VOLUMETRIC SURVEYS
OF
STRIKER CREEK RESERVOIR
AND LAKE KURTH

Prepared for:

ANGELINA AND NECHES RIVER AUTHORITY

Prepared by:

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INTRODUCTION

Staff of the Hydrographic Survey Unit of the Texas Water Development Board (TWDB) conducted hydrographic surveys of Lake Kurth on December 5 and 6, 1996 and of Striker Creek Reservoir on December 9 and 10, 1996. The purpose of the surveys were to determine the capacity of the lakes at the conservation pool elevation and to compare the results to any previous sediment surveys. From this information, future surveys will be able to determine the location and rates of sediment deposition 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 Striker Creek Reservoir and Lake Kurth are 293.0 feet and 197.5 feet respectively. At this elevation, the original estimate for the surface area of the Striker Creek Reservoir in 1957 was 2,426 acres and the estimated volume was 29,000 acre-feet of water. For Lake Kurth, the original estimate for the surface area in 1961 was 770 acres and the estimated volume was 16,200 acre-feet of water.

HISTORY AND GENERAL INFORMATION OF THE RESERVOIRS

Striker Creek Reservoir and dam are owned by the Angelina-Nacogdoches Counties Water Control and Improvement District No. 1 (Angelina-Nacogdoches Co. WCID#1). The lake is located on Striker Creek, in Cherokee and Rusk Counties, approximately 15 miles northeast of Rusk, Texas (see Figure 1). Records indicate the watershed for Striker Creek Reservoir is approximately 182 square miles. The shoreline at the conservation pool elevation is approximately 16 miles long. The lake is approximately 4.0 miles long from the dam to the headwaters. The widest area of the lake (located 2.0 miles upstream of the dam) is approximately 1.0 mile.

Permit No. 1808 dated January 25, 1956, issued by the State Board of Water Engineers to Angelina-Nacogdoches Co. WCID#1, authorized the construction of a dam to impound 26,500 acre-feet of water per annum. The permit authorized the annual diversion of 5,600 acre-feet of water for municipal use and 15,000 acre-feet of water for industrial use. On June 18, 1956, Permit No. 1830 amended the original permit by changing the location of the dam therefore increasing the capacity of the reservoir to 26,960 acre-feet. In subsequent years, a 1 foot stop log was added to the top of the tainter gates to increase the conservation pool elevation to 293.0 ft. A certificate of Adjudication (No. 06-4847) was issued to the owners on February 19, 1987. It basically reinforced the authorizations as stated in Permit No. 1830 to maintain an existing dam and reservoir and to impound not to exceed 26,960 acre-feet. It also authorized the owner to divert, circulate and recirculate as much water as necessary to consumptively use but not to exceed 20,600 acre-feet of water per annum for industrial purposes.

Records indicate the construction of Striker Creek dam began July 23, 1956. The designing engineers were J. M. Lloyd and Associates, W. H. Wolverton, and Freese and Nichols. The general contractor was Markham & Brown - McMullen & Larson. Deliberate impoundment of water began May 1, 1957 and the dam was completed July 1, 1957. The estimated cost of the facility based on a 1971 audit was $1,750,000. The dam is an earthfill structure, 2,400 feet in length (including the service spillway) and has a height of 42 feet above the natural streambed. The crest of the dam is 25 feet wide at elevation 309.0. The emergency spillway is an earth-cut channel located at the right end (west) of the dam's embankment. It has a crest length of 600 feet at elevation 294.0. The service spillway is a concrete ogee type structure consisting of four tainter gates, each 35 feet wide by 10 feet high, with an additional 1 foot stop log on top of each of the gates. The crest of the service spillway is 140 feet long at elevation 282.0. The low-flow outlet is a valved, controlled 24 inch concrete pipe with an invert elevation of 282.0. The discharge is into the channel of the service spillway.

Lake Kurth and Kurth Dam are owned by Champion International Corporation. The facility is an off-channel reservoir. The dam itself is located on the south bank of the Angelina River flood plain, in Angelina County, approximately 12 miles south of Nacogdoches, Texas (see Figure 1). Records indicate the watershed for Lake Kurth is approximately four square miles. The shoreline at the conservation pool elevation is approximately 10.5 miles long. The lake is approximately 1.0 mile long and 2.0 miles wide.

Permit No. 1912, dated June 3, 1958, issued by the State Board of Water Engineers to Southland Paper Mills, Inc. authorized the construction of a dam and off-channel reservoir to impound

16,200 acre-feet of water per annum. The permit authorized the owner to use annually 19,100 acre-feet of water for industrial purposes. Certificate of Adjudication (No. 06-4393) was issued to St. Regis Corporation(subsequently bought by Champion International Corporation) on August 8, 1986. It basically reinforced the authorizations as stated in Permit No. 1912 to maintain an existing dam and reservoir and to impound not to exceed 16,200 acre-feet of water. It also authorized the owner to divert, and use but not to exceed 19,100 acre-feet of water per annum for industrial purposes. Special conditions in the certificate included the authorization to use the bed and banks of Striker Creek downstream of Striker Creek Reservoir and the Angelina River to convey 10,000 acre-feet of water per annum that is purchased from the Angelina-Nacogdoches Counties Water Control and Improvement District No. 1 to the diversion point.

Records indicate the construction of Kurth Dam began May 26, 1959. The designing engineers were Lockwood, Andrews, and Newnam. The general contractor was Brown and Root, Inc. The project was completed July 21, 1961 and pumping began in September of 1961. The estimated cost of the facility was approximately $2,500,000. The dam is an earthfill levee, 8,600 feet in length and an average height of 37 feet. The crest of the dam is 16 feet wide at elevation 206.0. The service/emergency spillway is a drop inlet located at the left (west) end of the dam's embankment. The crest of the 25 foot diameter morning glory type opening is at elevation 197.5 feet. Three monolithic concrete conduits extend through the embankment and discharge any overflow waters downstream of the embankment into the Angelina River. There is no required outlet in the dam because this lake is a pumped storage facility.

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 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 a second 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 in 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 was still a major cost.

Another method used mainly prior to construction utilized aerial photography to generate elevation contours which could then be used 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 conservation pool boundary from USGS quad sheets. For Striker Creek Reservoir, the quad sheets used were New Salem, TX (1973) and New Summerfield, TX (1973), and for Lake Kurth, the quad sheet used was Redland, TX (Photo-revised 1980). The graphic boundary files 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 parameters. The area of the lake boundaries 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 Striker Creek Reservoir required approximately 54 survey lines to be placed along the length of the lake. For Lake Kurth, survey track lines were placed at 250 foot intervals along the length and 400 foot intervals along the width of the lake, and the survey design required 56 lines. 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 surveys of both Striker Creek Reservoir and Lake Kurth performed by the TWDB. Information regarding equipment calibration and operation, the field survey, and data processing is presented.

Equipment Calibration and Operation

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.

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 Striker Creek Reservoir, the speed of sound in the water column varied daily between 4,795 and 4,796 feet per second. For Lake Kurth, the speed of sound varied between 4,800 and 4,812. 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, plus an estimated error of ±0.3 feet due to the plane of the boat for a total accuracy of ±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.

Field Surveys

Data was collected on Striker Creek Reservoir on December 9 and 10, 1996. Approximately 22,796 data points were collected over the 51 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 53 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. Some random data lines were also collected, perpendicular to the survey layout, by the field crew during the survey. Figure 2 shows the location of all data collection points for Striker Creek Reservoir.

TWDB staff observed the lake's bathemetry of Striker Creek Reservoir to be fairly uniform with a gentle slope from the shoreline to the center of the lake. The bathemetry of the lake reflected similar characteristics of the terrain or topography surrounding the lake. Several creek channels could be distinguished on the depth sounder's analog charts. The climatic conditions were favorable, although the winds did pick up during the afternoon of the second day of data collection. The main body of the lake was clear of navigational hazards such as standing timber and submerged trees and stumps. The crew did encounter a few submerged trees, aquatic vegetation and shallow sand bars in the headwaters, or upper reaches of the reservoir. The crew was able to collect data on all the preplotted lines until they were in the headwaters. At that time, random data were collected as the crew traversed the creek channel and meandered through the navigational hazards. There were no major tributaries observed other than Striker Creek itself. The crew was unable to gain access to collect data in the service channel to the electric generating plant located on the west bank of the lake. 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 was collected at Lake Kurth on December 5 and 6, 1996. Approximately 15,676 data points were collected over the 40 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 51 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 5 shows the data points collected on Lake Kurth.

TWDB staff observed the lake's bathemetry of Lake Kurth to be fairly uniform in the main area of the lake, with a rapid rise of between 10 and 20 feet as you approached the shoreline. The bathemetry of the lake reflected the flood plain and flood channel walls of the terrain or topography surrounding the lake. The climatic conditions were favorable during the survey. The entire lake was clear of navigational hazards such as standing timber and submerged trees and stumps. There were no major tributaries observed in this off-channel reservoir. The crew was able to collect data on all the pre-plotted lines up to the shoreline edges. 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 stayed steady at 292.8 feet on Striker Creek Reservoir and at 197.43 feet on Lake Kurth. After all changes had been made to the raw data file, the edited file was saved with a different extension. After all the files were edited, the edited files were combined into a single 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 DOS data file was imported into the UNIX operating system used to run Environmental System Research Institutes's (ESRI) Arc/Info GIS software. The latitude and longitude coordinates of each point were then converted to decimal degrees by a UNIX awk command. The awk command manipulates the data file format into a MASS points format for use by the GIS software. The graphic boundary file previously digitized was also imported.

