VOLUMETRIC SURVEY OF LAKE J. B. THOMAS

Prepared for:

Colorado River Municipal Water District

Prepared by
Texas Water Development Board

October 30, 2000

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 J. B. Thomas during the period of November 3-5, 1999. Data collected during this survey covered only the inundated area of the lake, which at the time of the survey was significantly below normal levels. A second survey was conducted by SK Engineering of San Angelo, Texas to include the area of the lake from the lake surface up to conservation pool elevation. The two overlapping survey data sets were then merged to produce combined volume and area tables. The primary purpose of the survey was to determine the current volume of the lake at conservation pool elevation. This survey will establish a basis for comparison to future surveys from which the location and rates of sediment deposition in the conservation pool can be determined. Survey results are presented in the following pages in both graphical and tabular form. All elevations presented in this report are reported in feet above mean sea level based on the gage datum for United States Geological Survey (USGS) station 08118000 Lake J.B. Thomas near Vincent, TX. The conservation pool elevation for Lake J. B. Thomas is 2,258.0 feet, gage datum. Original design information from 1950 showed the surface area at this elevation to be 7,820 acres and the storage volume to be 203,600 acre-feet (TWDB, 1971).

LAKE HISTORY AND GENERAL INFORMATION

Historical information on Lake J. B. Thomas was obtained from the Texas Water Development Board (TWDB, 1966 and 1971). The Colorado River Municipal Water District (CRMWD) owns the water rights to Lake J. B. Thomas. CRMWD also owns, operates and maintains associated Colorado River Dam. The lake is located on the Colorado River (Colorado River Basin) in Scurry and Borden

Counties, 16 miles southwest of Snyder, Texas (see Figure 1). Records indicate the drainage area is approximately 3,524 square miles of which 2,590 square miles is probably noncontributing. At the conservation pool elevation, the lake has approximately 88 miles of shoreline and is 10 miles long. The widest point of the lake is approximately 3 miles and is located about 1.7 miles upstream of the dam.

Water Rights Permit No. 1394 (Application No. 1492) was issued to CRMWD on August 19, 1946. The permit authorized the construction of a dam to impound 111,000 acre-feet of water and to divert annually 30,000 acre-feet of water. Permit 1394B changed the location of the dam in order to increase the storage volume of the lake. The permit granted the right to impound 203,600 acre-feet of water and also authorized a dam across Bull Creek in order to divert water to Lake J. B. Thomas. The Texas Water Commission issued Certificate of Adjudication No. 14-1002 on August 19, 1977. The certificate authorizes the impoundment and uses as stated in Permit No. 1394B and authorizes CRMWD to maintain an existing dam and lake on the Colorado River known as Colorado River Dam and Lake J. B. Thomas. Impoundment was not to exceed 204,000 acre-feet of water and to use, not to exceed, 30,000 acre-feet of water annually for municipal purposes.

Records indicate that construction for Lake J. B. Thomas and Colorado River Dam started on March 26, 1951. Deliberate impoundment began in July of 1952 and the project was completed in September of 1952. The design engineer for the project was Freese, Nichols and Endress and the general contractor was J. W. Moorman and Son. The estimated cost of the dam was $1,452,877.

Colorado River Dam and appurtenant structures consist of an earthfill embankment approximately 14,500 feet in length, with a maximum height of 105 feet and a crest elevation of 2,280.0 feet, gage datum. A service road occupies the 28-foot wide crest.

The service spillway is a rectangular concrete drop inlet structure located near the left (north) end of the dam. The crest elevation is 2,258.0 feet, gage datum. Flows discharge into two 10-foot by 10-foot horseshoe shaped conduits. There are no controls for the service spillway.

The outlet works consist of a concrete pipe, 30-inches in diameter, located near the center of the dam. The invert elevation for the service outlet is 2,200.0 feet, gage datum. A 24-inch valve controls the service outlet.

Lake J.B. Thomas has two emergency spillways, one located on the north abutment and the other located on the south abutment. The north (left) emergency spillway, an excavated channel cut through natural ground, is 500 feet in length with a crest elevation of 2,264.0 feet, gage datum. The south (right) emergency spillway has a 1,660-foot crest length at elevation 2,267.0 feet, gage datum and is also a natural cut channel.

Original design information (TWDB, 1971) estimated the surface area at conservation pool elevation 2,258.0 feet, gage datum, to be 7,820 acres and the storage volume to be 203,600 acre-feet. This report will compare the results of the 1999 survey with those of the original design.

VOLUMETRIC SURVEYING TECHNOLOGY

The equipment used to perform the volumetric survey consists of a 20-foot aluminum flat bottom SeaArk craft with cabin, equipped with one 115-Horsepower Evinrude outboard motor. (Reference to brand names throughout this report does not imply endorsement by TWDB). The equipment included a Knudsen 320 B/P Echosounder (depth sounder) and 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. During the data collection phase, the depth sounder takes approximately ten bottom readings each second. The depth readings are stored on the laptop 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 lake from the collected data. The level of accuracy is equivalent to or better than previous methods used to determine lake volumes, some of which are discussed in Appendix F.

PRE-SURVEY PROCEDURES

The water's-edge boundary at elevation 2,258 feet was digitized prior to the with AutoCad software. The boundary file was created from the USGS 7.5-minute quadrangle map: IRA SW, TEX. (1951) (Photo-revised 1974), IRA NW, TEX. (1951) (Photo-revised 1974), GUNSIGHT DRAW NE, TEX. (1970) and GUNSIGHT DRAW SE, TEX. (1970). This boundary was subsequently used to determine the lake's area and volume.

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 56 survey lines along the length of the lake. Another 30 lines were placed perpendicular to the dam in order to collect a 500 feet grid pattern in the main basin of the lake.

SURVEY PROCEDURES

Equipment Calibration and Operation

At the beginning of each surveying day, the depth sounder was calibrated using the bar check feature in the Knudsen software program. This was accomplished by positioning the transducer over a known (measured) depth. The speed of sound was then adjusted (either higher or lower) until the depths displayed matched the known depth. The depth was then checked manually with a stadia (survey) rod to ensure that the depth sounder was properly calibrated and operating correctly. During the survey of Lake J. B. Thomas, the speed of sound in the water column varied from 4,862 to 4,868 feet per second. 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 F.

During the survey, the onboard GPS receiver was set to a horizontal mask of 10° and a PDOP (Position Dilution of Precision) limit of 7 to maximize the accuracy of horizontal positions. An internal alarm sounds if the PDOP rises above seven to advise the field crew that the horizontal position has degraded to an unacceptable level. The lake's 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. Both sets of coordinates were then stored in the survey data file.

Field Survey

Due to low water levels, data collection was divided into two surveys. TWDB was responsible for collecting data in the inundated portion of the lake. SK Engineering of San Angelo collected data on dry land from the water's edge to conservation pool elevation, 2,258.0 feet gage datum.

SK Engineering performed the dry land survey between April 5 and June 10, 1999. During that period the water-level was as low as 2,208.37 feet and as high as elevation 2,211.16 feet, gage datum. A major rainstorm fell in the watershed of Lake J. B. Thomas in mid June raising the lake-level approximately 16 feet to an elevation of 2,227.02 on June 30, 1999.

TWDB staff collected data at Lake J. B. Thomas during the period of November 3 – 5, 1999. Conditions during the survey consisted of mild temperatures with mild winds. The lake-level remained fairly constant at elevation 2,222.55 feet, allowing significant overlap with the survey data collected by SK Engineering.

The survey crew was able to collect data on approximately 62 of the 86 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. A 500-foot grid pattern was collected in the main basin of the reservoir or that area between the confluence of Bull Creek and the Colorado River Dam. Approximately 85,700 data points were collected over the 62 miles traveled. These points, shown in Figure 2, were stored digitally on the boat's computer in 97 data files. Data were not collected in areas with significant obstructions unless these areas represented a large amount of water.

The Colorado River flows in a west to east direction with Colorado River Dam being located at the eastern end of the lake basin. TWDB staff observed the land surrounding the lake to be generally flat. A few outcrops of sandstone were noted on the southern shoreline. There was minimal residential development around the perimeter of the lake. CRMWD established and maintains several parks surrounding the lake.

While performing the survey the field crew noted on the depth sounder chart that the bathymetry or contour of the lake bottom was quite flat and regular throughout that portion of the survey. There was no defined channel (thalweg) of the Colorado River in the main basin of the lake. There were no visible signs of shoreline erosion along the perimeter of the lake.

Navigational hazards such as submerged vegetation were encountered in the upper reaches of the lake, restricting data collection. The lake in this area had more riverine characteristics with closer or narrower banks. Data collection by boat stopped at approximately 500 feet downstream of the Big Spring intake structure where the banks of the Colorado River narrowed to approximately the width of the boat.

The collected data were 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 each 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. Offsets to account for the lake elevation during the data collection were also applied to each file with the EDIT routine. During the survey, the water surface varied from elevation 2,222.53 to 2,222.60 feet, gage datum, according to elevation data provided by the USGS. 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.

The resulting data file was downloaded to a Sun Sparc 20 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 and surface areas, presented in Appendices A and B, respectively, were calculated from the TIN using Arc/Info software. Results are shown in one-tenth of a foot interval from elevation 2,194.5 ft to elevation 2,258.0 ft, gage datum. An elevation-area-volume graph is presented in Appendix C.

Other products developed from the model include a shaded relief 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 contour map of the bottom surface at two-foot intervals is presented in Figure 5. Finally, cross-sections from the original survey, shown on the map in Figure 5, are presented in the plots in Appendix D.

RESULTS

Results from the 1999 TWDB survey indicate Lake J. B. Thomas encompasses 7,282 surface acres and contains a total volume of 200,604 acre-feet at the conservation pool elevation of 2,258.0 feet, gage datum. The shoreline at this elevation was calculated to be 87.8 miles. The deepest point of the lake, at elevation 2,194.5 feet, gage datum, and corresponding to a depth of 63.50 feet relative to conservation pool elevation, was located approximately 2000 feet upstream from the center of Colorado River Dam.

SUMMARY AND COMPARISONS

Lake J. B. Thomas was initially impounded in 1952. Storage calculations in 1950 reported the volume at conservation pool elevation 2,258.0 feet, gage datum, to be 203,600 acre-feet with a surface area of 7,820 acres.

During November 3-5, 1999, staff from the Texas Water Development Board's Surface Water Section completed a volumetric survey of Lake J. B. Thomas. From April 5 to June 10, 1999, SK Engineering of San Angelo, Texas collected land-based survey data from the water's edge to conservation pool elevation. Both resulting data sets were combined and analyzed by TWDB staff to generate volume and area data for Lake J. B. Thomas. The 1999 surveys took advantage of technological advances such as differential global positioning system and geographical information system technology to create a digital model of the lake's bathymetry. With these advances, the survey was completed more quickly and significantly more bathymetric data were collected than in previous surveys. Results indicate that the lake's volume at the conservation pool elevation of 2,258.0 feet, gage datum, is 200,604 acre-feet, with a corresponding area of 7,282 acres.

Comparing the findings from the original, 1950, survey and the current survey, the estimated reduction in area at conservation pool elevation 2,258.0 feet is 538 surface acres. The reduction in volume at conservation pool elevation is 2,996 acre-feet (-1.5%) or 61 acre-feet/year (since 1950). Compared to TWDB (1971) data, the current survey shows a decrease in storage volume at lower elevations (2,194.0 feet to approximately 2,236.0 feet, gage datum). There was a slight increase in volume at mid elevations (2,236.0 feet to 2,252.0 feet), and a decrease again at the highest elevations (2,252.0 feet to 2,258.0 feet) (Table 1). The average annual deposition rate of sediment in the lake can be estimated at 0.1 acre-feet/square mile of drainage area. Some differences among results may arise from differences in surveying procedures and technology. Based on the amount of data collected and the improved methods and technology used in the current survey, the current data set is considered to be an improvement over previous survey procedures. It is recommended that the same methodology be used in five to ten years or after major flood events to monitor changes to the lake's storage volume.

