7.3 Waters of the United States

Executive Order 11990, Protection of Wetlands: The Proposed Action has been analyzed for compliance with Executive Order 11990. Every attempt has been made to minimize impacts on wetlands and preserve the value of wetland areas. Impacts on wetlands from the Proposed Action have been identified in this EA. Special actions, including the use of airboats and specially designed tracked vehicles, have been developed to mitigate impacts on wetlands.

Clean Water Act Section 404 / Rivers and Harbors Act Section 10: Section 404 and Section 10, through the COE, afford protection of non-tidal and tidal waters of the United States, respectively. Samson will obtain authorization from the COE to conduct proposed operations in wetland areas under an amendment to Department of the Army Individual Permit SWG-2012-00906 for the Greens Lake 3-D. The amendment has been applied for and is being reviewed by COE and other resource agencies. Samson and all its contractors will comply with the terms and conditions of the COE permit.

### 7.4 Endangered Species Act Consultation

Endangered Species Act of 1973, as amended: Interagency consultation procedures under Section 7 of the Endangered Species Act will be conducted by FWS.



## **7.5 State Historic Preservation Office Notification**

The SHPO was notified by Samson of the proposed Project. Samson's contractor (Cardno ENTRIX) has completed a file search of cultural and archaeological resources within the Project Area in Brazoria NWR. This file search did not reveal any listed sites currently on the NRHP; however, 11 sites were identified within or very near the Project Area. This assessment is based on a search of the site files at TARL and the THC. The sites will be flagged and avoided. If a site of potential historical, archaeological, or cultural interest is encountered, work will be stopped and appropriate authorities notified immediately.

## **7.6 Water Quality**

State water quality certification through Section 401 of the Clean Water Act will be obtained from the Railroad Commission of Texas through the COE permit process. In addition, Samson has obtained a letter from the Railroad Commission of Texas stating that shotholes up to 500 feet in depth will not affect groundwater quality; therefore, the proposed Project shothole depth will adequately protect groundwater. Samson will also submit any required permits for surface water use to the TCEQ.

## **7.7 State Submerged Lands**

Some submerged tracts of land, Permanent School Fund tracts and/or Relinquishment Act tracts in the vicinity of the Refuge are owned and managed by the TGLO. An application for a permit to perform seismic work on state-owned lands will be submitted directly by Samson to the Minerals Leasing Division of TGLO. This permit application will be reviewed by State and Federal agencies.

## **7.8 Essential Fish Habitat**

FWS will consult with NMFS regarding impacts on Essential Fish Habitat.

## 8.0 REFERENCES

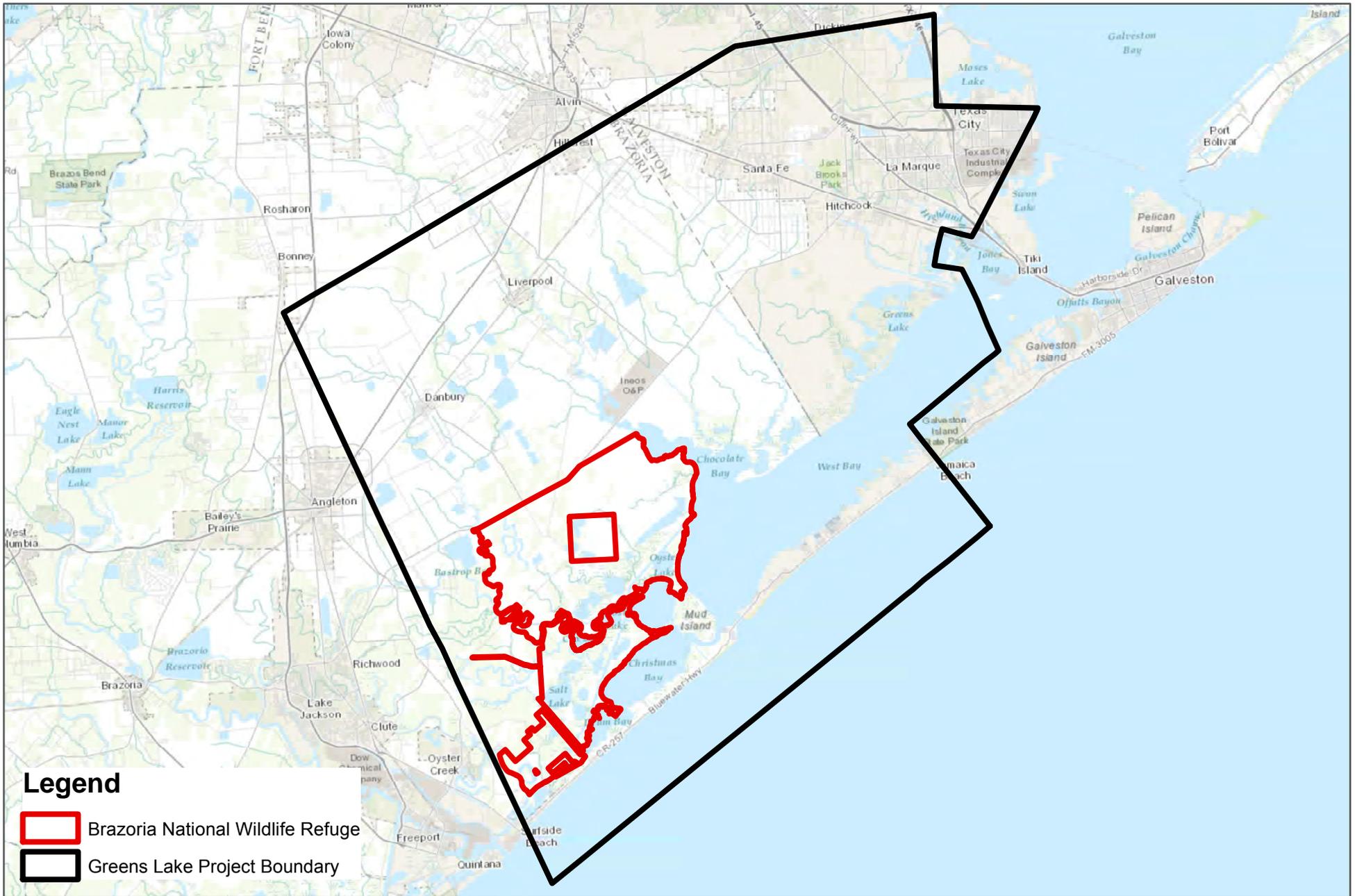
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Proposed 3-D Seismic Program  
on Brazoria National Wildlife  
Refuge

