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SURVEY METHODOLOGY REPORT

Topographic, Bathymetric, Magnetometer Surveys, and Healthy Marsh Survey

Project:

Long Point Bayou Marsh Creation Project (CS-0085)

Cameron Parish, Louisiana

Prepared for:

Ms. Renee Bennett, PM
Coastal Protection and Restoration Authority

Prepared by:

Mr. Ricardo Johnson, PLS
Fenstermaker

July 23, 2020
(Revised September 14, 2020)

135 Regency Square | Lafayette, LA 70508 | 337.237.2200 phone | 337.232.3299 fax
www.fenstermaker.com

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Coastal Protection and Restoration Authority

in Support of

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Introduction

The Long Point Bayou Marsh Creation Project (CS-0085) is funded by the Coastal Wetlands Planning, Protection, Restoration Act (CWPPRA) under Priority Project List 28 in partnership with U.S. Environmental Project Agency (USEPA) and the U.S. Army Corps of Engineers (USACE). The objective of this project is to create, maintain, and nourish existing deteriorating wetlands through hydraulic dredging material from the Calcasieu River Ship Channel.

Proposed Features

Approximately 392 acres of marsh will be created using borrow material from the Calcasieu Ship Channel. The borrow material will be dredged from the Calcasieu River Ship Channel from approximately Miles 5-12. The USACE will use their dredging contracts to complete the dredge and placement of the material in the fill area. This project will fund the incremental cost increase above the USACE's federal standard placement site. The fill site will be formed by constructing earthen dikes around the boundaries of the marsh creation area where needed. The marsh creation fill site will also be planted with wetland grasses to accelerate plant colonization, stabilize new sediments, and improve habitat. This scope of services involves conducting topographic, bathymetric, and magnetometer surveys within the proposed fill site, and other portions of the project area.

Location

The project site is located in Region 4, Calcasieu/Sabine Basin, Cameron Parish, south of Hackberry, north of Sabine National Wildlife Refuge, east of LA Highway 27 and west of the Calcasieu Ship Channel.

Proposed Survey Work Plan

On April 2, 2020, Fenstermaker submitted a Survey Cost Estimate to the CPRA Project Manager that

included a Survey Work Plan designated as Attachment A of the submittal.

Prior to mobilization, the CPRA Project Manager, staff associated with the CS-0085 project, and the Fenstermaker Team met via phone conference to review tasks to be performed, Cost Estimate, Proposed Survey Work Plan, and the Proposed Schedule.

On April 6, 2020, Fenstermaker received work authorization to commence surveys in support of Long Point Bayou Marsh Creation Project. Upon receiving the Task Order and Notice to Proceed, the Fenstermaker Team performed the following tasks:

1.0 **Landowner Permission/Pipeline Research** – Prior to commencement of surveys, Fenstermaker submitted a request for "Special Use Permit" from the Sabine National Wildlife Refuge. Once the request was approved, a Notice was sent to all landowners where data collection efforts took place. Fenstermaker performed desktop research to obtain information vital to the planning and preparation of the proposed surveys such as locating pipelines that may exist in the National Pipeline Mapping System (NPMS) database, LDNR SONRIS database, and Fenstermaker's Map Analyst GIS Database.

2.0 **Waterway Hazard Notification** – Prior to commencement of the bathymetric surveys within the Calcasieu River, the Fenstermaker project manager notified the U.S. Army Corps of Engineers (USACE) and the U.S. Coast Guard to issue any necessary Public Notice to Mariners once a date was determined. All relevant communications and documents were recorded and copies made available to CPRA.

3.0 **Healthy Marsh Elevation Survey** – Upon receiving locations of the proposed marsh elevation site locations from the CPRA Project Manager, the Fenstermaker Team with the assistance of an Ecological Scientist from the environmental group perform Marsh Elevation Surveys at five locations within the Marsh Creation Area. A minimum of twenty (20) elevations, separated by 20 to 40 feet were acquired at five (5) sites as specified by CPRA.

4.0 **Topographic Survey at Marsh Creation Area and Proposed Pipeline Corridor** – A 2-man survey crew performed topographic surveys from an airboat utilizing RTK along transects spaced at 250 foot intervals in open water, broken marsh, and across pipeline canals in the proposed marsh creation area. A centerline profile and cross sections were collected at points of inflection (PI) and spaced every 1000 feet along profile of northern bayou and eastern access routes through Lake Point Bayou. Cross sections at 500-foot intervals of 200-foot width were surveyed to locate the most accessible and less invasive route for the displacement pipeline to the creation area from the Calcasieu Ship Channel. Marsh elevations and water bottoms were recorded using an RTK rover pole with a 6" flatfoot attached to the bottom at a maximum distance of 25 feet along each transect, and where the change in elevation is greater than 0.5 feet, such as the marsh to water transition, spoil banks, etc. All features that may affect the design implementation, such as existing utilities, fences, well heads, meandering channels, etc., were located and surveyed.

