Volumetric and Sedimentation Survey of SQUAW CREEK RESERVOIR

December 2007 Survey

Prepared by:

The Texas Water Development Board

August 2008

Texas Water Development Board

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Executive Summary

In August of 2007, the Texas Water Development Board entered into agreement with TXU Generation Company LP, now Luminant, for the purpose of performing a volumetric and sedimentation survey of Squaw Creek Reservoir. This survey was performed using a multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. In addition, sediment core samples were collected in selected locations and were used in interpreting the multi-frequency depth sounder signal returns to derive sediment accumulation estimates.

Squaw Creek Dam and Reservoir are located on Squaw Creek in the Brazos River Basin in Somervell and Hood Counties, Texas. Bathymetric data collection for Squaw Creek Reservoir occurred on November 29th-30th of 2007, December 5th-7th of 2007, and June 26th of 2008. During surveying, the water surface elevation of Squaw Creek Reservoir ranged between 775.10 feet and 775.48 feet above mean sea level, NGVD29. The conservation pool elevation of Squaw Creek Reservoir is 775.0 feet above mean sea level.

The results of the TWDB 2007 Volumetric Survey indicate Squaw Creek Reservoir has a total reservoir capacity, including capacity of the Safe Shutdown Impoundment, of 151,273 acre-feet and encompasses 3,169 acres at conservation pool elevation (775.0 feet above mean sea level, NGVD29). Previously published[1] capacity estimates for Squaw Creek Reservoir are 151,047 acre-feet, 150,569 acre-feet, and 151,418 acre-feet based on surveys conducted in 1972, 1987, and 1997, respectively. The results of the 2007 Volumetric Survey indicate the Safe Shutdown Impoundment has a capacity of 641 acre-feet and encompasses 45 acres. Due to differences in the methodologies used in calculating areas and capacities from this and previous Squaw Creek Reservoir surveys, direct comparison of these values is not recommended. A detailed evaluation and comparison of the methodologies used to calculate previous capacity estimates of Squaw Creek Reservoir is presented in Appendix J. The TWDB considers the 2007 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Squaw Creek Reservoir in approximately 10 years or after a major flood event.

The results of the TWDB 2007 Sedimentation Survey indicate Squaw Creek Reservoir has accumulated 3,735 acre-feet of sediment since impoundment in 1977, with 40 acre-feet of sediment within the Safe Shutdown Impoundment. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Squaw Creek Reservoir loses approximately 125 acre-feet of capacity per year, with nearly 1 acre-foot lost within the Safe Shutdown Impoundment. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Squaw Creek channel. The maximum sediment thickness observed in Squaw Creek Reservoir was 7.38 feet.

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Squaw Creek Reservoir General Information

Squaw Creek Dam and Reservoir are located on Squaw Creek in the Brazos River Basin between the cities of Glen Rose, TX and Granbury, TX (Figure 1). Squaw Creek Reservoir is owned and operated by the TXU Generation Company LP, now Luminant.[2] Squaw Creek Reservoir serves primarily as a cooling pond for the Comanche Nuclear Power Plant, the sole nuclear power plant owned and operated by Luminant,[3] a competitive power generation business and subsidiary of Energy Future Holdings Corp, formerly TXU Corp.[4,5] Construction on Squaw Creek Dam began on November 17, 1974, and was completed on June 16, 1977.[1]

Luminant also maintains a smaller dam on Panther Branch, a tributary of Squaw Creek, designed to provide cooling water during an emergency situation to safely shutdown the Comanche Peak Steam Electric Station. This dam and reservoir is known as the Safe Shutdown Impoundment (SSI) facility. A service/ emergency spillway acts as an equalization channel between Squaw Creek Reservoir and the Safe Shutdown Impoundment.[1] Additional pertinent data about Squaw Creek Dam and Squaw Creek Reservoir can be found in Table 1.

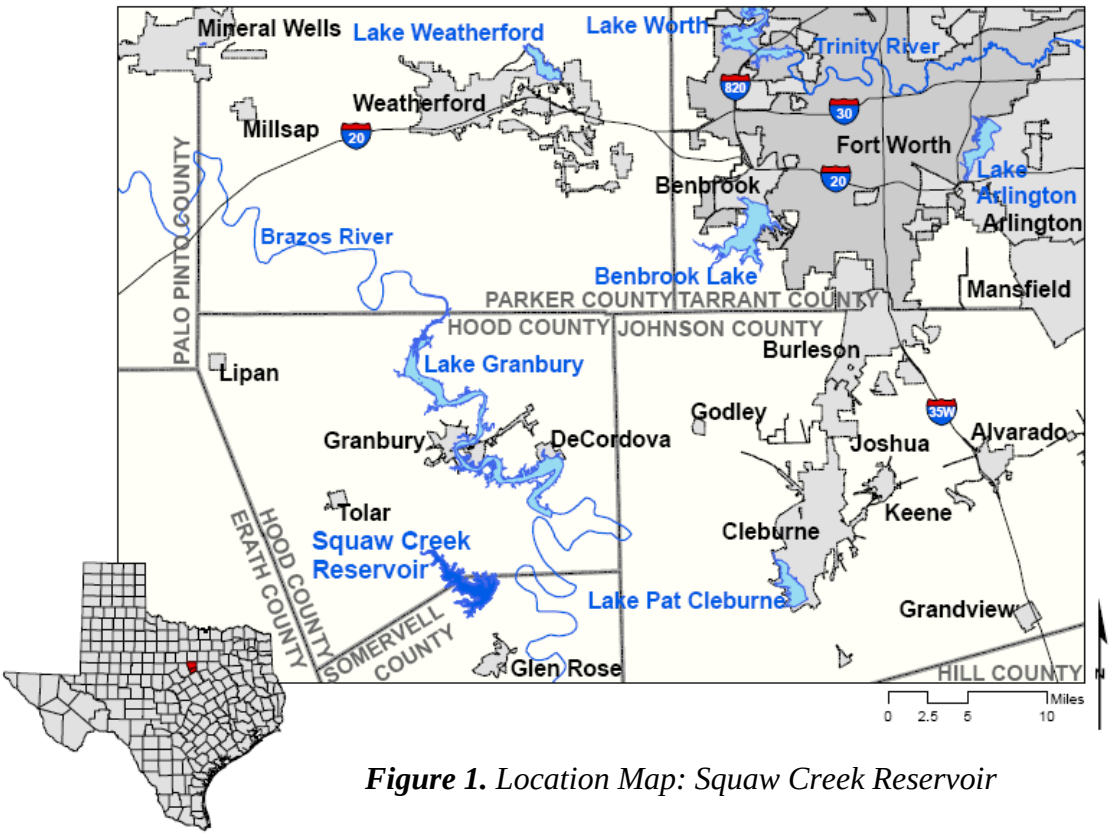


Figure 1. *Location Map: Squaw Creek Reservoir*

Table 1. Pertinent Data for Squaw Creek Dam and Squaw Creek Reservoir[1,3,4]

Owner	
Luminant, a subsidiary of Energy Future Holdings Corp.	
Engineer (Design)	
Freese and Nichols Consulting Engineers	
Location of Dam	
On Squaw Creek in Somervell and Hood Counties, approximately 4 miles north of Glen Rose, TX and approximately 80 miles southwest of downtown Dallas, TX	
Drainage Area	
64 square miles	
Dam	
Type	Earthfill
Length	4,360 feet
Maximum height	159 feet
Crest elevation	796.0 feet above mean sea level
Spillway (emergency)	
Location	Left abutment, northeast of the embankment
Type	Earthcut channel through bedrock
Channel width	2,200 feet
Crest elevation	783.0 feet above mean sea level
Spillway (service)	
Location	Between the right (southwest) end of the embankment and abutment
Type	Uncontrolled concrete ogee
Crest width	100 feet
Crest elevation	775.0 feet above mean sea level
Outlet (service)	
Type	Concrete tower
Control	3 gate-controlled outlets
Invert elevations	764.0 feet, 715.0 feet, and 666.5 feet above mean sea level
Discharge	From outlet tower through 6 foot diameter concrete encased conduit, released downstream of the embankment
Low flow outlet	30-inch diameter, invert elevation of 653.0 feet above mean sea level
Safe Shutdown Impoundment (SSI)	
Dam	
Location	On Panther Branch, a tributary of Squaw Creek
Type	Earthfill
Length	1,520 feet
Maximum height	70 feet
Crest elevation	796.0 feet above mean sea level
Crest Width	40 feet
Spillway (service/ emergency)	
Type	Earth cut channel
Width	40 feet
Length	400 feet
Control	3 foot tall by 3 foot wide concrete weir with a flowline elevation of 769.5 feet above mean sea level

Water Rights

The water rights for Squaw Creek Reservoir have been appropriated to the Texas Utilities Electric Company, now Luminant, through Certificate of Adjudication No. 12-4097. The certificate authorizes Luminant to maintain an existing dam and reservoir on Panther Creek and an existing dam and reservoir on Squaw Creek and impound a combined total of up to 151,500 acre-feet of water in the two reservoirs. Luminant is authorized to divert and use a maximum of 2,400 acre-feet of water per annum from the Squaw Creek Reservoir for ancillary purposes in operation of the Comanche Nuclear Power Plant. Luminant is also authorized to divert, circulate, and re-circulate water in Squaw Creek Reservoir and to consumptively use a maximum of 20,780 acre-feet of water per annum for industrial (condenser cooling) purposes. The complete certificate is on file in the Records Division of the Texas Commission on Environmental Quality.

Volumetric and Sedimentation Survey of Squaw Creek Reservoir

The Texas Water Development Board's (TWDB) Hydrographic Survey Program was authorized by the state legislature in 1991. The Texas Water Code Chapter 15, Subchapter M., authorizes TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In August of 2007, the Texas Water Development Board entered into agreement with TXU Generation Company LP, now Luminant, for the purpose of performing a volumetric and sedimentation survey of Squaw Creek Reservoir. This survey was performed using a single-beam multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. The 200 kHz return indicates the current bathymetric surface, while the combination of the three frequencies is analyzed for evidence of sediment accumulation throughout the reservoir. Sediment core samples are collected in order to validate the interpretation of the multi-frequency acoustic signals and to verify the identification of the reservoir bathymetric surface at the time of initial impoundment.

This report serves as the final contract deliverable from TWDB to Luminant, and contains as deliverables: (1) elevation-capacity tables and an elevation-area tables of the reservoir acceptable to the Texas Commission on Environmental Quality [Appendices A-

F], (2) a bottom contour map [Figure 5], and (3) a shaded relief plot of the reservoir bottom [Figure 3].

Datum

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gage USGS 08091730 Squaw Creek Res nr Glen Rose, TX.[6] The datum for this gage is reported as National Geodetic Vertical Datum 1929 (NGVD29) or mean sea level, thus elevations reported here are in feet above mean sea level. 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 of 1983 (NAD83), and the horizontal coordinate system is State Plane Texas North Central Zone (feet).

TWDB Bathymetric Data Collection

Bathymetric data collection for Squaw Creek Reservoir occurred on November 29th-30th and December 5th-7th of 2007, while the water surface elevation ranged between 775.45 feet and 775.48 feet above mean sea level, NGVD29. Additional data were collected on June 26th, 2008, while the water surface elevation was 775.10 feet above mean sea level, NGVD29. For data collection, TWDB used a Specialty Devices, Inc., multi-frequency sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. The pre-planned range lines surveyed during the 2007 survey consisted of 150 range lines that were originally developed for the 1997 TWDB Volumetric Survey. 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. During the 2007 survey, team members collected approximately 49,400 data points over cross-sections totaling nearly 72 miles in length. Figure 2 shows where data points were collected during the TWDB 2007 survey.

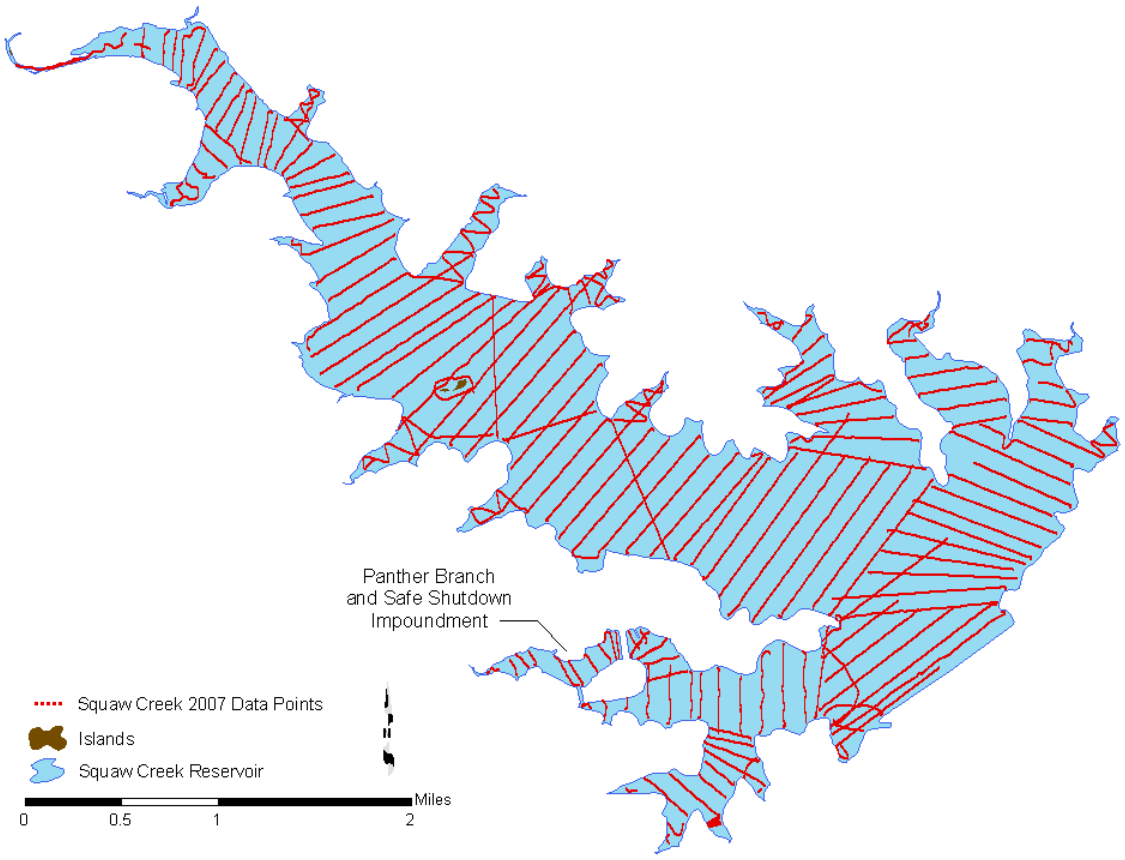


***Figure 2**. Data points collected during TWDB 2007 Survey*

Data Processing

Model Boundaries

The reservoir boundary was digitized from aerial photographs, or digital orthophoto quarter-quadrangle images (DOQQs)[7,8], using Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 software. The quarter-quadrangles that cover Squaw Creek Reservoir are Hill City NW, Hill City NE, Hill City SW, Hill City SE, Nemo NW and Nemo SW. These images were photographed on August 8, 2004, during which time the water surface elevation at Squaw Creek Reservoir measured 775.27 feet above mean sea level. Although the water surface elevation measured 0.27 feet above conservation pool elevation at the time of the photos, TWDB determined that there was not a significant difference in lake area between 775.27 feet and 775.00 feet, as discernable from the photographs and given the photographs have a 1-meter resolution. Therefore, the reservoir boundary was digitized

from the land water interface in the photos and labeled 775.00 feet to allow area and volume to be calculated to the conservation pool elevation.

Triangulated Irregular Network (TIN) Model

Upon completion of data collection, the raw data files collected by TWDB were edited using DepthPic to remove any data anomalies. DepthPic was used to display, interpret, and edit the multi-frequency data. The water surface elevations at the times of each sounding are used to convert sounding depths to corresponding bathymetric elevations. For processing outside of DepthPic, the sounding coordinates (X,Y,Z) were exported as a MASS points file. TWDB also created a MASS points file of interpolated data located between surveyed cross sections. This points file is described in the section entitled "Self-Similar Interpolation."

To create a surface representation of the Squaw Creek Reservoir bathymetry, the 3D Analyst Extension[9] of ArcGIS (ESRI, Inc.) was used. With this extension, a triangulated irregular network (TIN) model of the bathymetry is created following the Delaunay[8] criteria, where each MASS point and boundary node becomes the vertex of a triangular portion of the reservoir bottom surface. From the TIN model, reservoir capacities and areas are calculated at 0.1 foot intervals, from elevation 648.5 feet to elevation 775.0 feet.

The Elevation-Capacity and Elevation-Area Tables, updated for 2007, are presented in Appendices A through F. Elevation-Area-Capacity graphs are presented in Appendices G, H, and I.

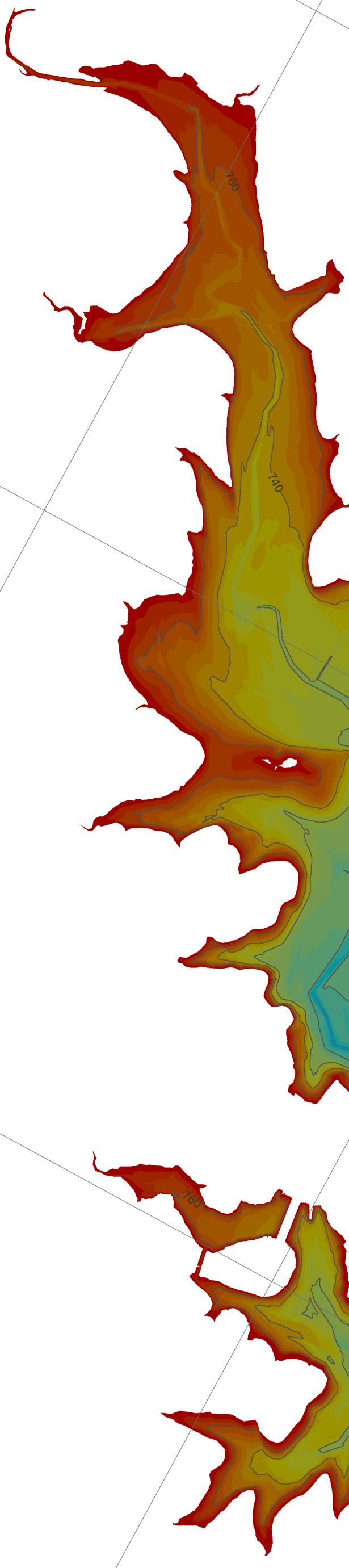
The TIN model was interpolated and averaged using a cell size of 1 foot by 1 foot and converted to a raster. The raster was used to produce Figure 3, an Elevation Relief Map representing the topography of the reservoir bottom, Figure 4, a map showing shaded depth ranges for Squaw Creek Reservoir, and Figure 5, a 10-foot contour map (attached).

Self-Similar Interpolation

A limitation of the Delaunay method for triangulation when creating TIN models results in artificially-curved contour lines extending into the reservoir where the reservoir walls are steep and the reservoir is relatively narrow. These curved contours are likely a poor representation of the true reservoir bathymetry in these areas. Also, if the surveyed

6,810,000 2,180,000 2,190,000

Figure 3
Squaw Creek Reservoir
Elevation Relief Map



Elevations
(in feet above mean sea level)

- 770.1 - 775
- 765.1 - 770
- 760.1 - 765
- 755.1 - 760
- 750.1 - 755
- 745.1 - 750
- 740.1 - 745
- 735.1 - 740
- 730.1 - 735
- 725.1 - 730
- 720.1 - 725
- 715.1 - 720
- 710.1 - 715
- 705.1 - 710
- 700.1 - 705
- 695.1 - 700
- 690.1 - 695
- 685.1 - 690
- 680.1 - 685
- 675.1 - 680
- 670.1 - 675
- 665.1 - 670
- 660.1 - 665
- 655.1 - 660
- 650.1 - 655
- 648.5 - 650
- 20 - foot contours

6,800,000 2,180,000 6,790,000 6,810,000 2,200,000 6,800,000

Miles
0 0.25 0.5 1

Conservation Pool elevation: 775.0 feet above mean sea level

Projection: NAD83 State Plane Texas North Central Zone

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2,190,000 2,200,000 6,790,000

Figure 4

Squaw Creek Reservoir

Depth Ranges Map

6,810,000
2,180,000
2,190,000
6,800,000
2,180,000
6,790,000
2,190,000
2,200,000
6,800,000
6,810,000

760
740
720
700
680
660
760

Depth Ranges

(in feet)

- 0 - 10'
- 10 - 20'
- 20 - 30'
- 30 - 40'
- 40 - 50'
- 50 - 60'
- 60 - 70'
- 70 - 80'
- 80 - 90'
- 90 - 100'
- 100 - 120'
- 120 - 140'
- 140 - 160'
- > 160'

Squaw Creek Reservoir Boundary

20 - foot contours

Miles
0 0.25 0.5 1

Conservation Pool elevation: 775.0 feet above mean sea level

Projection: NAD83 State Plane Texas North Central Zone

Prepared by: TEXAS WATER DEVELOPMENT BOARD December 2007 Survey

cross-sections are not perpendicular to the centerline of the submerged river channel (the location of which is often unknown until after the survey), then the TIN model is not likely to represent the true channel bathymetry very well.

To ameliorate these problems, a "Self-Similar" interpolation routine (developed by TWDB) was used to interpolate the bathymetry between many of the survey lines. The Self-Similar interpolation technique effectively increases the density of points input into the TIN model, and directs the TIN interpolation to better represent the reservoir topography.[8] In the case of Squaw Creek Reservoir, the application of Self-Similar interpolation helped represent the lake morphology near the banks and improved the representation of the submerged river channel (Figure 6). In areas where obvious geomorphic features indicate a high-probability of cross-section shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), the assumptions used in applying the Self-Similar interpolation technique are not likely to be valid; therefore, Self-Similar interpolation was not used in areas of Squaw Creek Reservoir where a high probability of change between cross-sections exists.[10] Figure 6 illustrates typical results of the application of the Self-Similar interpolation routine in Squaw Creek Reservoir, and the bathymetry shown in Figure 6C was used in computing reservoir capacity and area tables (Appendices A-F).

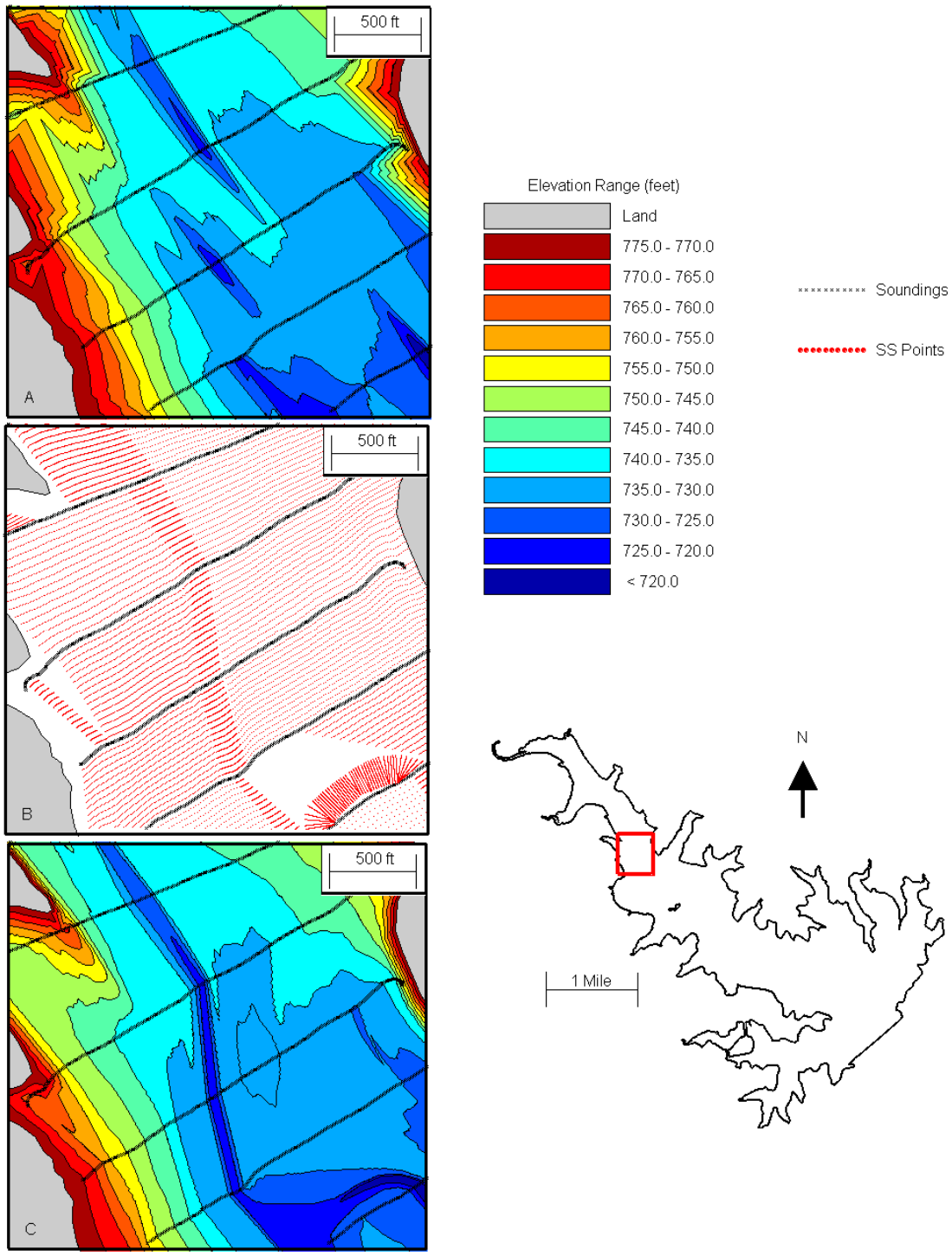


Figure 6. *Application of the Self-Similar Interpolation technique to Squaw Creek Reservoir sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black) and interpolated points (red) with reservoir boundary shown at elevation 775.0 feet (black), C) bathymetric contours with the interpolated points. Note: In 6A the steep banks and submerged river channel indicated by the surveyed cross sections are not represented for the areas in-between the cross sections. This is an artifact of the TIN generation routine when data points are too far apart. Inclusion of the interpolated points (6C) corrects this and smoothes the bathymetric contours.*

Survey Results

Volumetric Survey Results

The results of the TWDB 2007 Volumetric Survey indicate Squaw Creek Reservoir has a total reservoir capacity, including capacity of the Safe Shutdown Impoundment, of 151,273 acre-feet and encompasses 3,169 acres at conservation pool elevation (775.0 feet above mean sea level, NGVD29). Previously published[1] capacity estimates for Squaw Creek Reservoir are 151,047 acre-feet, 150,569 acre-feet, and 151,418 acre-feet based on surveys conducted in 1972, 1987, and 1997, respectively (Table 2). The results of the 2007 Volumetric Survey indicate the Safe Shutdown Impoundment has a capacity of 641 acre-feet and encompasses 45 acres.