# Figures



**Legend**

- Brazoria National Wildlife Refuge
- Greens Lake Project Boundary

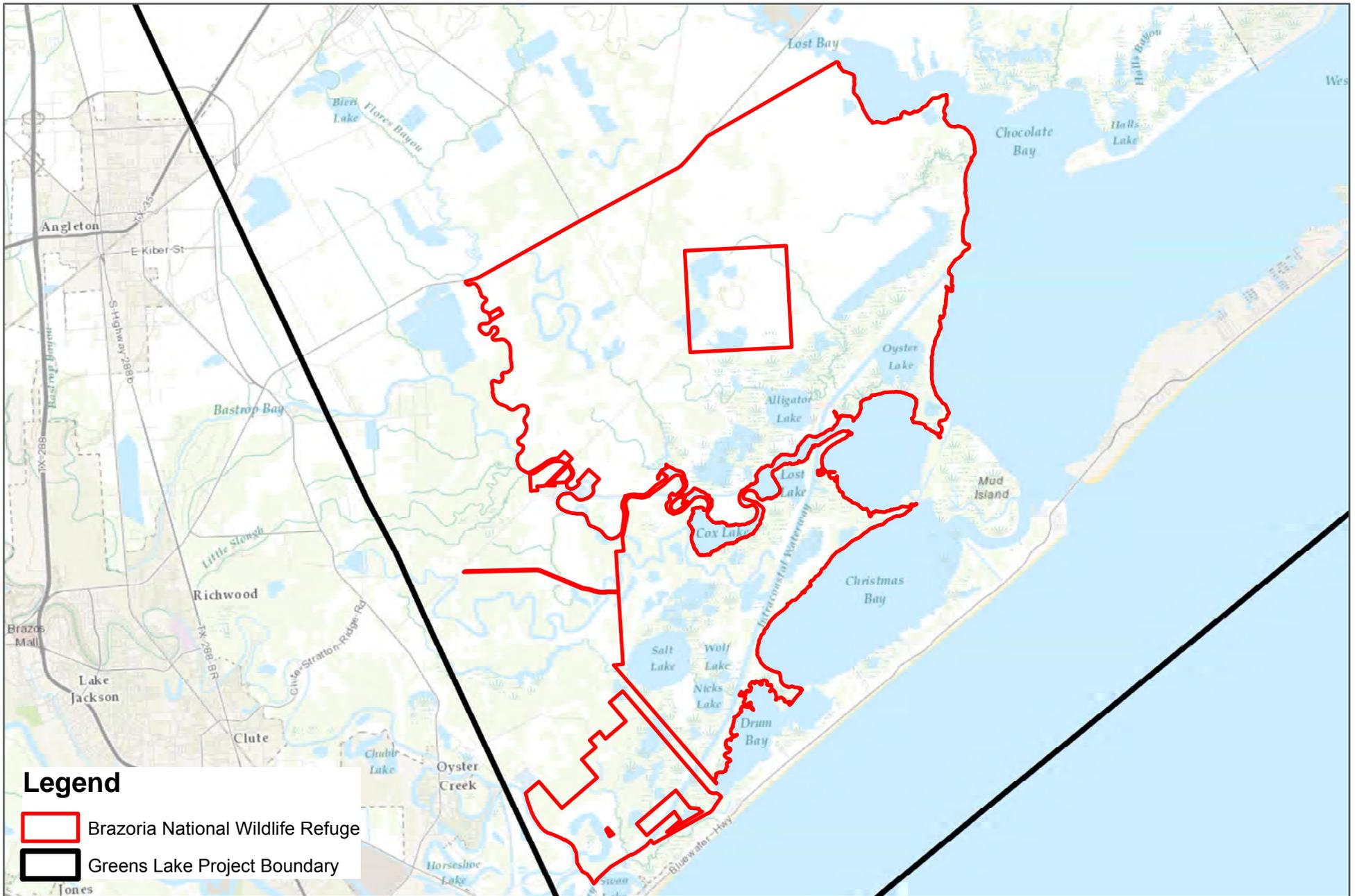


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**Figure 1.1-1: Project Site**  
**Samson Greens Lake 3-D Seismic Survey**  
**Brazoria County, Texas**



