VOLUMETRIC SURVEY
OF
LAKE BRIDGEPORT

Prepared for:

Tarrant Regional Water District

In cooperation with the

United States Army Corps of Engineers

Prepared by
Texas Water Development Board

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Texas Water Development Board

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INTRODUCTION

Staff of the Surface Water Section of the Texas Water Development Board (TWDB) conducted a volumetric survey of Lake Bridgeport between April 4 and April 17, 2000. The survey was conducted to determine the lake's volume at the pool elevation encountered during the survey. Lake levels varied between 821.21 feet and 821.50 feet at that time, or nearly 15 feet below the normal conservation pool elevation of 836.0 feet. Subsequent data was collected between July 25 and August 8, 2001 after the lake had filled to near normal pool elevation. At that time the lake levels varied between 834.04 feet and 832.87 feet. This report compares results from prior surveys to those of the current survey for elevation 836.0 feet and below. Results from this and future surveys will serve as a basis for comparison to allow the location and rates of sediment deposition to be determined. Survey results are presented in both graphical and tabular form in this report.

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gage at Lake Bridgeport (08043000 Bridgeport Reservoir above Bridgeport, Texas). The datum for this gage is reported as mean sea level (msl) (USGS, 1999). Thus, elevations are reported here in feet above mean sea level (msl). Volume and area calculations in this report are referenced to water levels provided by the USGS gage.

Survey data in 1956 for Lake Bridgeport shows the conservation storage capacity, at elevation 836.0 ft msl, to be 386,420 acre-feet, and the corresponding area to be 13,000 acres (TWDB, 1973). The 1968 volume and surface area for Lake Bridgeport at conservation pool elevation, 836.0 ft msl, were reported as 386,559 acres and 12,941 acre-feet, respectively (Freese and Nichols, 1988). In 1988, the volume and area were reported as 374,836 acre-feet and 12,900 acres, respectively, at conservation pool elevation (Freese and Nichols, 1988).

LAKE HISTORY AND GENERAL INFORMATION

Historical information for Lake Bridgeport was obtained from TWDB (1966), TWDB (1973) and Freese and Nichols (1988). The Tarrant Regional Water District (TRWD) owns the water rights to Lake Bridgeport. The District also owns, operates and maintains associated Bridgeport Dam. The lake is located on the West Fork Trinity River (Trinity River Basin) in Wise County, four miles west of Bridgeport, Texas (Figure 1). Records indicate the drainage area is approximately 1,111 square miles. At pool elevation 836.0 feet the lake has approximately 129 miles of shoreline and is approximately 19 miles long. Also at this elevation, the widest point of the lake is approximately 5.9 miles and is located about 2 miles upstream of the dam.

One of the main functions of Lake Bridgeport is to regulate flood flows on the West Fork Trinity River in coordination with the operations (releases) of Eagle Mountain Lake (located downstream of Lake Bridgeport). The Board of Water Engineers issued Water Rights Permit No. 1073 (Application No. 1144) to the Tarrant County Water Control and Improvement District No. 1 on May 1, 1928. The permit authorized the District to construct a dam across the West Fork Trinity River in Wise County and to impound 290,000 acre-feet of water. Annual diversions of 52,000 acre-feet of water for irrigation and 93,000 acre-feet of water to be transported (via the banks of the West Fork Trinity River) downstream to Eagle Mountain Lake for municipal purposes was also granted. Permit No. 1253 was granted to the District on February 28, 1938 as an amendment to Permit 1073. The permit basically included “recreational and pleasure” use of the water in Lake Bridgeport.

On February 19, 1969 Permit No. 1073B authorized the increase in impoundment to 438,510 acre-feet by raising the conservation pool elevation to 840.0 feet. An increase of 5,000 acre-feet of water for municipal purposes and 2,000 acre-feet of water for mining purposes was approved. Again, Permit 1073 (C) was amended on February 22, 1971. The permit reduced the impoundment to 386,000 acre-feet of water at elevation 836.0 feet. TRWD reported that the reason the conservation pool elevation was lowered to 836.0 feet was to have a safe vertical clearance for the Highway 380 bridge that spans the reservoir to the south of the main dam. The permit was amended twice more before the Certificate of Adjudication No. 08-3808 was issued. The Texas Water Commission issued the certificate on April 5, 1985. The certificate authorized the existing reservoir and dam known as

Lake Bridgeport and Bridgeport Dam to impound therein 387,000 acre-feet of water. Tarrant Regional Water District was authorized to use the impounded water for recreational purposes and to divert and use not to exceed 5,000 acre-feet of water per annum for municipal purposes in Wise County. The District could divert and use not to exceed 7,500 acre-feet of water per annum for mining purposes in Wise County. The owner of the certificate was also authorized to release and/or divert 2,500 acre-feet of water per annum for irrigation of 1,250 acres of land in Jack and Wise Counties. One last authorization was granted to use not to exceed 78,000 acre-feet of water per annum from Lake Bridgeport and to transport the stored water to Eagle Mountain for subsequent diversion for municipal and industrial use in Tarrant County.

Construction of Lake Bridgeport and the original Bridgeport Dam started on January 23, 1930. The dam was completed December 15, 1931 and impoundment began on April 1, 1932. The design engineer for the project was Hawley, Freese and Nichols. The general contractor was McKenzie and Uvalde Construction Companies. The estimated cost of the dam was $2,316,000.

Engineering designs (TWDB, 1974) show the original Bridgeport Dam and appurtenant structures to consist of a rolled-earth embankment approximately 1,900 feet in length (including a 60-foot-wide concrete spillway), with a maximum height of 110 feet and a crest elevation of 863.1 feet. The service spillway is a concrete structure located at the south end of the embankment and consists of three 20-foot-wide bays with a crest elevation of 826.2 feet. Lift gates controlled the left and middle bays of the service spillway and the right bay remained uncontrolled.

The facility was designed with two natural-ground emergency spillways. One is located 1.6 miles south of the main dam and has a crest elevation of 853.1 feet. The other emergency spillway is located 0.4 mile north of the main dam and has a crest elevation of 859.1 feet. The outlet works consist of two concrete conduits (approximately 12-foot diameter) that extend through the embankment. Two 48-inch diameter valve gates in each conduit are operated from a control house located on the upstream face of the embankment. The invert elevation of the valve gates is 751.4 feet. It was reported by TRWD that presently two of the four outlet works are operable. One outlet is used to supply water to local communities and the other is used for downstream releases.

A levee dam (named Berkshire Levee) was constructed at the facility approximately 3.5 miles south of the main dam. The levee dam is approximately 4,100 feet in length. Water reaches the toe of the levee dam when the stage height is at elevation 835.1 feet.

In 1971 modifications were made at the facility to enlarge the impoundment of Lake Bridgeport. This involved building a new spillway approximately 3,000 feet north of the main dam. The service spillway consists of an excavated channel from the lake to the concrete structure. The ogee crest of the spillway is 90 feet in length at elevation 820.0 feet. Eight vertical lift gates rest on the ogee crest. The elevation of the top of the gates is 842.0 feet. Under normal reservoir operations, these gates maintain the reservoir at conservation pool elevation of 836.0 feet. With the addition of the new spillway, the original three bay service spillway that was part of the main dam was closed (concrete) permanently.

New outlet works were added as part of the modification. A 60-inch diameter steel pipe with entrance elbow is located in part of the spillway wall. The invert elevation of the elbow is 810.0 feet and is controlled by a slide gate at the discharge end of the pipe.

Freese, Nichols, and Endress were the consulting engineers and H. B. Zachry Company was the contractor for the modification. The work was completed in October 1972 at an estimated cost of $3,000,000.

SURVEYING TECHNOLOGY

The equipment used to perform the volumetric survey consists of a 23-foot aluminum tri-hull SeaArk craft with cabin, equipped with twin 90-Horsepower Honda outboard motors. (Reference to brand names throughout this report does not imply endorsement by TWDB). Installed inside the enclosed cabin are a Coastal Oceanographics Helmsman Display (for navigation), an Innerspace Technology Model 449 Depth Sounder and Model 443 Velocity Profiler, Trimble Navigation, Inc. 4000SE GPS receiver, an OmniSTAR receiver, and an on-board 486 computer. A water-cooled generator provides electrical power through an in-line uninterruptible power supply. In shallow areas and where navigational hazards (tree stumps) were present, a 20-foot aluminum flat-bottom SeaArk craft with cabin and equipped with one 115-Horsepower Evinrude outboard motor was used. The portable data collection equipment on-board the boat included a Knudsen 320 B/P Echosounder (depth sounder), a Trimble Navigation, Inc. 4000SE GPS receiver, an OmniSTAR receiver, and a 486 laptop computer.

The GPS equipment, survey vessel, and depth sounder in combination provide an efficient hydrographic survey system. The depth sounder takes approximately ten bottom readings per second as the boat traverses the lake. The depth readings are stored on the survey vessel's on-board computer along with the corrected positional data generated by the boat's GPS receiver. The daily data files collected are downloaded from the computer and brought to the office for editing after the survey is completed. During editing, poor-quality data is removed or corrected, multiple data points are averaged to get one data point per second, and average depths are converted to elevation readings based on the lake elevation recorded on the day the survey was performed. Accurate estimates of the lake volume can be quickly determined by building a 3-D model of the reservoir from the collected data.

PRE-SURVEY PROCEDURES

The reservoir's boundary was digitized using Environmental Systems Research Institute’s (ESRI) Arcview from digital orthophoto quadrangle images (DOQ’s). The DOQ's were produced by VARGIS of Texas LLC for the TEXAS Orthoimagery Program (TOP). The DOQ products produced for the Department of Information Resources and the GIS Planning Council under the Texas Orthoimagery Program reside in the public domain. More information can be obtained on the Internet at http://www.tnris.state.tx.us/DigitalData/doqs.htm. The map boundary was created from the Crafton, Chico, Wizard Wells and Bridgeport West, Texas DOQs. The lake elevation at the time the DOQs were photographed was 836.04 feet (February 2, 1995). The survey layout was designed by placing survey track lines at 500-foot intervals within the digitized lake boundary using HyPack software. The survey design required the use of approximately 386 survey lines along the length of the lake.

SURVEY PROCEDURES

Equipment Calibration and Operation

Each day prior to surveying the depth sounder was calibrated with the Innerspace Velocity Profiler, an instrument used to measure the variation in the speed of sound at different depths in the water column. The average speed of sound through the entire water column below the boat was determined by averaging local speed-of-sound measurements collected through the water column. The velocity profiler probe was first placed in the water to moisten and acclimate the probe. The probe was next raised to the water surface where the depth was zeroed. The probe was then gradually lowered on a cable to a depth just above the lake bottom, and then raised to the surface. During this lowering and raising procedure, local speed-of-sound measurements were collected, from which the average speed was computed by the velocity profiler. This average speed of sound was entered into the ITI449 depth sounder, which then provided the depth of the lake bottom. The depth was then checked manually with a measuring tape to ensure that the depth sounder was properly calibrated and operating correctly.

On the shallow draft boat the depth sounder was calibrated using the "bar check" feature in the Knudsen software program. This was performed by adjusting the speed of sound setting on the Knudsen echosounder until the displayed depths matched the manually measured depth. The manual measurement was obtained using a stadia (survey) rod.

The average speed of sound in the water column ranged from 4,801feet per second to 4,825 feet per second during the survey. Based on the measured speed of sound for various depths and the average speed of sound calculated for the entire water column, the depth sounder is accurate to within ±0.2 feet. An additional estimated error of ±0.3 feet arises from variation in boat inclination. These two factors combine to give an overall accuracy of ±0.5 feet for any instantaneous reading. These errors tend to be minimized over the entire survey, since some readings are positive and some are negative. Further information on these calculations is presented in Appendix H.

During the survey, the horizontal mask setting on the on-board GPS receiver was set to 10°, and the PDOP (Position Dilution of Precision) limit was set to 7 to maximize the accuracy of the horizontal positioning. An internal alarm sounds if PDOP rises above seven to alert the field crew that the horizontal position has degraded to an unacceptable level. The initialization file used by the Hypack data collection program was set up to convert the collected DGPS positions on-the-fly to state-plane coordinates.

Field Survey

TWDB staff collected data at Lake Bridgeport for eight days between April 4 and April 17, 2000 and five days between July 25 and August 8, 2001. Elevations provided by USGS gauging station 08043000 at Lake Bridgeport varied between 821.21 feet to 821.50 feet during the April 2000 survey and 834.04 feet to 832.87 feet during the July-August 2001 survey. During most of the data collection period, days were sunny, with warm temperatures and 10 to 20 mile-per-hour winds. The crew was delayed a few hours due to adverse weather during the week of April 10, 2000.

The survey crew collected data on 386 of the 426 pre-plotted survey transects in the lake. Random data was collected along the shoreline and in those areas that were too restricted to drive the pre-plotted lines. Over 200,400 data points were collected over the 371 miles traveled. These points, shown in Figure 2, were stored digitally on the boat's computer in 737 data files. Survey data was collected along most of the perimeter of the lake to help establish the boundary for elevation 836.0 feet. This boundary was used in the modeling process.

Tributaries originating from several directions form the main body of Lake Bridgeport. The West Fork Trinity River meanders in a west to east direction and empties into the main body at the north end of the basin. Several creeks empty into the lake in an area south of the U. S Highway 380 bridge known as Runaway Bay.

TWDB staff observed the terrain surrounding the lake to have characteristics typical of north central Texas rolling hills. With the lake nearly 15 feet below conservation pool elevation during the April 2000 survey, much of the terrain that was observed along the perimeter of the lake would normally be inundated. Major relief with steep hills and valleys and outcrops of sandstone was observed along the east bank of the lake basin. This area stretched between the Lakeview subdivision and the Twin Hills subdivision, including the new spillway and main dam. This community, known as Lake Bridgeport, along with Runaway Bay and Blockers Camp (on the river portion of the lake), were the most developed areas surrounding the lake. The remaining land surrounding the lake basin was fairly flat and was either undeveloped or used for grazing. Several petroleum wells were located in the lake basin area. No major bank erosion was noted.

While performing the survey the field crew noted on the depth sounder chart that the lake bathymetry was fairly regular (no major drops or rises in the bathymetry) in the main basin of the lake. During the April 2000 survey, several islands were exposed in the main basin due to the low water levels. Data was collected around the perimeter of all the exposed islands. A defined channel (thalweg) for the West Fork Trinity River was evident on the analog chart as the crew traveled in a parallel (east and west) direction in the northern portion of the main basin of the lake.

Navigational hazards in the form of submerged stumps and shallow depths outside the old river channel were encountered in the upper reaches of Lake Bridgeport on the West Fork Trinity River. Data was collected in this area with the shallow draft boat at a much slower rate. Data collection was halted when depths in the upper reaches of the lake became less than one foot.

The collected data was stored in individual data files for each pre-plotted range line or random data collection event. These files were downloaded to diskettes at the end of the day for subsequent processing.

Data Processing

The collected data were downloaded from diskettes onto TWDB's computer network. Tape backups were made for future reference as needed. To process the data, the EDIT routine in the Hypack Program was run on each raw data file. Data points such as depth spikes or data with missing depth or positional information were deleted from the file. A correction for the lake elevation at the time of data collection was also applied to each file during the EDIT routine. During the April 2000 survey, the water surface fluctuated between elevation 821.21 and 821.50 feet. During the July-August 2001 survey, the water surface fluctuated between elevation 834.04 and 832.87 feet. Elevation data was provided by USGS elevation gage 08043000 Bridgeport Reservoir above Bridgeport, Texas. After all corrections were applied to the raw data file, the edited file was saved with a different extension. The edited files were combined into a single (x,y,z) data file to be used with the GIS software to develop a model of the lake's bottom surface.