Elevation (feet, gage datum)	* Original Survey (acre-feet)	1999 Survey (acre-feet)	Change (acre-feet)
2,200.0	1,500	673	-827
2,210.0	9,000	6,873	-2,127
2,220.0	27,000	24,089	-2,911
2,230.0	55,000	53,580	-1,420
2,240.0	93,000	94,801	+1,801
2,250.0	147,000	149,127	+2,127
2,258.0	203,600	200,604	-2,996

* Approximate, based on graph in TWDB (1971).

Table 1. Volume comparison between original (1950) and 1999 surveys.

REFERENCES

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

Texas Water Development Board. 1971. Engineering data on dams and lakes in Texas. Part III. Report 126.

Appendix A

Lake J. B. Thomas

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD — November 1999 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
2194						0	0	0	0	0
2195	1	1	2	4	6	8	11	14	17	21
2196	26	30	36	42	49	57	65	73	82	90
2197	100	110	120	131	143	155	167	181	195	209
2198	224	240	256	273	291	310	330	350	372	393
2199	416	439	462	486	511	537	563	589	617	644
2200	673	701	730	760	790	821	852	883	916	948
2201	981	1015	1049	1084	1119	1154	1190	1227	1263	1301
2202	1338	1376	1414	1453	1492	1532	1572	1612	1653	1694
2203	1736	1779	1822	1866	1909	1954	1999	2045	2091	2137
2204	2184	2232	2280	2329	2379	2429	2481	2533	2587	2641
2205	2697	2753	2811	2869	2928	2988	3050	3112	3175	3239
2206	3304	3370	3437	3505	3575	3645	3716	3789	3862	3937
2207	4013	4091	4170	4251	4333	4417	4502	4589	4677	4766
2208	4856	4947	5039	5132	5225	5319	5414	5510	5607	5705
2209	5805	5906	6007	6111	6215	6321	6428	6537	6647	6759
2210	6873	6988	7105	7224	7344	7466	7589	7714	7841	7969
2211	8099	8230	8362	8495	8630	8766	8903	9041	9181	9322
2212	9463	9606	9750	9895	10041	10188	10336	10484	10634	10784
2213	10936	11088	11241	11395	11550	11706	11862	12019	12178	12337
2214	12497	12657	12818	12980	13143	13307	13471	13636	13803	13970
2215	14138	14307	14477	14648	14819	14993	15167	15342	15518	15695
2216	15874	16053	16234	16416	16599	16783	16969	17155	17344	17533
2217	17724	17917	18110	18306	18502	18701	18901	19103	19306	19510
2218	19716	19924	20132	20341	20552	20764	20977	21191	21406	21622
2219	21839	22058	22278	22499	22721	22945	23171	23398	23627	23857
2220	24089	24322	24556	24792	25029	25268	25508	25750	25993	26236
2221	26482	26729	26977	27227	27478	27731	27985	28239	28496	28754
2222	29014	29275	29537	29801	30066	30333	30600	30869	31139	31409
2223	31681	31955	32229	32505	32782	33061	33342	33624	33908	34193
2224	34480	34768	35057	35348	35639	35932	36226	36520	36816	37113
2225	37411	37711	38010	38312	38614	38917	39222	39527	39834	40141
2226	40450	40761	41071	41383	41695	42009	42324	42639	42956	43273
2227	43591	43911	44230	44551	44873	45196	45519	45843	46169	46494
2228	46822	47150	47478	47808	48139	48471	48804	49138	49473	49809
2229	50146	50485	50824	51165	51506	51849	52193	52538	52884	53231
2230	53580	53930	54280	54633	54986	55341	55697	56053	56412	56771
2231	57132	57494	57857	58222	58588	58956	59325	59695	60066	60439
2232	60813	61189	61566	61945	62324	62705	63088	63471	63856	64241
2233	64629	65018	65407	65798	66190	66584	66979	67375	67773	68172
2234	68573	68975	69378	69783	70188	70596	71004	71413	71824	72235
2235	72649	73063	73478	73895	74312	74731	75152	75572	75994	76416
2236	76841	77267	77692	78120	78548	78979	79410	79841	80275	80709
2237	81145	81582	82019	82459	82899	83341	83784	84228	84674	85120
2238	85569	86019	86469	86921	87374	87829	88285	88742	89201	89660
2239	90121	90583	91046	91511	91977	92445	92914	93383	93855	94327
2240	94801	95277	95753	96231	96710	97191	97674	98157	98643	99129
2241	99617	100108	100598	101091	101585	102081	102578	103076	103577	104078
2242	104582	105087	105592	106100	106608	107119	107631	108144	108659	109174
2243	109692	110211	110731	111253	111775	112300	112827	113353	113882	114412
2244	114943	115477	116010	116547	117083	117622	118163	118703	119246	119790
2245	120336	120884	121431	121982	122532	123085	123639	124194	124750	125307
2246	125866	126426	126986	127549	128112	128677	129243	129809	130377	130945
2247	131516	132087	132659	133233	133807	134383	134960	135537	136116	136695
2248	137277	137860	138442	139027	139612	140199	140787	141375	141965	142555
2249	143148	143741	144334	144930	145526	146124	146723	147321	147922	148523
2250	149127	149731	150335	150941	151548	152156	152766	153375	153987	154598
2251	155212	155827	156441	157058	157675	158294	158914	159533	160155	160777
2252	161401	162026	162651	163278	163904	164533	165163	165792	166424	167056

Lake J. B. Thomas
RESERVOIR VOLUME TABLE

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
2253	167690	168324	168959	169595	170231	170870	171510	172149	172790	173431
2254	174075	174719	175363	176010	176655	177304	177953	178602	179253	179903
2255	180557	181211	181864	182520	183176	183834	184493	185151	185812	186473
2256	187136	187800	188463	189129	189794	190462	191131	191799	192470	193141
2257	193814	194488	195161	195837	196512	197191	197870	198549	199232	199915
2258	200604									

Appendix B

Lake J. B. Thomas

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD November 1999 SURVEY

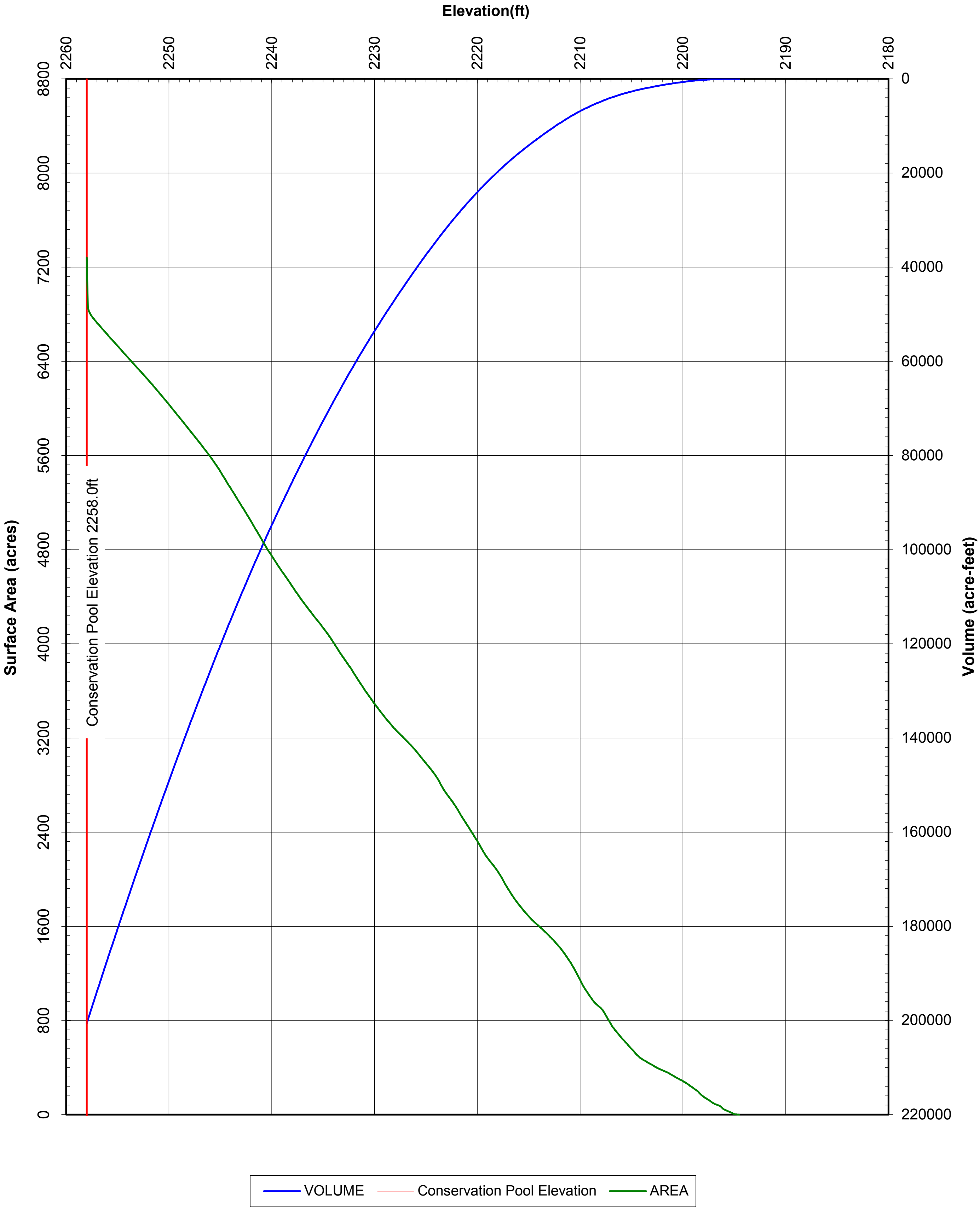
AREA IN ACRES ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet (gage datum)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2194						0	0	0	1	3
2195	5	8	13	17	22	26	29	33	37	40
2196	44	50	60	67	73	78	81	84	87	91
2197	95	100	106	113	119	125	130	136	141	147
2198	153	160	167	176	185	194	202	208	214	220
2199	227	233	239	245	252	258	264	269	274	279
2200	285	290	294	299	304	308	313	318	323	329
2201	334	338	343	348	354	358	362	366	370	373
2202	377	381	385	389	393	397	402	407	412	417
2203	423	428	433	437	442	447	454	458	463	468
2204	473	479	485	494	502	510	520	531	541	550
2205	559	568	578	588	598	607	616	627	636	646
2206	656	666	677	687	698	708	719	731	742	754
2207	770	785	800	815	829	845	861	874	886	897
2208	906	913	921	929	937	946	954	964	976	989
2209	1001	1013	1026	1039	1052	1066	1080	1095	1111	1128
2210	1144	1161	1178	1194	1211	1227	1243	1259	1274	1289
2211	1302	1315	1328	1341	1353	1365	1377	1389	1401	1413
2212	1424	1433	1443	1453	1463	1473	1483	1492	1500	1509
2213	1518	1527	1536	1544	1553	1561	1570	1578	1586	1594
2214	1601	1609	1616	1624	1632	1640	1649	1658	1667	1676
2215	1685	1695	1704	1714	1724	1735	1746	1756	1767	1778
2216	1791	1802	1813	1824	1836	1849	1862	1875	1889	1903
2217	1917	1931	1945	1960	1977	1993	2009	2024	2038	2051
2218	2065	2077	2089	2101	2112	2124	2135	2146	2157	2168
2219	2179	2191	2204	2218	2233	2248	2263	2279	2295	2310
2220	2324	2338	2351	2366	2380	2394	2408	2421	2435	2449
2221	2463	2477	2490	2504	2517	2530	2544	2560	2575	2589
2222	2603	2618	2631	2644	2657	2669	2680	2692	2703	2715
2223	2727	2739	2752	2765	2780	2797	2814	2830	2846	2860
2224	2874	2886	2898	2909	2921	2932	2943	2954	2965	2975
2225	2986	2997	3007	3018	3028	3038	3049	3061	3072	3083
2226	3093	3103	3113	3123	3132	3141	3151	3160	3169	3178
2227	3186	3195	3204	3213	3222	3230	3239	3248	3256	3265
2228	3274	3284	3293	3304	3314	3325	3335	3345	3355	3366
2229	3377	3388	3399	3411	3422	3433	3445	3456	3468	3480
2230	3491	3503	3515	3528	3540	3552	3564	3577	3589	3601
2231	3614	3627	3640	3654	3667	3681	3695	3709	3722	3736
2232	3749	3763	3777	3791	3804	3816	3829	3841	3854	3866
2233	3879	3891	3904	3917	3929	3943	3957	3971	3985	3999
2234	4013	4026	4040	4053	4065	4077	4088	4100	4112	4124
2235	4136	4148	4160	4171	4182	4193	4203	4214	4225	4236
2236	4247	4258	4269	4281	4292	4304	4315	4327	4339	4350
2237	4362	4374	4386	4398	4411	4423	4436	4449	4462	4475
2238	4488	4501	4514	4527	4540	4552	4565	4577	4590	4602
2239	4615	4628	4641	4654	4667	4680	4693	4707	4720	4733
2240	4746	4760	4773	4787	4801	4816	4830	4844	4859	4874
2241	4890	4905	4919	4934	4949	4964	4979	4994	5009	5024
2242	5039	5054	5068	5082	5096	5110	5124	5139	5153	5167
2243	5181	5195	5209	5223	5238	5252	5266	5280	5294	5308
2244	5322	5336	5350	5364	5378	5394	5408	5421	5435	5449
2245	5463	5478	5492	5506	5519	5531	5544	5556	5568	5580
2246	5592	5604	5615	5627	5639	5650	5662	5673	5684	5695
2247	5706	5717	5728	5739	5750	5761	5772	5783	5794	5805
2248	5816	5827	5838	5849	5860	5871	5881	5892	5903	5914
2249	5925	5936	5947	5958	5968	5979	5990	6000	6011	6022
2250	6033	6043	6054	6065	6075	6086	6096	6107	6117	6127

