VOLUMETRIC SURVEY
OF
LAKE TYLER

Prepared for:

CITY OF TYLER

Prepared by:

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INTRODUCTION

Staff of the Hydrographic Survey Unit of the Texas Water Development Board (TWDB) conducted a hydrographic survey of Lake Tyler during the period May 29 - June 5, 1997. The purpose of the survey was to determine the capacity of the lake at the conservation pool elevation. From this 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 noted otherwise. The conservation pool elevation for Lake Tyler is 375.4 feet (actually 375.38 feet). A 1967-68 survey that combined the two lakes that compose Lake Tyler estimated the lake's surface area at this elevation to be 4,880 acres and the storage volume to be 80,900 acre-feet of water.

HISTORY AND GENERAL INFORMATION OF THE RESERVOIR

Lake Tyler is unique in that it is really two lakes, connected later on by a canal, to form one system. Whitehouse Dam was built on Prairie Creek and created the original Lake Tyler. Mud Creek Dam was subsequently built on Mud Creek to form Lake Tyler East. On May 29, 1968, the two lakes were connected via canal to form one lake known today as "Lake Tyler."

Lake Tyler is owned and operated by the City of Tyler and is located in Smith County, eight miles southeast of Tyler, TX (See Figure 1). Records indicate the drainage area is approximately 107 square miles. At the conservation pool elevation of 375.4 feet, the lake has approximately 60 miles of shoreline and is five and one-half miles long. The widest continuous distance across water, approximately one and one-half miles, occurs in the western reservoir immediately upstream of Langley Island.

There is a long history regarding the permit information of the lake due to the construction of two separate dams. On March 25, 1945, Permit No. 1435 was issued by the State Board of Water Engineers to the City of Tyler authorizing the use of 30,000 acre-feet of water annually from a proposed impoundment on Prairie Creek known as Lake Tyler (Whitehouse Dam) for municipal, domestic and industrial purposes. On October 1, 1956, the Board of Water Engineers issued Permit No. 1843 to the City of Tyler. This permit authorized the construction of a dam (Mud Creek Dam) to create another reservoir (Lake Tyler East) with a capacity of 44,000 acre-feet of water. The water rights to the two reservoirs were also combined at this time, since both permits were granted to the City of Tyler. Authorization was granted to divert and use, not to exceed a total of 50,000 acre-feet of water annually (30,000 acre-feet from Lake Tyler and 20,000 acre-feet from Lake Tyler East). The city joined the two reservoirs with a canal on May 29, 1968. On February 19, 1987, Certificate of Adjudication No. 06-4853 was issued by the Texas Water Commission to the City of Tyler. The certificate authorizes the owner to maintain an existing dam and reservoir on Prairie Creek (Lake Tyler) and impound therein not to exceed 43,100 acre-feet of water. The certificate also authorizes the owner to maintain an existing dam and reservoir on Mud Creek (Lake Tyler East) and impound therein not to exceed 44,000 acre-feet of water. The owner was also given the authority to maintain an existing canal connecting the two reservoirs. Authorization was granted to the owner to divert and use not to exceed 40,325 acre-feet of water per annum from the aforesaid reservoirs for municipal, industrial and domestic purposes.

Records indicate the construction for Whitehouse Dam began April 30, 1948 and was completed on May 13, 1949. Deliberate impoundment began January 8, 1949. The engineer for the project was T. C. Forrest and the general contractor was Caruth Construction Company. Whitehouse Dam and appurtenant structures consist of an earthfill embankment 4,708 feet in length with a maximum height of 50 feet and a crest elevation of 390.0 feet. The service spillway is an uncontrolled concrete chute located approximately 800 feet east of the embankment in the left abutment. The crest of the spillway is 200 feet in width at elevation 375.38 feet. The service outlet structure, located approximately two miles upstream of Whitehouse Dam and just north of Langley Island, is a concrete tower housing three pairs of circular sluice gates. The invert elevations for one pair of gates is at elevation 362.0 feet, another pair of gates is at elevation 356.0 and the last pair of gates is at elevation 350.0 feet. A 48 inch diameter concrete pipe, 660 feet in length, connects the inlet tower to the pumphouse.

Construction began on Mud Creek Dam on February 11, 1966. Deliberate impoundment of water started November 22, 1966 and the dam was completed in January of 1967. Wisenbaker, Fix, and Associates was the engineer for the project and the general contractor was Vibig Construction Company. Mud Creek Dam is an earthfill embankment with a length of 4,700 feet and a maximum height of 50 feet. The crest elevation ranges from 390.0 to 391.5 feet. The service spillway is an uncontrolled concrete weir located approximately midway in the earthen embankment. The crest of the spillway is 300 feet in width at elevation 375.38 feet. The service outlet structure, located at the dam consists of an inlet box and 18 inch diameter concrete pipe outlet. The outlet is controlled by a slide valve with an invert elevation of 350.0 feet.

HYDROGRAPHIC SURVEYING TECHNOLOGY

The following sections will describe the theory behind Global Positioning System (GPS) technology and its accuracy. Equipment and methodology used to conduct the subject survey and previous hydrographic surveys are also addressed.

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 broadcasts from the satellites 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 obviously in error because its location is in space, and it is ignored. 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.

GPS technology was developed in the 1960's by the United States Air Force and the defense establishment. 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, the DOD has 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) can determine positions of moving objects in real-time or "on-the-fly." In the early stages of this 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. The large positional errors experienced by a single receiver when S/A is active are greatly reduced by utilizing DGPS. The reference receiver calculates satellite corrections based on its known fixed position, which results in positional accuracies within three meters for the moving receiver. DGPS was used to determine horizontal position only. Vertical information was supplied by the depth sounder.

The need for setting up a stationary shore receiver for current surveys has been eliminated with the development of fee-based reference position networks. These networks use a small network of GPS receivers to create differential corrections for a large network of transmitting stations, Wide Area Differential GPS (WADGPS). The TWDB receives this service from ACCQPOINT, a WADGPS correction network over a FM radio broadcast. A small radio receiver purchased from ACCQPOINT, collects positional correction information from the closest broadcast station and provides the data to the GPS receiver on board the hydrographic surveying boat to allow the position to be differentially corrected.

Equipment and Methodology

The equipment used in the performance of the hydrographic survey consisted 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 ACCQPOINT FM receiver, and an on-board 486 computer. Power was provided by a water-cooled generator 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 gathers 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 daily recorded lake elevation 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 below.

Previous Survey Procedures

Originally, reservoir surveys were conducted with a rope stretched across the reservoir along pre-determined range lines. A small boat would manually pole 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 again 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. Monumentation was set for 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 depth measurement locations 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. If triangulation could determine the boat location by electronic means, then the boat could take continuous depth soundings. A set of microwave transmitters positioned around the lake at known coordinates would allow 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 was generally one-half of the contour interval or ± five feet for a ten-foot contour interval. This method could be quite costly and was only applicable in areas that were not inundated.

PRE-SURVEY PROCEDURES

The reservoir's surface area was determined prior to the survey by digitizing with AutoCad software the lake's pool boundary (elevation 376) from 7.5 minute USGS quadrangle maps. The name of the quad maps used are as follows: TROUP WEST, TX (1973), TROUP EAST, TX (1973), BASCOM, TX (Photo-revised 1972), and HOPE POND, TX (1966). The graphic boundary file created was then transformed into the proper datum, from NAD '27 datum to NAD '83, using Environmental Systems Research Institutes's (ESRI) Arc/Info project command with the NADCOM (standard conversion method within the United States) parameters. The area of 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 226 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 Tyler 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. The Velocity Profiler calculates an average speed of sound through the water column of interest for a designated draft value of the boat (draft is the vertical distance that the boat penetrates the water surface). The draft of the boat was previously determined to average 1.2 ft. The velocity profiler probe is placed in the water to moisten and acclimate the probe. The probe is then raised to the water surface where the depth is zeroed. The probe is lowered on a cable to just below the maximum depth set for the water column, and then raised to the surface. The unit displays an average speed of sound for a given water depth and draft, which is entered into the depth sounder. The depth value on the depth sounder 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 Tyler, the speed of sound in the water column varied daily between 4915 and 4921 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 readings and some are negative readings. Further information on these calculations is presented in Appendix A.

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 setup 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 Tyler during the period of May 29 through June 5, 1997. Weather conditions were excellent with moderate temperatures and mild winds. Approximately 69,498 data points were collected over the 118 miles traveled along the pre-planned survey lines and the random data-collection lines. These points were stored digitally on the boat's computer in 237 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. Random data lines were also collected parallel to the original stream bed in the main body of the lake. Figure 2 shows the actual location of all data collection points.

TWDB staff observed the land surface around the lake to be mainly grasslands with some moderate development on the shoreline of the west reservoir and little development on the east reservoir. There were several large islands throughout the lake. The largest island is Langley Island, a wildlife and bird sanctuary in the west reservoir.

Below the water, there was a gentle but steady drop off of the lake bottom to depths of around 35 feet near the dam. The bottom was then fairly level across the old river flood plain. Within this flood plain, the original river and creek channels were easily distinguishable on the depth sounder chart.

Staff noted during the survey, that navigational hazards were minimal and that the majority of the lake was void of submerged trees and aquatic vegetation. A few sandbars were encountered, but they did not impede the survey. Three areas required manual data collection from a lake patrol boat because of low bridge clearances. Depths were collected in these areas via an electronic depth sounder and surveying rod. Data collection in the headwaters were discontinued 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 down-loaded 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. The depth information collected every 0.1 seconds was averaged to get one reading for each second of data collection. 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 held steady at 375.2 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, representative of the lake, to be used with the GIS software to develop a model of the lake's bottom surface.

