Volumetric and Sedimentation Survey of LAKE GEORGETOWN

December 2015 – January 2016 Survey

Texas Water Development Board

March 2017

Texas Water Development Board

Prepared for:

Brazos River Authority

With Support Provided by:

U.S. Army Corps of Engineers, Fort Worth District

This report was prepared by staff of the Surface Water Division:

Nathan Leber, Manager
Holly Holmquist
Khan Iqbal

Published and distributed by the

Texas Water Development Board

P.O. Box 13231, 1700 N. Congress Ave.
Austin, TX 78711-3231, www.twdb.texas.gov
Phone (512) 463-7847, Fax (512) 475-2053

Executive summary

In January 2016, the Texas Water Development Board (TWDB) entered into an agreement with the U.S. Army Corps of Engineers, Fort Worth District, and in February 2016, entered into an agreement with the Brazos River Authority, to perform a volumetric and sedimentation survey of Lake Georgetown (Williamson County, Texas). The Brazos River Authority provided 50 percent of the funding for this survey, while the U.S. Army Corps of Engineers, Fort Worth District, provided the remaining 50 percent of the funding through their Texas Water Allocation Assessment Program. Surveying was performed using a multi-frequency (208 kHz, 50 kHz, and 24 kHz), sub-bottom profiling depth sounder. In addition, sediment core samples were collected in select locations and correlated with the multi-frequency depth sounder signal returns to estimate sediment accumulation thicknesses and sedimentation rates.

North San Gabriel Dam and Lake Georgetown are located on the North Fork of the San Gabriel River, a tributary of the Brazos River, approximately 3.5 miles northwest of downtown Georgetown, in Williamson County, Texas. The conservation pool elevation of Lake Georgetown is 791.0 feet above mean sea level (NGVD29). The TWDB collected bathymetric data for Lake Georgetown between December 15, 2015 and January 15, 2016, while daily average water surface elevations measured between 794.74 and 791.57 feet above mean sea level (NGVD29).

The 2016 TWDB volumetric survey indicates that Lake Georgetown has a total reservoir capacity of 38,068 acre-feet and encompasses 1,307 acres at conservation pool elevation (791.0 feet above mean sea level, NGVD29). The original design estimate by the U.S. Army Corps of Engineers indicates Lake Georgetown encompassed 1,310 acres with a total reservoir capacity of 37,100 acre-feet. The TWDB previously surveyed Lake Georgetown in 1995 and 2005. The 1995 and 2005 TWDB surveys were re-evaluated using current processing procedures resulting in updated capacity estimates of 37,932 acre-feet and 38,582 acre-feet, respectively.

The 2016 TWDB sedimentation survey indicates Lake Georgetown has lost capacity at an average of 21 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (791.0 feet NGVD29). The sedimentation survey indicates sediment accumulation varies throughout the reservoir. Sediment accumulation is greater in the lower lying floodplains. The TWDB recommends that a similar methodology be used to resurvey Lake Georgetown in 10 years or after a major flood event.

Table of Contents

List of Tables

List of Figures

Appendices

Introduction

The Hydrographic Survey Program of the Texas Water Development Board (TWDB) was authorized by the 72nd Texas State Legislature in 1991. Texas Water Code Section 15.804 authorizes the TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In January 2016, the TWDB entered into an agreement with the U.S. Army Corps of Engineers, Fort Worth District, and in February 2016, entered into an agreement with the Brazos River Authority, to perform a volumetric and sedimentation survey of Lake Georgetown (Texas Water Development Board, 2016a; Texas Water Development Board, 2016b). This report provides an overview of the survey methods, analysis techniques, and associated results. Also included are the following contract deliverables: (1) a shaded relief plot of the reservoir bottom (Figure 4), (2) a bottom contour map (Figure 6), (3) an estimate of sediment accumulation and location (Figure 10), and (4) an elevation-area-capacity table of the reservoir acceptable to the Texas Commission on Environmental Quality (Appendices A and B).

Lake Georgetown general information

North San Gabriel Dam and Lake Georgetown, formerly known as North Fork (San Gabriel River) Dam and North Fork Lake, are located on the North Fork of the San Gabriel River, a tributary of the Brazos River, approximately 3.5 miles northwest of downtown Georgetown, in Williamson County, Texas (Figure 1). North San Gabriel Dam and Lake Georgetown are owned by the U.S. Government and operated by the U.S. Army Corps of Engineers, Fort Worth District (Texas Water Development Board, 1973). The U.S. Congress authorized the construction of Lake Georgetown for flood control, water conservation, and other multipurpose uses with the passage of the Flood Control Act approved October 23, 1962 (U.S. Army Corps of Engineers, 2017). Construction on North San Gabriel Dam initiated in 1968, and deliberate impoundment began on March 3, 1980. North San Gabriel Dam was completed in 1982 (U.S. Army Corps of Engineers, 2017). Additional pertinent data about North San Gabriel Dam and Lake Georgetown can be found in Table 1.

Water rights for Lake Georgetown have been appropriated to the Brazos River Authority through Certificate of Adjudication No. 12-5162. The complete certificate is on file in the Information Resources Division of the Texas Commission on Environmental Quality.

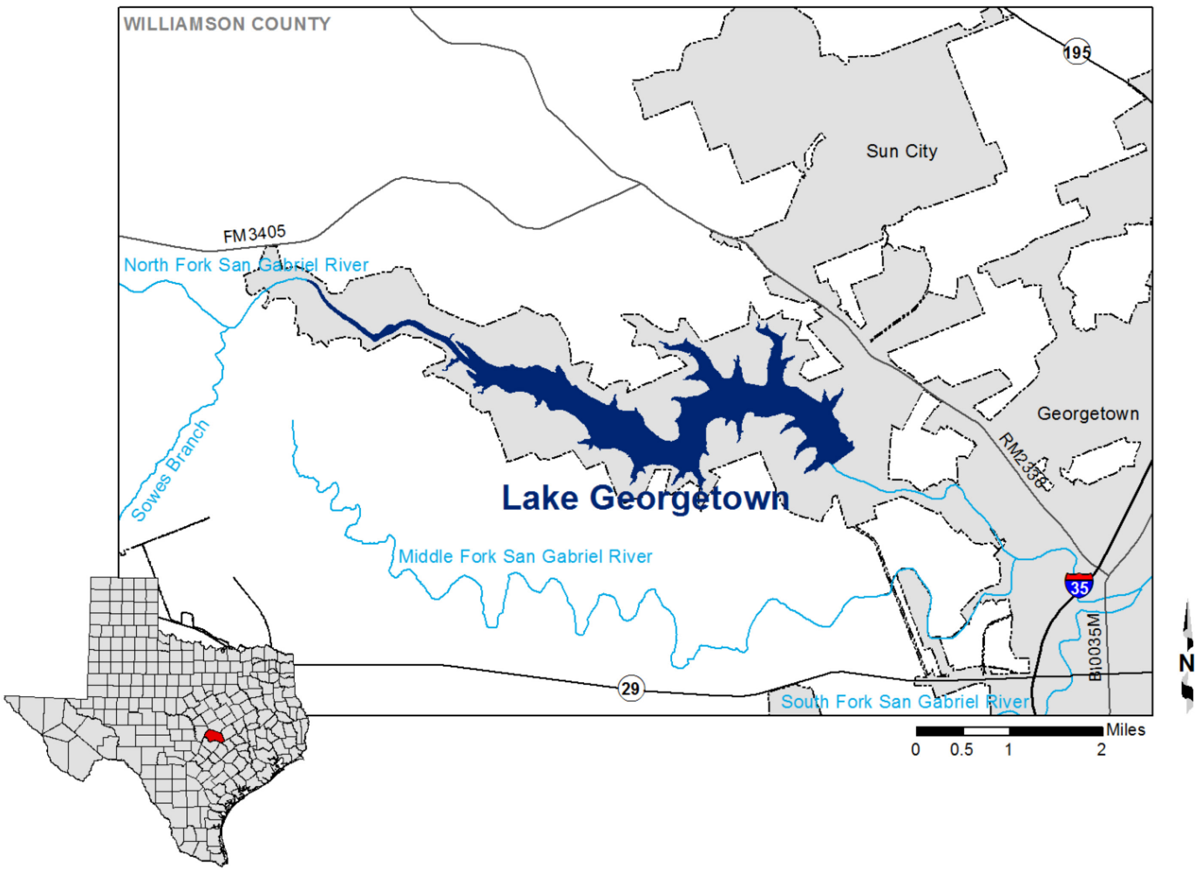


Figure 1. Location map of Lake Georgetown.

Table 1. Pertinent data for North San Gabriel Dam and Lake Georgetown.

Owner				
The U.S. Government				
Operated by the U.S. Army Corps of Engineers, Fort Worth District				
Design Engineer				
U.S. Army Corps of Engineers				
Location of dam				
On the North Fork of the San Gabriel River, a tributary of the Brazos River, approximately 3.5 miles west of the City of Georgetown				
Drainage area				
246 square miles				
Dam				
Type	Rock fill, impervious core			
Length	6,700 feet (including spillway)			
Maximum height	164 feet			
Top width	30 feet			
Spillway				
Type	Broad-crested weir			
Control	None			
Length	1,000 feet			
Crest elevation	834.0 feet above mean sea level			
Outlet Works				
Type	1 gate controlled conduit			
Dimension	11-foot diameter			
Control	2- 5 feet by 11 feet hydraulic operated slide gates			
Invert elevation	720.0 feet above mean sea level			
Reservoir data (Based on 2016 TWDB survey)				
Feature		**Elevation (feet** NGVD29[a]**)**	**Capacity (acre-feet)**	**Area (acres)**
Top of dam		861.0	N/A	N/A
Top of flood control pool and spillway crest elevation		834.0	N/A	N/A
Top of conservation pool		791.0	38,068	1,307
Invert elevation/ dead pool		720.0	63	16
Usable conservation storage space[b]		—	38,005	—

Source: (Texas Water Development Board, 1973; U.S. Army Corps of Engineers, 2017)
[a] NGVD29 = National Geodetic Vertical Datum 1929
[b] Usable conservation storage space equals total capacity at conservation pool elevation minus dead pool capacity. Dead pool refers to water that cannot be drained by gravity through a dam's outlet works.

Volumetric and sedimentation survey of Lake Georgetown

Datum

The vertical datum used during this survey is the National Geodetic Vertical Datum 1929 (NGVD29). This datum also is utilized by the United States Geological Survey (USGS) for the reservoir elevation gage *USGS 08104650 Lk Georgetown nr Georgetown, TX* (U.S. Geological Survey, 2017). Elevations herein are reported in feet relative to the NGVD29 datum. Volume and area calculations in this report are referenced to water levels provided by the USGS gage. The horizontal datum used for this report is North American Datum 1983 (NAD83), and the horizontal coordinate system is State Plane Texas Central Zone (feet).

TWDB bathymetric and sedimentation data collection

The TWDB collected bathymetric data for Lake Georgetown between December 15, 2015 and January 15, 2016, while the daily average water surface elevations measured between 794.74 and 791.57 feet above mean sea level (NGVD29). For data collection, the TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (208 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment. Data was collected along pre-planned survey lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. Many of the same survey lines also were used by the TWDB during the 1995 and 2005 surveys. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. Figure 2 shows the data collection locations for the 2016 TWDB survey.

All sounding data was collected and reviewed before sediment core sampling sites were selected. Sediment core samples were collected at regularly spaced intervals within the reservoir or at locations where interpretation of the acoustic display would be difficult without site-specific sediment core data. After analyzing the sounding data, the TWDB selected six locations to collect sediment core samples; however, sediment core sample 1 was not recoverable (Figure 2). The sediment core samples were collected on September 9, 2016, with a custom-coring boat and SDI VibeCore system.

Sediment cores are collected in 3-inch diameter aluminum tubes. Analysis of the acoustic data collected during the bathymetric survey assists in determining the depth of penetration the tube must be driven during sediment sampling. The goal is to collect a sediment core sample extending from the current reservoir-bottom surface, through the accumulated sediment, and into the pre-impoundment surface. After retrieving the sample, a stadia rod is inserted into the top of the aluminum tubes to assist in locating the top of the sediment in the tube. This identifies the location of the layer corresponding to the current reservoir-bottom surface. The aluminum tube is cut to this level, capped, and transported back to TWDB headquarters for further analysis. During this time, some settling of the upper layer can occur.

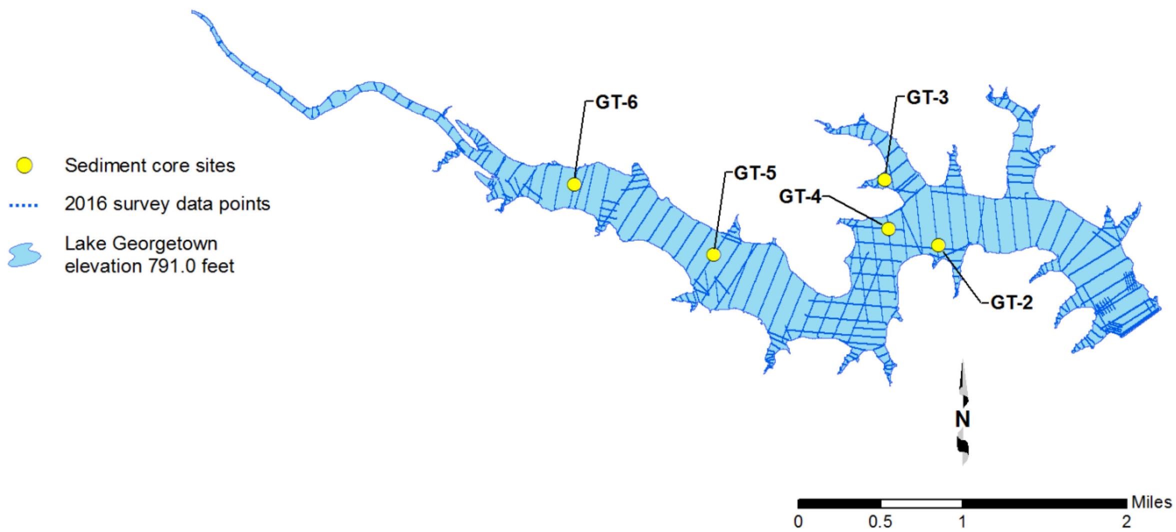


Figure 2. 2016 TWDB Lake Georgetown survey data (*blue dots*) and sediment coring locations (*yellow circles*).

Data processing

Model boundaries

The reservoir's model boundary was generated from Light Detection and Ranging (LIDAR) Data available from the Texas Natural Resource Information System (Texas Natural Resources Information System, 2017). The LIDAR data was collected on December 29, 2014, while the daily average reservoir elevation measured 778.89 feet. According to the associated metadata, the 2014 LIDAR data has a vertical accuracy of ±7 centimeters and a horizontal accuracy of 0.25 meters (Texas Natural Resources Information System, 2017). To generate the boundary, LIDAR data with a classification equal to 2, or ground, was imported into an Environmental Systems Research Institute's ArcGIS file geodatabase from .las files. A topographical model of the data was generated and converted to a raster.

The horizontal datum of the 2014 LIDAR data is Universal Transverse Mercator (UTM) North American Datum 1983 (NAD83; meters) Zone 14, and the vertical datum is North American Vertical Datum 1988 (NAVD88; meters). Therefore, a contour of 241.185806 meters NAVD88, equivalent to 791.0 feet NGVD29, was extracted from the raster. The vertical datum transformation offset for the conversion from NAVD88 to NGVD29 was determined by applying the National Oceanic and Atmospheric Administration National Geodetic Survey's NADCON software (National Geodetic Survey, 2017a) and VERTCON software (National Geodetic Survey, 2017b) to a single reference point in the vicinity of the survey, the reservoir elevation gage *USGS 08104650 Lk Georgetown nr Georgetown, TX Latitude 30º40'03.00"N, Longitude 97º43'38.00"W NAD27.* Horizontal coordinate transformations to NAD83 State Plane Texas Central Zone (feet) coordinates were done using the ArcGIS Project tool. Minor editing of the 791.0-foot contour was necessary to include all survey data with elevations below conservation pool elevation and remove anomalous artifacts.

