VOLUMETRIC SURVEY OF LAKE MURVAUL

Prepared for:

PANOLA COUNTY FRESH WATER SUPPLY DISTRICT NO. 1

Prepared by:

The Texas Water Development Board

April 15, 1999

Texas Water Development Board

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INTRODUCTION

Staff of the Hydrographic Survey Unit of the Texas Water Development Board (TWDB) conducted a hydrographic survey of Lake Murvaul during the period of November 22-24, 1998. The purpose of the survey was to determine the capacity of the lake at the conservation pool elevation. From this baseline information, future surveys will be able to determine the location and rates of sediment deposition in the conservation pool over time. Survey results are presented in the following pages in both graphical and tabular form. All elevations presented in this report will be reported in feet above mean sea level based on the National Geodetic Vertical Datum of 1929 (NGVD '29) unless the elevation is noted otherwise. The conservation pool elevation for Lake Murvaul is 265.3 feet. The original design information estimates the surface area at this elevation to be 3,820 acres and the storage volume to be 45,815 acre-feet of water.

LAKE HISTORY AND GENERAL INFORMATION

Historical information on Lake Murvaul was obtained from Texas Water Development Board and United States Geological Survey reports (TWDB 1967; TWDB 1974; USGS 1997). Panola County Fresh Water Supply District No. 1 owns the water rights to Lake Murvaul and operates and maintains associated Lake Murvaul Dam. The lake is located on Murvaul Bayou in Panola County, 10 miles southwest of Carthage, Texas (see Figure 1). Records indicate the drainage area is approximately 115 square miles. At the conservation pool elevation, the lake has approximately 38 miles of shoreline and is 5.5 miles long. The widest point of the reservoir is approximately 1.4 miles (located 200 feet upstream of the dam).

Water Rights Permit No. 1837 (Application No. 1985) was issued to Panola County Fresh Water Supply District No. 1 on September 10, 1956 and authorized the construction of a dam to impound 44,650 acre-feet of water. The owner was granted the right to divert and use up to 6,700 acre-feet of water for municipal purposes and 15,700 acre-feet of water for industrial purposes. The permit was amended to change water uses in 1968 and 1983. The Texas Water Commission issued Certificate of Adjudication No. 05-4654 on December 10, 1986. The certificate authorizes Panola County Fresh Water Supply District No. 1 to maintain an existing dam and reservoir on Murvaul Bayou (Lake Murvaul) and to impound, up to 44,650 acre-feet of water. The owner was authorized to divert and use up to 21,280 acre-feet of water per year for municipal purposes and 1,120 acre-feet of water for industrial purposes. The impounded water of Lake Murvaul was also authorized for recreational purposes.

Records indicate the construction for Lake Murvaul started in September 26, 1956. Deliberate impoundment began in November 1957 and the project was officially completed June 1, 1958. The design engineer for the facility was C. P. Smith and Associates along with Forrest and Cotton. The general contractors were Markham and Brown and McMullin and Larson. The estimated cost of the dam was $1,600,000.

Lake Murvaul Dam and appurtenant structures consist of a rolled earth fill embankment, 8,300 feet in length, with a maximum height of 51 feet and a crest elevation of 280.0 feet. The service spillway is located at the right (south) end of the main embankment. The spillway is an uncontrolled concrete broad-crested weir and chute, 270 feet in length with a crest elevation of 265.3 feet. The outlet works is a tower with three slide gate openings. The invert for the lowest 48- inch by 48-inch gate is 235.0 feet. Discharges flow into a 36-inch diameter cast iron pipe downstream to the channel and a “tee” valve to the water supply line.

HYDROGRAPHIC SURVEYING TECHNOLOGY

The equipment used in the performance of the hydrographic survey consists of a 23-foot aluminum tri-hull SeaArk craft with cabin, equipped with twin 90-Horsepower Johnson outboard motors. Installed within the enclosed cabin are an Innerspace Helmsman Display (for navigation), an

Innerspace Technology Model 449 Depth Sounder and Model 443 Velocity Profiler, a 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. Reference to brand names does not imply endorsement by the TWDB.

The GPS equipment, survey vessel, and depth sounder combine together to provide an efficient hydrographic survey system. As the boat travels across the lake surface, the depth sounder takes approximately ten readings of the lake bottom each second. 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, bad 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. The level of accuracy is equivalent to or better than previous methods used to determine lake volumes, some of which are discussed in Appendix G.

PRE-SURVEY PROCEDURES

An approximation of the reservoir's surface boundary at conservation pool elevation (elevation 265.3) was digitized prior to the survey with AutoCad software. The boundary was digitized from the LAKE MURVAUL, TX. (Provisional Edition, 1983) and LONG BRANCH, TX (Provisional Edition, 1983) 7.5-minute USGS quadrangle maps. The graphic boundary file created was then transformed into the proper datum, from NAD '27 datum to NAD '83, using Environmental Systems Research Institute’s (ESRI) Arc/Info PROJECT command with the NADCOM (standard conversion method within the United States) parameters. The lake boundary was checked to verify that the area was the same in both datums.

The survey layout was designed by placing survey track lines at 500-foot intervals across the lake. The survey design for this lake required approximately 86 survey lines to be placed along the length of the lake. Survey setup files were created using Coastal Oceangraphics, Inc. Hypack software for each group of track lines that represented a specific section of the lake. The setup files were copied onto diskettes for use during the field survey.

SURVEY PROCEDURES

The following procedures were followed during the hydrographic survey of Lake Murvaul performed by the TWDB. Information regarding equipment calibration and operation, the field survey, and data processing is presented.

Equipment Calibration and Operation

At the beginning of each surveying day, the depth sounder was calibrated with the Innerspace Velocity Profiler, an instrument that measures the local speed of sound. The average speed of sound in the water column extending below the boat-mounted transducers (at a the boat's draft of 1.2 ft) to the lake bottom was determined by averaging local speed-of-sound measurements collected by the velocity profiler 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 time the unit measured the local speed of sound. The average of the measurements was next computed and displayed by the unit. The displayed value of the 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. During the survey of Lake Murvaul, the speed of sound in the water column varied from 4804 to 4814 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 $\pm$0.2 feet, plus an estimated error of $\pm$0.3 feet due to the plane of the boat for a total accuracy of $\pm$0.5 feet for any instantaneous reading. These errors tend to be minimized over the entire survey, since some are positive and some are negative readings. 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

Data were collected at Lake Murvaul during the period of November 22-24, 1998. During data collection, the crew had excellent weather with moderate temperatures and mild winds.. Over 48,000 data points were collected and over 70 miles were traveled. These points were stored digitally on the boat's computer in 106 data files. Data were not collected in areas of shallow water (depths less than 3.0 feet) or with significant obstructions unless these areas represented a large amount of water. Figure 2 shows the actual location of all data collection points.

TWDB staff observed the land surrounding the lake to be generally flat to rolling hills. Along the north shoreline of the lake, between Ritter Point and Moss Point, the crew observed extensive residential development with bulkheads, piers and boat slips. There were fewer residential sites on the south shore between Dudley Williams Point and Smith Point. A minimal number of residences were located on the south shore upstream of the County Road 1971 bridge.

While performing the survey, the field crew noted on the depth sounder chart that the bathymetry or contour of the lake bottom reflected the characteristics of the terrain surrounding the lake. A gradual slope was noticed as the boat traveled from the shoreline to the center of the lake. Near the center of the lake, the old channel of Murvaul Bayou was easily distinguished during the data collection in the main body of the lake.

As the field crew collected data upstream in Lake Murvaul, navigational hazards such as submerged trees and stumps became apparent. Cleared boat lanes ran parallel to the north and south shorelines. In addition, sediment deposits and standing vegetation were observed mainly in the upper reaches of Murvaul Bayou. The crew was able to collect data in these areas, but at a much slower pace. Data collection in the headwaters was limited when the boat could no longer cross the lake due to shallow water and extensive vegetation.

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 future processing.