The resulting data file was downloaded to a Sun Ultra 10 workstation running the UNIX operating system. Environmental System Research Institute’s (ESRI) Arc/Info GIS software was used to convert the data to a MASS points file. The MASS points and the boundary file were then used to create a Digital Terrain Model (DTM) of the lake's bottom surface using Arc/Info's TIN software module. The module generates a triangulated irregular network (TIN) from the data points and the boundary file using a method known as Delauney's criteria for triangulation. A triangle is formed between three non-uniformly spaced points, including all points along the boundary. If there is another point within the triangle, additional triangles are created until all points lie on the vertex of a triangle. All of the data points are used in this method. The generated network of three-dimensional triangular planes represents the actual bottom surface. With this representation of the bottom, the software then calculates elevations along the triangle surface plane by determining the elevation along each leg of the triangle. The lake area and volume can be determined from the triangulated irregular network created using this method of interpolation.

Volumes presented in Appendices A and C were calculated from the TIN using Arc/Info software. Surface areas presented in Appendices B and D were computed using Arc/Info software below elevation 836.0 feet.

Other products developed from the model include a shaded elevation range map (Figure 3) and a shaded depth range map (Figure 4). To develop these maps, the TIN was converted to a lattice using the TINLATTICE command and then to a polygon coverage using the LATTICEPOLY command. Linear filtration algorithms were applied to the DTM to produce smooth cartographic contours. The resulting elevation contour map of the bottom surface at two-foot intervals is presented in Figure 5.

RESULTS

Results from the 2000-2001 TWDB survey indicate Lake Bridgeport encompasses 11,954 surface acres and contains a total volume of 366,236 acre-feet at the pool elevation of 836.0 feet. Dead pool storage, the volume below the invert elevation of the low-flow outlet pipe at 751.4 feet, is 0 acre-feet. Thus, the conservation storage at elevation 836.0 (total volume - dead storage) for Lake Bridgeport is 366,236 acre-feet. The shoreline at pool elevation 836.0 feet was calculated to be approximately 129 miles. The deepest point of the lake measured during the survey was 76.5 feet and corresponds to an elevation of 759.5 feet and was located approximately 530 feet upstream from the center of Bridgeport Dam.

SUMMARY AND COMPARISONS

Lake Bridgeport was initially impounded in 1932. Storage in 1956 at pool elevation 836.0 feet msl was reported as 386,420 acre-feet, and the area was reported as 13,000 acres (TWDB, 1973). At the same elevation, storage in 1968 was reported as 386,559 acre-feet with a surface area of 12,941 acres (Freese and Nichols, 1988). The volume and area in 1988 were reported as 374,836 acre-feet and 12,900 acres, respectively.

TWDB staff performed a volumetric survey of Lake Bridgeport between April 4 and April 17, 2000 with additional data being collected between July 25, 2001 and August 8, 2001. Utilizing differential global positioning systems technology and geographical information systems technology TWDB staff created a digital model of the lake's bathymetry. Results indicate that the lake's volume at pool elevation 836.0 feet is 366,236 acre-feet, with a corresponding area of 11,954 acres.

Comparisons between the 1956, 1968, 1988 and present (2000-2001) surveys are presented in Table 1 for elevation 836.0 feet msl. Possibly because of differences in methodology between surveys, direct comparisons between results are difficult, and results are not consistent between surveys. The area at elevation 836.0 was found to decrease linearly with time after 1968. The small volume increase from 1956 to 1968 is probably due to differences or accuracy of the methodology. Decreases in volume from 1968, 1988 and 2001 are probably from sedimentation. Comparing between the 1968 and 2001 results, the area was found to decrease by 41 acres (-0.3 %), and the volume was found to decrease by 11,723 acre-feet (-3.0 %). The difference in volume between the 1968 and 2001 data (volume measured in 2001 - volume measured in 1968) are presented in Appendix E for elevations between 760 feet and 836 feet msl. A similar plot for difference in area (area measured in 2001 - area measured in 1968) is presented in Appendix F. The loss in area shown in Appendix F between elevations 770 feet and 780 feet msl, and again between 807 feet and 836 feet msl, suggest that sedimentation occurs primarily between these elevations. The later elevations being contained in the areas of light blue on Figure 4. There is no evidence of erosion (increases in area) within the boundary of the lake for the data shown in Appendix F. Again, comparison between the data sets is difficult and some changes might simply be due to methodological differences.

It is recommended that another survey be completed when the lake reaches conservation pool elevation to allow comparisons up to that depth. It is also recommended that another survey be conducted in five to ten years or following major flood events to monitor changes to the lake's area and volume using the same methodology used in the current survey.

Table 1. Area and volume comparisons at elevation 836.0 feet msl.

Year	1956	1968	1988	2001
Area (acres)	13,000	12,941	12,900	11,954
Volume (acre-feet)	386,420	386,559	374,836	366,236

REFERENCES

1. Texas Water Development Board. 1966. Dams and Lakes in Texas, Historical and Descriptive Information. Report 48.

2. Texas Water Development Board. 1973. Engineering Data on Dams and Lakes in Texas. Part II Report 126.

3. Freese and Nichols. 1988. Lake Bridgeport / Eagle Mountain Lake Sedimentation Survey.

4. United States Geological Survey. 1999. Water Resources Data–Texas. Water Year 1999. Volume 2. Trinity River Basin.

Appendix A
Lake Bridgeport
RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD AUGUST 2001 SURVEY

VOLUME IN ACRE-FEET 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
759						0	0	0	0	0
760	0	0	0	0	0	0	0	0	0	0
761	0	0	0	0	0	1	1	1	1	1
762	1	1	1	1	2	2	2	2	2	3
763	3	3	3	4	4	4	5	5	5	6
764	6	7	7	8	8	9	10	10	11	12
765	13	14	15	16	17	18	19	21	22	24
766	25	27	29	31	33	35	37	39	42	44
767	47	49	52	55	58	61	64	67	70	73
768	77	81	84	88	92	96	100	104	109	113
769	118	123	127	132	138	143	148	154	160	165
770	171	178	184	190	197	204	211	218	226	233
771	241	249	257	266	274	283	292	302	311	321
772	332	342	353	364	375	387	399	412	425	438
773	452	466	481	497	513	530	548	567	587	608
774	630	653	679	705	734	764	796	829	864	901
775	940	980	1022	1065	1111	1157	1206	1255	1306	1359
776	1413	1469	1526	1585	1646	1709	1773	1841	1911	1983
777	2059	2138	2221	2306	2394	2485	2579	2675	2774	2875
778	2978	3085	3193	3304	3416	3531	3648	3767	3888	4011
779	4135	4262	4390	4521	4653	4788	4924	5063	5203	5346
780	5490	5637	5785	5935	6087	6241	6397	6554	6713	6874
781	7037	7202	7370	7541	7714	7890	8068	8248	8431	8615
782	8801	8989	9179	9371	9565	9760	9957	10156	10357	10559
783	10764	10970	11178	11388	11600	11813	12029	12246	12465	12686
784	12908	13133	13359	13587	13817	14048	14281	14516	14752	14990
785	15229	15470	15713	15958	16204	16451	16701	16951	17203	17457
786	17712	17969	18227	18487	18748	19011	19276	19542	19810	20080
787	20350	20623	20896	21172	21449	21727	22007	22289	22572	22857
788	23143	23431	23720	24011	24304	24597	24893	25190	25488	25789
789	26090	26394	26699	27006	27314	27625	27936	28250	28565	28883
790	29201	29521	29844	30167	30492	30818	31146	31476	31806	32139
791	32473	32808	33146	33484	33825	34167	34511	34856	35203	35552
792	35901	36253	36607	36961	37318	37676	38036	38397	38760	39124
793	39489	39856	40224	40594	40965	41337	41710	42085	42461	42838
794	43217	43597	43978	44360	44744	45129	45516	45904	46293	46684
795	47076	47469	47865	48261	48659	49059	49460	49863	50266	50672
796	51078	51486	51896	52307	52720	53135	53551	53969	54389	54810
797	55233	55658	56085	56513	56943	57375	57808	58243	58679	59118
798	59557	59999	60442	60887	61334	61782	62232	62684	63137	63592
799	64049	64507	64967	65428	65891	66356	66823	67292	67762	68235
800	68708	69184	69661	70140	70621	71103	71587	72074	72562	73053
801	73545	74040	74537	75035	75536	76038	76542	77049	77557	78067
802	78579	79093	79609	80127	80647	81168	81691	82217	82744	83273
803	83804	84336	84871	85407	85945	86485	87026	87569	88115	88662
804	89211	89763	90316	90871	91429	91988	92548	93111	93676	94243
805	94811	95382	95955	96530	97107	97686	98267	98851	99436	100024
806	100614	101206	101801	102398	102998	103599	104203	104810	105418	106029
807	106641	107255	107871	108489	109109	109730	110354	110979	111606	112236
808	112867	113500	114134	114771	115409	116049	116690	117334	117979	118626
809	119275	119925	120578	121232	121888	122545	123205	123866	124529	125195
810	125861	126530	127201	127873	128547	129223	129900	130580	131261	131945
811	132629	133316	134005	134695	135387	136081	136776	137474	138172	138873
812	139575	140279	140985	141692	142402	143113	143826	144541	145257	145976
813	146696	147418	148142	148867	149595	150324	151055	151788	152522	153259
814	153997	154738	155480	156224	156971	157719	158469	159222	159976	160733
815	161491	162252	163016	163781	164549	165318	166090	166865	167641	168421

Appendix A (continued)

Lake Bridgeport

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD AUGUST 2001 SURVEY

VOLUME IN ACRE-FEET 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
816	169202	169986	170772	171561	172352	173145	173940	174738	175537	176340
817	177144	177950	178760	179571	180385	181200	182018	182840	183663	184489
818	185316	186147	186980	187815	188652	189492	190333	191178	192024	192873
819	193723	194575	195431	196287	197147	198008	198871	199736	200603	201472
820	202343	203215	204090	204966	205844	206724	207605	208489	209373	210260
821	211149	212038	212931	213824	214719	215616	216514	217415	218317	219221
822	220126	221033	221943	222853	223766	224680	225595	226513	227432	228353
823	229275	230199	231126	232053	232983	233914	234846	235781	236718	237656
824	238596	239537	240481	241426	242374	243322	244272	245225	246179	247136
825	248093	249055	250018	250983	251951	252920	253891	254865	255840	256818
826	257798	258779	259763	260749	261737	262727	263719	264713	265709	266708
827	267709	268711	269717	270724	271733	272745	273758	274775	275793	276814
828	277837	278863	279893	280924	281959	282995	284034	285076	286120	287168
829	288217	289269	290324	291381	292441	293503	294567	295633	296702	297773
830	298846	299922	301001	302081	303164	304248	305335	306424	307514	308606
831	309700	310796	311893	312992	314093	315195	316298	317404	318510	319619
832	320728	321839	322952	324065	325181	326297	327415	328535	329655	330778
833	331901	333025	334152	335279	336408	337538	338670	339803	340937	342073
834	343210	344348	345488	346629	347772	348916	350061	351208	352355	353505
835	354655	355807	356961	358115	359271	360428	361587	362747	363909	365072
836	366236									

Appendix B

Lake Bridgeport

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD

AUGUST 2001 SURVEY

AREA IN ACRES

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
759						0	0	0	0	0
760	0	0	0	0	0	0	0	0	0	0
761	0	1	1	1	1	1	1	1	1	1
762	1	1	1	2	2	2	2	2	2	2
763	2	3	3	3	3	3	4	4	4	4
764	5	5	5	5	6	6	7	7	8	8
765	9	10	10	11	12	12	13	14	15	16
766	17	18	19	20	21	22	22	23	24	25
767	26	27	28	28	29	30	31	32	33	34
768	35	36	37	38	40	41	42	43	44	46
769	47	48	50	51	52	54	55	56	58	59
770	61	63	64	66	68	69	71	73	75	77
771	79	81	83	86	88	90	93	95	98	100
772	103	106	109	112	116	119	123	127	131	136
773	141	147	153	160	168	176	184	193	203	215
774	228	243	259	275	292	310	327	343	360	376
775	393	411	428	444	460	475	490	505	519	534
776	549	565	582	599	617	637	659	685	712	742
777	776	808	838	867	898	923	948	975	1000	1024
778	1049	1073	1095	1117	1138	1158	1179	1199	1218	1237
779	1256	1275	1296	1316	1335	1355	1374	1394	1415	1436
780	1456	1475	1493	1511	1528	1546	1564	1581	1599	1619
781	1641	1666	1694	1721	1746	1769	1793	1814	1833	1852
782	1871	1891	1910	1927	1944	1961	1980	1998	2017	2036
783	2054	2071	2090	2109	2127	2145	2163	2181	2199	2217
784	2235	2254	2271	2288	2305	2321	2338	2354	2370	2388
785	2405	2421	2436	2452	2468	2483	2499	2514	2529	2543
786	2558	2574	2590	2606	2623	2639	2656	2671	2686	2701
787	2715	2730	2745	2761	2778	2794	2810	2825	2840	2855
788	2870	2885	2900	2915	2931	2947	2962	2978	2994	3010
789	3027	3043	3059	3076	3094	3110	3127	3145	3162	3179
790	3196	3212	3227	3242	3257	3271	3286	3301	3316	3331
791	3347	3364	3380	3397	3415	3430	3445	3460	3476	3491
792	3509	3525	3541	3557	3573	3589	3605	3619	3634	3647
793	3661	3675	3689	3702	3715	3728	3741	3754	3767	3780
794	3793	3805	3818	3832	3845	3858	3872	3886	3900	3914
795	3928	3943	3958	3974	3989	4003	4018	4032	4046	4061
796	4075	4089	4104	4120	4136	4153	4171	4189	4206	4223
797	4241	4258	4275	4292	4309	4324	4340	4356	4373	4389
798	4406	4423	4441	4459	4476	4493	4509	4525	4541	4557
799	4573	4589	4606	4623	4642	4661	4679	4696	4713	4730
800	4746	4763	4780	4797	4815	4834	4854	4874	4895	4917
801	4938	4957	4976	4995	5014	5033	5053	5073	5092	5111
802	5130	5149	5168	5186	5206	5225	5244	5263	5282	5300
803	5317	5335	5352	5370	5387	5405	5424	5443	5463	5484
804	5504	5524	5543	5562	5581	5599	5618	5638	5657	5677
805	5697	5718	5738	5759	5780	5801	5823	5845	5867	5889
806	5911	5935	5959	5983	6008	6030	6052	6073	6094	6113
807	6132	6151	6170	6189	6208	6226	6245	6263	6282	6301
808	6320	6338	6356	6373	6391	6408	6425	6443	6461	6479
809	6496	6514	6532	6550	6568	6586	6604	6623	6641	6660
810	6678	6696	6714	6731	6749	6768	6786	6804	6823	6841
811	6859	6877	6895	6912	6929	6946	6962	6979	6996	7013
812	7031	7049	7067	7086	7104	7122	7139	7157	7175	7193
813	7211	7229	7246	7264	7282	7300	7319	7337	7356	7375
814	7394	7414	7433	7453	7473	7493	7513	7534	7555	7578
815	7599	7621	7642	7664	7686	7710	7733	7756	7779	7803

Appendix B (continued)