Triangulated Irregular Network model

Following completion of data collection, the raw data files collected by the TWDB were edited to remove data anomalies. The reservoir's current bottom surface is automatically determined by the data acquisition software. DepthPic© software, developed by SDI, Inc., was used to display, interpret, and edit the multi-frequency data by manually removing data anomalies in the current bottom surface and manually digitizing the reservoir-bottom surface at the time of initial impoundment (*i.e.* pre-impoundment surface). For further analysis, HydroTools, software developed by TWDB staff, was used to merge all the data into a single file including the current reservoir-bottom surface, pre-impoundment surface, and sediment thickness at each sounding location. The water surface elevation at the time of each sounding was used to convert each sounding depth to a corresponding reservoir-bottom elevation. This survey point dataset was then preconditioned by inserting a uniform grid of artificial survey points between the actual survey lines. Bathymetric elevations at these artificial points were determined using an anisotropic spatial interpolation algorithm described in the next section. This technique creates a high resolution, uniform grid of interpolated bathymetric elevation points throughout a majority of the reservoir (McEwen and others, 2011a). Finally, the point file resulting from spatial interpolation is used in conjunction with sounding and boundary data to create volumetric and sediment Triangulated Irregular Network (TIN) models utilizing the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (Environmental Systems Research Institute, 1995).

Spatial interpolation of reservoir bathymetry

Isotropic spatial interpolation techniques such as the Delaunay triangulation used by the 3D Analyst extension of ArcGIS are, in many instances, unable to suitably interpolate bathymetry between survey lines common to reservoir surveys. Reservoirs and stream channels are anisotropic morphological features where bathymetry at any particular location is more similar to upstream and downstream locations than to transverse locations. Interpolation schemes that do not consider this anisotropy lead to the creation of several types of artifacts in the final representation of the reservoir bottom surface and hence to errors in volume. These include artificially-curved contour lines extending into the reservoir where the reservoir walls are steep or the reservoir is relatively narrow, intermittent representation of submerged stream channel connectivity, and oscillations of contour lines in between survey lines. These artifacts reduce the accuracy of the resulting volumetric and sediment TIN models in areas between actual survey data.

To improve the accuracy of bathymetric representation between survey lines, the TWDB developed various anisotropic spatial interpolation techniques. Generally, the directionality of interpolation at different locations of a reservoir can be determined from external data sources. A basic assumption is that the reservoir profile in the vicinity of a particular location has upstream and downstream similarity. In addition, the sinuosity and directionality of submerged stream channels can be determined by directly examining the survey data, or more robustly by examining scanned USGS 7.5 minute quadrangle maps (known as digital raster graphics) and hypsography files (the vector format of USGS 7.5 minute quadrangle map contours) when available. Using the survey data, polygons are created to partition the reservoir into segments with centerlines defining directionality of interpolation within each segment. For surveys with similar spatial coverage, these interpolation definition files are, in principle, independent of the survey data and could be applied to past and future survey data of the same reservoir. In practice, however, minor revisions of the interpolation definition files may be needed to account for differences in spatial coverage and boundary conditions between surveys. Using the interpolation definition files and survey data, the current reservoir-bottom elevation, pre-impoundment elevation, and sediment thickness are calculated for each point in the high resolution uniform grid of artificial survey points. The reservoir boundary, artificial survey points grid, and survey data points are used to create volumetric and sediment TIN models representing reservoir bathymetry and sediment accumulation throughout the reservoir. Specific details of this interpolation technique can be found in the HydroTools manual (McEwen and others, 2011a) and in McEwen and others (2011b).

In areas inaccessible to survey data collection, such as small coves and shallow upstream areas of the reservoir, linear interpolation is used for volumetric and sediment accumulation estimations. Linear interpolation follows a line linking the survey points file to the lake boundary file (McEwen and others, 2011a). Without linearly interpolated data, the TIN model builds flat triangles. A flat triangle is defined as a triangle where all three vertices are equal in elevation, generally the elevation of the reservoir boundary. Reducing flat triangles by applying linear interpolation improves the elevation-capacity and elevation-area calculations, although it is not always possible to remove all flat triangles.

Figure 3 illustrates typical results from application of the anisotropic interpolation and linear interpolation techniques to Lake Georgetown. In Figure 3A, deeper channels and steep slopes indicated by surveyed cross-sections are not continuously represented in areas between survey cross-sections. This is an artifact of the TIN generation routine rather than an accurate representation of the physical bathymetric surface. Inclusion of interpolation points in creation of the volumetric TIN model, represented in Figure 3B, directs Delaunay triangulation to better represent the reservoir bathymetry between survey cross-sections. The bathymetry shown in Figure 3C was used in computing reservoir elevation-capacity (Appendix A) and elevation-area (Appendix B) tables.

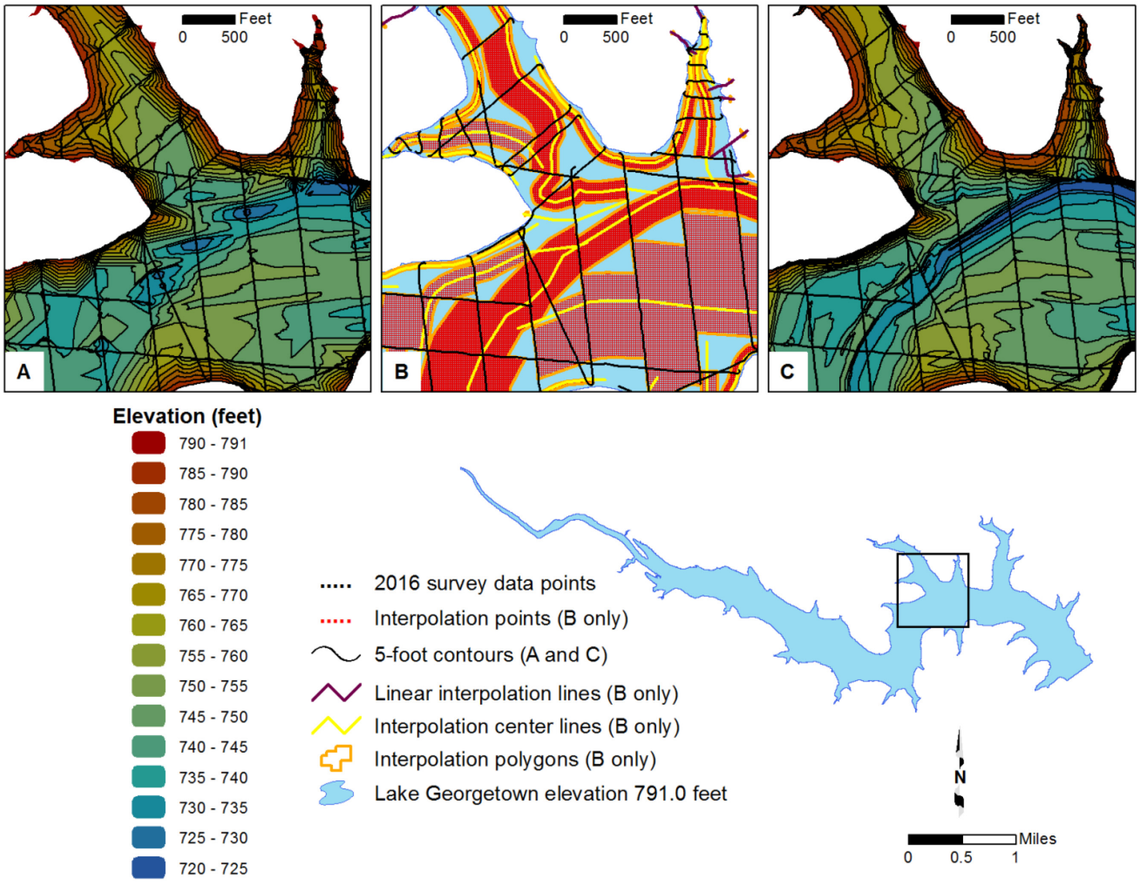


Figure 3. **Anisotropic spatial interpolation and linear interpolation of Lake Georgetown sounding data; A) bathymetric contours without interpolated points, B) sounding points (*black*) and interpolated points (*red*), C) bathymetric contours with interpolated points.**

Area, volume, and contour calculation

Using ArcInfo software and the volumetric TIN model, volumes and areas were calculated for the entire reservoir at 0.1-foot intervals, from 709.3 to 791.0 feet. While linear interpolation was used to estimate topography in areas that were inaccessible by boat or too shallow for the instruments to work properly, development of some flat triangles (triangles whose vertices all have the same elevation) in the TIN model are unavoidable. The flat triangles in turn lead to anomalous calculations of surface area and volume at the boundary elevation 791.0 feet. To eliminate the effects of the flat triangles on area and volume calculations, areas between elevations 790.0 and 791.0 feet were linearly interpolated between the computed values, and volumes above elevation 790.0 feet were calculated based on the corrected areas. The elevation-capacity table and elevation-area table, based on the 2016 survey and analysis, are presented in Appendices A and B, respectively. The capacity curve is presented in Appendix C, and the area curve is presented in Appendix D.

The volumetric TIN model was converted to a raster representation using a cell size of 1 foot by 1 foot. The raster data then was used to produce three figures: (1) an elevation relief map representing the topography of the reservoir bottom (Figure 4); (2) a depth range map showing shaded depth ranges for Lake Georgetown (Figure 5); and, (3) a 5-foot contour map (Figure 6).

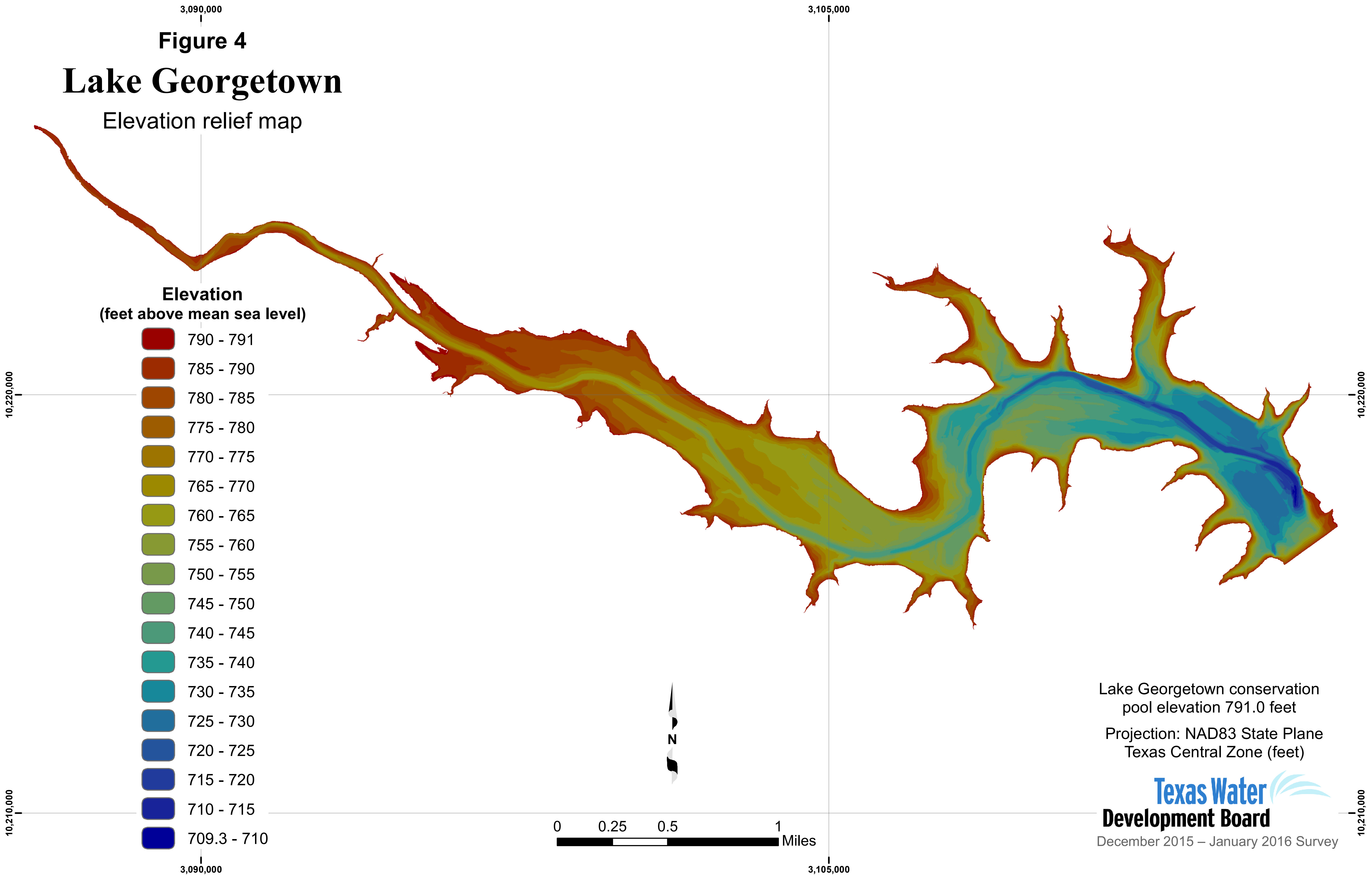


Figure 4
Lake Georgetown
Elevation relief map
3,090,000
3,105,000
10,220,000
10,210,000
Elevation
(feet above mean sea level)
790 - 791
785 - 790
780 - 785
775 - 780
770 - 775
765 - 770
760 - 765
755 - 760
750 - 755
745 - 750
740 - 745
735 - 740
730 - 735
725 - 730
720 - 725
715 - 720
710 - 715
709.3 - 710
N
0
0.25
0.5
1
Miles
Lake Georgetown conservation pool elevation 791.0 feet
Projection: NAD83 State Plane Texas Central Zone (feet)
Texas Water Development Board
December 2015 – January 2016 Survey

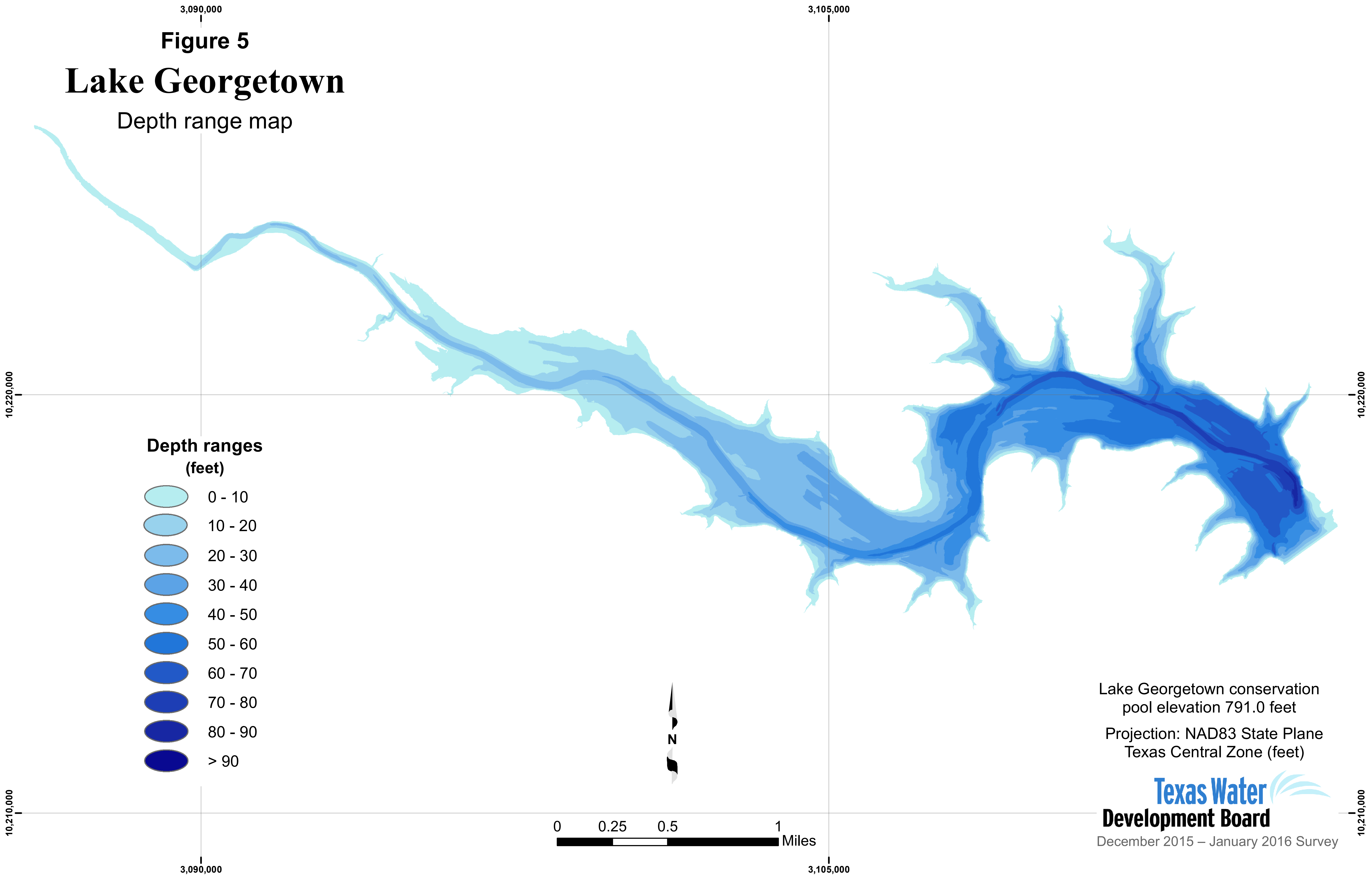


Figure 5
Lake Georgetown
Depth range map
Depth ranges
(feet)
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 60
60 - 70
70 - 80
80 - 90
> 90
N
0
0.25
0.5
1
Miles
Lake Georgetown conservation
pool elevation 791.0 feet
Projection: NAD83 State Plane
Texas Central Zone (feet)
Texas Water
Development Board
December 2015 – January 2016 Survey
3,090,000
3,105,000
10,220,000
10,210,000

