

# Hydrographic Survey of the Keith Lake-Salt Bayou System

April 2007 Survey



Prepared by:

The Texas Water Development Board

December 2007

# Texas Water Development Board

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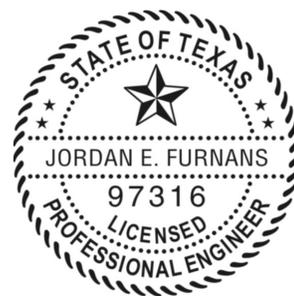
## **Texas Parks and Wildlife Department**

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## **Executive Summary**

In April of 2007, the Texas Water Development Board (TWDB) entered into agreement with the Texas Parks and Wildlife Department for the purpose of collecting bathymetric data within the Keith Lake-Salt Bayou system near Port Arthur, Texas. Data were collected in support of hydrodynamic modeling of the system. Data collection was performed on April 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup> of 2007 using a Knudsen 200 kHz echosounder integrated with differentially corrected global positioning system (DGPS) navigation equipment.

The survey data collected by TWDB was augmented by two other datasets. This report provides descriptions of the data collection effort, the descriptions of the data processing methods, and maps showing the bathymetry of the Keith Lake-Salt Bayou system as implied by the data collected by TWDB and other entities.

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## Keith Lake-Salt Bayou System General Information

The Keith Lake-Salt Bayou system is part of a large wetland complex composed of hydraulically connected shallow lakes and small bayous. These lakes and bayous once formed the coastal reach of a much larger coastal drainage system extending north as far as Beaumont, TX. This wetland serves as an important winter home for ducks, geese, and other migratory waterfowl, and contains a diverse assemblage of freshwater vegetation and marsh fauna. Historical and recent modifications to the landscape, most notably the introduction of navigation channels, have connected what was once a predominantly freshwater system to tidal waters with marine salinities. Studies are currently being conducted by the Texas Parks and Wildlife Department (TPWD) and Texas Water Development Board (TWDB) to assess the impact of the salinity increases on the Keith Lake-Salt Bayou ecosystem as well as to determine potential strategies reducing system salinities to levels commonly observed before the recent landscape modifications. In its current condition, the system continues to serve as an important site for migratory waterfowl, for wetland flora, and also as a nursery area for estuarine fish species.



Figure 1- Location of the Keith Lake-Salt Bayou System

# **Bathymetric Survey of the Keith Lake-Salt Bayou Area**

## **Introduction**

In April of 2007, the Texas Water Development Board (TWDB) entered into agreement with the Texas Parks and Wildlife Department for the purpose of collecting bathymetric data within the Keith Lake-Salt Bayou system near Port Arthur, Texas. Data were collected in support of a hydrodynamic and salinity transport modeling effort being undertaken by TWDB. The data collection effort was not designed to determine water volumes within the Keith Lake-Salt Bayou system or to aid in navigation. The data collected by TWDB was augmented with other bathymetric datasets available for the system in order to improve the bathymetric surface models representing the entire system. In areas where no bathymetric data are available, TWDB made water-depth approximations based on field observations and general knowledge of the system characteristics.