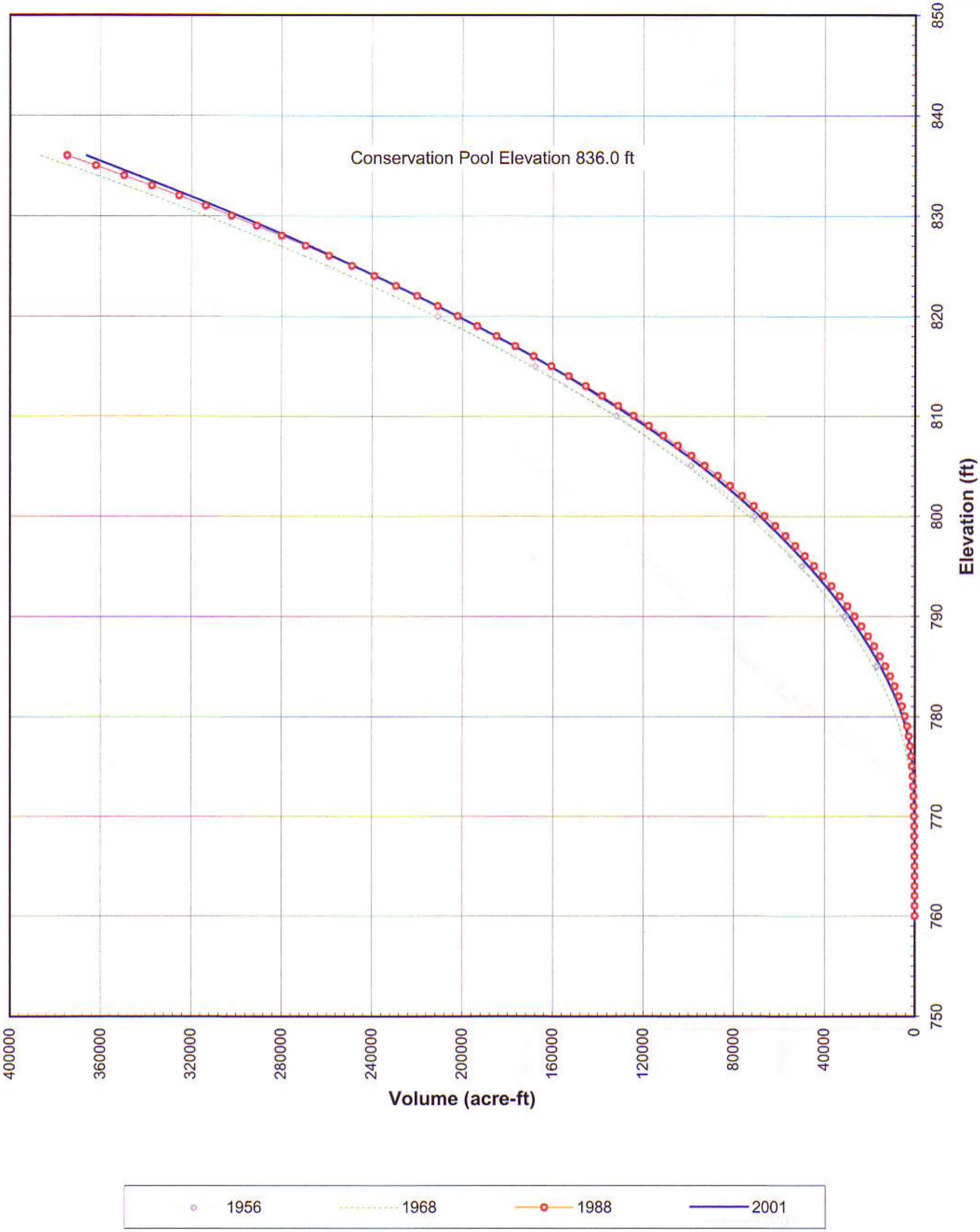
Lake Bridgeport

RESERVOIR AREA TABLE

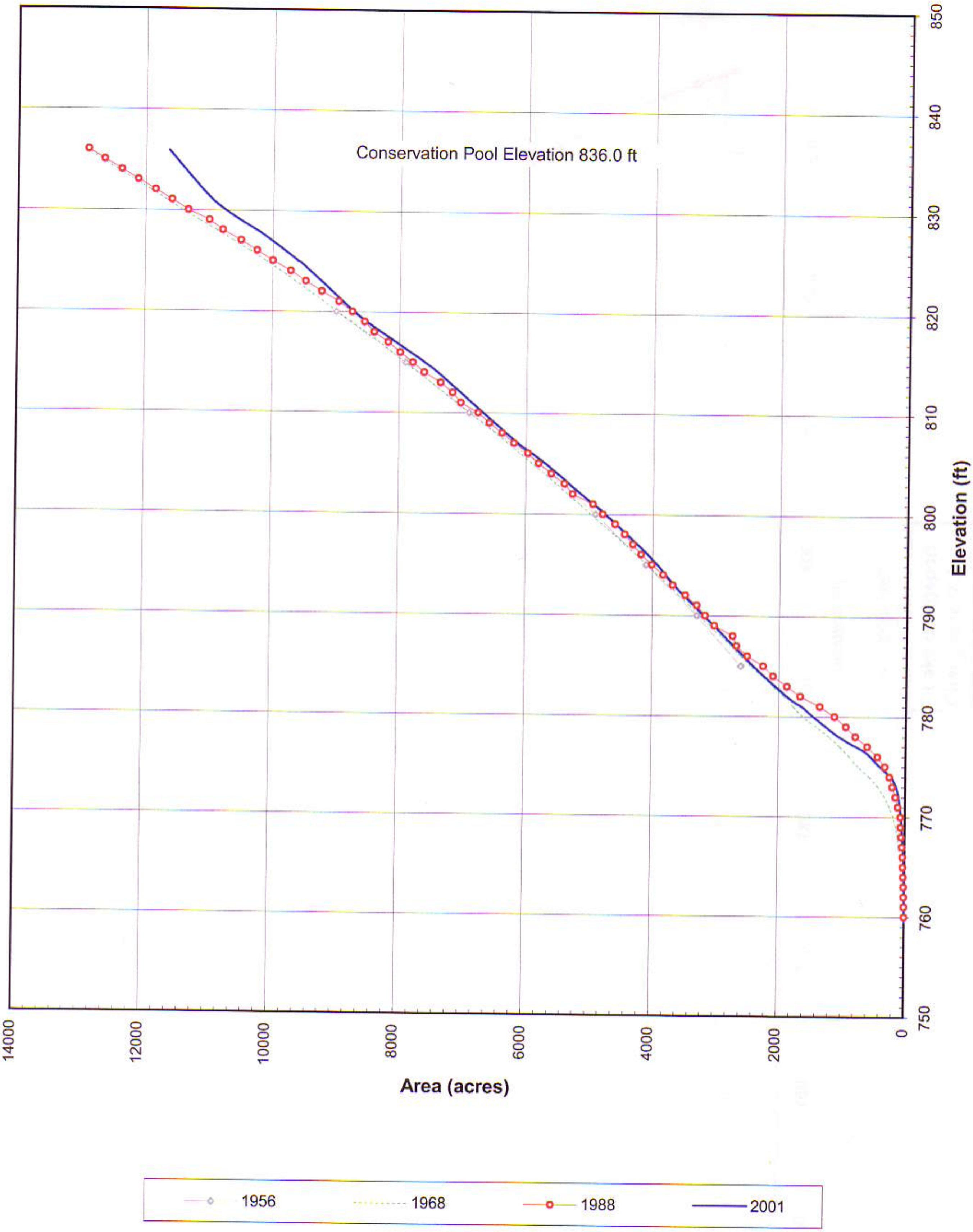
TEXAS WATER DEVELOPMENT BOARD — AUGUST 2001 SURVEY

AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

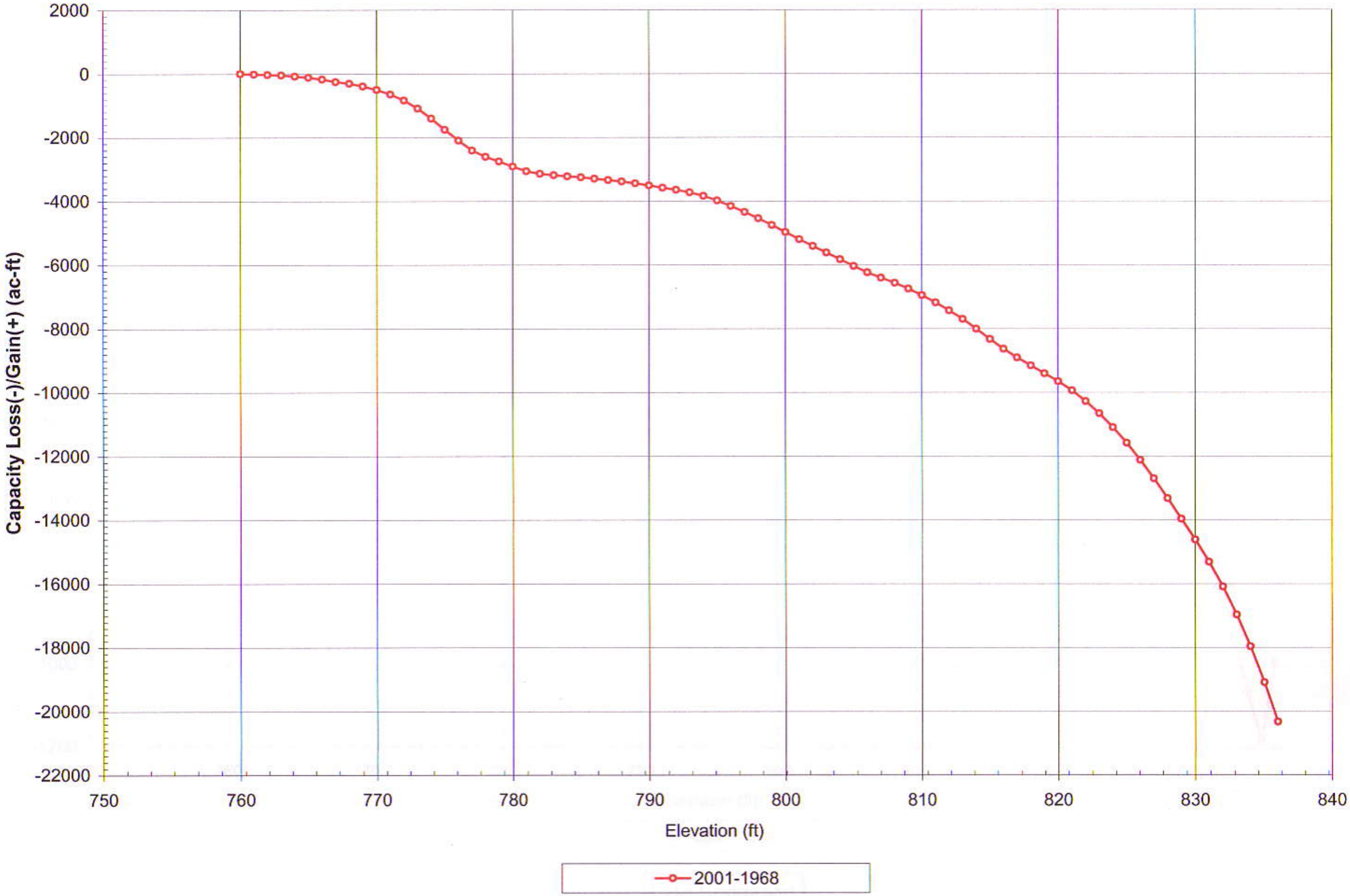
ELEVATION IN FEET	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
816	7827	7850	7874	7897	7920	7943	7965	7988	8010	8032
817	8055	8078	8101	8124	8148	8172	8196	8220	8245	8269
818	8293	8317	8340	8362	8384	8406	8429	8451	8474	8496
819	8517	8538	8559	8580	8601	8621	8641	8661	8679	8698
820	8717	8735	8754	8772	8789	8807	8824	8841	8858	8875
821	8892	8909	8926	8944	8961	8978	8995	9012	9029	9046
822	9063	9080	9098	9115	9132	9149	9166	9183	9200	9217
823	9234	9251	9268	9285	9303	9320	9338	9355	9373	9391
824	9408	9426	9444	9462	9479	9497	9515	9533	9551	9570
825	9606	9624	9643	9662	9682	9703	9724	9745	9766	9787
826	9807	9828	9848	9868	9889	9910	9932	9954	9975	9996
827	10017	10039	10061	10083	10105	10127	10150	10173	10196	10220
828	10247	10276	10303	10329	10355	10380	10405	10431	10457	10482
829	10508	10534	10560	10584	10608	10631	10654	10676	10698	10721
830	10746	10770	10793	10816	10837	10857	10876	10895	10914	10932
831	10949	10966	10982	10998	11013	11029	11044	11059	11075	11089
832	11103	11117	11131	11145	11159	11173	11186	11200	11214	11227
833	11241	11255	11268	11282	11296	11309	11323	11337	11350	11364
834	11377	11391	11404	11418	11432	11445	11459	11472	11486	11499
835	11513	11526	11540	11553	11567	11580	11594	11607	11621	11634
836	11954									