Analysis of sediment data from Lake Georgetown

Sedimentation in Lake Georgetown was determined by analyzing the acoustic signal returns of all three depth sounder frequencies in the DepthPic© software. While the 208 kHz signal is used to determine the current bathymetric surface, all three frequencies, 208 kHz, 50 kHz, and 24 kHz, are analyzed to determine the reservoir bathymetric surface at the time of initial impoundment, *i.e.*, pre-impoundment surface. Sediment core samples collected in the reservoir are correlated with the acoustic signals in each frequency to assist in identifying the pre-impoundment surface. The difference between the current surface bathymetry and the pre-impoundment surface bathymetry yields a sediment thickness value at each sounding location.

Analysis of the sediment core samples was conducted at TWDB headquarters in Austin. Each sample was split longitudinally and analyzed to identify the location of the pre-impoundment surface. The pre-impoundment surface is identified within the sediment core sample by one or more of the following methods: (1) a visual examination of the sediment core for terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, *etc.*, concentrations of which tend to occur on or just below the pre-impoundment surface; (2) changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials; and, (3) variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth (Van Metre and others, 2004). Total sample length, post impoundment sediment thickness, and pre-impoundment thickness were recorded. Physical characteristics of the sediment core, such as Munsell soil color, texture, relative water content, and presence of organic materials also were recorded (Table 2).

Table 2. Sediment core sampling analysis data for Lake Georgetown.

Sediment core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment	Sediment core description		Munsell soil color
GT-2	3110010.23	10218891.07	10.0"/7.5"	post-impoundment	0.0–2.0" Very high water content, silt	2.5Y 3/2 very dark grayish brown
					2.0–7.5" High water content, silt	2.5Y 3/2 very dark grayish brown
				pre-impoundment	7.5–10.0" Distinct water content drop and layer of organic debris (twigs, leaf litter, bark) at boundary at 7.5", clay, distinct color change in layer	2.5Y 5/3 light olive brown
GT-3	3108291.22	10220994.81	6.75"/2.25"	post-impoundment	0.0–0.5" water and fluff	N/A
					0.5–2.25" High water content, silt, very fine pebbles (<1/16") throughout	2.5Y 3/2 very dark grayish brown
				pre-impoundment	2.25–6.75" Distinct water content drop and organics (sticks >1") at 2.25" boundary, clay with small roots throughout layer	10 YR 3/1 very dark gray
GT-4	3108409.47	10219427.22	33.5"/27.75"	post-impoundment	0.0–1.0" water and fluff	N/A
					1.0–27.75" high water content slightly decreasing with depth, pudding-like consistency, silt	2.5Y 3/1 very dark grey
				pre-impoundment	27.75–33.5" Distinct water content drop and color change at boundary at 27.75", very dense clay, large shell pieces throughout layer	2.5Y 5/4 light olive brown

[a] Coordinates are based on NAD83 State Plane Texas Central System (feet)

Table 2. Sediment core sampling analysis data for Lake Georgetown (continued).

Sedimet core sample	Easting[a] (feet)	Northing[a] (feet)	Total core sample/ post-impoundment sediment	Sediment core description		Munsell soil color
GT-5	3102788.85	10218605.79	6.0”/3.0”	post-impoundment	0.0–0.5” water and fluff	N/A
					0.5–3.0” high water content, silt	2.5Y 4/2 dark grayish brown
				pre-impoundment	3.0–6.0” distinct water content drop at 3.0” boundary, sandy clay loam, pebbles (0.5” diameter) at 3.0” boundary, small roots throughout	2.5Y 3/2 very dark gray
GT-6	3098308.84	10220840.20	16.0”/ 4.0”	post-impoundment	0.0–4.0” very high water content, silt	2.5Y 4/2 dark grayish brown
				pre-impoundment	4.0–8.0” distinctly lower water content than above layer, dense material with pockets of high water content material, loam, organics (sticks, small roots) throughout layer	2.5Y 4/2 dark grayish brown
					8.0–16.0” similar to above layer without pockets of high water content, loam, organics (sticks, small roots) throughout layer	2.5Y 4/2 dark grayish brown

[a] Coordinates are based on NAD83 State Plane Texas Central System (feet)

A photograph of sediment core GT-4 (for location, refer to Figure 2) is shown in Figure 7 and is representative of sediment cores sampled from Lake Georgetown. The base of the sample is denoted by the blue line. The pre-impoundment boundary (yellow line) was evident within this sediment core sample at 27.75 inches and identified by the change in color, texture, moisture, porosity, and structure. Identification of the pre-impoundment surface for the other four sediment cores followed a similar procedure.

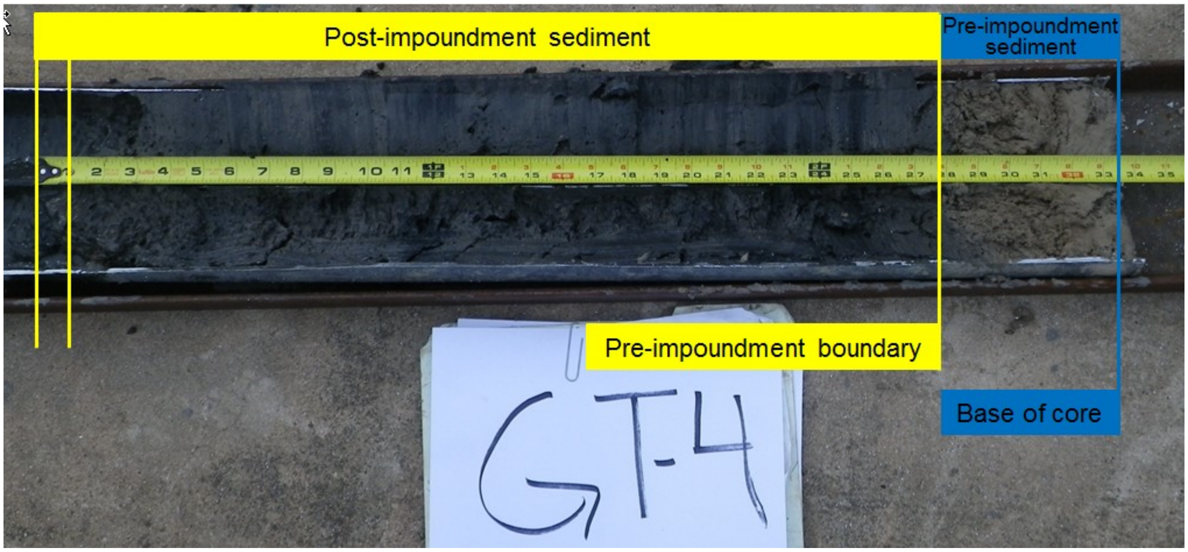


Figure 7. Sediment core GT-4 from Lake Georgetown. Post-impoundment sediment layers occur in the top 27.75 inches of this sediment core (identified by yellow boxes). Pre-impoundment sediment layers were identified and are defined by the blue box.

Figures 8 and 9 illustrate how measurements from sediment core samples are used with sonar data to help identify the post- and pre-impoundment layers in the acoustic signal. Figure 8 compares sediment core sample GT-4 with the acoustic signals for all frequencies combined (8A, 8E), and each individual frequency: 208 kHz (8B, 8F), 50 kHz (8C, 8G), and 24 kHz (8D, 8H). Within DepthPic©, the current bathymetric surface is automatically determined based on signal returns from the 208 kHz transducer as represented by the top black line in Figure 8E and red line in Figure 8F–H. The pre-impoundment surface is identified by comparing boundaries observed in the 208 kHz, 50 kHz, and 24 kHz signals to the location of the pre-impoundment surface as determined by the sediment core sample analysis. Many layers of sediment may be identified during core analysis based on changes in observed characteristics, such as water content, organic matter content, and sediment particle size, and each layer is classified as either post-impoundment or pre-impoundment. Each layer of sediment identified in the sediment core sample during analysis (Table 2) is represented in Figures 8 and 9 by a yellow or blue box. A yellow box represents post-impoundment sediments. A blue box indicates pre-impoundment sediments.

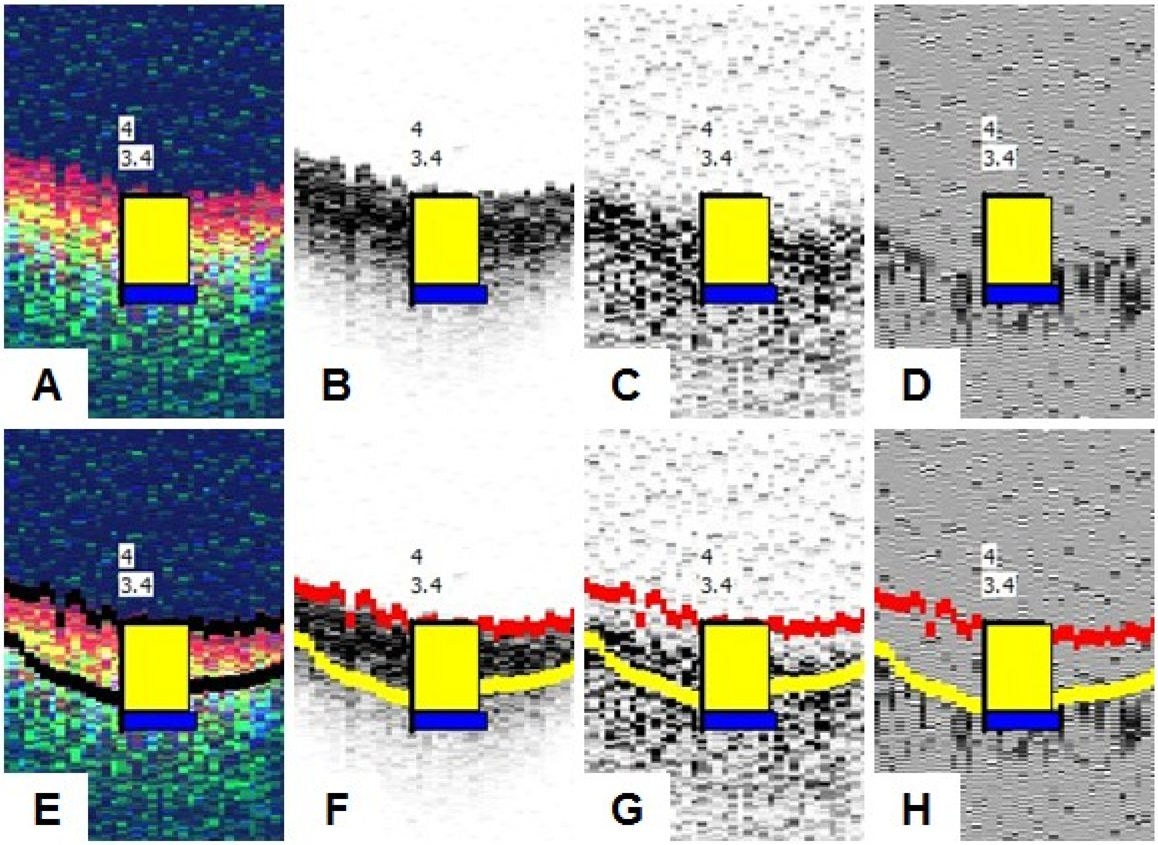


Figure 8.   Comparison of sediment core GT-4 with acoustic signal returns A, E) combined acoustic signal returns, B, F) 208 kHz frequency, C, G) 50 kHz frequency, and D, H) 24 kHz frequency.

In this case, the pre-impoundment boundary was most visible in the 24 kHz acoustic signal returns; therefore, the 24 kHz acoustic signal returns were used to locate the pre-impoundment surface (yellow line in Figure 8). Figure 9 shows sediment core sample GT-4 correlated with the 24 kHz acoustic signal returns of the nearest surveyed cross-section. The pre-impoundment surface was first identified along cross-sections for which sediment core samples have been collected. This information was then used as a guide for identifying the pre-impoundment surface along cross-sections where sediment core samples were not collected.