The boundary and MASS points files were graphically edited using the Arc/Edit module. The MASS points file was converted into a point coverage and plotted along with the boundary file. If data points were collected outside the boundary file, the boundary was modified to include the data points. Also, the boundary near the edges of the lake in areas of significant sedimentation was down-sized to reflect the observations of the field crew. The resulting boundary shape was considered to be the acreage at the conservation pool elevation of the lake. This was calculated as 1,920 acres for Striker Creek Reservoir and 726 acres for Lake Kurth. The Board does not represent the boundary, as depicted in this report, to be a detailed actual boundary. Instead, it is a graphical approximation of the actual boundary used solely to compute the volume and area of the lake. The boundary does not represent the true land versus water boundary of the lake. An aerial topographic map of the upper four feet of the lake or an aerial photo taken when the lake is at the conservation pool elevation would more closely define the present boundary. However, the minimal increase in accuracy does not appear to offset the cost of those services at this time.

The edited MASS points and modified boundary file were used to create a Digital Terrain Model (DTM) of the reservoir's bottom surface using Arc/Info's TIN 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.

There were some areas where values could not be calculated by interpolation because of a lack of information along the boundary of 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 298 additional points were required for interpolation and contouring of the entire lake surface of Striker Creek Reservoir and 568 additional points for Lake Kurth. There were 3,281 additional points added on Striker Creek Reservoir to reflect reported depths provided by plant personnel in the channel from the power plant to the lake. The TIN product calculated the surface areas and volumes of the each reservoir at one-tenth of a foot intervals from the three-dimensional triangular plane surface representation. The computed reservoir volume table for Striker Creek Reservoir is presented in Appendix B and the area table in Appendix C. An elevation-area-volume graph is presented in Appendix D. The computed reservoir volume table for Lake Kurth is presented in Appendix E and the area table in Appendix F. An elevation-area-volume graph is presented in Appendix G.

Other presentations developed from the model include a shaded relief map and a shaded depth range map. To develop the shaded relief map, the three-dimensional triangular surface was modified by a GRIDSHADE command. Colors were assigned to different elevation values of the grid. Using the command COLORRAMP, a set of colors that varied from navy to yellow was created. The lower elevation was assigned the color of navy, and the lake conservation pool elevation was assigned the color of yellow. Different color shades were assigned to the different depths in between. Figures 3 and 6 present the resulting depth shaded representations of the lakes. Figures 4 and 7 present a similar version of the same maps, using bands of color for selected depth intervals. The color increases in intensity from the shallow contour bands to the deep water bands.

The DTM was then smoothed and linear smoothing algorithms were applied to the smoothed model to produce smoother contours. The resulting contour maps of the bottom surface at two-foot intervals are presented in Figures 8 and 9.

STRIKER CREEK RESERVOIR RESULTS

Results from the 1996 TWDB survey indicate Striker Creek Reservoir encompasses 1,920 surface acres and contains a volume of 22,865 acre-feet at the conservation pool elevation of 293.0 feet. The shoreline at this elevation was calculated to be 16.0 miles. The lowest elevation encountered during the survey was 266.4 feet, or 26.6 feet of depth, and was found in the middle of the lake, within about 1,550 feet of the dam. The dead storage volume, or the amount of water below the lowest outlet in the dam, was calculated to be 5,931 based on the low flow outlet invert elevation of 282.0 feet. The conservation storage capacity, or the amount of water between the spillway and the lowest outlet, was determined to be 16,930 acre-feet.

LAKE KURTH RESULTS

Results from the 1996 TWDB survey indicate Lake Kurth encompasses 726 surface acres and contains a volume of 14,769 acre-feet at the conservation pool elevation of 197.5 feet. The shoreline at this elevation was calculated to be 10.5 miles. The lowest elevation encountered during the survey was 166.5 feet, or 31.0 feet of depth, and was found in the middle of the lake, about 755 feet from the dam. Since this is an off-channel, pumped facility, there is no dead storage in the lake. Therefore the conservation storage capacity is 14,769 acre-feet.

SUMMARY

Striker Creek Reservoir and Lake Kurth were formed in 1957 and 1961 respectively. Initial storage calculations for Striker Creek Reservoir estimated the volume at the conservation pool elevation of 293.0 feet to be 29,000 acre-feet with a surface area of 2,426 acres. For Lake Kurth, the estimated initial volume at the conservation pool elevation of 197.5 feet was 16,200 acre-ft with a surface area of 770 acres.

During the period of December 5-6, 1996 a hydrographic survey of Lake Kurth was performed by the Texas Water Development Board's Hydrographic Survey Program. The following week, December 9-10, 1996, a hydrographic survey was performed on Striker Creek Reservoir. The 1996 surveys used technological advances such as differential global positioning system and geographical information system technology to build models of the reservoir's bathemetry. These advances allowed a survey to be performed quickly and to collect significantly more data of the bathemetry of both Striker Creek Reservoir and Lake Kurth than previous survey methods.

Results indicate that Striker Creek Reservoir’s capacity at the conservation pool elevation of 293.0 feet was 22,865 acre-feet and the area was 1,920 acres. The estimated reduction in storage capacity between 1957 and 1996 was 6,135 acre-ft or 157 acre-ft per year. The average annual deposition rate of sediment in the reservoir can be estimated at 0.864 acre-ft per square mile of drainage area.

Results indicate that Lake Kurth's capacity at the conservation pool elevation of 197.5 feet was 14,769 acre-feet and the area was 726 acres. The estimated reduction in storage capacity between 1961 and 1996 was 1,431 acre-ft or 40.88 acre-ft per year.

It is difficult to compare the original design information and the surveys performed by the TWDB because of the different procedures, different data collection techniques, and the different ways the data were processed. Most of the reduction in storage in Lake Kurth can be attributed to the difference between the original estimate and the TWDB's survey because very little sediment is deposited in this off-channel lake from runoff. However, the TWDB considers the 1996 surveys 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 accurately monitor changes to each of the lake's storage capacities.

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

Mar 11 1997

STRIKER CREEK RESERVOIR DECEMBER 1996

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

LEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
267										
268										
269				1	1	1	1	1	1	2
270	3	3	4	6	8	10	12	15	19	22
271	27	31	36	42	49	56	64	73	83	93
272	105	118	132	147	164	182	202	222	244	267
273	290	314	339	365	392	419	447	476	506	537
274	568	601	634	670	706	743	781	820	859	900
275	941	983	1026	1069	1113	1157	1203	1249	1296	1344
276	1393	1443	1494	1545	1598	1652	1707	1763	1820	1878
277	1937	1996	2057	2118	2180	2243	2307	2372	2437	2504
278	2571	2640	2709	2779	2850	2921	2994	3067	3141	3215
279	3291	3367	3445	3523	3602	3681	3762	3843	3925	4007
280	4091	4175	4259	4345	4431	4518	4605	4694	4783	4874
281	4965	5057	5150	5244	5339	5435	5532	5630	5729	5830
282	5931	6034	6137	6242	6348	6456	6564	6674	6785	6898
283	7012	7126	7243	7360	7478	7598	7720	7842	7966	8091
284	8217	8345	8473	8603	8733	8865	8997	9130	9265	9400
285	9536	9673	9811	9949	10089	10229	10370	10512	10655	10799
286	10944	11090	11237	11385	11534	11683	11833	11984	12136	12288
287	12442	12596	12751	12907	13063	13221	13380	13539	13699	13859
288	14021	14183	14346	14509	14673	14838	15003	15169	15335	15502
289	15670	15838	16007	16176	16346	16517	16688	16860	17032	17205
290	17378	17553	17728	17904	18080	18257	18434	18611	18790	18968
291	19148	19328	19508	19690	19872	20054	20237	20421	20606	20791
292	20977	21163	21350	21538	21726	21915	22104	22293	22483	22674
293	22865									