5.0 **Topographic and Bathymetric Survey of Access Routes** – Proposed Access Routes were surveyed by a 3-man survey crew from a 28-foot shallow-draft marine vessel. Equipment utilized included RTK for positioning and a CV100 Echosounder integrated into Hypack to record depths and positions. A total of three lines were surveyed within each Proposed Access Route, one along the centerline and 50-foot offset either side of the centerline. Single-beam bathymetry was performed on Cross-sections along the access routes at 1000-foot intervals up to the 3-foot water depth. A 3-man survey crew utilizing an airboat performed topographic surveys from the 5-foot water depth (to ensure overlapping data) to the bank line on either side of the access route to facilitate with each cross-section being completely captured.

6.0 **Magnetometer Survey of Marsh Creation Area and Access Routes** – Prior to the magnetometer survey, Fenstermaker conducted a desktop analysis utilizing Fenstermaker's MapAnalyst GIS database to determine if there were any known pipelines throughout the project site. No known pipelines were found in the survey area using Rex Tag and MapAnalyst. After the analysis, a 2-man survey crew performed the magnetometer surveys from an airboat utilizing RTK along transects at 500-foot grid intervals, along the proposed pipeline corridor, and along access routes. Magnetic anomalies were be determined using a Cesium 882 marine magnetometer with positions recorded using RTK and integrated into Hypack.

7.0 **Pipeline and Anomaly Probing and Marking** – Upon completion of all surveys, magnetic anomalies were mapped in AutoCAD and included the anomaly number, durations, gammas, and geodetic positions. Any anomaly detected above fifty (50) Gammas was investigated farther using a land magnetometer by circling the anomaly at a radius of 25 feet. This information was provided to the survey crew to facilitate in the location of existing pipelines to be marked and probed for depth of cover, and depth of water, if submerged. Flagged cane poles were used to mark the existing pipelines at 200-foot intervals.

8.0 **Deliverables:** All deliverables were provided as specified in the Scope of Work

Static GPS Survey at Reference Control Monuments

Prior to the mobilization, all transects and coordinates for the reference monuments were setup in the Trimble Business Center (TBC) project file, and then uploaded to the surveyor's positioning device datalogger. On Monday, April 27, 2020, the survey crew mobilized and traveled from the Lafayette office to the project site to perform the required survey tasks.

Monument TT-147

Upon arriving at the project site, the survey crew navigated to an existing monument located north of the project site. After locating monument TT-147, the GPS base receiver was installed and initialized to begin logging static GPS. A GPS rover unit was then initialized to receive base corrections using Real-time Kinematic (RTK) for sub-centimeter positioning. The survey crew performed a quality control check at deep rod monument CS23-SM-01 to validate correct positioning of the GPS system. The survey crew then navigated along pre-plotted transect lines to obtain natural ground and water bottom elevations.

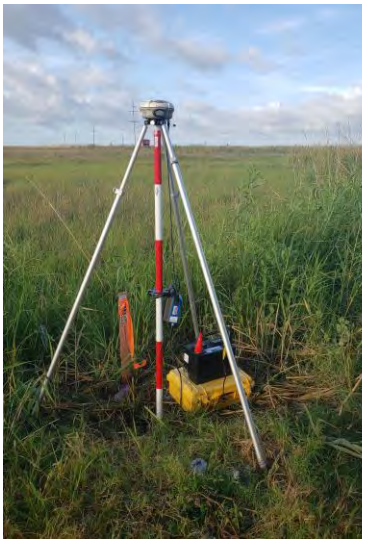
The following day, static GPS was performed at deep rod CS23-SM-01 and quality control checks performed at monument TT-147. The survey crew continued performing RTK surveys along pre-plotted transect lines to obtain natural ground and water bottom elevations. On Thursday, April 29th, a TBM was installed along an existing levee to provide a central location for performing RTK survey quality control checks. Fast static was performed on the TBM on Thursday and Friday to provide a more accurate solution. Static GPS surveys in support of the topographic RTK surveys continued and were completed on May 19, 2020.

Upon completing the static GPS surveys each day, GPS raw data files were downloaded, then uploaded to Fenstermaker's ftp site for post-processing and adjustment.

Static GPS survey activities performed are in conformance with CPRA survey standards as specified in *"A Contractor's Guide to the Standards of Practice Required by Louisiana Department of Natural Resources, Coastal Restoration Division for Contractor's Performing GPS Surveys and Establishing GPS Derived Orthometric Heights Within the Louisiana Coastal Zone Primary GPS Network"* dated January 2019.

Static GPS Downloading, Processing & Adjustments

Upon completing the static GPS survey, GPS log sheets were checked and compared to the data files on the receivers. The raw GPS data was then downloaded into the project file created in Trimble Business Center (TBC) software. The IGS Precise Ephemeris was also downloaded from the NOAA/NGS Internet website for each day that GPS data was collected. All CORS[1] stations which were located nearest to or within the project area were also downloaded from the National Geodetic Survey (NGS) website and processed with the static GPS data. CORS Stations that were incorporated into the GPS network included "TXOR", "MCNE", "CAMR", and "TONY".


Monument CS23-SM-01

After post-processing the GPS Network, a report was then generated in the TBC program and reviewed to determine satellite cycle slips to avoid baseline float solutions in the processed data. If a baseline float solution existed, the elevation mask was raised 5 degrees and the baseline was re-processed to eliminate satellite noise that may have existed close to the horizon.