The resulting data file was imported into the UNIX operating system used to run Environmental System Research Institutes's (ESRI) Arc/Info GIS software and converted 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 builds an irregular triangulated network from the data points and the boundary file. This software uses 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 preserved for use in determining the solution of the model by using this method. The generated network of three-dimensional triangular planes represents the actual bottom surface. Once the triangulated irregular network (TIN) is formed, the software then calculates elevations along the triangle surface plane by solving the equations for elevation along each leg of the triangle. Information for the entire reservoir area 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 down-sized 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 places 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. Approximately 252 additional points were required to be added to the data file for interpolation and contouring of the entire lake surface. Volumes and areas were calculated from the revised TIN for the entire reservoir at one-tenth of a foot intervals. From elevation 373.0 feet, the surface area and volume values for the lake were mathematically estimated up to elevation 375.4 feet. This was done by first distributing uniformly across each contour interval, the surface areas digitized from USGS topographic maps. Volumes for each 0.1 interval were calculated by adding to the existing volume, 0.1 of the existing area, and 0.5 of the difference between the existing area and the area value for the volume being calculated. The computed reservoir volume table is presented in Appendix B and the area table in Appendix C. An elevation-area-volume graph is presented in Appendix D.

Other presentations 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 375.4 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 1997 TWDB survey indicate Lake Tyler encompasses 4,737 surface acres and contains a volume of 80,198 acre-feet at the conservation pool elevation of 375.4 feet. The shoreline at this elevation was calculated to be 69.71 miles. The deepest point of the western portion of the lake, elevation 335.48 or 39.92 feet of depth, was located approximately 2,350 feet upstream from the western dam. The deepest point of the eastern portion of the lake, elevation 335.25 or 40.15 feet of depth, was located approximately 563 feet upstream from the eastern dam. The dead storage volume, or the amount of water below the lowest outlet in the dam, was calculated to be 6,942 acre-feet based on the low flow outlet invert elevation of 350.0 feet. The conservation storage capacity, or the amount of water between the spillway and the lowest outlet, is therefore calculated to be 73,260 acre-feet.

SUMMARY

The two lakes that now compose Lake Tyler were initially combined by a survey performed in 1967-68. Storage calculations estimated the volume at the conservation pool elevation of 375.4 feet to be 80,900 acre-feet with a surface area of 4,880 acres.

During the period of May 29 June 5, 1997, a hydrographic survey of Lake Tyler was performed by the Texas Water Development Board's Hydrographic Survey Program. The 1997 survey used technological advances such as differential global positioning system and geographical information system technology to build a model of the reservoir's bathemetry. These advances allowed a survey to be performed quickly and to collect significantly more data of the bathemetry of Lake Tyler than previous survey methods. Results indicate that the lake's capacity at the conservation pool elevation of 375.4 feet was 80,198 acre-feet and the area was 4,737 acres.

The estimated reduction in storage capacity at elevation 375.4 since 1968 was 702 acre-ft or 36.95 acre-ft per year. The average annual deposition rate of sediment in the conservation pool of the reservoir can be estimated at 0.345 acre-ft per square mile of drainage area.

It is difficult to compare the original design information and the survey performed by the

TWDB because little is known about the procedures and data used in calculating the original storage information. However, the TWDB considers the 1997 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. The second survey will remove any noticeable errors between the original design information and the 1997 survey and will facilitate accurate calculations of sedimentation rates and storage losses presently occurring in Lake Tyler.

CALCULATION OF DEPTH SOUNDER ACCURACY

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

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

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')

TEXAS WATER DEVELOPMENT BOARD
RESERVOIR VOLUME TABLE

Sep 26 1997

Lake Tyler June 1997 Survey

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
335										
336										1
337	1	1	2	2	3	4	6	8	10	13
338	16	20	24	29	34	39	46	53	61	70
339	79	89	100	112	124	137	151	166	181	197
340	215	233	252	273	294	317	340	364	390	416
341	444	473	502	533	565	597	631	666	701	738
342	775	813	852	892	933	975	1018	1062	1106	1152
343	1198	1245	1293	1342	1392	1442	1494	1546	1600	1654
344	1709	1765	1821	1879	1937	1997	2057	2119	2181	2245
345	2310	2376	2443	2510	2579	2648	2719	2790	2863	2936
346	3011	3087	3164	3242	3321	3401	3483	3566	3650	3736
347	3822	3910	4000	4090	4182	4275	4370	4465	4562	4659
348	4758	4858	4959	5061	5163	5267	5372	5478	5584	5692
349	5800	5910	6020	6132	6244	6358	6473	6589	6706	6823
350	6942	7062	7183	7305	7428	7552	7678	7804	7932	8062
351	8192	8324	8457	8591	8727	8864	9003	9142	9283	9425
352	9569	9713	9859	10006	10155	10305	10456	10609	10762	10918
353	11074	11232	11391	11552	11714	11877	12041	12207	12374	12543
354	12713	12884	13056	13230	13405	13581	13758	13937	14117	14299
355	14482	14666	14851	15038	15227	15416	15607	15799	15993	16188
356	16385	16582	16782	16982	17183	17386	17590	17796	18003	18211
357	18420	18631	18843	19057	19271	19487	19705	19924	20144	20365
358	20588	20812	21037	21263	21491	21720	21950	22182	22415	22649
359	22884	23120	23358	23597	23836	24078	24320	24563	24808	25054
360	25302	25551	25801	26052	26305	26558	26813	27070	27327	27585
361	27845	28106	28368	28631	28896	29161	29428	29697	29966	30237
362	30509	30782	31056	31332	31609	31887	32166	32447	32729	33012
363	33297	33583	33870	34159	34449	34740	35033	35327	35623	35920
364	36218	36518	36819	37122	37426	37733	38040	38349	38660	38972
365	39286	39601	39917	40235	40555	40876	41198	41522	41847	42174
366	42503	42832	43164	43496	43831	44166	44504	44843	45183	45525
367	45869	46214	46560	46909	47258	47610	47962	48317	48672	49030
368	49389	49749	50111	50475	50840	51207	51575	51945	52316	52689
369	53063	53439	53816	54195	54575	54957	55340	55724	56110	56497
370	56886	57276	57668	58062	58458	58855	59254	59654	60055	60459
371	60863	61269	61676	62086	62497	62910	63324	63740	64157	64577
372	64997	65420	65844	66269	66697	67125	67555	67986	68418	68851
373	69286	69722	70160	70600	71041	71484	71928	72374	72822	73271
374	73722	74174	74628	75084	75541	75999	76459	76921	77385	77850
375	78316	78784	79254	79725	80198					

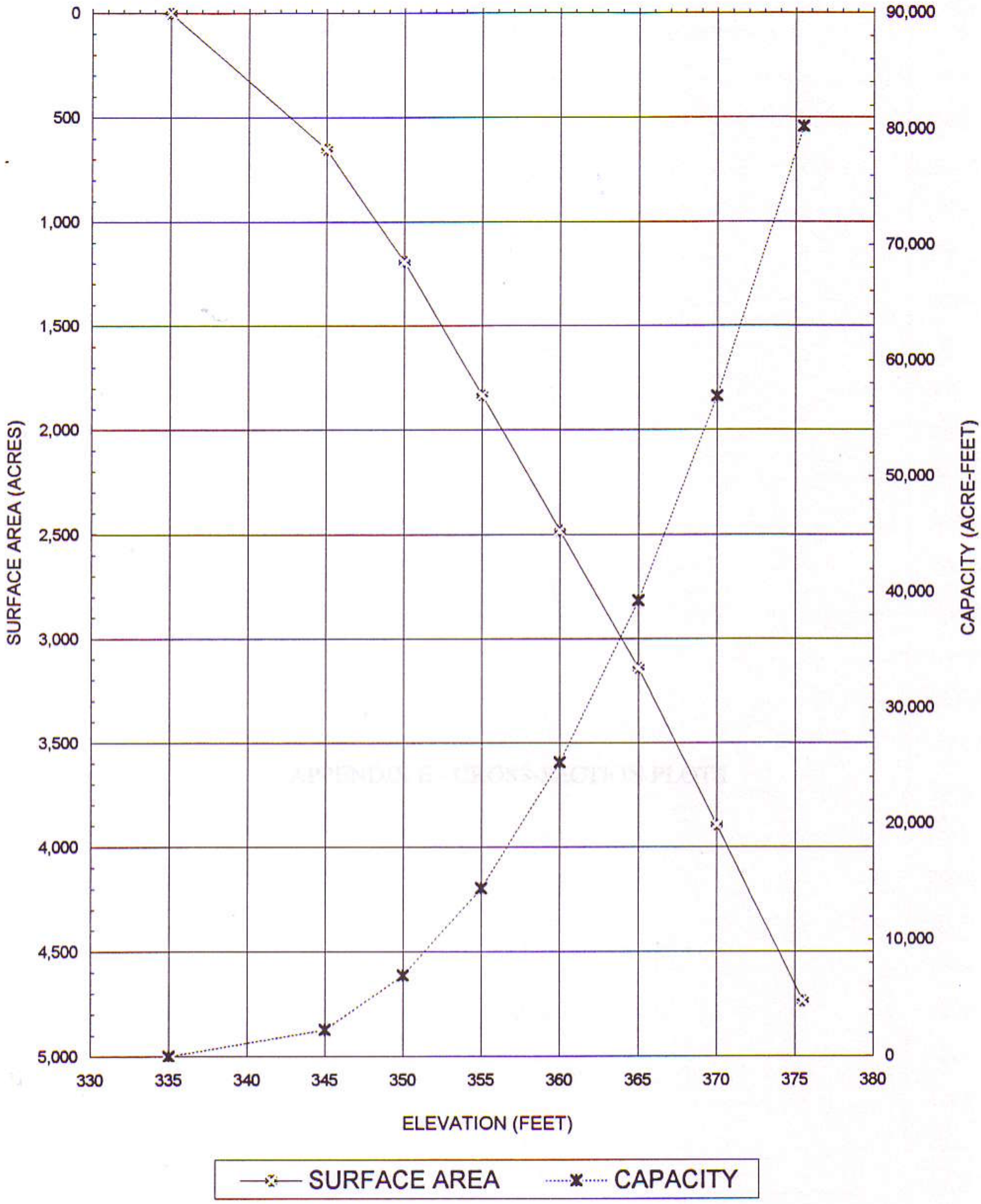
TEXAS WATER DEVELOPMENT BOARD
RESERVOIR AREA TABLE