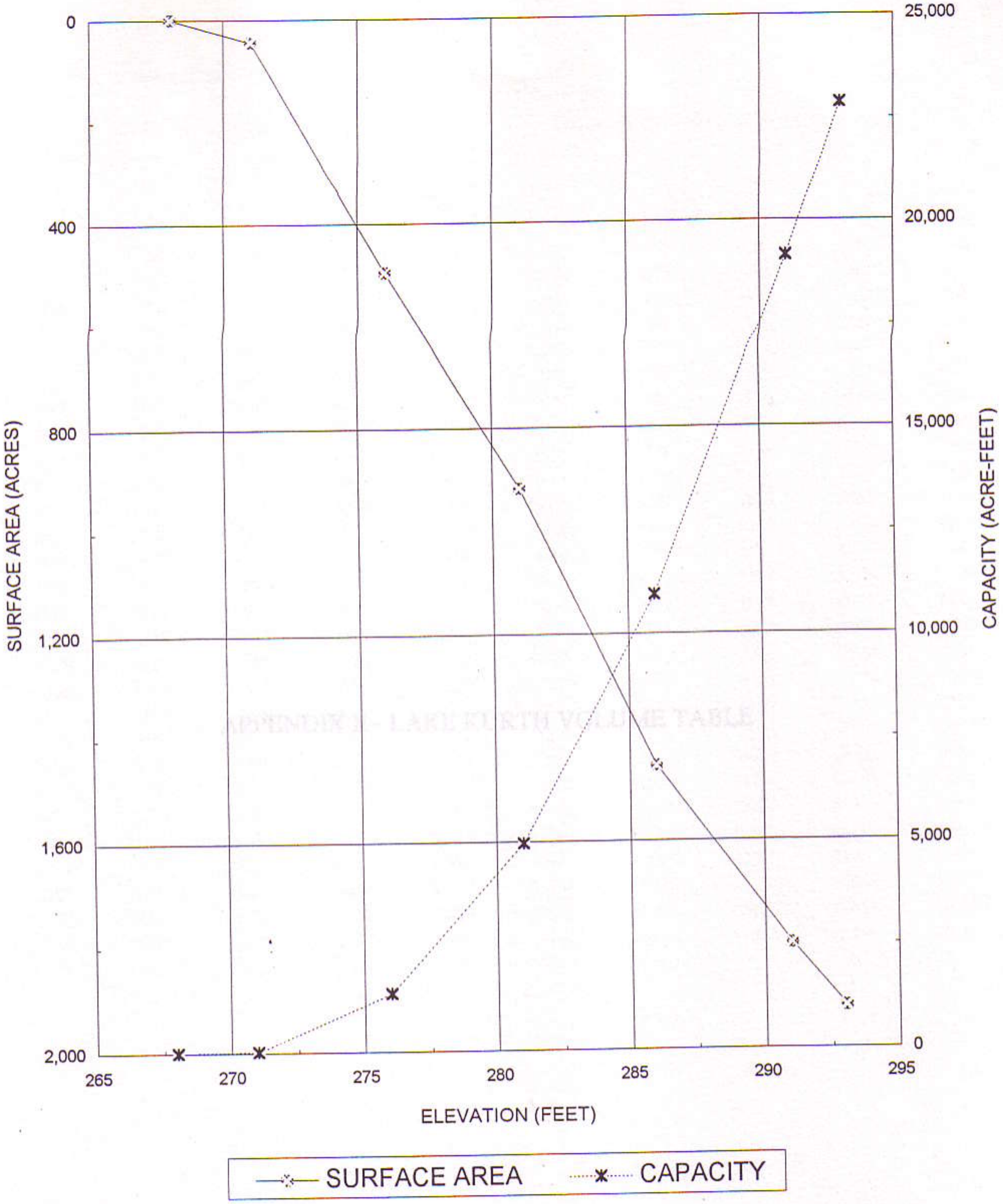
TEXAS WATER DEVELOPMENT BOARD
RESERVOIR AREA TABLE

Mar 11 1997

STRIKER CREEK RESERVOIR   DECEMBER 1996

AREA IN ACRES   ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
267										
268										
269	1	1	1	1	1	2	2	3	4	5
270	7	9	12	16	20	24	27	31	35	39
271	44	50	55	61	68	76	84	93	102	111
272	123	136	148	160	174	189	201	212	221	229
273	237	245	254	262	271	278	286	294	303	310
274	319	331	345	356	366	375	384	393	401	409
275	416	423	429	436	443	450	458	465	474	484
276	495	504	514	523	533	543	554	564	575	585
277	593	602	610	618	625	633	642	652	661	670
278	679	688	696	704	712	720	727	735	743	752
279	760	768	776	785	792	799	808	816	823	830
280	837	844	850	858	865	873	881	890	899	908
281	917	925	935	944	954	964	975	987	998	1009
282	1020	1031	1043	1055	1067	1080	1093	1106	1119	1131
283	1142	1154	1166	1179	1193	1206	1219	1232	1244	1256
284	1268	1279	1290	1300	1310	1320	1330	1338	1347	1356
285	1365	1373	1382	1390	1398	1407	1415	1425	1434	1444
286	1455	1465	1475	1484	1492	1499	1506	1513	1520	1528
287	1536	1546	1555	1564	1572	1581	1588	1596	1603	1610
288	1617	1624	1630	1637	1644	1650	1656	1662	1668	1673
289	1679	1685	1691	1697	1702	1708	1714	1720	1726	1733
290	1743	1749	1754	1759	1764	1769	1774	1779	1785	1790
291	1798	1804	1810	1816	1823	1829	1835	1842	1848	1855
292	1863	1868	1873	1878	1883	1889	1894	1899	1904	1909
293	1920									



LAKE STRIKER

December 1996 Survey

Prepared by: TWDB February 1997

TEXAS WATER DEVELOPMENT BOARD

RESERVOIR VOLUME TABLE

Mar 4 1997

LAKE KURTH DECEMBER 1996 SURVEY

VOLUME IN ACRE-FEET ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
167								1	1	1
168	2	2	3	4	5	6	8	11	15	19
169	24	29	36	43	51	60	70	81	92	104
170	117	131	146	161	178	194	212	230	249	268
171	288	308	329	351	373	396	419	443	467	492
172	518	544	571	599	627	656	685	715	746	777
173	809	841	874	907	941	976	1011	1046	1082	1118
174	1155	1192	1230	1268	1307	1346	1385	1425	1465	1506
175	1547	1589	1630	1673	1715	1758	1801	1844	1888	1931
176	1975	2019	2064	2108	2153	2198	2243	2289	2334	2380
177	2426	2472	2519	2565	2612	2659	2706	2753	2800	2848
178	2896	2944	2992	3040	3088	3136	3185	3234	3283	3332
179	3381	3431	3480	3530	3580	3630	3680	3730	3781	3832
180	3883	3934	3985	4036	4088	4139	4191	4243	4295	4348
181	4400	4453	4506	4559	4612	4666	4719	4773	4827	4881
182	4935	4989	5044	5099	5153	5208	5263	5319	5374	5430
183	5485	5541	5597	5653	5709	5766	5822	5879	5936	5993
184	6050	6107	6165	6222	6280	6337	6395	6453	6511	6569
185	6628	6686	6745	6803	6862	6921	6979	7038	7098	7157
186	7216	7275	7335	7394	7454	7514	7574	7634	7694	7754
187	7814	7874	7935	7995	8056	8117	8178	8239	8300	8361
188	8422	8483	8545	8606	8668	8730	8791	8853	8915	8977
189	9040	9102	9164	9227	9289	9352	9415	9478	9541	9604
190	9667	9731	9794	9858	9922	9986	10050	10114	10178	10243
191	10307	10372	10437	10502	10567	10632	10697	10763	10828	10894
192	10960	11026	11092	11158	11225	11291	11358	11425	11492	11559
193	11626	11693	11760	11828	11895	11963	12031	12099	12167	12235
194	12303	12371	12440	12509	12577	12646	12715	12785	12854	12923
195	12993	13062	13132	13202	13272	13342	13412	13482	13553	13623
196	13694	13765	13835	13907	13978	14049	14120	14192	14264	14335
197	14407	14479	14551	14624	14696	14769				

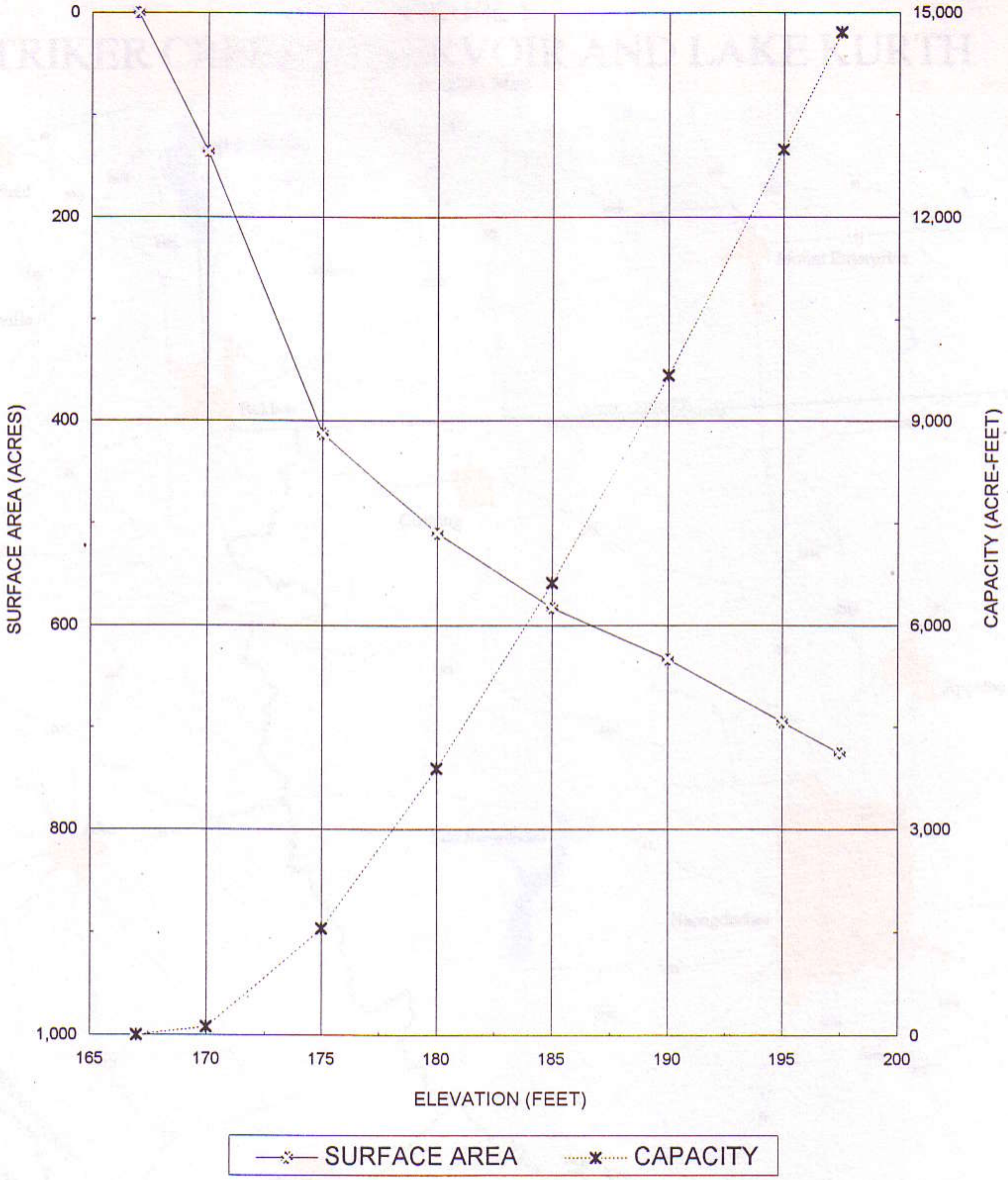
TEXAS WATER DEVELOPMENT BOARD
RESERVOIR AREA TABLE