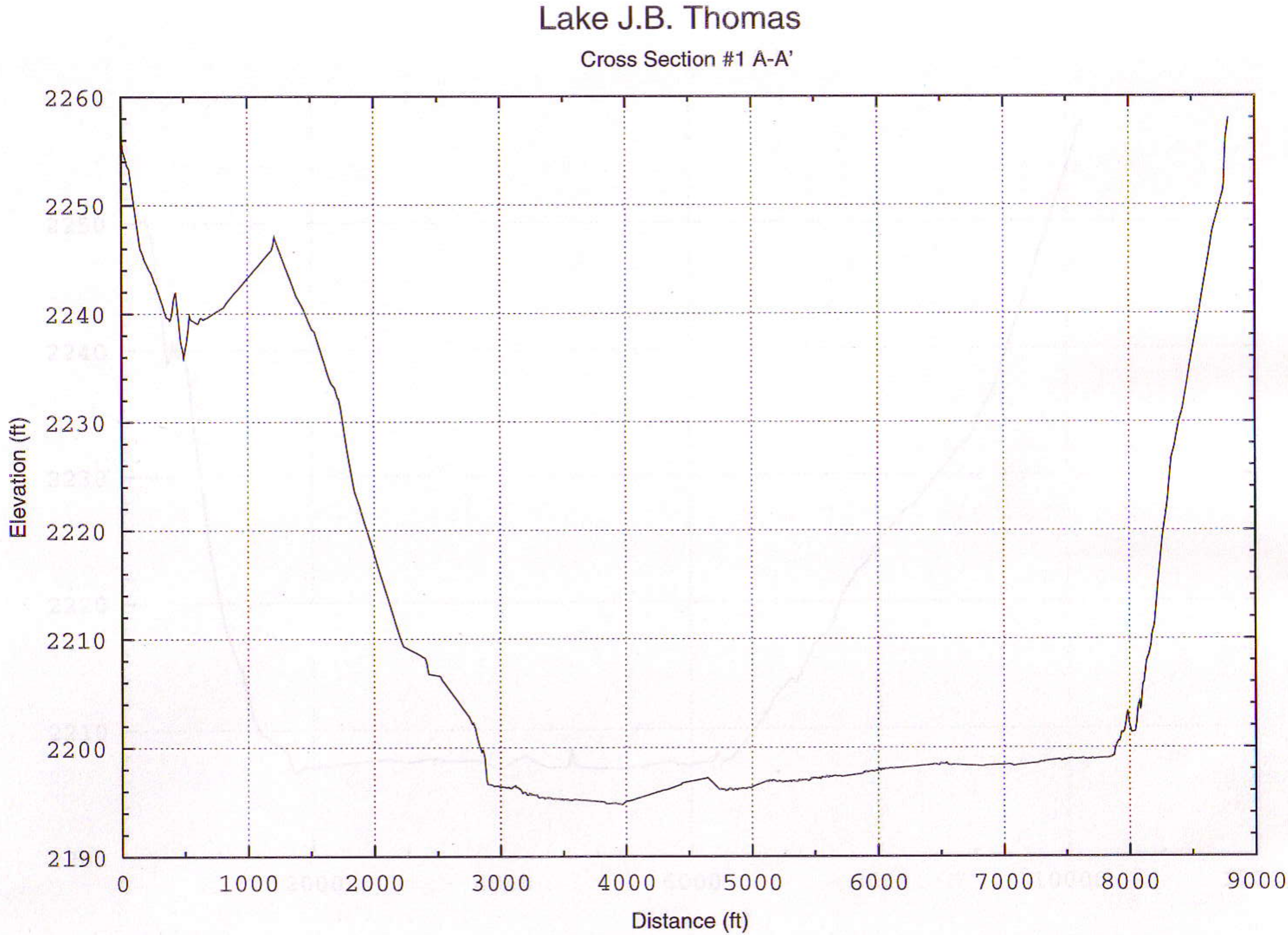
Lake J. B. Thomas
RESERVOIR AREA TABLE

AREA IN ACRES ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet (gage datum)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
2251	6138	6148	6158	6169	6179	6189	6199	6210	6220	6230
2252	6240	6249	6259	6269	6279	6289	6298	6308	6318	6327
2253	6337	6347	6356	6366	6376	6385	6395	6405	6414	6424
2254	6433	6443	6453	6462	6472	6482	6491	6501	6511	6521
2255	6530	6540	6550	6560	6569	6579	6589	6599	6609	6618
2256	6628	6638	6648	6658	6668	6678	6688	6698	6708	6718
2257	6728	6738	6749	6759	6770	6781	6794	6810	6830	6858
2258	7282									



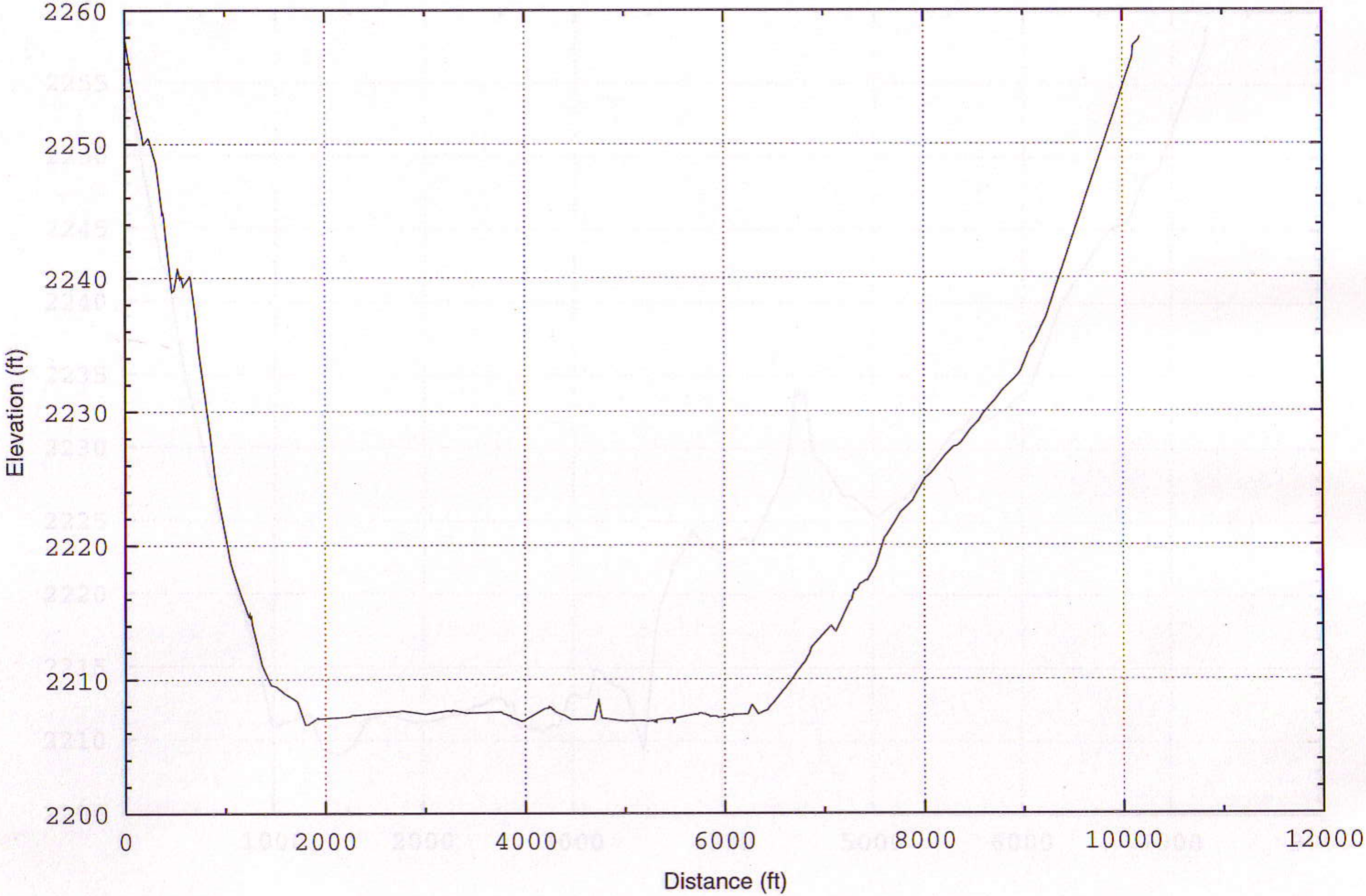
Lake J. B. Thomas
November 1999
Prepared by: TWDB October 2000