Sep 26 1997

Lake Tyler June 1997 Survey

AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
335										
336						1	1	1	1	2
337	3	4	5	7	10	14	18	22	26	30
338	34	39	43	48	55	61	68	76	83	90
339	98	105	112	120	128	135	142	150	159	167
340	177	188	199	210	220	229	240	250	260	270
341	280	291	301	312	322	332	342	351	360	369
342	377	386	396	405	415	424	433	442	450	459
343	468	476	485	493	501	509	519	528	537	546
344	554	563	572	581	590	599	609	620	633	643
345	653	663	672	681	691	700	710	719	730	740
346	751	763	775	787	799	811	823	835	848	861
347	874	887	899	913	925	937	949	960	972	982
348	993	1003	1013	1023	1034	1043	1052	1061	1070	1080
349	1090	1100	1110	1121	1133	1144	1154	1163	1173	1182
350	1192	1202	1213	1225	1237	1249	1262	1274	1287	1299
351	1311	1324	1338	1351	1364	1377	1390	1402	1415	1427
352	1440	1453	1465	1479	1492	1505	1519	1532	1545	1559
353	1573	1586	1598	1611	1624	1638	1652	1665	1679	1692
354	1705	1717	1730	1743	1756	1769	1782	1795	1808	1822
355	1835	1848	1862	1876	1889	1903	1916	1930	1944	1958
356	1971	1984	1997	2010	2022	2035	2048	2061	2075	2088
357	2101	2114	2128	2141	2154	2168	2181	2195	2207	2220
358	2233	2246	2258	2271	2283	2296	2309	2322	2334	2346
359	2358	2369	2381	2393	2405	2417	2429	2441	2454	2468
360	2482	2495	2507	2520	2532	2544	2556	2567	2579	2591
361	2602	2614	2626	2639	2651	2664	2676	2688	2700	2713
362	2725	2738	2750	2763	2775	2788	2801	2813	2826	2840
363	2853	2867	2880	2894	2907	2921	2935	2949	2963	2976
364	2990	3004	3020	3037	3054	3069	3085	3100	3114	3129
365	3143	3158	3172	3187	3202	3217	3231	3246	3261	3276
366	3290	3305	3320	3335	3350	3366	3381	3396	3412	3428
367	3443	3459	3474	3490	3505	3520	3536	3551	3566	3581
368	3597	3612	3628	3643	3659	3675	3690	3706	3721	3736
369	3750	3765	3780	3795	3809	3823	3837	3851	3866	3880
370	3896	3912	3932	3948	3964	3979	3994	4009	4023	4038
371	4052	4066	4087	4103	4119	4135	4151	4168	4184	4200
372	4216	4232	4249	4264	4278	4291	4303	4316	4328	4341
373	4357	4373	4389	4404	4420	4436	4452	4468	4484	4499
374	4515	4531	4547	4563	4579	4594	4610	4626	4642	4658
375	4673	4689	4705	4721	4737					