Table 2. Published Areas and Capacities of Squaw Creek Reservoir[11]

Feature	Freese and Nichols, Inc.* Original Design[12]	Jones and Boyd, Inc.**	TWDB Volumetric Survey†	TWDB Volumetric and Sedimentation Survey††
Year	1972	1987	1997	2007
Total Area (acres)	3,228	3,189	3,297	3,169
Total Capacity (acre-feet)	151,047	150,569	151,418	151,273
Estimated Sedimentation Rate (acre-feet per year)	111	160	N/A	125
Area (acres) Safe Shutdown Impoundment	39.8	N/A	53	45
Capacity (acre-feet) Safe Shutdown Impoundment	558	N/A	701	641

* Data based on planimetering USGS maps.
**Surface area and capacity based on normal pool elevation (775.0 feet) using 25 sediment range lines
†Surface area and capacity based on normal pool elevation (775.0 feet) using 150 pre-planned survey lines across lake (approximately 500 feet apart). In addition, many random lines of data were collected.[1]
†† Surface area and capacity based on normal pool elevation (775.0 feet) using 150 pre-planned survey lines across lake (approximately 500 feet apart). In addition, many random lines of data were collected.

Due to differences in the methodologies used in calculating areas and capacities from this and previous Squaw Creek Reservoir surveys, direct comparison of these values is not recommended. At the request of Luminant, TWDB performed an in-depth analysis of the methodologies used to estimate the capacity of Squaw Creek Reservoir in 1972 and 1987. TWDB also applied the 2007 data processing techniques to the 1997 survey data to directly compare the 2007 survey to the 1997 survey. The results from these detailed comparisons can be found in Appendix J. The TWDB considers the 2007 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Squaw Creek Reservoir in approximately 10 years or after a major flood event.

Sedimentation Survey Results

The 200 kHz, 50 kHz, and 24 kHz frequency data were used to interpret sediment distribution and accumulation throughout Squaw Creek Reservoir. Figure 7 shows the thickness of sediment throughout the reservoir. To assist in the interpretation of post-impoundment sediment accumulation, ancillary data was collected in the form of three core samples. Sediment cores were collected on June 25th-26th, 2008 using a Specialty Devices, Inc. VibraCore system.

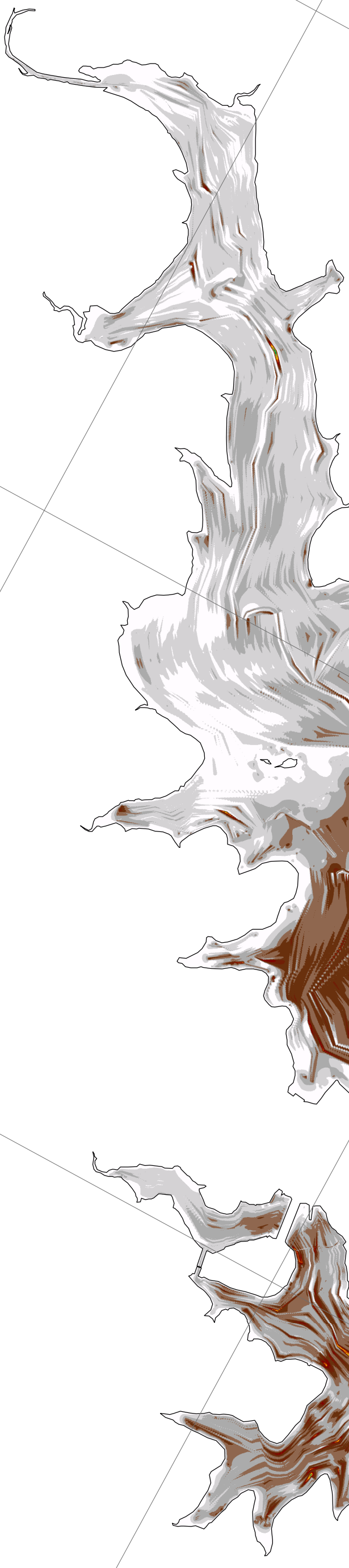
The results of the TWDB 2007 Sedimentation Survey indicate Squaw Creek Reservoir has accumulated 3,735 acre-feet of sediment since impoundment in 1977, with 40 acre-feet of sediment within the Safe Shutdown Impoundment. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Squaw Creek Reservoir loses approximately 125 acre-feet of capacity per year, with nearly 1 acre-foot lost within the Safe Shutdown Impoundment. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Squaw Creek channel. The maximum sediment thickness observed in Squaw Creek Reservoir was 7.38 feet.

A complete description of the sediment measurement methodology and sample results is presented in Appendix K.

Figure 7

Squaw Creek Reservoir

Sediment Thickness Map



Sediment Thickness
(in feet)

- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- 3.0 - 3.5
- 3.5 - 4.0
- 4.0 - 4.5
- 4.5 - 5.0
- 5.0 - 5.5
- 5.5 - 6.0
- 6.0 - 6.5
- 6.5 - 7.0
- 7.0 - 7.5
- Squaw Creek Reservoir

Miles
0 0.25 0.5 1

Projection: NAD83
State Plane
Texas North Central Zone

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6,810,000
2,180,000
2,190,000
6,800,000
2,180,000
2,200,000
6,810,000
6,800,000
6,790,000
2,190,000
2,200,000
6,790,000

Sediment Range Lines

In 1997, TU Electric, now Luminant, provided TWDB with coordinate listings for 25 sedimentation ranges. These ranges were surveyed as part of the 150 pre-planned survey lines during both the 1997 and 2007 surveys conducted by TWDB. Cross-sectional plots comparing the 2007 bathymetry, the revised 1997 bathymetry (See Appendix J), and pre-impoundment bathymetry (as determined from the 2007 survey data) are plotted in Appendix L for informational purposes. Appendix L includes a map of the location of each range line in Squaw Creek Reservoir, and a table listing the coordinates of each range line end point, converted from North American Datum (NAD27) State Plane Texas North Central Zone to NAD83 State Plane Texas North Central Zone (feet).

Cross-sections were extracted from ArcGIS TIN models of the lake bathymetry using standard GIS techniques[13]. Cross-sections of the approximate pre-impoundment bathymetry were derived by subtracting sediment-thickness values from the 2007 bathymetric elevations. All TIN models from which the cross-sections were derived were adjusted using the self-similar interpolation technique as described in the section titled "Self-Similar Interpolation."

TWDB Contact Information

More information about the Hydrographic Survey Program can be found at:

http://www.twdb.state.tx.us/assistance/lakesurveys/volumetricindex.asp

Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:

Barney Austin, Ph.D., P.E.
Director of the Surface Water Resources Division
Phone: (512) 463-8856
Email: Barney.Austin@twdb.state.tx.us

Or

Jason Kemp
Team Leader, TWDB Hydrographic Survey Program
Phone: (512) 463-2465
Email: Jason.Kemp@twdb.state.tx.us

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12. Freese and Nichols, Inc. 1972. "Engineering Report on Squaw Creek Reservoir."

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Appendix A

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Total Reservoir

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
648	0	0	0	0	0	0	0	0	0	0
649	0	0	0	0	0	0	0	0	0	0
650	0	0	0	0	0	0	0	1	1	1
651	1	1	2	2	2	3	4	4	5	6
652	7	8	10	11	12	14	16	17	19	21
653	23	25	27	29	32	34	36	39	41	44
654	46	49	52	54	57	60	63	66	69	72
655	75	79	82	85	89	92	95	99	102	106
656	110	113	117	121	125	128	132	136	140	144
657	148	152	156	160	165	169	173	177	182	186
658	191	195	200	204	209	214	219	223	228	233
659	238	243	249	254	259	265	270	276	282	287
660	293	299	305	312	318	324	331	338	344	351
661	358	365	372	379	386	394	401	409	417	424
662	432	440	449	457	465	474	482	491	500	509
663	519	528	538	548	558	568	578	589	599	610
664	621	632	643	655	666	678	690	702	714	726
665	738	751	764	777	790	803	817	830	844	858
666	872	886	901	916	930	945	961	976	991	1,007
667	1,023	1,039	1,055	1,071	1,088	1,104	1,121	1,138	1,155	1,173
668	1,190	1,208	1,226	1,244	1,262	1,280	1,299	1,317	1,336	1,355
669	1,374	1,394	1,413	1,433	1,452	1,472	1,492	1,512	1,533	1,553
670	1,574	1,595	1,616	1,637	1,658	1,680	1,702	1,724	1,746	1,768
671	1,791	1,813	1,836	1,860	1,883	1,906	1,930	1,954	1,978	2,002
672	2,027	2,051	2,076	2,101	2,127	2,152	2,178	2,204	2,230	2,256
673	2,283	2,310	2,337	2,364	2,392	2,419	2,447	2,475	2,504	2,532
674	2,561	2,589	2,618	2,647	2,676	2,706	2,735	2,765	2,794	2,824
675	2,854	2,884	2,914	2,945	2,975	3,006	3,037	3,068	3,099	3,130
676	3,161	3,193	3,224	3,256	3,288	3,320	3,352	3,384	3,417	3,449
677	3,482	3,515	3,548	3,581	3,614	3,648	3,681	3,715	3,749	3,783
678	3,817	3,851	3,886	3,920	3,955	3,990	4,025	4,060	4,096	4,131
679	4,167	4,203	4,239	4,275	4,311	4,348	4,384	4,421	4,458	4,495
680	4,532	4,569	4,607	4,644	4,682	4,720	4,757	4,796	4,834	4,872
681	4,911	4,950	4,988	5,027	5,066	5,106	5,145	5,185	5,224	5,264
682	5,304	5,344	5,384	5,424	5,465	5,505	5,546	5,586	5,627	5,668
683	5,709	5,751	5,792	5,833	5,875	5,917	5,959	6,001	6,043	6,085
684	6,128	6,170	6,213	6,256	6,299	6,342	6,385	6,428	6,472	6,515
685	6,559	6,603	6,647	6,691	6,735	6,779	6,824	6,868	6,913	6,958
686	7,003	7,048	7,093	7,139	7,184	7,230	7,275	7,321	7,367	7,414
687	7,460	7,506	7,553	7,600	7,647	7,694	7,741	7,789	7,837	7,885
688	7,933	7,982	8,030	8,079	8,128	8,177	8,227	8,276	8,326	8,376
689	8,426	8,477	8,527	8,578	8,629	8,680	8,731	8,782	8,834	8,885
690	8,937	8,989	9,041	9,093	9,145	9,198	9,250	9,303	9,356	9,409
691	9,462	9,515	9,568	9,622	9,676	9,729	9,783	9,837	9,892	9,946
692	10,001	10,056	10,111	10,166	10,221	10,277	10,332	10,388	10,444	10,501
693	10,557	10,614	10,670	10,728	10,785	10,842	10,900	10,958	11,016	11,074
694	11,133	11,191	11,250	11,309	11,368	11,428	11,487	11,547	11,607	11,667
695	11,727	11,788	11,849	11,909	11,970	12,032	12,093	12,155	12,216	12,278
696	12,341	12,403	12,465	12,528	12,591	12,654	12,717	12,781	12,844	12,908
697	12,972	13,036	13,101	13,165	13,230	13,295	13,360	13,425	13,491	13,557
698	13,622	13,688	13,755	13,821	13,888	13,955	14,022	14,089	14,157	14,225
699	14,293	14,361	14,430	14,498	14,567	14,636	14,706	14,775	14,845	14,915
700	14,985	15,055	15,126	15,196	15,267	15,338	15,410	15,481	15,553	15,625
701	15,697	15,770	15,843	15,916	15,989	16,062	16,136	16,210	16,284	16,358

Appendix A (continued)

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Total Reservoir

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
702	16,433	16,508	16,583	16,659	16,734	16,810	16,887	16,963	17,040	17,117
703	17,195	17,272	17,350	17,428	17,506	17,585	17,664	17,743	17,822	17,901
704	17,981	18,061	18,141	18,222	18,303	18,384	18,465	18,546	18,628	18,710
705	18,793	18,875	18,958	19,041	19,125	19,209	19,292	19,377	19,461	19,546
706	19,631	19,716	19,802	19,887	19,973	20,059	20,146	20,233	20,319	20,407
707	20,494	20,582	20,669	20,758	20,846	20,935	21,023	21,112	21,202	21,291
708	21,381	21,471	21,562	21,652	21,743	21,834	21,926	22,017	22,109	22,201
709	22,294	22,386	22,479	22,572	22,665	22,759	22,852	22,946	23,040	23,134
710	23,229	23,324	23,418	23,514	23,609	23,704	23,800	23,896	23,992	24,089
711	24,185	24,282	24,379	24,477	24,574	24,672	24,770	24,868	24,967	25,066
712	25,165	25,264	25,364	25,463	25,563	25,664	25,764	25,865	25,966	26,067
713	26,169	26,271	26,373	26,476	26,578	26,681	26,785	26,888	26,992	27,096
714	27,201	27,305	27,410	27,515	27,621	27,726	27,832	27,938	28,044	28,151
715	28,258	28,365	28,472	28,579	28,687	28,795	28,903	29,011	29,120	29,229
716	29,338	29,447	29,557	29,667	29,777	29,887	29,998	30,109	30,220	30,331
717	30,443	30,555	30,667	30,779	30,892	31,004	31,117	31,231	31,344	31,458
718	31,572	31,687	31,801	31,916	32,031	32,147	32,262	32,378	32,495	32,611
719	32,728	32,845	32,962	33,079	33,197	33,315	33,433	33,551	33,670	33,789
720	33,908	34,028	34,148	34,268	34,388	34,509	34,630	34,751	34,872	34,994
721	35,116	35,238	35,361	35,483	35,606	35,730	35,853	35,977	36,101	36,226
722	36,350	36,475	36,601	36,727	36,853	36,979	37,105	37,232	37,359	37,487
723	37,615	37,743	37,871	38,000	38,129	38,258	38,388	38,518	38,649	38,779
724	38,911	39,042	39,174	39,306	39,438	39,571	39,704	39,838	39,971	40,106
725	40,240	40,375	40,510	40,645	40,781	40,917	41,053	41,190	41,327	41,464
726	41,602	41,740	41,878	42,016	42,155	42,295	42,434	42,574	42,714	42,855
727	42,996	43,137	43,278	43,420	43,563	43,705	43,848	43,991	44,135	44,279
728	44,424	44,568	44,713	44,859	45,005	45,151	45,297	45,444	45,591	45,739
729	45,887	46,035	46,183	46,332	46,482	46,631	46,782	46,932	47,083	47,234
730	47,385	47,537	47,689	47,842	47,995	48,148	48,302	48,456	48,610	48,765
731	48,920	49,075	49,231	49,387	49,544	49,700	49,857	50,015	50,173	50,331
732	50,489	50,648	50,807	50,966	51,126	51,286	51,447	51,608	51,769	51,930
733	52,092	52,255	52,417	52,580	52,744	52,907	53,071	53,236	53,401	53,566
734	53,731	53,897	54,063	54,230	54,397	54,564	54,731	54,899	55,068	55,236
735	55,405	55,574	55,744	55,914	56,084	56,255	56,425	56,597	56,768	56,940
736	57,112	57,284	57,457	57,630	57,804	57,977	58,151	58,325	58,500	58,675
737	58,850	59,026	59,201	59,378	59,554	59,731	59,908	60,085	60,263	60,441
738	60,619	60,798	60,977	61,156	61,336	61,516	61,696	61,877	62,058	62,239
739	62,421	62,603	62,785	62,968	63,151	63,334	63,518	63,702	63,886	64,071
740	64,256	64,441	64,626	64,812	64,999	65,185	65,372	65,559	65,747	65,935
741	66,123	66,312	66,501	66,690	66,880	67,069	67,260	67,450	67,641	67,833
742	68,024	68,216	68,409	68,601	68,794	68,988	69,182	69,376	69,570	69,765
743	69,960	70,156	70,351	70,548	70,744	70,941	71,138	71,336	71,533	71,732
744	71,930	72,129	72,328	72,527	72,727	72,928	73,128	73,329	73,530	73,732
745	73,934	74,136	74,339	74,542	74,745	74,949	75,153	75,357	75,561	75,766
746	75,972	76,177	76,383	76,590	76,797	77,004	77,211	77,419	77,627	77,835
747	78,044	78,253	78,463	78,673	78,883	79,094	79,305	79,516	79,728	79,940
748	80,153	80,365	80,579	80,792	81,006	81,220	81,435	81,650	81,865	82,081
749	82,297	82,513	82,730	82,947	83,164	83,382	83,600	83,819	84,037	84,257
750	84,476	84,696	84,916	85,137	85,358	85,580	85,801	86,024	86,246	86,469
751	86,692	86,916	87,140	87,365	87,590	87,815	88,040	88,267	88,493	88,720
752	88,947	89,174	89,402	89,630	89,859	90,088	90,317	90,547	90,777	91,007
753	91,238	91,469	91,701	91,933	92,165	92,398	92,630	92,864	93,097	93,332
754	93,566	93,800	94,036	94,271	94,507	94,743	94,979	95,216	95,453	95,691
755	95,929	96,167	96,406	96,645	96,884	97,124	97,364	97,604	97,845	98,087

Appendix A (continued)

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Total Reservoir

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
756	98,328	98,570	98,813	99,056	99,299	99,542	99,786	100,031	100,276	100,521
757	100,766	101,012	101,259	101,505	101,752	102,000	102,247	102,495	102,744	102,993
758	103,242	103,491	103,741	103,992	104,242	104,493	104,745	104,997	105,249	105,501
759	105,754	106,007	106,261	106,515	106,770	107,025	107,280	107,536	107,793	108,049
760	108,306	108,564	108,822	109,080	109,338	109,597	109,857	110,116	110,377	110,637
761	110,898	111,159	111,421	111,683	111,946	112,208	112,472	112,736	113,000	113,264
762	113,529	113,795	114,060	114,327	114,593	114,860	115,128	115,396	115,664	115,932
763	116,201	116,470	116,740	117,010	117,281	117,552	117,823	118,095	118,367	118,639
764	118,912	119,185	119,459	119,733	120,008	120,282	120,558	120,833	121,109	121,386
765	121,663	121,940	122,217	122,495	122,774	123,052	123,331	123,611	123,891	124,171
766	124,452	124,733	125,014	125,296	125,578	125,860	126,143	126,427	126,710	126,994
767	127,279	127,563	127,849	128,134	128,420	128,706	128,993	129,281	129,568	129,856
768	130,144	130,433	130,722	131,012	131,302	131,592	131,883	132,174	132,465	132,757
769	133,049	133,342	133,635	133,928	134,222	134,516	134,810	135,105	135,400	135,695
770	135,991	136,287	136,584	136,881	137,178	137,476	137,774	138,072	138,371	138,670
771	138,969	139,269	139,569	139,870	140,171	140,472	140,774	141,076	141,378	141,681
772	141,984	142,288	142,592	142,896	143,201	143,507	143,812	144,118	144,424	144,731
773	145,038	145,346	145,654	145,962	146,271	146,580	146,890	147,200	147,511	147,822
774	148,133	148,445	148,757	149,070	149,383	149,697	150,011	150,326	150,641	150,957
775	151,273									

Appendix B

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Main Reservoir Body

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
648	0	0	0	0	0	0	0	0	0	0
649	0	0	0	0	0	0	0	0	0	0
650	0	0	0	0	0	0	0	1	1	1
651	1	1	2	2	2	3	4	4	5	6
652	7	8	10	11	12	14	16	17	19	21
653	23	25	27	29	32	34	36	39	41	44
654	46	49	52	54	57	60	63	66	69	72
655	75	79	82	85	89	92	95	99	102	106
656	110	113	117	121	125	128	132	136	140	144
657	148	152	156	160	165	169	173	177	182	186
658	191	195	200	204	209	214	219	223	228	233
659	238	243	249	254	259	265	270	276	282	287
660	293	299	305	312	318	324	331	338	344	351
661	358	365	372	379	386	394	401	409	417	424
662	432	440	449	457	465	474	482	491	500	509
663	519	528	538	548	558	568	578	589	599	610
664	621	632	643	655	666	678	690	702	714	726
665	738	751	764	777	790	803	817	830	844	858
666	872	886	901	916	930	945	961	976	991	1,007
667	1,023	1,039	1,055	1,071	1,088	1,104	1,121	1,138	1,155	1,173
668	1,190	1,208	1,226	1,244	1,262	1,280	1,299	1,317	1,336	1,355
669	1,374	1,394	1,413	1,433	1,452	1,472	1,492	1,512	1,533	1,553
670	1,574	1,595	1,616	1,637	1,658	1,680	1,702	1,724	1,746	1,768
671	1,791	1,813	1,836	1,860	1,883	1,906	1,930	1,954	1,978	2,002
672	2,027	2,051	2,076	2,101	2,127	2,152	2,178	2,204	2,230	2,256
673	2,283	2,310	2,337	2,364	2,392	2,419	2,447	2,475	2,504	2,532
674	2,561	2,589	2,618	2,647	2,676	2,706	2,735	2,765	2,794	2,824
675	2,854	2,884	2,914	2,945	2,975	3,006	3,037	3,068	3,099	3,130
676	3,161	3,193	3,224	3,256	3,288	3,320	3,352	3,384	3,417	3,449
677	3,482	3,515	3,548	3,581	3,614	3,648	3,681	3,715	3,749	3,783
678	3,817	3,851	3,886	3,920	3,955	3,990	4,025	4,060	4,096	4,131
679	4,167	4,203	4,239	4,275	4,311	4,348	4,384	4,421	4,458	4,495
680	4,532	4,569	4,607	4,644	4,682	4,720	4,757	4,796	4,834	4,872
681	4,911	4,950	4,988	5,027	5,066	5,106	5,145	5,185	5,224	5,264
682	5,304	5,344	5,384	5,424	5,465	5,505	5,546	5,586	5,627	5,668
683	5,709	5,751	5,792	5,833	5,875	5,917	5,959	6,001	6,043	6,085
684	6,128	6,170	6,213	6,256	6,299	6,342	6,385	6,428	6,472	6,515
685	6,559	6,603	6,647	6,691	6,735	6,779	6,824	6,868	6,913	6,958
686	7,003	7,048	7,093	7,139	7,184	7,230	7,275	7,321	7,367	7,414
687	7,460	7,506	7,553	7,600	7,647	7,694	7,741	7,789	7,837	7,885
688	7,933	7,982	8,030	8,079	8,128	8,177	8,227	8,276	8,326	8,376
689	8,426	8,477	8,527	8,578	8,629	8,680	8,731	8,782	8,834	8,885
690	8,937	8,989	9,041	9,093	9,145	9,198	9,250	9,303	9,356	9,409
691	9,462	9,515	9,568	9,622	9,676	9,729	9,783	9,837	9,892	9,946
692	10,001	10,056	10,111	10,166	10,221	10,277	10,332	10,388	10,444	10,501
693	10,557	10,614	10,670	10,728	10,785	10,842	10,900	10,958	11,016	11,074
694	11,133	11,191	11,250	11,309	11,368	11,428	11,487	11,547	11,607	11,667
695	11,727	11,788	11,849	11,909	11,970	12,032	12,093	12,155	12,216	12,278
696	12,341	12,403	12,465	12,528	12,591	12,654	12,717	12,781	12,844	12,908
697	12,972	13,036	13,101	13,165	13,230	13,295	13,360	13,425	13,491	13,557
698	13,622	13,688	13,755	13,821	13,888	13,955	14,022	14,089	14,157	14,225
699	14,293	14,361	14,430	14,498	14,567	14,636	14,706	14,775	14,845	14,915
700	14,985	15,055	15,126	15,196	15,267	15,338	15,410	15,481	15,553	15,625
701	15,697	15,770	15,843	15,916	15,989	16,062	16,136	16,210	16,284	16,358

Appendix B (continued)

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Main Reservoir Body

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
702	16,433	16,508	16,583	16,659	16,734	16,810	16,887	16,963	17,040	17,117
703	17,195	17,272	17,350	17,428	17,506	17,585	17,664	17,743	17,822	17,901
704	17,981	18,061	18,141	18,222	18,303	18,384	18,465	18,546	18,628	18,710
705	18,793	18,875	18,958	19,041	19,125	19,209	19,292	19,377	19,461	19,546
706	19,631	19,716	19,802	19,887	19,973	20,059	20,146	20,233	20,319	20,407
707	20,494	20,582	20,669	20,758	20,846	20,935	21,023	21,112	21,202	21,291
708	21,381	21,471	21,562	21,652	21,743	21,834	21,926	22,017	22,109	22,201
709	22,294	22,386	22,479	22,572	22,665	22,759	22,852	22,946	23,040	23,134
710	23,229	23,324	23,418	23,514	23,609	23,704	23,800	23,896	23,992	24,089
711	24,185	24,282	24,379	24,477	24,574	24,672	24,770	24,868	24,967	25,066
712	25,165	25,264	25,364	25,463	25,563	25,664	25,764	25,865	25,966	26,067
713	26,169	26,271	26,373	26,476	26,578	26,681	26,785	26,888	26,992	27,096
714	27,201	27,305	27,410	27,515	27,621	27,726	27,832	27,938	28,044	28,151
715	28,258	28,365	28,472	28,579	28,687	28,795	28,903	29,011	29,120	29,229
716	29,338	29,447	29,557	29,667	29,777	29,887	29,998	30,109	30,220	30,331
717	30,443	30,555	30,667	30,779	30,892	31,004	31,117	31,231	31,344	31,458
718	31,572	31,687	31,801	31,916	32,031	32,147	32,262	32,378	32,495	32,611
719	32,728	32,845	32,962	33,079	33,197	33,315	33,433	33,551	33,670	33,789
720	33,908	34,028	34,148	34,268	34,388	34,509	34,630	34,751	34,872	34,994
721	35,116	35,238	35,361	35,483	35,606	35,730	35,853	35,977	36,101	36,226
722	36,350	36,475	36,601	36,727	36,853	36,979	37,105	37,232	37,359	37,487
723	37,615	37,743	37,871	38,000	38,129	38,258	38,388	38,518	38,649	38,779
724	38,911	39,042	39,174	39,306	39,438	39,571	39,704	39,838	39,971	40,106
725	40,240	40,375	40,510	40,645	40,781	40,917	41,053	41,190	41,327	41,464
726	41,602	41,740	41,878	42,016	42,155	42,295	42,434	42,574	42,714	42,855
727	42,996	43,137	43,278	43,420	43,563	43,705	43,848	43,991	44,135	44,279
728	44,424	44,568	44,713	44,859	45,005	45,151	45,297	45,444	45,591	45,739
729	45,887	46,035	46,183	46,332	46,482	46,631	46,782	46,932	47,083	47,234
730	47,385	47,537	47,689	47,842	47,995	48,148	48,302	48,456	48,610	48,765
731	48,920	49,075	49,231	49,387	49,544	49,700	49,857	50,015	50,173	50,331
732	50,489	50,648	50,807	50,966	51,126	51,286	51,447	51,608	51,769	51,930
733	52,092	52,255	52,417	52,580	52,744	52,907	53,071	53,236	53,401	53,566
734	53,731	53,897	54,063	54,230	54,397	54,564	54,731	54,899	55,068	55,236
735	55,405	55,574	55,744	55,914	56,084	56,255	56,425	56,597	56,768	56,940
736	57,112	57,284	57,457	57,630	57,804	57,977	58,151	58,325	58,500	58,675
737	58,850	59,026	59,201	59,378	59,554	59,731	59,908	60,085	60,263	60,441
738	60,619	60,798	60,977	61,156	61,336	61,516	61,696	61,877	62,058	62,239
739	62,421	62,603	62,785	62,968	63,151	63,334	63,518	63,702	63,886	64,071
740	64,256	64,441	64,626	64,812	64,999	65,185	65,372	65,559	65,747	65,935
741	66,123	66,312	66,501	66,690	66,880	67,069	67,260	67,450	67,641	67,833
742	68,024	68,216	68,409	68,601	68,794	68,988	69,181	69,376	69,570	69,765
743	69,960	70,155	70,351	70,547	70,744	70,941	71,138	71,335	71,533	71,731
744	71,929	72,128	72,327	72,527	72,727	72,927	73,127	73,328	73,529	73,731
745	73,932	74,135	74,337	74,540	74,743	74,946	75,150	75,354	75,558	75,763
746	75,968	76,174	76,380	76,586	76,792	76,999	77,206	77,413	77,621	77,829
747	78,038	78,246	78,456	78,665	78,875	79,086	79,296	79,507	79,718	79,930
748	80,142	80,354	80,567	80,780	80,994	81,207	81,421	81,636	81,850	82,066
749	82,281	82,497	82,713	82,929	83,146	83,363	83,581	83,799	84,017	84,235
750	84,454	84,673	84,893	85,113	85,334	85,554	85,775	85,997	86,219	86,441
751	86,663	86,886	87,110	87,333	87,557	87,782	88,007	88,232	88,457	88,683
752	88,909	89,136	89,363	89,590	89,818	90,046	90,274	90,503	90,732	90,962
753	91,191	91,422	91,652	91,883	92,114	92,346	92,577	92,810	93,042	93,275
754	93,508	93,741	93,975	94,209	94,444	94,679	94,914	95,149	95,385	95,621
755	95,858	96,095	96,332	96,569	96,807	97,045	97,284	97,523	97,762	98,002