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**Legend**

- Brazoria National Wildlife Refuge
- Greens Lake Project Boundary

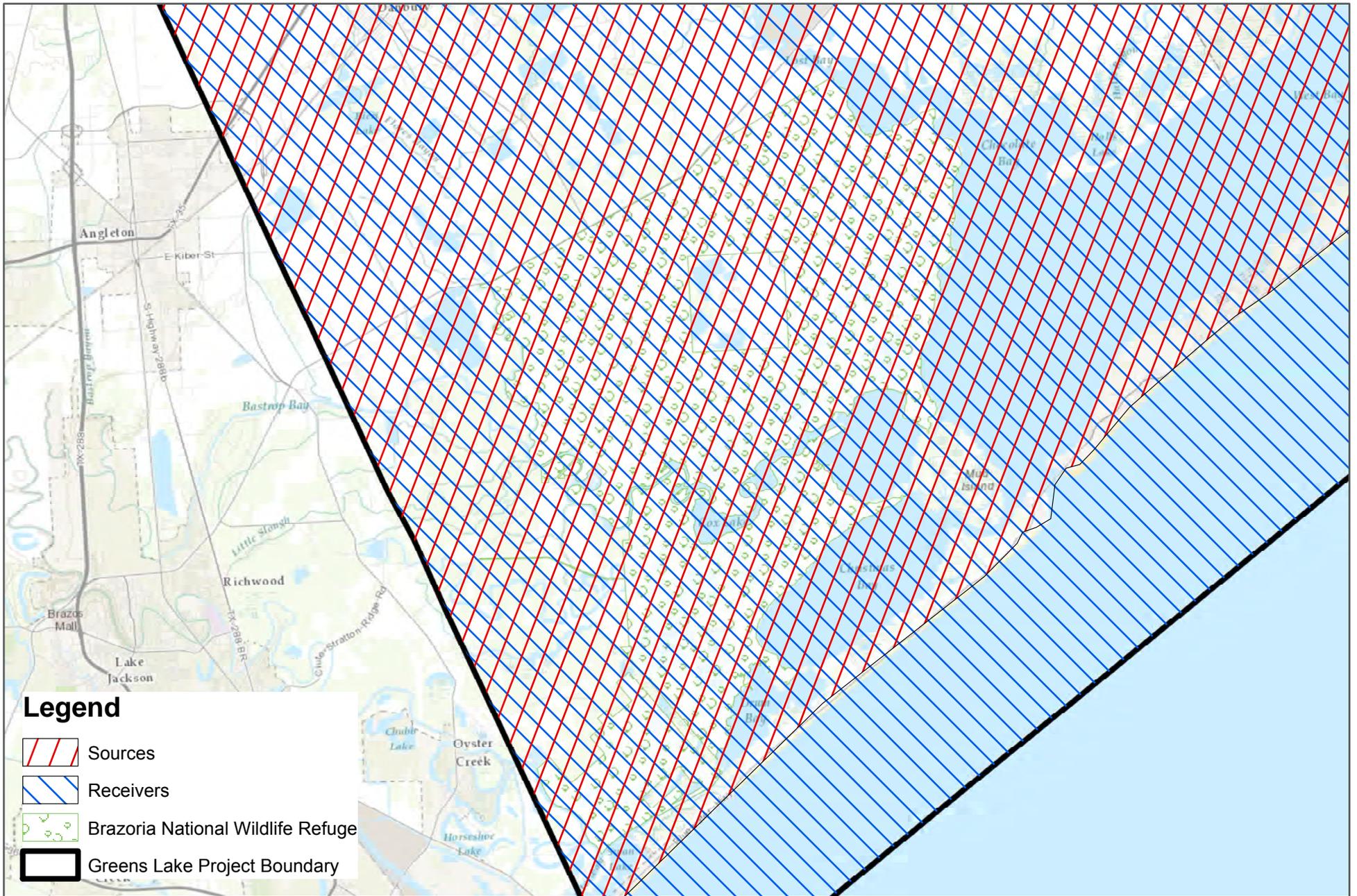
**Figure 1.1-2: Environmental Assessment Area**  
**Samson Greens Lake 3-D Seismic Survey**  
**Brazoria County, Texas**