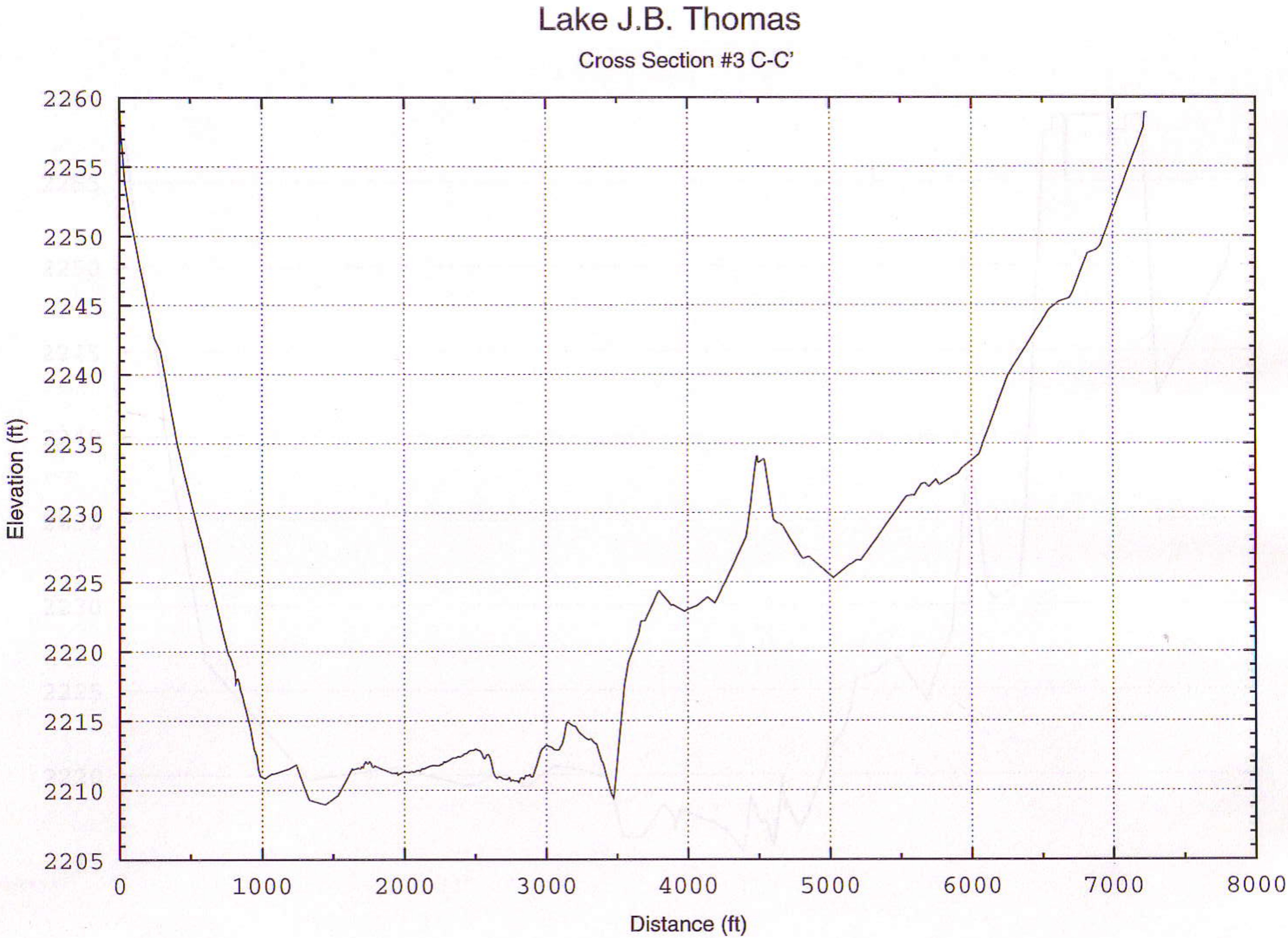

Lake J.B. Thomas
Cross Section #1 A-A'
Elevation (ft)
2260
2250
2240
2230
2220
2210
2200
2190
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Distance (ft)

Appendix D

Lake J.B. Thomas

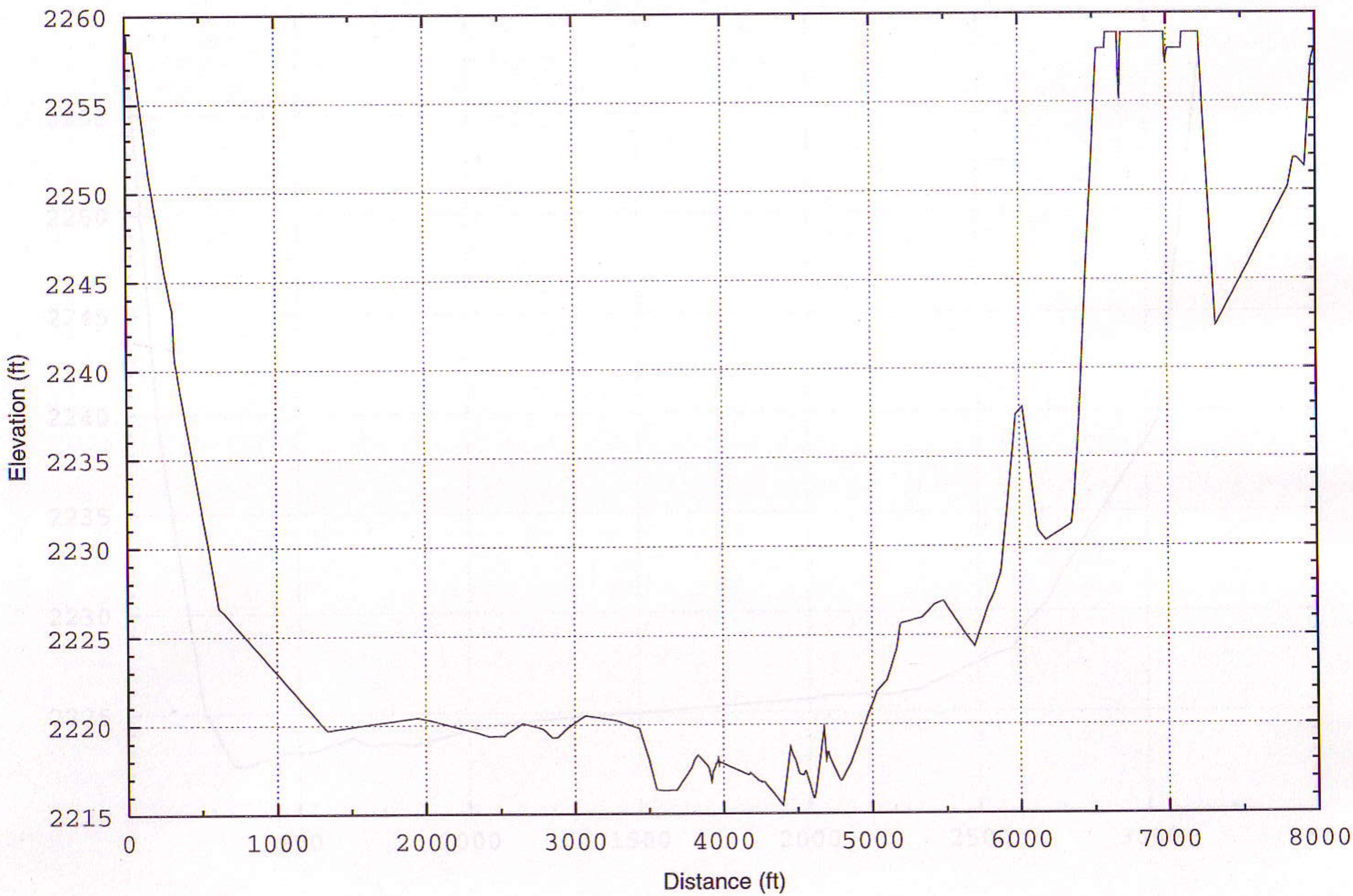
Cross Section #2 B-B'




Lake J.B. Thomas
Cross Section #3 C-C'
Elevation (ft)
2260
2255
2250
2245
2240
2235
2230
2225
2220
2215
2210
2205
0
1000
2000
3000
4000
5000
6000
7000
8000
Distance (ft)

Lake J.B. Thomas

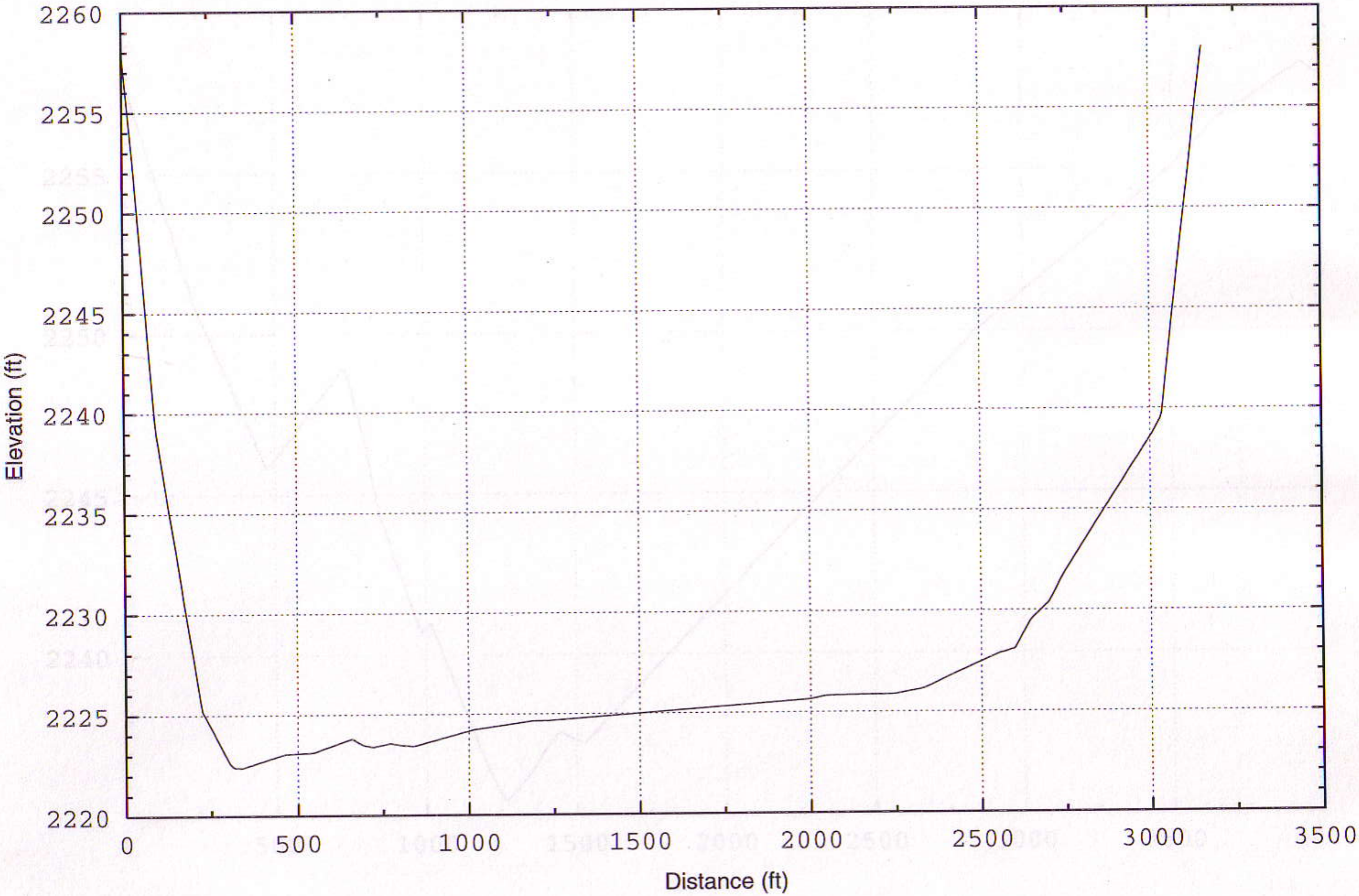
Cross Section #4 D-D'