Appendix B (continued)

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Main Reservoir Body

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
756	98,242	98,482	98,723	98,964	99,206	99,448	99,690	99,933	100,176	100,420
757	100,663	100,907	101,152	101,397	101,642	101,888	102,133	102,380	102,626	102,873
758	103,121	103,368	103,616	103,865	104,113	104,362	104,612	104,862	105,112	105,362
759	105,613	105,865	106,116	106,368	106,621	106,874	107,127	107,381	107,635	107,890
760	108,145	108,400	108,656	108,912	109,168	109,425	109,682	109,940	110,198	110,456
761	110,715	110,974	111,233	111,493	111,753	112,014	112,275	112,536	112,798	113,060
762	113,323	113,586	113,849	114,113	114,377	114,642	114,907	115,172	115,438	115,704
763	115,970	116,237	116,504	116,772	117,040	117,308	117,577	117,846	118,116	118,386
764	118,656	118,926	119,198	119,469	119,741	120,013	120,285	120,558	120,832	121,105
765	121,379	121,654	121,929	122,204	122,479	122,755	123,032	123,308	123,585	123,863
766	124,140	124,418	124,697	124,976	125,255	125,534	125,814	126,095	126,375	126,656
767	126,938	127,219	127,501	127,784	128,067	128,350	128,634	128,918	129,202	129,487
768	129,772	130,058	130,344	130,630	130,917	131,204	131,491	131,779	132,067	132,355
769	132,644	132,933	133,223	133,513	133,803	134,093	134,384	134,675	134,967	135,259
770	135,551	135,844	136,137	136,430	136,724	137,018	137,312	137,607	137,902	138,197
771	138,493	138,789	139,085	139,382	139,679	139,977	140,274	140,573	140,871	141,170
772	141,469	141,769	142,069	142,370	142,671	142,972	143,273	143,575	143,877	144,180
773	144,483	144,787	145,091	145,395	145,699	146,004	146,310	146,616	146,922	147,229
774	147,536	147,843	148,152	148,460	148,769	149,078	149,388	149,698	150,009	150,320
775	150,632									

Appendix C

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Safe Shutdown Impoundment

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
740	0	0	0	0	0	0	0	0	0	0
741	0	0	0	0	0	0	0	0	0	0
742	0	0	0	0	0	0	0	0	0	0
743	0	0	0	0	0	0	0	0	0	0
744	0	1	1	1	1	1	1	1	1	1
745	1	2	2	2	2	2	3	3	3	3
746	3	4	4	4	4	5	5	5	6	6
747	6	7	7	8	8	8	9	9	10	10
748	11	11	12	12	12	13	14	14	15	15
749	16	16	17	17	18	19	19	20	21	21
750	22	23	23	24	25	25	26	27	28	28
751	29	30	31	31	32	33	34	35	36	36
752	37	38	39	40	41	42	43	44	45	46
753	47	48	49	50	51	52	53	54	55	57
754	58	59	60	62	63	64	65	67	68	70
755	71	72	74	75	77	78	80	81	83	85
756	86	88	89	91	93	94	96	98	100	101
757	103	105	107	108	110	112	114	116	118	119
758	121	123	125	127	129	131	133	135	137	139
759	141	143	145	147	149	151	153	155	157	159
760	162	164	166	168	170	172	175	177	179	181
761	183	186	188	190	192	195	197	199	202	204
762	206	209	211	214	216	218	221	223	226	228
763	231	233	236	238	241	243	246	249	251	254
764	256	259	262	264	267	270	272	275	278	280
765	283	286	289	291	294	297	300	303	306	308
766	311	314	317	320	323	326	329	332	335	338
767	341	344	347	350	353	356	359	363	366	369
768	372	375	378	382	385	388	391	395	398	402
769	405	408	412	415	419	422	426	429	433	436
770	440	443	447	451	454	458	462	465	469	473
771	477	480	484	488	492	496	499	503	507	511
772	515	519	523	527	531	535	539	543	547	551
773	555	559	563	567	572	576	580	584	588	593
774	597	601	606	610	614	619	623	627	632	636
775	641									

Appendix D

Squaw Creek Reservoir

RESERVOIR AREA TABLE - Total Reservoir

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

AREA IN ACRES — Conservation Pool Elevation 775.0 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
648	0	0	0	0	0	0	0	0	0	0
649	0	0	0	0	0	0	0	0	0	0
650	0	0	0	1	1	1	1	1	2	2
651	2	3	3	4	5	6	7	8	9	10
652	11	12	13	14	15	16	17	18	19	20
653	20	21	21	22	23	23	24	24	25	26
654	26	27	27	28	28	29	29	30	31	32
655	32	33	33	33	34	34	35	35	36	36
656	36	37	37	38	38	38	39	39	40	40
657	40	41	41	42	42	43	43	43	44	44
658	45	45	46	46	47	48	48	49	50	50
659	51	52	52	53	54	55	55	56	58	59
660	60	61	62	63	64	65	66	66	67	68
661	69	70	71	72	73	74	75	76	77	79
662	80	81	82	83	85	86	88	89	91	92
663	94	95	97	99	101	103	104	106	107	109
664	110	112	113	114	116	117	119	120	122	123
665	125	127	128	130	132	134	136	137	139	141
666	142	144	146	148	149	151	152	154	156	157
667	159	161	162	164	166	167	169	171	172	174
668	175	177	179	181	182	184	186	188	189	191
669	192	194	195	197	198	199	201	203	204	206
670	208	209	211	213	215	217	219	221	222	224
671	226	229	230	232	234	236	238	240	241	243
672	245	247	250	252	254	256	259	261	263	265
673	268	270	272	274	276	278	279	281	283	285
674	286	288	289	291	292	294	295	296	298	299
675	300	302	303	304	306	307	309	310	311	313
676	314	315	317	318	320	321	322	324	325	326
677	328	329	331	332	333	335	336	338	339	341
678	342	344	345	347	349	350	352	353	355	356
679	358	359	360	362	363	365	366	368	369	371
680	372	373	375	376	377	379	380	382	383	385
681	386	388	389	391	392	393	394	396	397	398
682	399	401	402	403	404	406	407	408	409	410
683	412	413	414	416	417	418	420	421	422	424
684	425	426	427	429	430	431	433	434	435	436
685	438	439	440	442	443	444	445	447	448	449
686	450	452	453	454	455	457	458	460	461	463
687	464	466	467	469	471	473	475	477	479	481
688	483	485	487	489	491	493	495	497	499	501
689	503	504	506	508	509	511	512	514	515	517
690	518	519	521	522	523	525	526	528	529	530
691	532	533	534	536	537	539	540	542	544	546
692	547	549	551	552	554	556	558	560	562	564
693	566	567	569	571	573	575	578	580	582	584
694	586	588	589	591	593	595	597	599	600	602
695	604	606	608	609	611	613	615	617	619	621
696	622	624	626	628	630	632	634	635	637	639
697	641	643	645	646	648	650	652	654	656	658
698	660	662	664	666	668	670	673	675	677	680
699	682	684	686	688	690	692	694	696	698	700
700	702	704	706	708	710	712	715	717	719	721
701	724	726	728	731	733	735	738	740	743	745

Appendix D (continued)

Squaw Creek Reservoir

RESERVOIR AREA TABLE - Total Reservoir

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

AREA IN ACRES — Conservation Pool Elevation 775.0 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
702	748	751	754	756	759	762	765	767	770	772
703	775	777	780	782	784	787	789	791	794	796
704	799	801	804	806	809	811	814	817	819	822
705	825	828	830	833	836	838	841	843	846	848
706	851	854	856	858	861	863	866	868	870	873
707	875	877	880	882	885	887	890	892	895	897
708	900	902	905	907	910	912	915	918	920	922
709	925	927	929	931	933	935	937	940	942	944
710	946	948	950	952	954	956	959	961	963	965
711	968	970	972	974	977	979	982	984	986	989
712	991	994	997	999	1,002	1,004	1,007	1,009	1,012	1,015
713	1,018	1,020	1,023	1,026	1,029	1,032	1,035	1,037	1,040	1,042
714	1,045	1,047	1,050	1,052	1,055	1,057	1,059	1,062	1,064	1,066
715	1,069	1,071	1,073	1,076	1,078	1,080	1,083	1,085	1,088	1,090
716	1,092	1,095	1,097	1,100	1,103	1,105	1,107	1,110	1,112	1,114
717	1,117	1,119	1,122	1,124	1,127	1,129	1,132	1,135	1,137	1,140
718	1,142	1,145	1,148	1,150	1,153	1,155	1,158	1,160	1,163	1,165
719	1,168	1,170	1,173	1,176	1,178	1,181	1,183	1,186	1,189	1,191
720	1,194	1,197	1,199	1,202	1,205	1,208	1,210	1,213	1,216	1,218
721	1,221	1,224	1,226	1,229	1,232	1,234	1,237	1,240	1,243	1,246
722	1,249	1,252	1,255	1,258	1,261	1,264	1,267	1,270	1,273	1,276
723	1,280	1,283	1,286	1,289	1,292	1,296	1,299	1,302	1,306	1,309
724	1,312	1,316	1,319	1,323	1,326	1,330	1,333	1,336	1,339	1,342
725	1,345	1,349	1,352	1,355	1,358	1,362	1,365	1,369	1,372	1,375
726	1,378	1,381	1,384	1,387	1,390	1,394	1,397	1,400	1,404	1,407
727	1,411	1,414	1,417	1,421	1,424	1,428	1,431	1,435	1,438	1,442
728	1,446	1,449	1,452	1,456	1,459	1,463	1,466	1,470	1,474	1,477
729	1,481	1,484	1,488	1,492	1,495	1,499	1,502	1,506	1,510	1,513
730	1,517	1,521	1,524	1,528	1,531	1,535	1,538	1,542	1,545	1,549
731	1,552	1,555	1,559	1,562	1,566	1,569	1,572	1,576	1,579	1,583
732	1,586	1,590	1,593	1,596	1,600	1,603	1,606	1,610	1,614	1,617
733	1,621	1,624	1,628	1,632	1,636	1,639	1,643	1,646	1,650	1,653
734	1,656	1,660	1,663	1,667	1,670	1,674	1,677	1,681	1,684	1,688
735	1,691	1,694	1,697	1,701	1,704	1,707	1,710	1,713	1,717	1,720
736	1,723	1,726	1,729	1,732	1,735	1,738	1,741	1,744	1,747	1,750
737	1,754	1,757	1,760	1,763	1,766	1,769	1,772	1,775	1,779	1,782
738	1,785	1,788	1,792	1,795	1,799	1,802	1,805	1,808	1,812	1,815
739	1,818	1,821	1,825	1,828	1,831	1,834	1,838	1,841	1,844	1,847
740	1,851	1,854	1,858	1,861	1,864	1,868	1,871	1,874	1,878	1,881
741	1,884	1,888	1,891	1,894	1,898	1,901	1,905	1,908	1,911	1,915
742	1,918	1,922	1,925	1,929	1,933	1,936	1,940	1,943	1,946	1,950
743	1,953	1,956	1,960	1,963	1,966	1,970	1,973	1,976	1,980	1,983
744	1,987	1,990	1,993	1,997	2,001	2,004	2,008	2,011	2,014	2,018
745	2,021	2,024	2,028	2,031	2,034	2,038	2,041	2,044	2,048	2,051
746	2,055	2,058	2,062	2,065	2,069	2,072	2,076	2,079	2,083	2,087
747	2,090	2,094	2,098	2,101	2,105	2,109	2,112	2,116	2,119	2,123
748	2,126	2,130	2,133	2,137	2,140	2,144	2,147	2,151	2,155	2,158
749	2,162	2,165	2,169	2,172	2,176	2,179	2,183	2,187	2,190	2,194
750	2,198	2,201	2,205	2,208	2,212	2,216	2,220	2,224	2,228	2,232
751	2,235	2,239	2,243	2,247	2,250	2,254	2,258	2,262	2,265	2,269
752	2,273	2,277	2,281	2,284	2,288	2,292	2,295	2,299	2,303	2,306
753	2,310	2,313	2,317	2,321	2,324	2,328	2,331	2,335	2,338	2,342
754	2,345	2,349	2,352	2,356	2,360	2,363	2,367	2,370	2,374	2,377
755	2,381	2,384	2,388	2,392	2,395	2,399	2,403	2,407	2,411	2,415

Appendix D (continued)

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Total Reservoir

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
756	2,419	2,423	2,427	2,430	2,434	2,438	2,442	2,446	2,450	2,453
757	2,457	2,461	2,465	2,468	2,472	2,476	2,479	2,483	2,486	2,490
758	2,494	2,497	2,501	2,505	2,508	2,512	2,516	2,520	2,524	2,528
759	2,531	2,535	2,540	2,544	2,548	2,552	2,556	2,560	2,565	2,569
760	2,572	2,576	2,580	2,584	2,588	2,592	2,596	2,599	2,603	2,607
761	2,611	2,615	2,619	2,623	2,627	2,631	2,635	2,639	2,644	2,648
762	2,652	2,656	2,660	2,664	2,668	2,672	2,676	2,680	2,684	2,688
763	2,692	2,695	2,699	2,703	2,707	2,711	2,715	2,719	2,723	2,727
764	2,731	2,735	2,738	2,742	2,746	2,750	2,754	2,758	2,762	2,766
765	2,770	2,774	2,778	2,782	2,785	2,789	2,793	2,797	2,801	2,804
766	2,808	2,812	2,816	2,819	2,823	2,827	2,831	2,834	2,838	2,842
767	2,846	2,850	2,854	2,858	2,862	2,866	2,870	2,874	2,878	2,882
768	2,885	2,889	2,893	2,897	2,901	2,905	2,909	2,913	2,916	2,920
769	2,924	2,927	2,931	2,935	2,938	2,942	2,946	2,949	2,953	2,957
770	2,960	2,964	2,967	2,971	2,975	2,978	2,982	2,985	2,989	2,993
771	2,996	3,000	3,004	3,007	3,011	3,015	3,019	3,023	3,027	3,031
772	3,034	3,038	3,042	3,046	3,050	3,054	3,058	3,062	3,066	3,070
773	3,074	3,078	3,082	3,086	3,090	3,094	3,099	3,103	3,107	3,112
774	3,116	3,121	3,125	3,130	3,135	3,140	3,144	3,149	3,155	3,160
775	3,169									

Appendix E

Squaw Creek Reservoir

RESERVOIR AREA TABLE - Main Reservoir Body

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

AREA IN ACRES — Conservation Pool Elevation 775.0 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
648	0	0	0	0	0	0	0	0	0	0
649	0	0	0	0	0	0	0	0	0	0
650	0	0	0	1	1	1	1	1	2	2
651	2	3	3	4	5	6	7	8	9	10
652	11	12	13	14	15	16	17	18	19	20
653	20	21	21	22	23	23	24	24	25	26
654	26	27	27	28	28	29	29	30	31	32
655	32	33	33	33	34	34	35	35	36	36
656	36	37	37	38	38	38	39	39	40	40
657	40	41	41	42	42	43	43	43	44	44
658	45	45	46	46	47	48	48	49	50	50
659	51	52	52	53	54	55	55	56	58	59
660	60	61	62	63	64	65	66	66	67	68
661	69	70	71	72	73	74	75	76	77	79
662	80	81	82	83	85	86	88	89	91	92
663	94	95	97	99	101	103	104	106	107	109
664	110	112	113	114	116	117	119	120	122	123
665	125	127	128	130	132	134	136	137	139	141
666	142	144	146	148	149	151	152	154	156	157
667	159	161	162	164	166	167	169	171	172	174
668	175	177	179	181	182	184	186	188	189	191
669	192	194	195	197	198	199	201	203	204	206
670	208	209	211	213	215	217	219	221	222	224
671	226	229	230	232	234	236	238	240	241	243
672	245	247	250	252	254	256	259	261	263	265
673	268	270	272	274	276	278	279	281	283	285
674	286	288	289	291	292	294	295	296	298	299
675	300	302	303	304	306	307	309	310	311	313
676	314	315	317	318	320	321	322	324	325	326
677	328	329	331	332	333	335	336	338	339	341
678	342	344	345	347	349	350	352	353	355	356
679	358	359	360	362	363	365	366	368	369	371
680	372	373	375	376	377	379	380	382	383	385
681	386	388	389	391	392	393	394	396	397	398
682	399	401	402	403	404	406	407	408	409	410
683	412	413	414	416	417	418	420	421	422	424
684	425	426	427	429	430	431	433	434	435	436
685	438	439	440	442	443	444	445	447	448	449
686	450	452	453	454	455	457	458	460	461	463
687	464	466	467	469	471	473	475	477	479	481
688	483	485	487	489	491	493	495	497	499	501
689	503	504	506	508	509	511	512	514	515	517
690	518	519	521	522	523	525	526	528	529	530
691	532	533	534	536	537	539	540	542	544	546
692	547	549	551	552	554	556	558	560	562	564
693	566	567	569	571	573	575	578	580	582	584
694	586	588	589	591	593	595	597	599	600	602
695	604	606	608	609	611	613	615	617	619	621
696	622	624	626	628	630	632	634	635	637	639
697	641	643	645	646	648	650	652	654	656	658
698	660	662	664	666	668	670	673	675	677	680
699	682	684	686	688	690	692	694	696	698	700
700	702	704	706	708	710	712	715	717	719	721
701	724	726	728	731	733	735	738	740	743	745

Appendix E (continued)

Squaw Creek Reservoir

RESERVOIR AREA TABLE - Main Reservoir Body

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

AREA IN ACRES — Conservation Pool Elevation 775.0 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
702	748	751	754	756	759	762	765	767	770	772
703	775	777	780	782	784	787	789	791	794	796
704	799	801	804	806	809	811	814	817	819	822
705	825	828	830	833	836	838	841	843	846	848
706	851	854	856	858	861	863	866	868	870	873
707	875	877	880	882	885	887	890	892	895	897
708	900	902	905	907	910	912	915	918	920	922
709	925	927	929	931	933	935	937	940	942	944
710	946	948	950	952	954	956	959	961	963	965
711	968	970	972	974	977	979	982	984	986	989
712	991	994	997	999	1,002	1,004	1,007	1,009	1,012	1,015
713	1,018	1,020	1,023	1,026	1,029	1,032	1,035	1,037	1,040	1,042
714	1,045	1,047	1,050	1,052	1,055	1,057	1,059	1,062	1,064	1,066
715	1,069	1,071	1,073	1,076	1,078	1,080	1,083	1,085	1,088	1,090
716	1,092	1,095	1,097	1,100	1,103	1,105	1,107	1,110	1,112	1,114
717	1,117	1,119	1,122	1,124	1,127	1,129	1,132	1,135	1,137	1,140
718	1,142	1,145	1,148	1,150	1,153	1,155	1,158	1,160	1,163	1,165
719	1,168	1,170	1,173	1,176	1,178	1,181	1,183	1,186	1,189	1,191
720	1,194	1,197	1,199	1,202	1,205	1,208	1,210	1,213	1,216	1,218
721	1,221	1,224	1,226	1,229	1,232	1,234	1,237	1,240	1,243	1,246
722	1,249	1,252	1,255	1,258	1,261	1,264	1,267	1,270	1,273	1,276
723	1,280	1,283	1,286	1,289	1,292	1,296	1,299	1,302	1,306	1,309
724	1,312	1,316	1,319	1,323	1,326	1,330	1,333	1,336	1,339	1,342
725	1,345	1,349	1,352	1,355	1,358	1,362	1,365	1,369	1,372	1,375
726	1,378	1,381	1,384	1,387	1,390	1,394	1,397	1,400	1,404	1,407
727	1,411	1,414	1,417	1,421	1,424	1,428	1,431	1,435	1,438	1,442
728	1,446	1,449	1,452	1,456	1,459	1,463	1,466	1,470	1,474	1,477
729	1,481	1,484	1,488	1,492	1,495	1,499	1,502	1,506	1,510	1,513
730	1,517	1,521	1,524	1,528	1,531	1,535	1,538	1,542	1,545	1,549
731	1,552	1,555	1,559	1,562	1,566	1,569	1,572	1,576	1,579	1,583
732	1,586	1,590	1,593	1,596	1,600	1,603	1,606	1,610	1,614	1,617
733	1,621	1,624	1,628	1,632	1,636	1,639	1,643	1,646	1,650	1,653
734	1,656	1,660	1,663	1,667	1,670	1,674	1,677	1,681	1,684	1,688
735	1,691	1,694	1,697	1,701	1,704	1,707	1,710	1,713	1,717	1,720
736	1,723	1,726	1,729	1,732	1,735	1,738	1,741	1,744	1,747	1,750
737	1,754	1,757	1,760	1,763	1,766	1,769	1,772	1,775	1,779	1,782
738	1,785	1,788	1,792	1,795	1,799	1,802	1,805	1,808	1,812	1,815
739	1,818	1,821	1,825	1,828	1,831	1,834	1,838	1,841	1,844	1,847
740	1,851	1,854	1,858	1,861	1,864	1,868	1,871	1,874	1,878	1,881
741	1,884	1,888	1,891	1,894	1,898	1,901	1,905	1,908	1,911	1,915
742	1,918	1,922	1,925	1,929	1,932	1,936	1,939	1,943	1,946	1,950
743	1,953	1,956	1,960	1,963	1,966	1,969	1,973	1,976	1,979	1,983
744	1,986	1,989	1,993	1,996	2,000	2,003	2,007	2,010	2,013	2,016
745	2,020	2,023	2,026	2,029	2,033	2,036	2,039	2,042	2,046	2,049
746	2,052	2,056	2,059	2,063	2,066	2,069	2,073	2,076	2,080	2,083
747	2,087	2,090	2,094	2,098	2,101	2,105	2,108	2,111	2,115	2,118
748	2,122	2,125	2,129	2,132	2,135	2,139	2,142	2,146	2,149	2,152
749	2,156	2,159	2,163	2,166	2,170	2,173	2,177	2,180	2,184	2,187
750	2,191	2,194	2,198	2,201	2,205	2,209	2,213	2,217	2,220	2,224
751	2,228	2,231	2,235	2,239	2,242	2,246	2,250	2,253	2,257	2,260
752	2,264	2,268	2,272	2,275	2,279	2,282	2,286	2,289	2,293	2,296
753	2,300	2,303	2,307	2,310	2,313	2,317	2,320	2,323	2,327	2,330
754	2,333	2,336	2,340	2,343	2,346	2,350	2,353	2,356	2,360	2,363
755	2,366	2,370	2,373	2,377	2,380	2,384	2,388	2,391	2,395	2,399

Appendix E (continued)

Squaw Creek Reservoir

RESERVOIR CAPACITY TABLE - Main Reservoir Body

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 775.0 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
756	2,403	2,406	2,410	2,414	2,418	2,421	2,425	2,429	2,432	2,436
757	2,440	2,443	2,447	2,450	2,454	2,457	2,461	2,464	2,468	2,471
758	2,475	2,478	2,482	2,485	2,489	2,493	2,496	2,500	2,504	2,508
759	2,511	2,515	2,519	2,523	2,527	2,531	2,536	2,540	2,543	2,547
760	2,551	2,555	2,559	2,562	2,566	2,570	2,574	2,577	2,581	2,585
761	2,589	2,592	2,596	2,600	2,604	2,608	2,612	2,616	2,620	2,624
762	2,628	2,632	2,636	2,640	2,644	2,648	2,651	2,655	2,659	2,663
763	2,667	2,670	2,674	2,678	2,682	2,686	2,689	2,693	2,697	2,701
764	2,705	2,708	2,712	2,716	2,720	2,723	2,727	2,731	2,735	2,739
765	2,742	2,746	2,750	2,754	2,757	2,761	2,765	2,768	2,772	2,776
766	2,779	2,783	2,786	2,790	2,794	2,797	2,801	2,804	2,808	2,812
767	2,815	2,819	2,823	2,827	2,831	2,835	2,839	2,842	2,846	2,850
768	2,854	2,857	2,861	2,865	2,868	2,872	2,876	2,879	2,883	2,886
769	2,890	2,893	2,897	2,900	2,904	2,907	2,911	2,914	2,917	2,921
770	2,924	2,928	2,931	2,935	2,938	2,941	2,945	2,948	2,952	2,955
771	2,959	2,962	2,966	2,969	2,973	2,977	2,980	2,984	2,988	2,991
772	2,995	2,999	3,003	3,006	3,010	3,014	3,017	3,021	3,025	3,029
773	3,033	3,037	3,041	3,045	3,049	3,053	3,057	3,061	3,065	3,069
774	3,074	3,078	3,082	3,087	3,091	3,096	3,100	3,105	3,110	3,116
775	3,124									