Lake Bridgeport
Surveyed by: TWDB August 2001

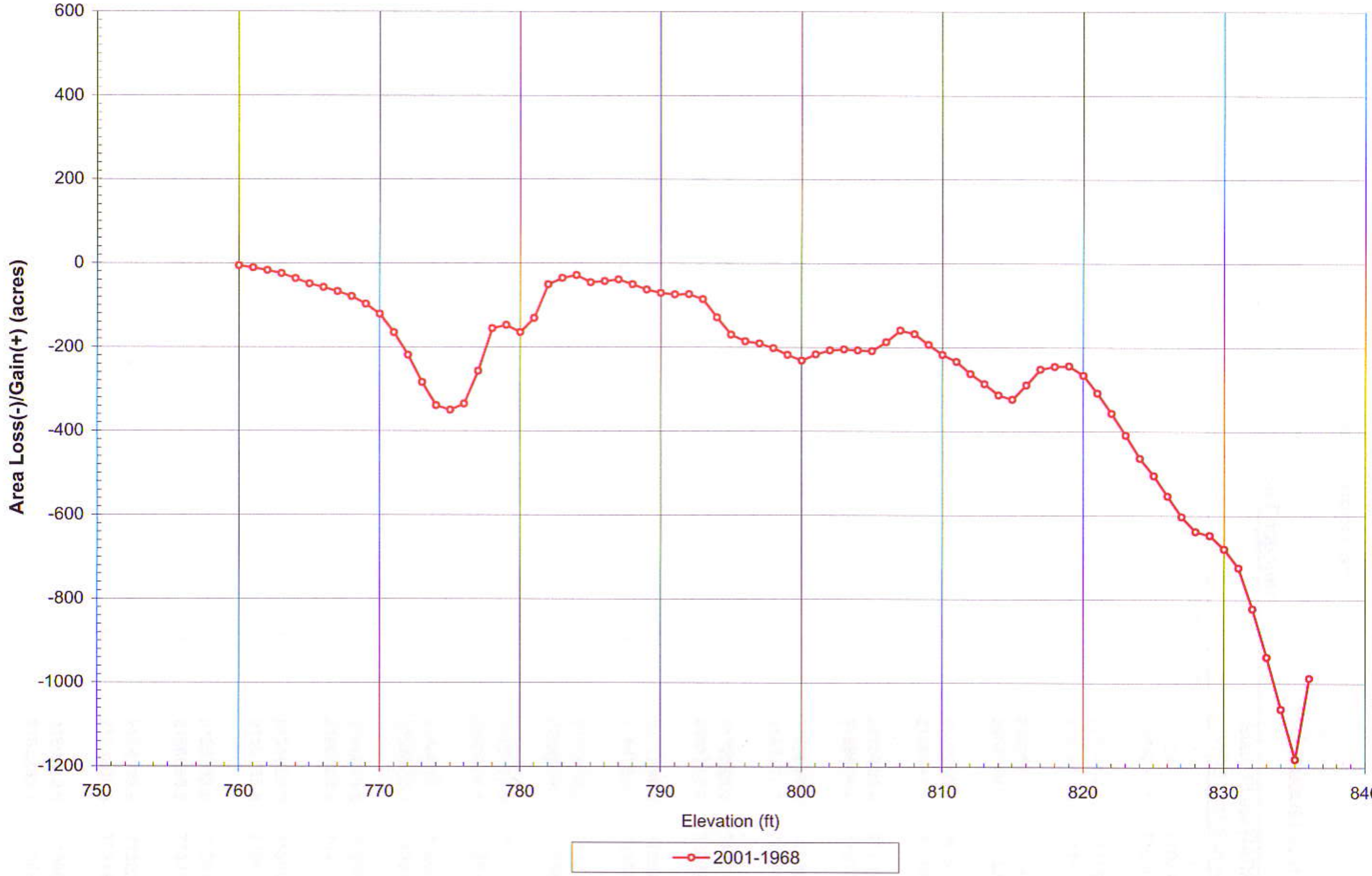


Lake Bridgeport
Surveyed by: TWDB August 2001



Lake Bridgeport Changes in Volume

Appendix E



Lake Bridgeport Changes in Area

Appendix F

Appendix G

Lake Bridgeport

TEXAS WATER DEVELOPMENT BOARD — AUGUST 2001 SURVEY

Range Line Endpoints

State Plane NAD27 Units-feet from 1988 Sedimentation Survey					State Plane NAD83 Units-feet TWDB 2001 Survey	
	X	Y	Elevation	Range Line	X	Y
1	1888081.72	545792.63	834.57	A	2162471.1	7107900.3
2	1889807.36	544481.56	837.90	A'	2164211.1	7106616.5
3	1892816.93	548185.38	835.07	B	2165407.8	7110579.2
4	1890839.86	549158.67	832.46	B'	2167218.6	7110342.3
6	1894027.10	551135.66	851.08	C	2163554.7	7110627.0
7	1888127.70	549347.80	841.27	C'	2167758.1	7112340.9
8	1881777.47	553108.42	835.48	D	2168352.5	7113304.3
9	1895344.56	553406.01	854.13	D'	2156087.6	7115165.2
10	1884278.92	558955.89	834.85	E	2170425.6	7119381.5
11	1896171.62	557188.92	863.23	E'	2158545.7	7121030.1
12	1883448.93	562818.40	839.48	F	2172020.5	7123231.8
13	1897774.21	561023.82	834.60	F'	2157710.1	7124885.4
14	1869570.37	565822.60	837.35	G	2172522.0	7126532.9
15	1898306.09	564321.24	843.22	G'	2163213.2	7131223.2
16	1889041.30	569099.60	834.25	H	2171249.2	7133905.3
17	1890080.71	571682.51	837.95	H'	2164233.8	7133815.6
18	1897069.87	571705.16	834.61	I	2170919.2	7135848.7
19	1890941.59	576621.57	834.32	I'	2162930.4	7136667.8
20	1896791.45	573650.52	836.33	J	2169728.8	7140035.9
21	1895640.09	577848.68	842.42	J'	2165007.5	7138755.9
22	1890590.82	578199.44	842.40	K	2164680.8	7140321.2
24	1889195.90	548504.39	839.77	K'	2164872.4	7139112.5
25	1886595.07	578658.74	834.13	L	2159015.8	7140662.2
26	1884936.97	578578.70	836.78	L'	2160689.8	7140742.0
27	1886969.25	582667.50	834.05	M	2158653.0	7135932.9
28	1888414.07	584730.91	832.56	M'	2160185.8	7136751.5
29	1890325.62	584097.65	843.28	N	2155392.0	7135113.8
30	1889475.80	588108.95	840.54	N'	2156696.5	7134112.9
31	1894326.34	587986.03	836.47	O	2154338.8	7132229.8
32	1888649.92	580832.69	835.85	O'	2153208.5	7131600.3
33	1886057.62	574652.78	838.14	P	2150512.9	7136633.1
34	1884529.81	573844.83	836.19	P'	2150393.1	7135596.9
35	1882554.03	572049.86	836.04	Q	2145407.6	7132113.5
36	1881248.75	573064.70	845.16	Q'	2145965.2	7131904.1

Lake Bridgeport

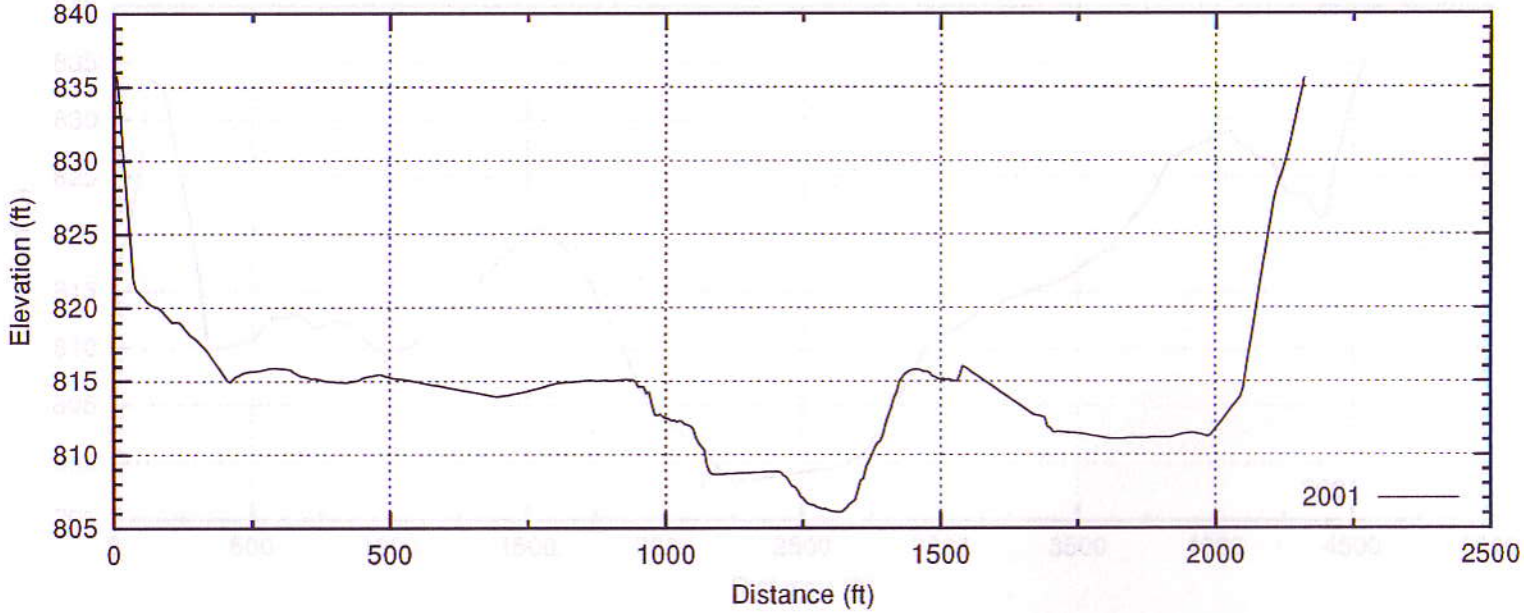
TEXAS WATER DEVELOPMENT BOARD APRIL 2000 SURVEY

Range Line Endpoints

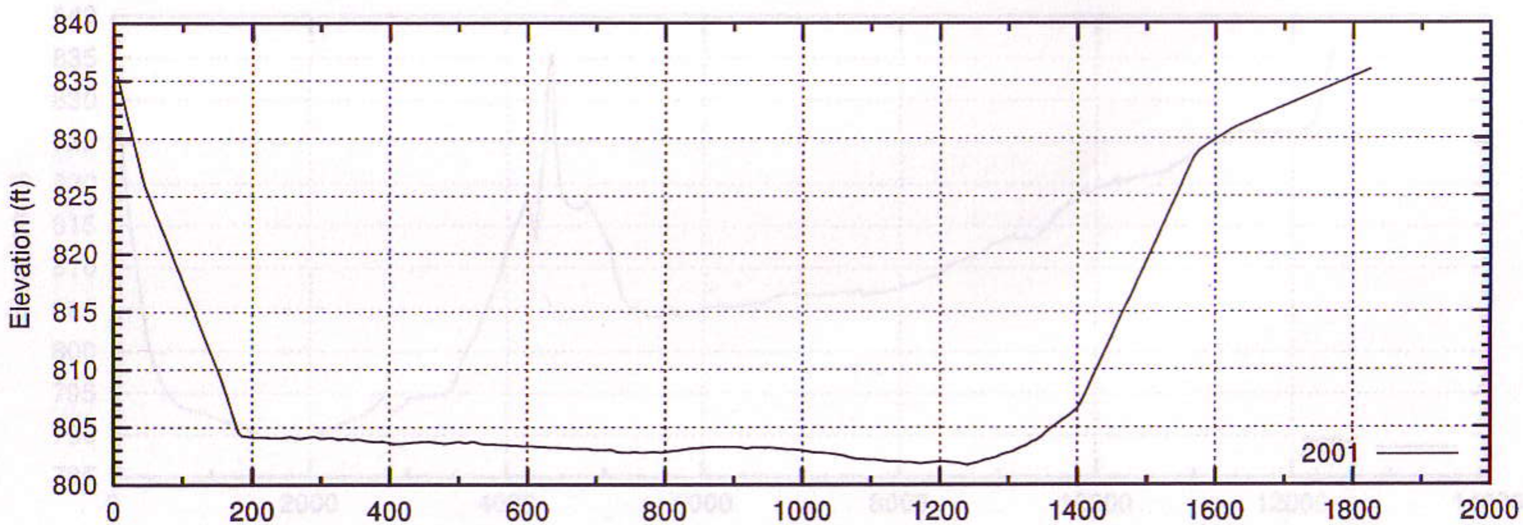
	State Plane NAD27 Units-feet from 1988 Sedimentation Survey				State Plane NAD83 Units-feet TWDB 2000 Survey	
	X	Y	Elevation	Range Line	X	Y
37	1880179.46	570186.34	835.45	R	2139729.2	7132204.3
38	1879041.41	569570.85	835.62	R'	2140298.9	7131119.4
39	1876260.22	573620.96	831.19	S	2139729.2	7132204.3
40	1876391.20	574603.69	832.68	S'	2136869.4	7132017.4
41	1871778.64	569951.28	832.45	T	2141315.5	7134794.4
42	1871244.83	570158.53	842.91	T'	2137127.7	7137399.0
43	1865896.18	570057.28	833.89	U	2161602.0	7144087.6
44	1866137.93	569188.04	841.76	U'	2161004.5	7144767.2
45	1862729.01	570132.38	834.31	V	2163323.9	7146371.6
46	1866033.61	571454.63	833.32	V'	2163241.8	7146934.9
47	1862631.94	571993.10	829.98	W	2164886.6	7152133.5
				W'	2163474.4	7150253.2
				X	2165813.1	7149298.7
				X'	2165660.3	7151092.4

Lake Bridgeport

A-A'



B-B'

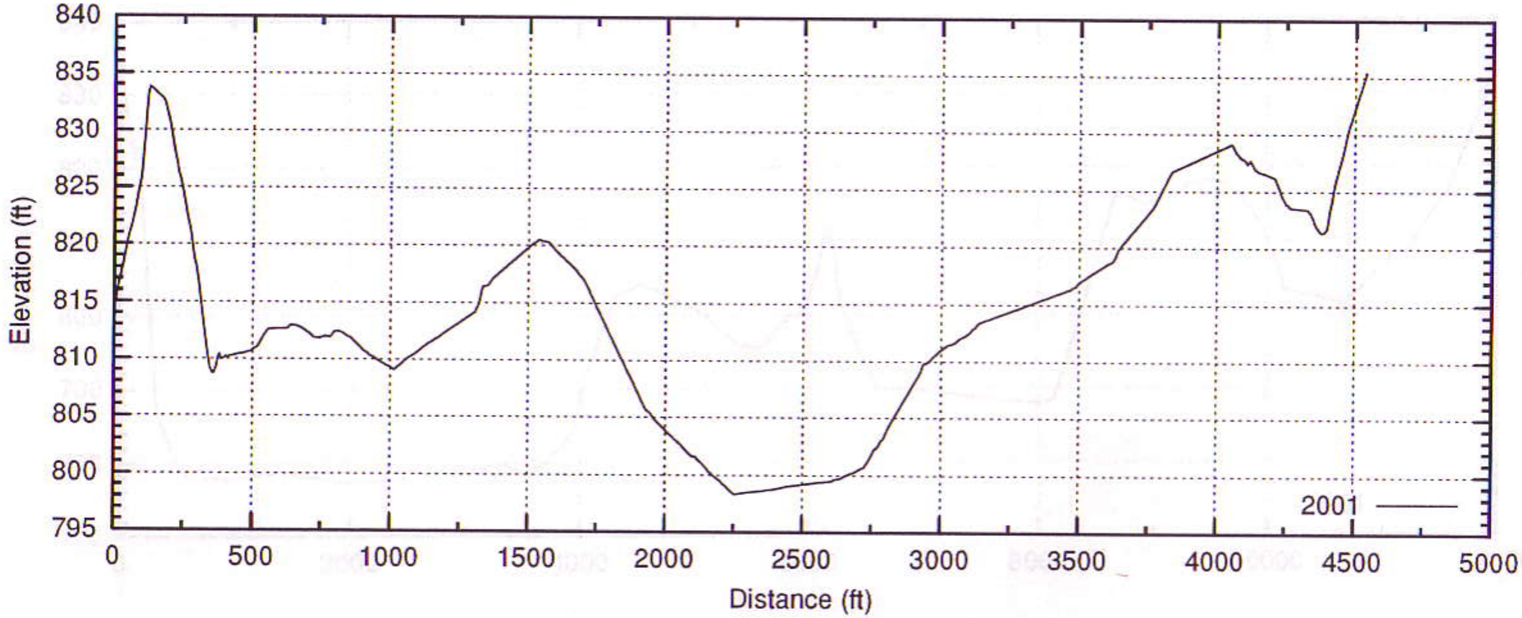


Distance (ft)

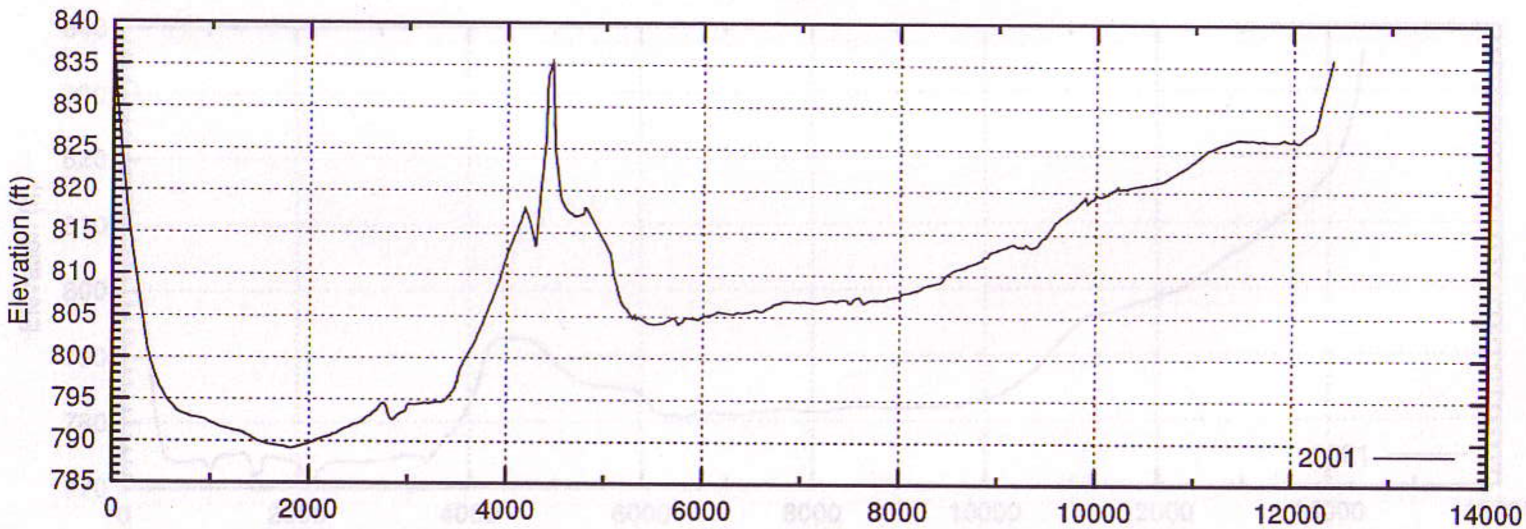
Appendix G

Lake Bridgeport

C-C'