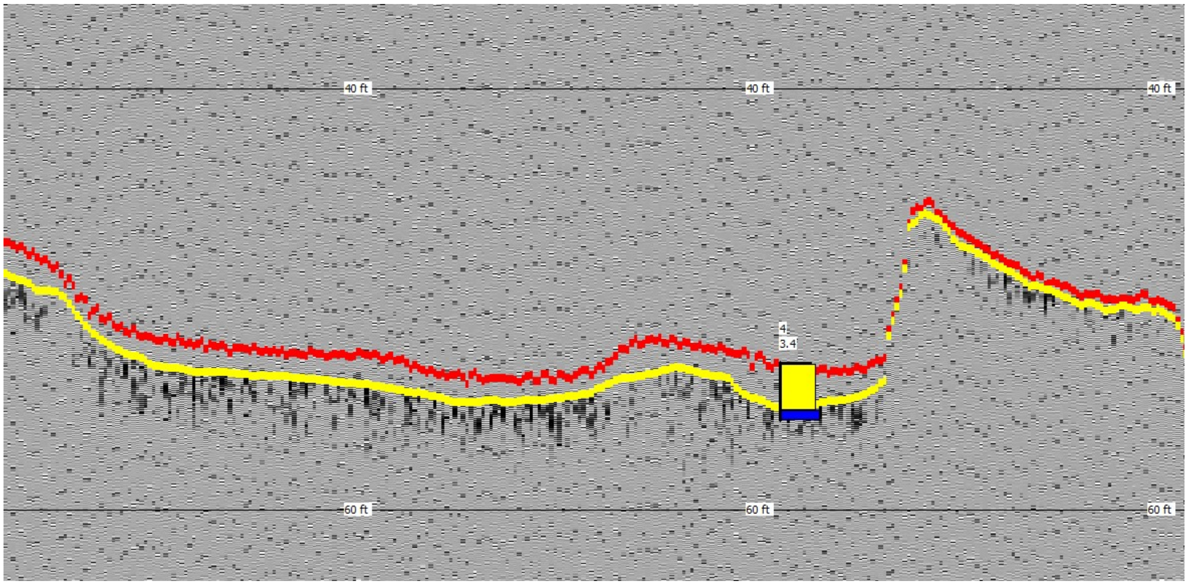


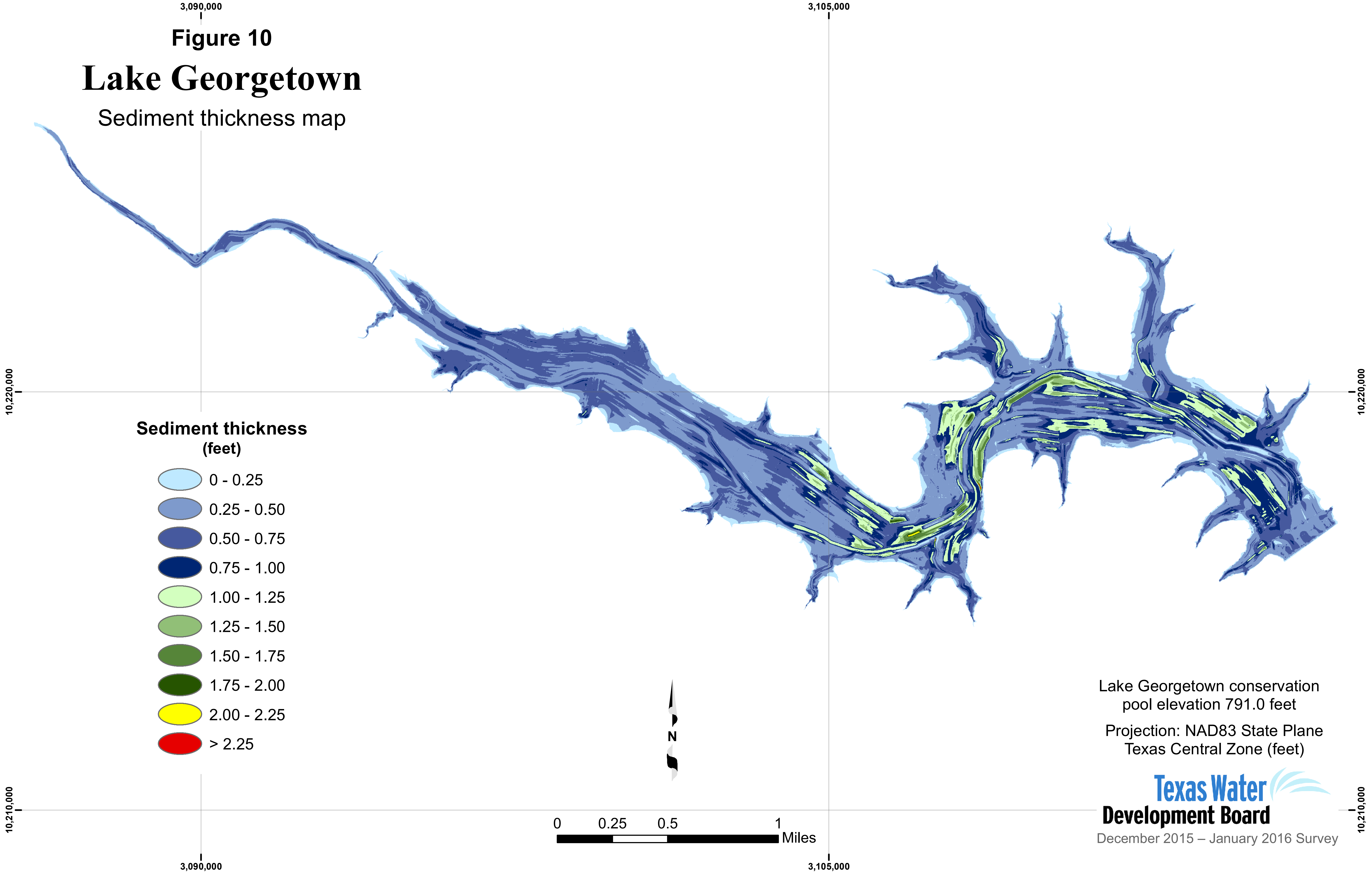
Figure 9. Cross-section of data collected during the 2016 survey, displayed in DepthPic© (24 KHz acoustic signal returns), correlated with sediment core sample GT-4 and showing the current surface as the top red line, and pre-impoundment surface as the bottom yellow line.

After the pre-impoundment surface for all cross-sections was identified, a sediment thickness TIN model was created following standard GIS techniques (Furnans and Austin, 2007). Sediment thicknesses were interpolated between surveyed cross-sections using HydroTools with the same interpolation definition file used for bathymetric interpolation. For the purposes of TIN model creation, the TWDB assumed the sediment thickness at the reservoir boundary was 0 feet (defined as the 791.0 foot NGVD29 elevation contour). The sediment thickness TIN model was converted to a raster representation using a cell size of 2 feet by 2 feet and was used to produce a sediment thickness map of Lake Georgetown (Figure 10).

Figure 10

Lake Georgetown

Sediment thickness map



Survey results

Volumetric survey

The 2016 TWDB volumetric survey indicates that Lake Georgetown has a total reservoir capacity of 38,068 acre-feet and encompasses 1,307 acres at conservation pool elevation (791.0 feet above mean sea level, NGVD29). The original design estimate by the U.S. Army Corps of Engineers indicates Lake Georgetown encompassed 1,310 acres with a total reservoir capacity of 37,100 acre-feet (U.S. Army Corps of Engineers, 2017). TWDB previously surveyed Lake Georgetown in 1995 and 2005. Because of differences in survey methodologies, direct comparison of this volumetric survey to others to estimate changes in capacity can be unreliable. To more accurately compare results from the TWDB surveys of Lake Georgetown, TWDB applied the 2016 data processing techniques to the survey data collected in 1995 and 2005. Specifically, the TWDB applied anisotropic spatial interpolation to the survey data collected in 1995 and 2005 using the same interpolation definition file as was used for the 2016 survey, with minor edits to account for differences in data coverage and boundary conditions.

The original 1995 survey boundary was digitized from the 791.0 foot contour from 7.5 minute USGS quadrangle maps: Georgetown 1982 and Leander NE 1962 (Photo-revised 1976), with a stated accuracy of ± ½ the contour interval (U.S. Bureau of the Budget, 1947). The 1995 survey boundary was revised and a new TIN model was created using the revised boundary. Additionally, surveys data points with anomalous elevations were removed from the new model. While linear interpolation was used to estimate the topography in areas without data, flat triangles led to anomalous area and volume calculations at the boundary elevation of 791.0 feet. Therefore, areas between 790.0 feet and 791.0 feet were linearly interpolated between the computed values, and volumes above 790.0 feet were calculated based on the corrected areas.

The 2005 survey boundary was digitized from aerial photographs taken on January 7, February 2, and February 3, 1995, while the daily average water surface elevation of the reservoir measured 784.78 feet, 786.81 feet, and 786.88 feet above mean sea level, respectively, therefore field observations, 1:24,000 scale hypsography (contours), and beaches and vegetation visible in the 1995–1996 DOQQs were used to interpret the boundary at elevation 791.0 feet. According to the associated metadata, the 1995–1996 DOQQs have a resolution of 1-meter, with a horizontal positional accuracy that meets the

National Map Accuracy Standards (NMAS) for 1:12,000-scale products. While linear interpolation was used to estimate the topography in areas without data, flat triangles led to anomalous area and volume calculations at the boundary elevation of 791.0 feet. Therefore, areas between 790.5 feet and 791.0 feet were linearly interpolated between the computed values, and volumes above 790.5 feet were calculated based on the corrected areas. Re-evaluation of the 1995 and 2005 survey resulted in a 2.5 percent and 4.6 percent increase in total capacity estimates at conservation pool elevation 791.0 feet (Table 3).

Table 3. Current and previous survey capacity and surface area estimates for Lake Georgetown.

Survey	Surface area (acres)	Capacity (acre-feet)
Original design 1965 [a]	1,310	37,100
TWDB 1995 [b]	1,297	37,010
TWDB 1995 (re-calculated) [c]	1,285	37,932
TWDB 2005[d]	1,287	36,904
TWDB 2005 (re-calculated) [c]	1,287	38,582
Marchand, 2005[e]	1,200	39,760
TWDB 2016	1,307	38,068

[a] Source: (U.S. Army Corps of Engineers, 2017; Texas Water Development Board, 1973)
[b] Source: (Texas Water Development Board, 2003)
[c] Source: (Texas Water Development Board, 2016c)
[d] Source: (Texas Water Development Board, 2006)
[e] Source: (Marchand, 2005)

Sedimentation survey

The 2016 TWDB sedimentation survey indicates Lake Georgetown has lost capacity at an average of 21 acre-feet per year since impoundment due to sedimentation below conservation pool elevation (791.0 feet NGVD29). The sedimentation survey indicates sediment accumulation varies throughout the reservoir. Sediment accumulation is greater in the lower lying floodplains. Comparison of capacity estimates of Lake Georgetown derived using differing methodologies are provided in Table 4 for sedimentation rate calculation. Comparison with the TWDB 1995 survey estimate suggests capacity has increased over time; however, the 1995 study is believed to have underestimated capacity due to a lack of cross-channel transect data in reservoir coves, which is necessary for proper bathymetric representation.

Table 4. Capacity loss comparisons for Lake Georgetown

Survey	Volume comparisons at conservation pool elevation (acre-feet)			
Original design[a,b]	37,100	<>	<>	<>
TWDB 1995 (re-calculated)	<>	37,932	<>	<>
TWDB 2005 (re-calculated)	<>	<>	38,582	<>
TWDB pre-impoundment estimate based on 2016 survey	<>	<>	<>	38,805[b]
2016 volumetric survey	38,068	38,068	38,068	38,068
Volume difference (acre-feet)	-968 (-2.6%)	-136 (-0.4%)	514 (1.3%)	737 (1.9%)
Number of years	35	21	12	35
Capacity loss rate (acre-feet/year)	-28	-6	43	21

[a] Source: (U.S. Army Corps of Engineers, 2017; Texas Water Development Board, 1973), note: Deliberate impoundment began on March 3, 1980, and North San Gabriel Dam was completed on 1982.
[b] 2016 TWDB surveyed capacity of 38,068 acre-feet plus 2016 TWDB surveyed sediment volume of 737 acre-feet below elevation 791.0 feet

Sediment range lines

In 1978, the U.S. Army Corps of Engineers established seventeen sediment range lines throughout Lake Georgetown to measure sediment accumulation over time. A cross-sectional comparison of eleven of the seventeen 1978 sediment range lines with the TWDB 2016 survey, 2005 re-calculated survey, and the TWDB 1995 re-calculated survey is presented in Appendix E. Also presented in Appendix E are a map, depicting the historical locations of the sediment range lines and Table E1, a list of the endpoint coordinates for each line. Cross-sections for 1978 were unavailable for sediment range lines SR01 through SR03 for comparison. Sediment range line SR11 is outside the 1995 model boundary and a cross-section for this year is not compared at this location. Some differences in the cross-sections may be a result of spatial interpolation and the interpolation routine of the TIN Model.

Recommendations

The TWDB recommends a volumetric and sedimentation survey of Lake Georgetown within a 10 year time-frame or after a major flood event to assess changes in lake capacity and to further improve estimates of sediment accumulation rates.

TWDB contact information

More information about the Hydrographic Survey Program can be found at:
http://www.twdb.texas.gov/surfacewater/surveys/index.asp
Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:
Hydrosurvey@twdb.texas.gov

References

Environmental Systems Research Institute, 1995, ARC/INFO Surface Modeling and Display, TIN Users Guide: ESRI, California.

Furnans, J. and Austin, B., 2007, Hydrographic survey methods for determining reservoir volume, Environmental Modeling & Software, v. 23, no. 2: Amsterdam, The Netherlands, Elsevier Science Publishers B.V., p. 139-146. doi: 10.1016/j.envsoft.2007.05.011

Marchand, R., 2005, Sediment Budget Lake Georgetown, Grand Prairie, Texas, published M.S. thesis, Baylor University, Waco, Texas.

McEwen, T., Brock, N., Kemp, J., Pothina, D. and Weyant, H., 2011a, HydroTools User's Manual: Texas Water Development Board.

McEwen, T., Pothina, D. and Negusse, S., 2011b, Improving efficiency and repeatability of lake volume estimates using Python: Proceedings of the 10th Python for Scientific Computing Conference.

National Geodetic Survey, 2017a, NADCON computations, accessed March 2017, at http://www.ngs.noaa.gov/cgi-bin/nadcon.prl.

National Geodetic Survey, 2017b, Orthometric Height Conversion, accessed March 2017, at http://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl.

Texas Natural Resources Information System, 2017, City of Georgetown 2015 50cm | TNRIS – Texas Natural Resources Information System, accessed March 22, 2017a, at https://tnris.org/data-catalog/entry/city-of-georgetown-2015-50-cm/.

Texas Water Development Board, 1973, North Fork (San Gabriel River) Dam and North Fork Lake, Report 126: Engineering Data on Dams and Reservoirs in Texas, Part II.

Texas Water Development Board, 2003, Volumetric Survey of Lake Georgetown, accessed March 17, 2017, at http://www.twdb.texas.gov/hydro_survey/Georgetown/1995-05/Georgetown1995_FinalReport.pdf.

Texas Water Development Board, 2006, Volumetric Survey Report of Lake Georgetown, accessed March 17, 2017, at http://www.twdb.texas.gov/hydro_survey/Georgetown/2005-05/LakeGeorgetown2005_FinalReport.pdf.

Texas Water Development Board, 2016a, Contract No. R1648011923 with U.S. Army Corps of Engineers, Galveston District.

Texas Water Development Board, 2016b, Contract No. R1548011897 with Brazos River Authority.

Texas Water Development Board, 2016c, Application of new procedures to re-assess reservoir capacity, accessed March 31, 2017, at http://www.twdb.texas.gov/hydro_survey/Re-assessment/

U.S. Army Corps of Engineers, 2017, Pertinent Data – North San Gabriel Dam and Lake Georgetown, accessed March 16, 2017, at http://www.swf-wc.usace.army.mil/pertdata/gglt2.pdf.

U.S. Bureau of the Budget, 1947, United States National Map Accuracy Standards, accessed September 5, 2016, at http://nationalmap.gov/standards/pdf/NMAS647.PDF.

U.S. Geological Survey, 2017, U.S. Geological Survey National Water Information System: Web Interface, *USGS 08104650 Lk Georgetown nr Georgetown, TX*, accessed March 16, 2016, at https://waterdata.usgs.gov/nwis/inventory/?site_no=08104650.

Van Metre, P.C., Wilson, J.T., Fuller, C.C., Callender, E., and Mahler, B.J., 2004, Collection, analysis, and age-dating of sediment cores from 56 U.S. lakes and reservoirs sampled by the U.S. Geological Survey, 1992-2001: U.S. Geological Survey Scientific Investigations Report 2004-5184, 180 p.