Appendix F

Squaw Creek Reservoir

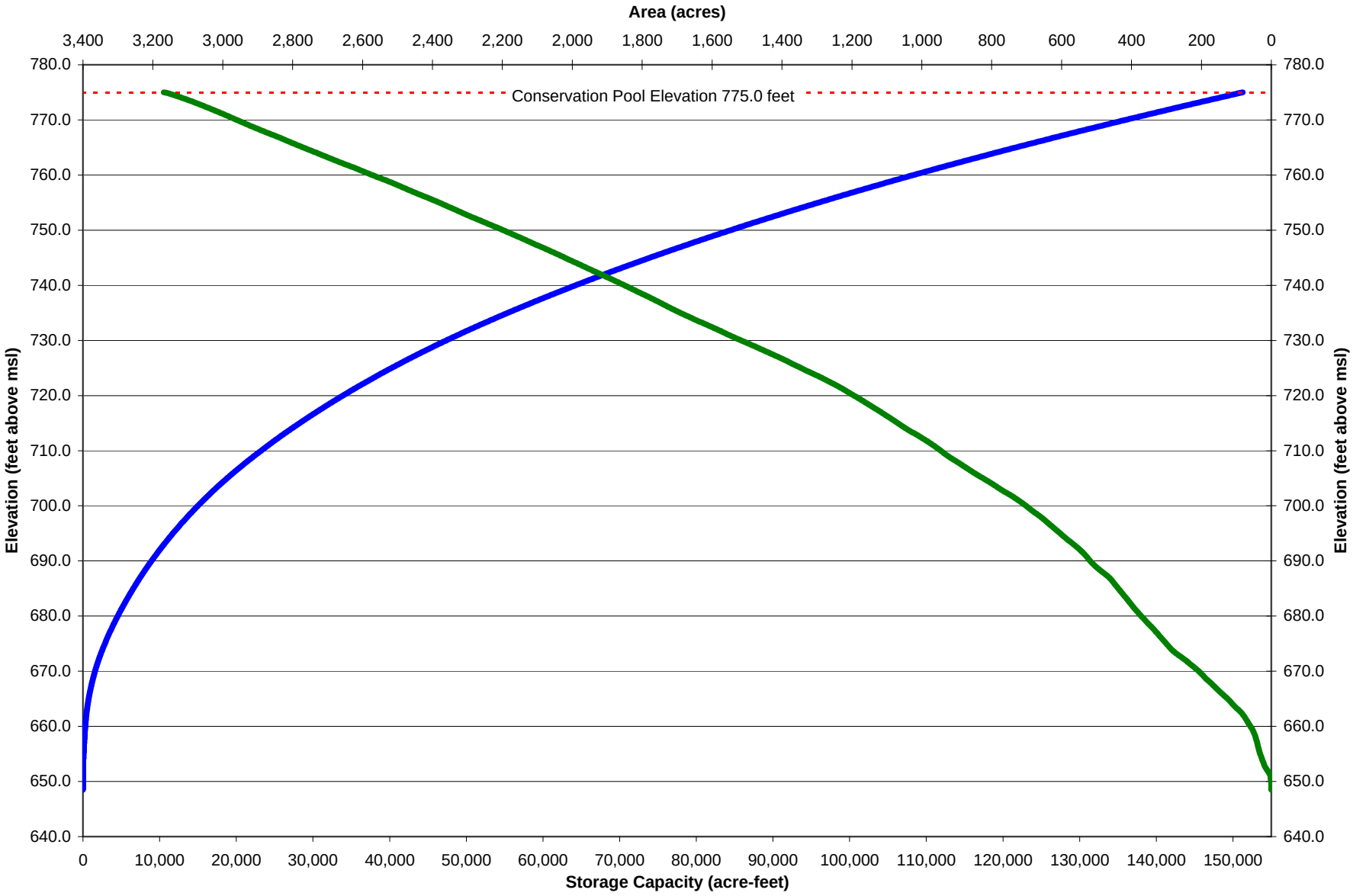
RESERVOIR AREA TABLE - Safe Shutdown Impoundment

TEXAS WATER DEVELOPMENT BOARD — December 2007 SURVEY

AREA IN ACRES — Conservation Pool Elevation 775.0 Feet NGVD29

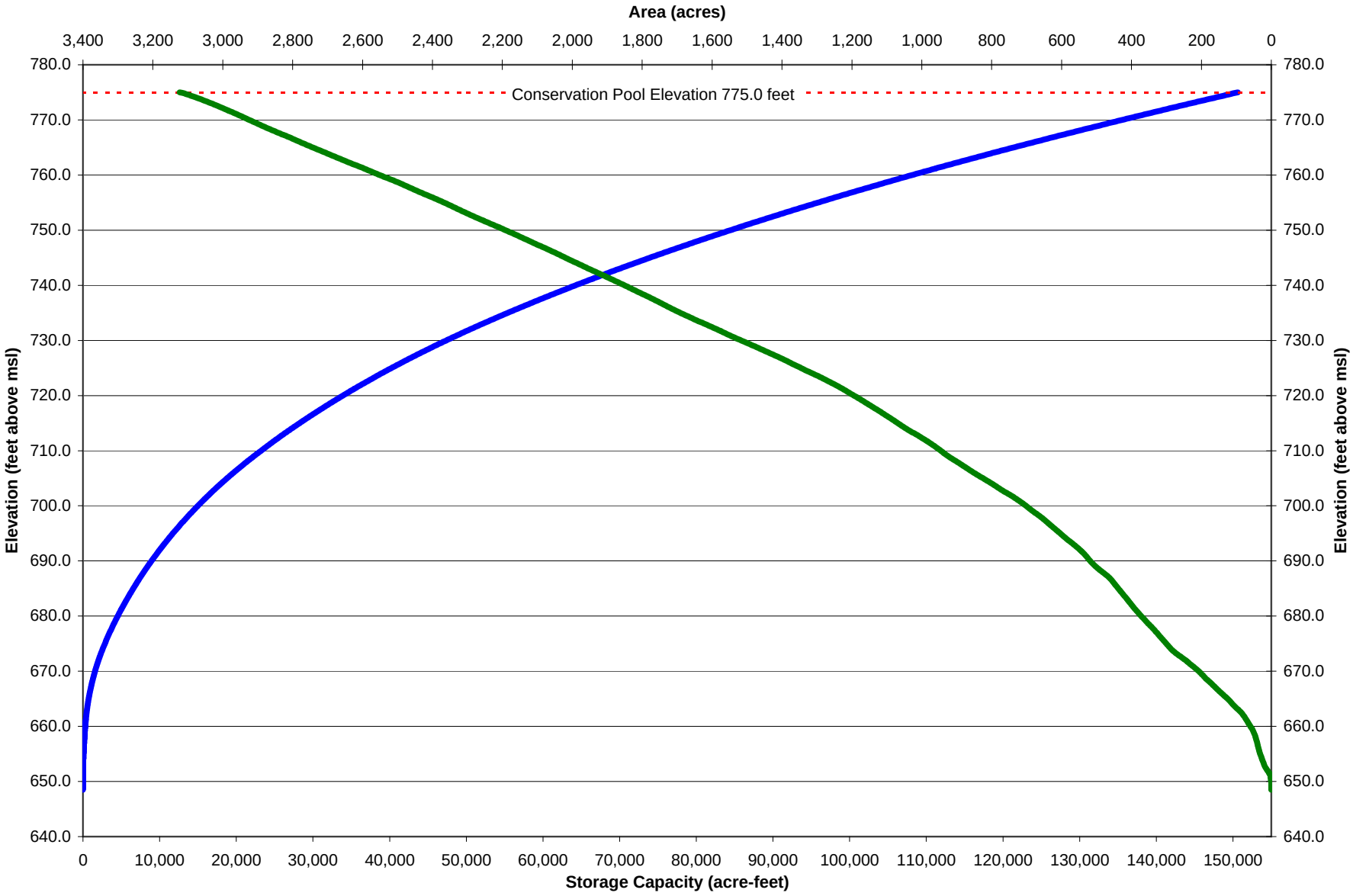
ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
740	0	0	0	0	0	0	0	0	0	0
741	0	0	0	0	0	0	0	0	0	0
742	0	0	0	0	0	0	0	0	0	0
743	0	0	0	0	0	0	0	0	0	1
744	1	1	1	1	1	1	1	1	1	1
745	1	2	2	2	2	2	2	2	2	2
746	2	3	3	3	3	3	3	3	3	3
747	4	4	4	4	4	4	4	4	4	5
748	5	5	5	5	5	5	5	5	6	6
749	6	6	6	6	6	6	6	6	6	7
750	7	7	7	7	7	7	7	7	7	8
751	8	8	8	8	8	8	8	8	9	9
752	9	9	9	9	9	9	10	10	10	10
753	10	10	10	11	11	11	11	11	12	12
754	12	12	13	13	13	13	14	14	14	14
755	14	14	15	15	15	15	15	16	16	16
756	16	16	16	17	17	17	17	17	17	17
757	18	18	18	18	18	18	18	19	19	19
758	19	19	19	19	19	20	20	20	20	20
759	20	20	20	21	21	21	21	21	21	21
760	21	21	22	22	22	22	22	22	22	22
761	22	22	23	23	23	23	23	23	23	24
762	24	24	24	24	24	24	25	25	25	25
763	25	25	25	25	25	25	26	26	26	26
764	26	26	26	27	27	27	27	27	27	27
765	28	28	28	28	28	28	28	28	29	29
766	29	29	29	29	29	30	30	30	30	30
767	30	30	31	31	31	31	31	31	32	32
768	32	32	32	33	33	33	33	33	34	34
769	34	34	34	35	35	35	35	35	36	36
770	36	36	36	36	37	37	37	37	37	37
771	38	38	38	38	38	38	39	39	39	39
772	39	39	40	40	40	40	40	40	41	41
773	41	41	41	42	42	42	42	42	42	43
774	43	43	43	43	44	44	44	44	44	45
775	45									



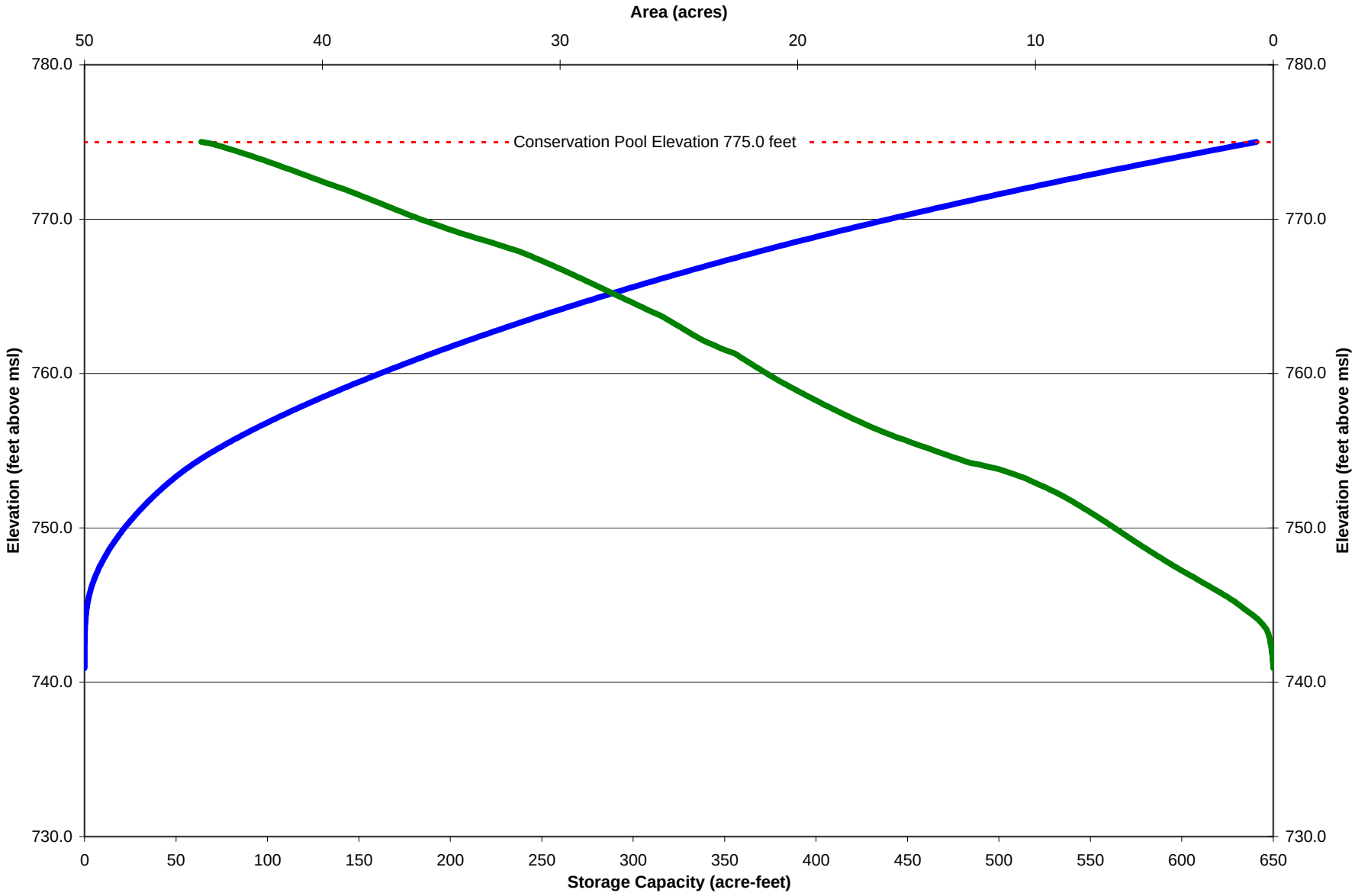
Squaw Creek Reservoir
December 2007 Survey
Prepared by: TWDB

Appendix G: Area and Capacity Curves



Squaw Creek Reservoir
December 2007 Survey
Prepared by: TWDB

Appendix H: Area and Capacity Curves



Squaw Creek Reservoir
December 2007 Survey
Prepared by: TWDB

Appendix I: Area and Capacity Curves

Appendix J

Comparison of the Current and Previous Squaw Creek Reservoir Surveys

Introduction

Based on information provided by Luminant[1], the capacity of Squaw Creek Reservoir was previously estimated as the result of surveys conducted in 1972[2], 1987[3], and 1997[4] (Table J1). Comparing these previous estimates to that derived from the 2007 TWDB survey might provide further insight into sediment accumulation rates for Squaw Creek Reservoir; however, comparisons should only be made between surveys conducted using similar techniques (including data processing techniques). In order to assess the validity of such comparisons, TWDB performed a detailed analysis of the methods used during each of the previous surveys. The results of the analyses are presented in Table J1. The processes used to simulate or replicate the 1972[2] and 1987[3] methodologies and revise the 1997[4] survey are discussed below.

Table J1 – Published and Revised Squaw Creek Reservoir Capacity Estimates

Year	Agency	Method	Capacity (Acre-Feet)	
			Published	Revised**
1972	Freese & Nichols, Inc.[2]	Planimetering USGS Maps	151,047	153,573
1972	TWDB	2007 Survey Analysis	N/A	155,008
1987	Jones & Boyd, Inc.[3]	Range-Contour Method	150,569	N/A
2007	TWDB***	Range-Contour Method	N/A	155,605
1997	TWDB[4]	Survey at 500-foot intervals	151,418	150,643
2007	TWDB	Survey at 500-foot intervals	151,273	N/A

** Revision methodology is explained below

*** TWBD assessed the Jones & Boyd, Inc.[3] capacity estimate by applying the range-contour method to the 2007 survey dataset.

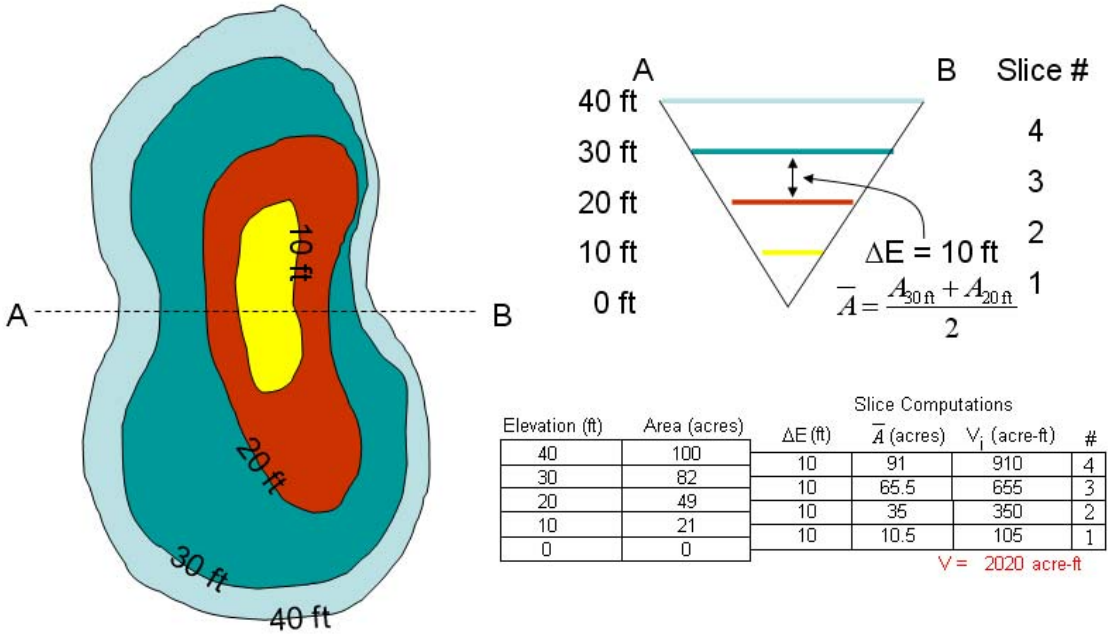
Evaluating the Original Freese & Nichols, Inc. Capacity (1972)

As reported by Luminant[1], the original capacity of Squaw Creek Reservoir was computed by Freese & Nichols, Inc.[2] in 1972. Freese & Nichols, Inc. used a planimeter to determine lake areas at contour elevations discernible from USGS quadrangle maps.[1] The quadrangle maps available in 1972 presented topographic contours at 10-foot intervals, with the pertinent contours for Squaw Creek Reservoir ranging from elevation 780-feet to elevation 650-feet. The lowest possible accuracy of each contour is ± 5.0 feet (one-half of the contour interval). TWDB did not review the Freese and Nichols, Inc. report[2], and assumes that the reservoir capacity was computed from the planimetered contours using the average-area method[3]. This technique for reservoir volume computation was the generally accepted technique at the time which the analysis was performed. The average-area method involves computing volumes of the reservoir in "slices," where each slice is bounded by an upper and lower polygon representing the reservoir extent at the specified elevation (Figure J1). A volume is computed for each slice by averaging the areas of the upper and lower bounding polygons of each slice then multiplying the average-area by the elevation difference between the bounding polygons. The reservoir capacity is then computed by summing the slice volumes as in Equation J1:

$$V = \sum_{i=1}^{n} V_i = \sum_{i=1}^{n} (\Delta E)(\overline{A}) = \sum_{i=1}^{n} (E_{i+1} - E_i)\left(\frac{A_{i+1} + A_i}{2}\right) \qquad \text{Eq. J1}$$

$n =$ Number of slices

Where V is the capacity of the reservoir, E is the elevation of a given polygon, and A is the area of the polygon.



Elevation (ft)	Area (acres)
40	100
30	82
20	49
10	21
0	0

Slice Computations

ΔE (ft)	$\overline{A}$ (acres)	V_i (acre-ft)	#
10	91	910	4
10	65.5	655	3
10	35	350	2
10	10.5	105	1

V = 2020 acre-ft

Figure J1 – The Average-Area method for computing reservoir volume

The average-area technique requires the assumption that the reservoir area changes linearly with elevation between successive contours. This assumption is a necessary engineering approximation which is likely to be less-valid if the land surface has a complex, irregular topography (as is common in most reservoir sites). The validity of this assumption directly affects the validity of the resulting volumetric calculations.

To assess the validity of the capacity estimate derived in 1972 by Freese & Nichols, Inc., TWDB created a "Pre-Impoundment" TIN model within ArcGIS of Squaw Creek Reservoir using digital contours[5] derived from USGS quadrangle maps at 10-foot intervals from elevation 650 feet to 780 feet. As such, TWDB used the same contour dataset as Freese & Nichols, Inc. However, TWDB also employed the line-extrapolation technique[6] to estimate the elevations between contours where the Pre-Impoundment TIN model would otherwise suggest the terrain remained perfectly flat.[6] The location of the dam and of the Safe Shutdown Impoundment (both of which were not incorporated into available contour data) were approximated by TWDB. The TIN model boundary at elevation 775.0 feet was determined by using the ArcGIS 3D Analyst contouring function. The resulting Pre-Impoundment TIN model (Figure J2) contains a well-defined river channel with possibly poorly-defined floodplains in areas where the distance between successive

contours is relatively large and the contour shapes irregular. Inaccuracies in the TIN model are evident near the dam and near the embankments around the Safe-Shutdown pool.

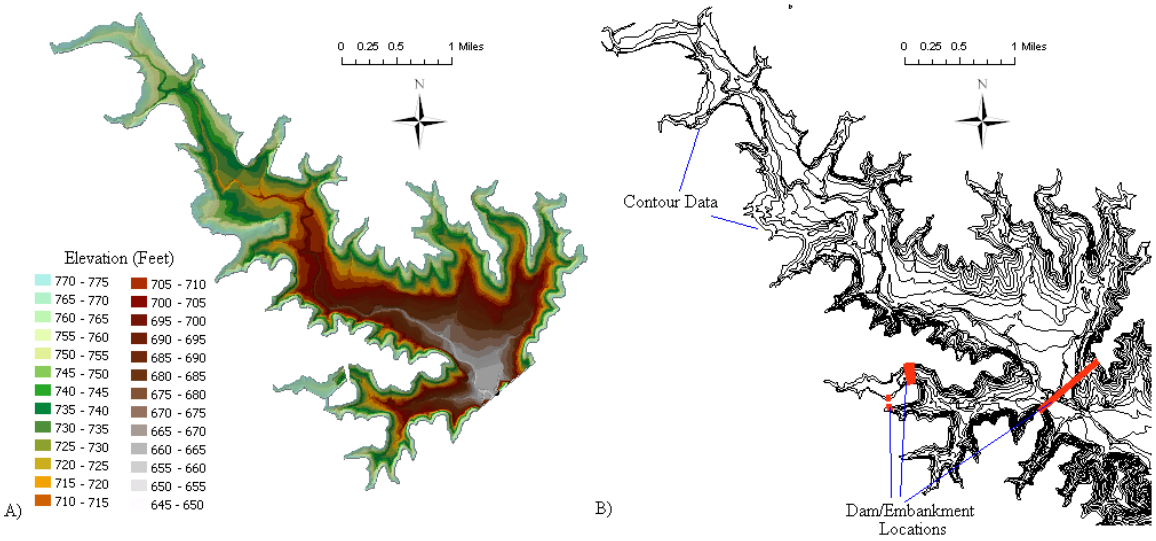


Figure J2 – A) Pre-Impoundment TIN model for Squaw Creek Reservoir derived from B) USGS contour data.

To estimate the capacity of Squaw Creek Reservoir from the Pre-Impoundment TIN model, TWDB performed two analyses:

1. Apply the average-area method to USGS & ArcGIS contours
2. Compute TIN Volume using ArcGIS

For analysis #1 listed above, TWDB ran a customized ArcInfo AML script which analyzes the Pre-Impoundment TIN model and determines the water surface areas at user-specified elevations. For this analysis, TWDB determined 1) the areas at each of the elevations of the USGS contour data from which the Pre-Impoundment TIN was derived (Elevations 650 feet to 770 feet at 10-foot intervals), and 2) the area at conservation pool elevation (775 feet), TWDB then linearly interpolated the reservoir areas at all other elevations (from 651 feet to 774 feet), and applied Equation X1 to determine reservoir capacity. Using this method, TWDB determined the pre-impoundment capacity of Squaw Creek Reservoir to be 153,573 acre-feet.

To apply Analysis #2 (listed above), TWDB used the “Area and Volume…” tool in the 3D Analyst extension of ArcGIS in order to compute the volume of the “Pre-Impoundment” TIN model of Squaw Creek Reservoir. This method applies geometric

relationships to compute the volume of water above each triangle within the TIN model up to the elevation of the TIN model boundary (conservation pool elevation). Using this method, TWDB determined the pre-impoundment capacity of Squaw Creek Reservoir to be 151,901 acre-feet, or 1,672 acre-feet (1.1%) less than the volume computed with the average-area method. This difference in computed elevations is likely due to the inappropriateness of the linearly-varying elevation-area relationship assumed in the average-area method. It is likely that the steep slopes within Squaw Creek Reservoir make the linear-area change assumption inappropriate, leading to a higher computed reservoir capacity.

It is interesting to note that the capacity computed with the average-area method is 2,526 acre-feet (1.7%) greater than that computed by Freese & Nichols, Inc.[2] in 1972. The volume differences may be due to differences in where TWDB and Freese & Nichols, Inc. located the reservoir dam and safe-shutdown pool embankments, or may be due to inaccuracies in the planimeter measurements. TWDB's use of the line extrapolation technique in generating the Pre-Impoundment TIN model would not contribute to capacity differences computed through use of the average-area method. This is because the average-area method is only applied to areas calculated at the USGS contour elevations, and the line extrapolation technique only improves the bathymetry in elevations between the USGS contours. Use of the line extrapolation technique will affect the area of the 775-foot elevation contour, which is used in computing capacity estimates with the average-area method. In this instance, however, use of the line extrapolation technique caused only minor adjustments to the computed 775-foot contour when compared to the contour derived without usage of the technique; the resulting capacity difference was far smaller than the difference between the TWDB and Freese & Nichols Inc. capacity estimates.

In comparing the capacity computed from the Pre-Impoundment TIN model to that calculated by Freese & Nichols, Inc, the volumetric differences amount to 854 acre-feet (0.6%). The volume differences here are likely due to TWDB's use of the line extrapolation technique in order to approximate the depths of the river channels in between contour data. It is likely that Freese & Nichols, Inc. did not attempt to approximate the depths in-between such contours, thereby resulting in a decreased capacity estimate. This assertion was not verified as TWDB did not review the original Freese & Nichols, Inc. report[2].

Overall, the relative agreement between volumes computed by TWDB and Freese & Nichols, Inc. suggests that each capacity estimate is valid given methods available and the accuracy limitations of the contour data. Further assessments of the validity of capacity estimates derived from contour data would require performing a sensitivity analysis of volumes derived from TIN models computed upon consideration of the stated accuracy of the contour data.