Upon completing the processing phase, the data was loaded into the adjustment program and adjusted. All necessary adjustments were performed using the TBC Network Adjustment software.

The initial adjustment for the GPS network was minimally constrained to the published adjusted NAD83 (2011) Epoch 2010.00 and the published ellipsoid height at the antenna reference point (ARP) for CORS Station "MCNE". A re-adjustment was performed and all outliners removed from the adjustment. A scale factor was determined from the Statistics Summary and applied to the network and re-adjusted until the Chi-Square Test passed with a 95% confidence level.

The final fully constrained adjustment was performed by holding to the published values for the CORS Stations antenna reference points (ARP) at "MCNE", "CAMR", and "TXOR". Orthometric heights (elevations) were calculated using the Geoid18 model. The adjusted ellipsoid heights for the remainder of the CORS Stations were compared with their published NAD83 (2011) values as a quality control check. All GPS files were submitted to the NGS Online Positioning User Service (OPUS) Program[2] for an independent solution and comparisons made with the final adjustment results.

Figure 1: Tabulation of Final GPS Adjustment Results at Reference Control

Long Point Bayou Marsh Creation Project (CS-0085)

Static GPS Adjustment Results

NAD83 (2011) LA South Zone 1702 - NAVD88 (2011) Geoid18

MONUMENT	LATITUDE	LONGITUDE	ELLIPSOID HGT	NORTHING	EASTING	ELEVATION	DESCRIPTION
CS23-SM-01	29d54'33.16308"	-93d23'00.16838"	-87.38	518,286.24	2,631,372.11	0.82	Deep Rod
TBM-1	29d55'18.62117"	-93d21'55.35765"	-85.77	522,775.92	2,637,156.34	2.46	TBM
TT-147	29d56'12.91304"	-93d22'31.36774"	-82.11	528,315.73	2,634,085.88	6.25	NGS CAP

[1] The National Geodetic Survey (NGS) coordinates two networks of continuously operating reference stations (CORS): the National CORS network and the Cooperative CORS network. Each CORS site provides Global Positioning System (GPS) carrier phase and code range measurements in support of 3-dimensional positioning activities throughout the United States and its territories. Surveyors, GIS/LIS professionals, engineers, scientists, and others can apply CORS data to position points at which GPS data have been collected. The CORS system enables positioning accuracies that approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically.

[2] The National Geodetic Survey operates the On-line Positioning User Service (OPUS) as a means to provide GPS users easier access to the National Spatial Reference System (NSRS). OPUS allows users to submit their GPS data files to NGS, where the data will be processed to determine a position using NGS computers and software. Each data file that is submitted will be processed with respect to 3 CORS sites.

RTK Survey of Topographic Features

Upon mobilization and travel to the project on Monday, April 27, 2020, the RTK base unit was initialized at reference monument TT-147. A quality control shot was measured at deep rod CS23-SM-01 with the roving unit to verify that the system was operational and delivering corrected positions. The survey crew then navigated by airboat to capture topographic features along pre-plotted transects that included existing natural ground shots, existing levees, shorelines, and water bottoms using a 2-meter pole with the RTK rover unit attached. In addition, water surface shots were acquired daily to facilitate in determining a relationship to the nearby NOAA Tidal Station.

Topographic features were collected along transects as specified in the Section above titled "Proposed Survey Work Plan" using RTK. A flatfoot was attached to the bottom of the rover rod to prevent penetration into the water bottom.

Static GPS was collected at the base station concurrent with the RTK topographic survey for each day of data collection. All topographic surveys conducted to capture existing features, including magnetometer surveys and pipeline probing, were completed on May 19, 2020.

GPS and RTK Survey Equipment

The equipment used for the static GPS survey consisted of a Trimble© Navigation's dual-frequency GNSS GPS receiver with integrated GPS antenna, also called base stations. A two-meter fixed height tripod was used to eliminate human error that could be introduced by miss-measurement of the GPS antenna heights. The GPS data was downloaded, processed and adjusted using Trimble Business Center (TBC) Software, Version 5.20. The Geoid18 model was used to determine the geoid separation and applied to the ellipsoid heights to determine elevation as specified in the scope.

To perform the RTK survey, a rover consisting of a Trimble© Navigation's dual-frequency GNSS GPS receivers with an integrated GPS antenna and a radio link was employed to transmit corrections to the rover from the base setup. A fixed height rod with attached flatfoot was used at the rover. The data was collected and stored on a Trimble© TSC3 datalogger and downloaded using TBC, Version 5.20.

Single-Beam Bathymetric Surveys

Prior to commencing the single-beam bathymetric surveys, coordinates and line files for the proposed transect lines were provided to the survey crew. On May 13, 2020, the bathymetric survey crew commenced single-beam surveys in Calcasieu Ship Channel adjacent to the marsh creation site. Positioning was accomplished using Real-time kinematic (RTK) with the base station delivering GPS corrections from the reference marks located within the project site.