Data Processing

The collected data were downloaded from diskettes onto the 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 survey, the water surface remained constant at elevation 265.5 feet. After all changes had been made 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 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 reservoir's bottom surface using Arc/Info's TIN software module. The module generates a triangulated irregular network (TIN) network 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 reservoir area and volume can be determined from the triangulated irregular network created using this method of interpolation.

If data points were collected outside the boundary file, the boundary was modified to include the data points. The boundary file in areas of significant sedimentation was also downsized as deemed necessary based on the data points and the observations of the field crew. The resulting boundary shape was used to develop each of the map presentations of the lake in this report.

There were some areas where volume and area values could not be calculated by interpolation because of a lack of information within the reservoir. "Flat triangles" were drawn at these locations. Arc/Info does not use flat triangle areas in the volume or contouring features of the model. These areas were determined to be insignificant for this project, therefore no additional points were needed to allow for interpolation and contouring of the entire lake surface at elevation 265.3. Volumes and areas were calculated from the TIN for the entire reservoir at one-tenth of a foot intervals. From elevation 234.27 to elevation 265.3, the surface areas and volumes of the lake were mathematically estimated using Arc/Info software. The computed area of the lake at elevation 265.3 was 3,507 surface acres. The computed area was 313 surface acres less than originally calculated in 1955 (Texas Water Development Board, 1967). The computed reservoir volume table is presented in Appendix A and the area table in Appendix B. An elevation-area-volume graph is presented in Appendix C.

Other products developed from the model include a shaded relief map and a shaded depth range map. 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. Using the POLYSHADE command, colors were assigned to the range of elevations represented by the polygons that varied from navy to yellow. The lower elevation was assigned the color of navy, and the 265.3 lake elevation was assigned the color of yellow. Different color shades were assigned to the intermediate depths. Figure 3 presents the resulting depth shaded representation of the lake. Figure 4 presents a similar version of the same map, using bands of color for selected depth intervals. The color increases in intensity from the shallow contour bands to the deep-water bands.

Linear filtration algorithms were then applied to the DTM smooth cartographic contours versus using the sharp-engineered contours. The resulting contour map of the bottom surface at two-foot intervals is presented in Figure 5.

RESULTS

Results from the 1998 TWDB survey indicate Lake Murvaul encompasses 3,507 surface acres and contains a total volume of 38,284 acre-feet at the conservation pool elevation of 265.3 feet. The shoreline at this elevation was calculated to be 38 miles. The deepest point of the lake, elevation 234.3 or 31 feet of depth, was located approximately 360 feet upstream from the center of Lake Murvaul Dam. The dead storage volume, or the amount of water below the lowest outlet in the dam, was calculated to be 0.004 acre-feet based on the low flow outlet invert elevation of 235.0 feet. The conservation storage capacity, or the amount of water between the spillway and the lowest outlet, is therefore essentially the same as the total lake volume of 38,284 acre-feet.

SUMMARY

Lake Murvaul was initially impounded in 1957, and filled by May 1958. Initial storage calculations estimated the volume at the conservation pool elevation of 265.3 feet to be 45,815 acre-feet with a surface area of 3,820 acres.

During the period of November 22 - 24, 1998, a hydrographic survey of Lake Murvaul was performed by the Texas Water Development Board's Hydrographic Survey Program. The 1998 survey used technological advances such as differential global positioning and geographical information system technology to model the reservoir's bathymetry. These advances allowed a survey to be performed quickly and to collect significantly more bathymetric data on Lake Murvaul than previous survey methods. Results indicate that the lake's volume at the conservation pool elevation of 265.3 feet is 38,284 acre-feet with an area is 3507 acres.

The estimated reduction in storage capacity at the conservation pool elevation of 265.3 feet since 1958 is 7,531 acre-feet, or roughly 188 acre-feet per year. The average annual deposition rate of sediment in the conservation pool of the reservoir can be estimated at 1.64 acre-feet per square mile of drainage area. *(Please note that this is just a mathematical estimate based on the difference between the original design and the current survey. Limited knowledge on actual sedimentation can be determined from one field survey.)*

It is difficult to compare the original design area amd volume for Lake Murvaul to that determided by the current TWDB survey because little is known about the original design method, the amount of data collected, and the method used to process the collected data. However, TWDB considers the 1998 survey to be a significant improvement over previous survey procedures and recommends that the same methodology be used in five to ten years or after major flood events to monitor changes to the lake's storage capacity.

REFERENCES

Texas Water Development Board. 1967. Dams and reservoirs in Texas, historical and descriptive information, Report 48, June 1967.

Texas Water Development Board. 1974. Engineering data on dams and reservoirs in Texas. Part I. Report 126. October 1974.

United States Geological Survey. Water resources data - Texas. Water year 1997. Volume I. Report TX-97-1.

Appendix A

LAKE MURVAUL

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD NOVEMBER 1998 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
234		0	0	0	0	0	0	0	0	0
235	0	0	0	0	0	0	0	0	0	0
236	0	0	0	0	0	0	0	0	1	1
237	1	1	1	1	2	2	2	3	3	3
238	4	4	5	5	6	7	8	9	10	11
239	13	15	18	21	24	28	32	37	42	48
240	54	61	68	76	84	93	103	113	125	137
241	149	163	178	194	211	229	248	268	289	311
242	333	357	382	407	434	461	489	518	548	579
243	611	644	678	712	748	784	820	857	895	934
244	973	1013	1054	1096	1139	1182	1227	1272	1318	1365
245	1413	1462	1512	1562	1614	1666	1720	1775	1832	1889
246	1948	2008	2070	2133	2197	2263	2330	2398	2467	2538
247	2610	2682	2756	2831	2907	2984	3061	3140	3220	3301
248	3383	3466	3551	3636	3723	3810	3899	3989	4079	4171
249	4265	4359	4454	4551	4648	4747	4847	4948	5050	5153
250	5258	5363	5470	5578	5687	5797	5909	6021	6135	6249
251	6365	6482	6599	6718	6837	6958	7079	7201	7325	7450
252	7575	7702	7830	7959	8089	8219	8351	8484	8618	8753
253	8889	9026	9164	9303	9443	9585	9728	9873	10020	10168
254	10318	10469	10622	10777	10933	11090	11249	11409	11570	11732
255	11896	12061	12227	12394	12563	12732	12903	13074	13247	13421
256	13596	13773	13951	14130	14311	14494	14679	14865	15053	15243
257	15435	15630	15826	16025	16225	16428	16633	16840	17049	17260
258	17474	17689	17906	18125	18347	18570	18796	19024	19254	19486
259	19720	19956	20195	20435	20678	20922	21169	21418	21668	21921
260	22175	22432	22690	22950	23211	23474	23739	24005	24273	24543
261	24814	25088	25363	25641	25920	26202	26485	26770	27058	27347
262	27639	27933	28229	28528	28830	29135	29446	29758	30071	30386
263	30701	31018	31336	31655	31976	32297	32620	32944	33269	33595
264	33922	34251	34580	34911	35243	35576	35911	36246	36583	36921
265	37260	37600	37942	38284						