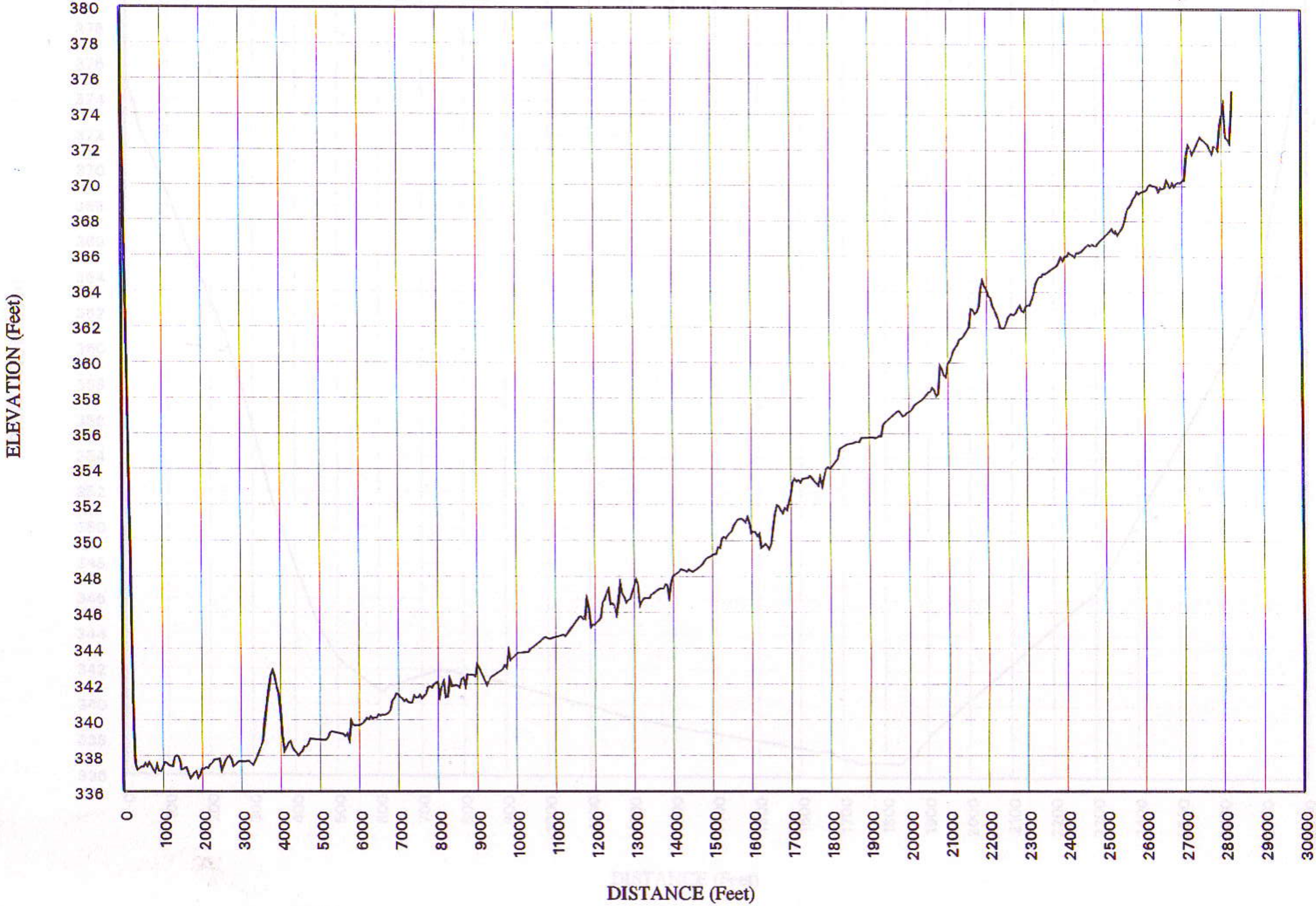
LAKE TYLER

June 1997 Survey

Prepared by: TWDB September 1997

LAKE TYLER

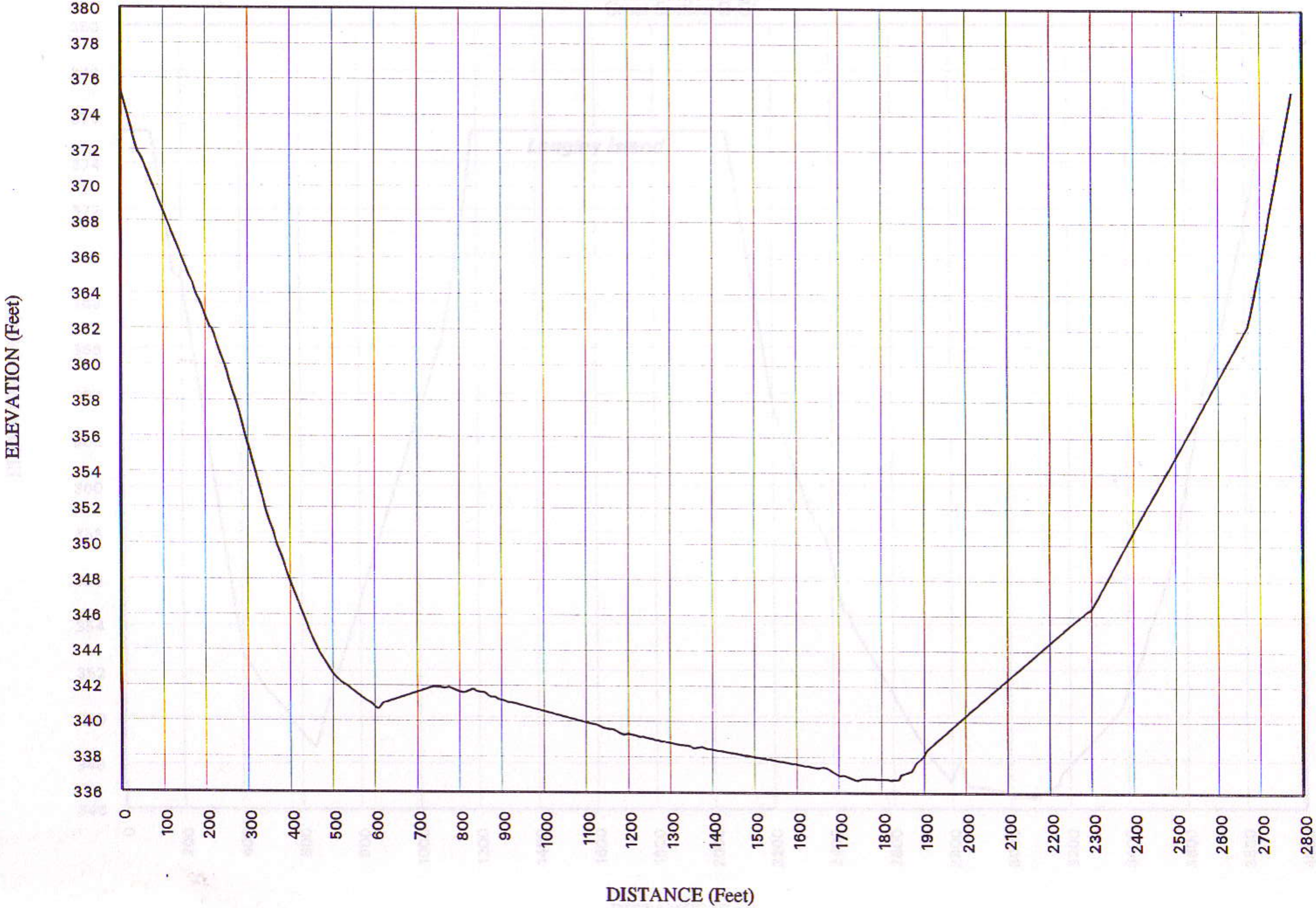
Cross Section A-A′



PREPARED BY: TWDB SEPTEMBER 1997

LAKE TYLER

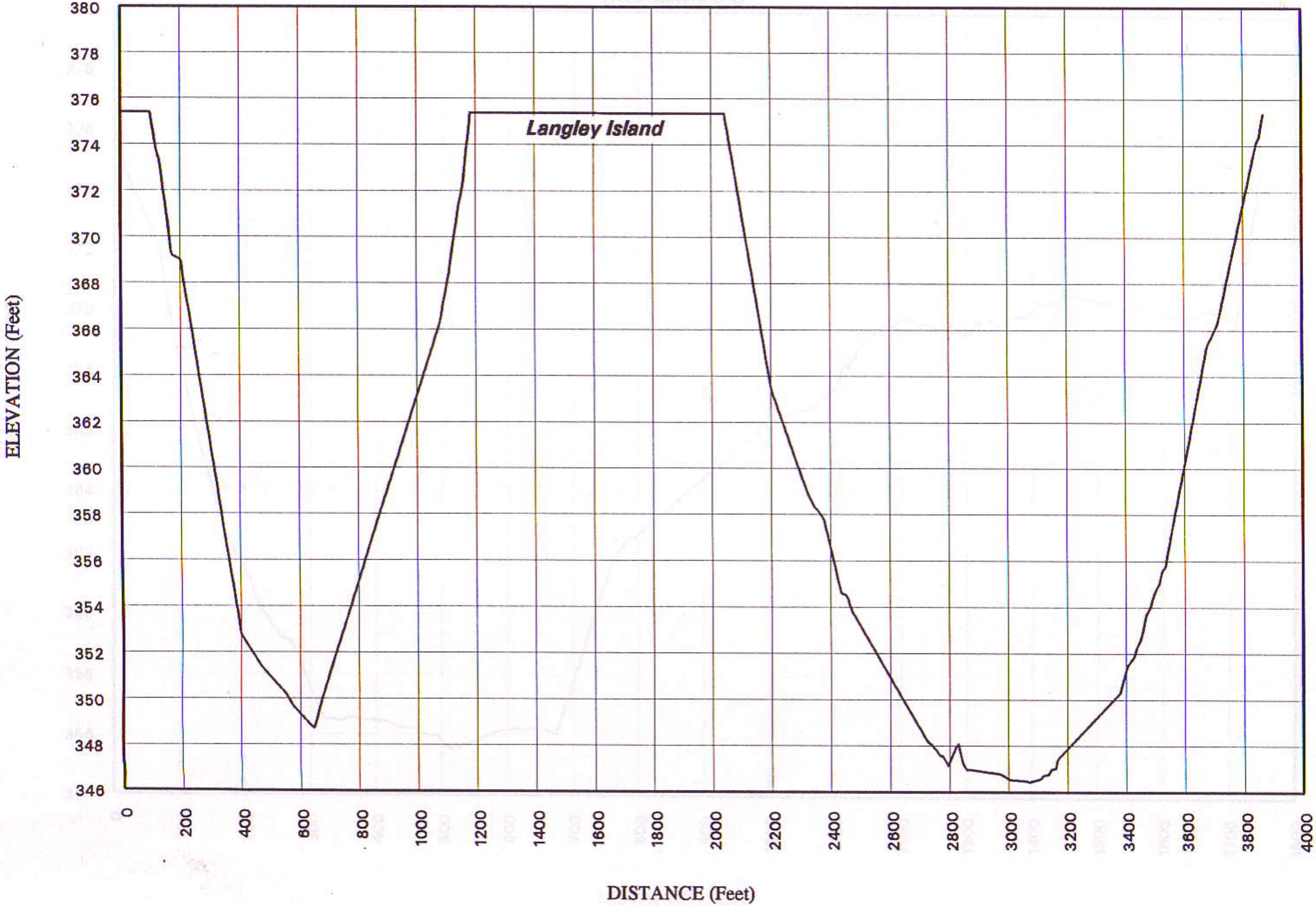
Cross Section B-B′



PREPARED BY: TWDB SEPTEMBER 1997

LAKE TYLER