Appendix A

Lake Georgetown

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2015 - January 2016 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 791.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
709	0	0	0	0	0	0	0	0	0	0
710	0	0	0	0	1	1	1	1	1	1
711	1	2	2	2	2	2	3	3	3	3
712	4	4	4	5	5	5	5	6	6	6
713	7	7	7	8	8	8	9	9	9	10
714	10	11	11	11	12	12	12	13	13	14
715	14	14	15	15	16	16	17	18	18	19
716	19	20	21	22	22	23	24	25	25	26
717	27	28	29	30	31	32	33	34	35	36
718	37	38	39	40	41	42	43	45	46	47
719	48	50	51	53	54	55	57	58	60	61
720	63	64	66	68	69	71	73	75	76	78
721	80	82	84	86	87	89	91	93	95	97
722	99	102	104	106	108	110	112	115	117	119
723	122	124	126	129	131	134	136	139	141	144
724	147	149	152	155	158	161	164	167	170	173
725	176	179	182	186	189	192	196	199	202	206
726	210	213	217	221	225	229	234	238	243	247
727	252	257	262	268	273	278	284	290	295	301
728	307	313	319	325	332	338	345	352	358	365
729	372	380	387	395	403	411	419	427	436	444
730	453	462	471	480	489	499	509	518	528	538
731	549	559	570	580	591	602	613	624	635	647
732	658	670	682	693	705	718	730	742	754	767
733	780	792	805	818	831	845	858	871	885	898
734	912	926	940	954	968	983	997	1,012	1,026	1,041
735	1,056	1,071	1,086	1,101	1,116	1,132	1,147	1,163	1,179	1,195
736	1,211	1,228	1,244	1,261	1,277	1,294	1,311	1,328	1,345	1,362
737	1,380	1,397	1,415	1,433	1,451	1,469	1,487	1,506	1,524	1,543
738	1,562	1,581	1,601	1,620	1,640	1,660	1,681	1,701	1,722	1,742
739	1,763	1,785	1,806	1,827	1,849	1,871	1,893	1,915	1,937	1,960
740	1,983	2,005	2,029	2,052	2,075	2,099	2,123	2,146	2,171	2,195
741	2,219	2,244	2,268	2,293	2,318	2,343	2,369	2,394	2,420	2,445
742	2,471	2,497	2,523	2,550	2,576	2,603	2,630	2,656	2,684	2,711
743	2,738	2,766	2,793	2,821	2,849	2,877	2,905	2,934	2,962	2,991
744	3,020	3,049	3,078	3,107	3,136	3,166	3,195	3,225	3,255	3,285
745	3,315	3,345	3,376	3,406	3,437	3,468	3,499	3,530	3,561	3,593
746	3,624	3,656	3,688	3,720	3,752	3,785	3,817	3,850	3,883	3,916
747	3,949	3,982	4,016	4,050	4,084	4,118	4,153	4,187	4,222	4,257
748	4,292	4,328	4,363	4,399	4,435	4,471	4,507	4,543	4,580	4,616
749	4,653	4,690	4,727	4,765	4,802	4,840	4,878	4,916	4,954	4,992
750	5,031	5,069	5,108	5,147	5,187	5,226	5,265	5,305	5,345	5,385
751	5,425	5,465	5,506	5,546	5,587	5,628	5,669	5,710	5,751	5,792
752	5,834	5,875	5,917	5,959	6,001	6,043	6,086	6,128	6,170	6,213
753	6,256	6,299	6,342	6,385	6,428	6,471	6,515	6,558	6,602	6,646
754	6,690	6,734	6,778	6,822	6,867	6,911	6,956	7,001	7,046	7,091
755	7,136	7,182	7,227	7,273	7,319	7,365	7,411	7,458	7,504	7,551
756	7,598	7,646	7,693	7,740	7,788	7,836	7,884	7,933	7,981	8,030
757	8,079	8,128	8,177	8,227	8,276	8,326	8,376	8,427	8,477	8,528
758	8,579	8,630	8,681	8,732	8,784	8,836	8,888	8,940	8,992	9,045
759	9,098	9,151	9,204	9,257	9,311	9,365	9,419	9,473	9,527	9,582

Appendix A (Continued)

Lake Georgetown

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD
CAPACITY IN ACRE-FEET
ELEVATION INCREMENT IS ONE TENTH FOOT

December 2015 - January 2016 Survey
Conservation Pool Elevation 791.0 feet NGVD29

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
760	9,637	9,692	9,748	9,803	9,859	9,915	9,971	10,028	10,084	10,141
761	10,198	10,255	10,313	10,371	10,428	10,486	10,545	10,603	10,661	10,720
762	10,779	10,838	10,898	10,957	11,017	11,077	11,137	11,198	11,258	11,319
763	11,380	11,441	11,502	11,564	11,625	11,687	11,749	11,812	11,874	11,937
764	12,000	12,063	12,127	12,191	12,254	12,319	12,383	12,448	12,513	12,578
765	12,643	12,709	12,775	12,841	12,907	12,974	13,041	13,108	13,175	13,242
766	13,310	13,378	13,446	13,515	13,584	13,653	13,722	13,791	13,861	13,931
767	14,001	14,072	14,143	14,214	14,285	14,356	14,428	14,500	14,573	14,645
768	14,718	14,791	14,865	14,938	15,012	15,087	15,161	15,236	15,311	15,386
769	15,462	15,538	15,614	15,690	15,767	15,844	15,922	16,000	16,078	16,156
770	16,235	16,314	16,393	16,473	16,553	16,633	16,713	16,794	16,875	16,957
771	17,038	17,120	17,202	17,285	17,367	17,450	17,533	17,617	17,700	17,784
772	17,868	17,953	18,037	18,122	18,207	18,292	18,377	18,463	18,548	18,634
773	18,721	18,807	18,894	18,980	19,067	19,154	19,242	19,330	19,418	19,506
774	19,594	19,683	19,772	19,861	19,950	20,040	20,129	20,219	20,309	20,399
775	20,490	20,580	20,671	20,762	20,854	20,945	21,037	21,129	21,221	21,313
776	21,405	21,498	21,591	21,684	21,777	21,871	21,964	22,059	22,153	22,247
777	22,342	22,437	22,532	22,628	22,723	22,819	22,915	23,012	23,108	23,205
778	23,302	23,399	23,497	23,595	23,693	23,791	23,890	23,988	24,087	24,187
779	24,286	24,386	24,486	24,586	24,686	24,787	24,887	24,988	25,090	25,191
780	25,293	25,395	25,497	25,599	25,702	25,805	25,908	26,011	26,115	26,219
781	26,323	26,428	26,532	26,637	26,743	26,848	26,954	27,060	27,166	27,273
782	27,380	27,487	27,594	27,702	27,810	27,918	28,027	28,136	28,245	28,354
783	28,463	28,573	28,683	28,794	28,904	29,015	29,126	29,237	29,349	29,461
784	29,573	29,685	29,798	29,911	30,024	30,137	30,251	30,365	30,479	30,593
785	30,708	30,823	30,938	31,054	31,169	31,286	31,402	31,518	31,635	31,752
786	31,869	31,987	32,105	32,223	32,341	32,460	32,579	32,698	32,818	32,937
787	33,057	33,178	33,298	33,419	33,540	33,661	33,782	33,904	34,026	34,149
788	34,271	34,394	34,517	34,640	34,764	34,888	35,012	35,136	35,261	35,386
789	35,511	35,636	35,762	35,888	36,014	36,141	36,267	36,394	36,521	36,648
790	36,776	36,904	37,032	37,160	37,289	37,418	37,548	37,677	37,807	37,937
791	38,068									

Note: Capacities above 790.0 feet calculated from interpolated areas

Appendix B

Lake Georgetown

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — December 2015 - January 2016 Survey

AREA IN ACRES — Conservation Pool Elevation 791.0 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
709	0	0	0	0	0	0	0	0	0	1
710	1	1	1	1	1	1	1	1	2	2
711	2	2	2	2	2	2	2	3	3	3
712	3	3	3	3	3	3	3	3	3	3
713	3	3	3	3	3	3	3	4	4	4
714	4	4	4	4	4	4	4	4	4	4
715	4	4	4	5	5	6	6	6	6	7
716	7	7	7	7	8	8	8	8	8	8
717	9	9	9	9	9	9	10	10	10	10
718	11	11	11	11	12	12	12	12	13	13
719	13	13	14	14	14	14	15	15	15	15
720	16	16	16	17	17	17	17	18	18	18
721	18	18	19	19	19	20	20	20	20	21
722	21	21	21	22	22	22	22	23	23	23
723	24	24	24	24	25	25	25	26	26	27
724	27	27	28	28	29	29	30	30	31	31
725	31	32	32	33	33	33	34	34	35	36
726	37	38	39	40	41	42	44	45	47	48
727	49	50	52	53	54	55	56	57	58	59
728	60	61	62	63	64	65	66	67	69	70
729	72	74	76	78	79	81	82	84	85	86
730	88	90	91	93	94	96	97	99	101	102
731	103	104	106	107	108	110	111	112	113	114
732	116	117	118	119	121	121	122	123	124	126
733	127	128	129	131	132	133	134	135	136	137
734	138	139	140	141	142	143	144	145	146	148
735	149	150	151	153	154	155	157	158	160	162
736	163	164	165	166	168	169	170	171	172	173
737	174	176	177	179	180	182	183	185	187	189
738	191	193	195	197	199	201	203	205	207	209
739	211	212	214	216	217	219	221	222	225	226
740	228	230	232	233	235	237	239	240	242	243
741	245	246	247	249	251	252	254	255	257	258
742	259	261	262	264	265	267	268	270	271	273
743	275	276	278	279	280	282	283	284	286	287
744	288	290	291	292	294	295	297	298	299	301
745	302	304	305	307	308	310	311	312	314	315
746	317	318	319	321	323	324	326	328	330	331
747	333	336	338	340	342	343	345	347	349	351
748	353	354	356	358	359	361	363	364	366	368
749	369	371	373	374	376	377	379	381	383	384
750	386	388	389	391	393	394	396	397	399	400
751	402	403	405	406	408	409	410	412	413	415
752	416	417	418	420	421	422	423	424	426	427
753	428	429	430	432	433	434	435	436	438	439
754	440	441	442	444	445	446	447	449	450	452
755	453	455	457	459	460	462	464	466	468	469
756	471	473	475	476	478	480	482	484	486	488
757	490	492	494	497	499	500	502	504	506	508
758	509	511	513	515	517	519	521	523	525	527
759	529	531	533	535	537	539	541	543	545	548

Appendix B (Continued)

Lake Georgetown

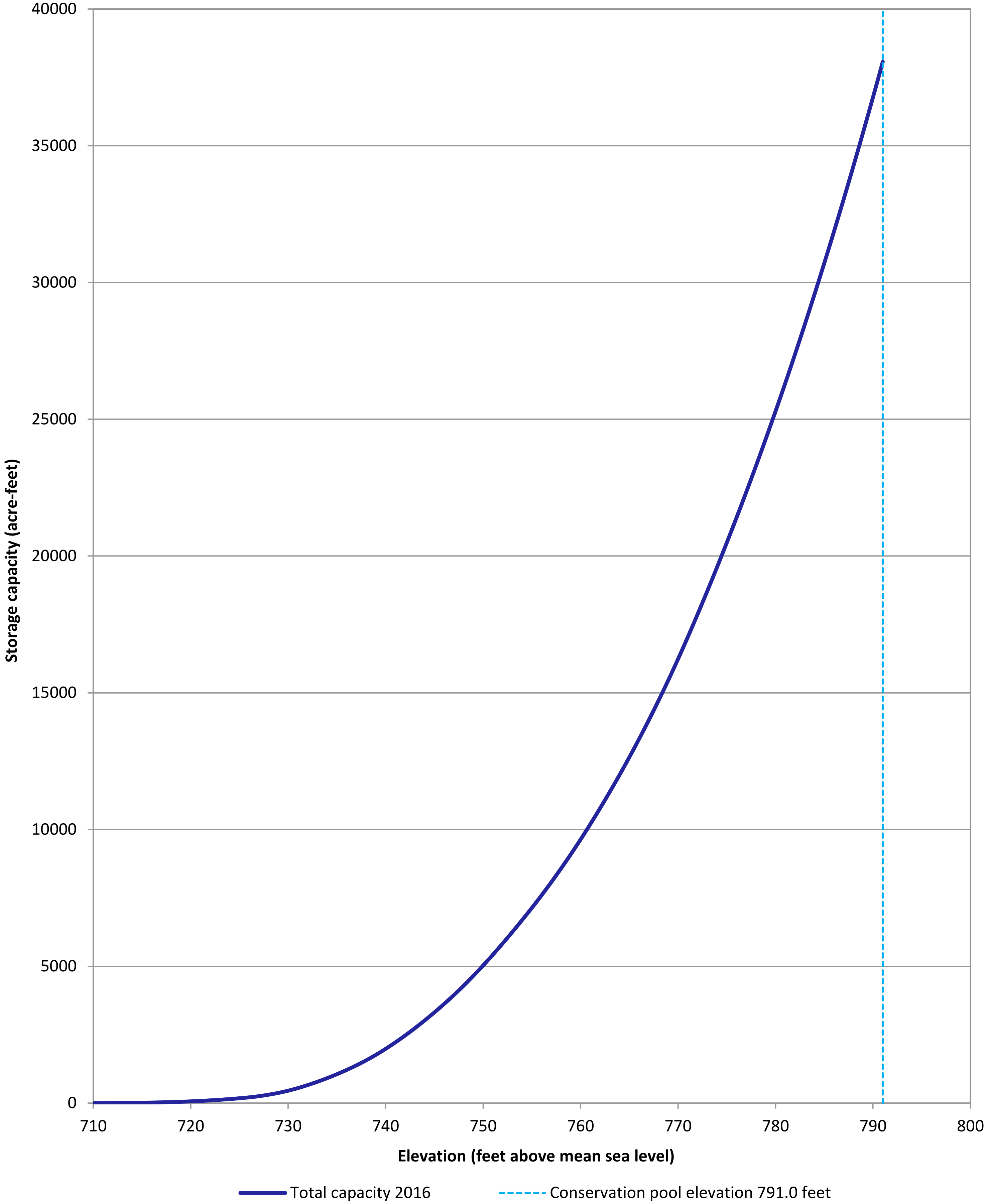
RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

December 2015 - January 2016 Survey
Conservation Pool Elevation 791.0 feet NGVD29

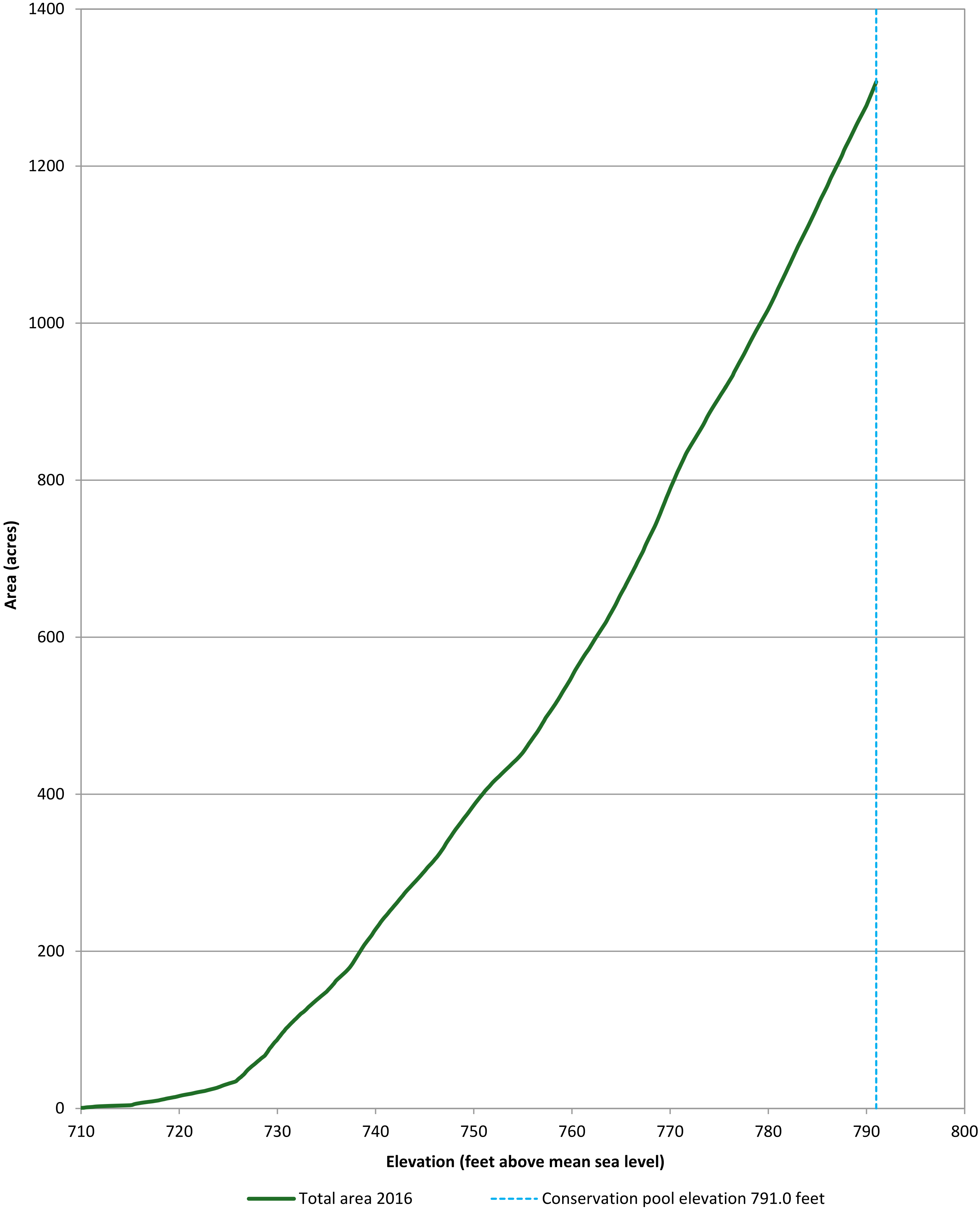
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
760	550	553	555	557	559	561	563	565	567	569
761	571	573	575	577	579	581	583	584	586	588
762	591	593	595	597	599	601	603	604	606	608
763	610	612	614	616	618	620	622	625	627	629
764	631	634	636	638	640	643	645	648	651	653
765	655	658	660	662	664	667	669	672	674	677
766	679	681	684	686	689	691	694	696	699	701
767	704	706	708	711	714	717	720	723	725	728
768	730	733	735	738	740	743	746	749	752	755
769	758	761	764	767	770	773	777	780	783	786
770	789	792	795	797	800	803	806	809	812	814
771	817	820	822	825	828	830	833	836	838	840
772	842	844	846	848	850	852	854	856	858	860
773	863	865	867	869	871	873	876	879	881	883
774	885	887	890	892	894	896	898	900	902	904
775	906	908	910	912	913	915	917	919	921	923
776	925	928	930	932	934	937	939	942	944	946
777	949	951	953	955	958	960	962	965	967	970
778	972	975	977	979	982	984	986	989	991	993
779	996	998	1,000	1,002	1,004	1,007	1,009	1,011	1,013	1,015
780	1,018	1,020	1,023	1,025	1,028	1,030	1,033	1,035	1,038	1,041
781	1,044	1,046	1,049	1,052	1,054	1,057	1,059	1,062	1,065	1,067
782	1,070	1,073	1,075	1,078	1,081	1,083	1,086	1,089	1,092	1,094
783	1,097	1,100	1,102	1,105	1,107	1,110	1,112	1,114	1,117	1,119
784	1,122	1,124	1,127	1,130	1,132	1,135	1,138	1,140	1,143	1,146
785	1,148	1,151	1,154	1,157	1,159	1,162	1,164	1,167	1,169	1,172
786	1,174	1,177	1,180	1,183	1,186	1,188	1,191	1,193	1,196	1,198
787	1,201	1,203	1,206	1,208	1,211	1,213	1,216	1,220	1,222	1,225
788	1,227	1,230	1,232	1,235	1,237	1,240	1,242	1,245	1,248	1,250
789	1,253	1,255	1,258	1,260	1,263	1,265	1,267	1,270	1,272	1,275
790	1,277	1,280	1,283	1,286	1,289	1,292	1,295	1,298	1,301	1,304
791	1,307									