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 Topo Maps

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**Legend**

-  Sources
-  Receivers
-  Brazoria National Wildlife Refuge
-  Greens Lake Project Boundary

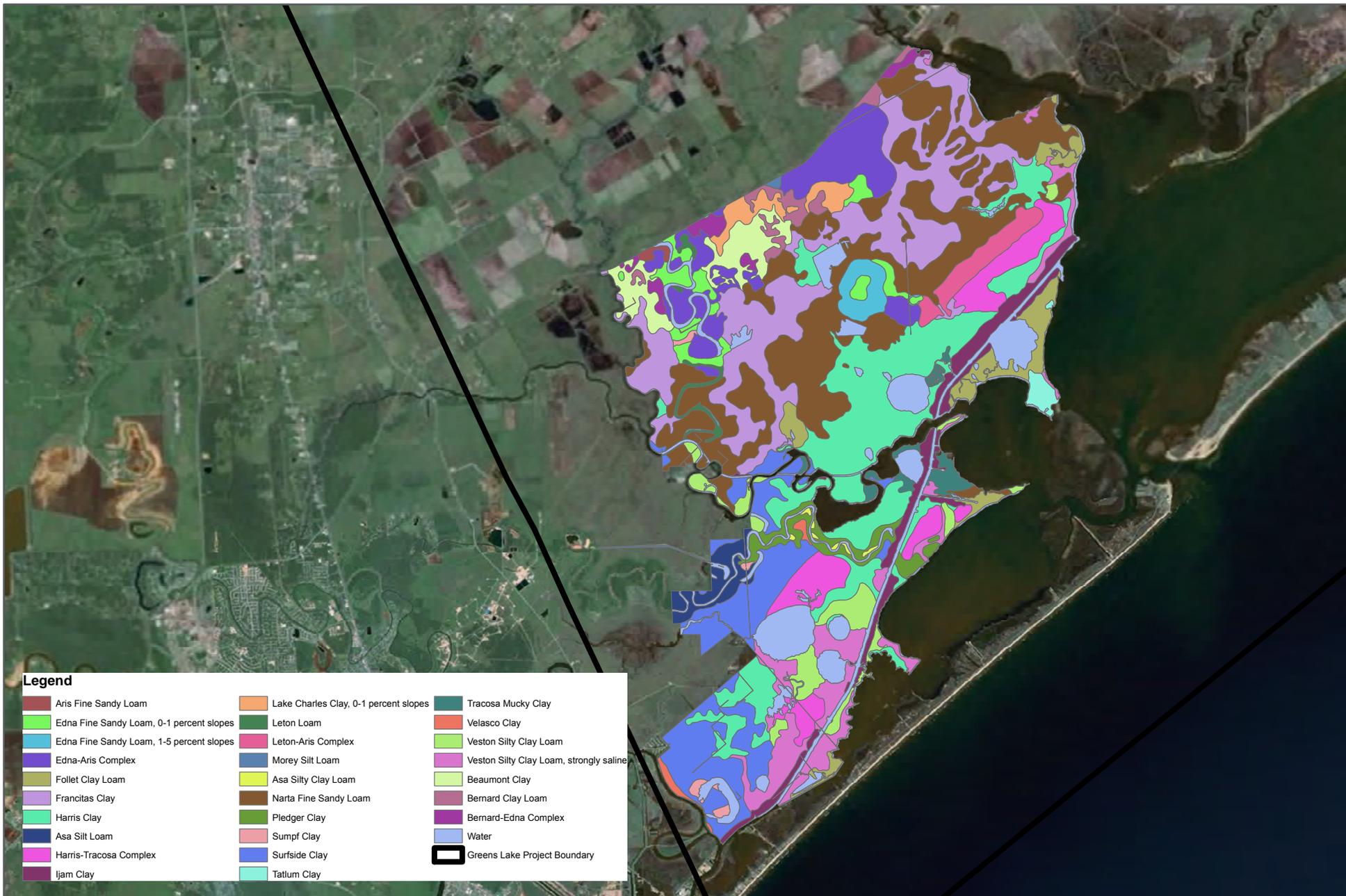
**Figure 2.6-1: Seismic Survey Program Layout**  
**Samson Greens Lake 3-D Seismic Survey**  
 Brazoria County, Texas