Appendix B

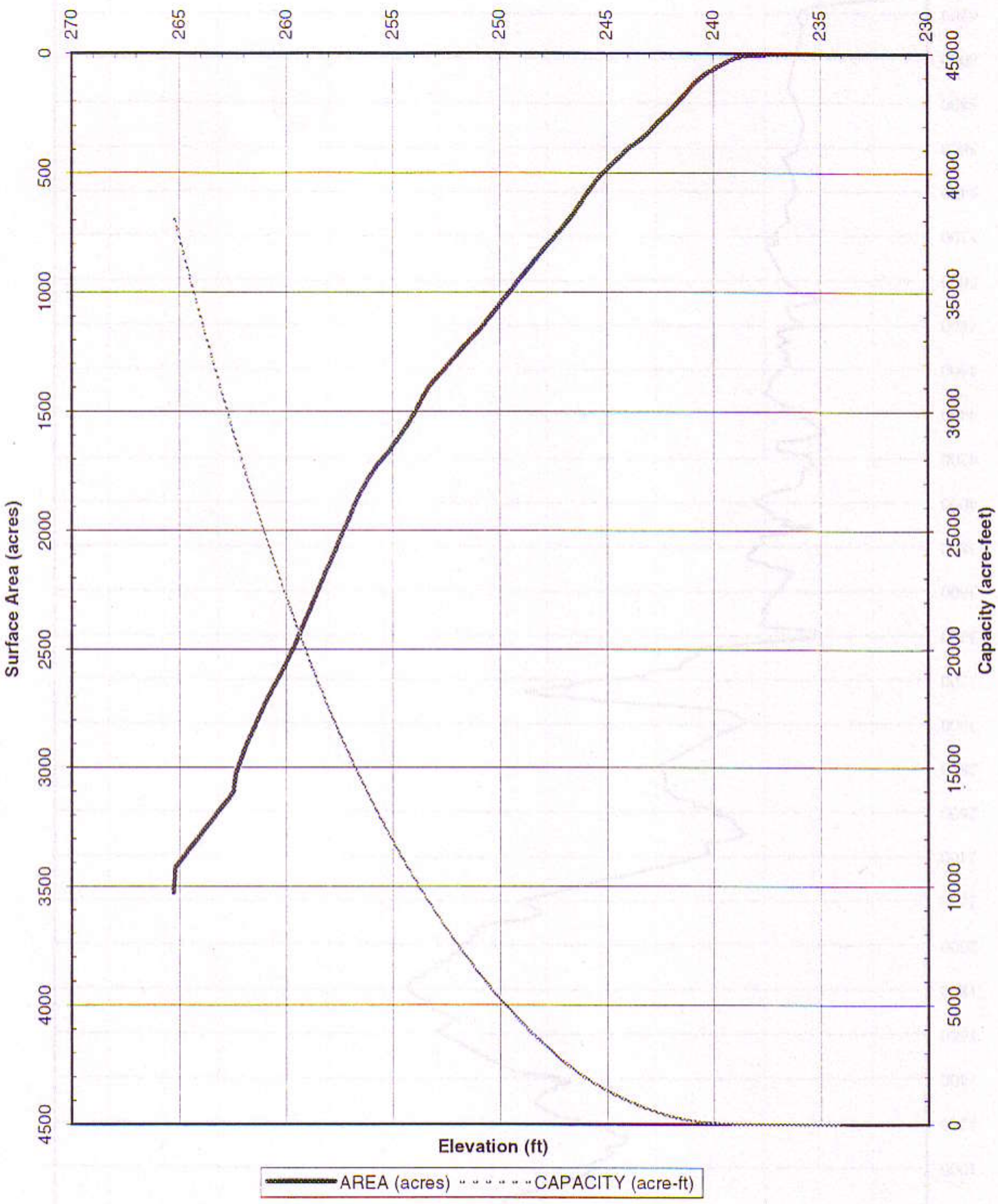
LAKE MURVAUL

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD NOVEMBER 1998 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
236	0	0	0	0	1	1	1	1	1	1
237	2	2	2	2	2	3	3	3	4	4
238	5	5	6	6	7	8	10	11	13	16
239	19	22	26	30	35	40	45	50	55	61
240	66	71	76	81	87	93	100	108	115	124
241	133	143	154	165	175	185	194	204	214	223
242	233	243	252	260	268	276	285	294	305	315
243	325	333	342	350	357	363	370	376	382	389
244	397	405	414	423	432	440	448	457	466	475
245	483	493	502	511	522	533	545	556	569	582
246	596	609	623	636	649	663	676	688	700	711
247	722	733	743	753	763	773	783	793	804	815
248	826	838	849	859	870	881	892	903	914	926
249	937	948	959	970	981	993	1005	1016	1027	1039
250	1050	1061	1072	1085	1097	1108	1119	1130	1141	1152
251	1162	1172	1181	1190	1199	1209	1219	1229	1240	1253
252	1263	1273	1283	1293	1303	1314	1324	1334	1344	1354
253	1363	1373	1384	1396	1410	1425	1441	1458	1475	1491
254	1508	1523	1539	1553	1568	1580	1592	1604	1618	1631
255	1643	1655	1667	1678	1689	1699	1710	1722	1733	1745
256	1758	1773	1788	1804	1820	1836	1852	1870	1891	1913
257	1935	1956	1976	1995	2016	2037	2059	2082	2102	2122
258	2142	2162	2182	2203	2224	2246	2269	2291	2311	2331
259	2352	2372	2393	2415	2437	2457	2478	2497	2516	2534
260	2554	2572	2590	2607	2623	2639	2656	2672	2689	2706
261	2724	2744	2764	2785	2805	2825	2844	2863	2884	2905
262	2928	2952	2976	3002	3030	3103	3115	3127	3139	3151
263	3162	3174	3186	3197	3209	3221	3232	3244	3256	3268
264	3279	3291	3303	3314	3326	3338	3350	3361	3373	3385
265	3397	3409	3420	3507						



LAKE MURVAUL

November 1998

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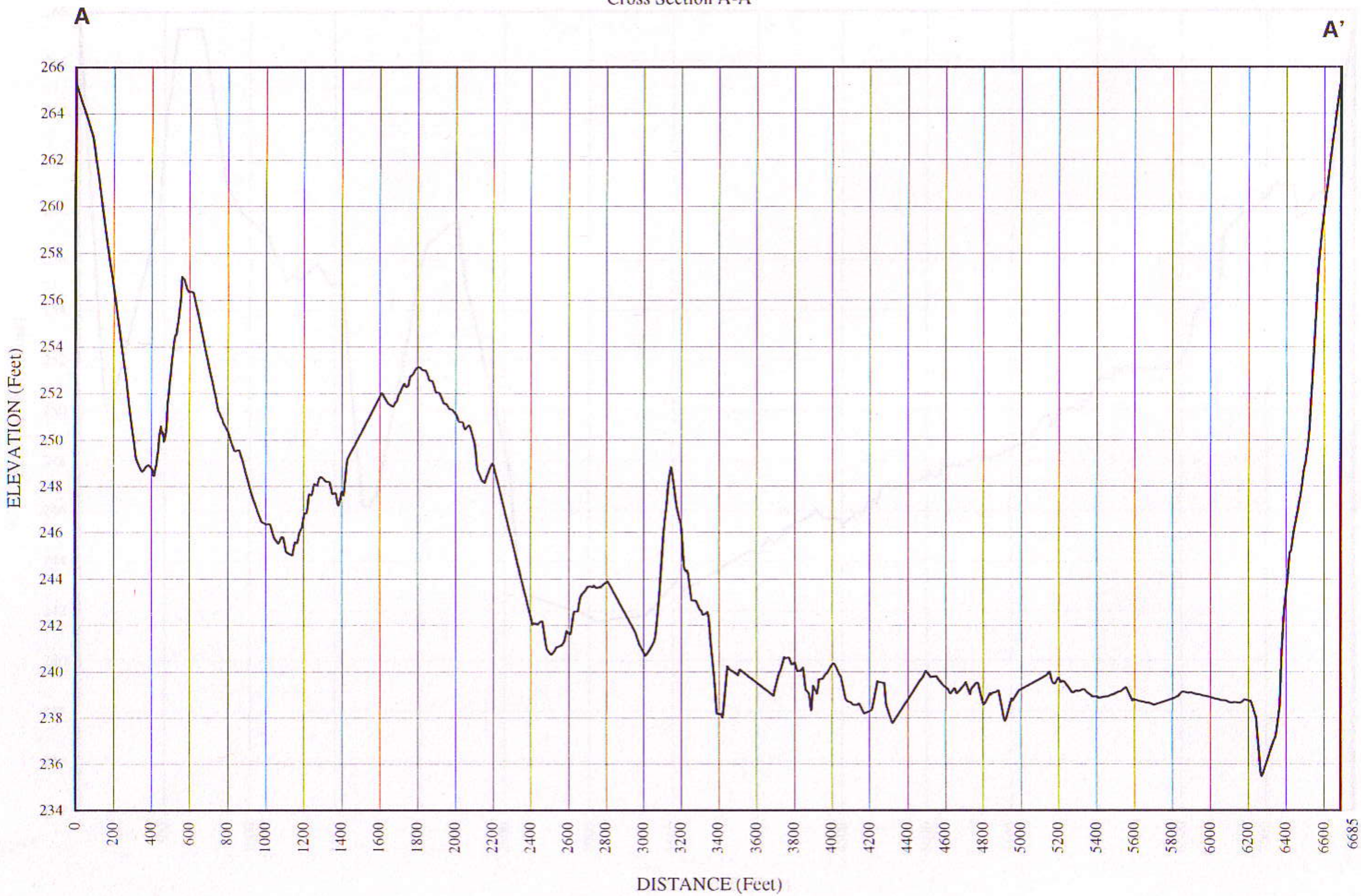
Appendix C