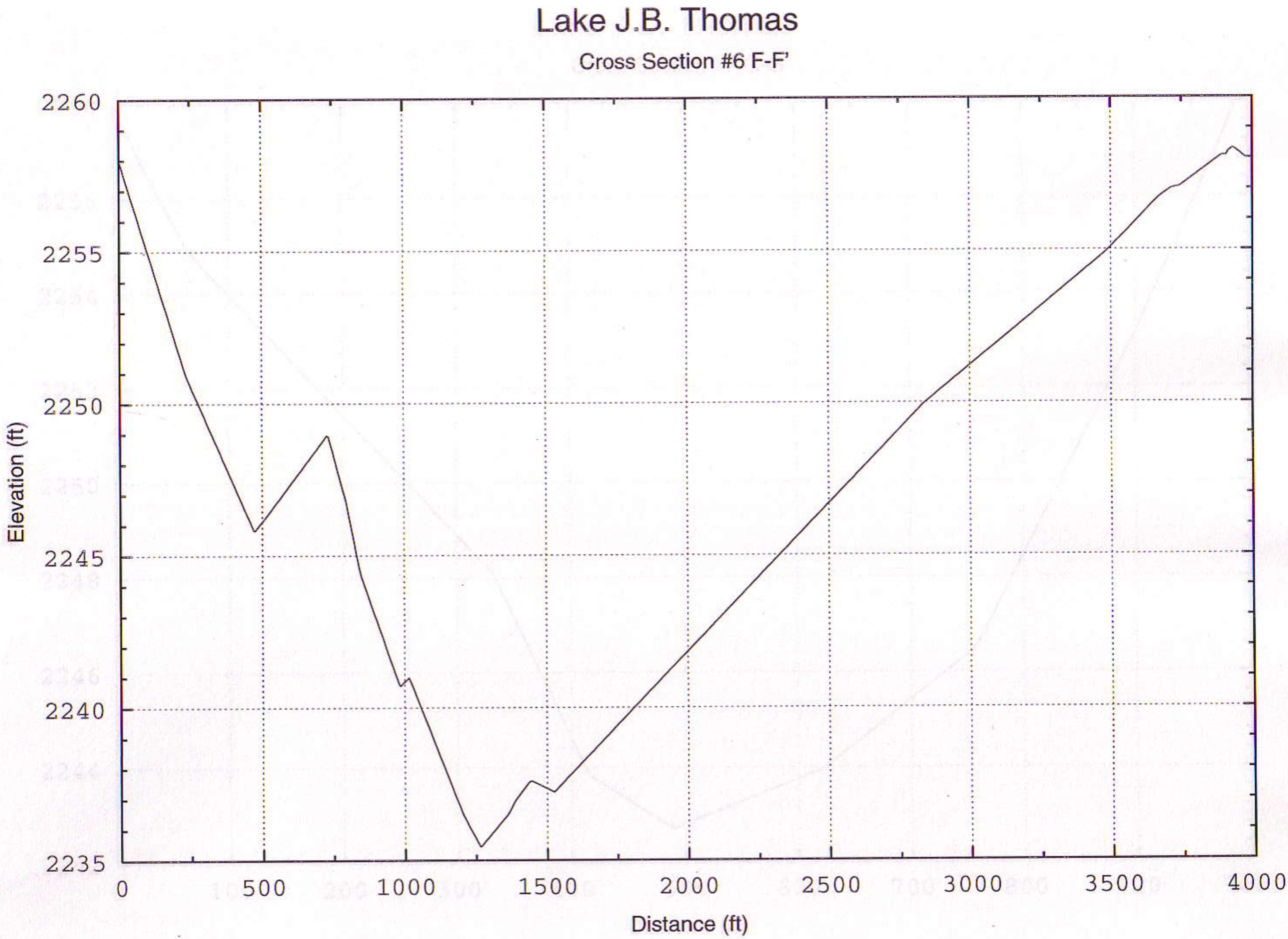
Appendix D

Lake J.B. Thomas

Cross Section #5 E-E'



Appendix D

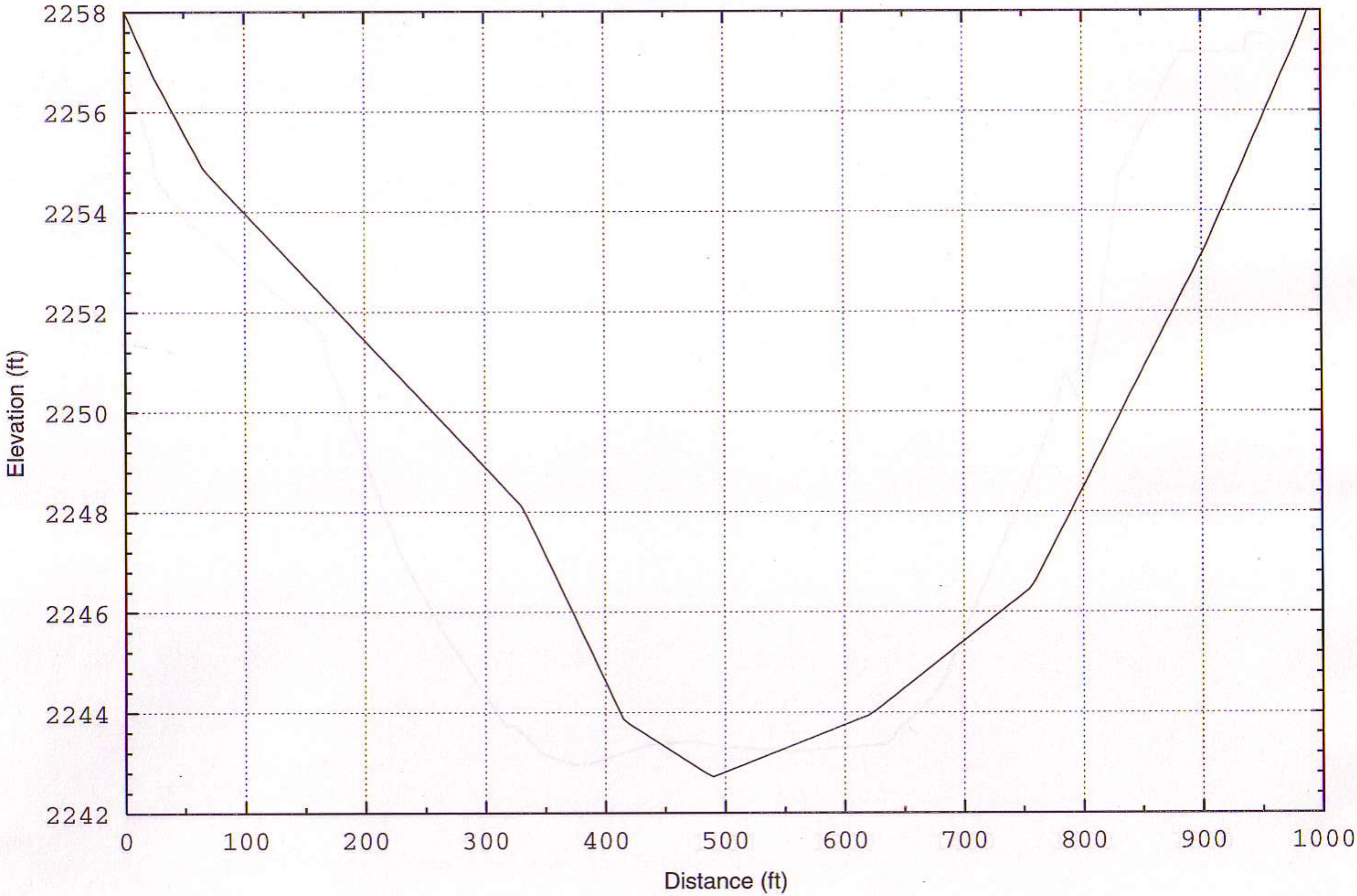


Lake J.B. Thomas
Cross Section #6 F-F'
Elevation (ft)
2260
2255
2250
2245
2240
2235
0
500
1000
1500
2000
2500
3000
3500
4000
Distance (ft)

Appendix D

Lake J.B. Thomas

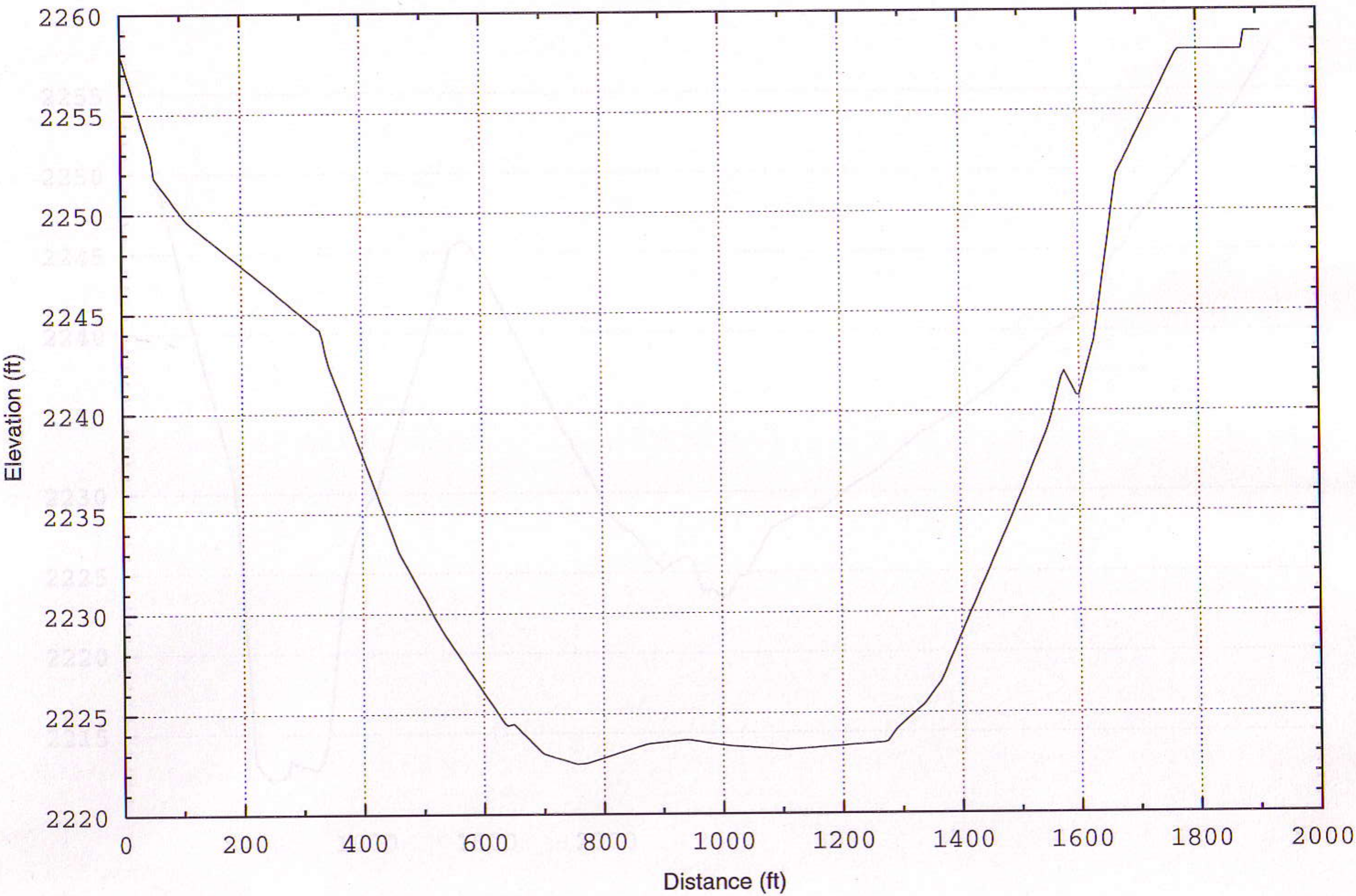
Cross Section #7 G-G'