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**Legend**

Aris Fine Sandy Loam	Lake Charles Clay, 0-1 percent slopes	Tracosa Mucky Clay
Edna Fine Sandy Loam, 0-1 percent slopes	Leton Loam	Velasco Clay
Edna Fine Sandy Loam, 1-5 percent slopes	Leton-Aris Complex	Veston Silty Clay Loam
Edna-Aris Complex	Morey Silt Loam	Veston Silty Clay Loam, strongly saline
Follet Clay Loam	Asa Silty Clay Loam	Beaumont Clay
Francitas Clay	Narta Fine Sandy Loam	Bernard Clay Loam
Harris Clay	Pledger Clay	Bernard-Edna Complex
Asa Silt Loam	Sumpf Clay	Water
Harris-Tracosa Complex	Surfside Clay	Greens Lake Project Boundary
Ijam Clay	Tatum Clay	

**Figure 4.1-1: Soil Types, Brazoria National Wildlife Refuge**  
 Samson Greens Lake 3-D Seismic Survey  
 Brazoria County, Texas

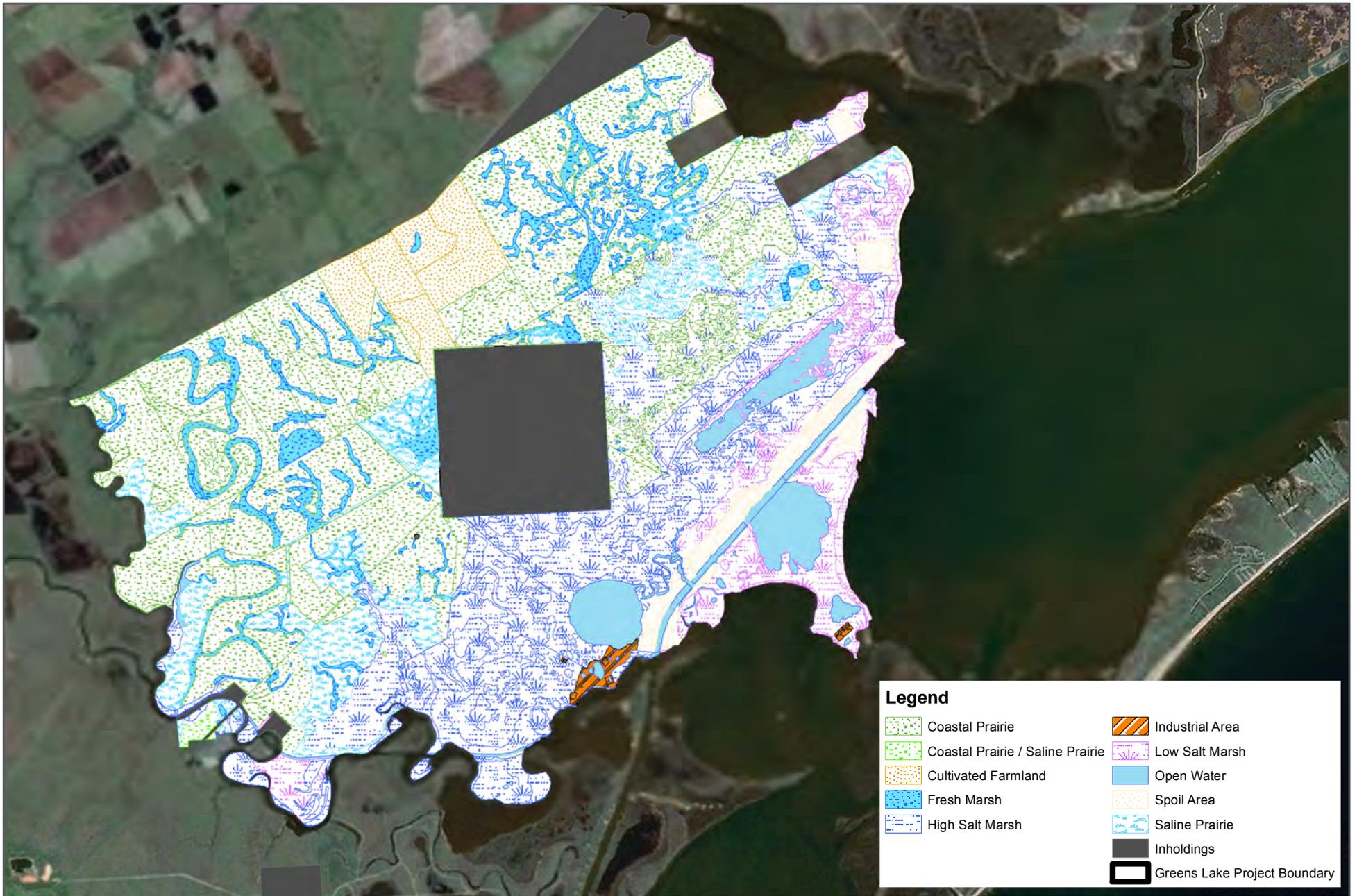


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**Legend**

Coastal Prairie	Industrial Area
Coastal Prairie / Saline Prairie	Low Salt Marsh
Cultivated Farmland	Open Water
Fresh Marsh	Spoil Area
High Salt Marsh	Saline Prairie
	Inholdings
	Greens Lake Project Boundary