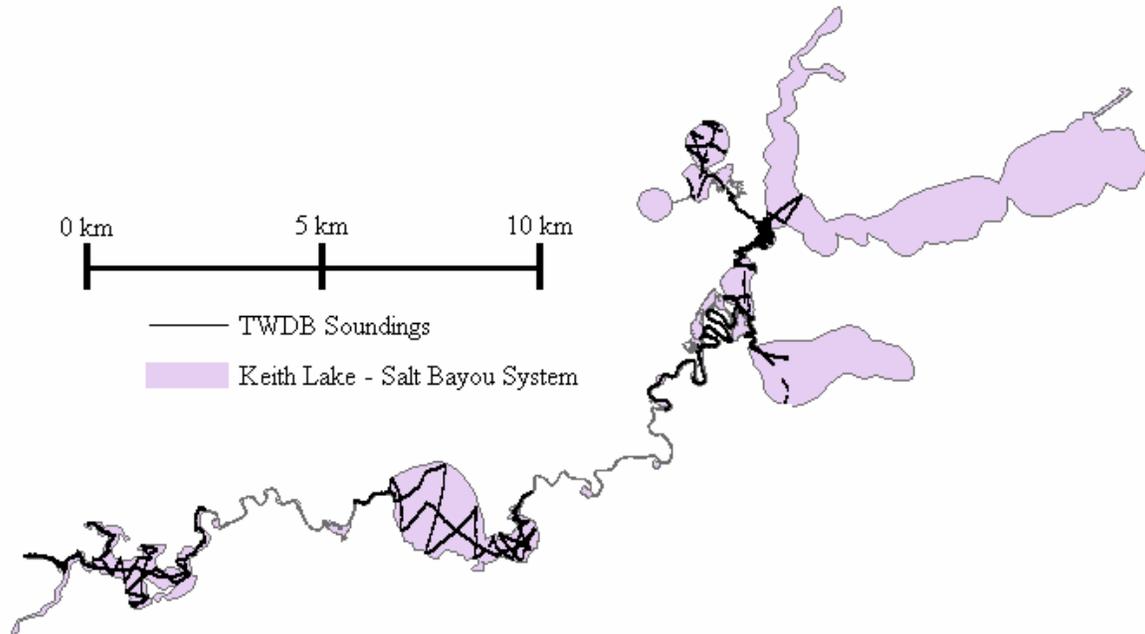
## **Datum**

All elevations reported throughout this report are referenced to the North American Vertical Datum of 1988 (NAVD 88). The horizontal datum used for this report is North American Datum of 1983 (NAD83) State Plane Texas South Central Zone (feet). Unless otherwise noted, all elevations provided herein are referenced to the NAVD 88 datum.

## **TWDB Bathymetric Data Collection & Processing**

Data collection was performed on April 10<sup>th</sup>, 11<sup>th</sup>, and 12<sup>th</sup> of 2007 using a Knudsen 200 kHz echosounder integrated with differentially corrected global positioning system (DGPS) navigation equipment. Where possible, data was collected to ensure maximal coverage of the system. Data collection efforts were also focused in areas of importance for the hydrodynamic model, as determined by TWDB. Within such areas, a greater number of depth soundings were recorded. Where such focused data collection was not possible, as in constricted channels or areas clogged with vegetation, limited data were collected, allowing for only rough approximations of the local bathymetric surface to be made. Data collection efforts were also located in areas previously surveyed by other

entities in order to appropriately couple bathymetries derived from each available dataset. For all data collection efforts, the depth sounder was calibrated daily with a stadia rod. During the 2007 survey, team members collected 37,841 data points over boat tracks totaling nearly 50 miles in length (Figure 2).



*Figure 2 – TWDB data collection within the Keith Lake-Salt Bayou system*

TWDB data was processed using the HydroEdit [1] software developed by TWDB. This program applies a median filter to collected data in order to remove data spikes and other invalid data points. The HydroEdit software is also used to convert the water depth measurements to bathymetric elevations, by subtracting the depths from the water surface elevations at the time of each measurement. Water surface elevations were recorded at five locations within the Keith Lake-Salt Bayou system (Table 1), although, differences exist for the elevations measured at each station at equal times (Figure 3). To determine the approximate water surface elevation at the location of each TWDB sounding point, a simple division of the system areas was used. All sounding points were grouped by proximity to the Star Lake, Ten Mile Bridge, or Salt Bayou gauging stations (Figure 4). Elevations measured at each gauging station were then assumed to be equal to the water surface elevation at each sounding location within the designated grouping.

Table 1 – Water surface elevation gauging stations in the Keith Lake – Salt Bayou System

Station Name	Latitude	Longitude	Description	Collecting Agency
Ten Mile Bridge	29.69167° N	94.08056° W	On Clam Lake Road	Drainage District 6
Star Lake	29.68528° N	94.18417° W	From Marsh Chevron Duck Camp	Drainage District 6
Keith Lake	29.76056° N	93.93806° W	On HW 87	Drainage District 6
Salt Bayou	29.79278° N	94.00944° W	At GIWW outfall	Drainage District 6
JDM4	29.71730° N	94.04035° W	TWDB Temporary Site	TWDB