LAKE MURVAUL

Cross Section A-A'



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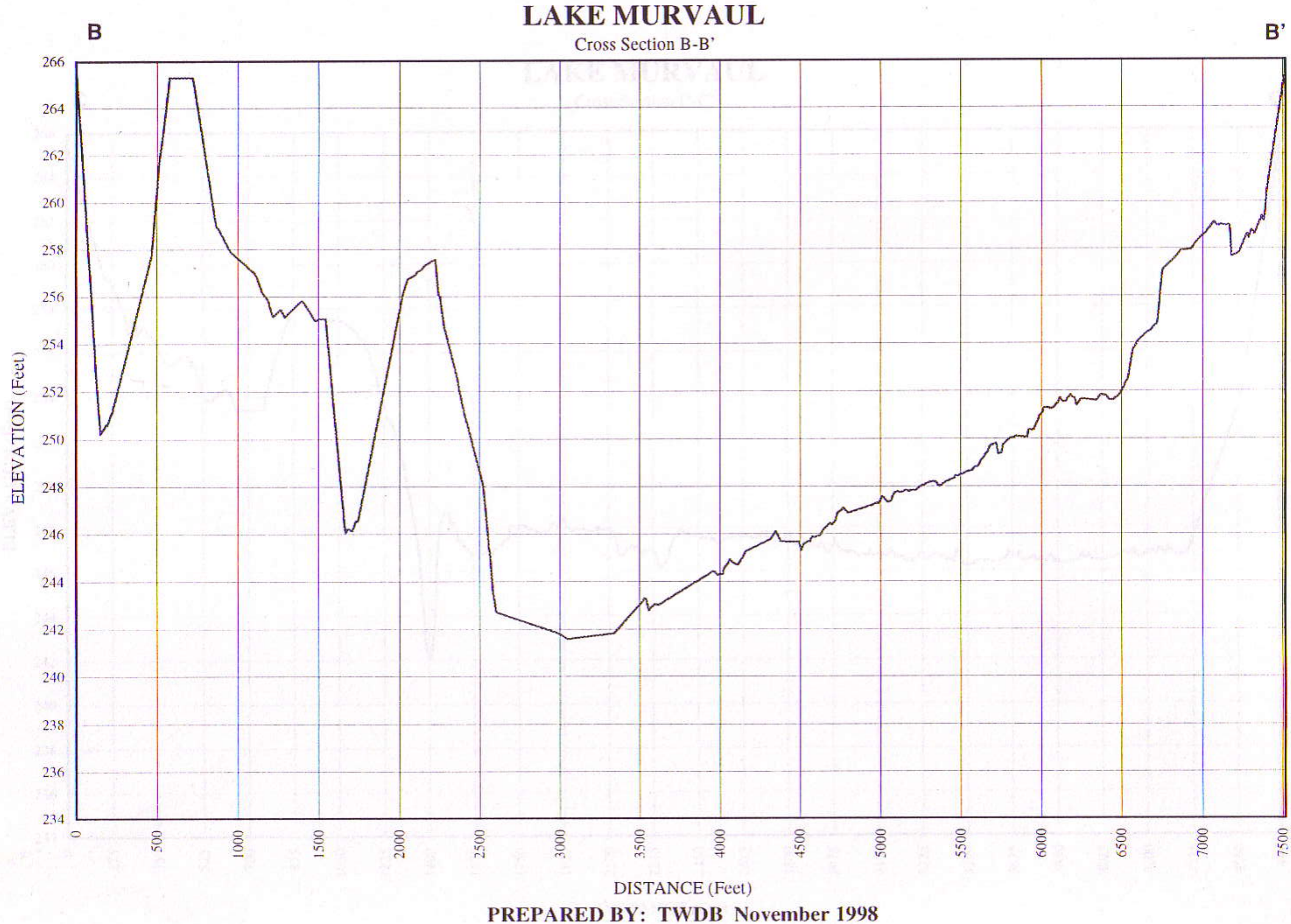
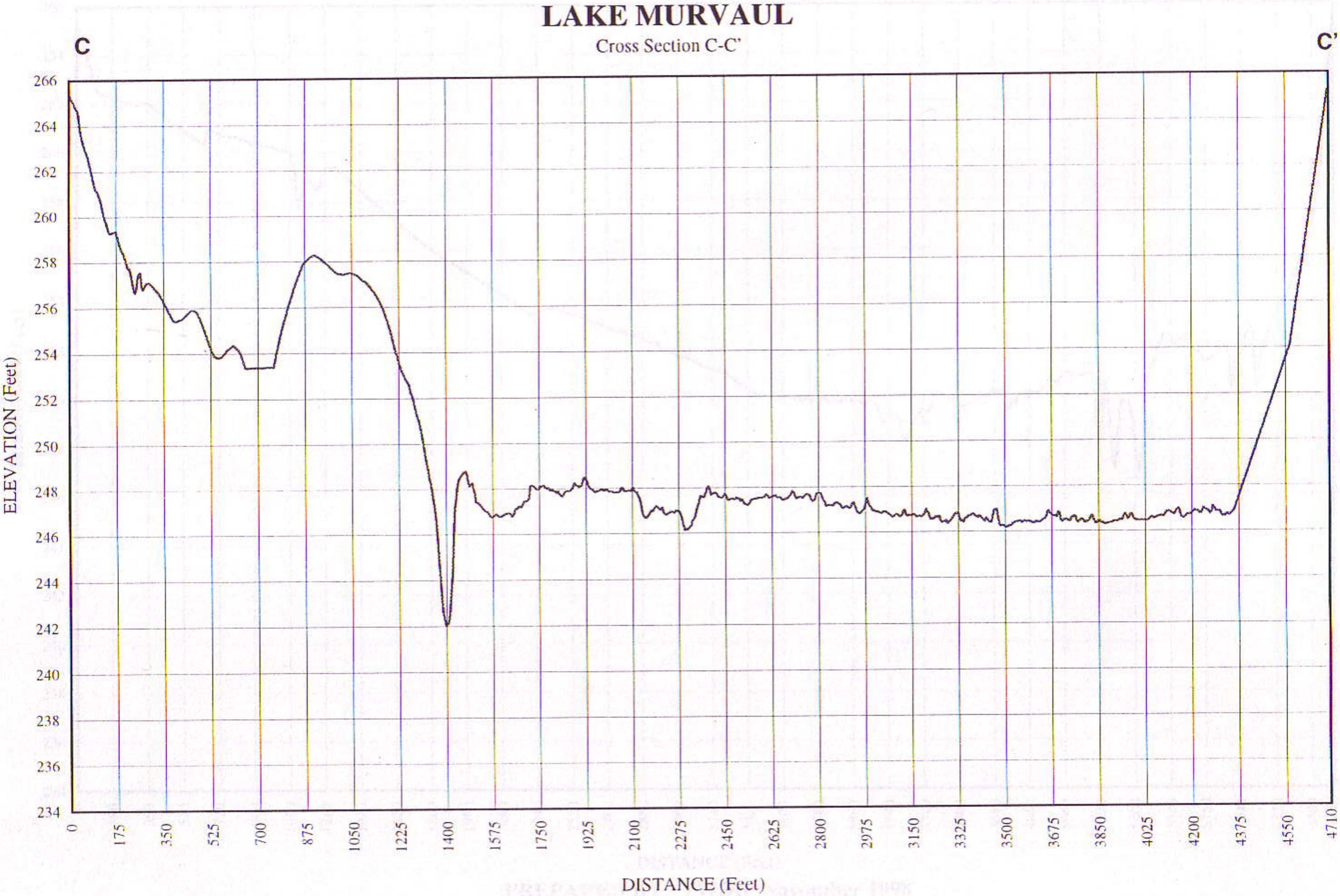