With the installation of a GPS base station at monument CS23-SM-01 and performing a QC check at the TBM, the survey crew mounted the RTK rover system on the marine vessel and integrated the positioning system with the onboard single-beam echo-sounder using HyPack. This allowed the survey crew to navigate along pre-plotted transect lines to obtain corrected water bottom elevations.

Data acquisition for the single-beam survey was accomplished using HYPACK® digital data acquisition and navigation software. An Echotrac CV100 fathometer was used to determine the water depths along the pre-plotted transect lines. The fathometer was integrated with RTK to accurately position in three dimensions. Water surface shots were taken in the morning and afternoon by the bathymetric survey crew using RTK to obtain the water surface elevations relative to NAVD88 using Geoid18. Sound velocities were performed to determine the speed of sound in the water column using an Odom DigiBar Sound Velocity Sensor. Once the sound of velocity was determined and applied to the software, bar checks were performed at the beginning of the day to measure the actual depths relative to the recorded depths on the echo sounder with the average sound velocity, draft and index applied. Once the sound of velocity was determined and applied

to the software, a steel plate was lowered beneath the transducer head at 5-foot intervals to validate correct depth readings delivered from the echosounder.

Back at the office, the raw data was imported into HYPACK® program, which includes the raw bathymetry data and corrected tide file. A graphic image was generated so that the digital sounder data could be swath edited to remove outliers. The final adjusted and edited file was exported in ascii format and vertically adjusted using NAVD88 using Geoid18.

Bathymetric Survey Equipment

Horizontal positioning was logged real-time using a Trimble R8 GNSS GPS Receiver integrated with RTK for GPS corrections resulting in a 5cm horizontal accuracy or better. Pitch and roll was recorded with the CDL MiniTilt Motion Sensor to correct for motion changes. Odom Echotrac CV100 was also used to determine water depths along all transect lines. Bathymetry data was corrected for velocity and adjusted to NAVD88 using Geoid18.

Magnetometer Hazard Surveys

Prior to performing the magnetometer surveys, a search was made using the National Pipeline Mapping System (NPMS) database and RexTag within Fenstermaker's Map Analyst GIS Mapping System (See Attachment A). The database revealed no pipelines existed within the project footprint.

The magnetometer surveys were performed from an airboat along the north/south transects at 500-foot spacings and perpendicular to the transects at 500-foot intervals to locate potential hazards and existing pipelines within the project footprints. The topographic survey crew located existing anomalies using a magnetometer towed behind the airboat to record positions. Although ferrous debris was located, no pipelines were located within the marsh creation footprint.

Pipeline Warning Sign

However, a pipeline was determined to exist between the eastern limits of the footprint and Calcasieu River Ship Channel, which was apparent during the topographic surveys performed on May 7th when the survey crew located pipeline crossing signs at Long Point Bayou. The east/west mag route lines that extended eastward beyond the marsh footprint indicated anomalies that were coincidental with the pipeline crossing signs.

On May 13th, the survey crew performed probing to locate an existing pipeline running north-south between the Marsh Creation Area and the Calcasieu Ship Channel. Probing along the pipeline were approximately at 200-foot intervals The probing facilitated with confirming the pipeline location and depth of cover. The position and elevation were recorded on the RTK unit along with the depth of cover. Although the pipeline size is unknown, a found sign indicated that the pipeline is operated by the Strategic Petroleum Reserve.

Instruments utilized for the surveys included a Trimble® R7 GNSS RTK system providing centimeter accuracy positioning and a Geometrics® 882 Cesium Marine Magnetometer.

The magnetometer on the airboat was operated in a towed configuration with the tow point at the stern of the vessel. The magnetometer dataset was collected through HYPACK® at a sampling rate of 10 Hz and a very high sensitivity of less than 0.1 gammas. Chesapeake Technology, Inc.'s SonarWiz.SBP software was used to interpret the magnetometer dataset.

A nomogram (See Figure 2) provides a visual reference of the relationship between a ferrous object and magnetic deflection generated by the object. The amplitude and signature width of a magnetic deflection are dependent on a variety of factors that include object size and configuration, ferrous content, and distance from the sensor (Breiner, 1973). Since all the variables involved in anomaly classification are not readily available, the nomogram provides only a rough estimate for anomalies and source size. The positions of the unidentified anomalies were recorded using the onboard Differential GPS system. Water surface shots were taken occasionally by the crew using RTK to obtain the water surface elevations relative to NAVD88 using Geoid18.

Back at the office, all raw data was imported into SonarWiz, which includes the raw magnetometer data and Magnetometer tow point position on the vessel. The magnetometer data is then laid back using the recorded laid-back values. A hydrographic survey specialist analyzed each file picking all magnetometer anomalies. The specialist then exported a file with all anomaly positions and amplitudes to be mapped.

Significant anomalies that were located and identified on this survey are associated with existing pipelines and ferrous debris, all of which are located within the project footprint. The remainder of these anomalies are determined to be consistent with targets usually associated with minor debris such as crab traps, steel cans and buckets, anchors, etc. Upon further investigations of the anomalies, crab traps seemed to be the most common debris source.