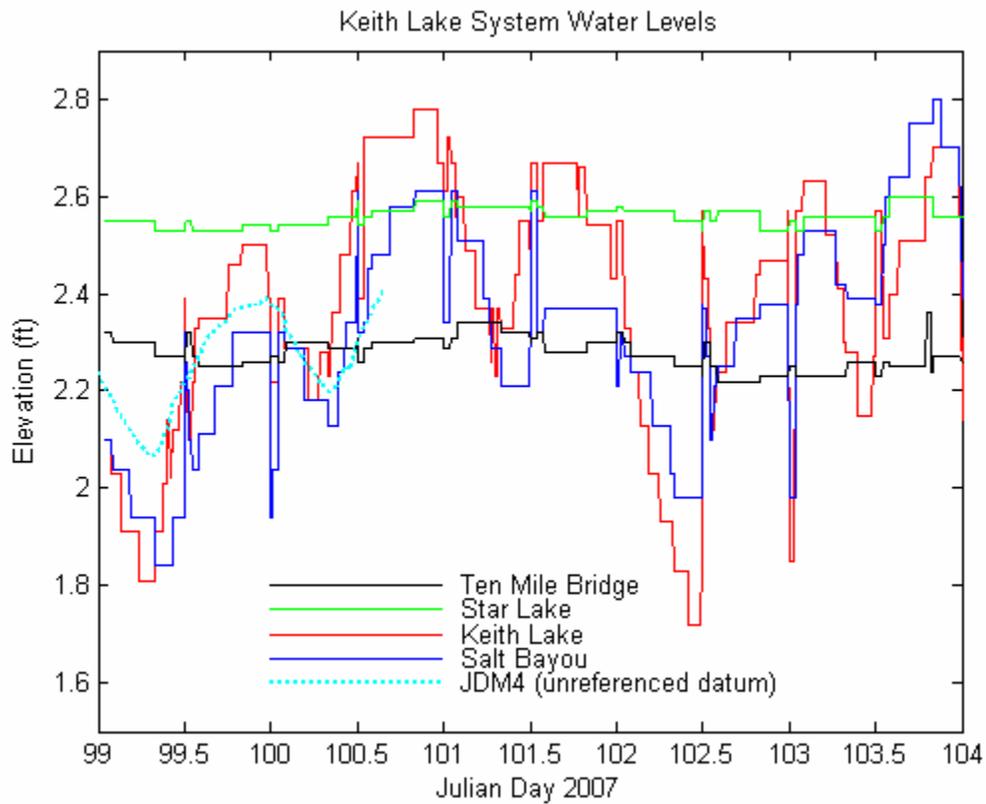
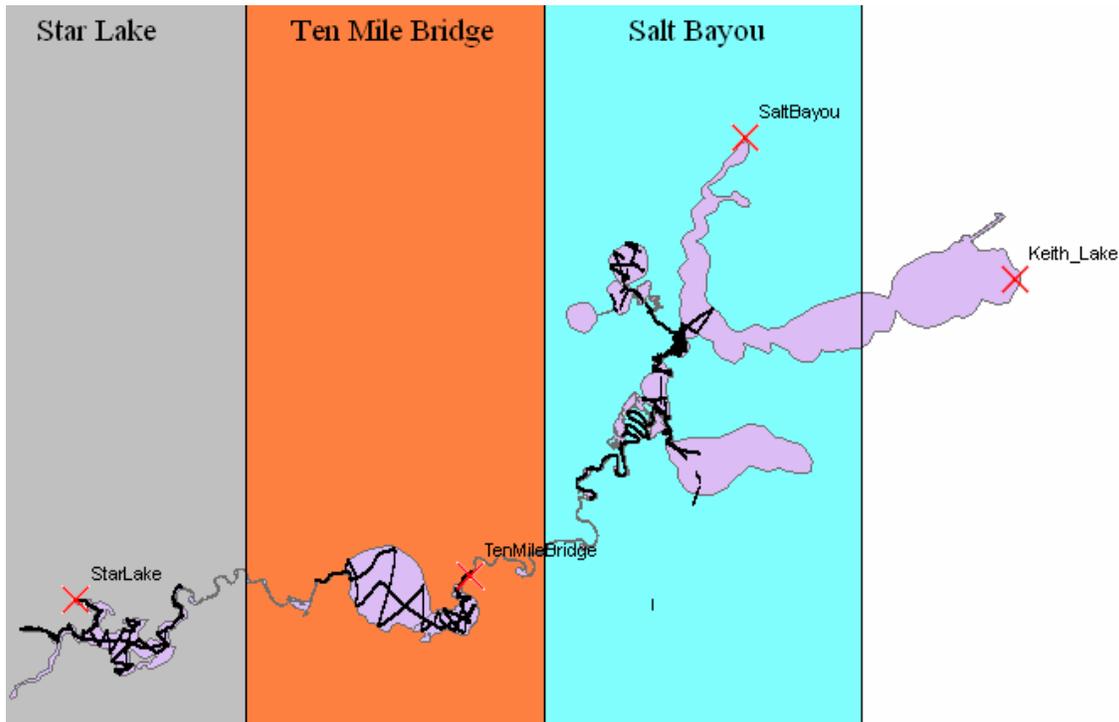