LAKE MURVAUL
Cross Section B-B'
B
B'
266
264
262
260
258
256
254
252
250
248
246
244
242
240
238
236
234
ELEVATION (Feet)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
DISTANCE (Feet)
PREPARED BY: TWDB November 1998



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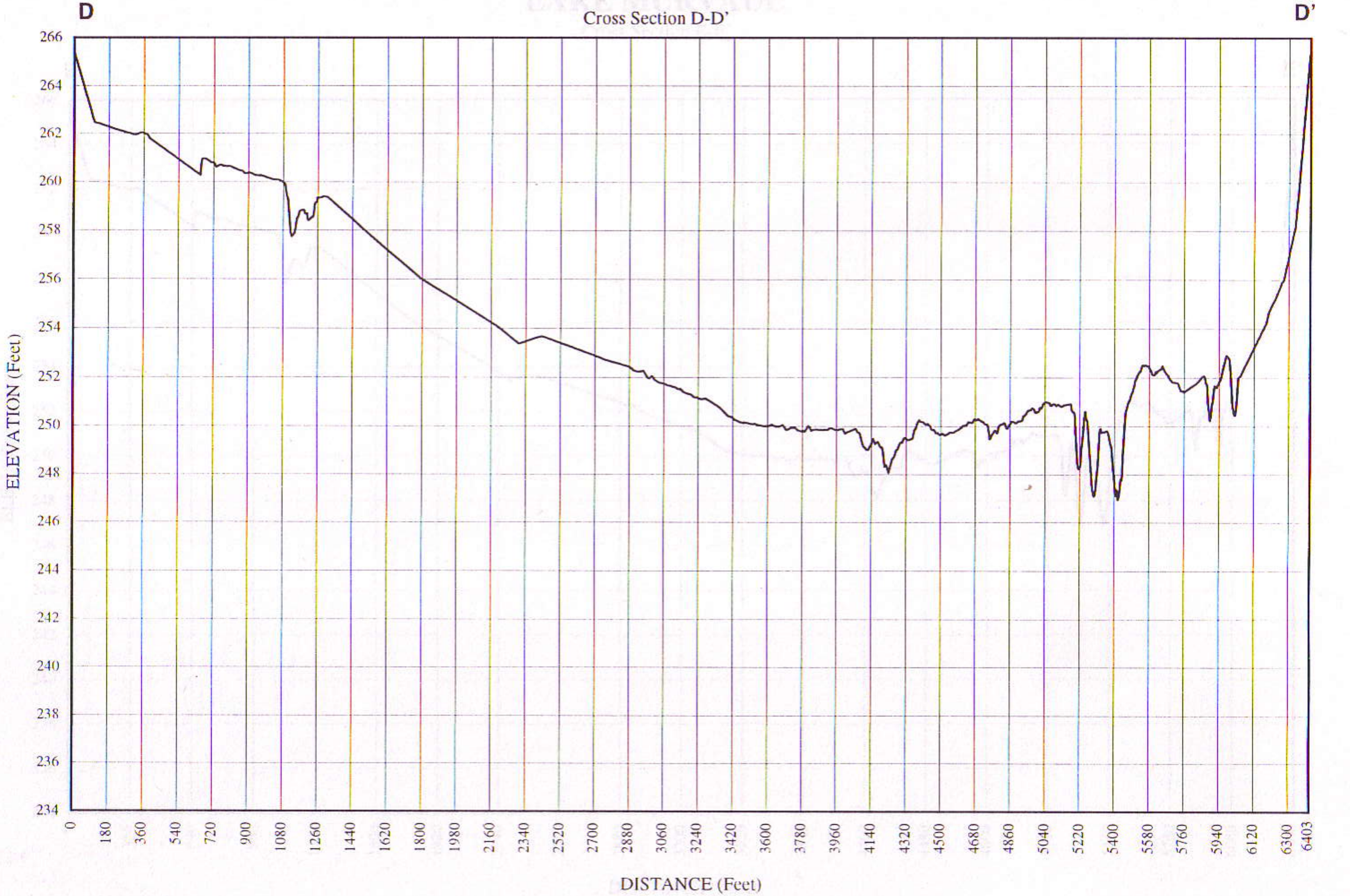
LAKE MURVAUL



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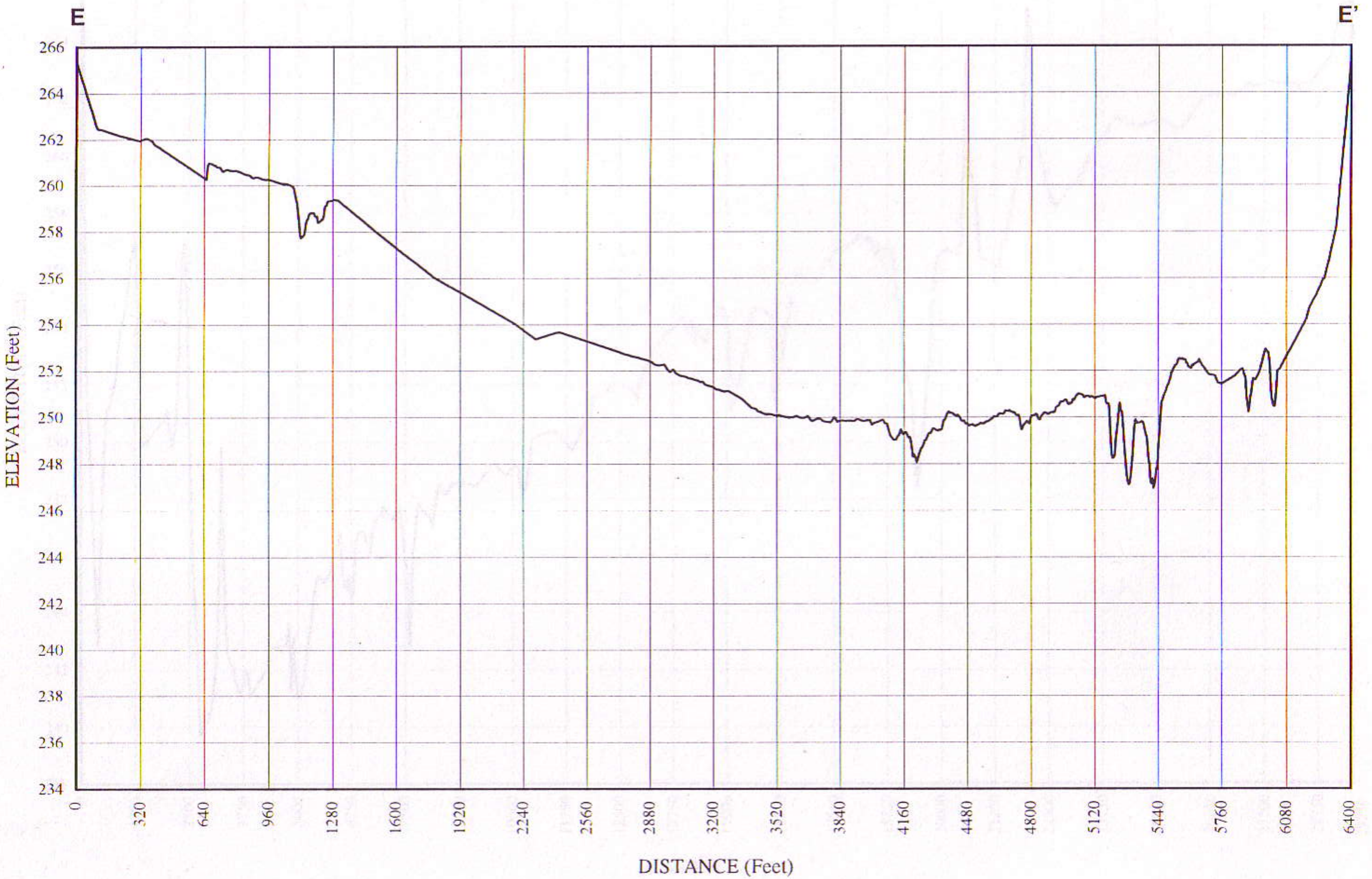
LAKE MURVAUL