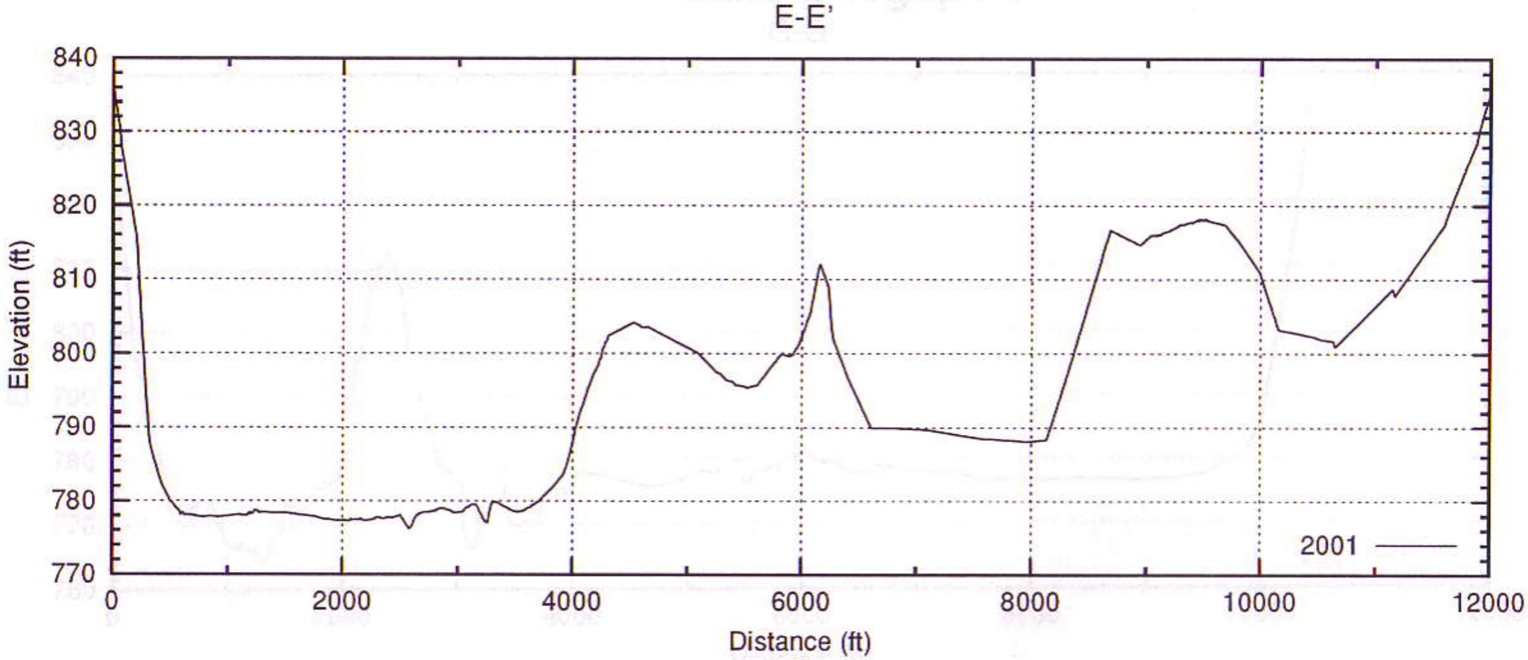
D-D'

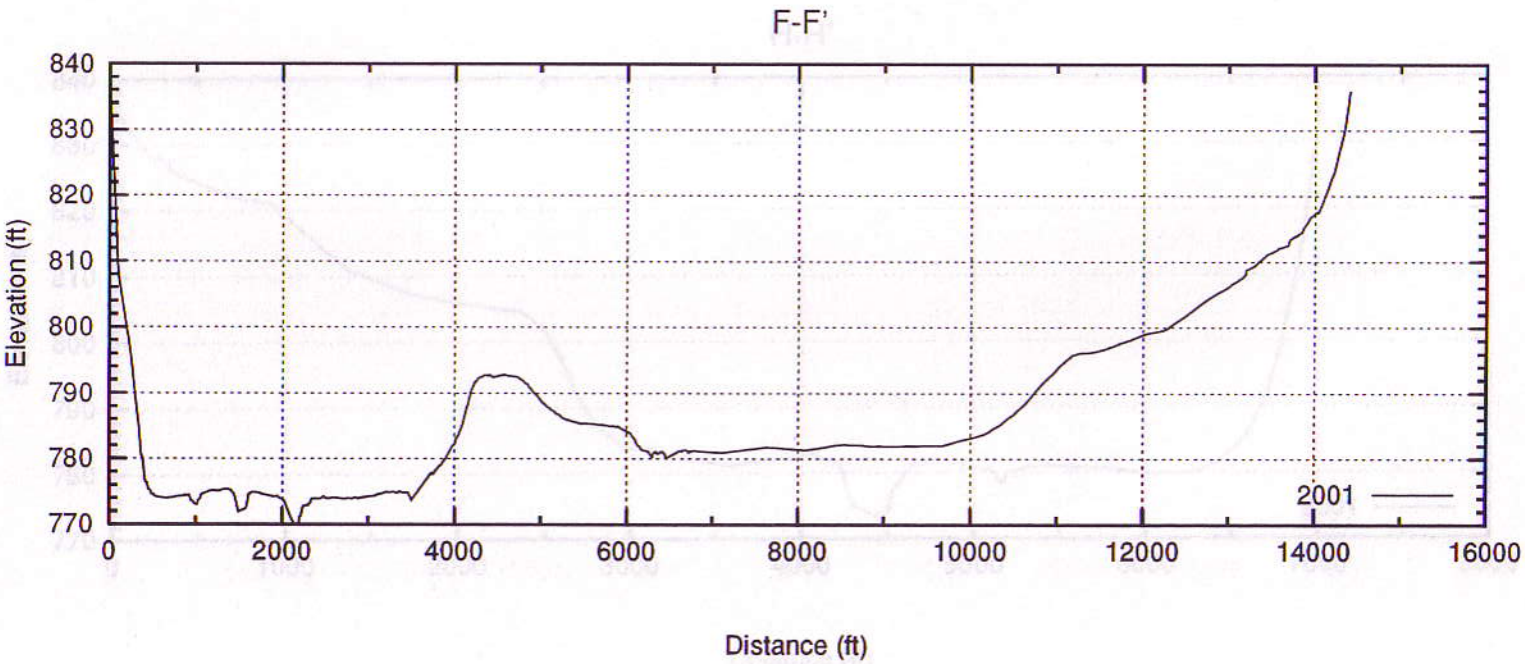


Distance (ft)