Image: ESRI  
World Imagery

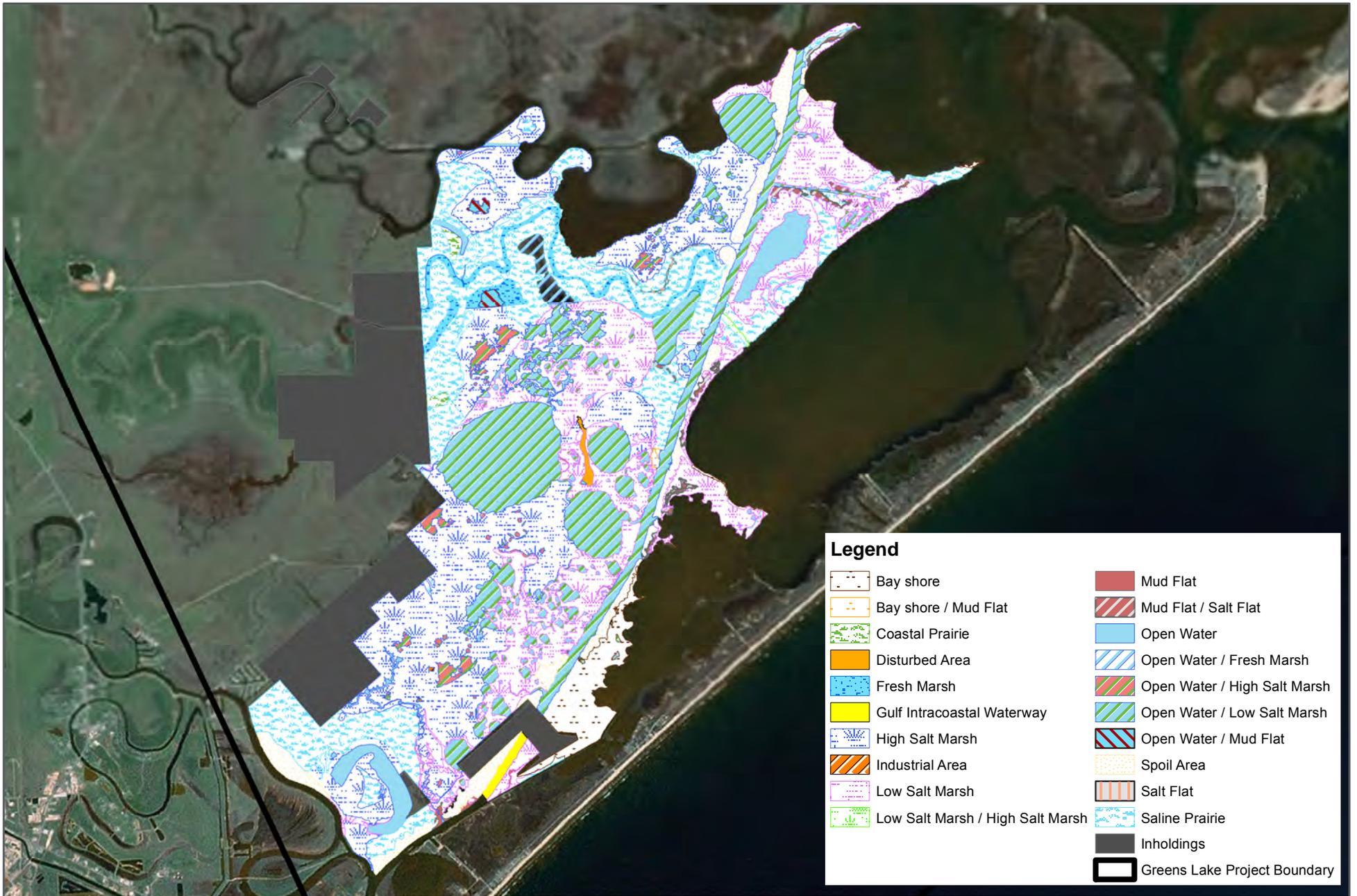


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**Figure 4.3-1: Habitat Types, North Brazoria NWR**  
 Samson Greens Lake 3-D Seismic Survey  
 Brazoria County, Texas