Note: Areas between elevations 790.0 and 791.0 feet linearly interpolated



Lake Georgetown
December 2015 - January 2016 Survey
Prepared by: TWDB

Appendix C: Capacity curve



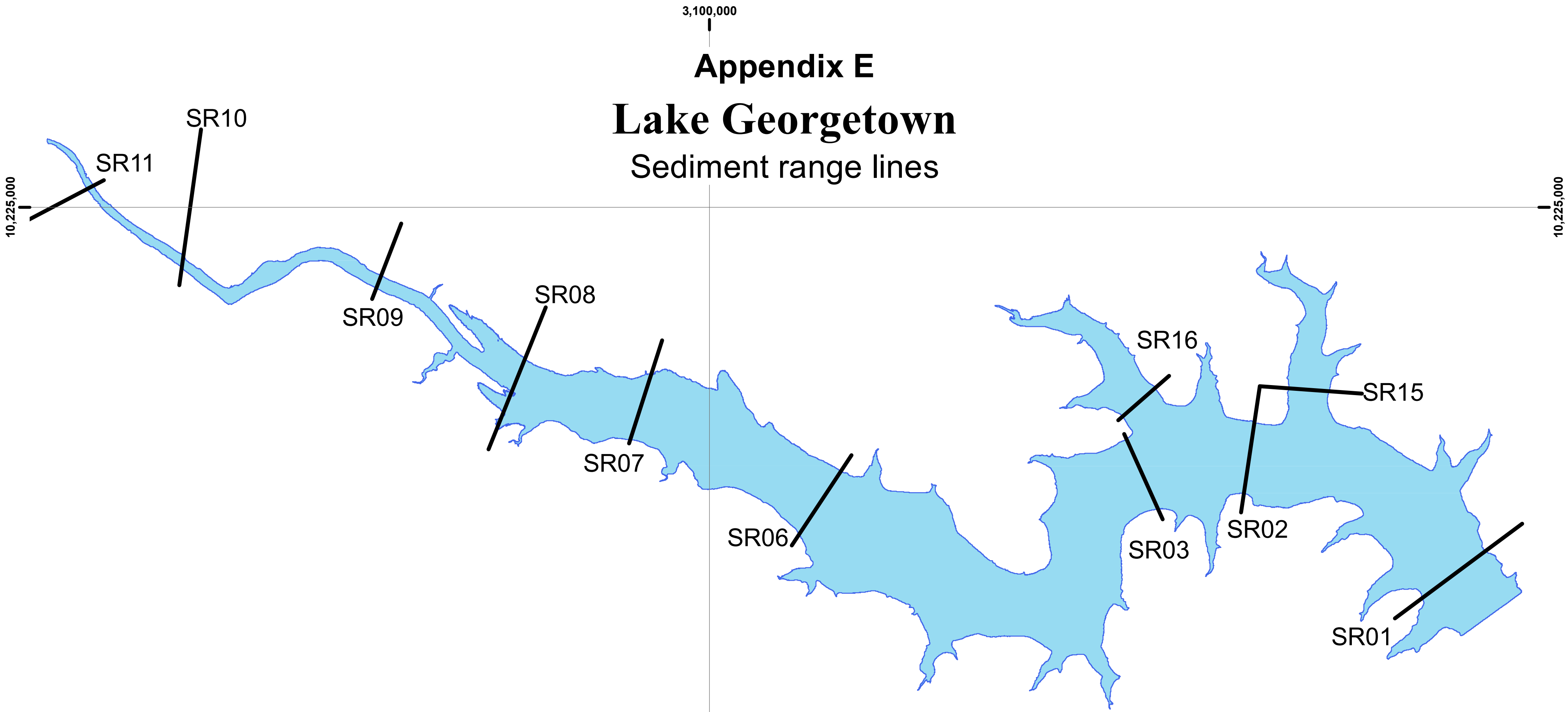
Lake Georgetown
December 2015 - January 2016 Survey
Prepared by: TWDB