Mar 4 1997

LAKE KURTH DECEMBER 1996 SURVEY

AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEV. FEET	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
167					1	1	1	2	3	4
168	5	7	8	10	13	17	23	30	38	46
169	53	61	69	77	85	93	101	110	118	127
170	135	143	151	158	165	172	178	184	190	195
171	201	206	212	219	225	230	236	242	248	254
172	261	267	273	279	285	291	297	303	309	315
173	320	326	331	336	341	346	351	356	361	365
174	370	375	379	384	388	393	397	401	405	409
175	413	417	420	423	426	429	431	434	436	439
176	441	443	445	447	449	451	453	455	457	459
177	461	463	464	466	468	470	472	473	475	476
178	478	479	481	482	484	485	487	488	490	492
179	493	495	497	498	500	501	503	505	506	508
180	510	511	513	514	516	518	519	521	523	524
181	526	528	530	532	533	535	537	538	540	541
182	543	544	546	547	549	550	552	553	555	556
183	558	559	560	562	563	565	566	568	569	570
184	572	573	574	575	577	578	579	580	581	582
185	583	584	585	586	587	588	589	590	591	592
186	593	594	595	596	597	598	599	600	601	602
187	603	604	605	606	607	608	609	610	611	612
188	613	614	615	616	617	618	619	620	621	622
189	623	624	625	626	627	628	629	630	631	632
190	633	635	636	637	639	640	641	642	644	645
191	646	648	649	650	651	653	654	655	657	658
192	660	661	662	663	664	666	667	668	669	670
193	671	673	674	675	676	677	679	680	681	682
194	684	685	686	688	689	690	691	692	693	694
195	695	697	698	699	700	701	702	703	704	706
196	707	709	710	711	712	713	715	716	717	718
197	720	721	722	723	725	726				