Figure 3 – Comparative plot of water surface elevations within the Keith Lake-Salt Bayou system

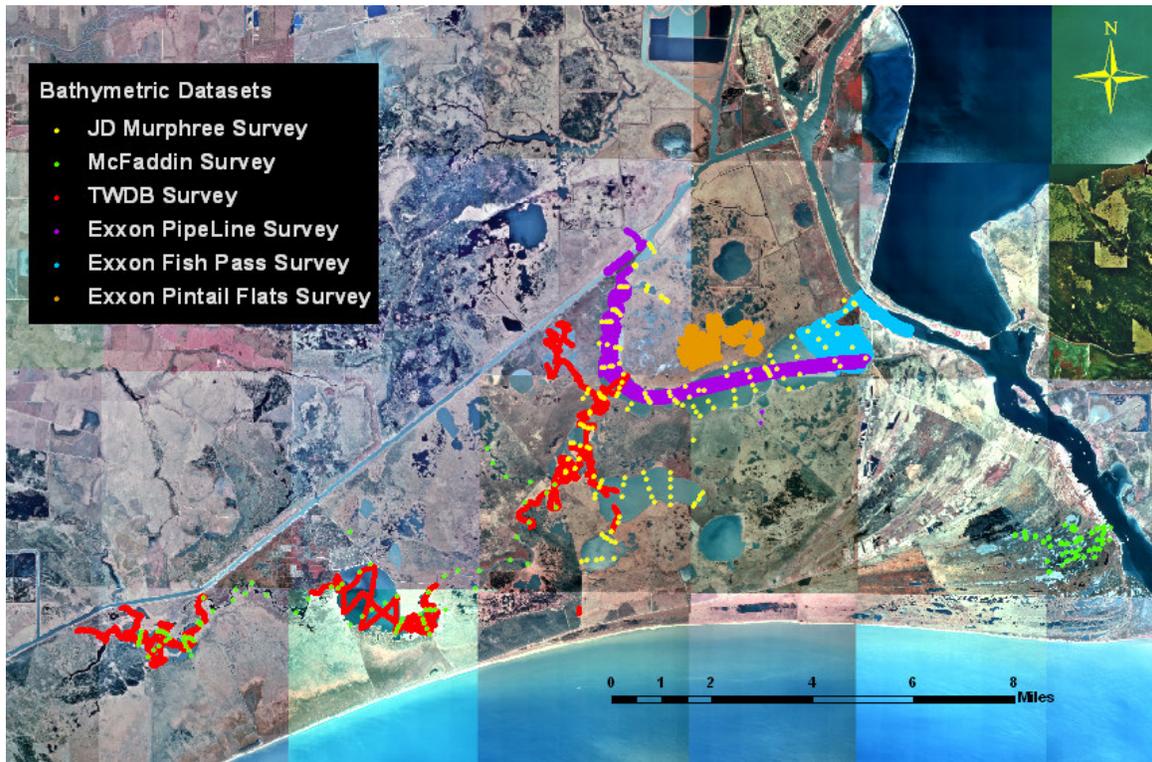


*Figure 4 – Assigning water surface elevations based on proximity to referenced gauging stations. TWDB soundings were divided into 3 groups and assigned water surface elevations as recorded at the gauge (red X) within each grouping.*