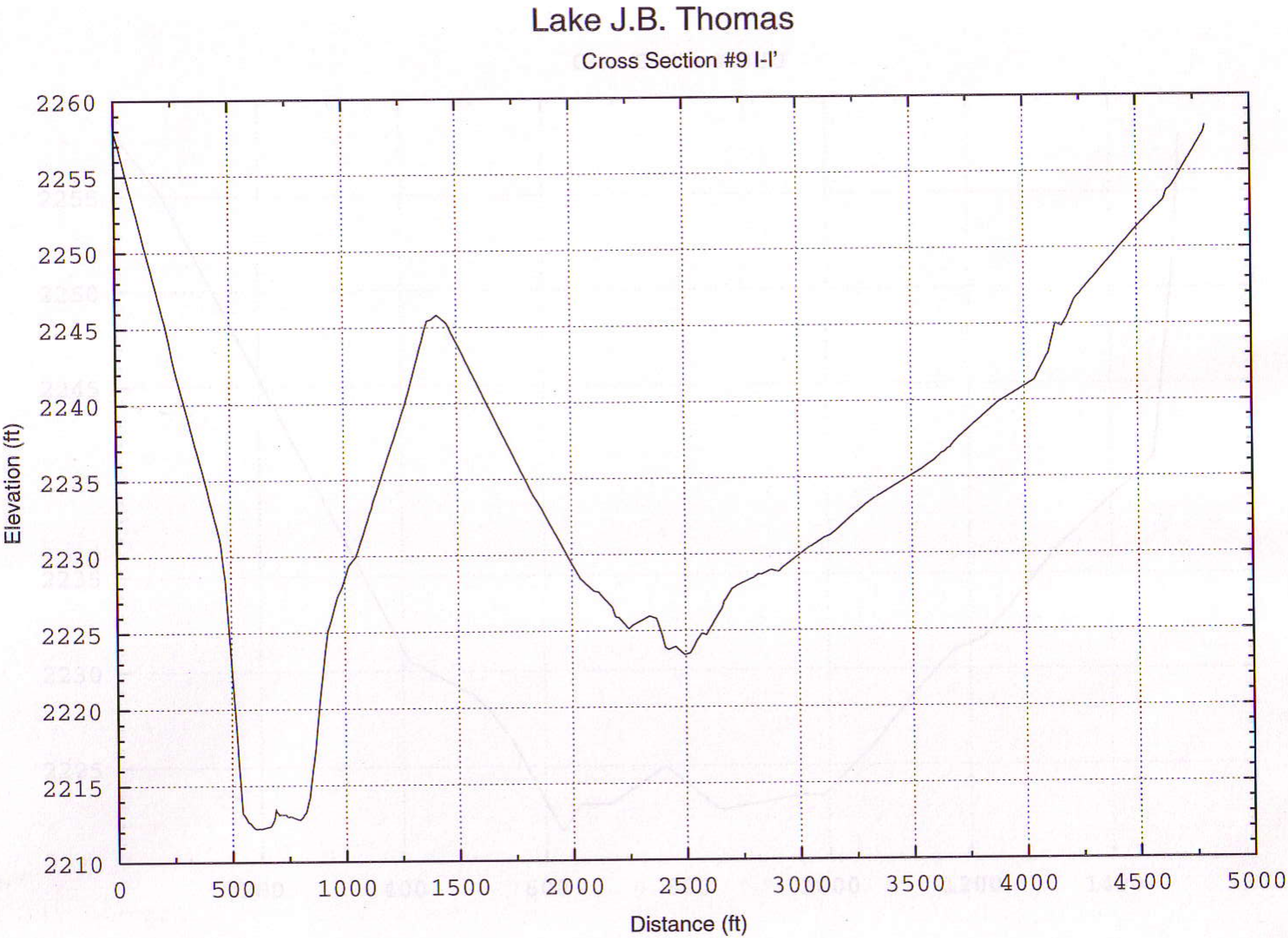


Appendix D

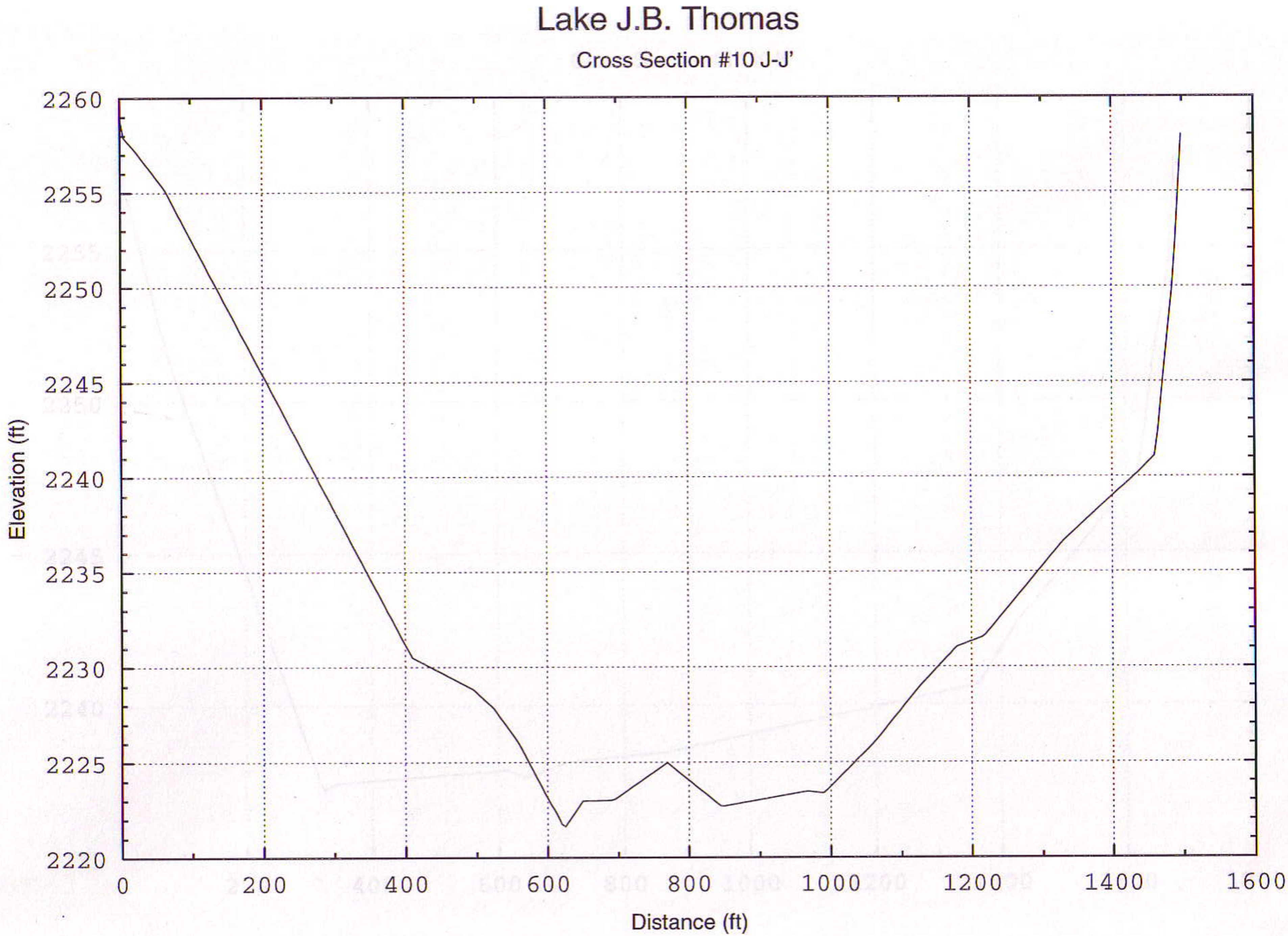
Lake J.B. Thomas

Cross Section #8 H-H'



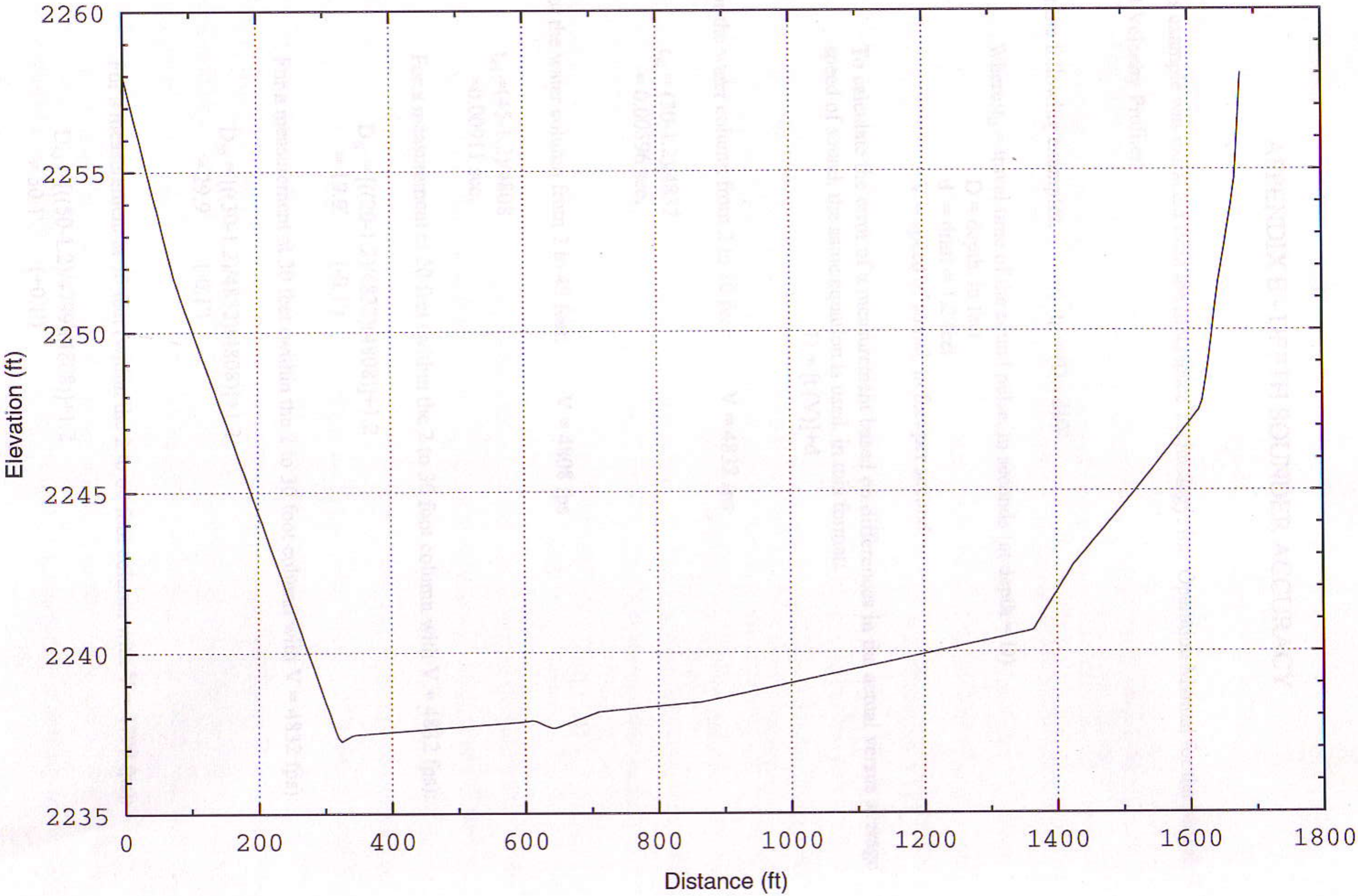

Lake J.B. Thomas
Cross Section #9 I-I'
Elevation (ft)
2260
2255
2250
2245
2240
2235
2230
2225
2220
2215
2210
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Distance (ft)