Cross Section E-E'



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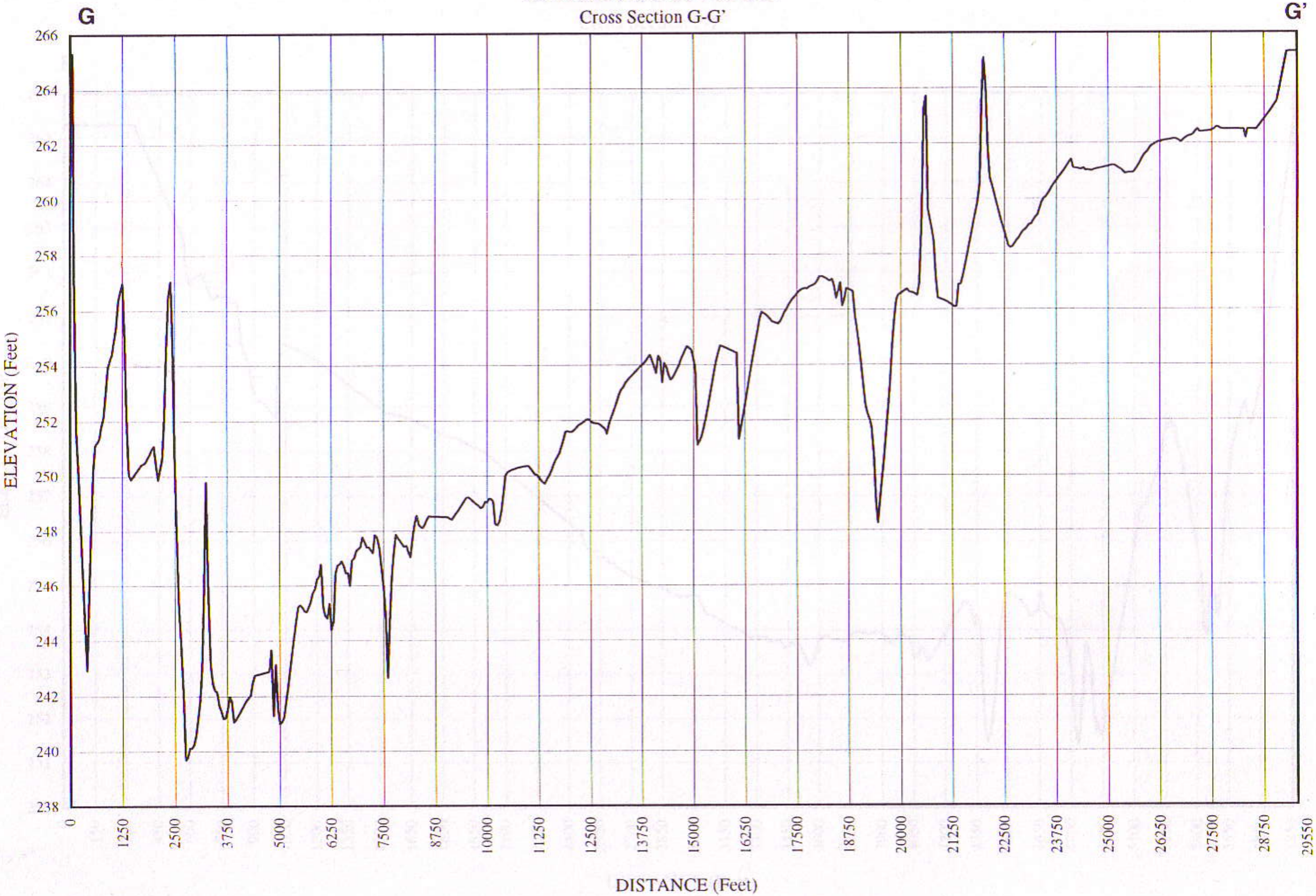
LAKE MURVAUL

Cross Section G-G'



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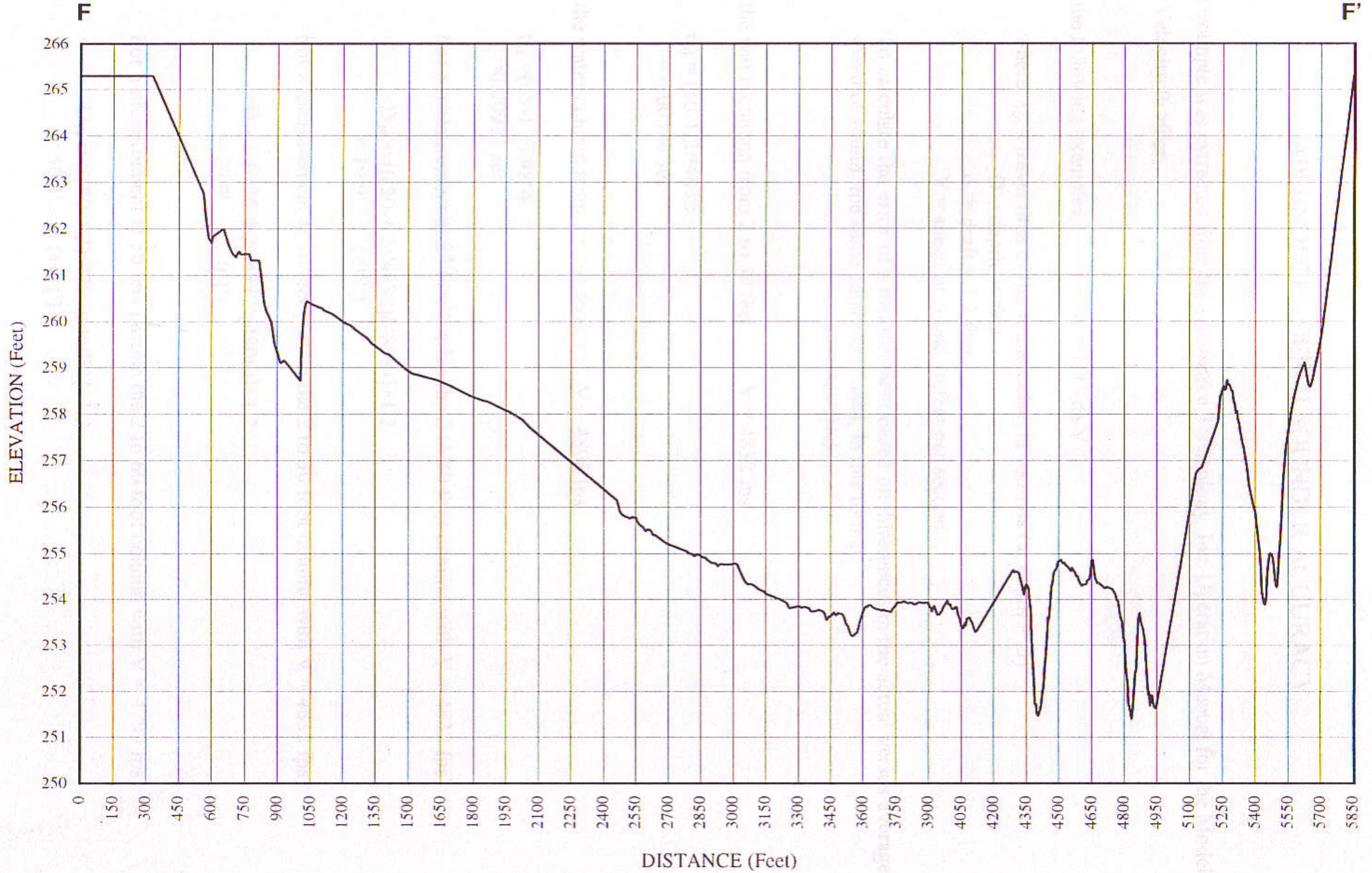
LAKE MURVAUL

Cross Section F-F'



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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, one of which 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 are 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, reservoir surveys were conducted by stretching a rope across the reservoir 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 reservoirs.