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**Figure 4.3-2: HabitatTypes, South Brazoria NWR**  
 Samson Greens Lake 3-D Seismic Survey  
 Brazoria County, Texas

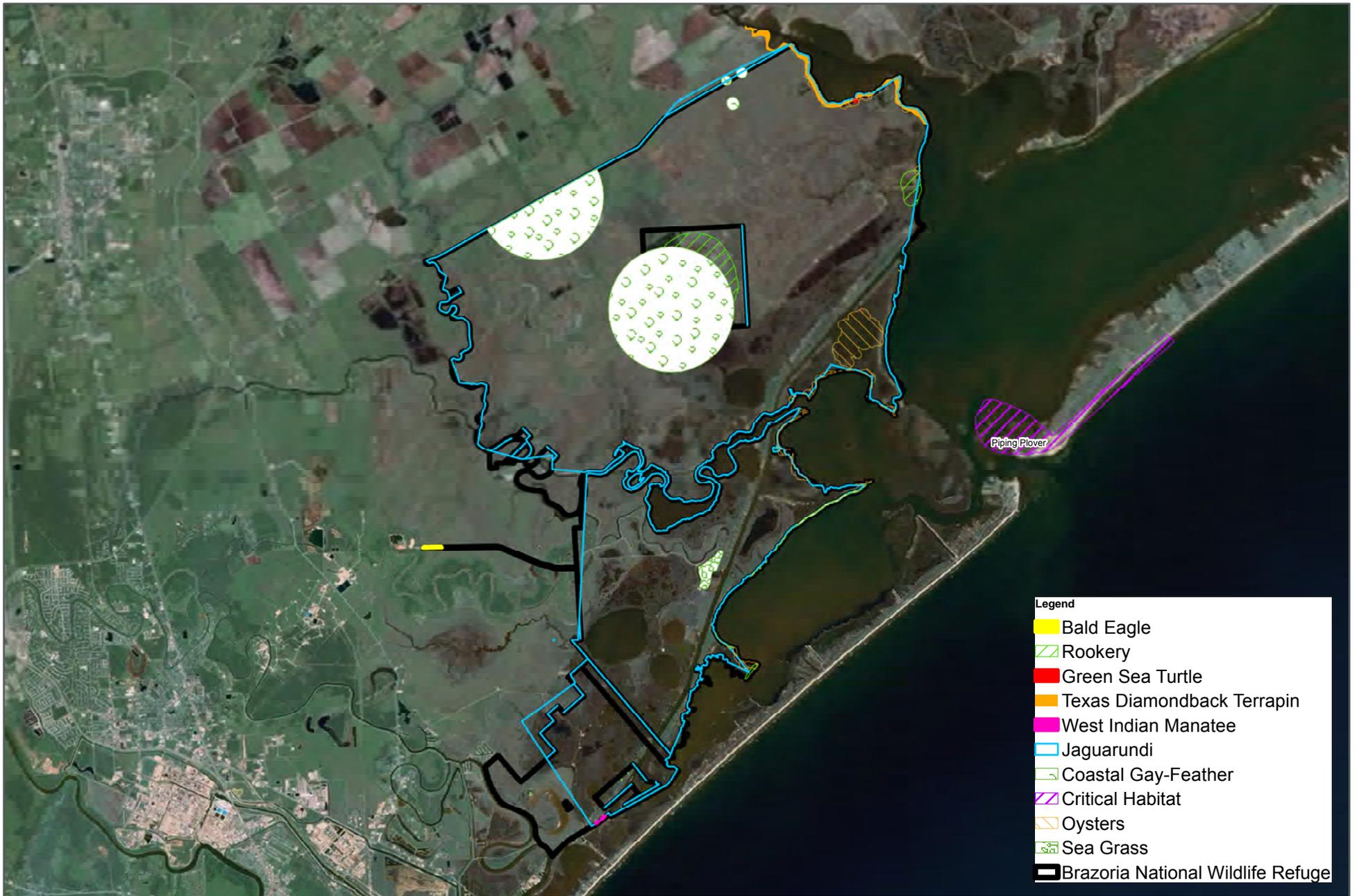


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- Legend**
- Bald Eagle
  - Rookery
  - Green Sea Turtle
  - Texas Diamondback Terrapin
  - West Indian Manatee
  - Jaguarundi
  - Coastal Gay-Feather
  - Critical Habitat
  - Oysters
  - Sea Grass
  - Brazoria National Wildlife Refuge