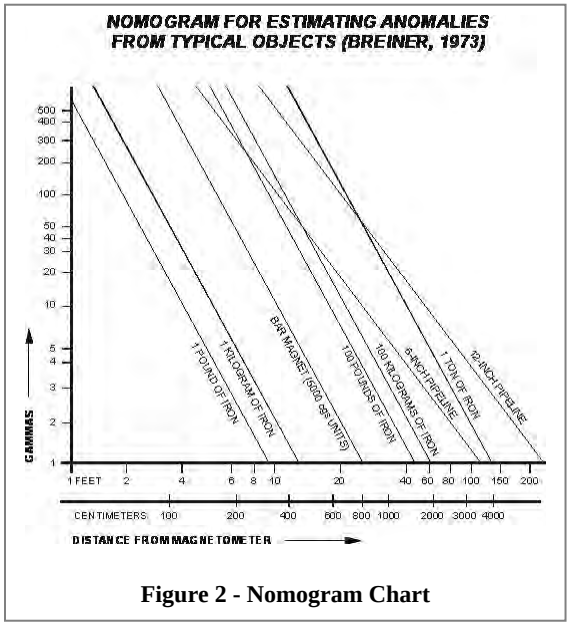


Figure 2 - Nomogram Chart

Conclusion

While reasonable efforts are made to locate all pipelines and magnetic anomalies, the equipment used and the characteristics of pipelines themselves make it impossible to guarantee total success. Accordingly, it is incumbent upon the owners, operators and/or contractors conducting operations, to do so with extreme caution, and recognize that hazards, in addition to those detected and reported by Fenstermaker, may exist within the areas of operation, regardless of Fenstermaker's most diligent efforts. The presence of debris can have an adverse impact on the success of construction activities.

Louisiana (Louisiana One Call™ www.laonecall.com) maintains an information center and link between those who dig (excavators) and those who own and operate underground facilities (operators). It is advisable, and in most States, it is the law for the contractor to contact the center for assistance in locating and marking underground utilities.

Healthy Marsh Survey

On May 23, 2020 two (2) environmental specialist preformed flights over the entire Long Point Bayou Marsh Creation project area using a multi-spectral camera. Images were corrected, rectified and used to produce a normalized difference vegetation index (NDVI) map. The map reflects areas of healthy marsh, as well as areas of distressed marsh that is color coded. The NDVI map along with a orthomosaic image that was submitted to the CPRA Lafayette office for review and analysis. After review, CPRA's Margaret Luent of the Lafayette Field Office provided Fenstermaker with a map showing the locations of where the Healthy Marsh Elevation Surveys were to be performed. On June 26, 2020, a survey crew and an environmental specialist from Fenstermaker surveyed the healthy marsh areas as directed from CPRA.

A total of Five (5) sites were selected by the CPRA to perform these surveys. RTK surveys to determine marsh elevations were taken at twenty (20) locations within each selected site, separated by 20 to 40 feet. Elevations were recorded on datalogger at the top of the marsh root mass and top of the mudline adjacent to the root mass utilizing a topo foot on the bottom of the two-meter pole. The results were tabulated in a spreadsheet to determine average elevations for root mass and mudline for each site surveyed (See Figure 3).