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 reservoir 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 reservoirs 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 reservoir. Fairly accurate results could be obtained, although the vertical accuracy of the aerial topography is generally one-half of the contour interval or ± 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 MURVAUL

Location Map

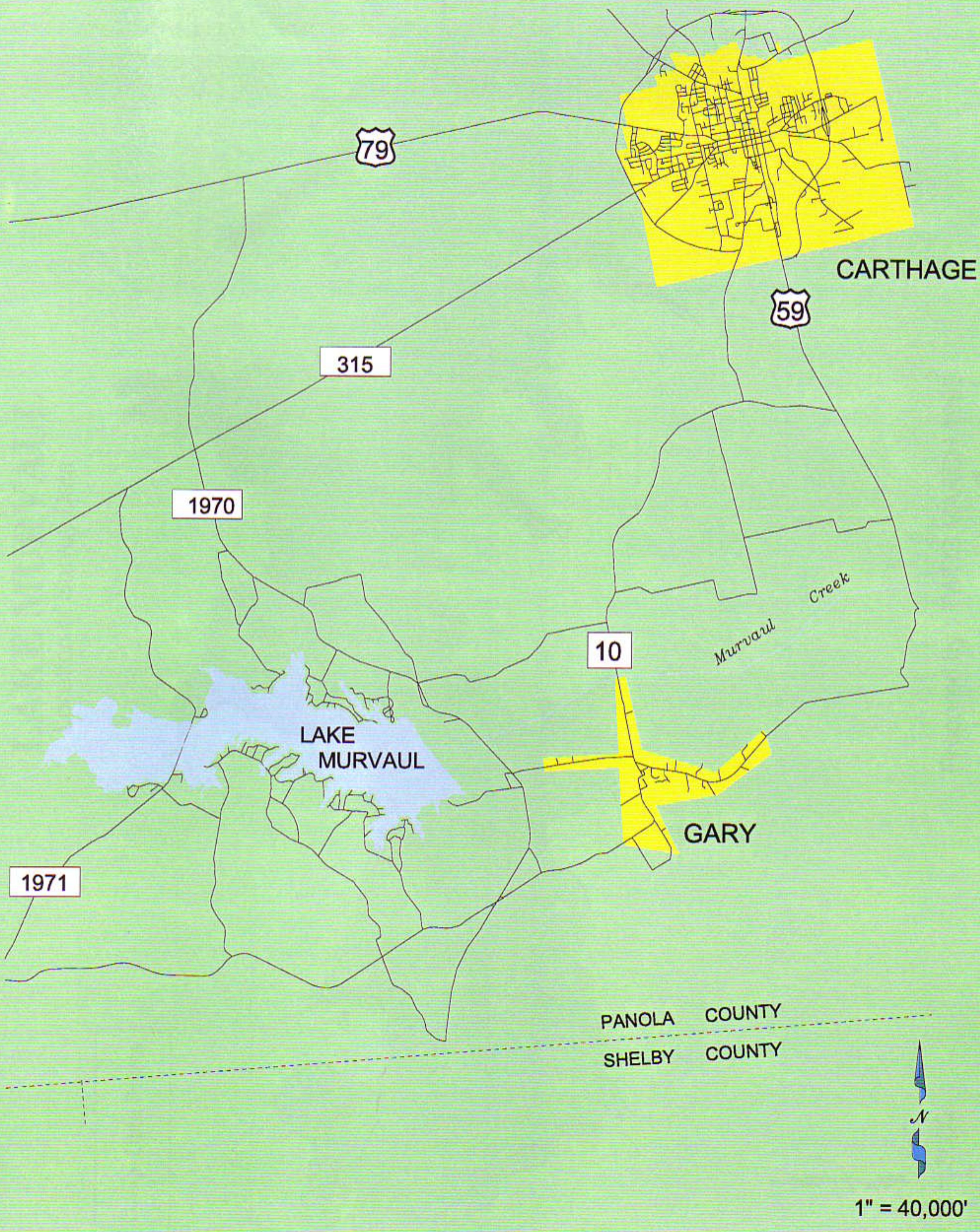

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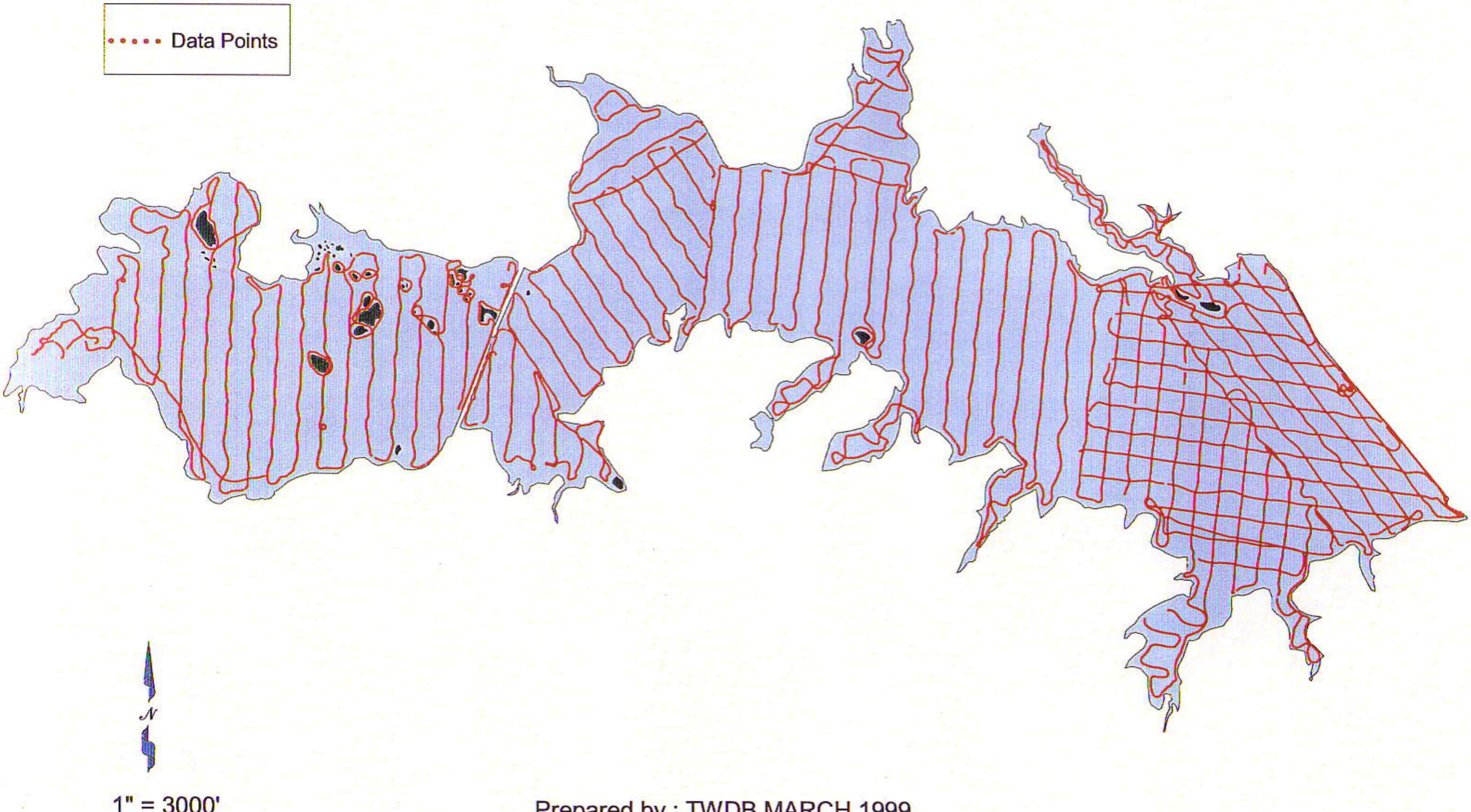
Figure 2