Estimating the Pre-Impoundment Capacity from 2007 Survey Results

An additional estimate of the Squaw Creek Reservoir pre-impoundment capacity can be derived directly from the results of the 2007 TWDB volumetric and sedimentation survey. Specifically, the pre-impoundment capacity equals the current computed capacity plus the computed accumulated sediment volume (Equation J2):

$$V_{PRE-IMPOUNDMENT} = V_{2007,WATER} + V_{2007,SEDIMENT} \qquad \text{Eq. J2}$$

Results of the 2007 volumetric and sedimentation survey indicate that Squaw Creek Reservoir has a capacity of 151,273 acre-feet and contains 3,735 acre-feet of accumulated sediment. Using Equation X2, the pre-impoundment capacity of Squaw Creek Reservoir is 155,008 acre-feet. This calculated pre-impoundment capacity is 3,107 acre-feet (2.1%) greater than the pre-impoundment capacity estimate derived from analysis #2, discussed above. The difference in pre-impoundment estimates may be attributed to inaccuracies in the USGS contour data from which capacity estimates were derived. Differences are also likely attributable to the non-linearity of the bathymetry of Squaw Creek Reservoir as measured between elevations corresponding to those of the USGS contour data. For example, TIN models derived from contour data (Figure J3A) will consist of triangular surfaces connecting points along adjacent contours. Elevations for points located between contours will therefore be linear-interpolations from the contour elevation values. Alternatively, TIN models derived from survey data will contain triangular surfaces between the surveyed datapoints (Figure J3B), and will therefore better match the shape of the surveyed terrain. If the surveyed terrain is non-linear, as in Squaw Creek Reservoir

where steep irregular slopes are common, TIN models derived solely from sparse contour data will result in underestimates of the reservoir capacity.

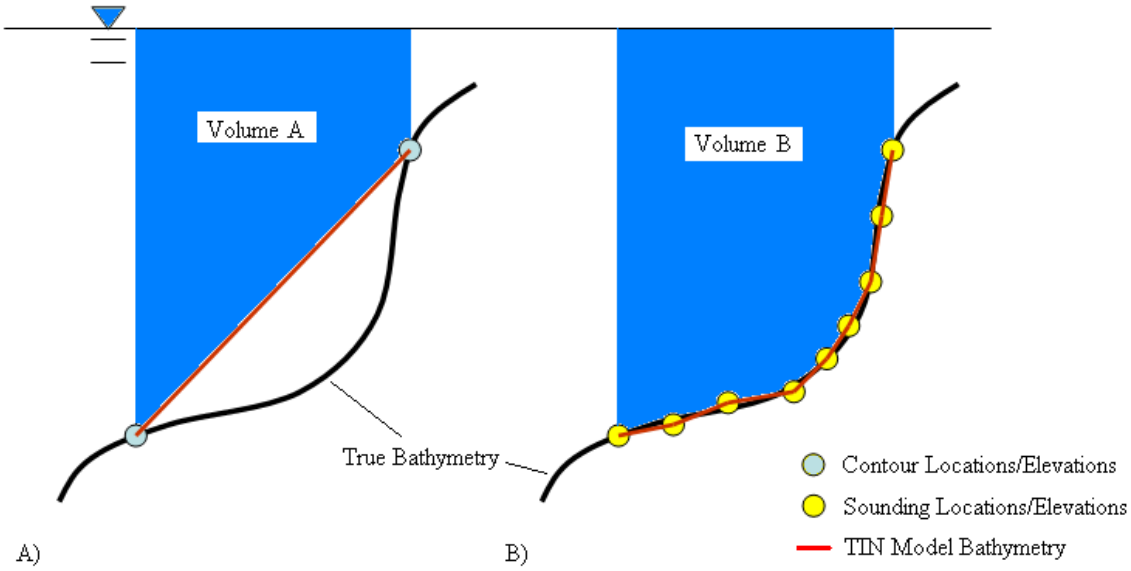


Figure J3 – TIN models and Resulting Volumes – A) derived from contour data, B) derived from sounding data. Greater volumes can be derived from sounding data, depending on the true bathymetric shape.

Evaluating the Jones & Boyd, Inc. Capacity (1987)

Per the report "Report on Squaw Creek Reservoir Sediment Survey" (1987) provided to TWDB by Luminant, Jones & Boyd, Inc.[3] estimated the capacity of Squaw Creek Reservoir after surveying elevations along 25 pre-existing range lines (Figure J4). Cross sections at each range line location were plotted on scales equal to those used in available USGS topographic maps of the area, and:

> "from the cross section plots, the location of each point of an even ten feet in elevation along each range line was measured and marked on an overlay sheet. This sheet was then overlain on the quadrangle map enlargement. The points of equal elevation were connected from range line to range line using the underlaying topography as a guide for shaping the [updated]contours between range lines."[3]

Areas of each updated contour were measured using a planimeter, and capacities were calculated from the area data using the average-area method as described above.[3] This

method of creating revised contours for capacity estimation is referred to as the "contour-range" method[7], and was deemed less accurate than the constant factor method (created in 1951) and the width-adjustment method (created in 1980)[7]. It is unknown why Jones & Boyd, Inc. chose to use the contour-range method when other, more modern methods were available in 1987.

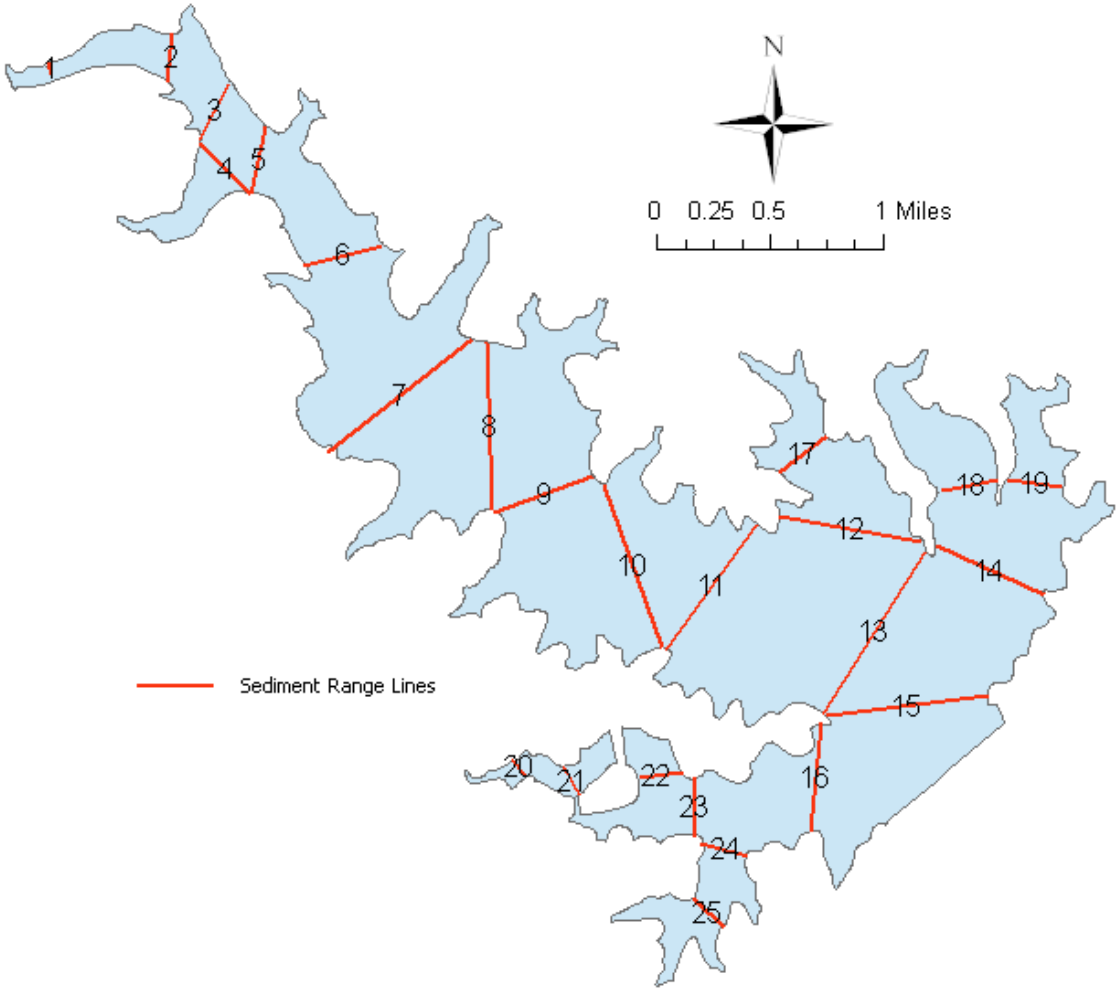


Figure J4 – Sediment Range Line locations for Squaw Creek Reservoir

To assess the validity of the Jones & Boyd, Inc. 1987[3] capacity estimate, TWDB attempted to apply the contour-range method to range line data extracted from the Squaw Creek Reservoir bathymetric TIN model resulting from the 2007 survey. TWDB was not able to obtain the actual surveyed cross-section data collected by Jones & Boyd, Inc.; therefore, this comparison is only intended to demonstrate the validity of the contour-

range method with respect to the current surveying method employed by TWDB. TWDB considers the contour-range method, as described by Jones & Boyd, Inc.[3] to be potentially inaccurate in that computed areas are highly dependent upon the skill of the analyst connecting points of equal elevation while using previous topography as a guide. There is also no assurance that the current surface contours suggested by the survey data should have the same shape as the previously determined contours (whose accuracy may be unknown or at least questionable).

To eliminate the subjectiveness of the contour-range line method, TWDB implemented the method in a series of Matlab scripts which automatically force contours drawn between sediment range lines to mimic the shape of previously existing contour data. With reference to Figure J5, the Matlab script determines the portion of the pre-impoundment contour that lies between adjacent sediment range lines (black line), determines the location of the intersection between the contour and the range lines (red dot), determines the location on the range line where the surveyed elevation is equal to that of the contour (green dot), and determines the deviation in location along the range line of the contour intersection and the surveyed point elevation. The script then creates a new contour (grey line) between the range-line surveyed points (green dots), linearly altering the original contour location based on distance along the original contour (black line) between sediment range lines and the deviations measured at each range line. The scripts also adjust the revised contour to eliminate loops and prevent the contour from crossing itself.

Upon running the Matlab processing scripts for each contour elevation, TWDB re-calculated the reservoir capacity using the average-area method with the revised contour data. The resulting reservoir capacity was 155,605 acre-feet, which is 4,332 acre-feet (2.9%) greater than the volume calculated from the complete set of 2007 survey data. Upon review of this analysis, TWDB determined that the larger capacity resulting from the sediment range line method is due to the lack of resolution/accuracy of the available pre-impoundment contour data. This is especially evident in plots of the cross-section data measured at sediment range line #11 (Figure J6) and sediment range line #13 (Figure J7). These lines are located in the widest portion of the lake, and due to the inaccuracies of the pre-impoundment contours in these areas, the revised contour areas at elevation

690 feet and elevation 700 feet were greatly increased. This increase in area at relatively low elevations within the lake contributes to the overall increase in lake volume calculated with the average area method.

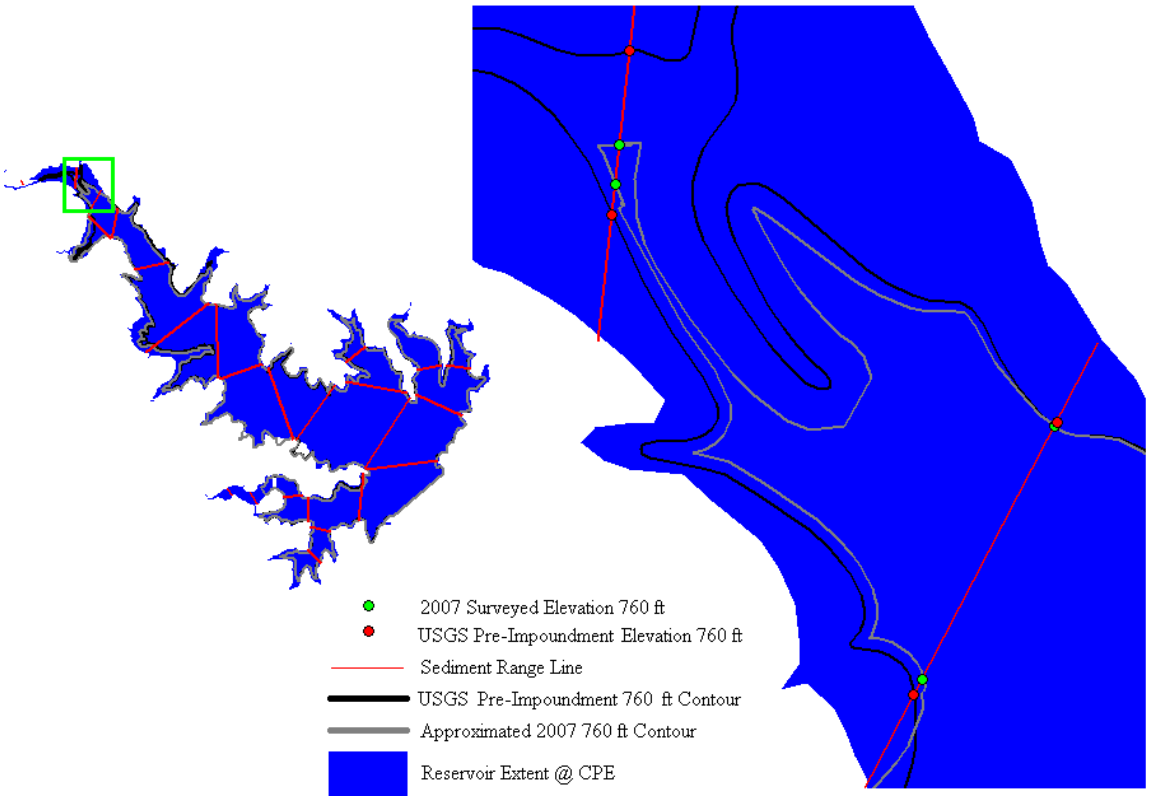


Figure J5 – Automatic creation of revised contours using the contour-range method. Note: figure depicts sediment range line #2 and #3.

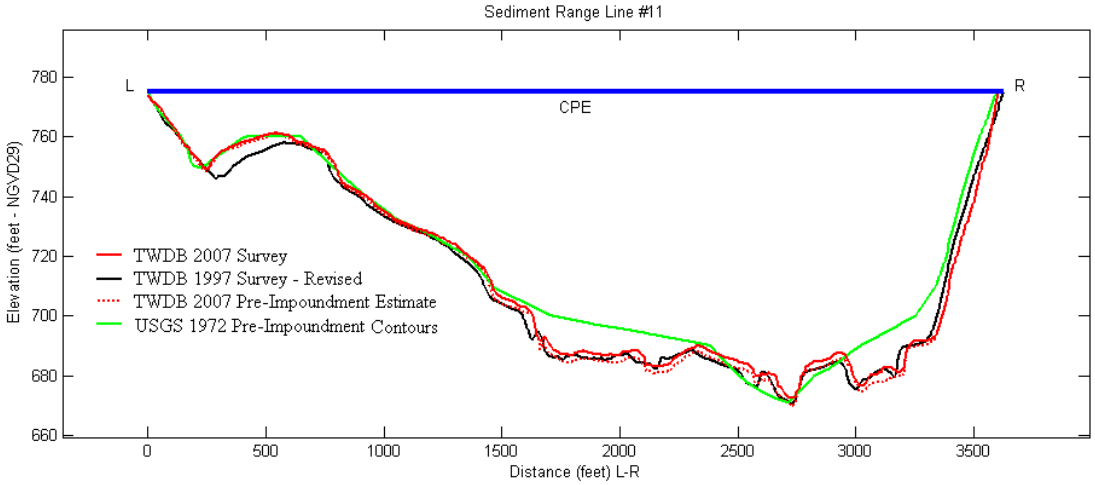


Figure J6 – Cross section plots along sediment range line #11, demonstrating the inaccuracy of the pre-impoundment surface implied by contour data. The contour-derived cross-section is inaccurate assuming dredging did not occur during construction of Squaw Creek Reservoir.

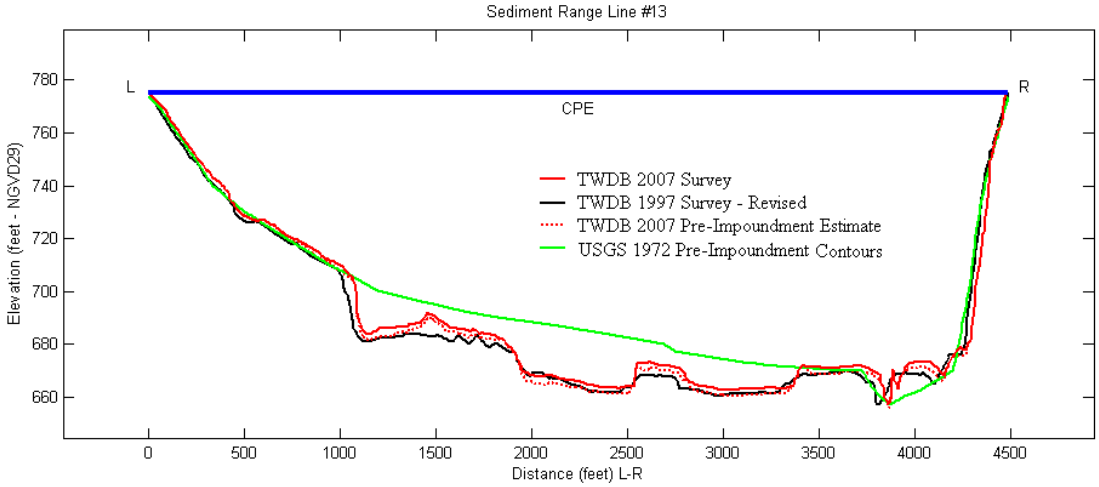


Figure J7 – Cross section plots along sediment range line #13, demonstrating the inaccuracy of the pre-impoundment surface implied by contour data. The contour-derived cross-section is inaccurate assuming dredging did not occur during construction of Squaw Creek Reservoir.

TWDB recognizes that the above contour-range analysis does not confirm or refute the analysis performed by Jones & Boyd, Inc.[3], but merely demonstrates how the method is dependent upon the accuracy of pre-existing topographic information in representing the true bathymetric surface. TWDB does not imply that analyses made with

the contour-range method will always produce volumes deviating by approximately 3% from volumes derived with the TWDB-standard surveying methods; further study of this technique would be needed to assess the method's accuracy and applicability. At this time, TWDB agrees with the conclusion from the U.S. Bureau of Reclamation[7], that the contour-range method is not the best method for calculating reservoir capacity. In instances where the only available capacity information was derived through use of the contour-range method, TWDB recommends re-surveying the reservoir using TWDB-standard methods, and/or carefully analyzing the contour-range data using technology such as GIS and Matlab.

Revising the TWDB 1997 Capacity[4]

Before comparing reservoir capacity results from TWDB surveys of Squaw Creek Reservoir, TWDB applied the 2007 data processing techniques to the survey data collected in 1997[4]. Specifically, TWDB re-edited the raw 1997 survey data using HydroEdit and applied the Self-Similar Interpolation and line extrapolation techniques[6] to the 1997 survey dataset. TWDB did not revise the 1997 lake area as the original 1997 lake boundary was used in the re-assessment. TWDB notes that the lake areas at conservation pool elevation are different for the 1997 and 2007 surveys, and that some of the reported volume differences are directly attributable to this area difference.

Upon review of the original 1997 TIN model (from which the 1997 capacity estimate was derived), TWDB discovered apparent errors within the sounding dataset. (Figure J8). These errors were removed from the dataset, resulting in a smoother bathymetric TIN model. The 1997 dataset also consisted of data collected along a grid pattern and data collected as the survey boat traveled between the boat ramp and the starting location for each day's data collection. TWDB no longer collects data in grid patterns, as the resulting TIN models do not properly represent the bathymetric surface topography. TWDB also no longer collects data when traveling to (or from) the boat ramp, as current survey practice limits data collection to when the survey boat is traveling less than 5 miles per hour; traveling long distances at such slow speeds becomes impractical. In 1997 while traveling to and from the Squaw Creek boat ramp (and

collecting data), the TWDB survey boat traveled at speeds in excess of 20 miles per hour. Independent TWDB studies have found data collection to be unreliable and inaccurate at speeds exceeding 15 miles per hour. Therefore, TWDB further revised the 1997 sounding dataset by removing data collected to and from the boat ramp, and removing data collected along lines running parallel to the longitudinal axis of the reservoir. Note: survey lines for the 2007 TWDB survey of Squaw Creek Reservoir were chosen to reproduce the revised 1997 dataset describe here. All survey line datasets are displayed in Figure J9.

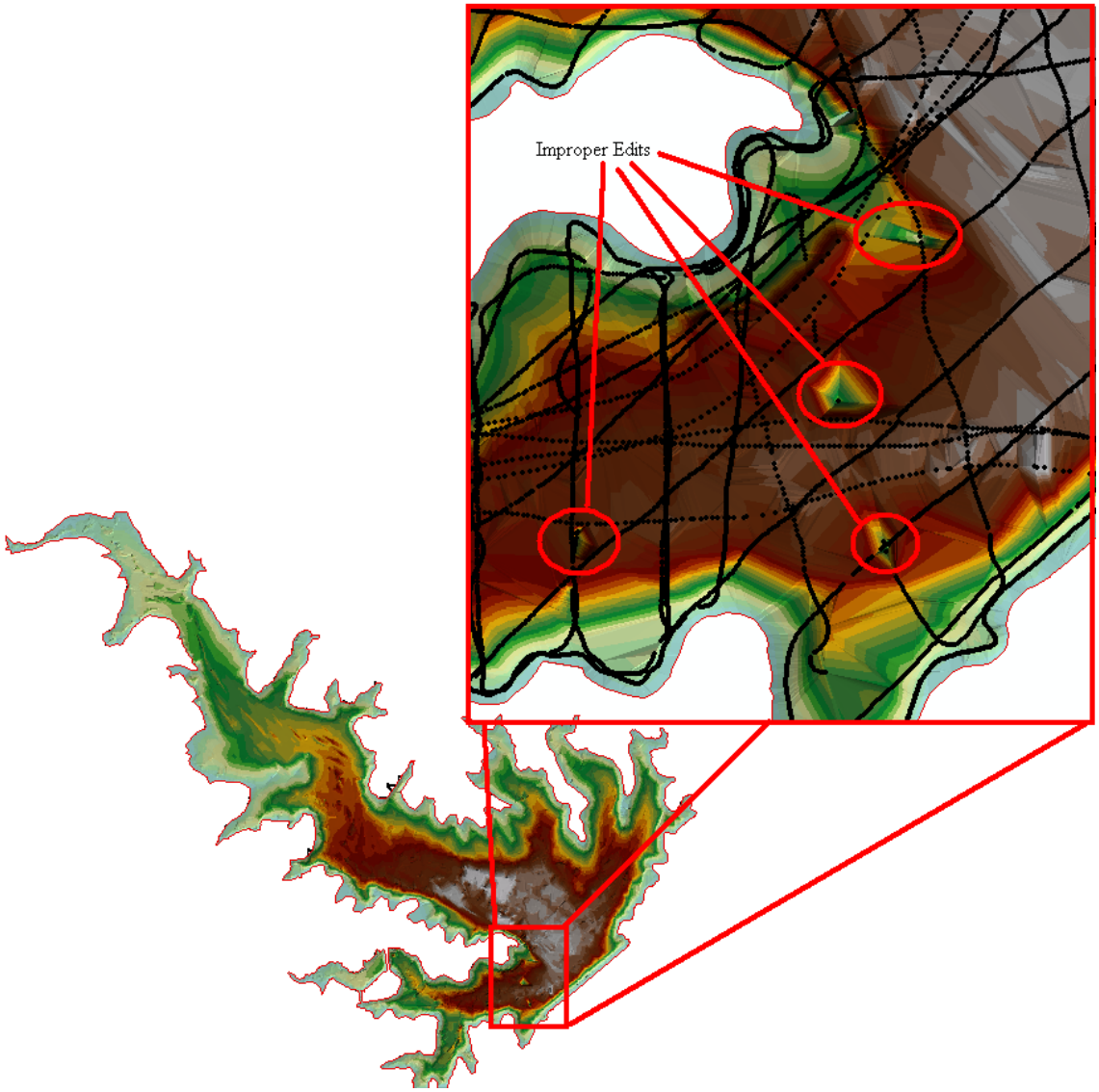


Figure J8 – Sample sounding errors in the original 1997 TIN model. Errors were removed to create a smoother TIN model.

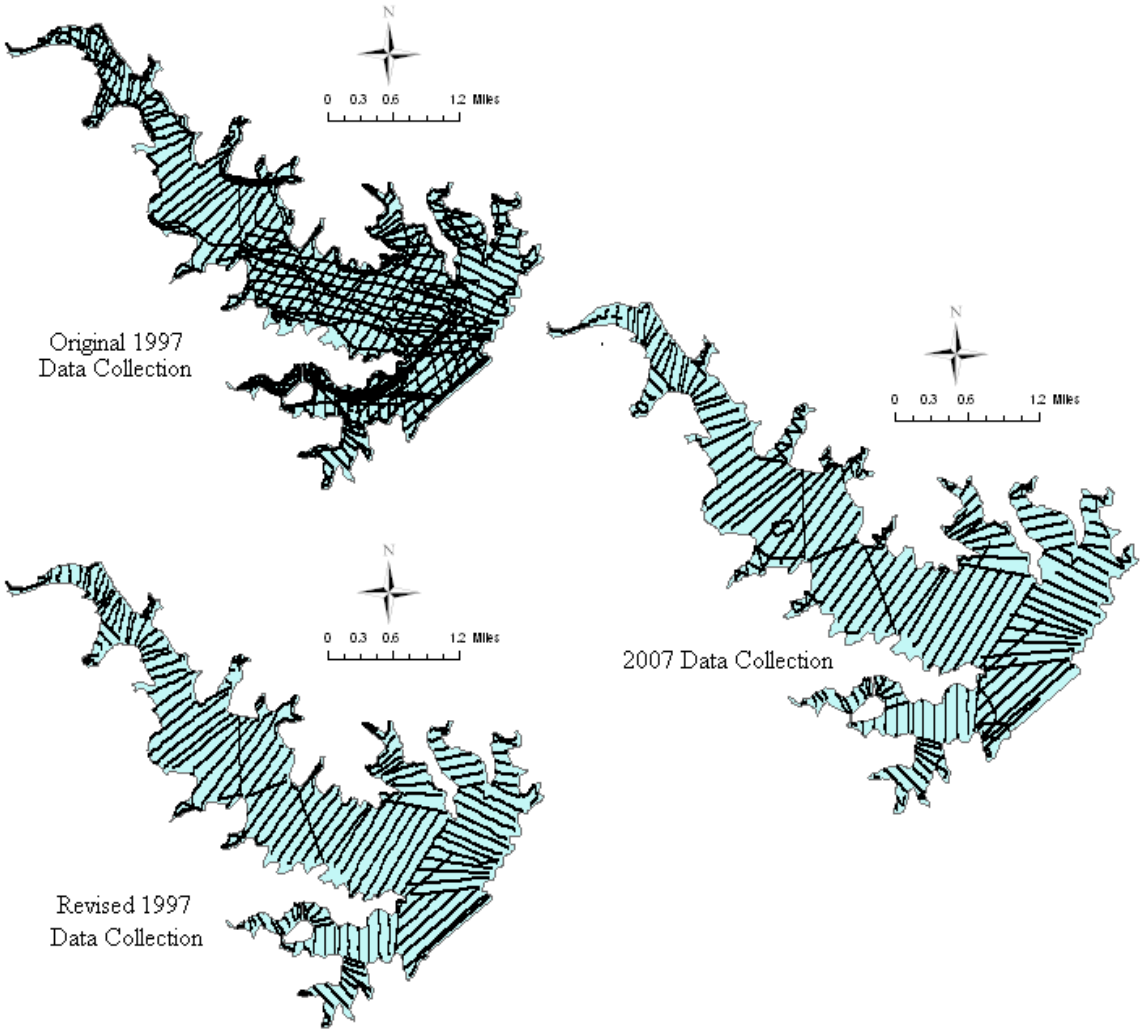


Figure J9 – Original and Revised 1997 Sounding data points used in computing Squaw Creek Reservoir volumes. The 2007 data collection occurred on lines resulting from the revised 1997 dataset.