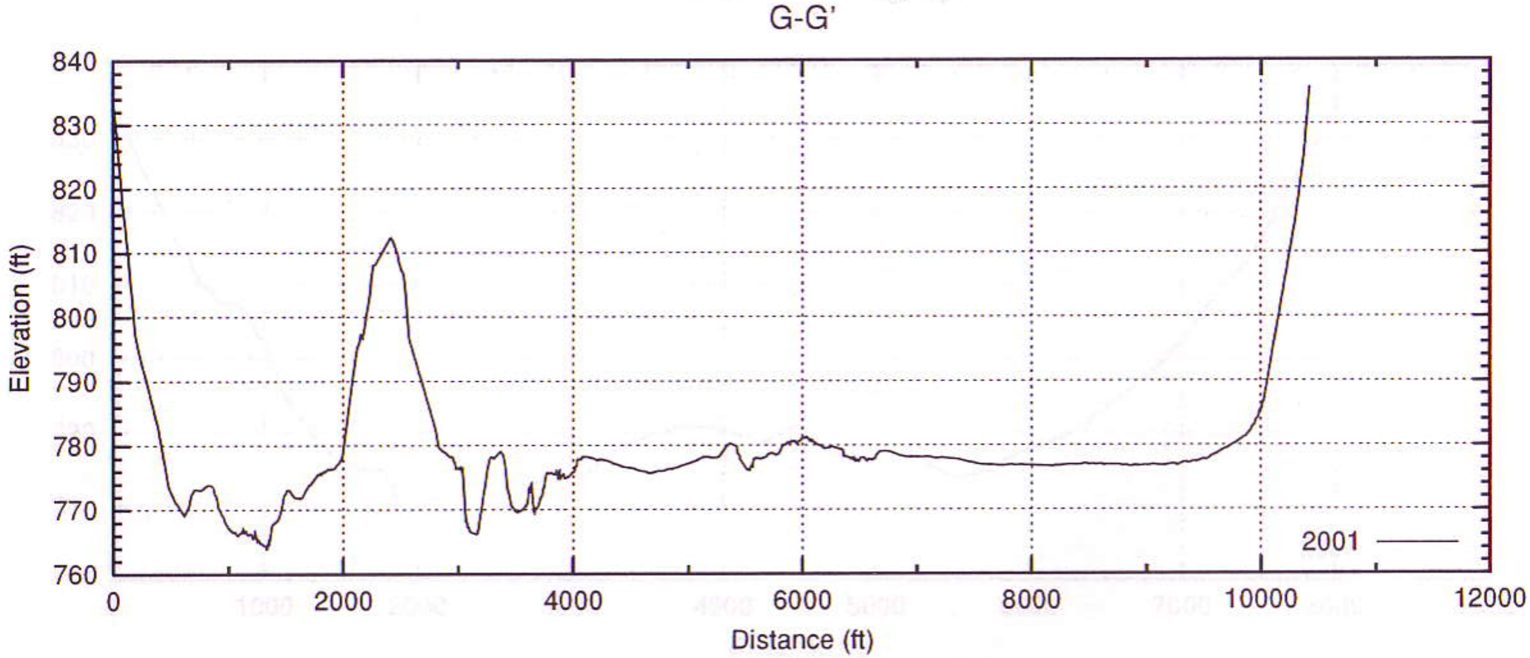
Appendix G

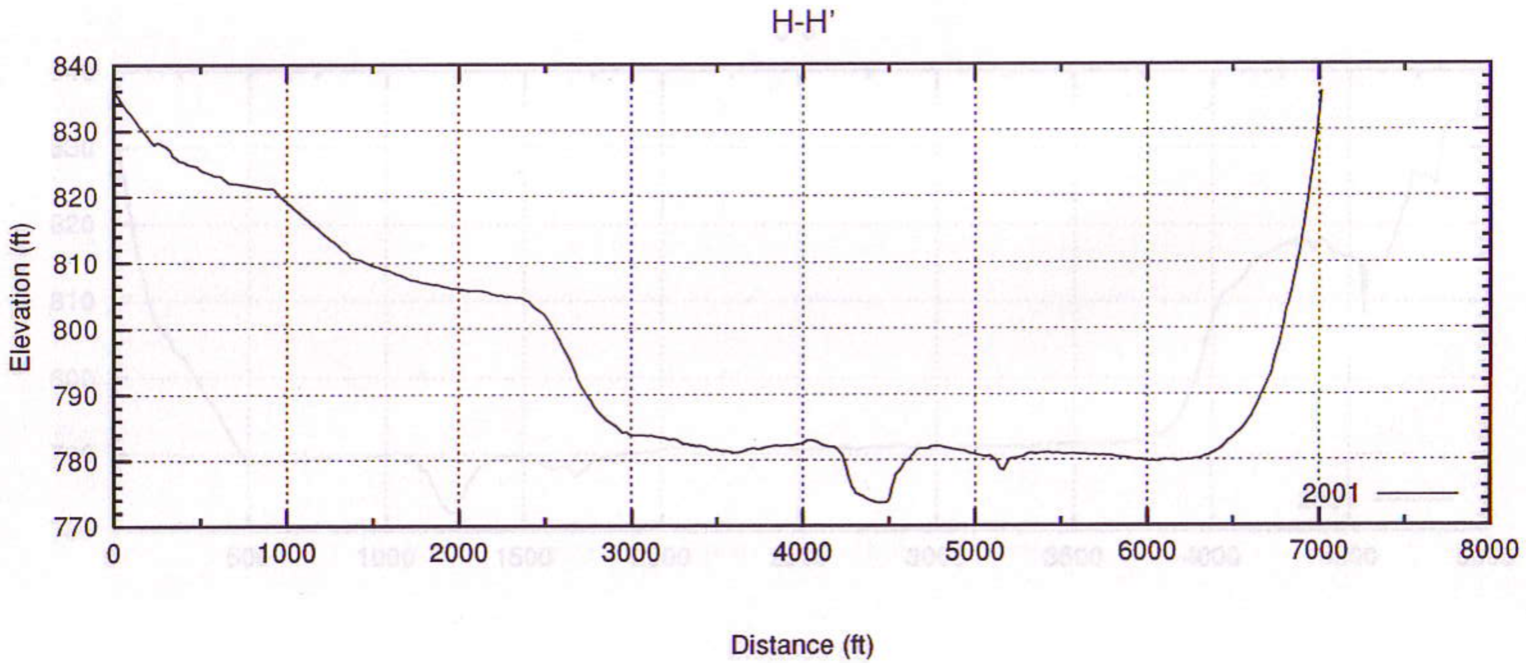
Lake Bridgeport





Lake Bridgeport

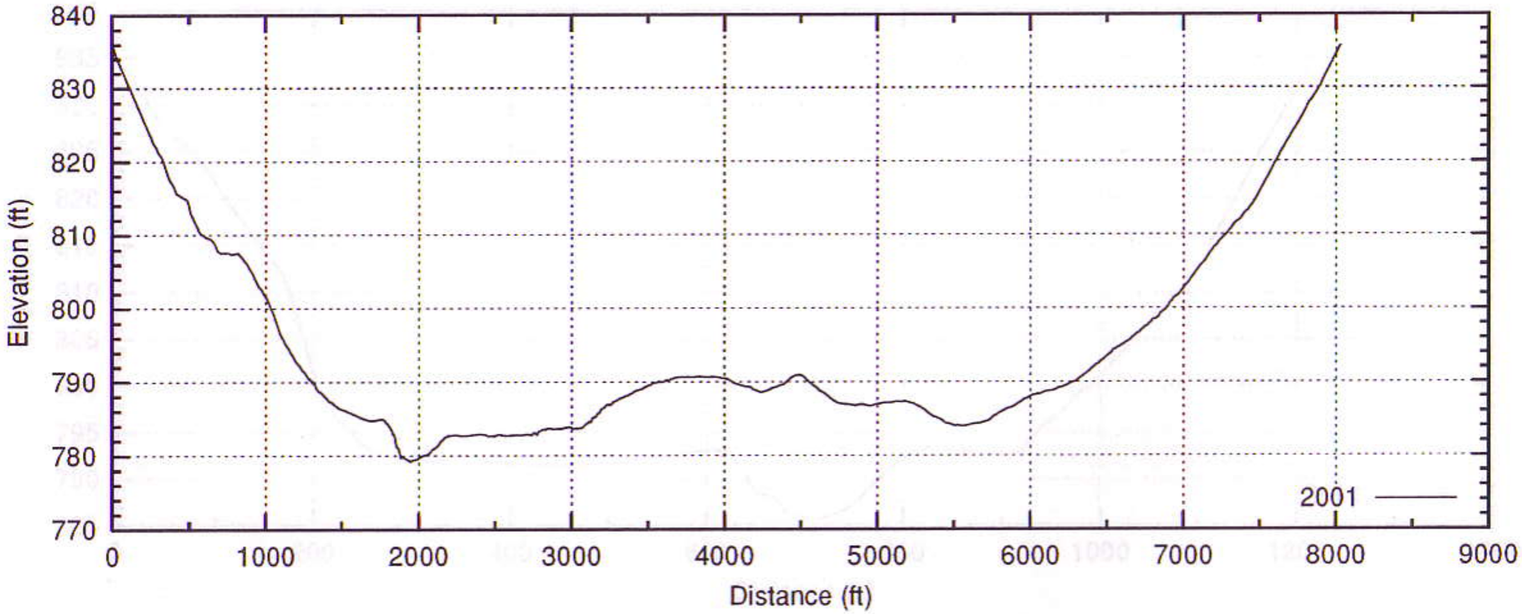




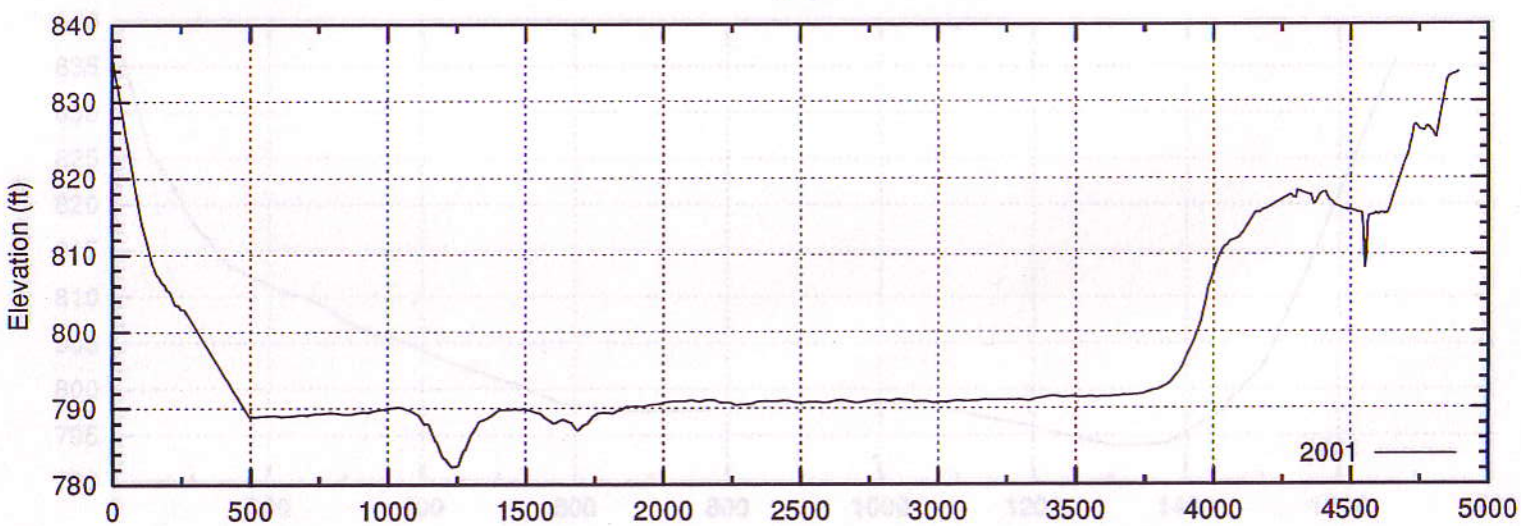
Appendix G

Lake Bridgeport

I-I'



J-J'

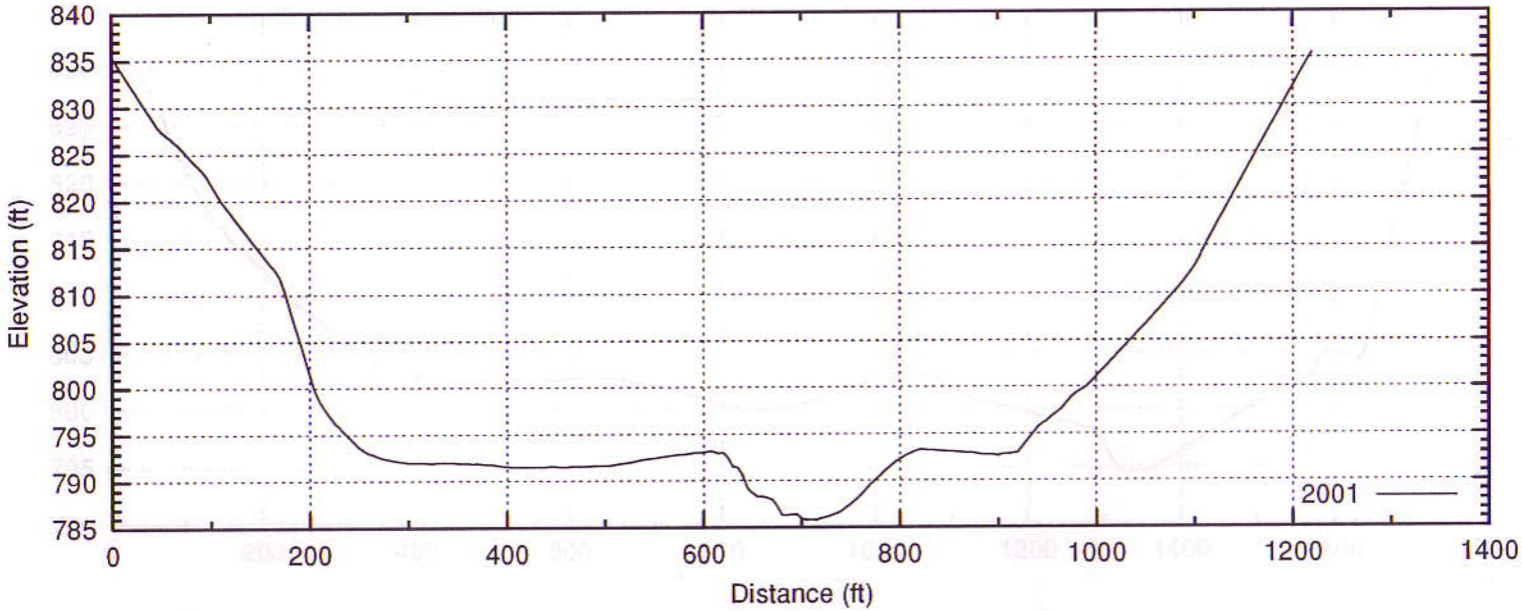


Distance (ft)

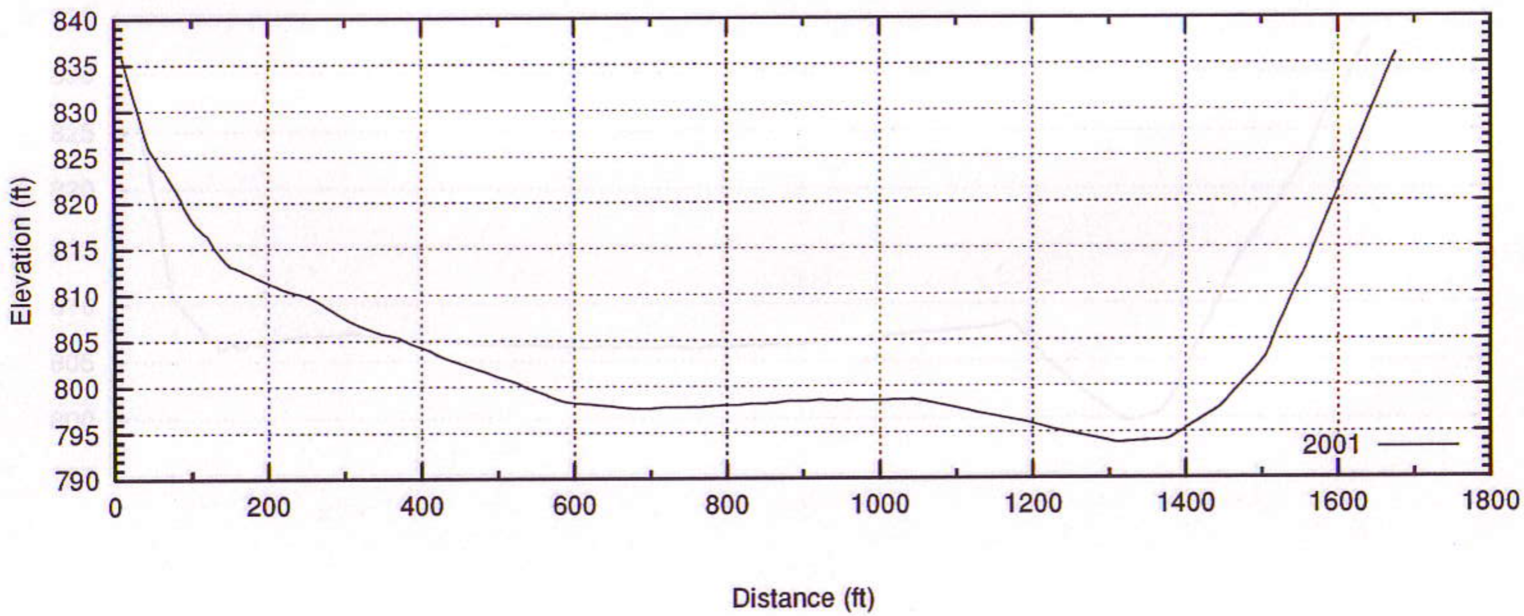
Appendix G

Lake Bridgeport

K-K'



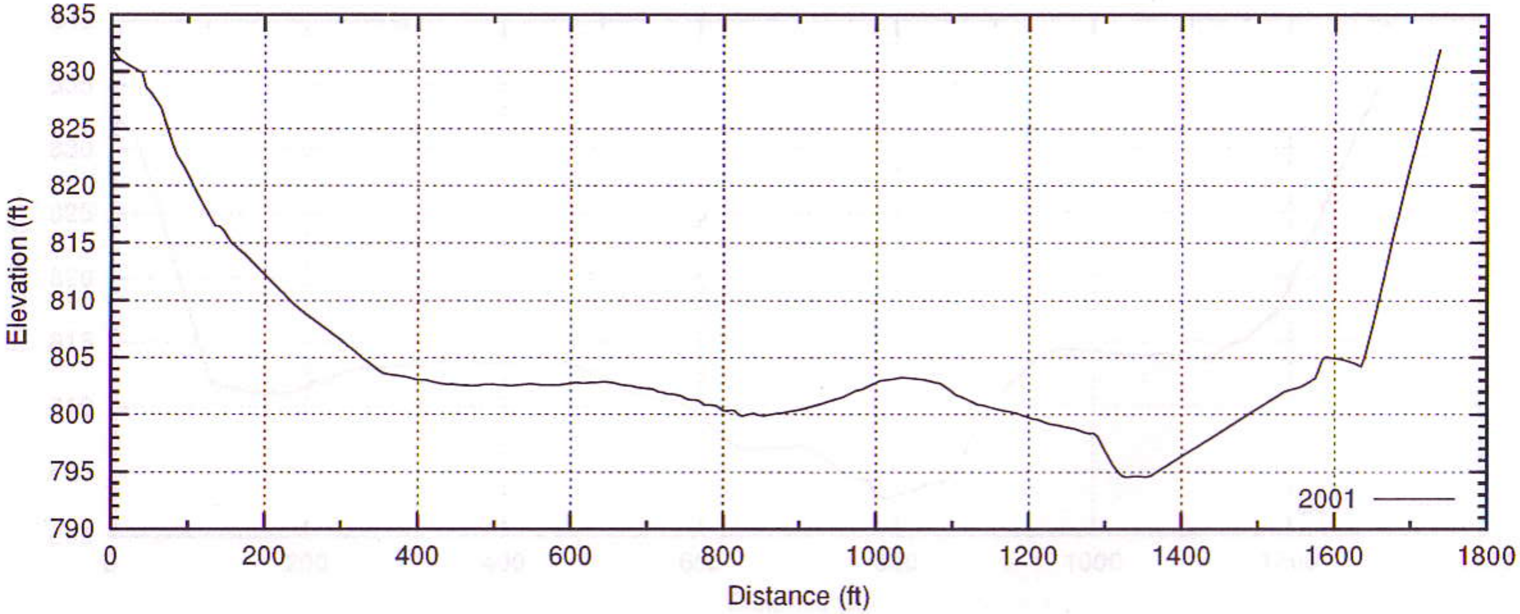
L-L'



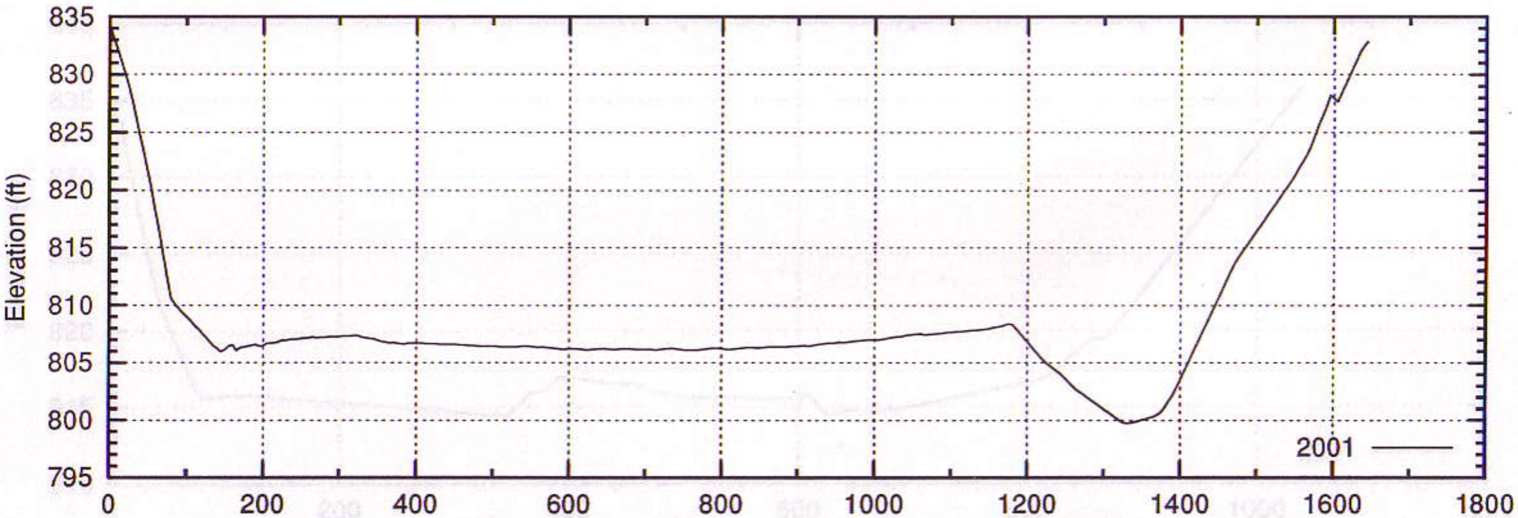
Appendix G

Lake Bridgeport

M-M'



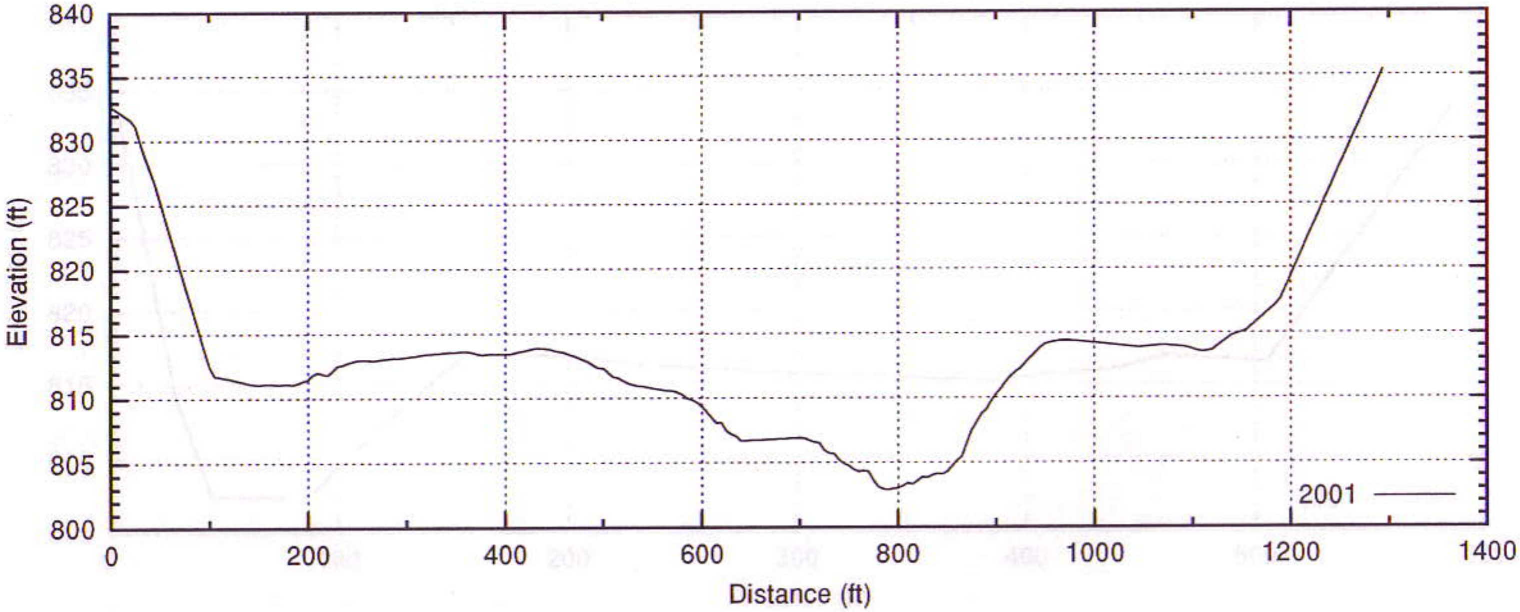
N-N'