LAKE MURVAUL

Location of Survey Data



Prepared by : TWDB MARCH 1999

Figure 3

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Shaded Relief

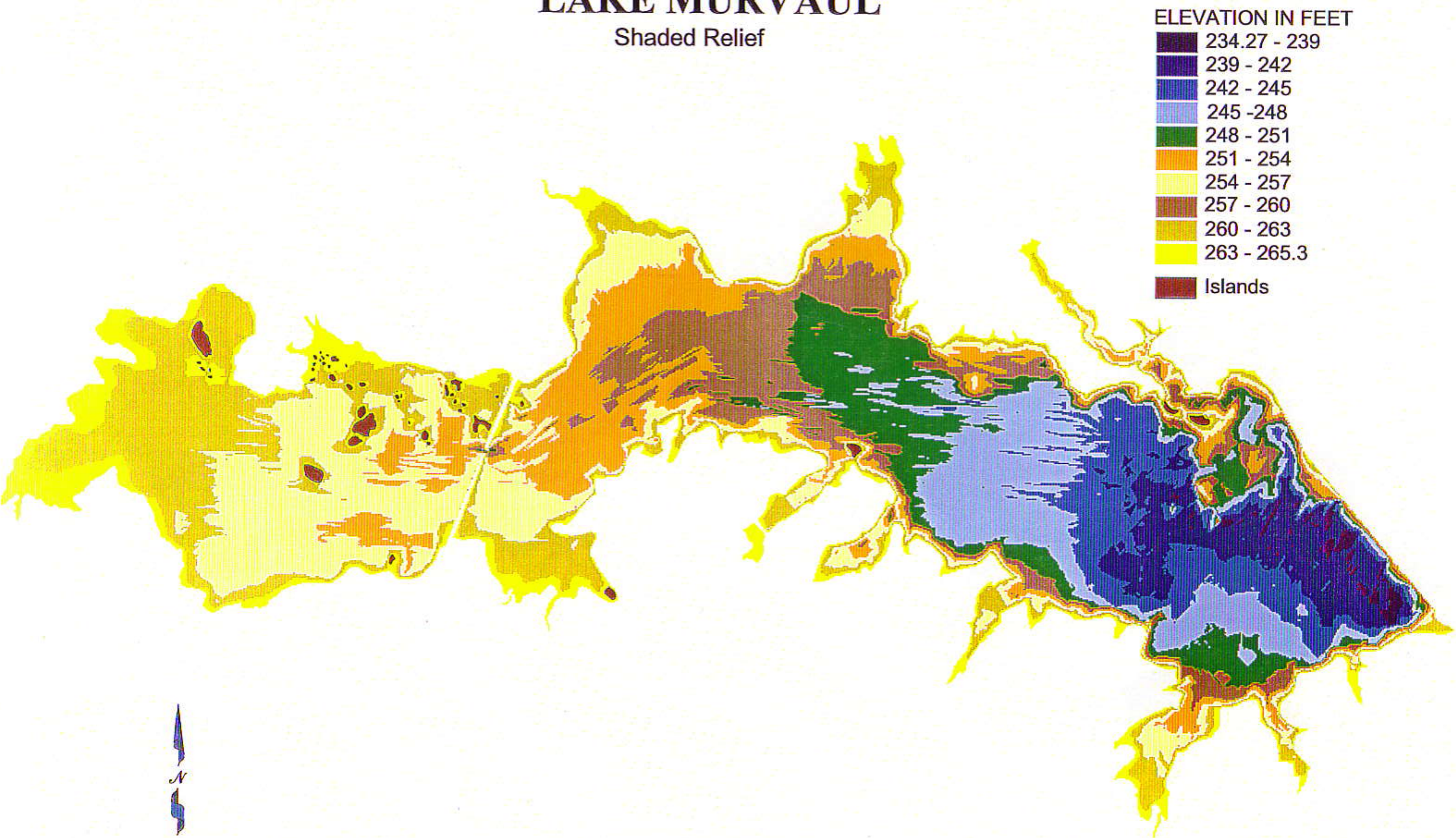

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Figure 4

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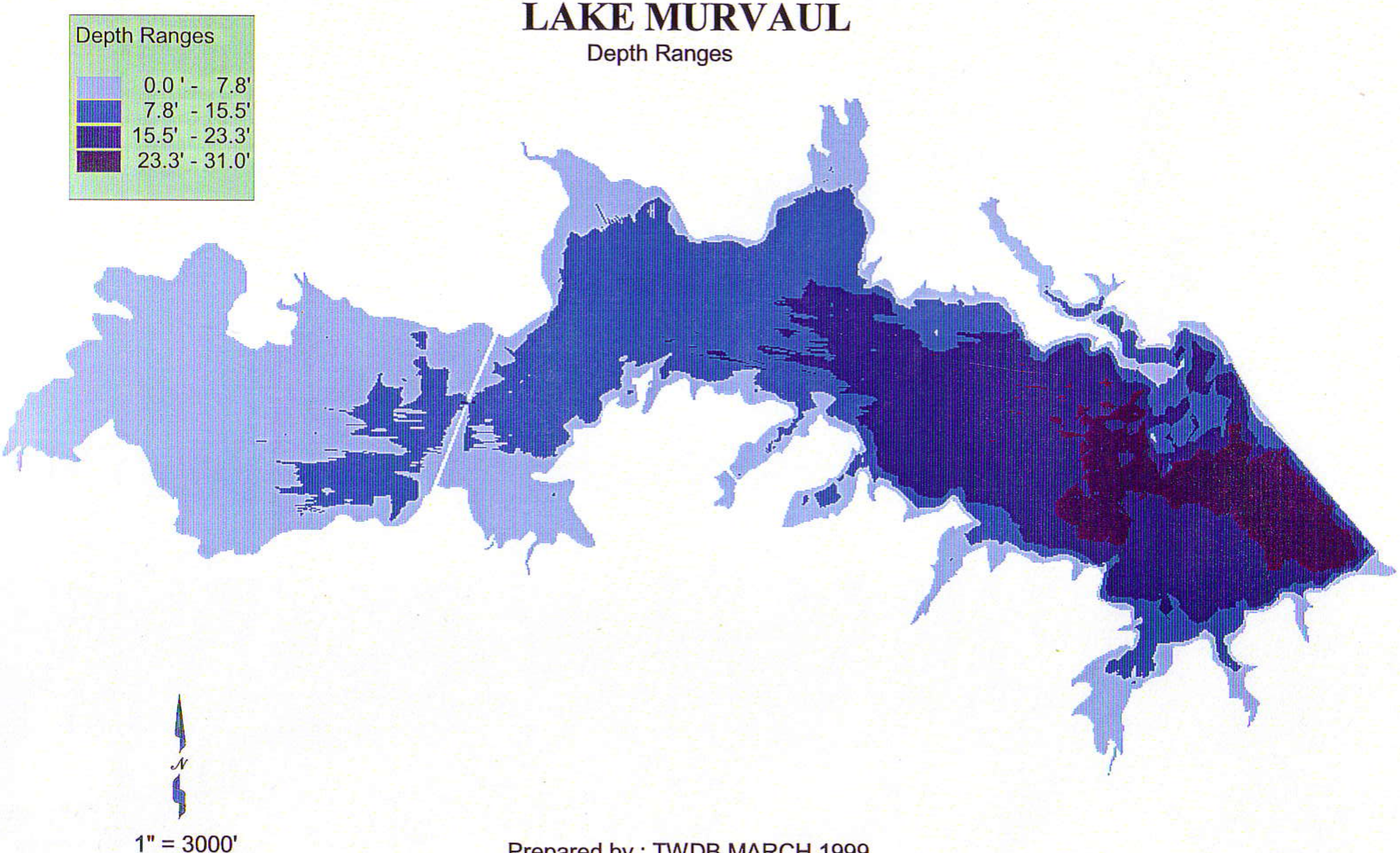
Depth Ranges



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