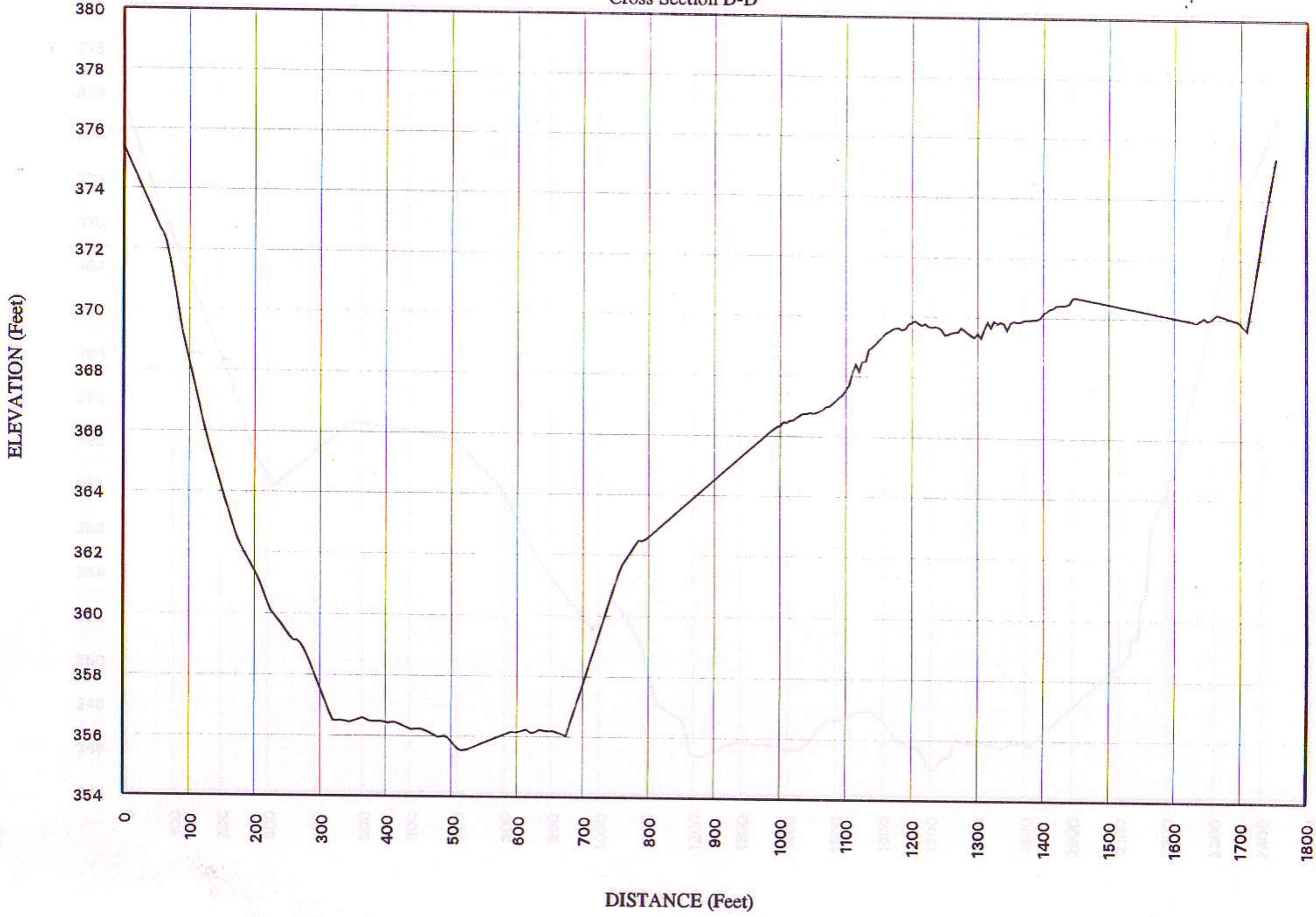
Cross Section C-C′



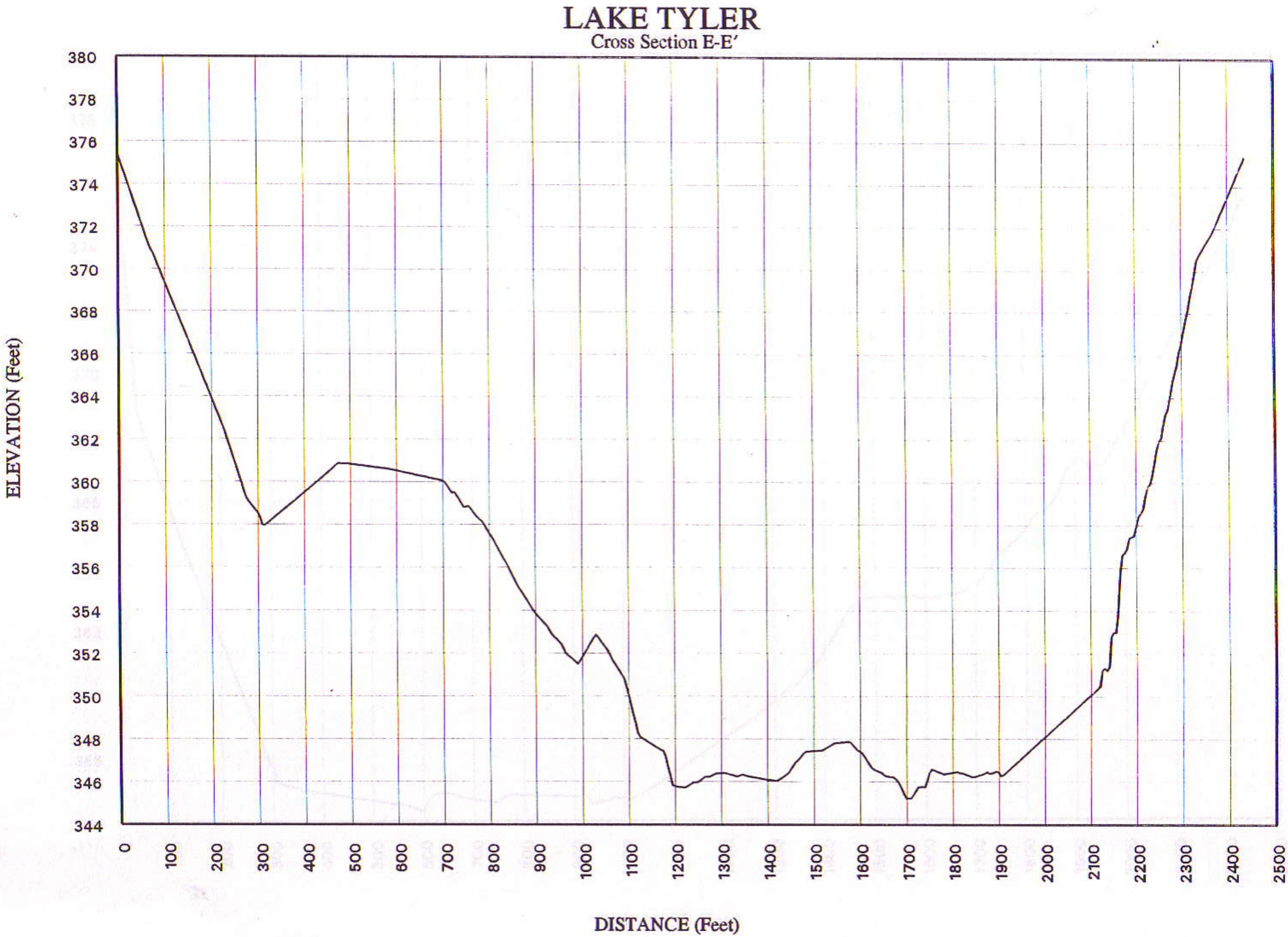
PREPARED BY: TWDB SEPTEMBER 1997

LAKE TYLER

Cross Section D-D′



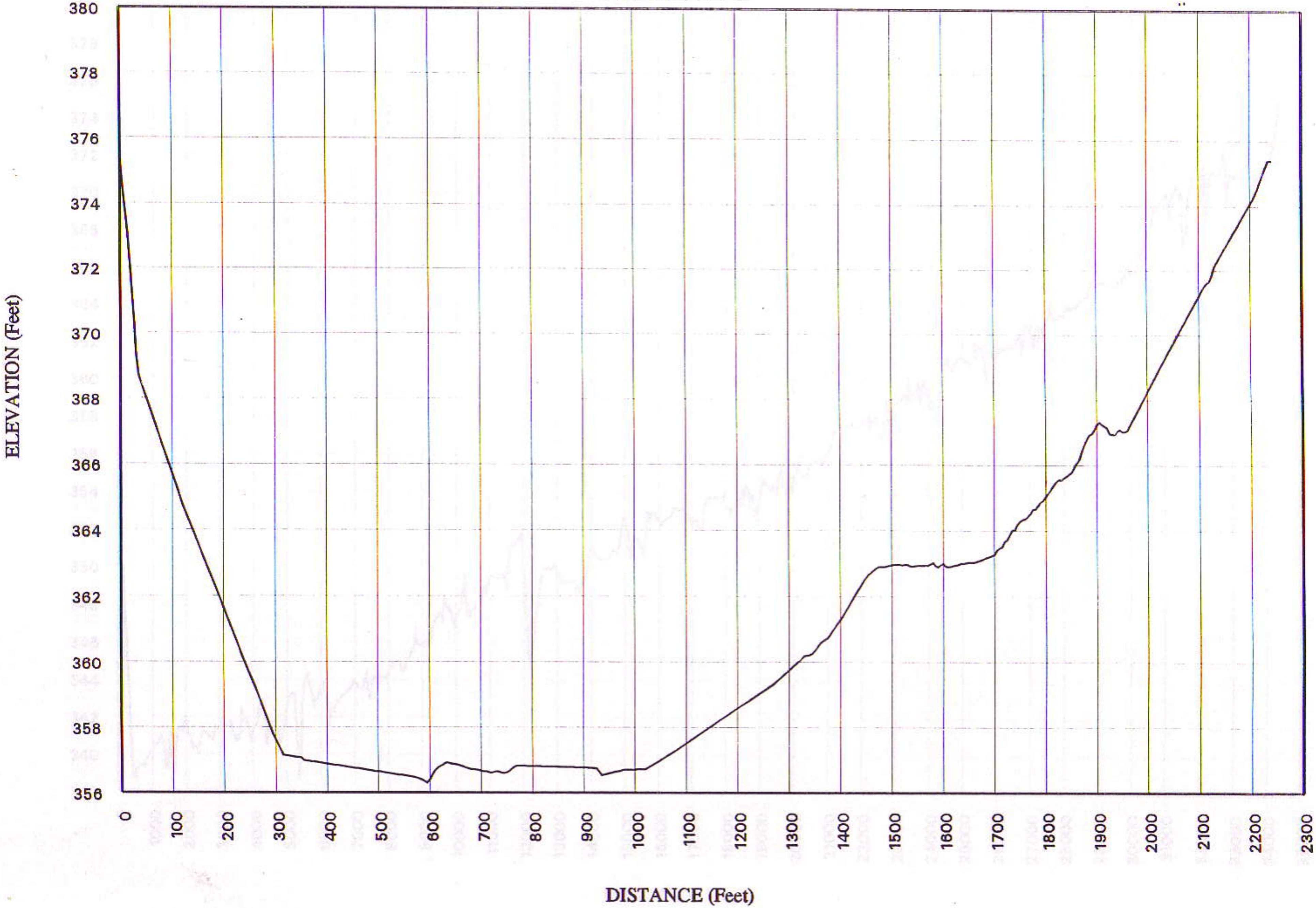
PREPARED BY: TWDB SEPTEMBER 1997



PREPARED BY: TWDB SEPTEMBER 1997

LAKE TYLER

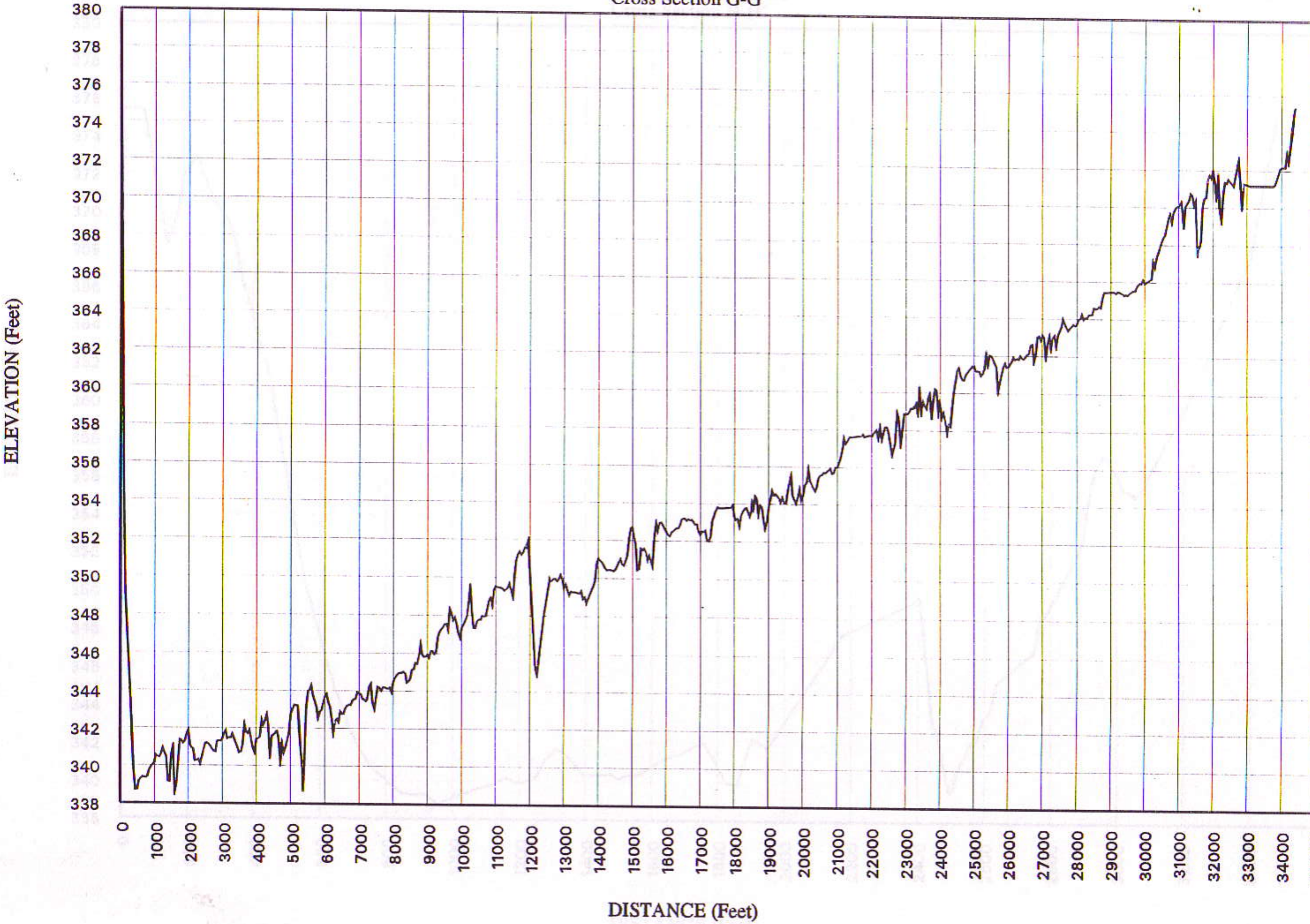
Cross Section F-F'