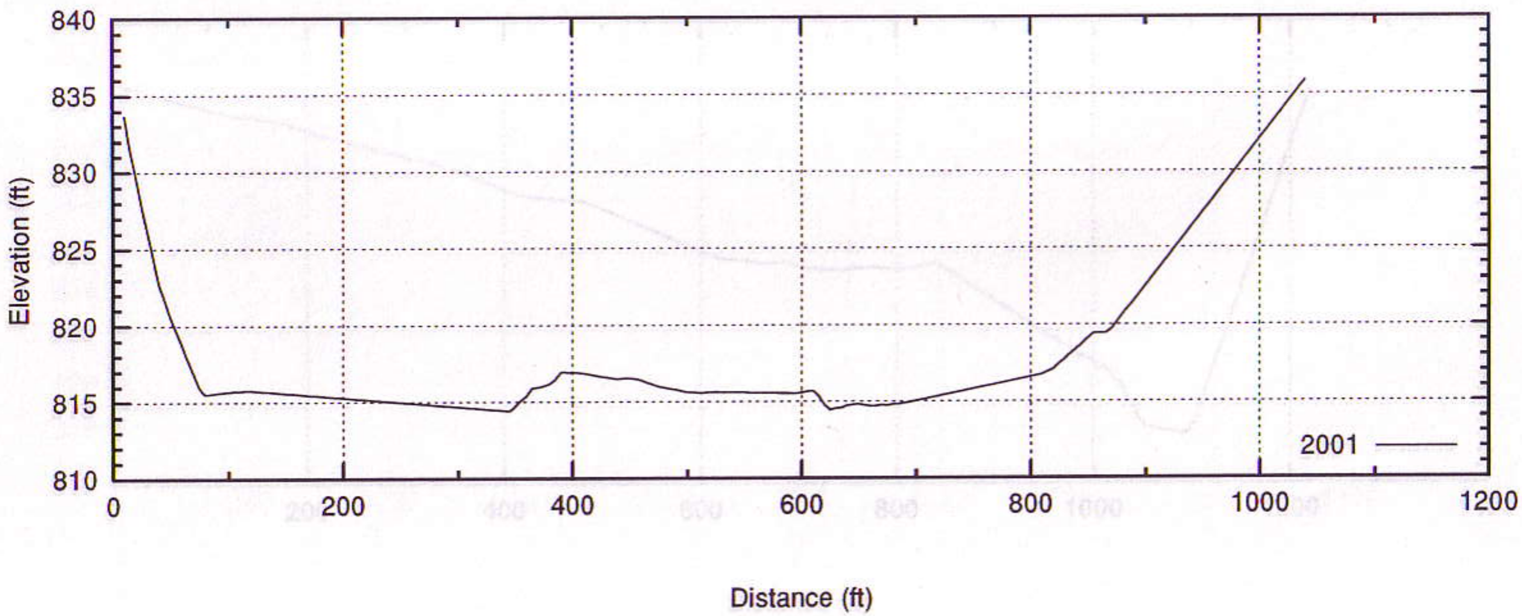
Distance (ft)

Lake Bridgeport

O-O'



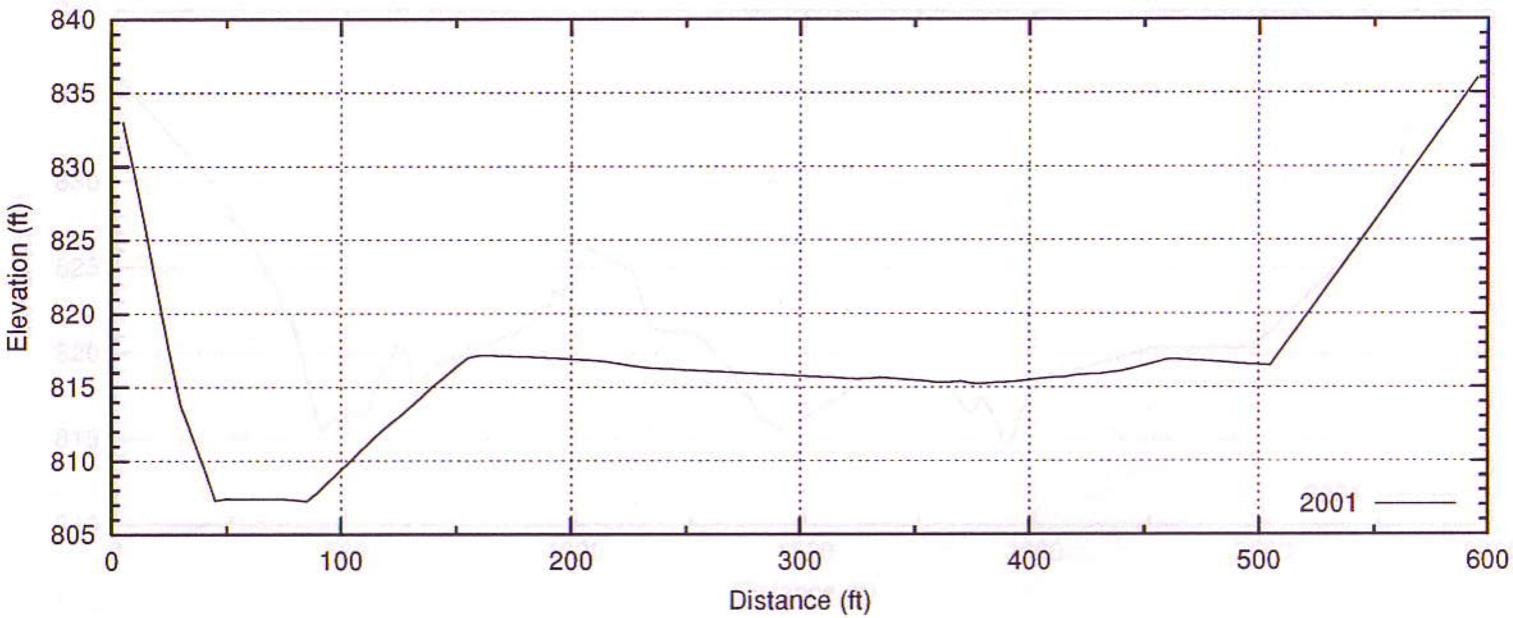
P-P'



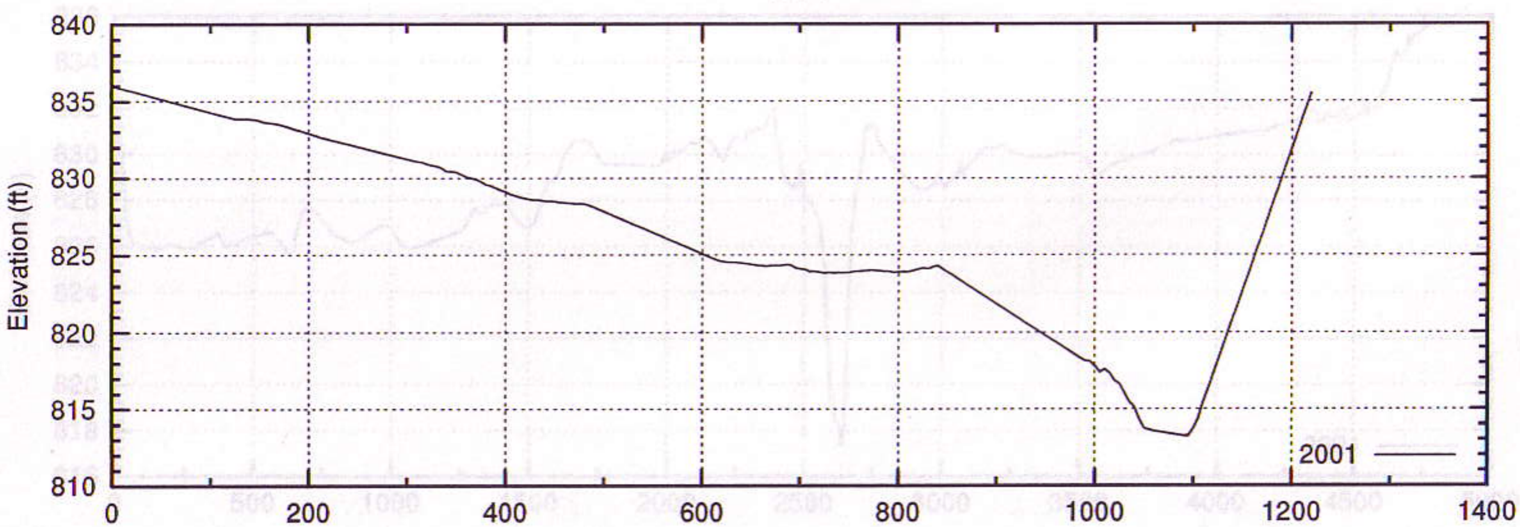
Appendix G

Lake Bridgeport

Q-Q'



R-R'

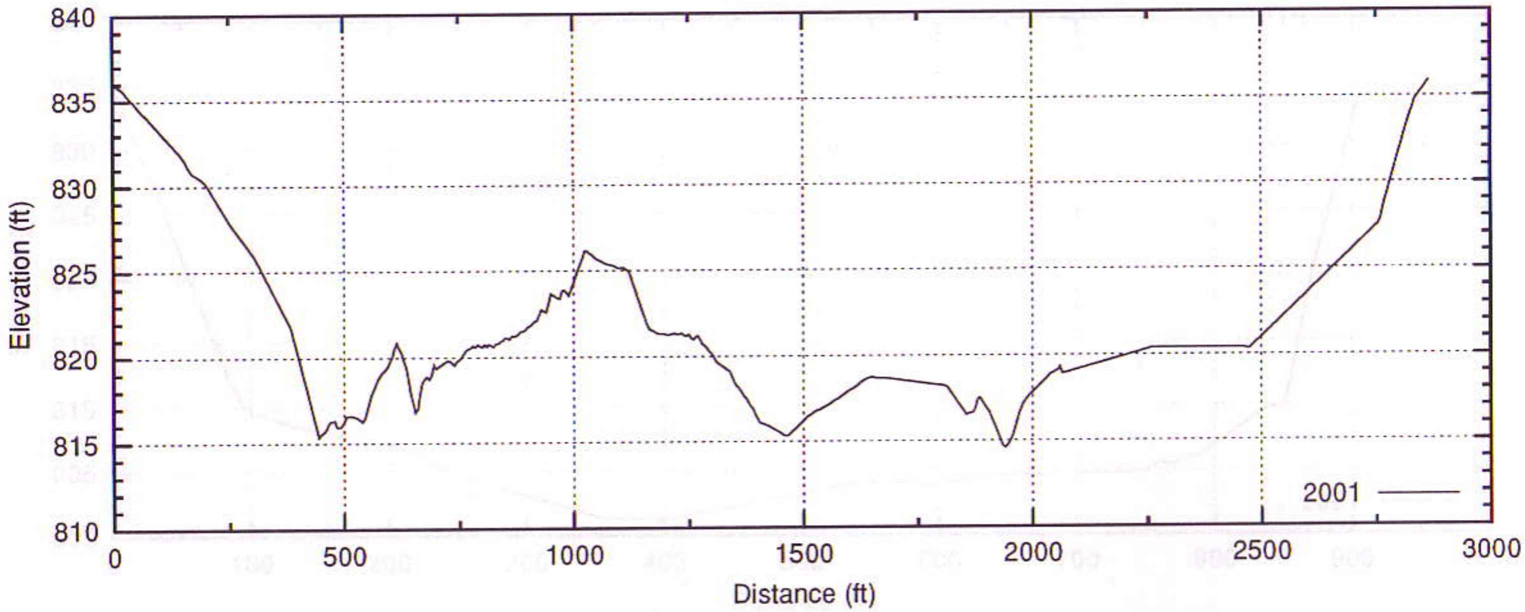


Distance (ft)

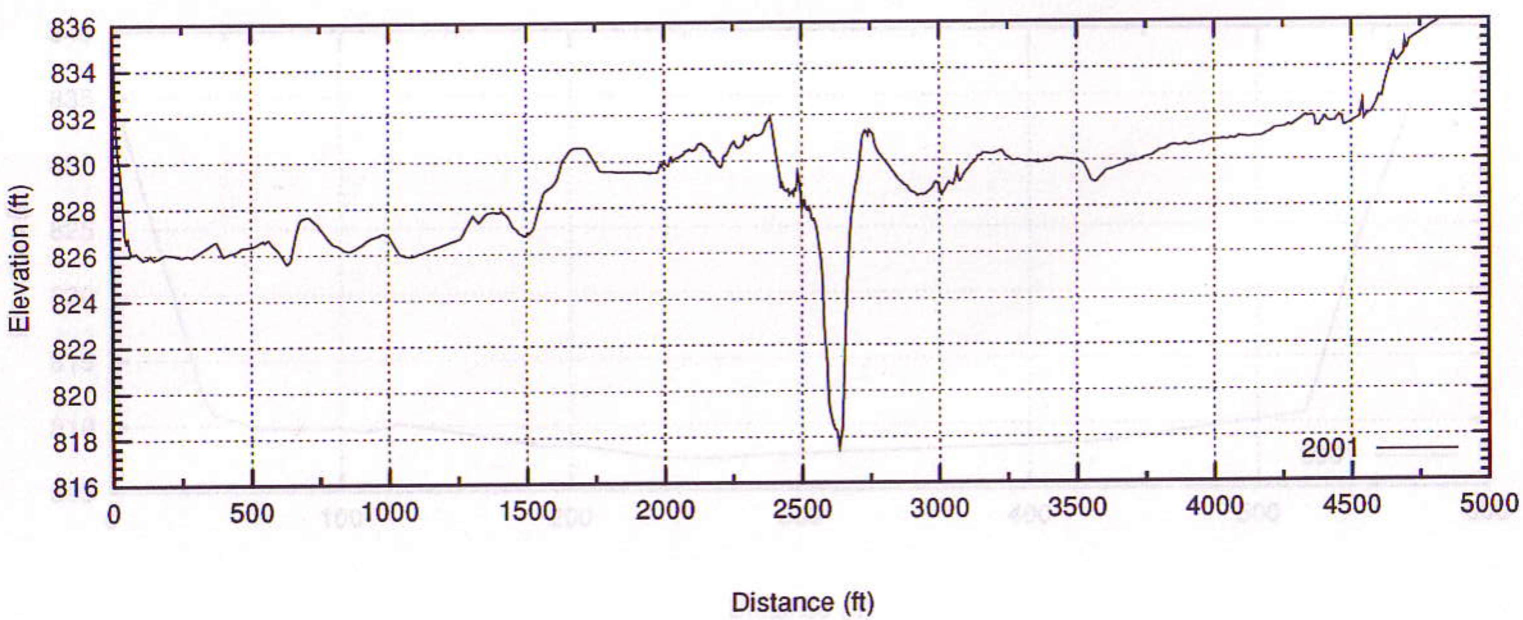
Appendix G

Lake Bridgeport

S-S'