## **Generating Bathymetric Coverage for the Entire System**

### **Description of Bathymetric Datasets**

The data collected by the TWDB was augmented with data from surveys conducted during projects sponsored by the J.D Murphree Wildlife Management Area and the McFaddin National Wildlife Refuge in June 2002 [2], and by Exxon-Mobil (as part of the Golden Pass Pipeline project) in July 2006 [3]. Figure 5 shows the spatial extent of each survey as well as the TWDB survey. The surveys conducted by staff from the J.D Murphree Wildlife Management Area and the McFaddin National Wildlife Refuge used a handheld GPS unit and a handheld fathometer. The Exxon-Mobil sponsored-survey was conducted in three parts using various depth sounding equipment. Only the Exxon-Mobil Pintail Flats survey is referenced to the NAVD88 vertical datum. None of the other surveys are referenced to a vertical datum. The Exxon-Mobil Pintail Flats survey was not used in developing this report, however, because the Pintail Flats area is not part of the main Keith Lake-Salt Bayou system.



*Figure 5 - Spatial Coverage of Bathymetric Surveys. Background aerial imagery photographed during 1995-1996 [6].*

### **Merging the Bathymetric Surveys**

This section contains a description of the procedures used by TWDB in merging the unreferenced survey data with the TWDB survey data referenced to the NAVD88 datum. To combine the available surveys the following empirical procedure was used:

1. Overlap regions between surveys were selected, where data from a referenced survey is coincident with that from an unreferenced survey
2. Elevations derived from the higher resolution survey were interpolated to “target” locations of soundings in the lower resolution survey within each overlap region
3. At these “target” locations, the difference in bathymetry values between the two datasets was computed and geometrically averaged. The averaged difference value was then used as a correction factor to be added to the unreferenced survey data. The overlap regions were examined to check that the datum shift was reasonably consistent
4. After the correction factors were applied the surveys were merged into a single bathymetric dataset

Table 2 lists the bathymetric surveys and their calculated correction factors.

*Table 2- Vertical Datum Corrections for Bathymetric Surveys*

<b>Survey</b>	<b>Year</b>	<b>Vertical Datum</b>	<b>Correction Factor (ft)</b>
TWDB	2007	NAVD88	0.0000
Exxon Pipeline	2006	Not Referenced	+1.6530
Exxon Fish pass	2006	Not Referenced	+0.5128
Exxon Pintail Flats	2006	NAVD88	+0.0000
J.D. Murphree	2002	Not Referenced	+2.5922
McFaddin	2002	Not Referenced	+1.6185

### **Data Interpolation Methods**

The merged bathymetric dataset has spatial gaps in its coverage. To generate system wide coverage, the SMS 10.0 [4] software was used. The Keith Lake-Salt Bayou system was divided into a series of polygons, with the polygons serving as interpolation boundaries (preventing interpolation between data from adjacent polygons). Within each polygon a linear interpolation scheme and an inverse distance weighted extrapolation scheme was used to generate polygon wide data coverage. Areas with insufficient data were excluded and certain shallow regions (which were inaccessible by boat) were assumed to be 1 foot deep (-1.3 feet NAVD88) based on observations made during field surveys.

### **Bathymetric Maps & Data Distribution**

Figures 6 and 7, respectively, show a relief and contour map of the entire system. Electronic copies of raw and processed data files are provided on a DVD accompanying this report. Two additional datasets are provided on the DVD for completeness: 1) “Hydrodynamic Model Bathymetry” obtained from the US Army Corps of Engineers [5], and 2) LIDAR elevation data (5-meter resolution) for Jefferson County obtained from the Texas Natural Resource Information System (TNRIS) [7]. A description of all the electronic files on the DVD can be found in Appendix A. Appendix B contains additional information pertaining to the generation of bathymetry for the combined Keith Lake – Sabine Lake Estuary hydrodynamic model grid developed by TWDB.