Upon revision of the 1997 dataset, TWDB applied the Self-Similar Interpolation and line extrapolation techniques[6]. These techniques improve the TIN model's representation of the surveyed bathymetric surface, and yield a more accurate assessment of the reservoir capacity. The revised 1997 TIN model suggested Squaw Creek Reservoir had a capacity of 150,643 acre-feet, or 775 acre-feet (0.5%) less than estimated in the 1997 survey report. Upon inspection, the main difference between the original and revised 1997 TIN models appears to be located in the main body of the lake, approximately 1 mile upstream from the dam (Figure J10). The revised 1997 capacity estimate is 630 acre-feet (0.4%) less than the capacity estimate derived from the 2007

survey, which suggests either sediment accumulation between 1997 and 2007 was negligible, or that differences in the data collection between the successive surveys resulted in volume differences greater than those due to sediment accumulation

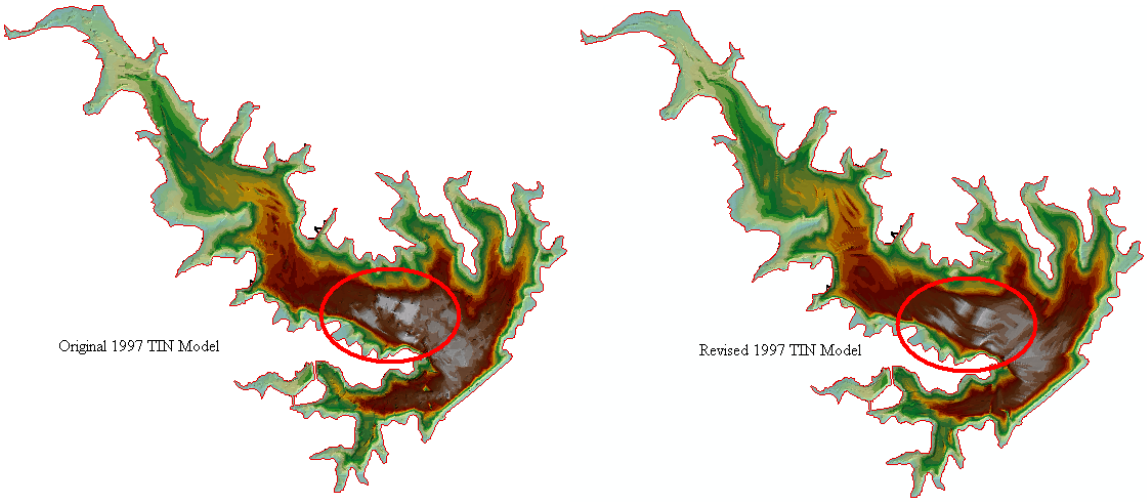


Figure J10 – Comparing the original and revised 1997 TIN models of Squaw Creek Reservoir. The area within the red circle is highlighted in Figure X10.

Shown in Figure J11 is a comparison of the bathymetric TIN models from the original and revised 1997 datasets, as well as from the 2007 dataset for the area approximately 1 mile upstream of the dam. This area is the deepest area of the lake, and data inaccuracies in this location could have a significant impact on the computed capacity estimates. As indicated by the red arrows, the 1997 dataset contained a line of sounding data running NNE-SSW which implied the existence of a 25-foot mountain in-between the adjacent survey lines. This mountain was not indicated by the 1997 survey lines collected parallel to the main axis of the reservoir, suggesting that the data on the NNE-SSW line was incorrect. Similar data from the 2007 dataset also support that the 1997 data in this area was incorrect. As the incorrect data was used in the 1997 TIN models, the overall reservoir volume in this area would be less in 1997 than in 2007. This difference led to the difference in volume calculated from the 2007 and revised 1997 datasets. Whereas the red arrows depict an area of greater volume in 2007 than in 1997, the blue arrows demonstrate an area where less volume is likely to exist than reported in the original 1997 survey. The blue arrows indicate where the original 1997 TIN model suggested a deeper bathymetry than implied by the NNE-SSW trending surveyed data. In TIN models adjusted through self-similar interpolation, the bowl-shaped surface near the

blue arrow in Figure J11a is smoothed out to form a ridge separating the deeper and shallower portions of the reservoir. As such, the lake bathymetry is better represented by the TIN model. Depending on the slope of the reservoir walls, self-similar interpolation in areas such as presented in Figure J11 can have a significant impact on the reservoir volume.

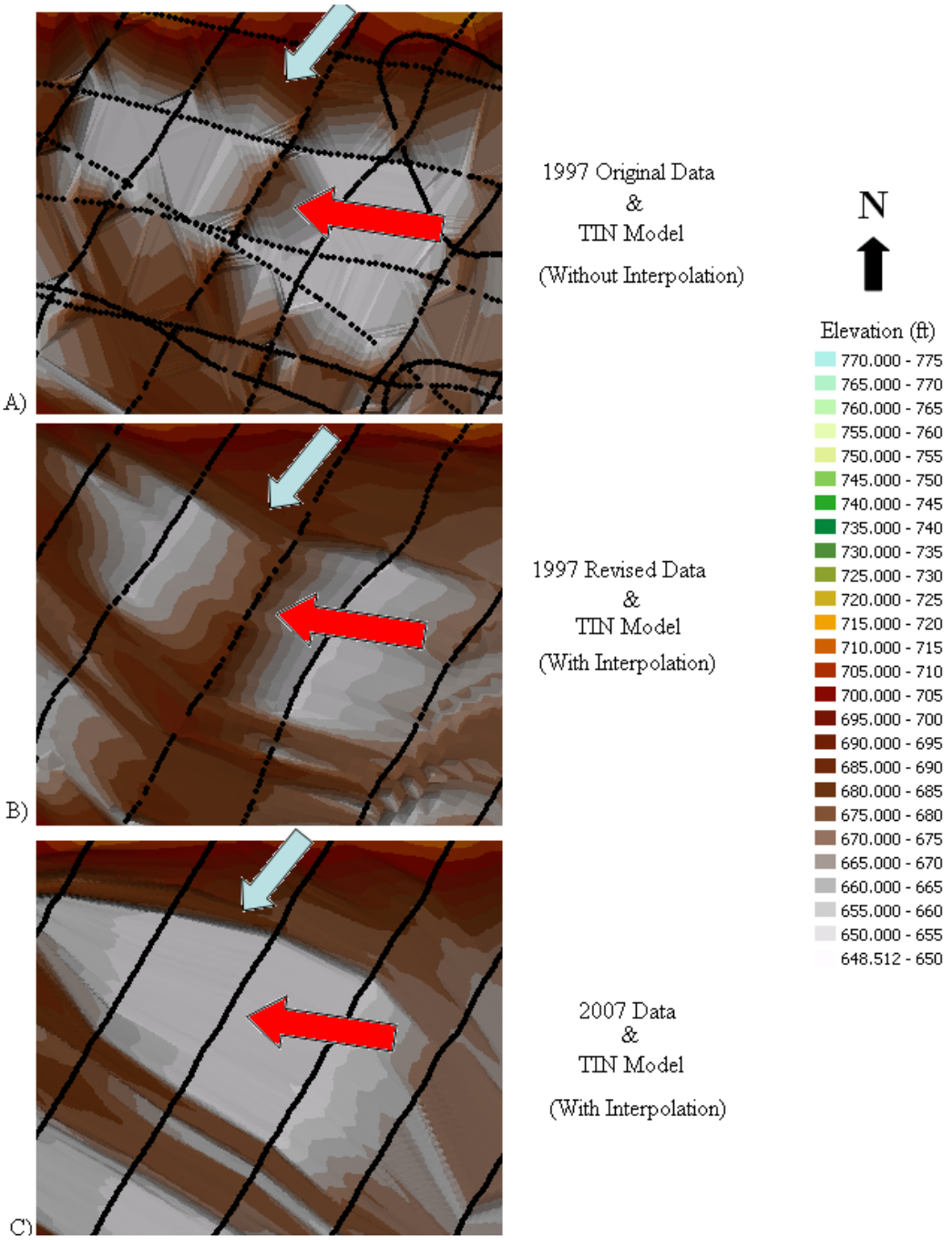


Figure J11 – Comparing 1997 and 2007 TIN Models of Squaw Creek Reservoir

Conclusions

In theory, comparing lake volumes from multiple lake surveys allows for the computation of capacity loss rates, which are identical to sediment accumulation rates if all lost capacity is due to sediment accumulation. In practice, however, the differences in methodologies used in each lake survey may yield greater differences in computed lake volumes than physical volume differences due to sediment accumulation over time. For this reason, TWDB prefers to estimate sediment accumulation rates through sedimentation surveys, which directly measure the sediment layer thicknesses throughout the reservoir. The sediment accumulation rates derived from such surveys reflect the average rate of sediment accrual since the time of impoundment. To estimate temporal trends in sediment accumulation, multiple sedimentation surveys would be beneficial. Comparing results from multiple volumetric surveys, however, would also yield sediment accumulation rate estimates as long as similar methodologies were used when generating each capacity estimate.

As demonstrated in this appendix, capacity estimates for Squaw Creek Reservoir were estimated using a variety of different methods. The quality of the data employed by each method is also uncertain. As such, TWDB does not support the direct comparison of published or revised capacities for Squaw Creek Reservoir in order to estimate sediment accumulation rates. To estimate a sediment accumulation rate for Squaw Creek Reservoir, TWDB recommends using the accumulated volume of sediment as computed from the 2007 sounding data. Based on this measured sediment volume and assuming a constant sediment accumulation rate since the date of initial impoundment, Squaw Creek Reservoir loses approximately 125 acre-feet of capacity per year. This estimate is reasonably close to the 111 acre-feet per year estimate provided by Freese & Nichols in 1972[2].

References

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2. Freese & Nichols, Inc. 1972. “Engineering Report on Squaw Creek Reservoir.”
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6. Furnans, Jordan. Texas Water Development Board. 2006. “HydroEdit User’s Manual.”
7. Blanton, James. 1982. “Procedures for Monitoring Reservoir Sedimentation”. U.S. Bureau of Reclamation.

Appendix K

Analysis of Sediment Accumulation Data from Squaw Creek Reservoir

Executive Summary

The results of the TWDB 2007 Sediment Survey indicate Squaw Creek Reservoir has accumulated 3,735 acre-feet of sediment since impoundment in 1977, with 40 acre-feet of sediment within the Safe Shutdown Impoundment. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Squaw Creek Reservoir loses approximately 125 acre-feet of capacity per year, with nearly 1 acre-foot lost within the Safe Shutdown Impoundment. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Squaw Creek channel. The maximum sediment thickness observed in Squaw Creek Reservoir was 7.38 feet.

Introduction

This appendix includes the results of the sediment investigation using multi-frequency depth sounder data collected on November 29th-30th and December 5th-7th of 2007 and June 26th, 2008 by the Texas Water Development Board (TWDB). Through careful analysis and interpretation of the multi-frequency signal returns, it is possible to discern the pre-impoundment bathymetric surface, as well as the current surface and sediment thickness. Such interpretations are aided and validated through comparisons with sediment core samples which provide independent measurements of sediment thickness. On June 25th-26th, 2008 TWDB collected three core samples of the impoundment bottom throughout the reservoir. The remainder of this appendix presents a discussion of the results from and methodology used in the core sampling and multi-frequency data collection efforts, followed by a composite analysis of sediment measured in Squaw Creek Reservoir.

Data Collection & Processing Methodology

TWDB conducted the Squaw Creek Reservoir bathymetric survey on November 29th-30th and December 5th-7th of 2007, while the water surface elevation ranged between 775.45 feet and 775.48 feet above mean sea level (NGVD29). TWDB returned to the reservoir on June 26th, 2008 for additional data collection when the water surface elevation as 775.10 feet (NGVD29). For all data collection efforts, TWDB used a Specialty Devices, Inc., multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. For all data collection efforts, 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. During the survey, TWDB collected approximately 49,400 data points over cross-sections totaling nearly 72 miles in length. Figure K1 shows where data points were collected during the TWDB 2007 survey.

Core samples collected by TWDB were collected at locations near where sounding data had been previously collected (Figure K1). The coordinates and a description of each core sample are provided in Table K1. All cores were collected with a custom-coring boat and SDI VibraCore system. Cores were analyzed by TWDB, and both the sediment thickness and the distance the core penetrated the pre-impoundment boundary were recorded.

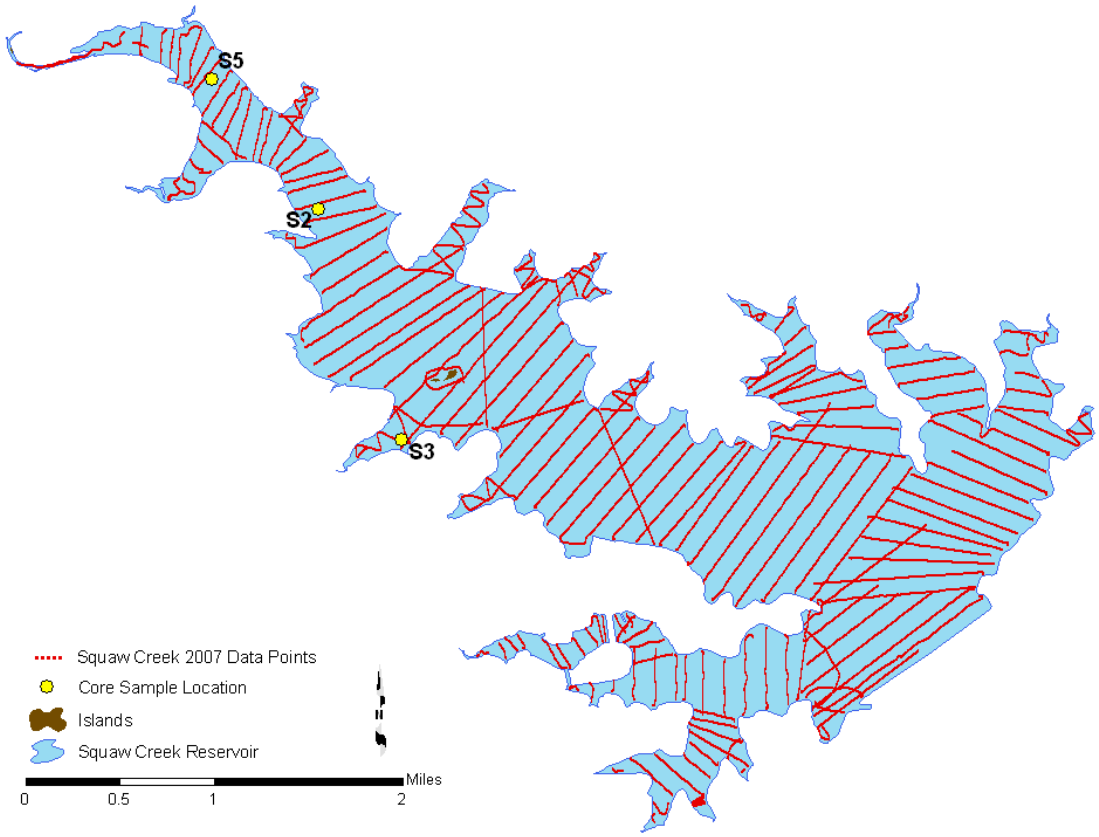


Figure K1 – TWDB 2007 survey data points for Squaw Creek Reservoir

Table K1 – Core Sampling Analysis Data

Core	Easting** (feet)	Northing** (feet)	Description
S2	2182733.05	6802740.61967	21” of muddy sediment with plant material and woody debris visible.
S3	2184747.83434	6796298.48203	12” of grey sediment with shells and plant material visible
S5	2180183.08114	6806336.50654	12” of sandy sediment, brown-black in color. Some plant material and shells present.

** Coordinates are based on NAD 1983 State Plane Texas North Central system

All sounding data is processed using the DepthPic software, within which both the pre-impoundment and current bathymetric surfaces are identified and manually digitized. These surfaces are first identified along cross-sections for which core samples have been collected, thereby allowing the user to identify color bands in the DepthPic display that correspond to the sediment layer(s) observed in the core samples. This process is illustrated in Figure K2 where core sample S2 is shown with its corresponding sounding data. Core sample S2 contained 21 inches of sediment above the pre-impoundment bathymetry, as indicated by the yellow and green boxes, respectively, representing the core sample in Figure K2. The pre-impoundment surface is usually identified within the core sample by one of the following methods: (1) a visual examination of the core for in-place 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.

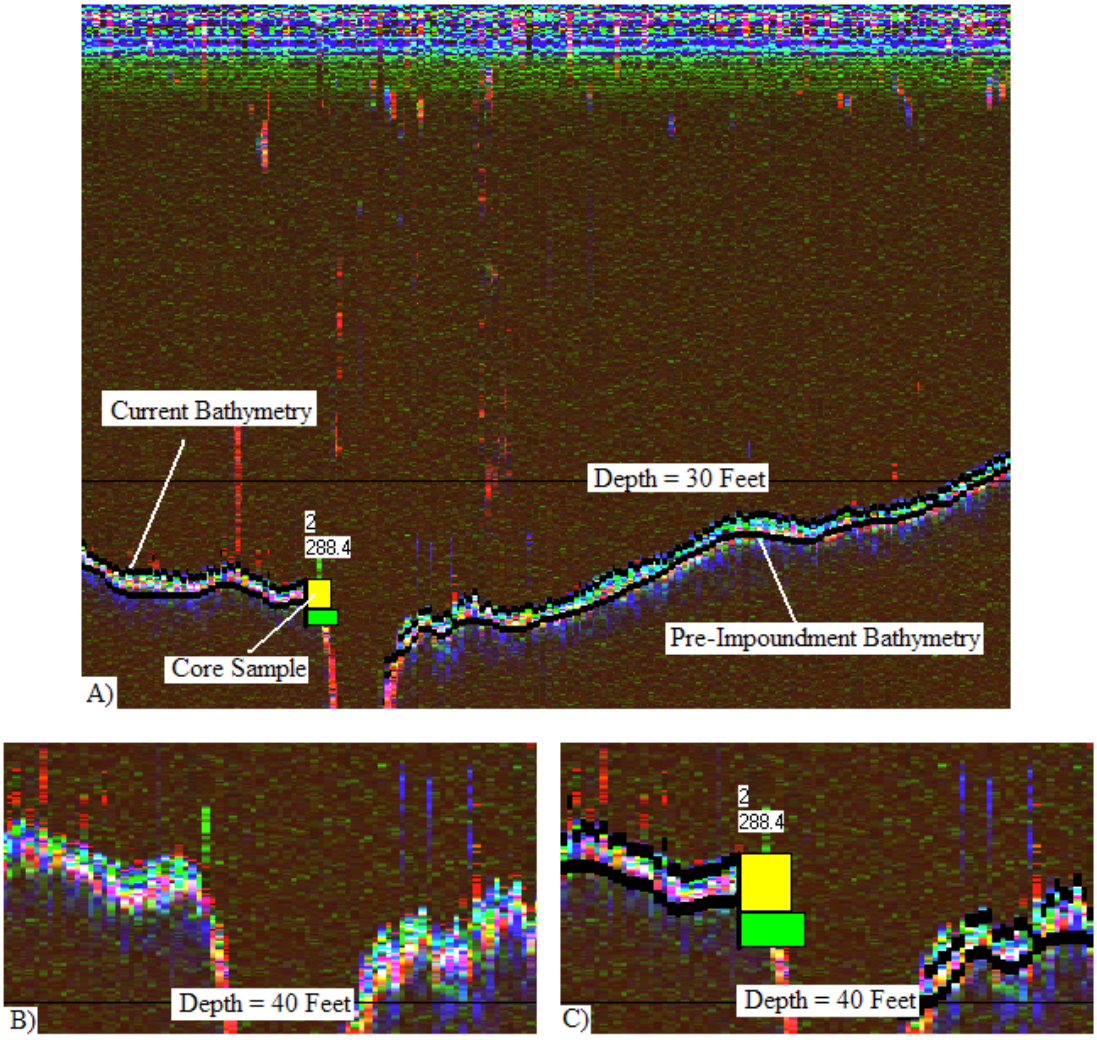


Figure K2 – DepthPic and core sample use in identifying the pre-impoundment bathymetry.

Within DepthPic, the current surface is automatically determined based on the signal returns from the 200 kHz transducer. The pre-impoundment surface must be determined visually based on the pixel color display and any available core sample data. Based on core sample S2, it is clear that the pre-impoundment bathymetric surface for this cross-section may be identified as the base of the bright-colored pink pixels in the DepthPic display. The top of the sediment layer is also clearly identifiable as the band of red and green pixels (Figure K2).

In analyzing data from cross-sections where core samples were not collected, the assumption is made that sediment layers may be identified in a similar manner as when core sample data is available. To improve the validity of this assumption, core samples

are collected at regularly spaced intervals within the lake, or at locations where interpretation of the DepthPic display would be difficult without site-specific core data. For this reason, all sounding data is collected and reviewed before core sites are selected and cores are collected.

After manually digitizing the pre-impoundment surface from all cross-sections, both the pre-impoundment and current bathymetric surfaces are exported as X-,Y-,Z-coordinates from DepthPic into text files suitable for use in ArcGIS. Within ArcGIS, the sounding points are then processed into TIN models following standard GIS techniques[1].

Results

The results of the TWDB 2007 Sediment Survey indicate Squaw Creek Reservoir has accumulated 3,735 acre-feet of sediment since impoundment in 1977, with 40 acre-feet of sediment within the Safe Shutdown Impoundment. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Squaw Creek Reservoir loses approximately 125 acre-feet of capacity per year, with nearly 1 acre-foot lost within the Safe Shutdown Impoundment. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Squaw Creek channel. The maximum sediment thickness observed in Squaw Creek Reservoir was 7.38 feet.

The accumulated sediment volume for Squaw Creek Reservoir was calculated from a sediment thickness TIN model created in ArcGIS. Sediment thicknesses were computed as the difference in elevations between the current and pre-impoundment bathymetric surfaces as determined with the DepthPic software. Sediment thicknesses were interpolated for locations between surveyed cross-sections using the TWDB Self-Similar interpolation technique[2]. For the purposes of the TIN model creation, TWDB assumed 0-foot sediment thicknesses at the model boundaries (defined as the 775.00 foot NGVD29 elevation contour). Figure K3 depicts the sediment thickness in Squaw Creek Reservoir.