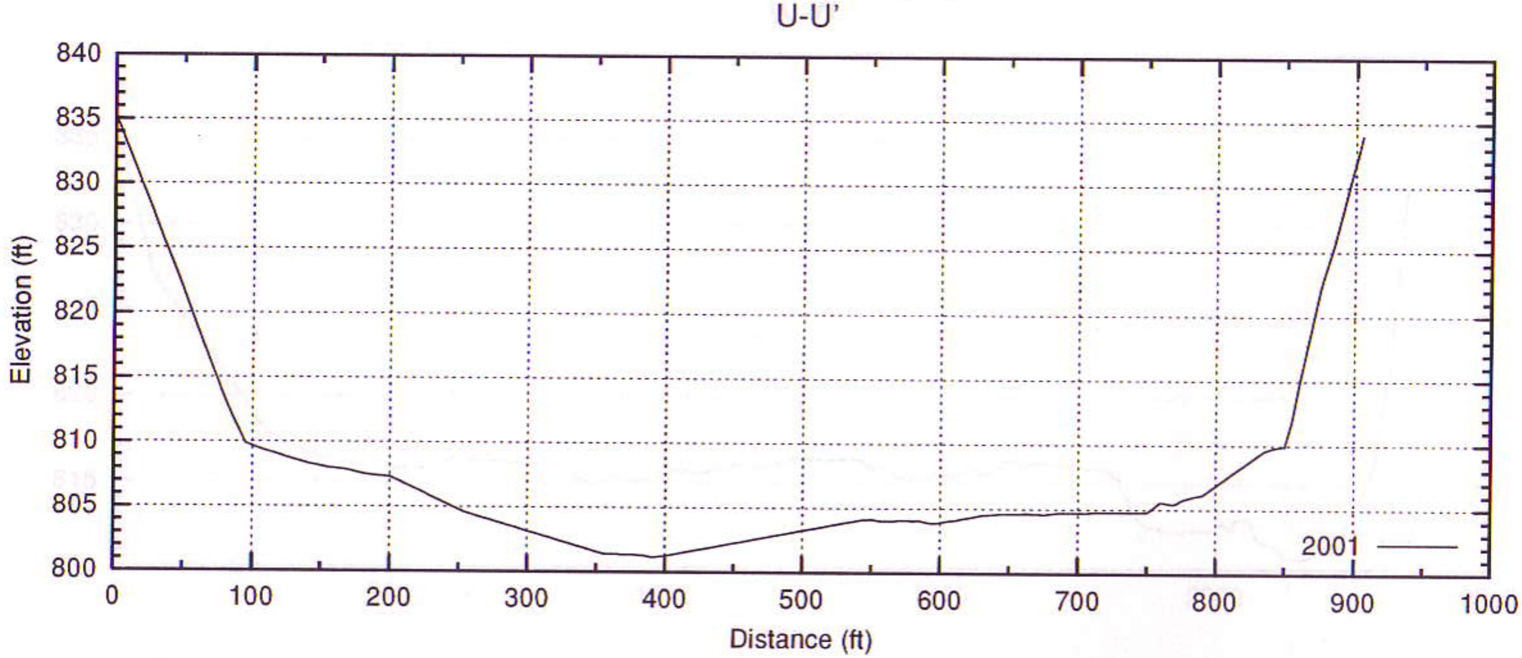


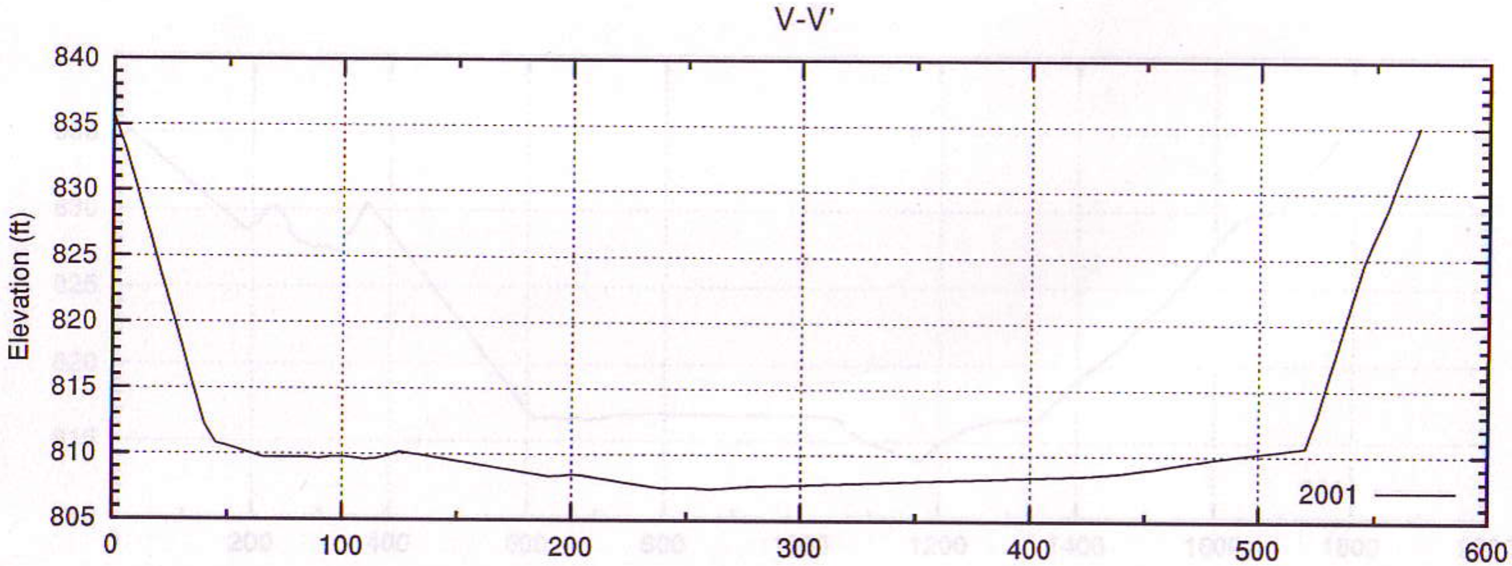
T-T'



Appendix G

Lake Bridgeport

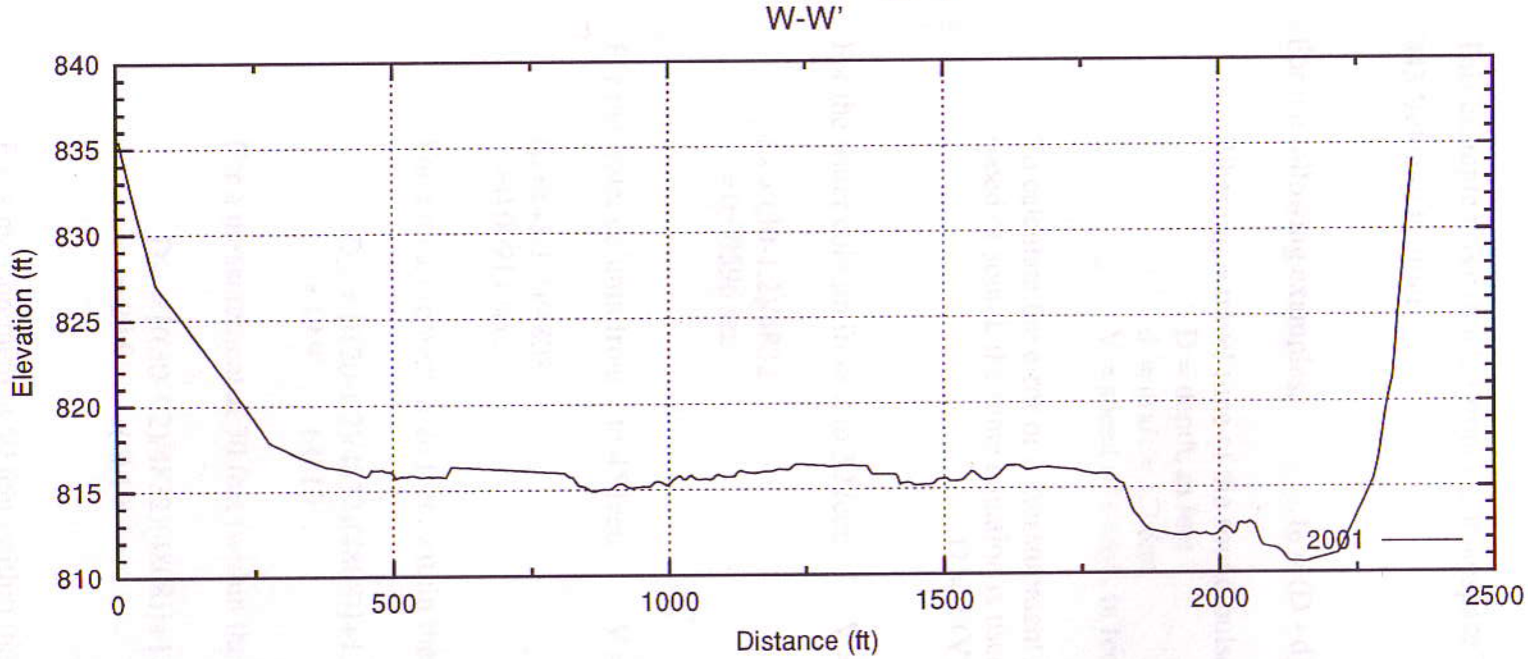


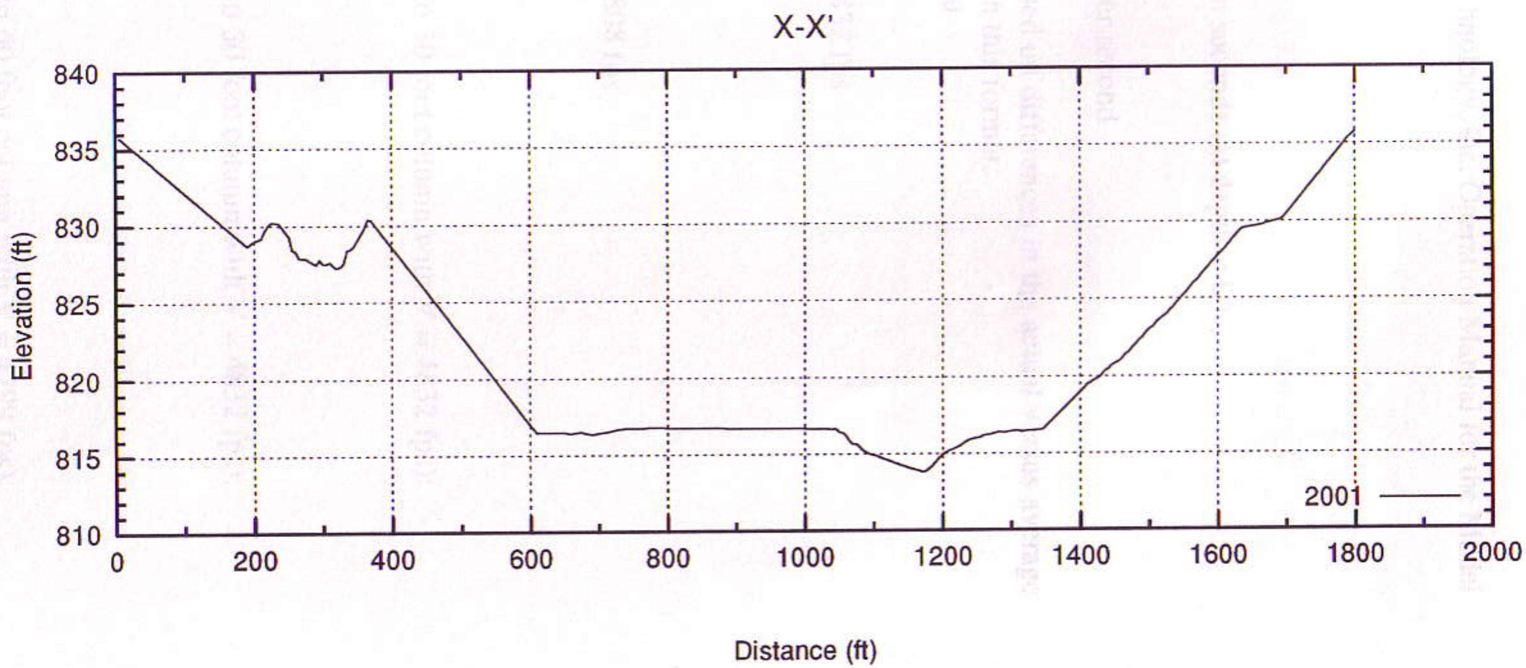


Distance (ft)

Appendix G

Lake Bridgeport





APPENDIX H - DEPTH SOUNDER ACCURACY

This example was extracted from the Innerspace Technology, Inc. Operation Manual for the Model 443 Velocity Profiler.

For the following examples, $t_D = (D - d)/V$

Where: t_D = travel time of the sound pulse, in seconds (at depth = D)
D = depth, in feet
d = draft = 1.2 feet
V = speed of sound, in feet per second

To calculate the error of a measurement based on differences in the actual versus average speed of sound, the same equation is used, in this format:

$$D = [t\ (V)]+d$$

For the water column from 2 to 30 feet: V = 4832 fps

$t_{30} = (30-1.2)/4832$
$= 0.00596$ sec.

For the water column from 2 to 45 feet: V = 4808 fps

$t_{45} = (45-1.2)/4808$
$= 0.00911$ sec.

For a measurement at 20 feet (within the 2 to 30 foot column with V = 4832 fps):

$D_{20} = [((20-1.2)/4832)(4808)]+1.2$
$= 19.9'$ (-0.1')

For a measurement at 30 feet (within the 2 to 30 foot column with V = 4832 fps):

$D_{30} = [((30-1.2)/4832)(4808)]+1.2$
$= 29.9'$ (-0.1')

For a measurement at 50 feet (within the 2 to 60 foot column with V = 4799 fps):

$D_{50} = [((50-1.2)/4799)(4808)]+1.2$
$= 50.1'$ (+0.1')

For the water column from 2 to 60 feet: V = 4799 fps Assumed V_{80} = 4785 fps

t_{60} =(60-1.2)/4799
=0.01225 sec.

For a measurement at 10 feet (within the 2 to 30 foot column with V = 4832 fps):

D_{10} = [((10-1.2)/4832)(4799)]+1.2
= 9.9' (-0.1')

For a measurement at 30 feet (within the 2 to 30 foot column with V = 4832 fps):

D_{30} = [((30-1.2)/4832)(4799)]+1.2
= 29.8' (-0.2')

For a measurement at 45 feet (within the 2 to 45 foot column with V = 4808 fps):

D_{45} = [((45-1.2)/4808)(4799)]+1.2
= 44.9' (-0.1')

For a measurement at 80 feet (outside the 2 to 60 foot column, assumed V = 4785 fps):

D_{80} = [((80-1.2)/4785)(4799)]+1.2
= 80.2' (+0.2')

Figure 5
2' - Contour Map
LAKE BRIDGEPORT
N
2000 0 2000 4000 Feet
Water Surface @ 821.3'
Area Not Surveyed
Islands
Conservation Pool 836'
Elevation 821.3'
Cross Sections
Contours
764
766
768
770
772
774
776
778
780
782
784
786
788
790
792
794
796
798
800
802
804
806
808
810
812
814
816
818
820
TEXAS WATER DEVELOPMENT BOARD
This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Lake Bridgeport. The Texas Water Development Board makes no representations or assumes any liability if this information is used for other purposes such as boating maps.
TEXAS WATER DEVELOPMENT BOARD APRIL 2000 SURVEY