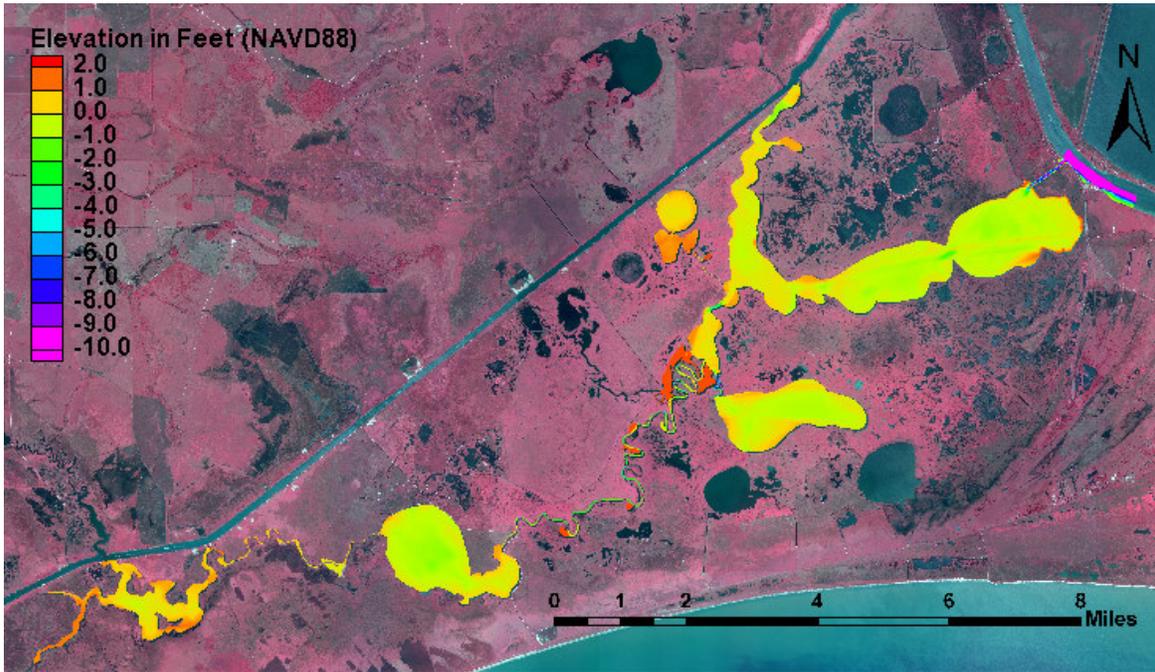


Figure 6 - Relief Map showing bathymetry. Vertical Datum is NAVD88. Background aerial imagery photographed during 2004 [7].

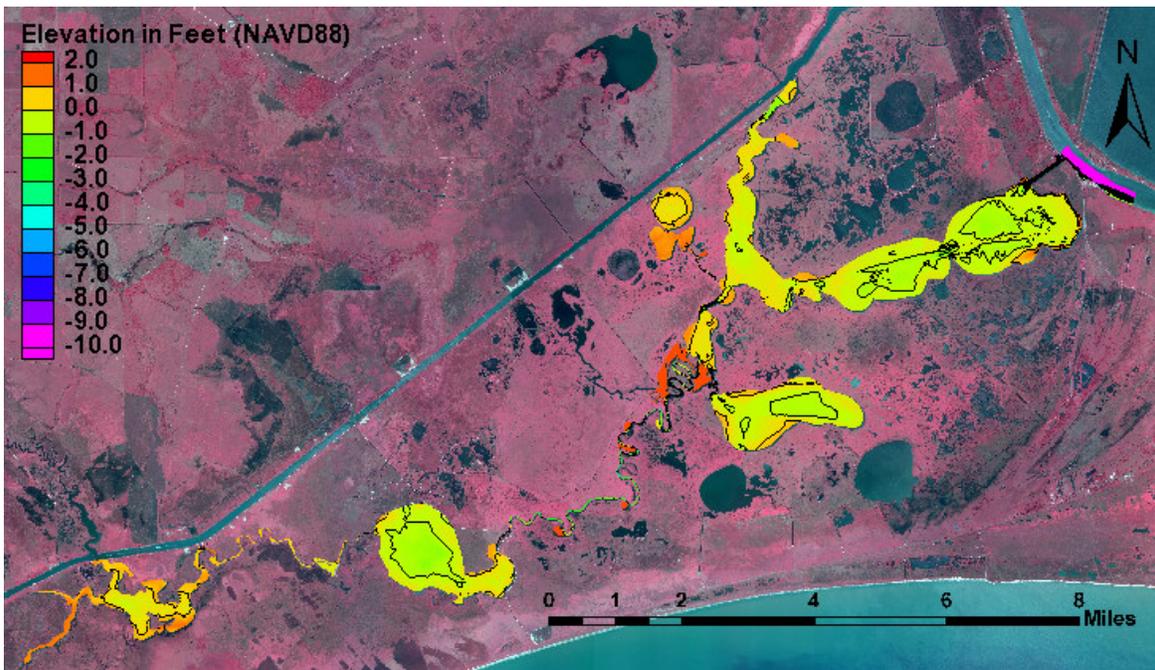


Figure 7 - 1-foot Contour Map showing bathymetry. Vertical Datum is NAVD88. Background aerial imagery photographed during 2004 [7].