PREPARED BY: TWDB SEPTEMBER 1997

LAKE TYLER

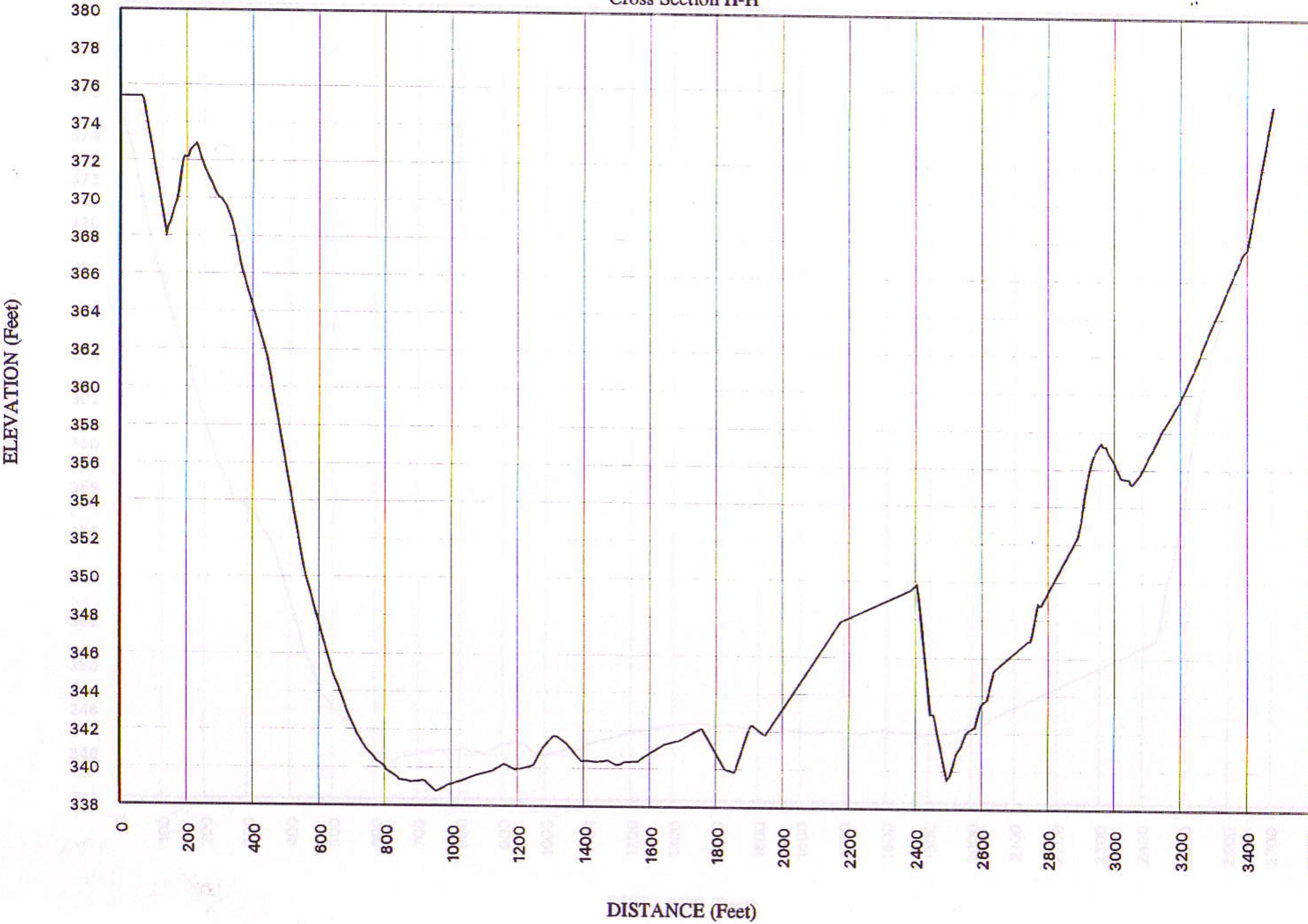
Cross Section G-G'



PREPARED BY: TWDB SEPTEMBER 1997

LAKE TYLER

Cross Section H-H′



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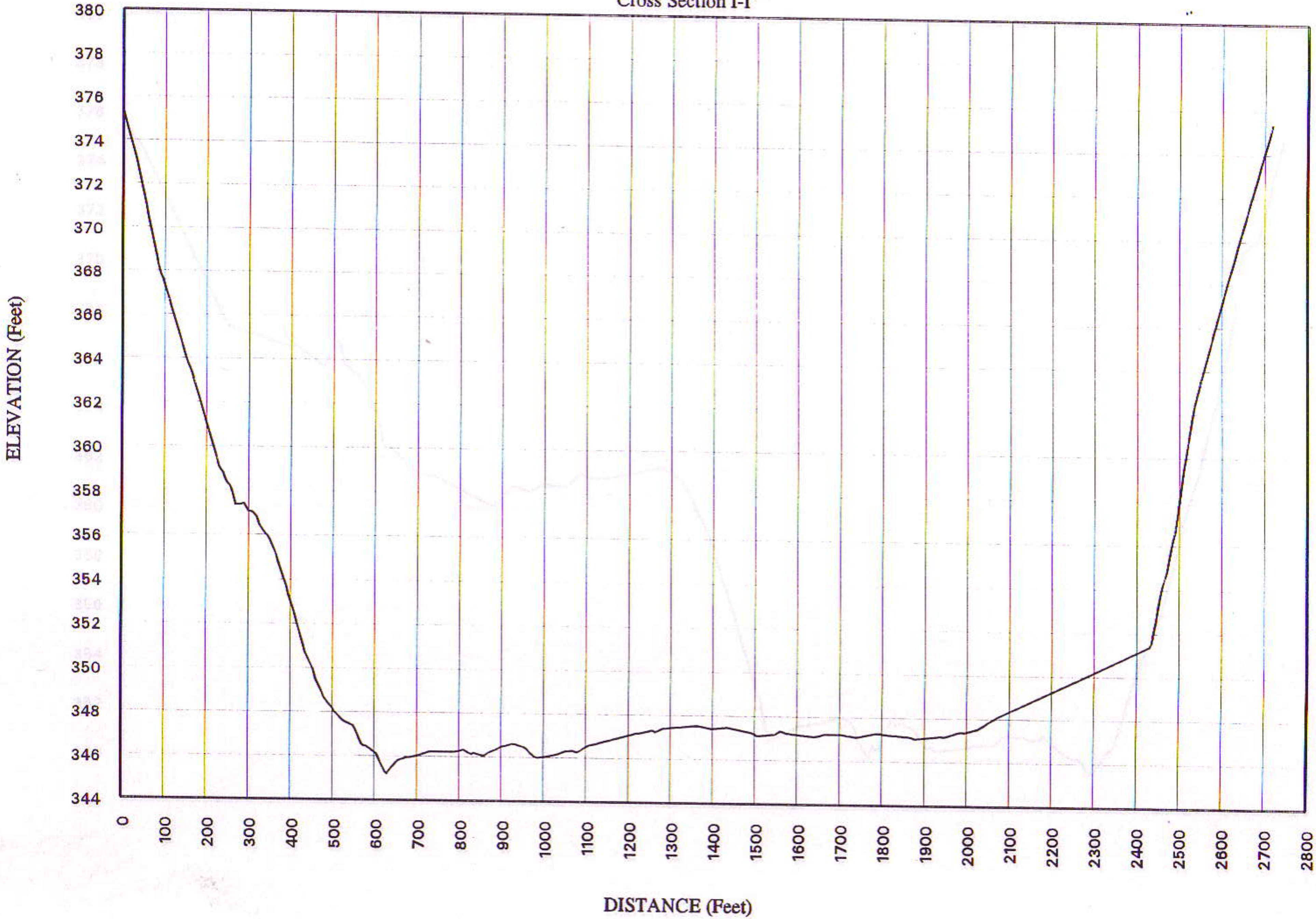
LAKE TYLER

Cross Section I-I'