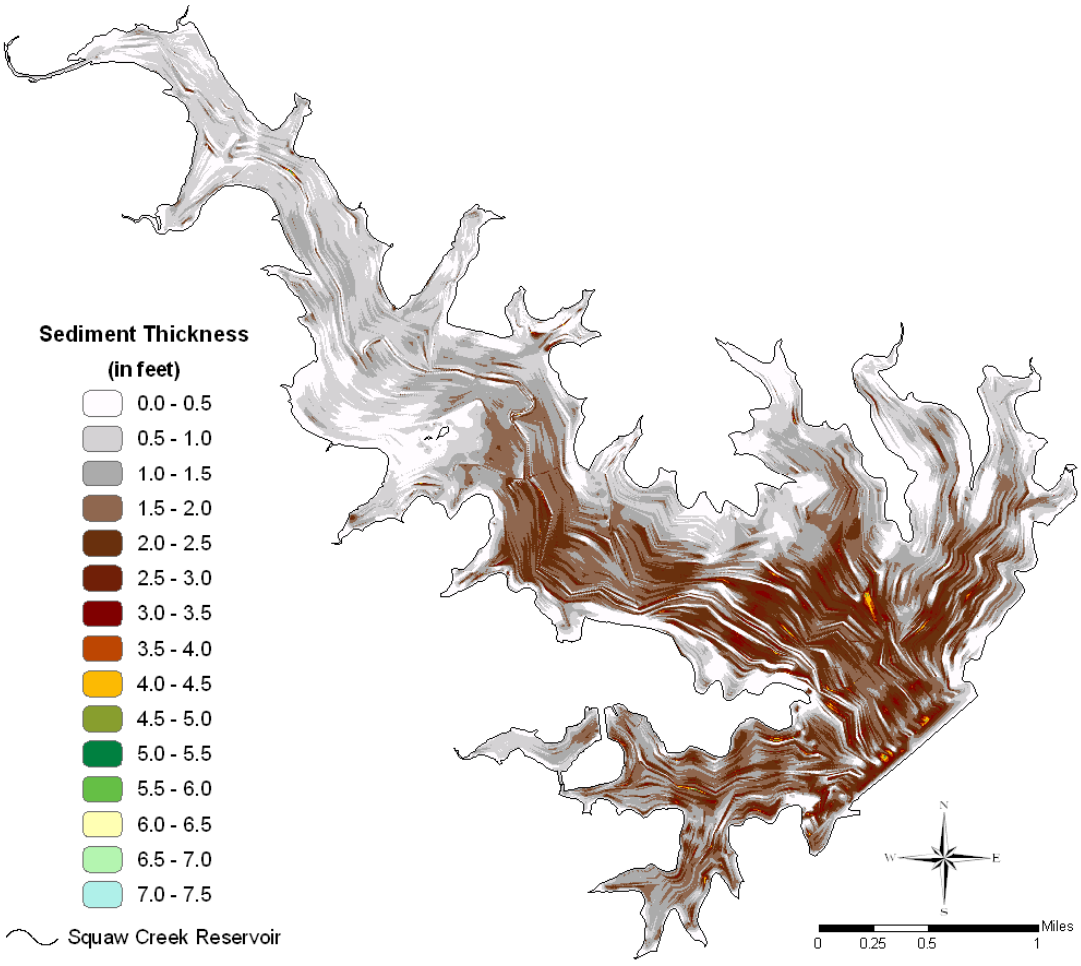
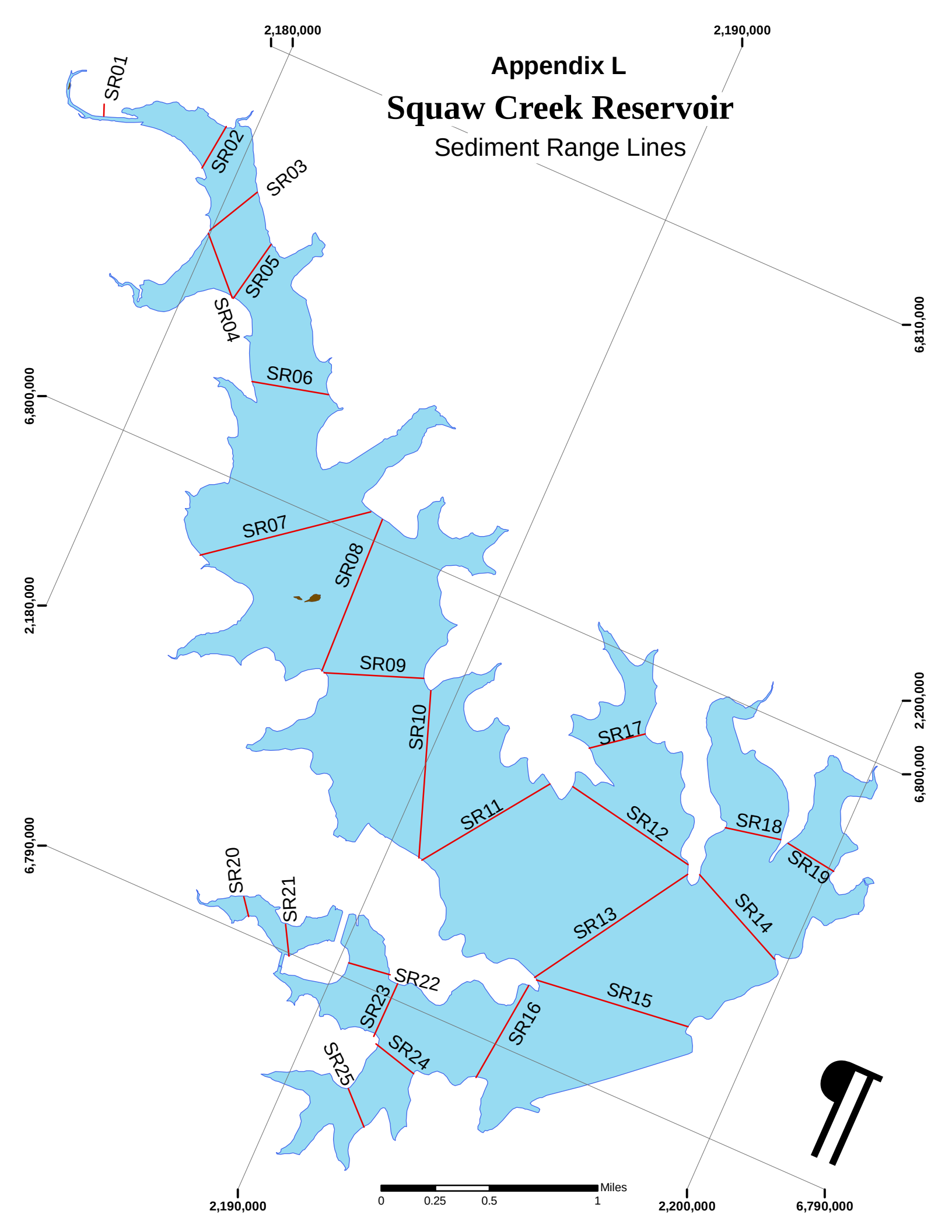


Figure K3 - Sediment thicknesses in Squaw Creek Reservoir derived from multi-frequency sounding data.

References

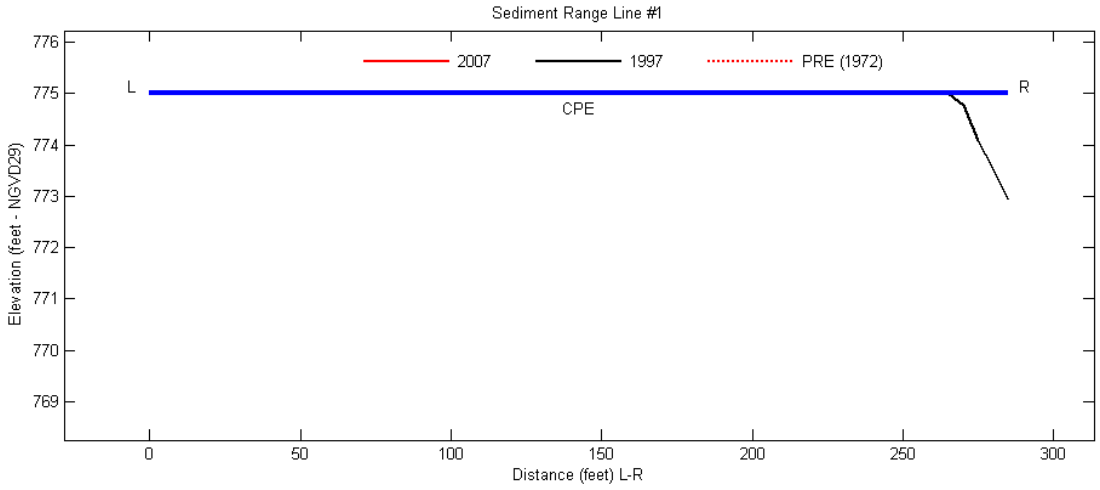
1. Furnans, J., Austin, B., Hydrographic survey methods for determining reservoir volume, Environmental Modelling & Software (2007), doi: 10.1016/j.envsoft.2007.05.011
2. Furnans, Jordan. Texas Water Development Board. 2006. "HydroEdit User's Manual."

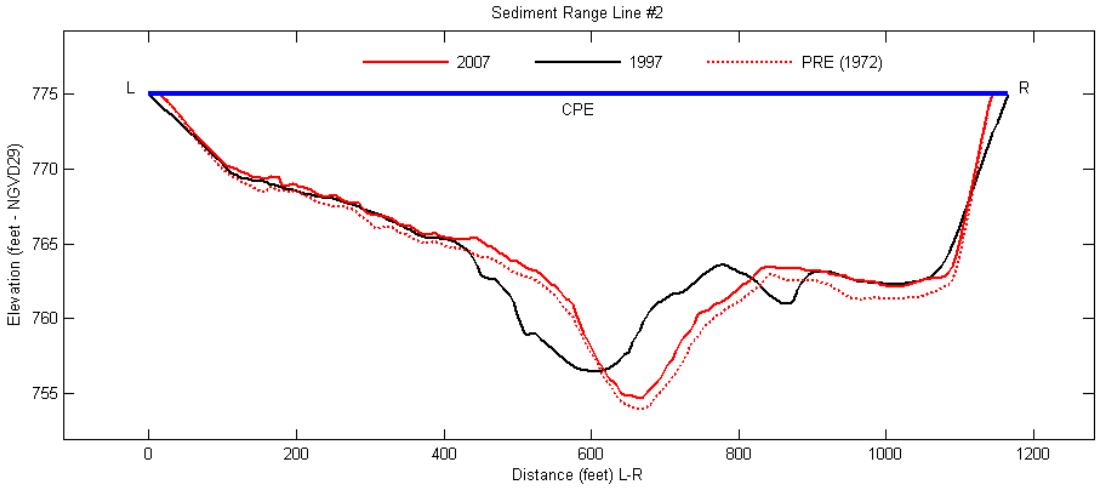

Appendix L
Squaw Creek Reservoir
Sediment Range Lines
2,180,000
2,190,000
6,810,000
6,800,000
2,180,000
2,200,000
6,800,000
6,790,000
SR01
SR02
SR03
SR04
SR05
SR06
SR07
SR08
SR09
SR10
SR11
SR12
SR13
SR14
SR15
SR16
SR17
SR18
SR19
SR20
SR21
SR22
SR23
SR24
SR25
2,190,000
2,200,000
6,790,000
0
0.25
0.5
1
Miles

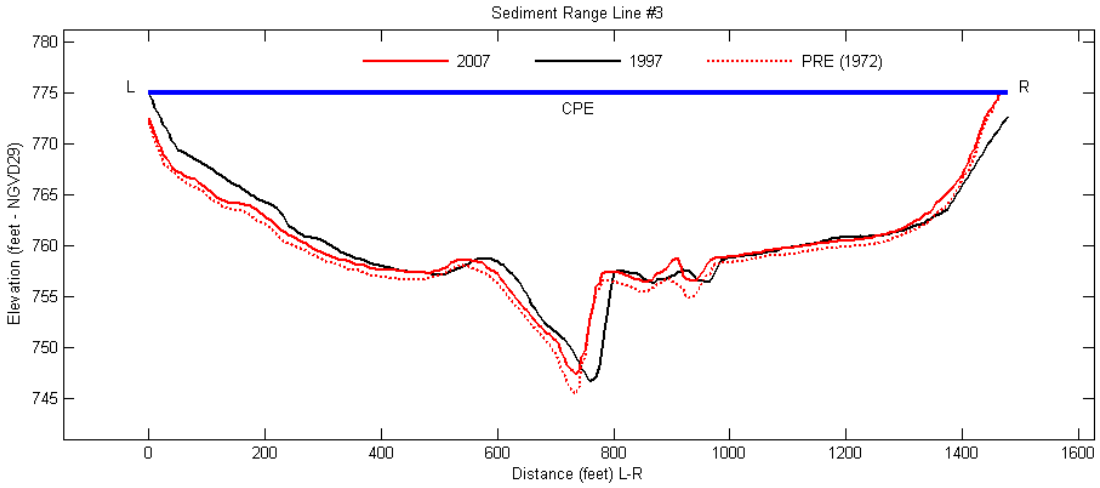
Appendix L: Squaw Creek Reservoir Sediment Range Lines

Table L1 - Squaw Creek Reservoir Sediment Range Lines Endpoint Coordinates

Sediment Range Line	X_L	Y_L	X_R	Y_R
SR01	2,176,375.86	6,807,075.69	2,176,474.61	6,806,808.41
SR02	2,179,304.49	6,807,772.12	2,179,178.21	6,806,613.95
SR03	2,180,638.96	6,806,616.46	2,179,956.91	6,805,304.39
SR04	2,181,122.17	6,804,023.91	2,179,955.41	6,805,221.07
SR05	2,181,463.47	6,805,590.85	2,181,152.59	6,804,022.00
SR06	2,184,215.03	6,802,815.90	2,182,382.63	6,802,353.52
SR07	2,186,305.01	6,800,623.58	2,182,937.91	6,797,978.36
SR08	2,186,639.84	6,800,559.56	2,186,778.05	6,796,598.25
SR09	2,189,123.91	6,797,435.54	2,186,846.11	6,796,581.30
SR10	2,189,404.38	6,797,230.20	2,190,773.10	6,793,390.22
SR11	2,192,963.90	6,796,323.15	2,190,862.52	6,793,367.77
SR12	2,193,495.48	6,796,486.12	2,196,832.37	6,795,885.97
SR13	2,196,915.46	6,795,666.75	2,194,522.44	6,791,872.64
SR14	2,197,186.71	6,795,778.84	2,199,681.44	6,794,633.93
SR15	2,198,425.05	6,792,283.03	2,194,589.08	6,791,826.77
SR16	2,194,204.61	6,789,068.45	2,194,467.04	6,791,630.80
SR17	2,193,489.41	6,797,502.82	2,194,595.59	6,798,372.71
SR18	2,197,301.32	6,797,071.60	2,198,646.66	6,797,348.23
SR19	2,200,134.66	6,797,167.09	2,198,844.30	6,797,344.31
SR20	2,187,258.25	6,790,811.60	2,187,562.05	6,790,413.57
SR21	2,188,463.04	6,790,609.36	2,188,851.93	6,789,929.72
SR22	2,191,284.05	6,790,507.92	2,190,239.50	6,790,370.66
SR23	2,191,536.69	6,790,379.72	2,191,522.45	6,788,976.10
SR24	2,192,780.08	6,788,538.46	2,191,642.92	6,788,832.44
SR25	2,191,471.00	6,787,562.33	2,192,200.16	6,786,866.24
Projection: NAD83 State Plane Texas North Central Zone (feet) $_L$= left $_R$= right				