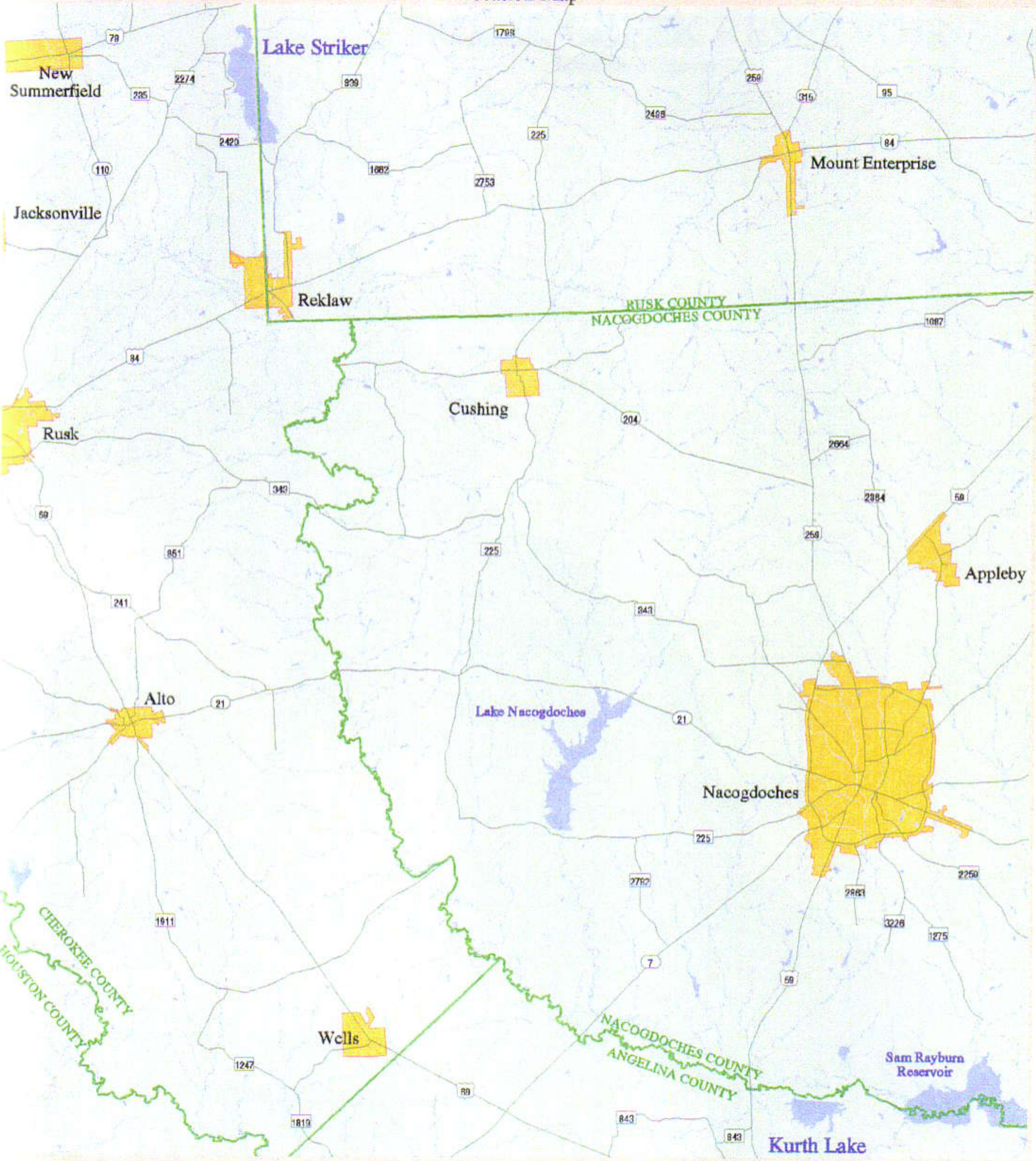


LAKE KURTH

December 1996 Survey

Prepared by: TWDB February 1997

FIGURE 1
STRIKER CREEK RESERVOIR AND LAKE KURTH
Location Map

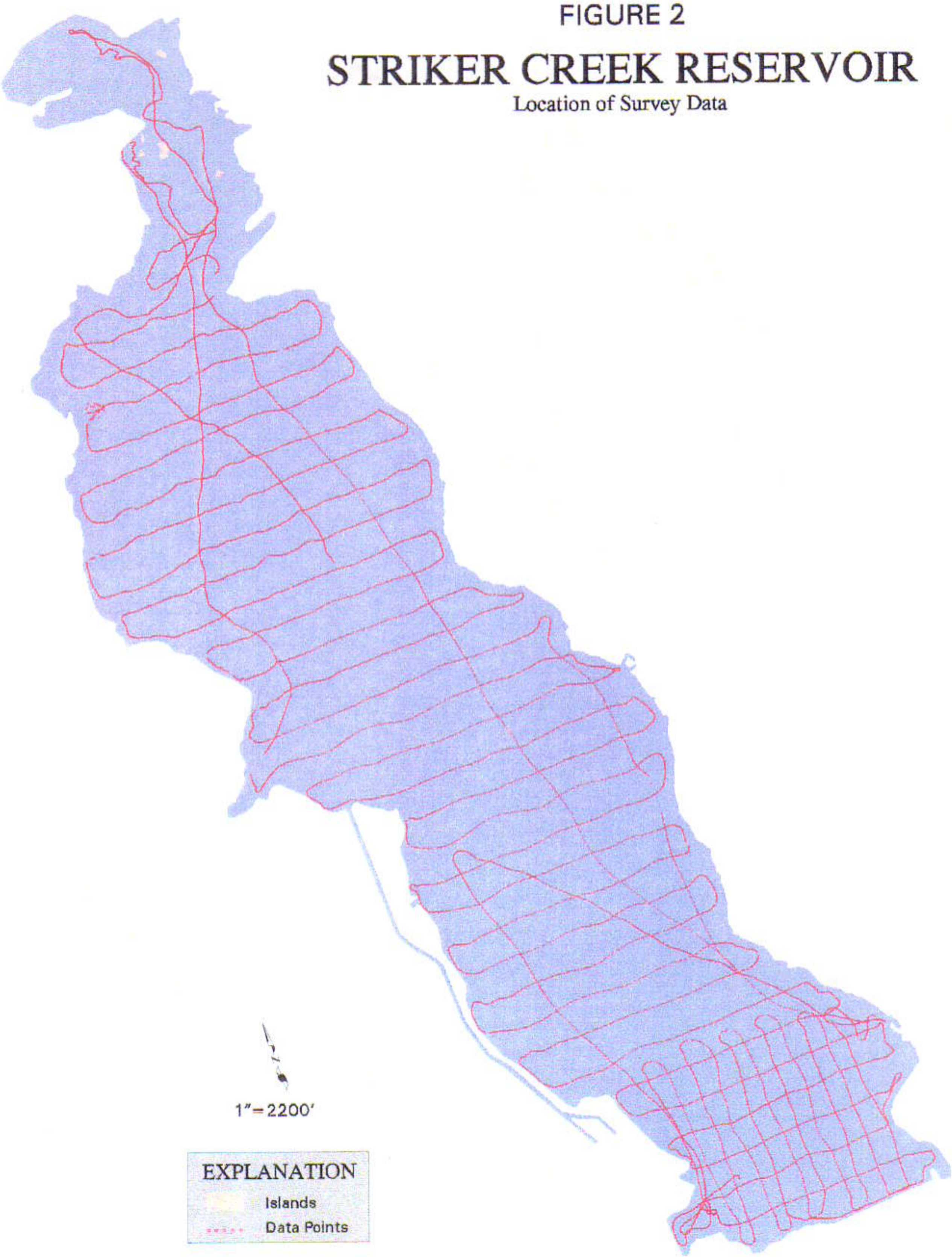


PREPARED BY: TWDB FEBRUARY 1997

FIGURE 2

STRIKER CREEK RESERVOIR

Location of Survey Data

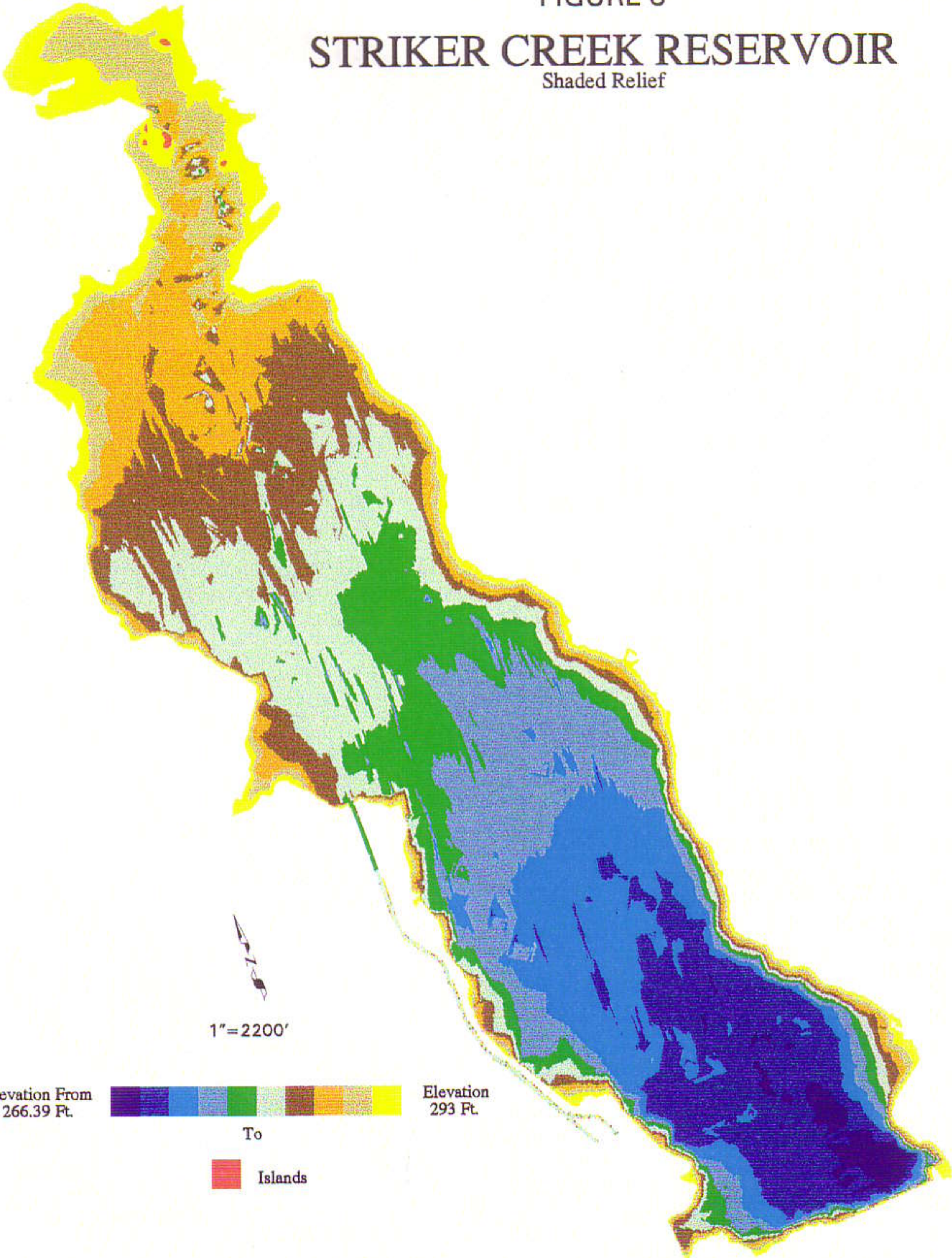


PREPARED BY: TWDB FEBRUARY 1997

FIGURE 3

STRIKER CREEK RESERVOIR

Shaded Relief