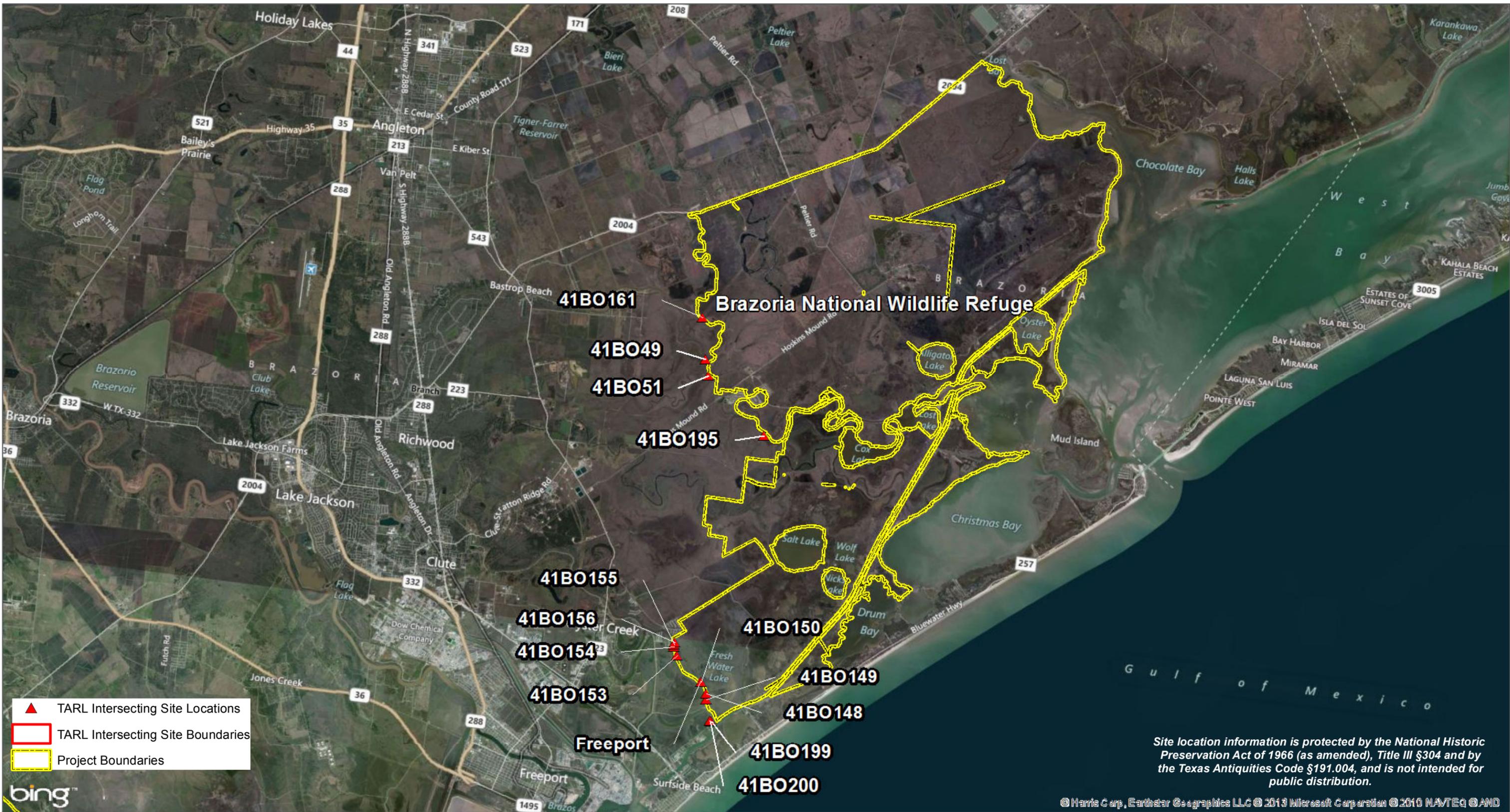
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**Figure 4.5-1: Sensitive Biological Resources**  
Samson Greens Lake 3-D Seismic Survey  
Brazoria County, Texas

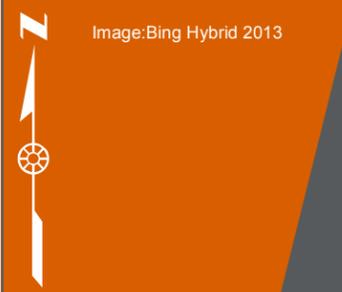


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### Intersecting TARL Archeological Features within Brazoria NWR

Samson Energy Special Use Permit (SUP) and Environmental Assessment (EA)  
Brazoria County, Texas

\*200 Meter Buffer applied to Boundary

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Proposed 3-D Seismic Program  
on Brazoria National Wildlife  
Refuge

ATTACHMENT

1

DRILLING EQUIPMENT  
PHOTOGRAPHS



**Lightweight aluminum tracked vehicle  
(marsh buggy) drill**



**Aluminum pontoon drill**



**Airboat drill**



**ARDCO drill with TERRA tires**