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## Appendix A: Description of Electronic Data Files

Table A1. Description of Directories on CD

Directory	Description
Data\RawData	Contains CSV files of bathymetry data from all surveys
Data\DatumOffsetCalculations	Contains files used during calculation of datum offsets for each survey
Data\SMSFiles	Contains SMS files generated during the merging and interpolation of surveys
Data\LIDAR	Contains LIDAR elevation data obtained from the Texas Natural Resource Information System
Data\ProcessedData	Contains CSV files of processed bathymetry data
Figures	Figures used in this report

Table A2. Description of Processed Data Files in directory Data\ProcessedData\

Description	Datum	Vertical Datum	Processed Data File Name
Merged survey data in CSV format.	NAD83 State Plane Texas South Central Zone (feet).	NAVD88	KeithLake_Merged_StatePlaneTXSouthCentralUSft_NAVD88.csv
System wide interpolated bathymetric dataset in CSV format.	NAD83 State Plane Texas South Central Zone (feet).	NAVD88	KeithLake_Interpolated_StatePlaneTXSouthCentraUSft_NAVD88.csv
Hydrodynamic Model Bathymetry for the Kieth Lake – Sabine Lake system in CSV format.	NAD83 UTM15 (m).	Mean Sea Level	KL-Sabine_Model_NAD83UTM15_MSL.csv

Table A3. Description of Survey Raw Data Files

Survey Name	Source	Datum	Vertical Datum	Raw Data File Name
Fishpass	Exxon-Mobil	NAD83 State Plane Texas South Central Zone (feet).	Below Sea Level (i.e unreferenced)	KL_Exxon_FishPass_StatePlaneTxSouthCentralUSft.csv
Pintail Flats	Exxon-Mobil	NAD83 State Plane Texas South Central Zone (feet).	NAVD88	KL_Exxon_Pintail_StatePlaneTxSouthCentralUSft.csv
Pipeline	Exxon-Mobil	NAD83 State Plane Texas Central Zone (feet).	Below Sea Level (i.e unreferenced)	KL_Exxon_PipeLine_StatePlaneTxCentralUSft.csv
JDM	J.D Murphree Wildlife Management Area	Geographic NAD83	Unreferenced	KL_JDM_Bathymetry_GeoNAD83_Feet.csv
MCF	McFaddin National Wildlife Refuge	Geographic NAD83	Unreferenced	MCF_Bathymetry_GeoNAD83_Feet.csv
TWDB	Texas Water Development Board	NAD83 State Plane Texas South Central Zone (feet).	NAVD88	KL_TWDB_Bathymetry_GeoNAD83_Feet.csv
USACE-SNWW	US Army Corps of Engineers	NAD83 UTM15 (m)	Mean Tide Level	USACE_SNWW_NAD83UTM15_MLT.csv

## **Appendix B: Hydrodynamic Model Bathymetry**

To generate bathymetry for the TWDB hydrodynamic model the merged and extrapolated bathymetry dataset was converted from NAVD88 to Mean Sea Level (MSL). Since there exists no established datum conversion from the NAVD88 vertical datum to tidal MSL datum, we chose to approximate a conversion by subtracting 2.32 feet. This 2.32 feet value is the average correction that was used in converting sounding depths to bathymetric elevations based on field level measurements in the TWDB survey. Shallow pools of water that the survey boats were unable to traverse were set to be 1.3 feet NAVD (or approximately -1 foot MSL).

Another model bathymetric dataset developed for a modeling project of the Sabine-Neches Waterway was obtained from the U.S. Army Corps of Engineers (USACE) [5]. This data was referenced to the Mean Low Tide (MLT) tidal datum. The USACE dataset was clipped to exclude areas covered by the merged bathymetric dataset described in this report. The USACE data was then referenced to the same MSL data of the TWDB hydrodynamic model bathymetry by subtracting 1 foot. This shift was calculated from a comparison of an overlapping region in the Sabine-Neches Ship Channel.