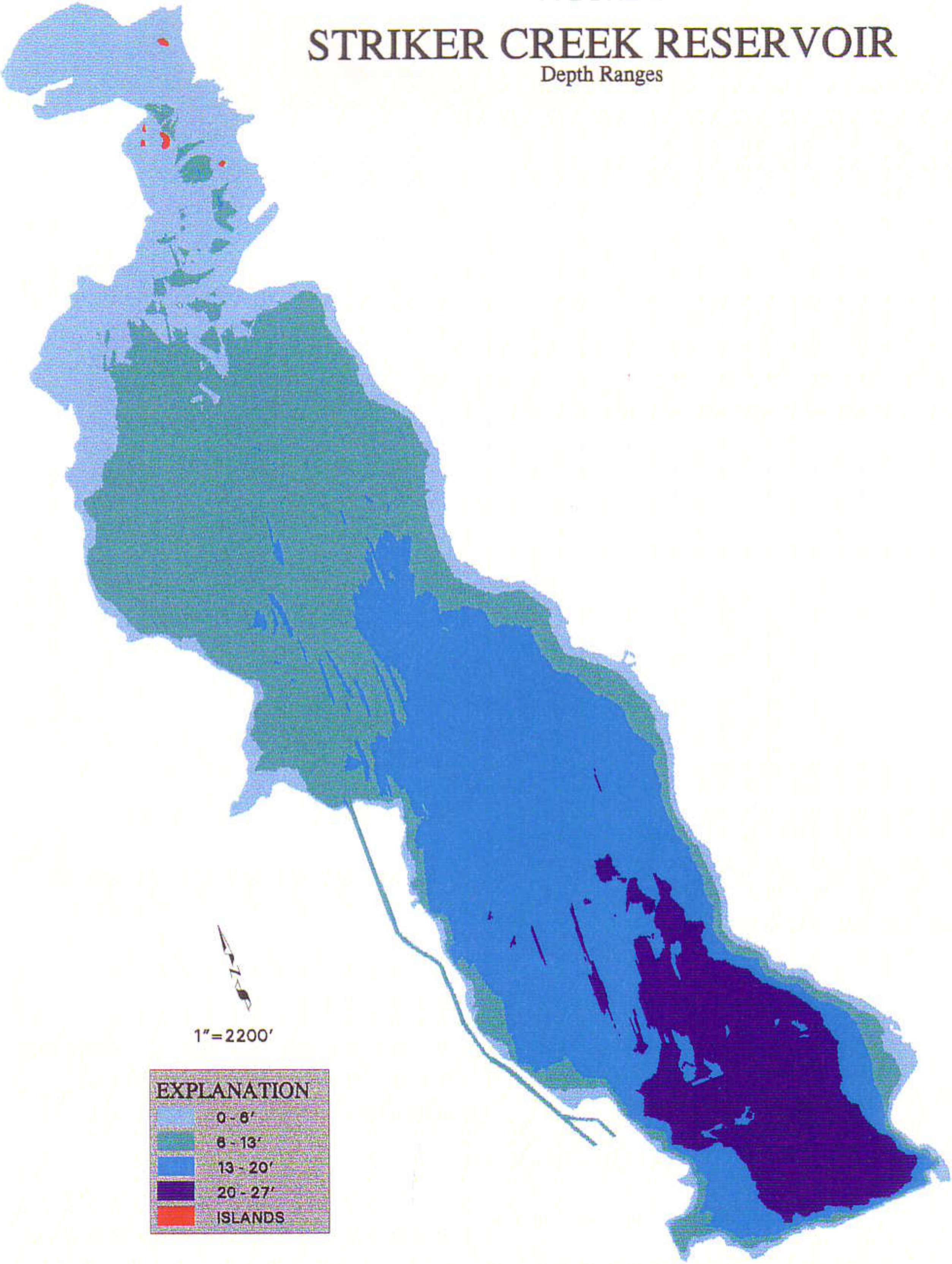


PREPARED BY: TWDB MARCH 1997

FIGURE 4

STRIKER CREEK RESERVOIR

Depth Ranges

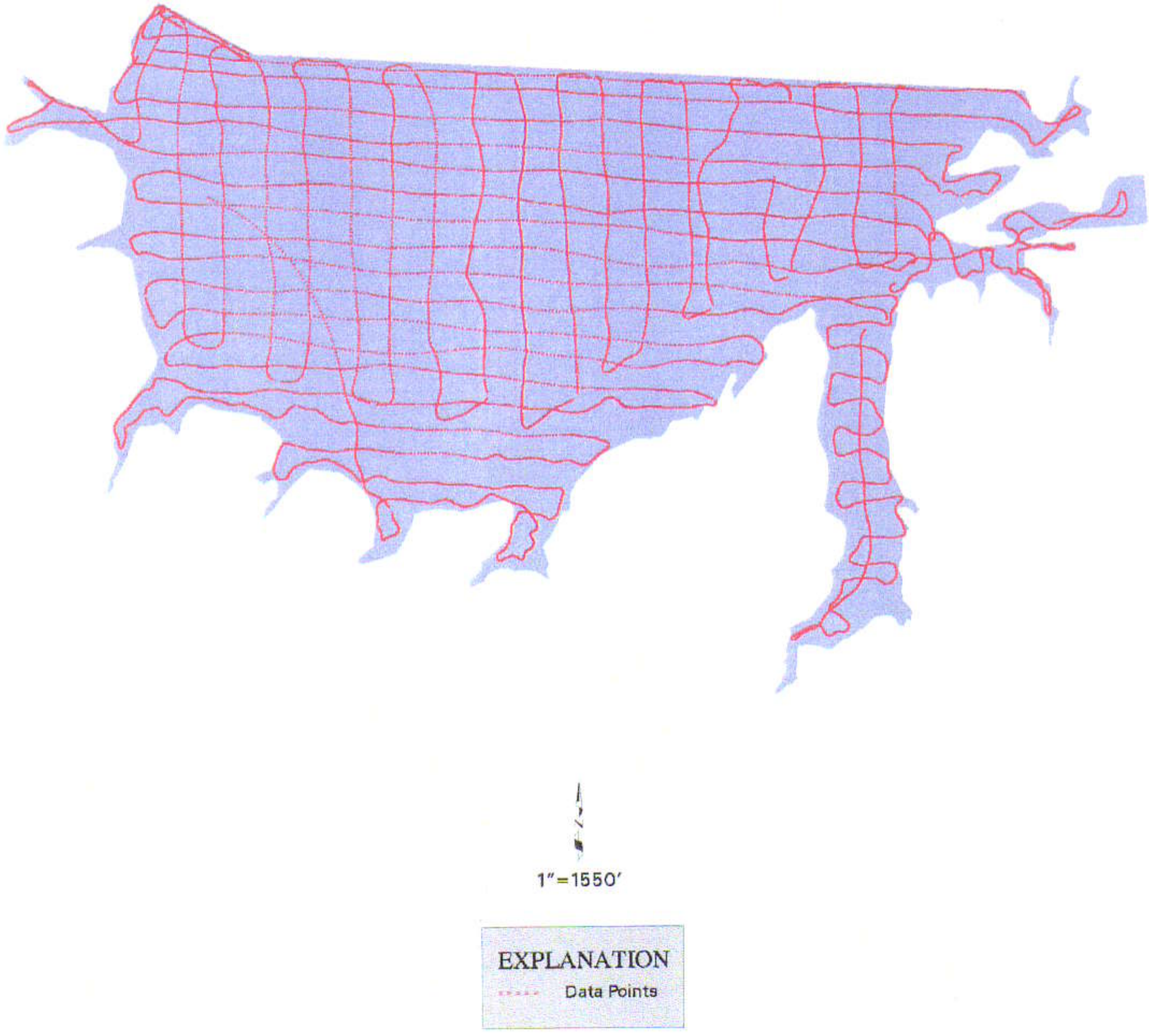


PREPARED BY: TWDB MARCH 1997

FIGURE 5

LAKE KURTH

Location of Survey Data

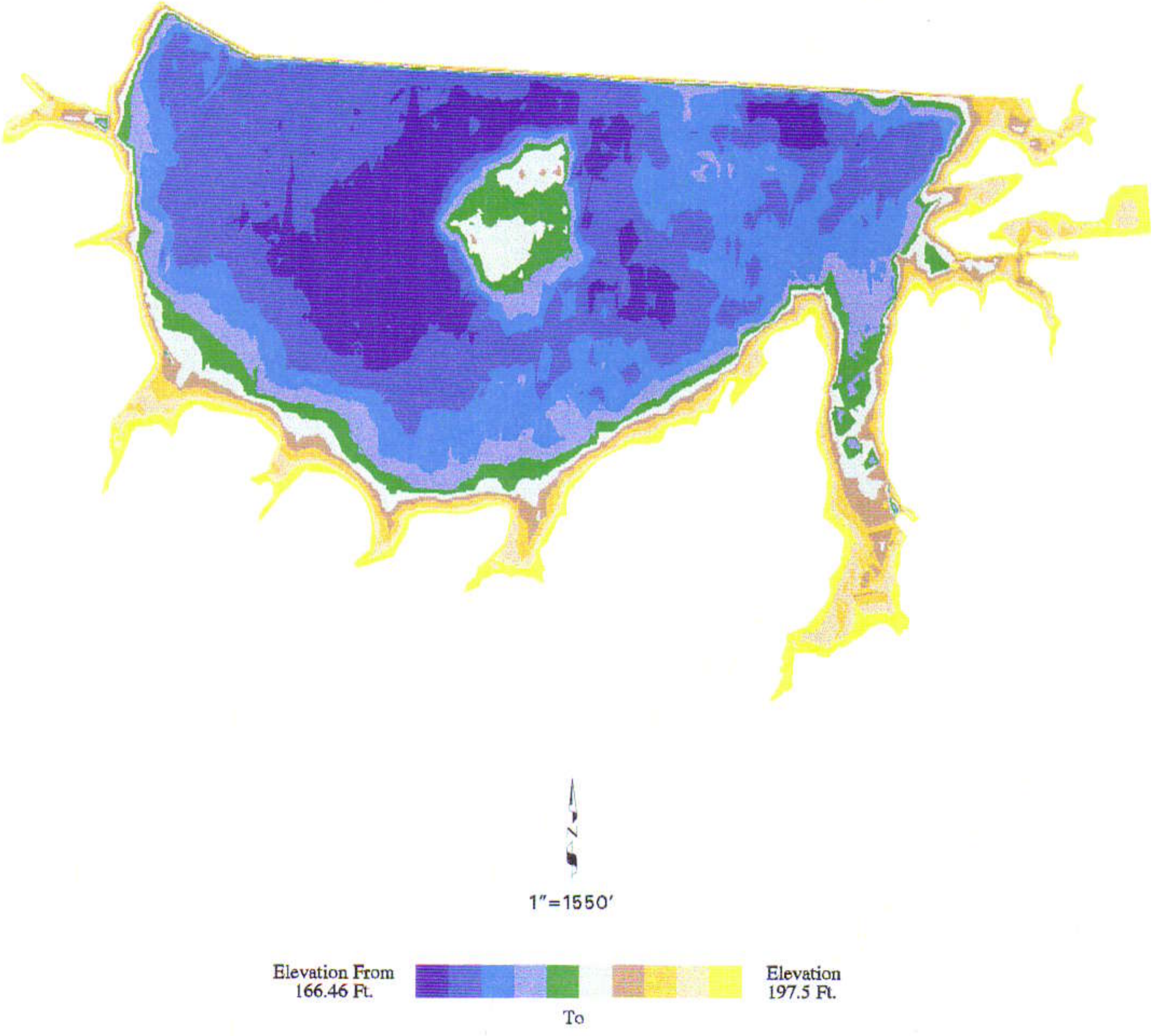


PREPARED BY: TWDB FEBRUARY 1997

FIGURE 6

LAKE KURTH

Shaded Relief

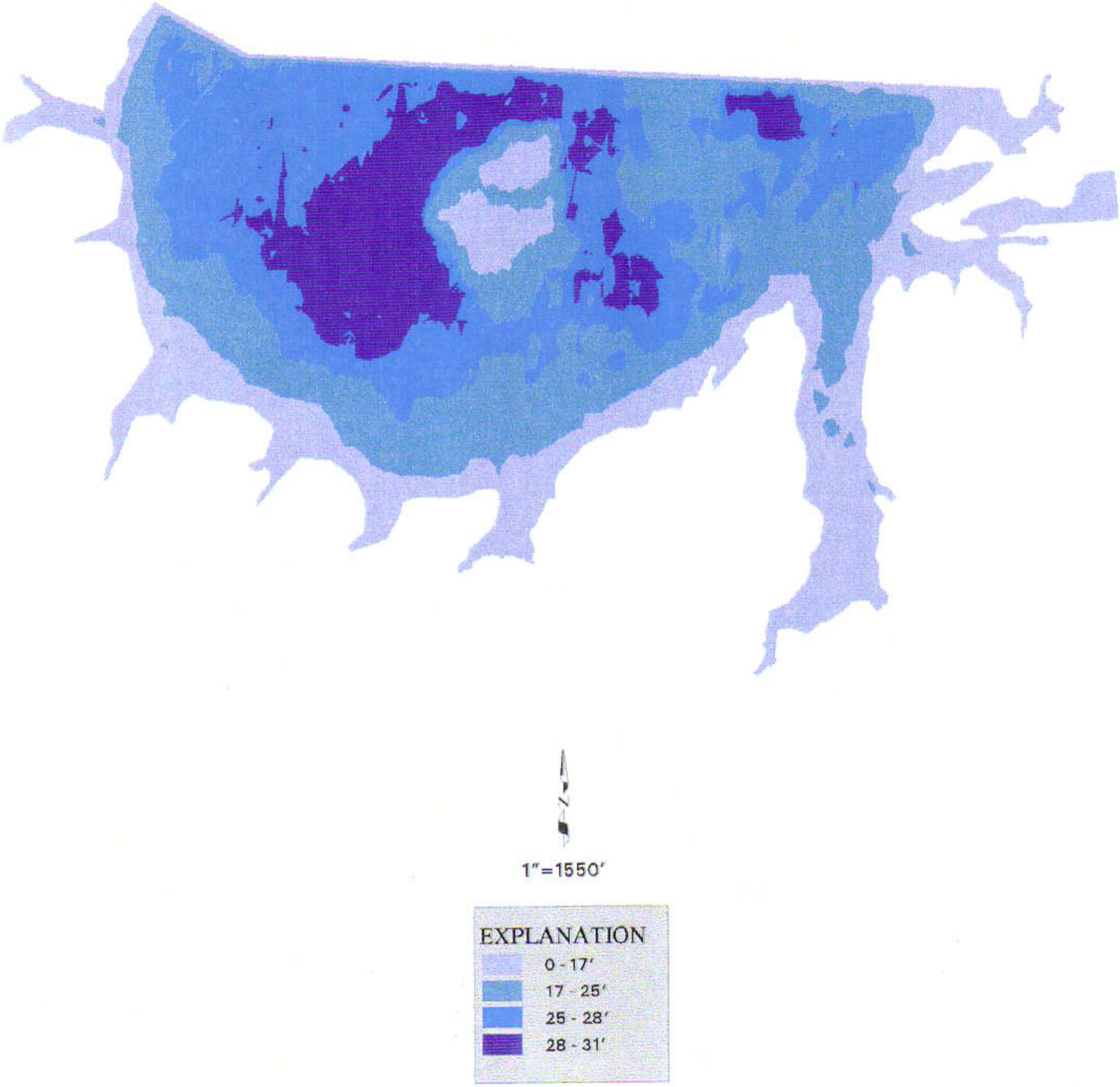


PREPARED BY: TWDB FEBRUARY 1997

FIGURE 7