Appendix D: Area curve

Appendix E

Lake Georgetown

Sediment range lines



Lake Georgetown conservation pool elevation 791.0 feet

Texas Water Development Board

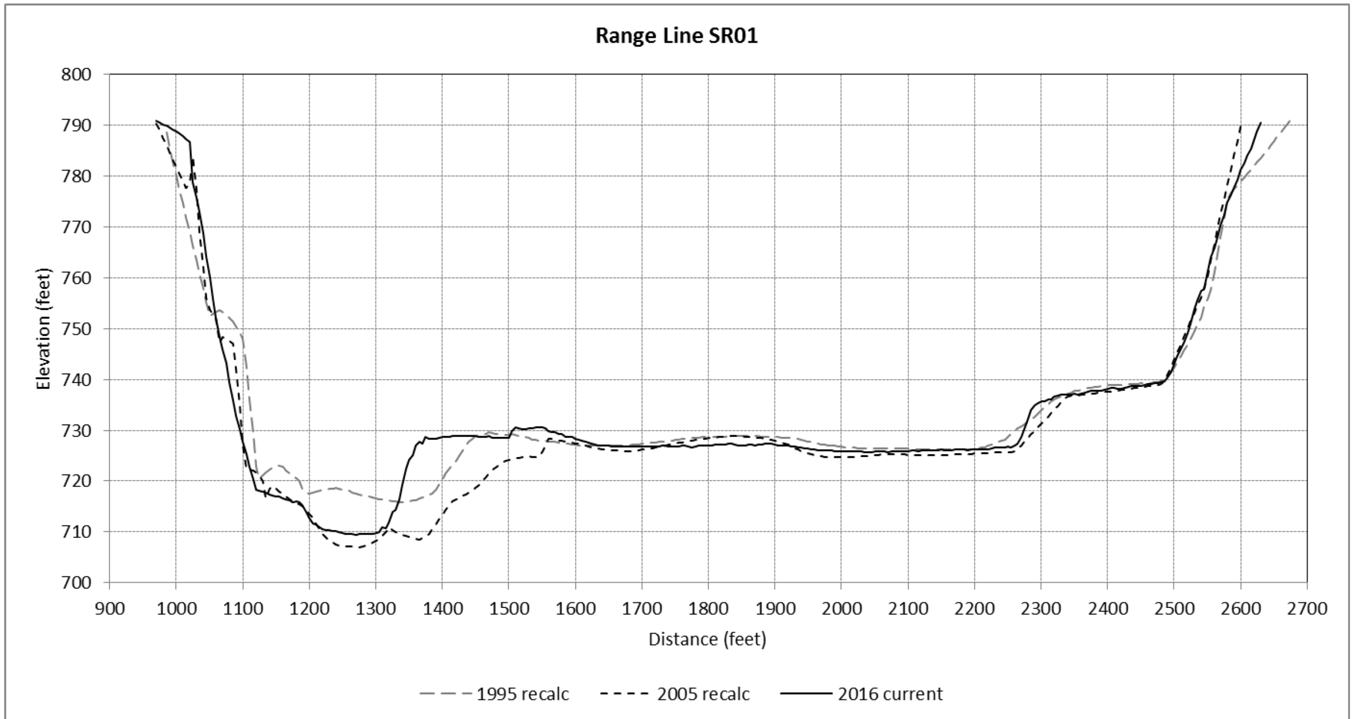
December 2015 - January 2016 Survey

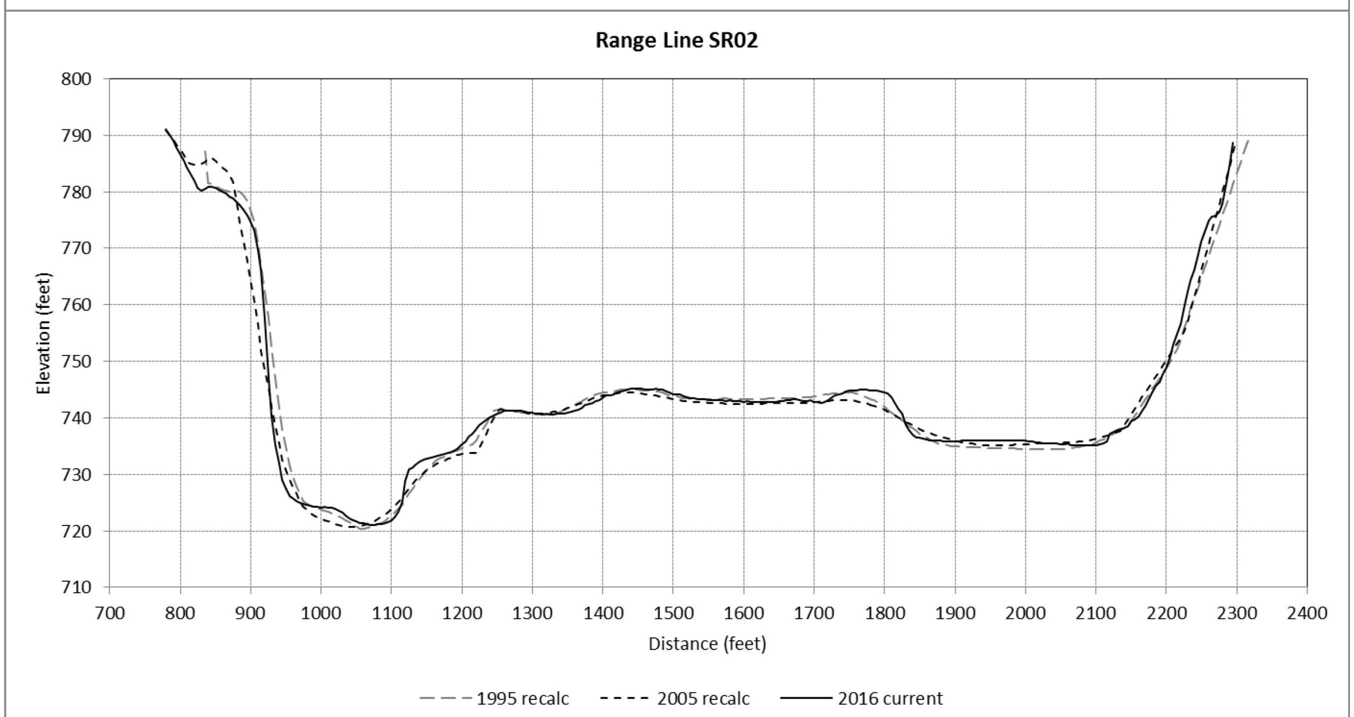
0 0.25 0.5 1 Miles

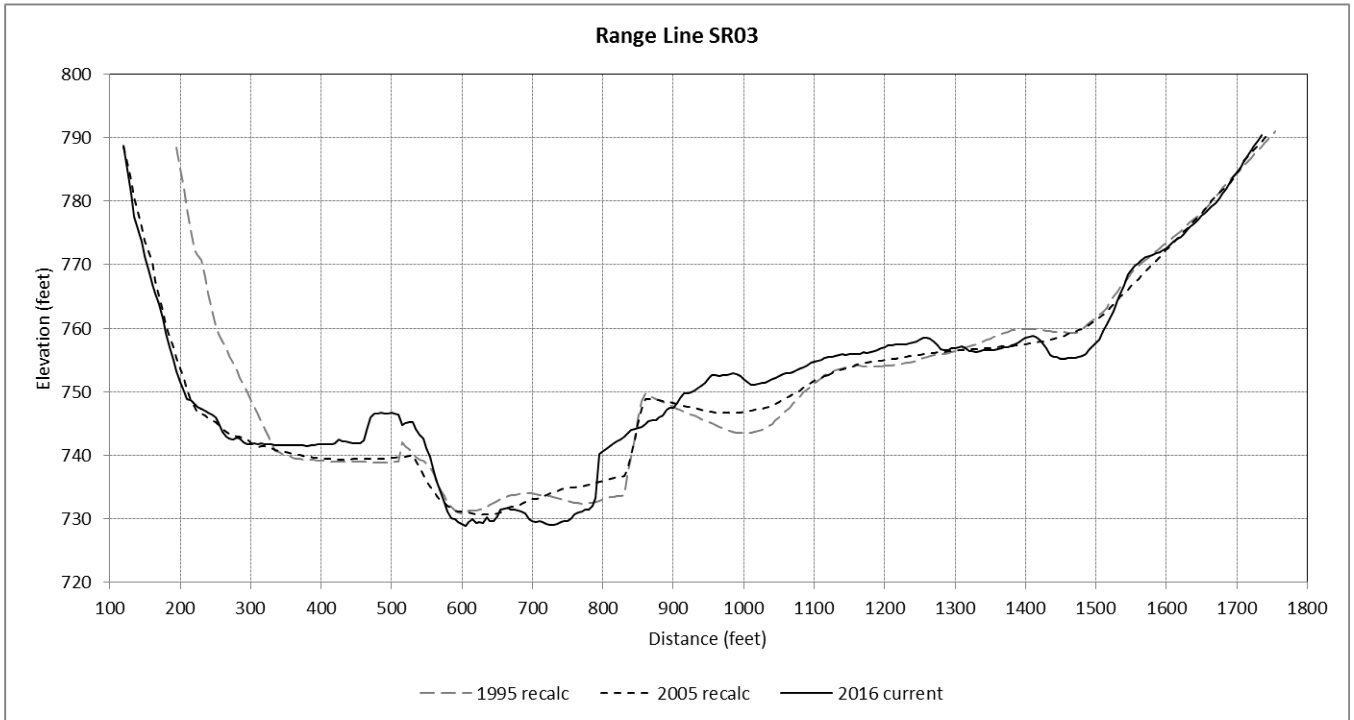
N

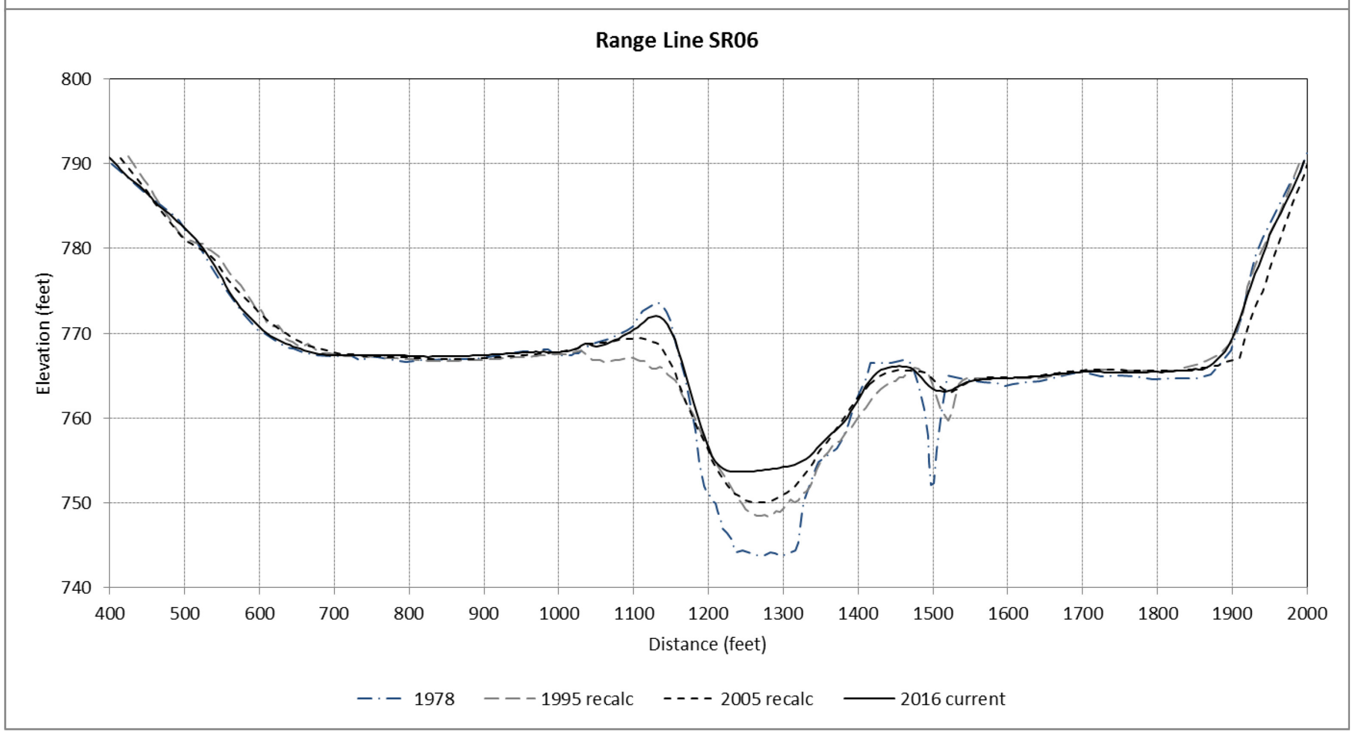
Table E1: Lake Georgetown sediment range line endpoints				
Sediment Range Line	X_L	Y_L	X_R	Y_R
SR01	2,820,695.56	375,734.64	2,818,009.32	373,728.01
SR02	2,815,159.06	378,640.20	2,814,763.21	375,972.37
SR03	2,812,284.95	377,623.70	2,813,104.96	375,818.84
SR06	2,806,525.87	377,172.58	2,805,271.62	375,271.97
SR07	2,802,524.41	379,602.24	2,801,834.00	377,422.96
SR08	2,800,070.01	380,304.86	2,798,862.10	377,297.99
SR09	2,797,015.27	382,073.51	2,796,402.25	380,480.53
SR10	2,792,793.12	384,063.08	2,792,334.69	380,773.05
SR11	2,790,740.85	382,988.09	2,788,934.00	382,041.33
SR15	2,817,312.71	378,482.72	2,815,159.06	378,640.29
SR16	2,813,234.28	378,853.61	2,812,163.85	377,917.39

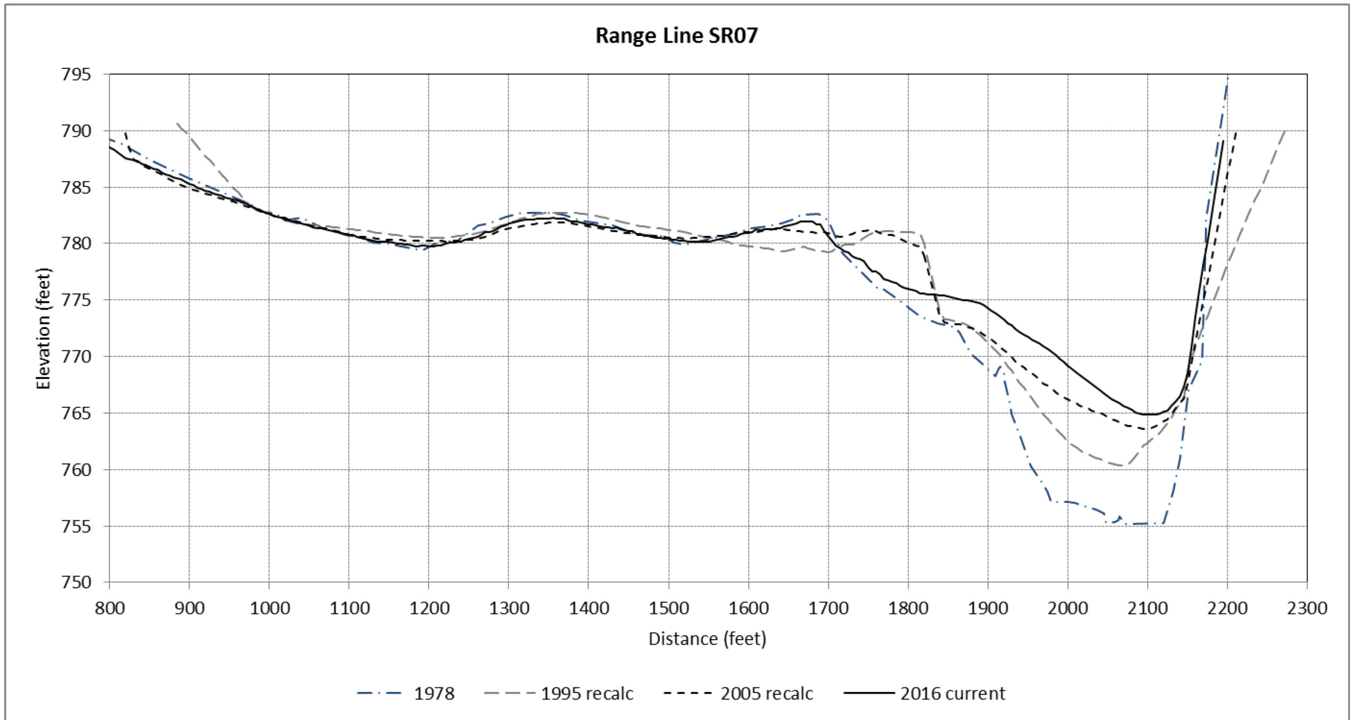
XY: Lambert Grid Coordinates North American Datum 1927 L= Left End Point R= Right End Point


Range Line SR01
Elevation (feet)
800
790
780
770
760
750
740
730
720
710
700
900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400 2500 2600 2700
Distance (feet)
1995 recalc
2005 recalc
2016 current

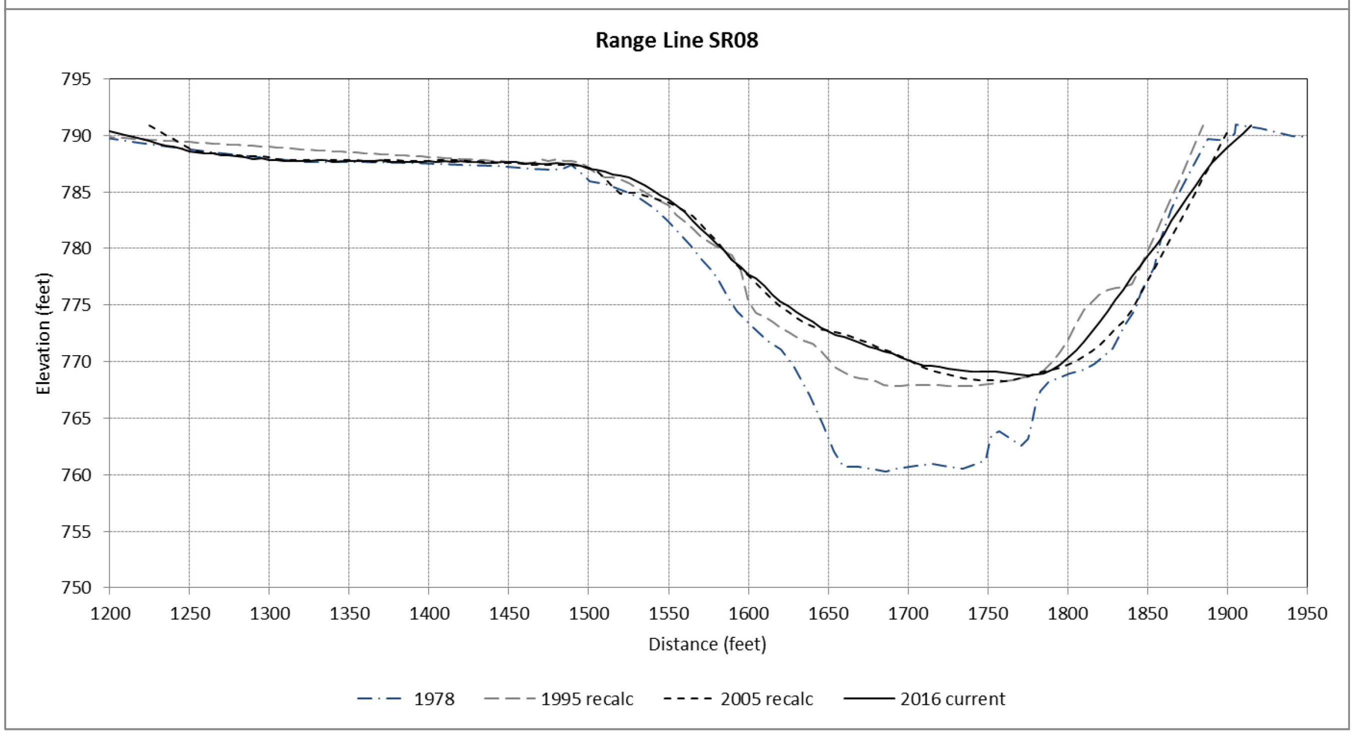

Range Line SR02
Elevation (feet)
800
790
780
770
760
750
740
730
720
710
700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000 2100 2200 2300 2400
Distance (feet)
1995 recalc
2005 recalc
2016 current


Range Line SR03
800
790
780
770
760
750
740
730
720
Elevation (feet)
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800
Distance (feet)
1995 recalc
2005 recalc
2016 current

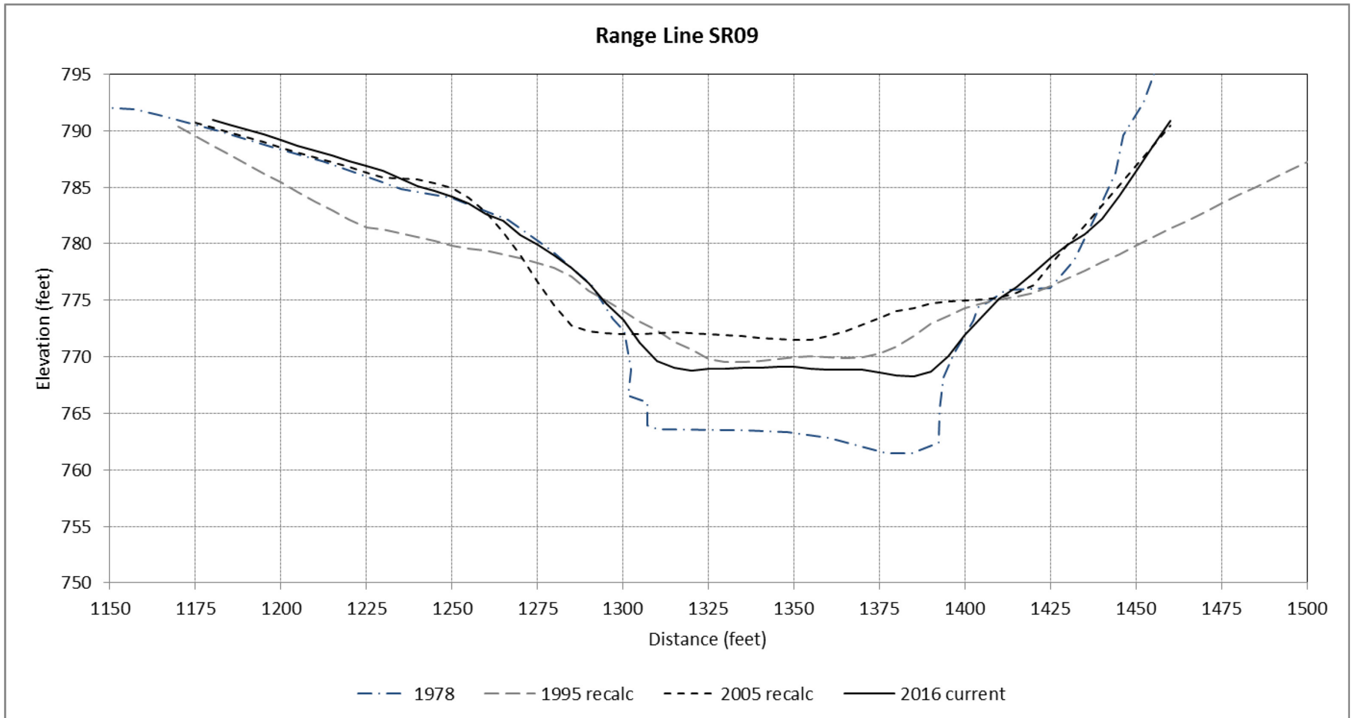

Range Line SR06
800
790
780
770
760
750
740
Elevation (feet)
400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
Distance (feet)
1978
1995 recalc
2005 recalc
2016 current



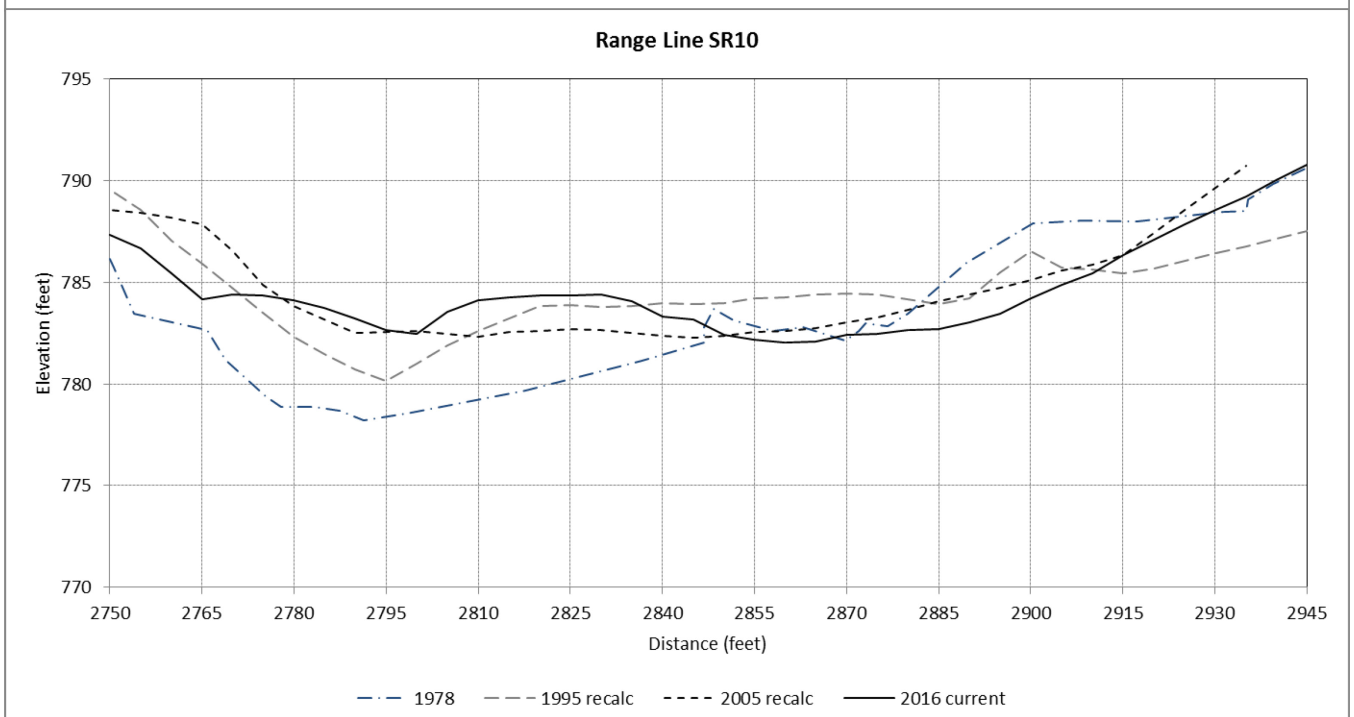
Range Line SR07
795
790
785
780
775
770
765
760
755
750
Elevation (feet)
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
2300
Distance (feet)
1978
1995 recalc
2005 recalc
2016 current