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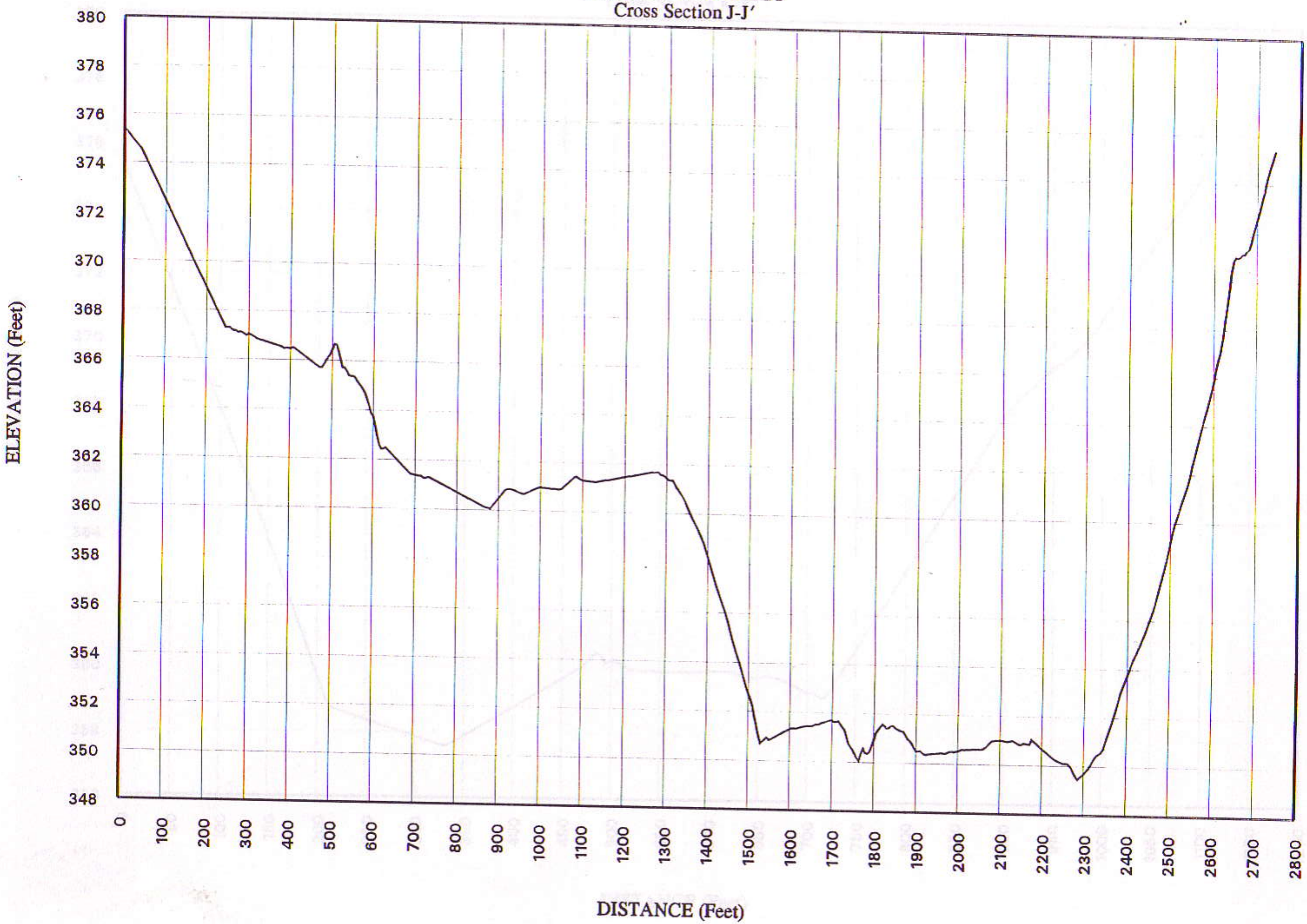
LAKE TYLER

Cross Section J-J′



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LAKE TYLER

Cross Section K-K′

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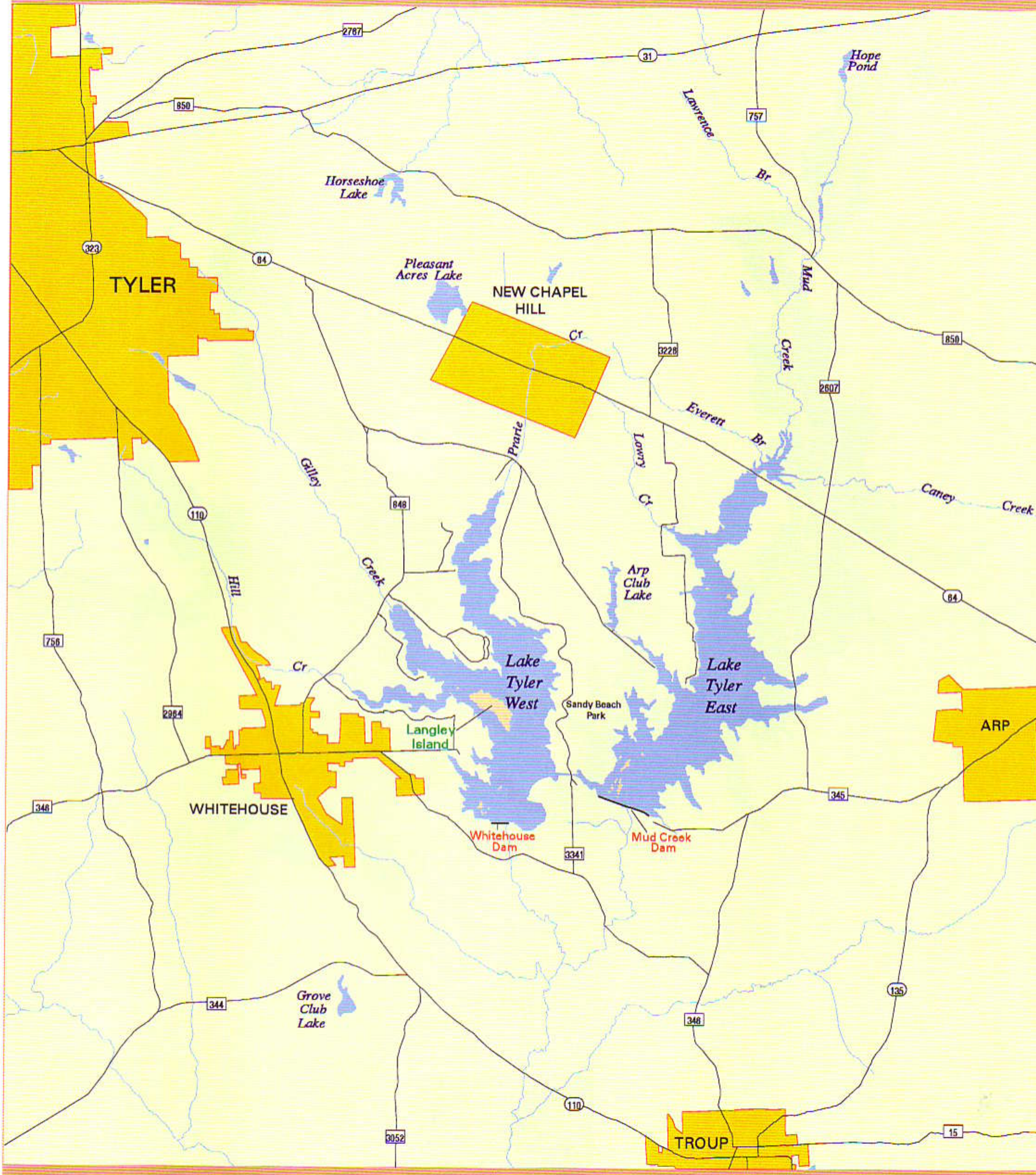
FIGURE 1
LAKE TYLER
Location Map



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N

1" = 10000'