LAKE KURTH

Depth Ranges

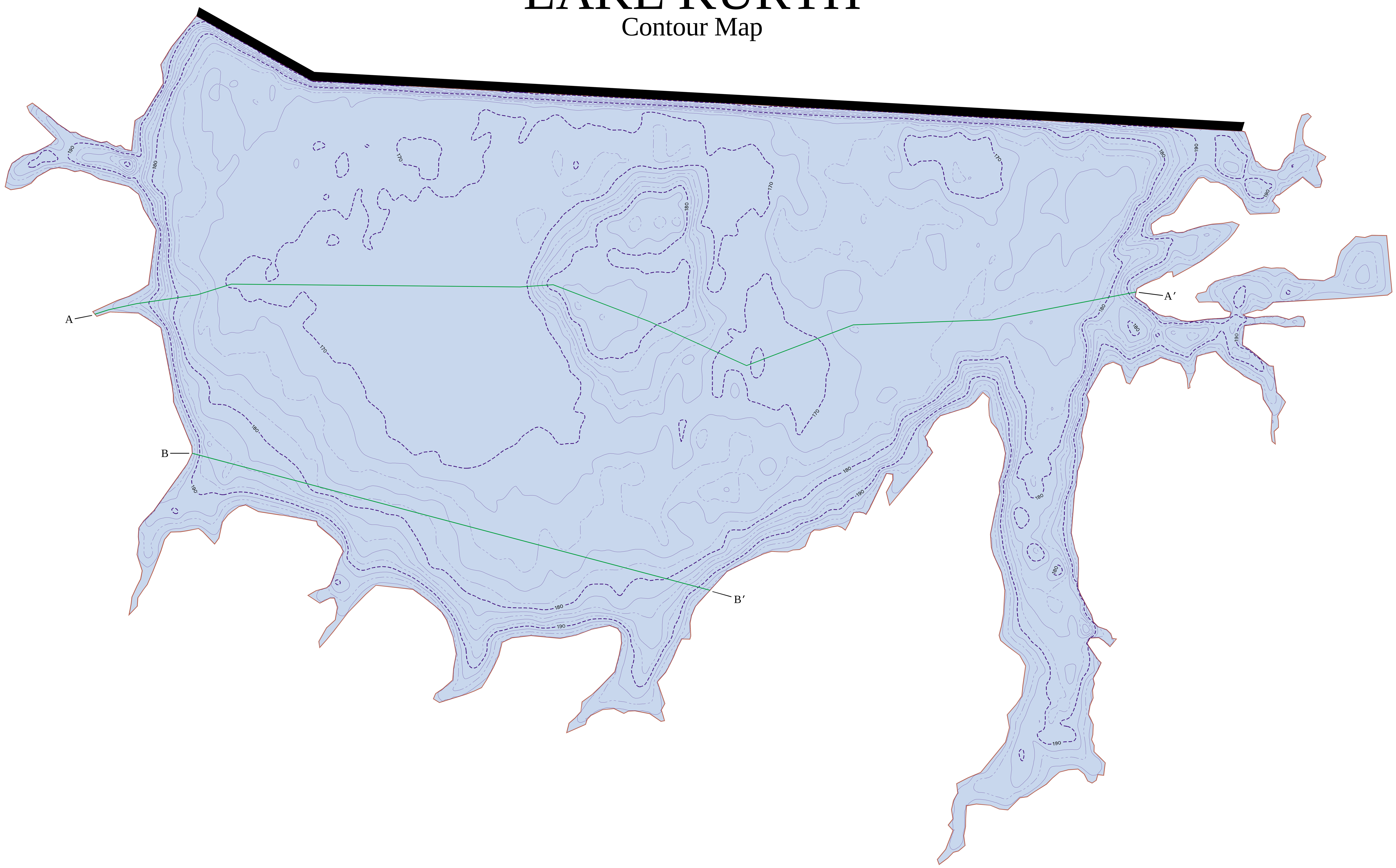


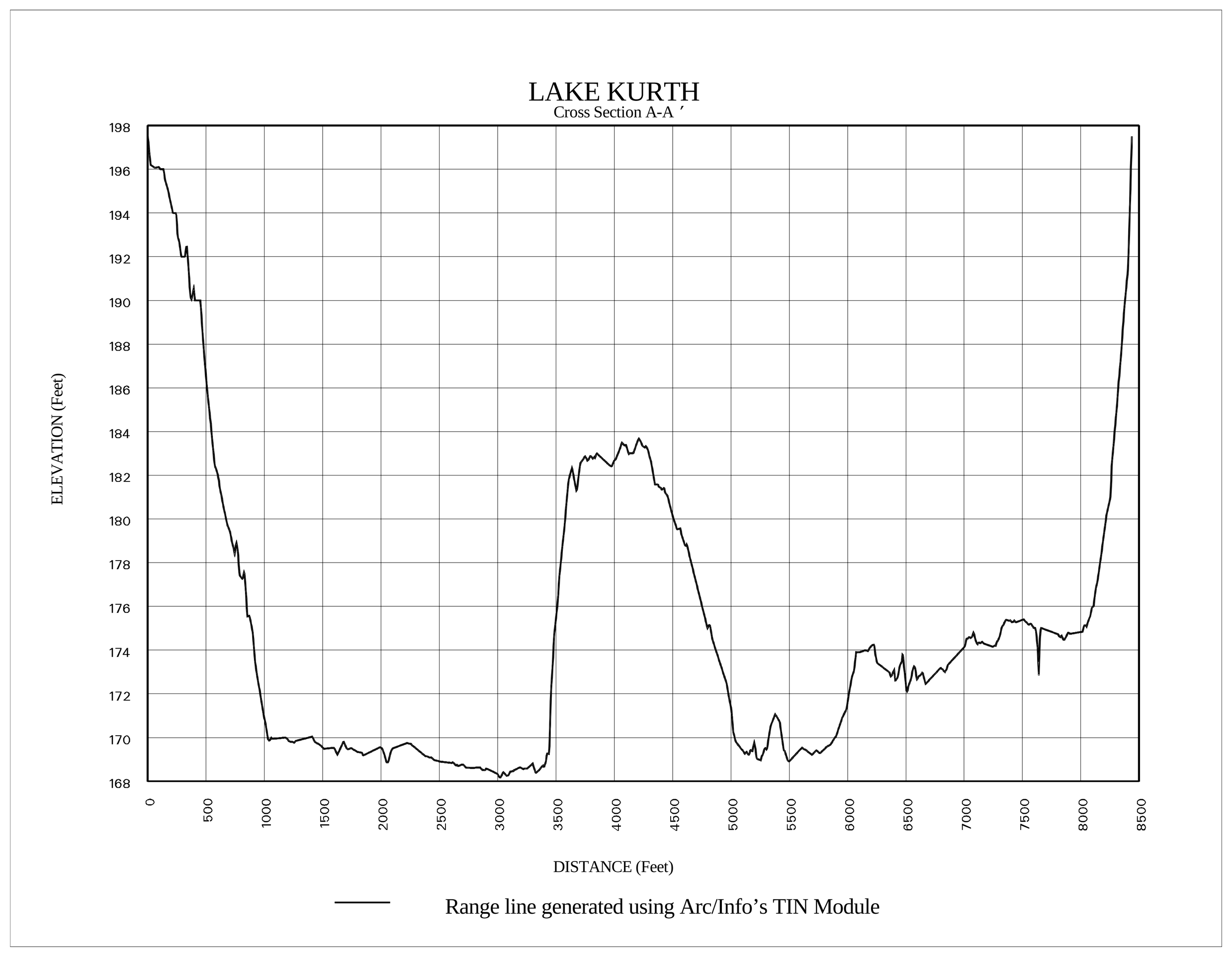
PREPARED BY: TWDB FEBRUARY 1997

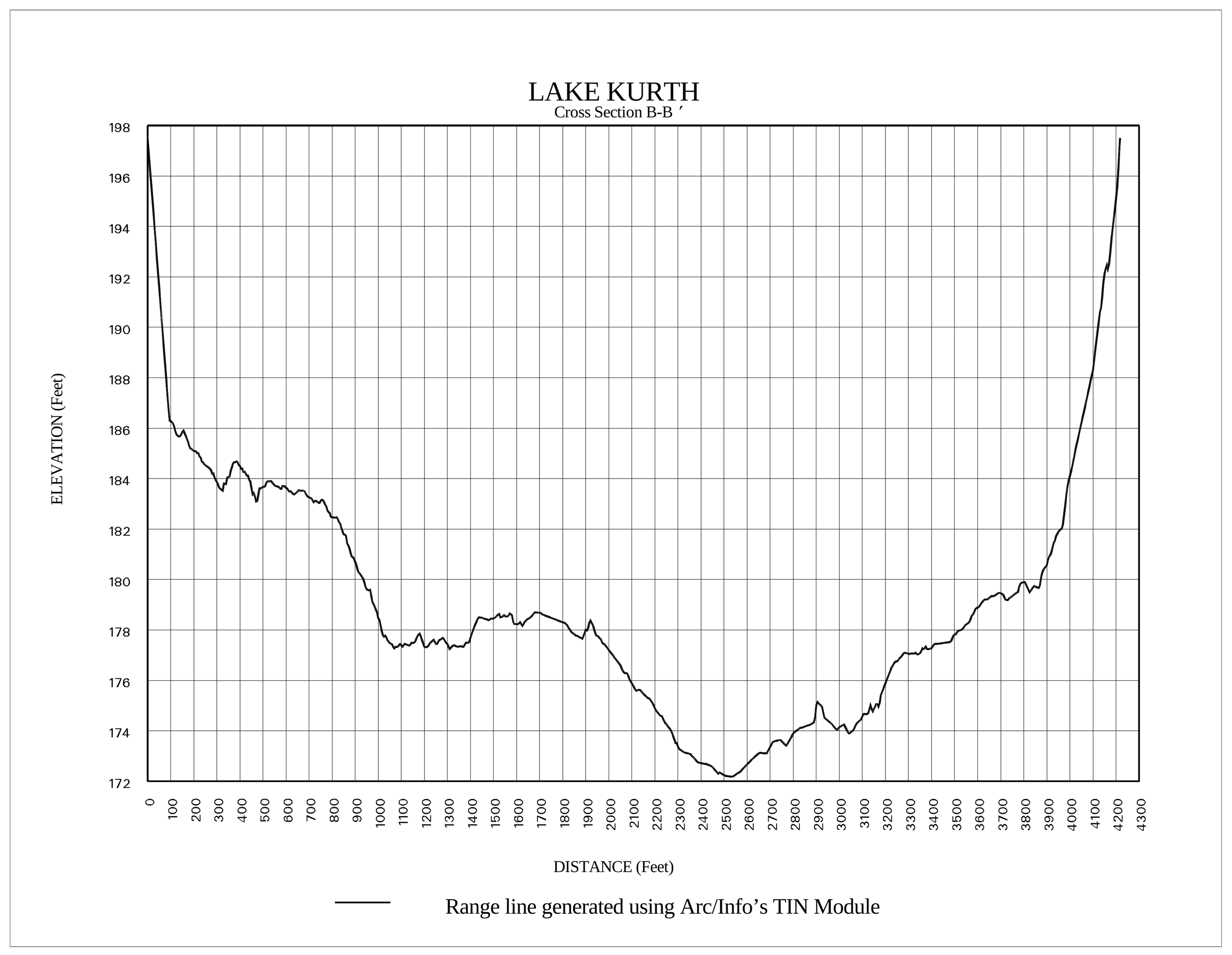
FIGURE 8

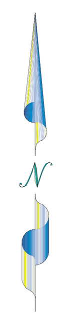
LAKE KURTH

Contour Map









1″=350′

ANGELINA COUNTY

EXPLANATION

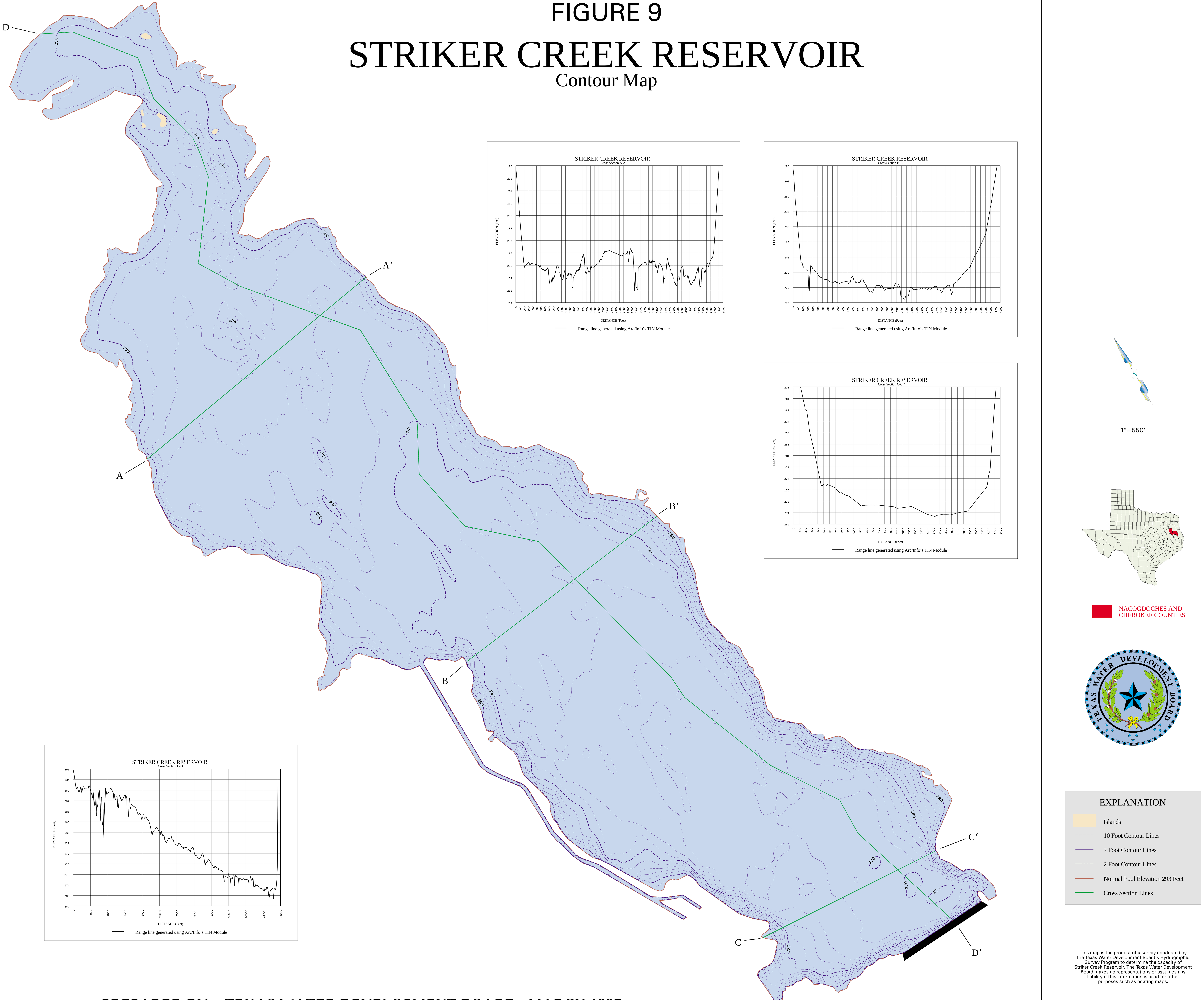
- 10 Foot Contour Lines
- 2 Foot Contour Lines
- 2 Foot Contour Lines
- Normal Pool Elevation 197.5 Feet
- Cross Section Lines

PREPARED BY: TEXAS WATER DEVELOPMENT BOARD MARCH 1997

FIGURE 9

STRIKER CREEK RESERVOIR

Contour Map



This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Striker Creek Reservoir. The Texas Water Development Board makes no representations or assumes any liability if this information is used for other purposes such as boating maps.

PREPARED BY: TEXAS WATER DEVELOPMENT BOARD MARCH 1997