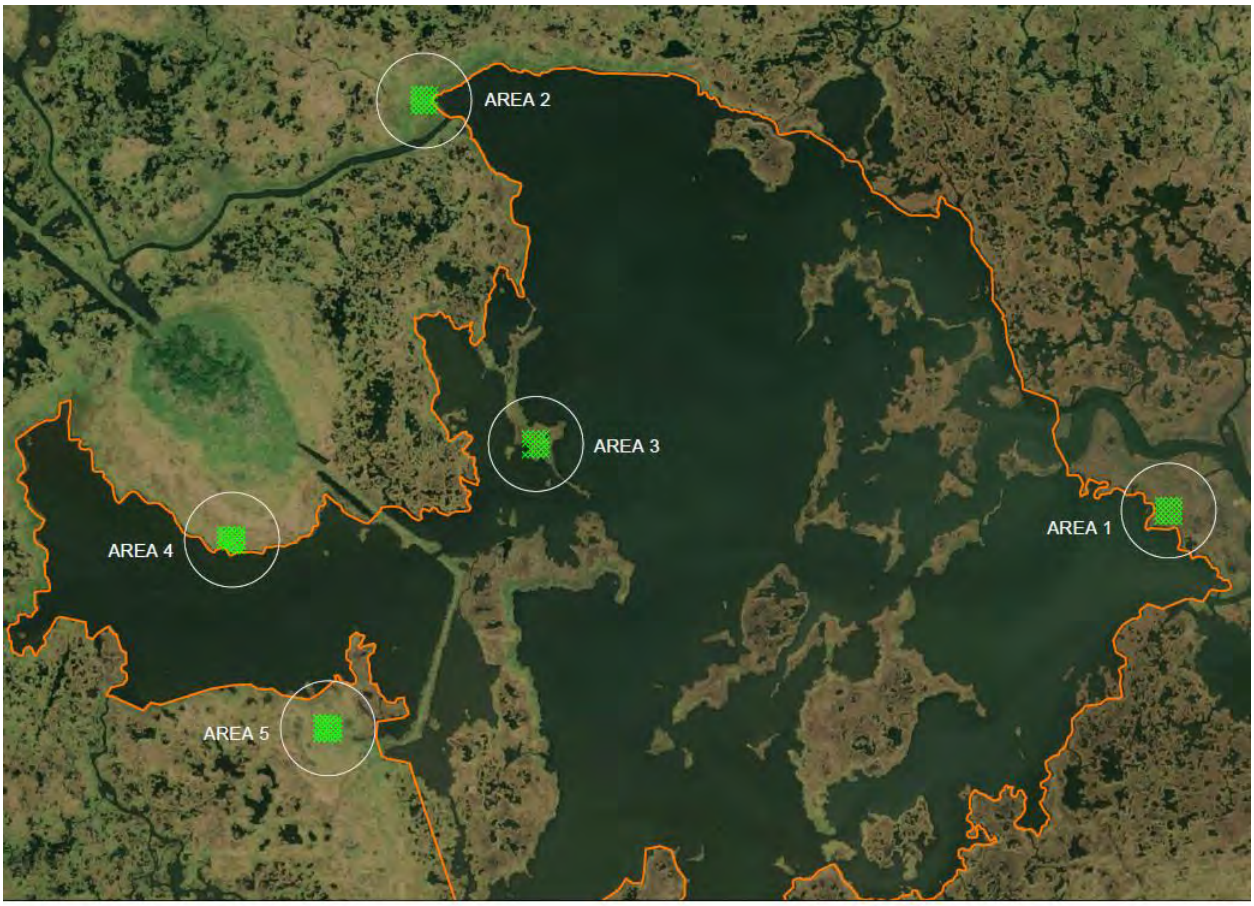


Figure 3 – Marsh Elevation Survey

Aerial Drone Survey to Document Marsh Health

Prior to UAV flights, the project area was divided into 10 quadrants to allow pilots to maintain line of site during each flight. Twelve locations for ground control targets were selected along the quadrant boundaries to allow for multiple appearance in multiple flights throughout the project. With target locations chosen and the site divided into multiple flights, three launch areas were selected (See Figure 4).

Flight lines were created in order to ensure both 70% side overlap (transect distances apart) as well as 70% front overlap (forward speed of aircraft) during all flights. All flights were conducted at 390 ft. above ground level. Flights were conducted using the DJI Inspire 2 equipped with the MicaSense Altum Multispectral sensor.

Prior to data being collected, all targets were surveyed in using the same methods identified in the ***RTK Survey of Topographic Features*** listed previously on page 6. These surveyed locations were used in post processing to georectify the images.

On May 23, 2020 two environmental specialists from Fenstermaker mobilized to Long Point Bayou and performed flights over the project area using a multi-spectral camera. Images were corrected, rectified and used to produce a normalized difference vegetation index (NDVI) map. The map which was produced reflects areas of healthy marsh, as well as areas of distressed marsh (See Figure 5). This map was submitted to the CPRA office as well as a true image for review.

Figure 4 – Aerial Target Panels (GCPs)

Each flight started with a photo of the calibration board. The calibration image is used to help calibrate each image in post processing. In addition to the calibration board, the Altum sensor is equipped with a downwelling light sensor (DWL). The DWL is used to measure the irradiance (radiant energy per unit area) reaching the Earth's surface during each sensor capture, as well as to estimate the angle of radiance. Both the image of the calibration board and the DWL are used in post processing to calibrate the radiometric properties of the data. During the flight approximately 26,500 images were collected over 4 hours of flight time, starting at 9 AM and ending at 4 PM. The flights were flown in an east to west direction over the entire project.

The MicaSense Altum captures 6 wavelengths (nm) at each position. The capture location consists of a 6 bands; blue (475 nm center, 32 nm bandwidth, green (560 nm center, 27 bandwidth), red (668 nm center, 16 nm bandwidth), red edge (717 nm center, 12 nm bandwidth), and near-IR (842 nm center, 57 nm bandwidth). Each band was combined in Pix4D to create a mosaic dataset for each band. During this process each dataset used the survey targets to correct the positional accuracy of the data as well as the calibration board and the DWL sensor to correct the radiometric properties.

Once processed four bands were used to create the two image maps (see page 11). First, the true image photo was created by using the Red, Green and Blue bands (See Figure 6). Second, the NDVI map used

the near-IR and Red bands. These bands were created in ESRI and exported to geotiff format (See Figure 5).