FIGURE 2

LAKE TYLER

Location of Survey Data

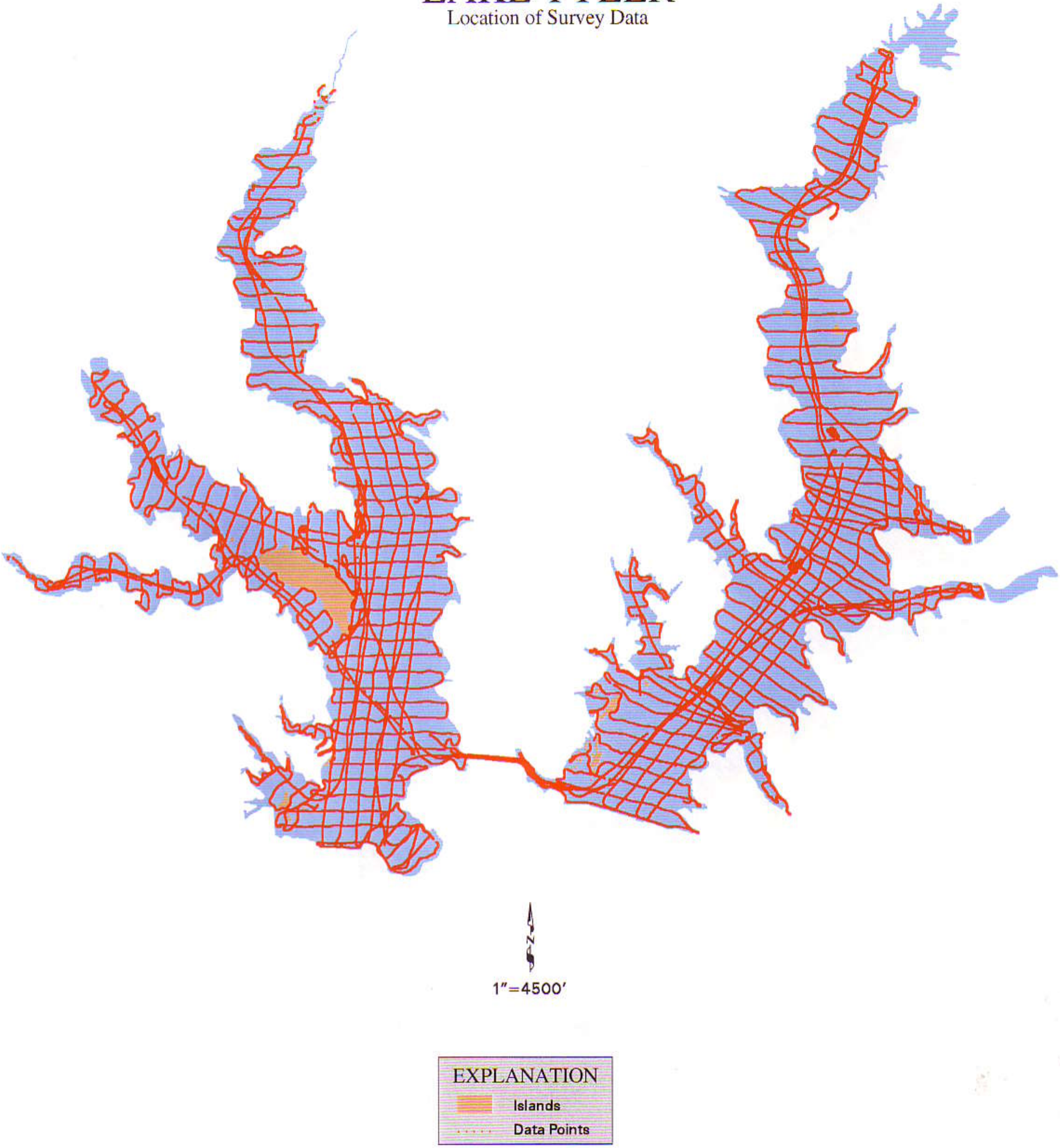

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FIGURE 3

LAKE TYLER

Shaded Relief

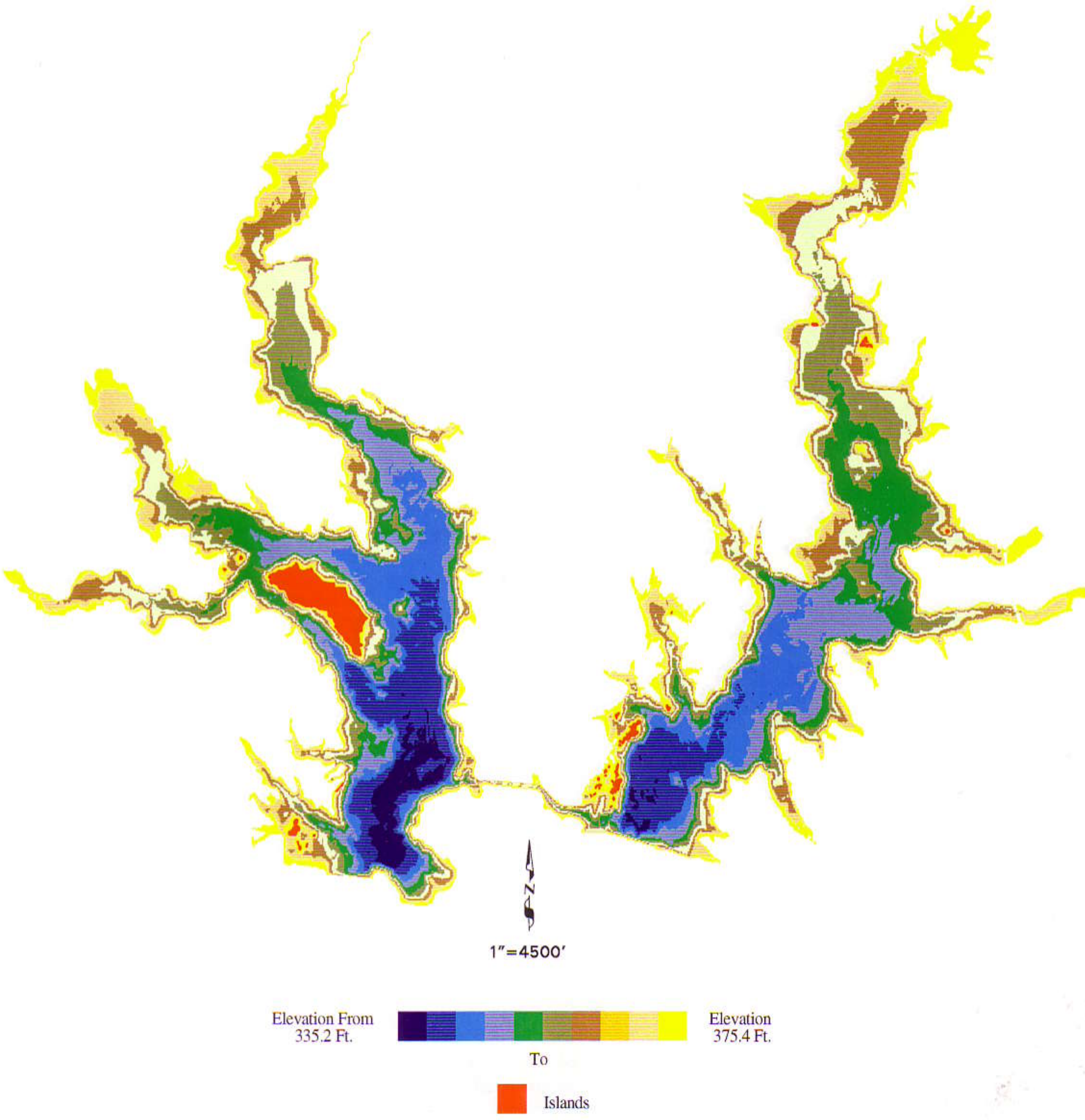

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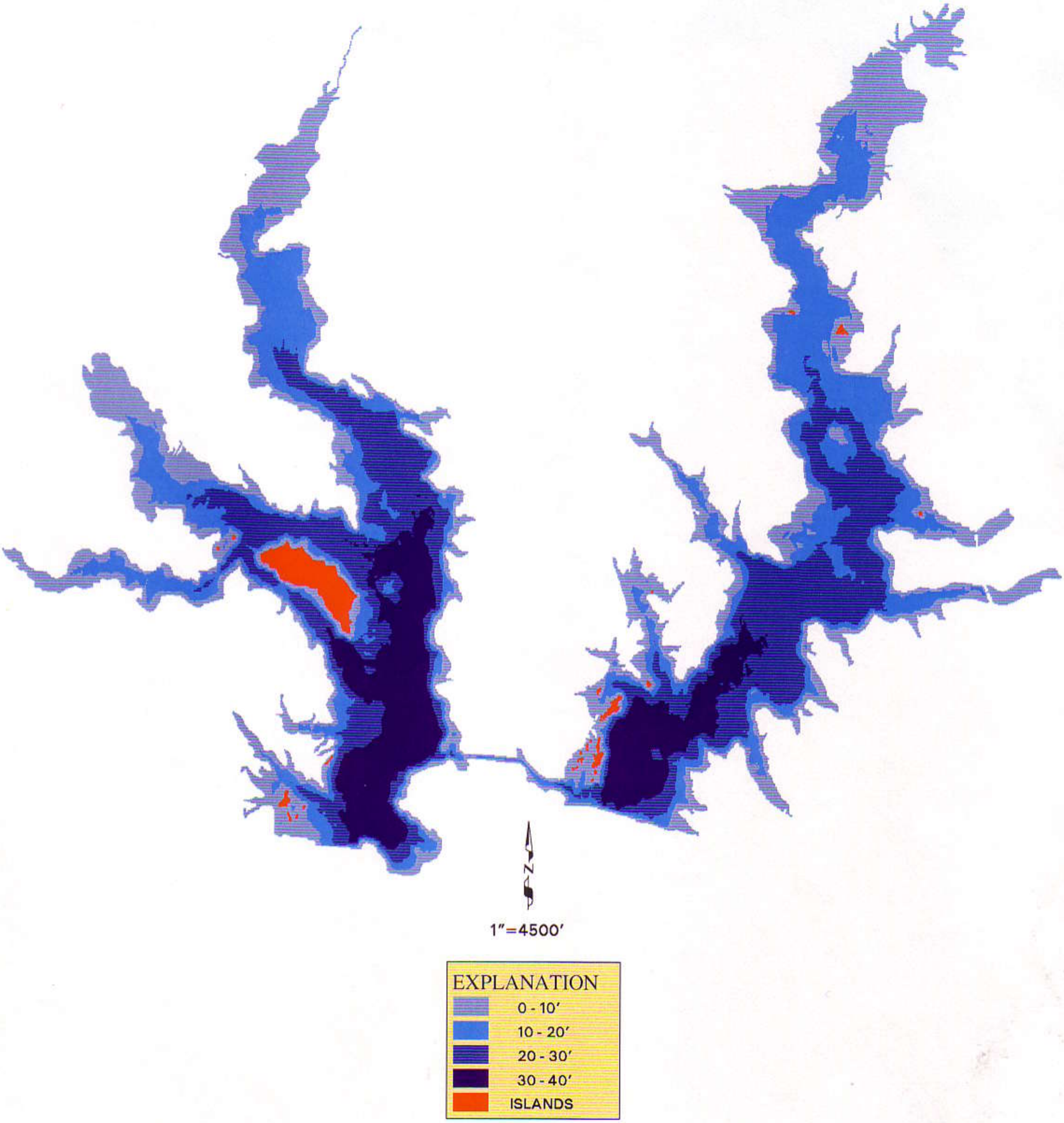
FIGURE 4

LAKE TYLER

Depth Ranges



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