Appendix D


Lake J.B. Thomas
Cross Section #10 J-J'
Elevation (ft)
2260
2255
2250
2245
2240
2235
2230
2225
2220
0
200
400
600
800
1000
1200
1400
1600
Distance (ft)

Lake J.B. Thomas

Cross Section #11 K-K'



APPENDIX E - 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')

APPENDIX F - GPS BACKGROUND

GPS Information

The following is a brief and simple description of Global Positioning System (GPS) technology. GPS is a relatively new technology that uses a network of satellites, maintained in precise orbits around the earth, to determine locations on the surface of the earth. GPS receivers continuously monitor the satellite broadcasts to determine the position of the receiver. With only one satellite being monitored, the point in question could be located anywhere on a sphere surrounding the satellite with a radius of the distance measured. The observation of two satellites decreases the possible location to a finite number of points on a circle where the two spheres intersect. With a third satellite observation, the unknown location is reduced to two points where all three spheres intersect. One of these points is located in space, and is ignored, while the second is the point of interest located on earth. Although three satellite measurements can fairly accurately locate a point on the earth, the minimum number of satellites required to determine a three dimensional position within the required accuracy is four. The fourth measurement compensates for any time discrepancies between the clock on board the satellites and the clock within the GPS receiver.

The United States Air Force and the defense establishment developed GPS technology in the 1960's. After program funding in the early 1970's, the initial satellite was launched on February 22, 1978. A four-year delay in the launching program occurred after the Challenger space shuttle disaster. In 1989, the launch schedule was resumed. Full operational capability was reached on April 27, 1995 when the NAVSTAR (NAVigation System with Time And Ranging) satellite constellation was composed of 24 Block II satellites. Initial operational capability, a full constellation of 24 satellites, in a combination of Block I (prototype) and Block II satellites, was achieved December 8, 1993. The NAVSTAR satellites provide data based on the World Geodetic System (WGS '84) spherical datum. WGS '84 is essentially identical to the 1983 North American Datum (NAD '83).

The United States Department of Defense (DOD) is currently responsible for implementing and maintaining the satellite constellation. In an attempt to discourage the use of these survey units as a guidance tool by hostile forces, DOD implemented means of false signal projection called Selective Availability (S/A). Positions determined by a single receiver when S/A is active result in errors to the actual position of up to

100 meters. These errors can be reduced to centimeters by performing a static survey with two GPS receivers, of which one is set over a point with known coordinates. The errors induced by S/A are time-constant. By monitoring the movements of the satellites over time (one to three hours), the errors can be minimized during post processing of the collected data and the unknown position computed accurately.

Differential GPS (DGPS) is an advance mode of satellite surveying in which positions of moving objects can be determine in real-time or "on-the-fly." This technological breakthrough was the backbone of the development of the TWDB's Hydrographic Survey Program. In the early stages of the program, one GPS receiver was set up over a benchmark with known coordinates established by the hydrographic survey crew. This receiver remained stationary during the survey and monitored the movements of the satellites overhead. Position corrections were determined and transmitted via a radio link once per second to another GPS receiver located on the moving boat. The boat receiver used these corrections, or differences, in combination with the satellite information it received to determine its differential location. This type of operation can provide horizontal positional accuracy within one meter. In addition, the large positional errors experienced by a single receiver when S/A is active are negated. The lake surface during the survey serves as the vertical datum for the bathymetric readings from a depth sounder. The sounder determines the lake's depth below a given horizontal location at the surface.

The need for setting up a stationary shore receiver for current surveys has been eliminated by registration with a fee-based satellite reference position network (OmniSTAR). This service works on a worldwide basis in a differential mode basically the same way as the shore station. For a given area in the world, a network of several monitoring sites (with known positions) collect GPS signals from the NAVSTAR network. GPS corrections are computed at each of these sites to correct the GPS signal received to the known coordinates of the site. The correction corresponding to each site is automatically sent to a "Network Control Center" where they are checked and repackaged for up-link to a "Geostationary" L-band satellite. The "real-time" corrections are then broadcast by the satellite to users of the system in the area covered by that satellite. The OmniSTAR receiver translates the information and supplies it to the on-board Trimble receiver for correction of the boat's GPS positions. The accuracy of this system in a real-time mode is normally 1 meter or less.

Previous Survey Procedures

Originally, lake surveys were conducted by stretching a rope across the lake along pre-determined range lines and, from a small boat, poling the depth at selected intervals along the rope. Over time, aircraft cable replaced the rope and electronic depth sounders replaced the pole. The boat was hooked to the cable, and depths were recorded at selected intervals. This method, used mainly by the Soil Conservation Service, worked well for small lakes.

Larger bodies of water required more involved means to accomplish the survey, mainly due to increased size. Cables could not be stretched across the body of water, so surveying instruments were utilized to determine the path of the boat. Monuments were set at the end points of each line so the same lines could be used on subsequent surveys. Prior to a survey, each end point had to be located (and sometimes reestablished) in the field and vegetation cleared so that line of sight could be maintained. One surveyor monitored the path of the boat and issued commands via radio to insure that it remained on line while a second surveyor determined the horizontal location by turning angles. Since it took a major effort to determine each of the points along the line, the depth readings were spaced quite a distance apart. Another major cost was the land surveying required prior to the lake survey to locate the range line monuments and clear vegetation.

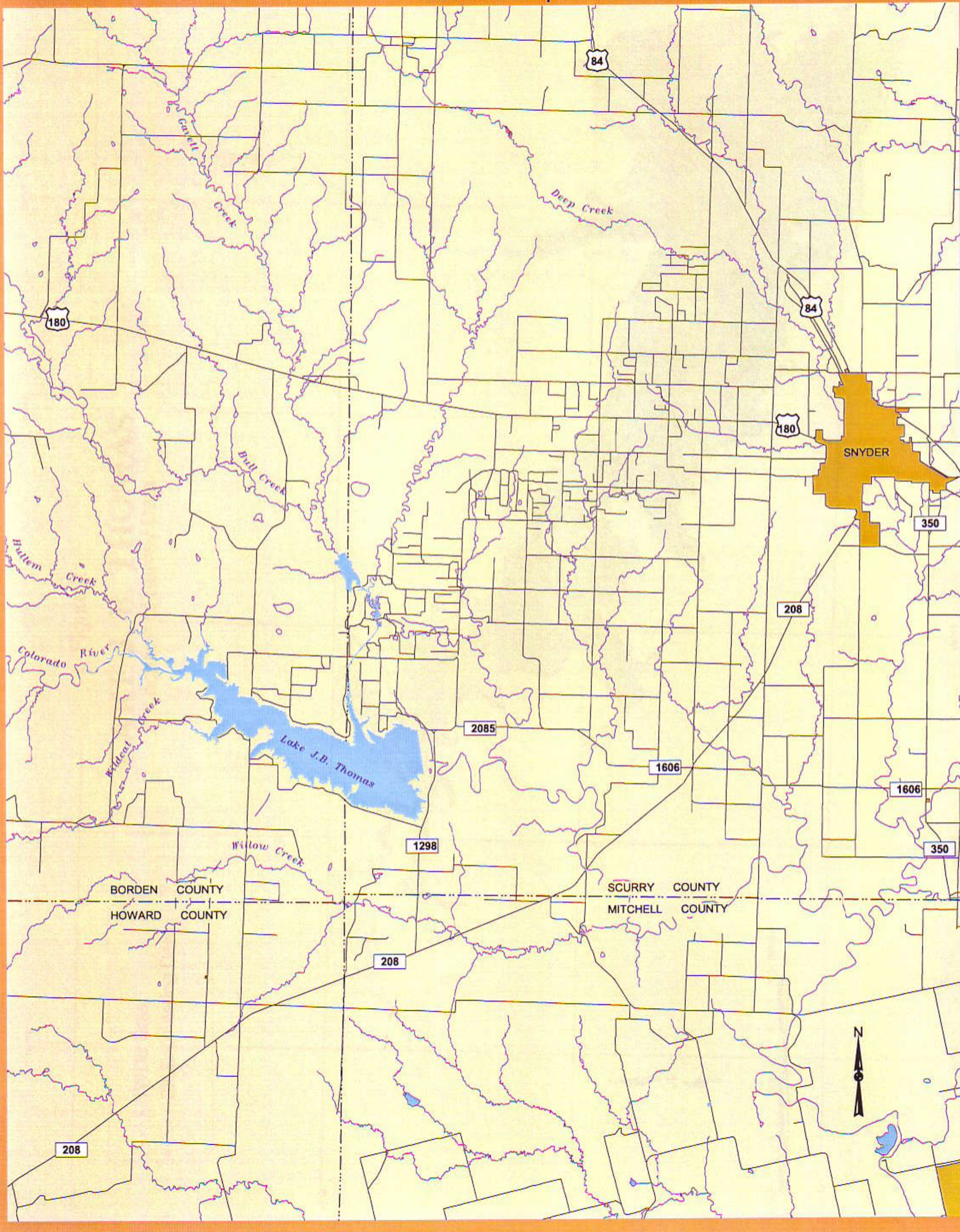
Electronic positioning systems were the next improvement. Continuous horizontal positioning by electronic means allowed for the continuous collection of depth soundings by boat. A set of microwave transmitters positioned around the lake at known coordinates allowed the boat to receive data and calculate its position. Line of site was required, and the configuration of the transmitters had to be such that the boat remained within the angles of 30 and 150 degrees with respect to the shore stations. The maximum range of most of these systems was about 20 miles. Each shore station had to be accurately located by survey, and the location monumented for future use. Any errors in the land surveying resulted in significant errors that were difficult to detect. Large lakes required multiple shore stations and a crew to move the shore stations to the next location as the survey progressed. Land surveying remained a major cost with this method.

More recently, aerial photography has been used prior to construction to generate elevation contours from which to calculate the volume of the lake. Fairly accurate results could be obtained, although the vertical accuracy of the aerial topography is generally one-half of the contour interval or $\pm$ five feet for a ten-foot contour interval. This method can be quite costly and is applicable only in areas that are not inundated.