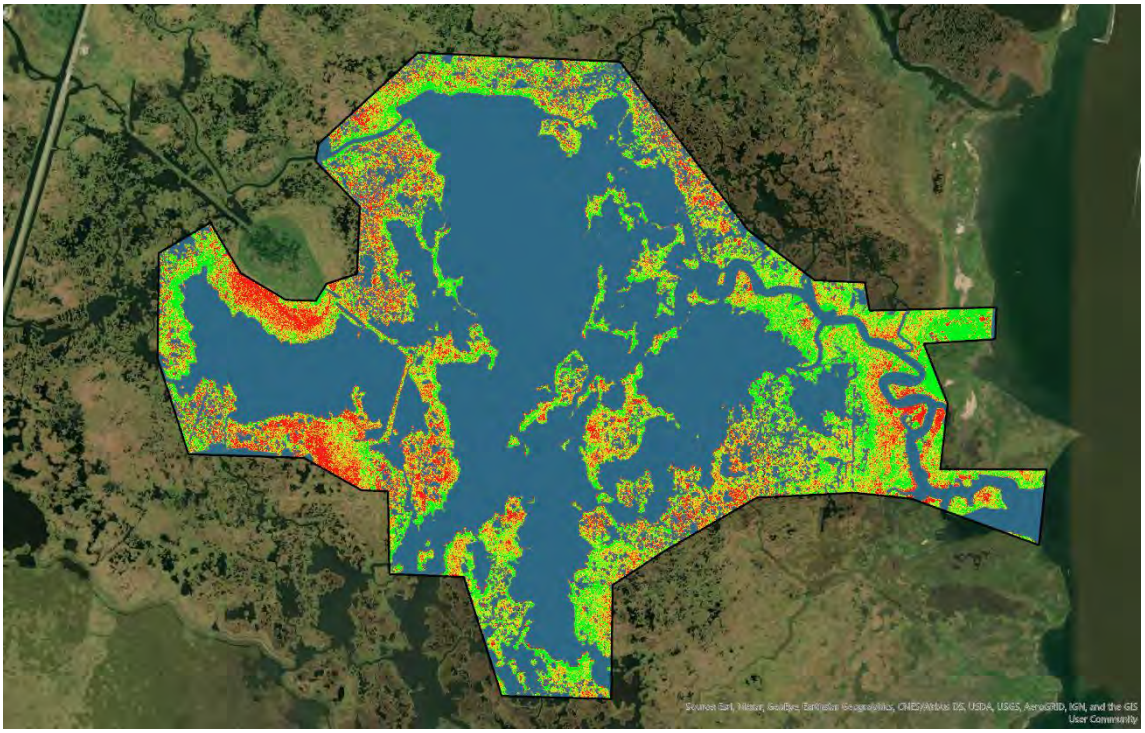


Figure 5 – NDVI Map

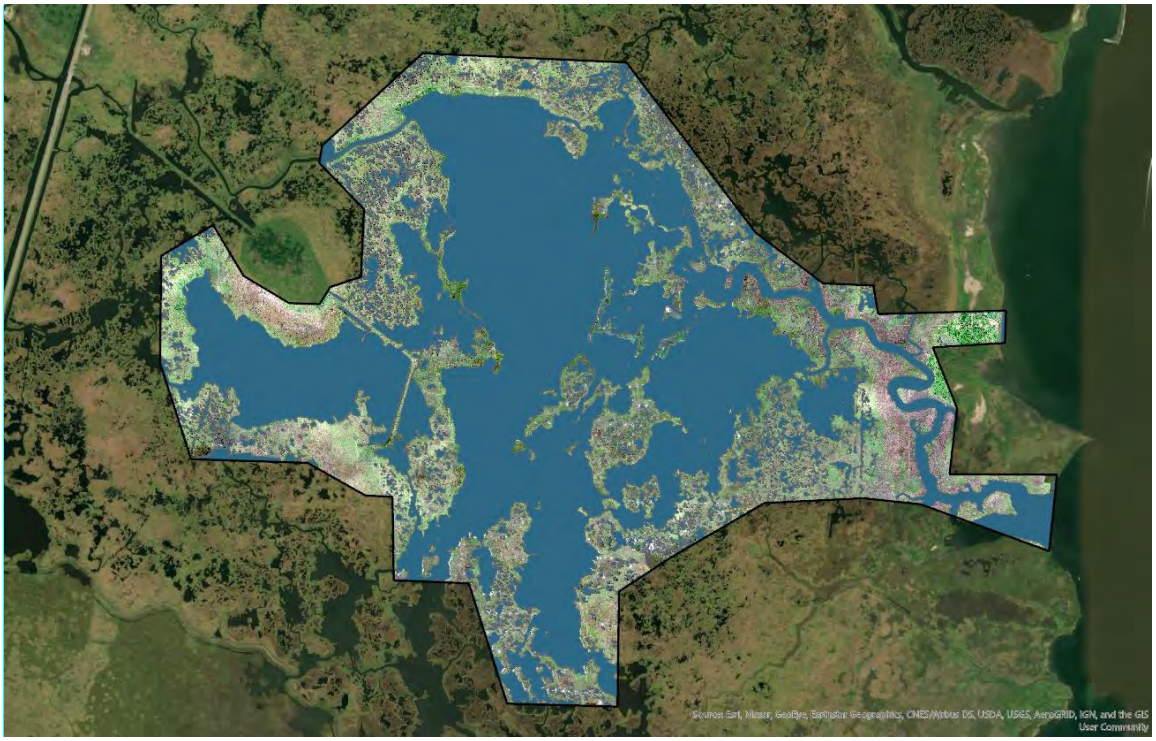


Figure 6– True Image Map

FINAL NOTE

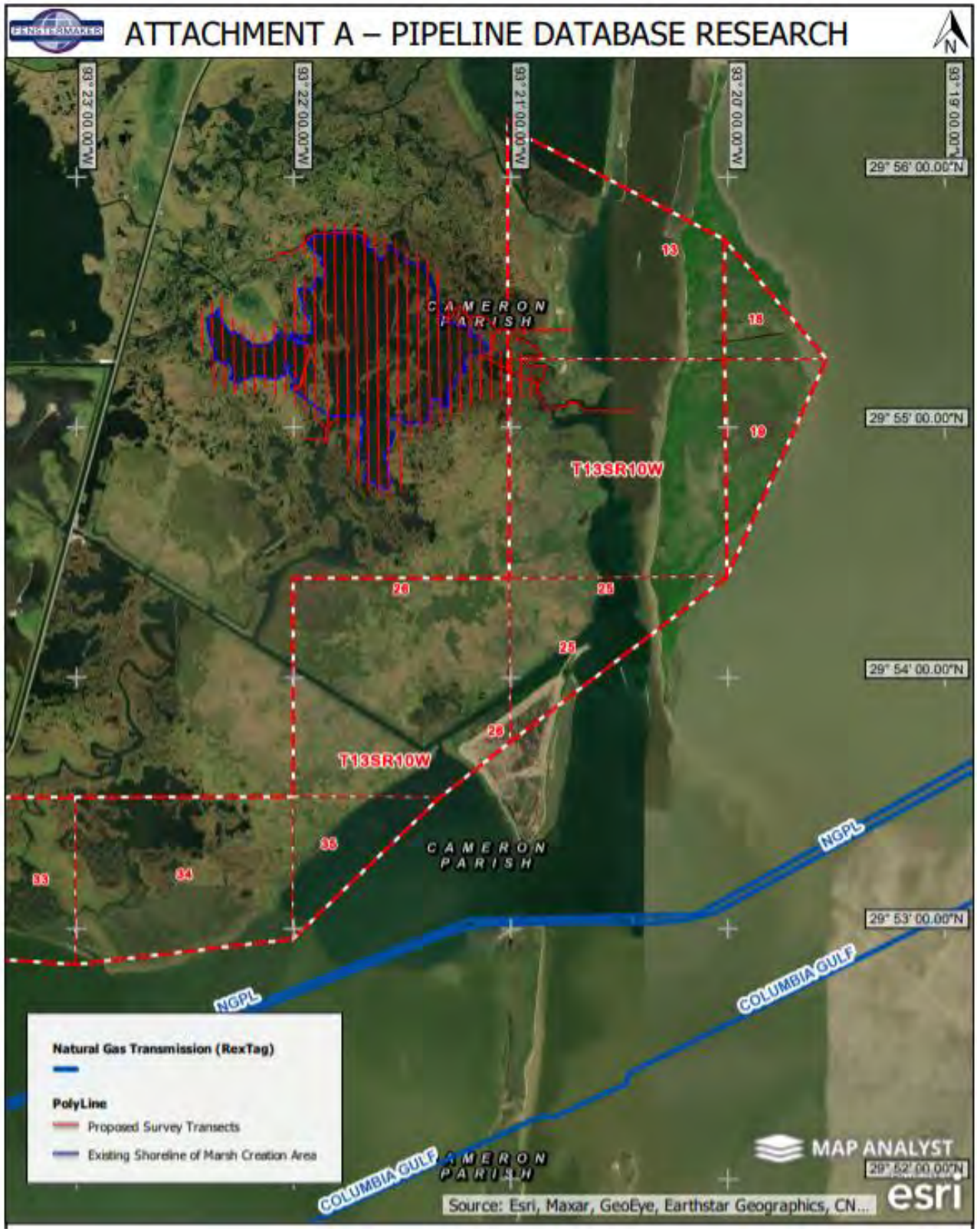
Please be advised that the data, which was collected during the survey of this project, represents an epoch, a snapshot at the time that the survey was performed. Due to the effects of crustal motion, subsidence, upheaval, drought and other conditions which influence the physical position and stability of surface monuments, topographic features, and other structures within the Louisiana Coastal Zone, it is recommended that GPS monuments used for this project be re-observed and reprocessed on future surveys using the same reference control, if possible, for the purpose of updating the three dimensional position of the reference monuments.

The GPS/RTK Survey protocols performed in support of this project were in accordance with the Coastal Protection and Restoration Authority of Louisiana requirements as described in "A Contractor's Guide to the Standards of Practice Required by Louisiana Department of Natural Resources, Coastal Restoration Division for Contractor's Performing GPS Surveys and Establishing GPS Derived Orthometric Heights Within the Louisiana Coastal Zone Primary GPS Network" dated January 2019. All Static GPS were adjusted using Trimble Business Center software to determine the final positions for all reference control monuments.

C. H. Fenstermaker & Associates, LLC

7/23/2020

Ricardo M. Johnson, PLS LA Reg. 4767
Director of Coastal Services, Survey & Mapping



(Source: Fenstermaker Map Analyst/RexTag)