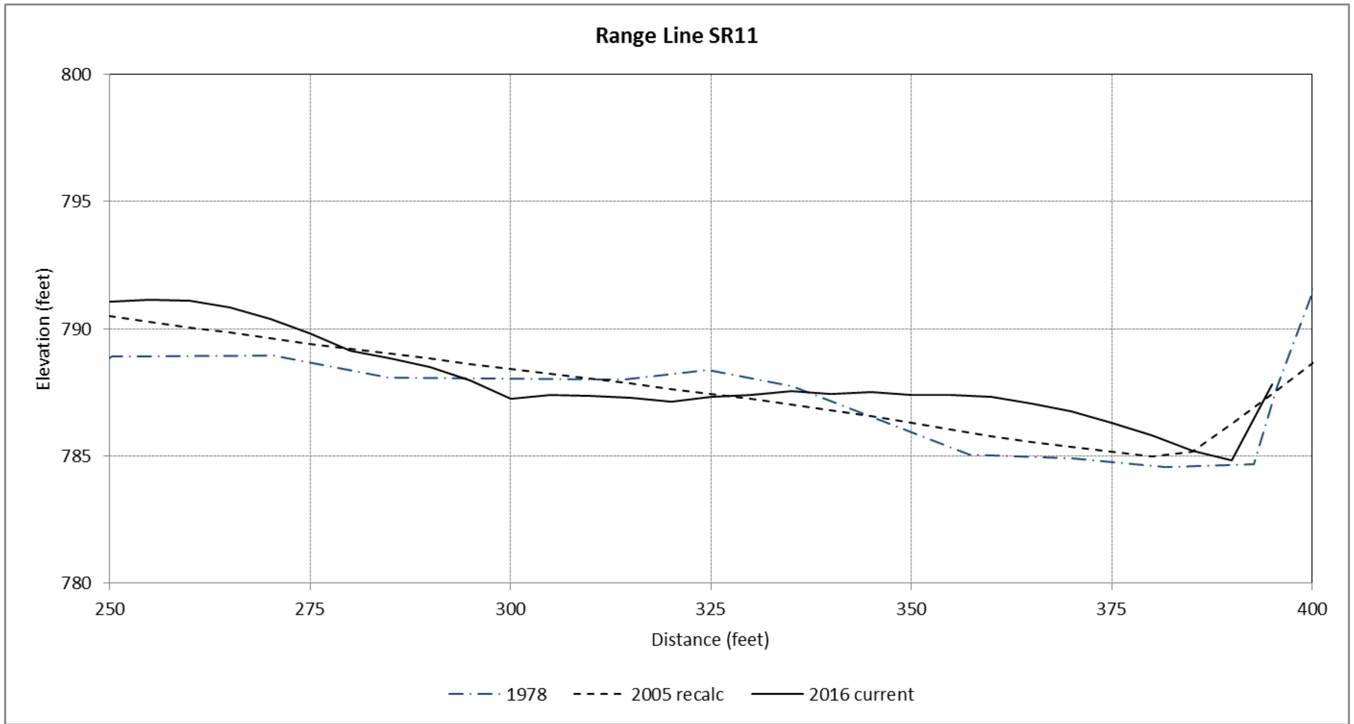
Range Line SR08
795
790
785
780
775
770
765
760
755
750
Elevation (feet)
1200
1250
1300
1350
1400
1450
1500
1550
1600
1650
1700
1750
1800
1850
1900
1950
Distance (feet)
1978
1995 recalc
2005 recalc
2016 current



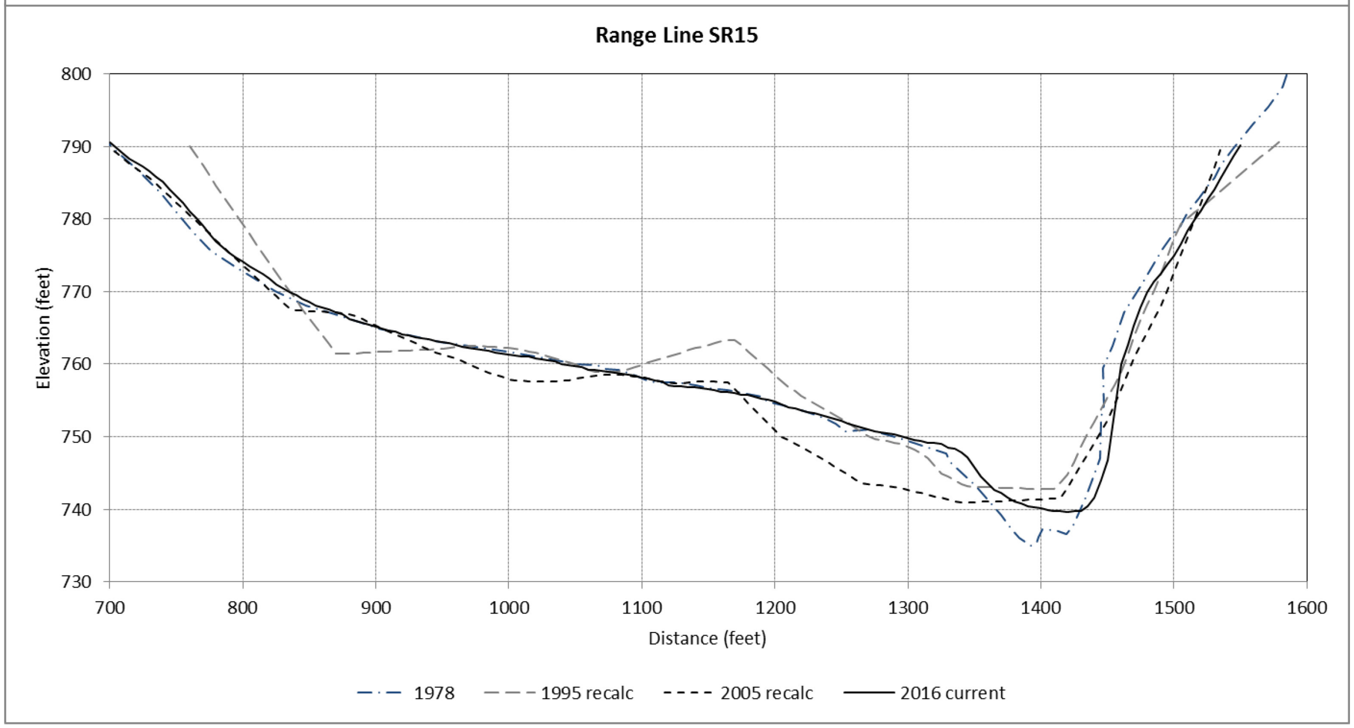
Range Line SR09
Elevation (feet)
Distance (feet)
795
790
785
780
775
770
765
760
755
750
1150
1175
1200
1225
1250
1275
1300
1325
1350
1375
1400
1425
1450
1475
1500
1978
1995 recalc
2005 recalc
2016 current



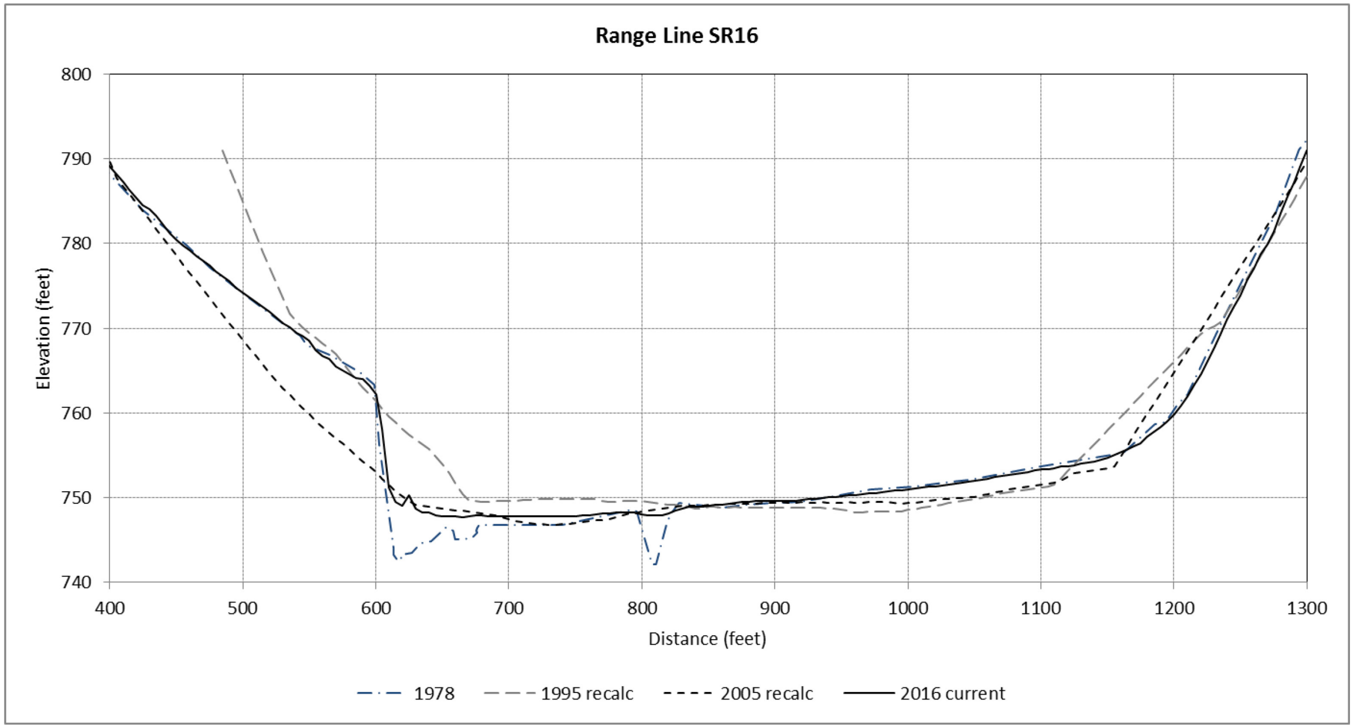
Range Line SR10
Elevation (feet)
Distance (feet)
795
790
785
780
775
770
2750
2765
2780
2795
2810
2825
2840
2855
2870
2885
2900
2915
2930
2945
1978
1995 recalc
2005 recalc
2016 current



Range Line SR11
Elevation (feet)
800
795
790
785
780
250
275
300
325
350
375
400
Distance (feet)
1978
2005 recalc
2016 current



Range Line SR15
Elevation (feet)
800
790
780
770
760
750
740
730
700
800
900
1000
1100
1200
1300
1400
1500
1600
Distance (feet)
1978
1995 recalc
2005 recalc
2016 current


Range Line SR16
800
790
780
770
760
750
740
Elevation (feet)
400
500
600
700
800
900
1000
1100
1200
1300
Distance (feet)
1978
1995 recalc
2005 recalc
2016 current

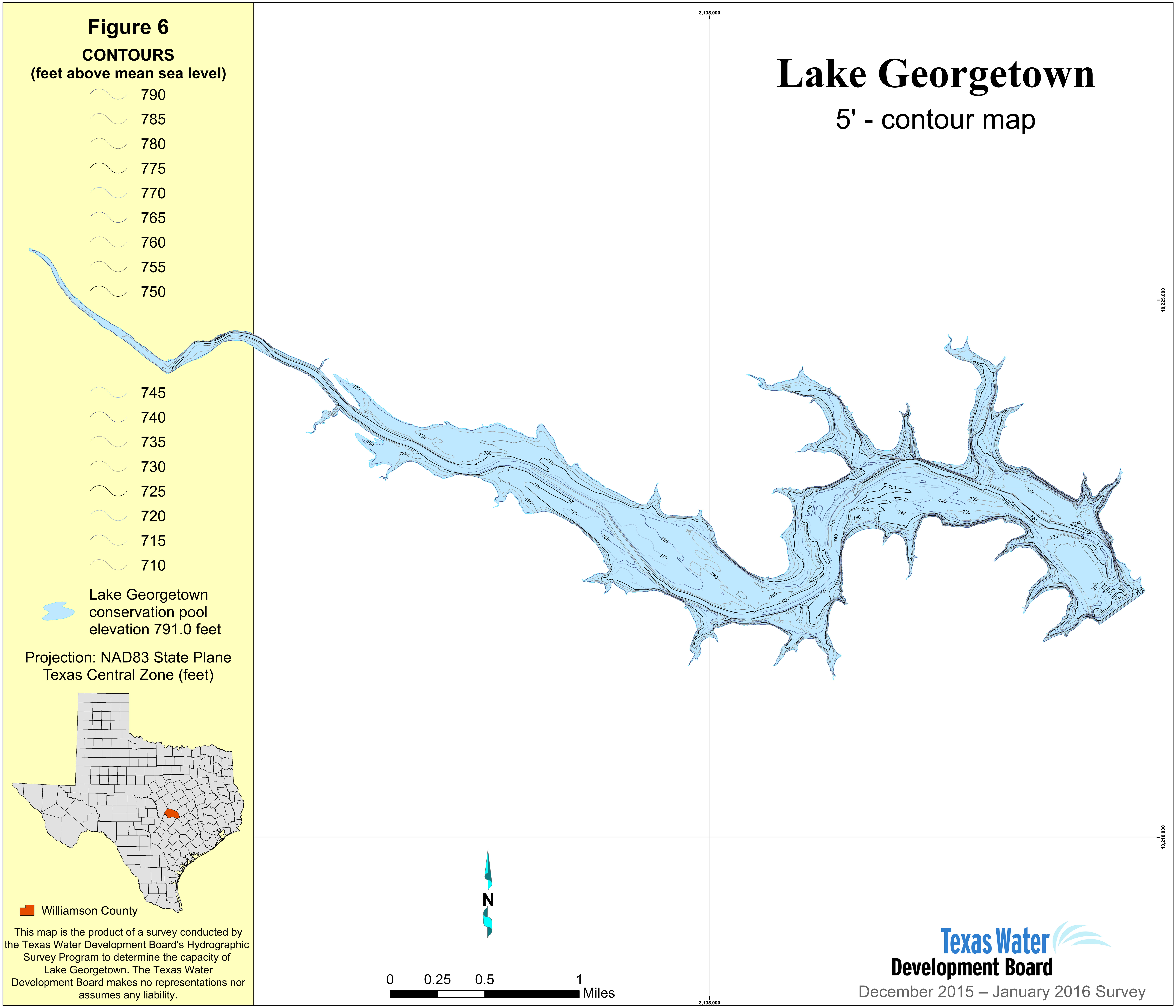


Figure 6
CONTOURS
(feet above mean sea level)
790
785
780
775
770
765
760
755
750
745
740
735
730
725
720
715
710
Lake Georgetown conservation pool elevation 791.0 feet
Projection: NAD83 State Plane Texas Central Zone (feet)
Williamson County
This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Lake Georgetown. The Texas Water Development Board makes no representations nor assumes any liability.
Lake Georgetown
5' - contour map
3,105,000
10,225,000
10,210,000
N
0
0.25
0.5
1
Miles
Texas Water Development Board
December 2015 – January 2016 Survey