FIGURE 1

LAKE J. B. THOMAS

Location Map

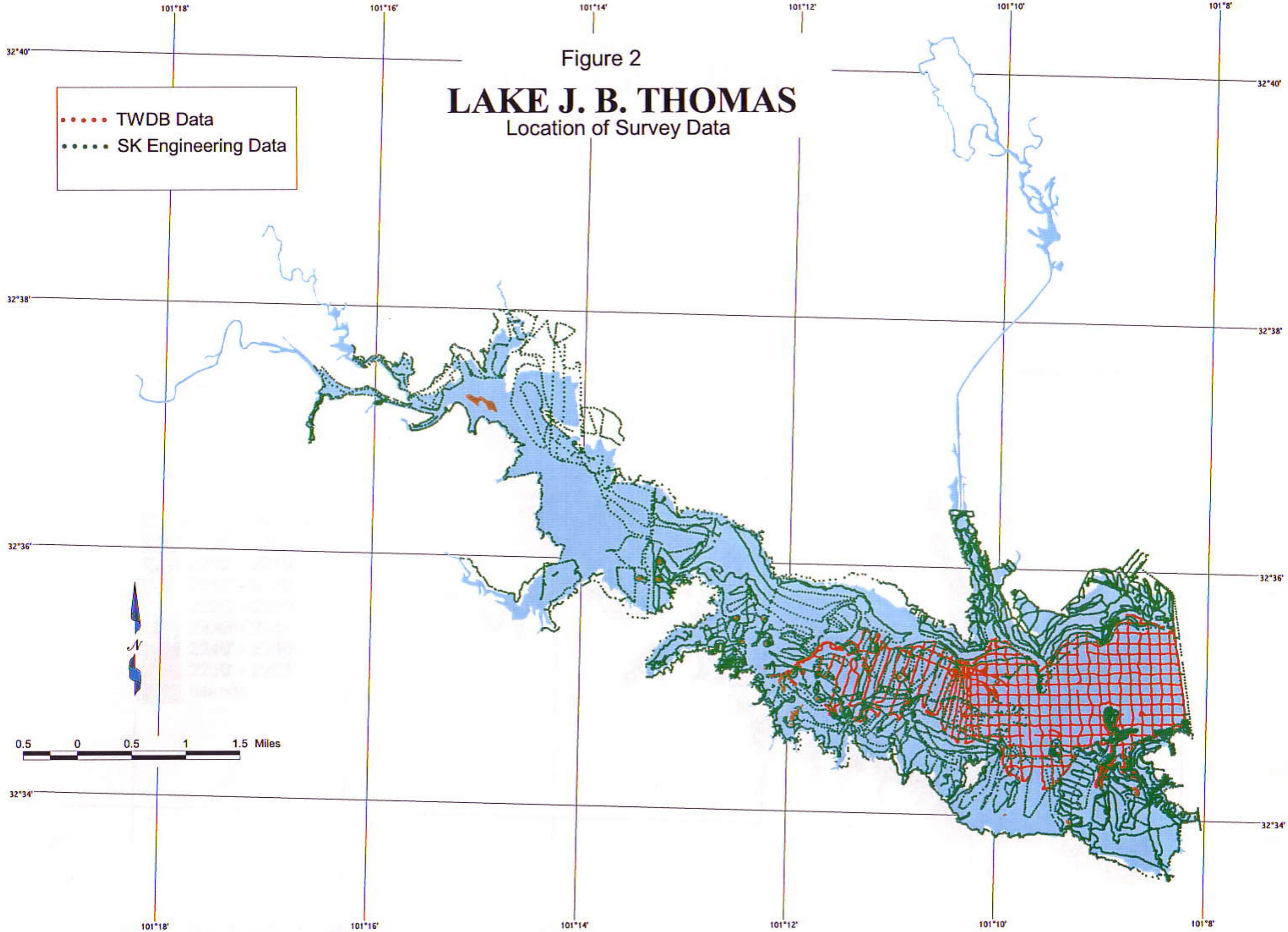


Prepared by : TWDB October 2000

Figure 2

LAKE J. B. THOMAS

Location of Survey Data

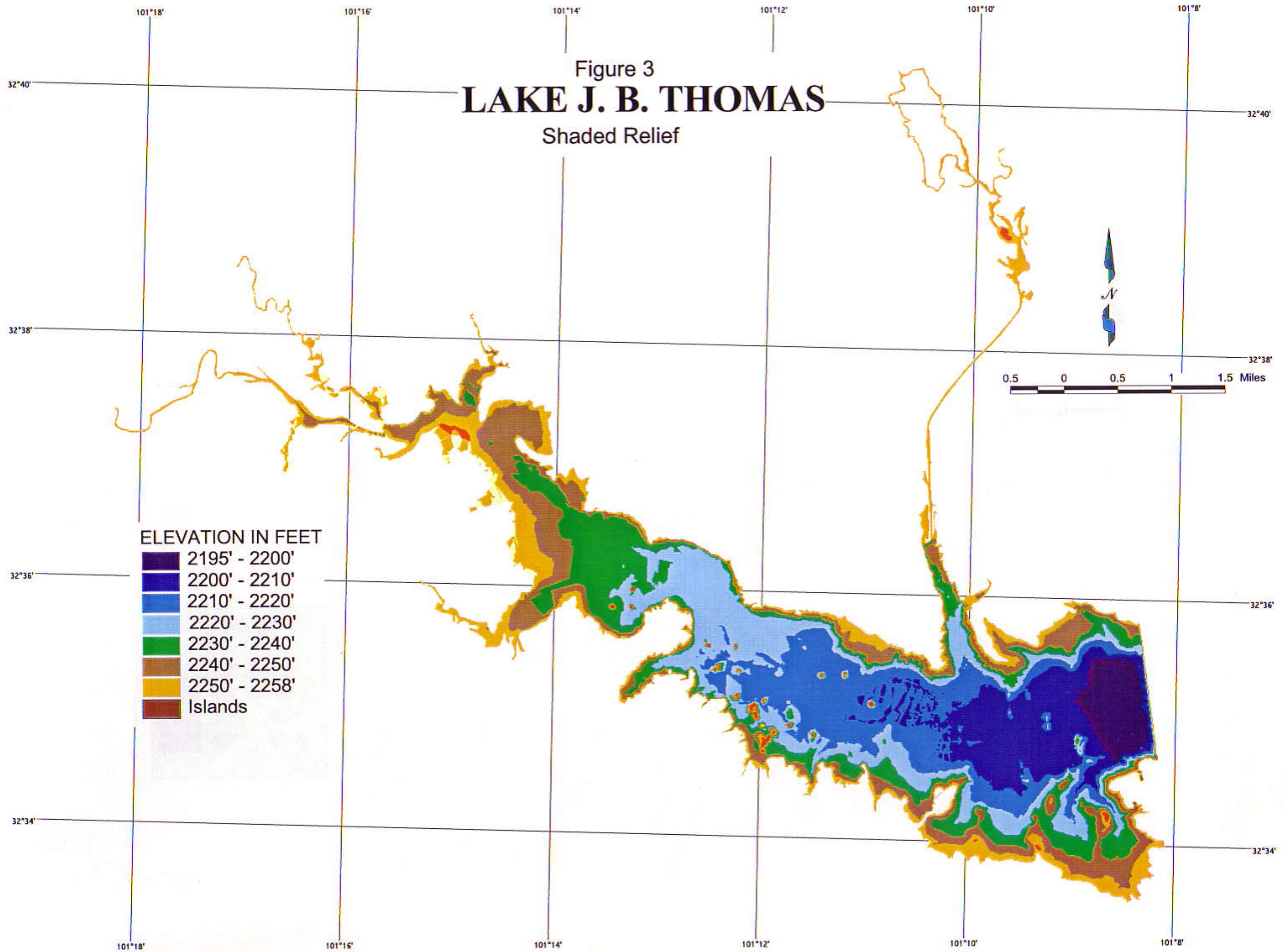


Prepared by : TWDB October 2000

Figure 3

LAKE J. B. THOMAS

Shaded Relief



Prepared by : TWDB October 2000

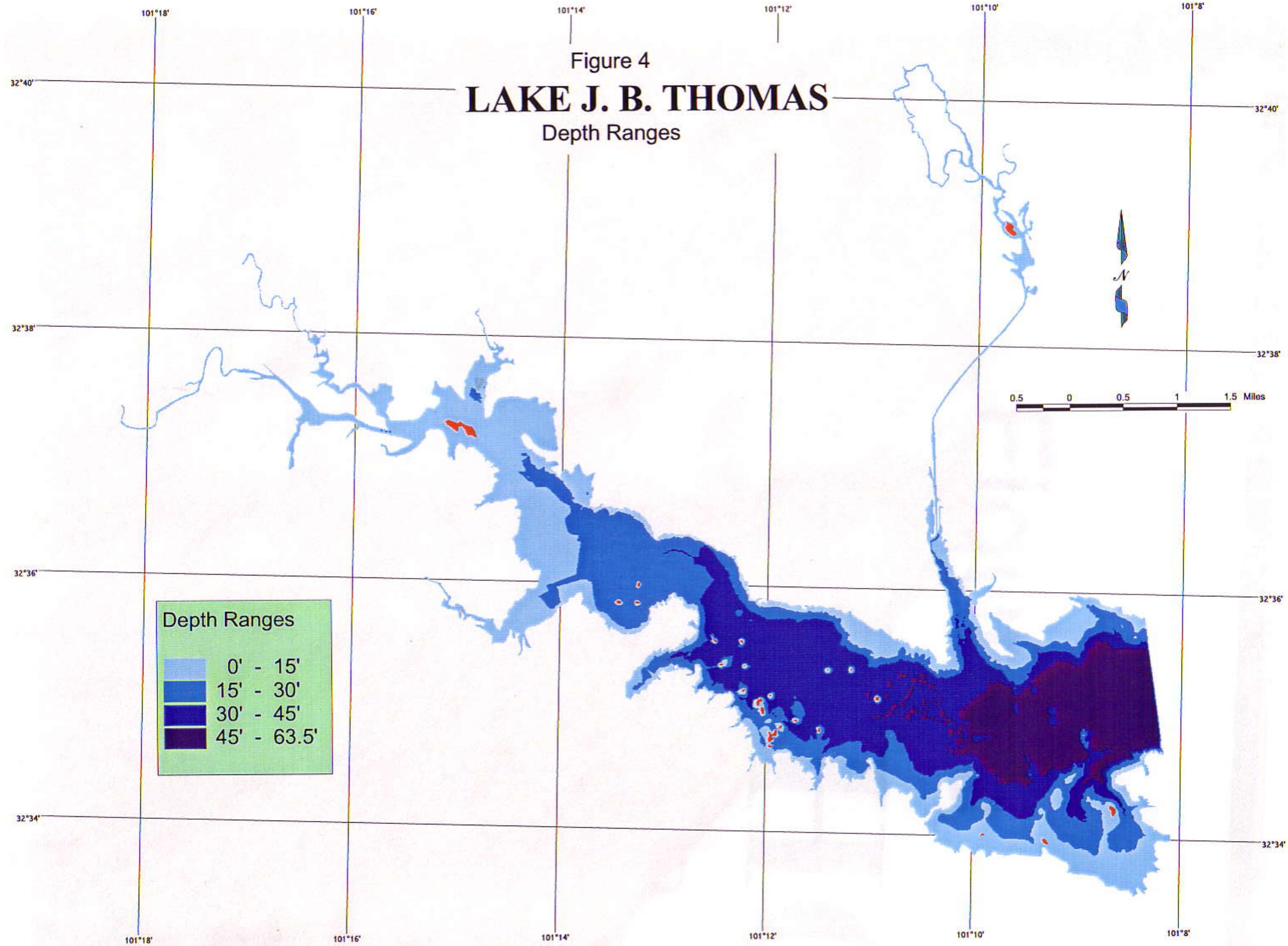


Figure 4
LAKE J. B. THOMAS
Depth Ranges

Prepared by : TWDB OCTOBER 2000