Sediment Range Line #2
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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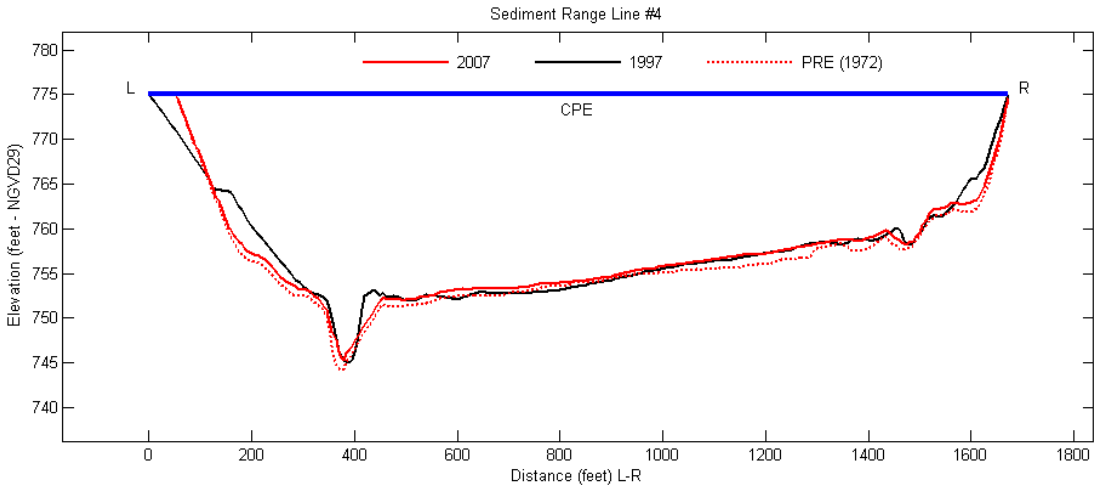
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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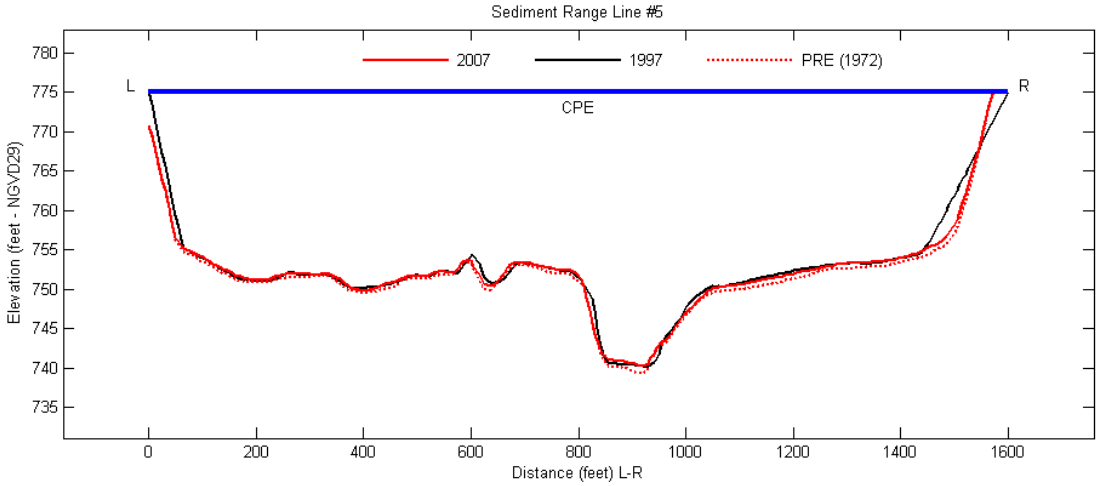
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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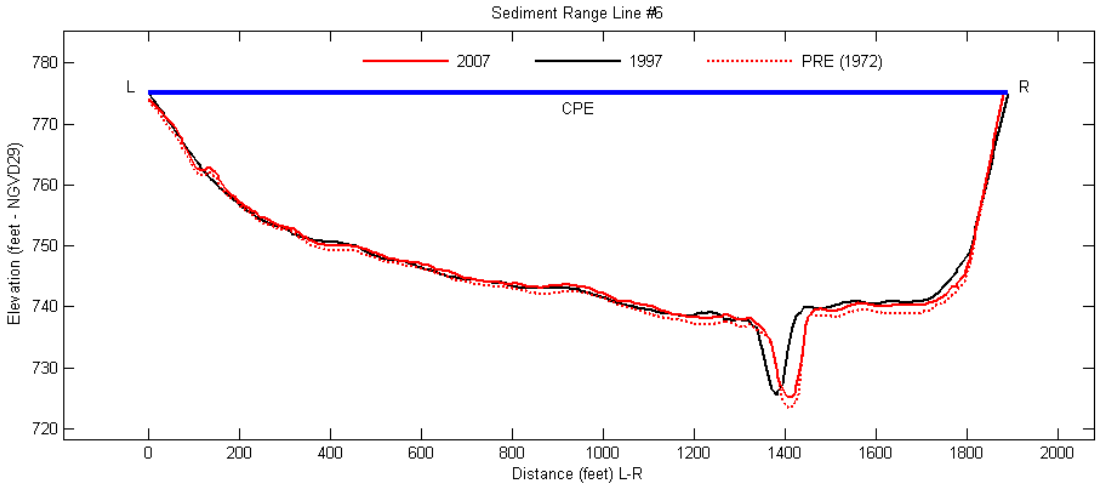
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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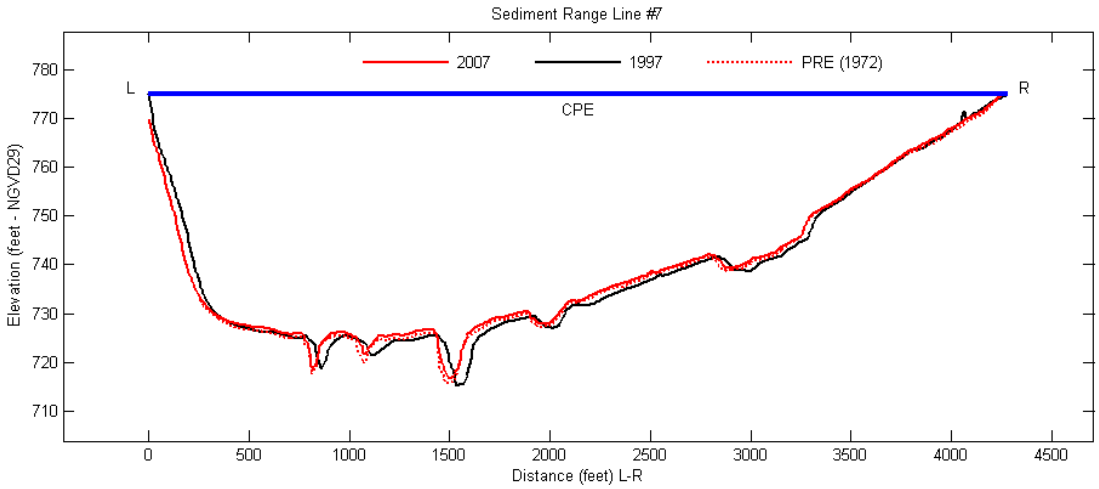
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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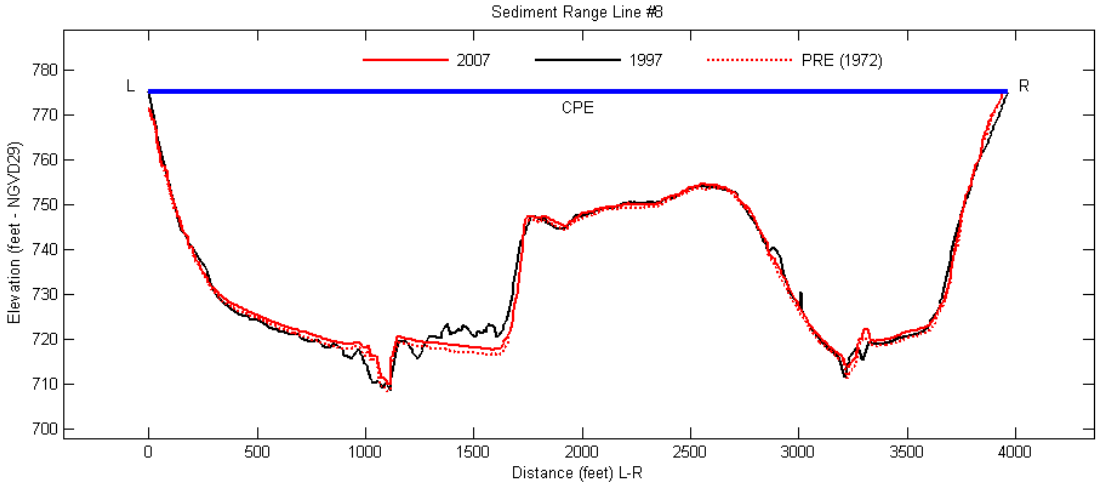
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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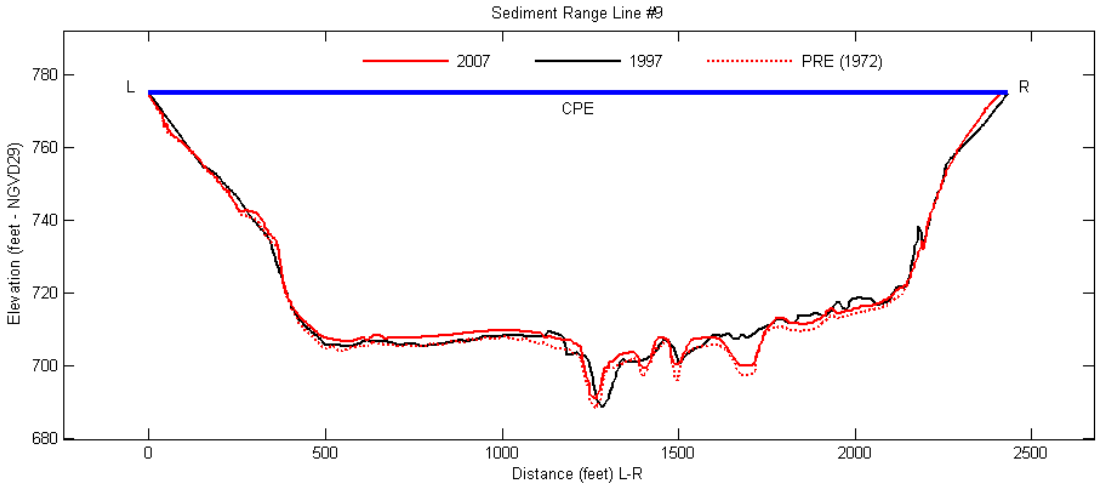
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
780
770
760
750
740
730
720
710
700
0
500
1000
1500
2000
2500
3000
3500
4000
Distance (feet) L-R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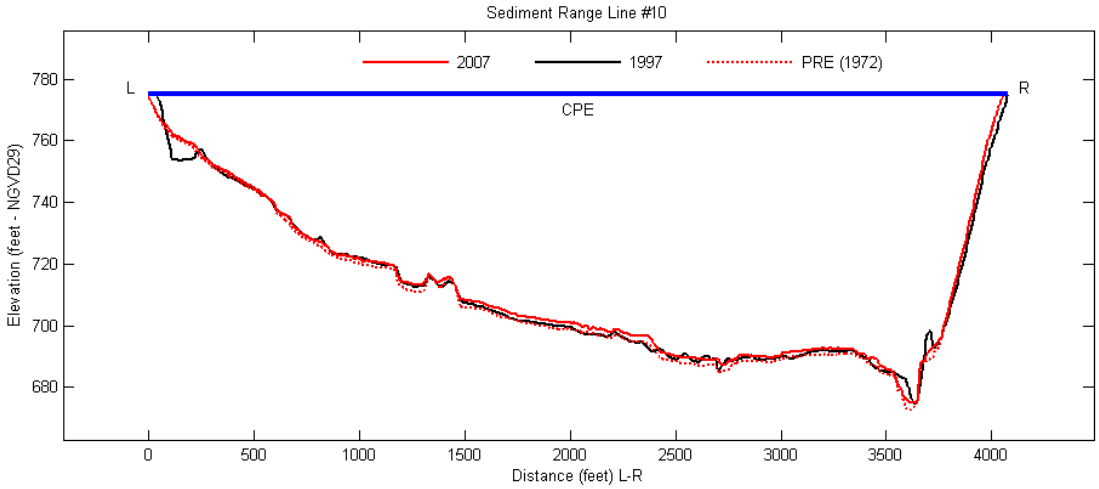
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
780
760
740
720
700
680
0
500
1000
1500
2000
2500
Distance (feet) L-R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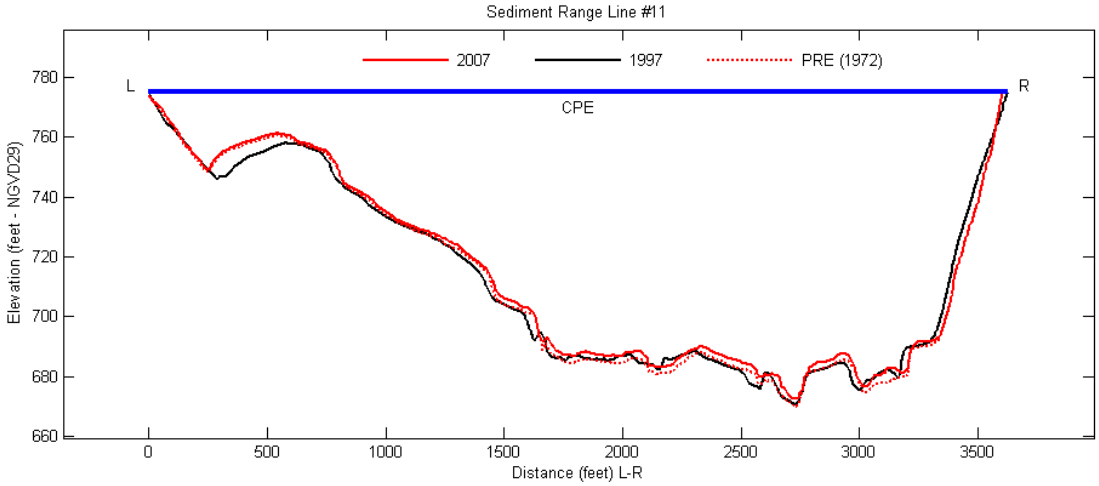
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
780
760
740
720
700
680
0
500
1000
1500
2000
2500
3000
3500
4000
Distance (feet) L-R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1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
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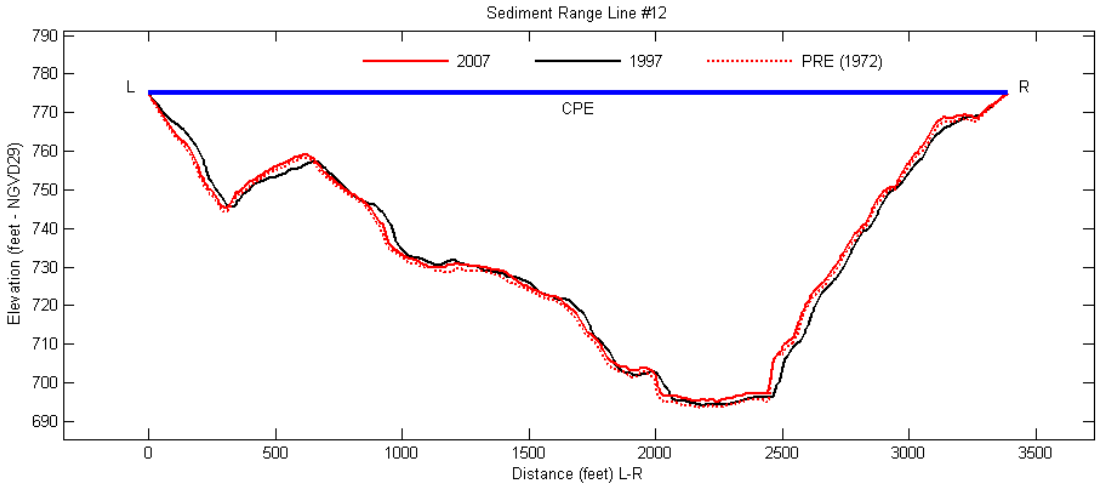
760
740
720
700
680
660
0
500
1000
1500
2000
2500
3000
3500
Distance (feet) L-R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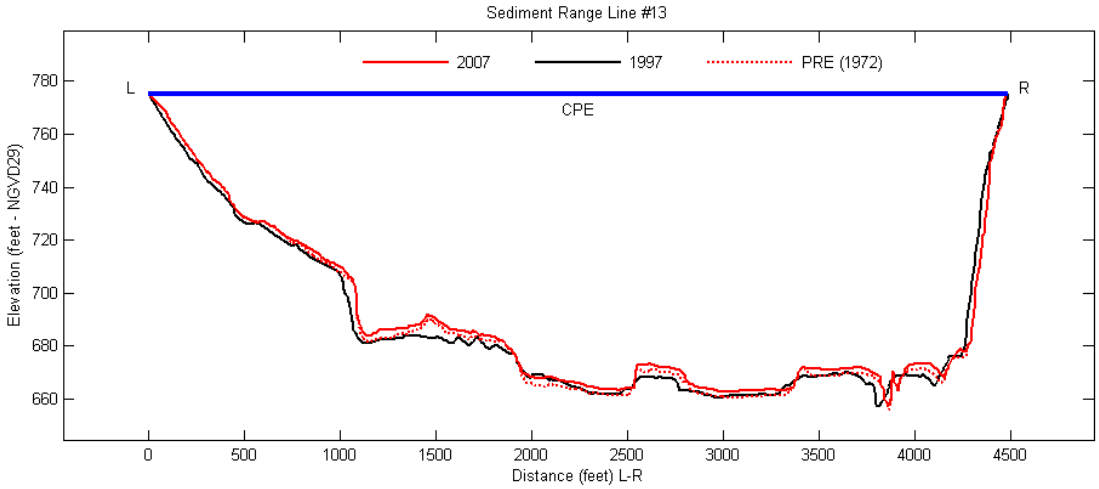
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
790
780
770
760
750
740
730
720
710
700
690
0
500
1000
1500
2000
2500
3000
3500
Distance (feet) L-R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2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
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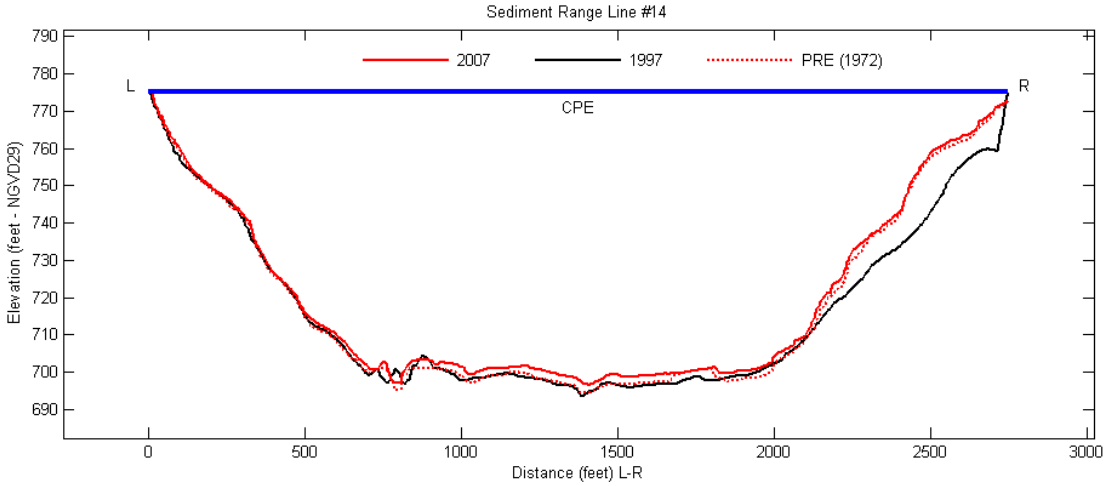
760
740
720
700
680
660
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Distance (feet) L-R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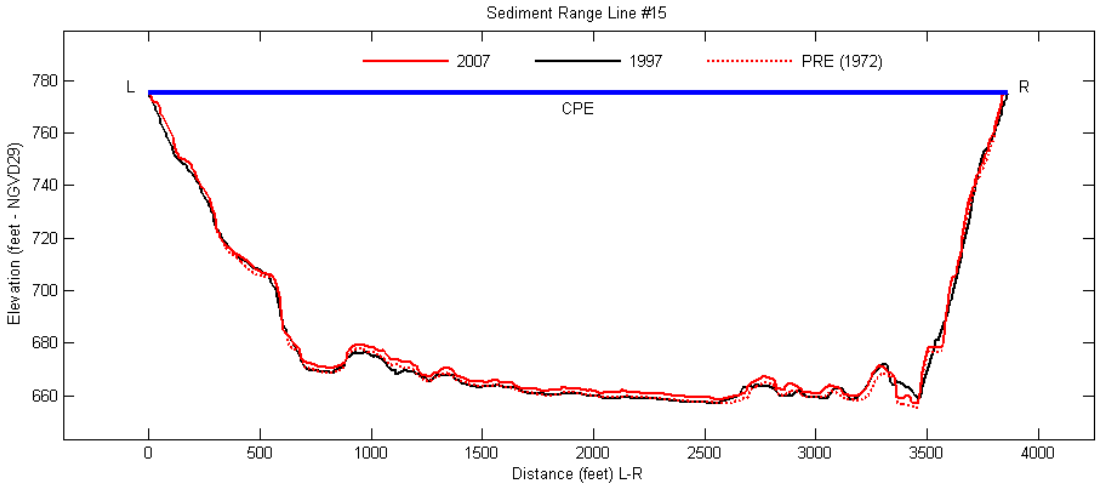
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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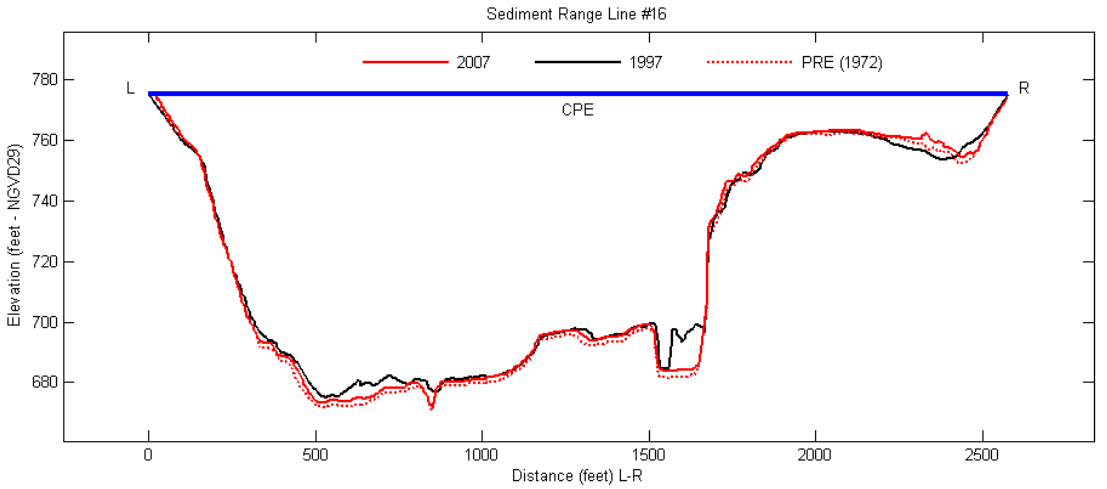
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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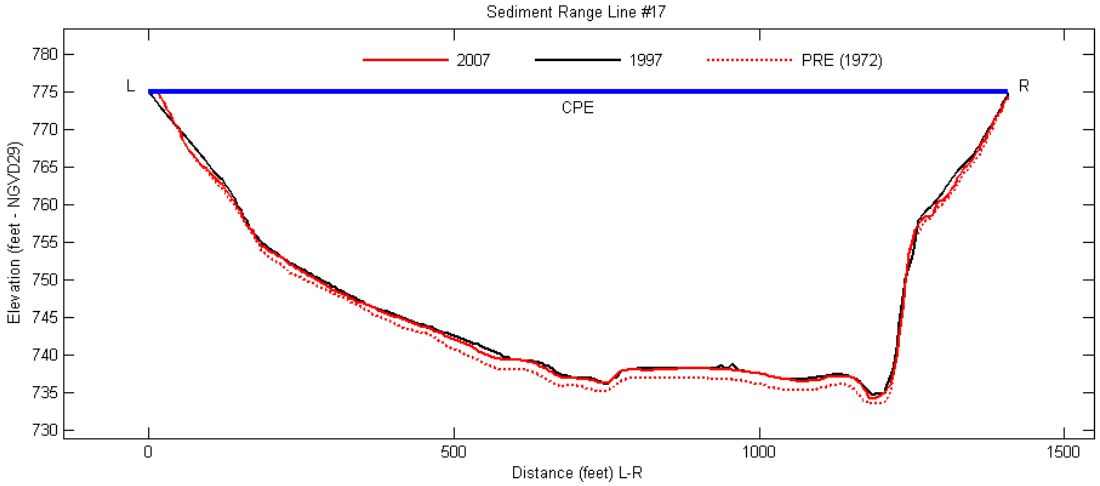
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
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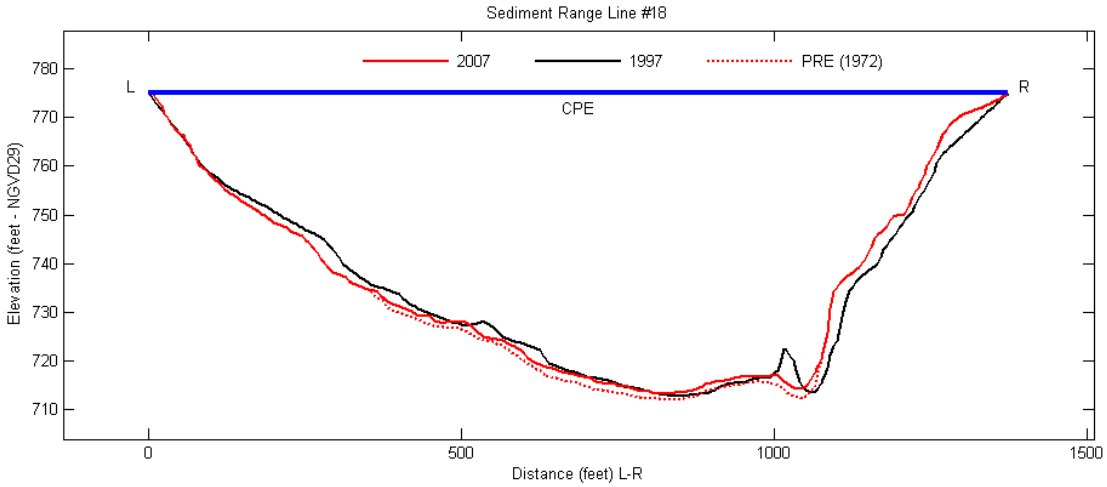
775
770
765
760
755
750
745
740
735
730
0
500
1000
1500
Distance (feet) L-R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1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
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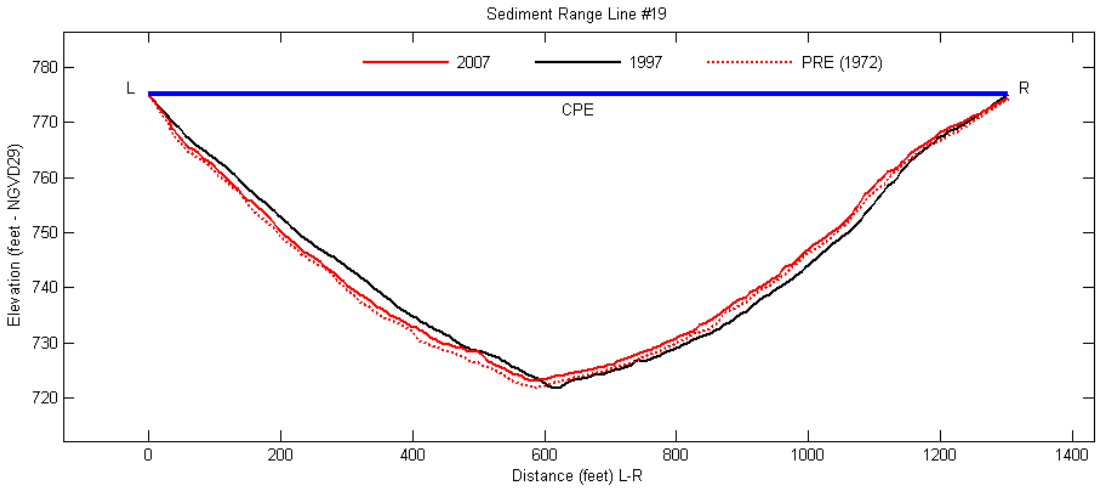
760
750
740
730
720
710
0
500
1000
1500
Distance (feet) L-R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2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
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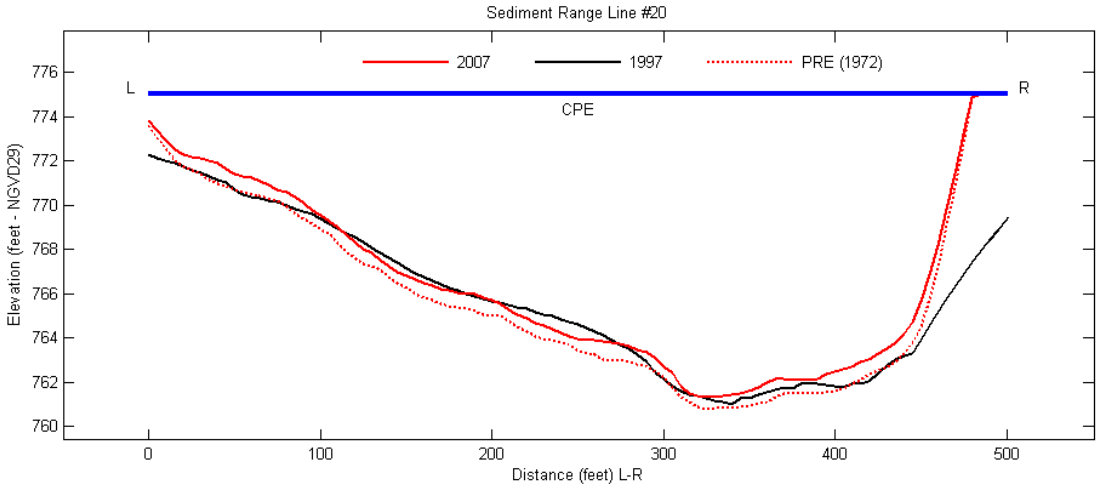
760
750
740
730
720
0
200
400
600
800
1000
1200
1400
Distance (feet) L-R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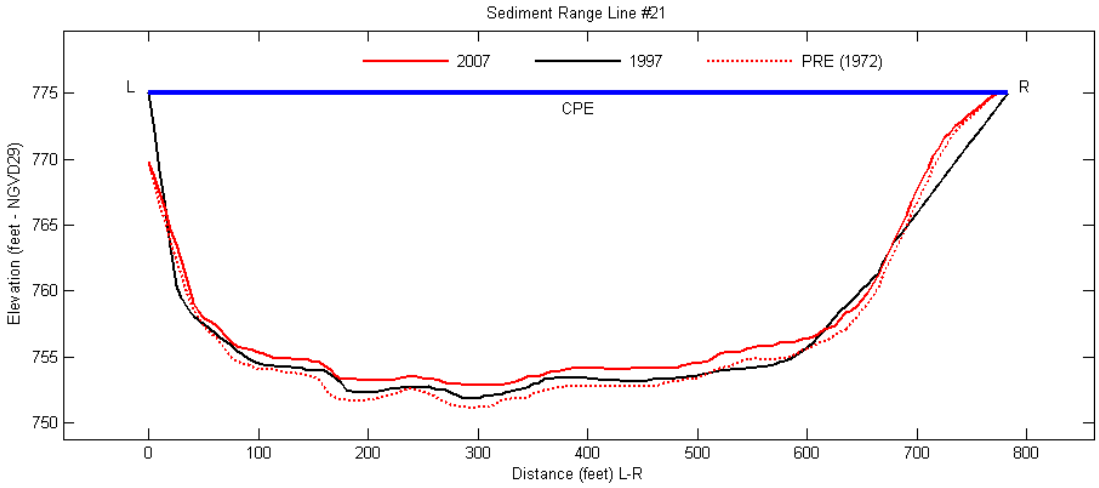
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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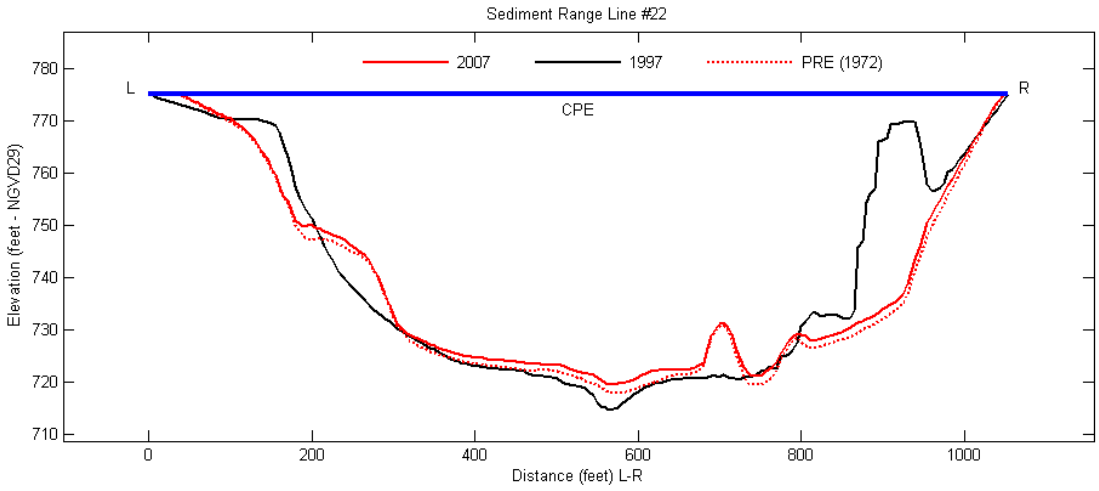
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R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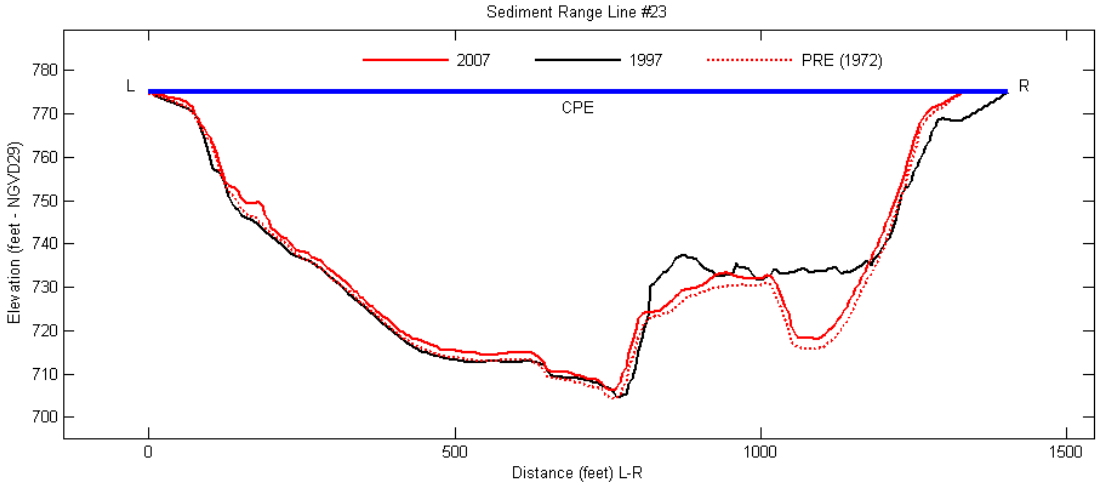
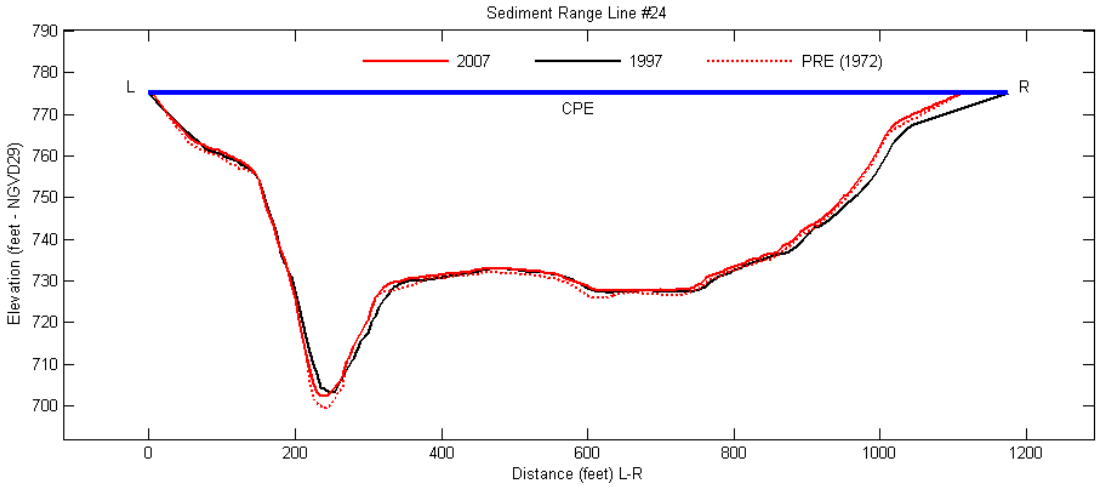
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
Distance (feet) L-R


Sediment Range Line #23
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
780
770
760
750
740
730
720
710
700
0
500
1000
1500
Distance (feet) L-R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1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
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760
750
740
730
720
710
700
0
200
400
600
800
1000
1200
Distance (feet) L-R

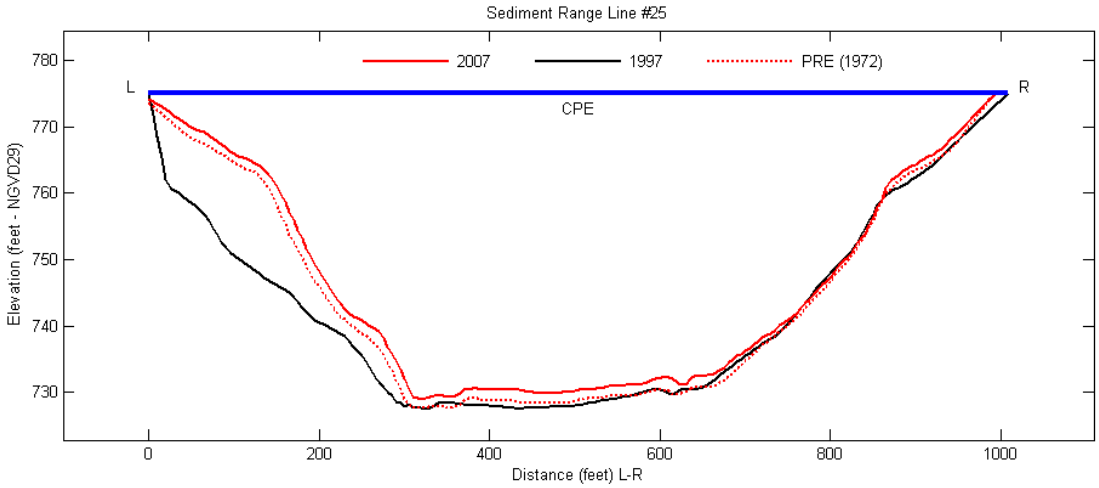

Sediment Range Line #25
2007
1997
PRE (1972)
L
R
CPE
Elevation (feet - NGVD29)
780
770
760
750
740
730
0
200
400
600
800
1000
Distance (feet) L-R

Figure 5

SQUAW CREEK RESERVOIR

10' - Contour Map

2,180,000 2,190,000 2,200,000

6,800,000 6,790,000

CONTOURS

(in feet above mean sea level)

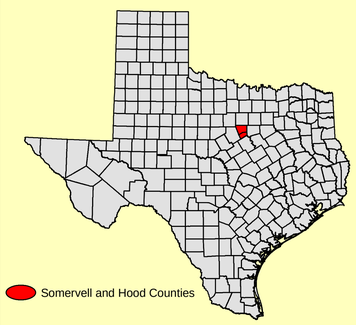
650
660
670
680
690
700
710
720
730
740
750
760
770

Islands

Squaw Creek Reservoir

Conservation Pool Elevation:
755.0 feet above mean sea level

Projection: NAD83
State Plane
Texas North Central Zone



This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Squaw Creek Reservoir. The Texas Water Development Board makes no representation or assumes any liability.

Prepared by: Texas Water Development Board December 2007 Survey

N

0 0.25 0.5 1 Miles