VOLUMETRIC SURVEY OF WHITE ROCK LAKE

Prepared for:

THE CITY OF DALLAS

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INTRODUCTION

Staff of the Hydrologic Survey Unit of the Texas Water Development Board (TWDB) conducted a hydrographic survey on White Rock Lake in March, 1993. The purpose of the survey was to determine the capacity of the lake at the normal pool elevation and to establish baseline information for future surveys. From this information, future surveys will be able to determine sediment deposition locations and rates over time. Survey results are presented in the following pages in both graphical and tabular form.

HISTORY AND GENERAL INFORMATION OF THE RESERVOIR

White Rock Lake, owned by the City of Dallas, is located within the city limits, northeast of the central business district. White Rock Dam is located on White Rock Creek, a tributary of the Trinity River. Dam construction commenced in March, 1910, was completed in September of 1911, and the reservoir filled in August, 1912.

Certified Filing No. 75 authorized the City of Dallas to impound 21,345 acre-feet of water in White Rock Lake and to divert and use a maximum of 8,696.8 acre-feet of water annually for municipal purposes with a priority date of April 22, 1914. An Amendment To Certified Filing No. 75 was granted by the Texas Water Commission on November 8, 1982, and authorized a change in use of 3,000 acre-feet from municipal to irrigation.

Certificate of Adjudication No. 2461 was issued July 22, 1983 by the Texas Water Commission. Consistent with the Amendment to Certified Filing, it authorized the City of Dallas to divert and use a maximum of 5,696.8 acre-feet for municipal purposes and 3,000 acre-feet for irrigation purposes. It also authorized the City of Dallas to divert and use a maximum of 6.35

acre-feet of water per annum for recreational purposes.

White Rock Dam is an earthfill structure approximately 2,100 feet in length and 40 feet in height. The elevation of the top of the dam is 468.5 feet above mean sea level based on the National Geodetic Vertical Datum of 1929 (NGVD '29). All elevations presented in this report are reported in NGVD '29 unless noted otherwise. Results of a 1970 survey indicate the conservation storage to be 10,740 acre-feet with a surface area of 1,119 acres. The service/emergency spillway is a concrete, broad-crested, uncontrolled weir 450 feet in length at elevation 458.0 feet.

HYDROGRAPHIC SURVEYING TECHNOLOGY

GPS Information

The following is a brief and simple description of Global Positioning System (GPS) technology. GPS is a 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 monitor the broadcasts from the satellites over time 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. Additional satellite readings would also produce a possible location on a sphere surrounding that satellite with a radius of the distance measured. The observation of two satellites from an unknown point 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 first put into use on February 22, 1978, when the first satellite was launched. The NAVSTAR (NAVigation System with Time And Ranging) satellite constellation will consist of 24 satellites when fully implemented. At the time of the survey, 21 satellites of the constellation were fully functional. The United States Department of Defense (DOD) is 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 (1 to 3 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" and was used during the survey of White Rock Lake. 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. Positional accuracies can be produced within 3 meters for the moving receiver. DGPS was used to determine horizontal position only. Vertical information was supplied by the depth sounder.

As the boat traveled across the lake surface, the depth sounder gathered approximately ten readings of the lake bottom each second. The depth readings were averaged over the one-second interval and stored with the positional data to an on-board computer. After the survey, the average depths were corrected to elevation using the daily lake elevation. The set of data points logged during the survey were used to calculate the lake volume. Accurate estimates of the lake volume can be quickly determined using these methods, to produce an affordable survey. The level of accuracy is equivalent to or better than other methods previously used to determine lake volumes.

TWDB staff verified the horizontal accuracy of the DGPS used in the White Rock Lake survey to within the specified accuracy of three meters. The shore station was set up over a known United States Geological Service (USGS) first order monument and placed in differential mode. The second receiver was set up over another known USGS first order monument. Based on the differentially-corrected coordinates received and the published coordinates for these points, the results compared within 2.8 meters.

Equipment

The equipment used in the hydrographic survey of White Rock Lake 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 Depth Sounder and Velocity Profiler, a Trimble Navigation, Inc. 4000SE GPS receiver, a Motorola Radius radio with an Advanced Electronic Applications, Inc. packet modem, and an on-board computer. The computer is supported by a dot matrix printer and a B-size plotter. Power is provided by a water-cooled generator through an in-line uninterruptible power supply. References to brand names does not imply endorsement by the TWDB.

The shore station included a second Trimble 4000SE GPS receiver, Motorola Radius radio and Advanced Electronic Applications, Inc. packet modem, and an omni-directional antenna mounted on a modular aluminum tower to a total height of 30 feet. The combination of this equipment provided a data link with a reported range of 25 miles over level to rolling terrain that does not require that line-of-sight be maintained with the survey vessel in most conditions, thereby reducing the time required to conduct the survey.

Survey Methods

The Hydrographic Survey crew set a benchmark at the top of the hill at Winfrey Point in November of 1992 that would serve as control for the shore station site. A brass cap marked TWDB #004 was embedded into the sidewalk approximately forty feet west of the southwest corner of the building. This location was chosen because of its close proximity to the lake, the unobstructed view of the lake, and relative security of the area.

A static survey using the two Trimble 4000SE GPS receivers was performed to obtain coordinates for TWDB #004. One GPS receiver was positioned over a Corps of Engineers first-order monument named RESERVOIR, located approximately three miles west of the lake. RESERVOIR was established in 1947. Satellite data were gathered from this station for almost two hours, with up to seven satellites visible to the receiver. During the same time period, data were gathered from the second receiver positioned over TWDB #004.

Once data collection ended, the data were retrieved from the two receivers using Trimble Trimvec software, and processed to determine coordinates for the shore station benchmark. The NAVSTAR satellites use the World Geodetic System (WGS '84) datum. The WGS' 84 coordinates for TWDB #004 were determined to be North latitude 32° 29' 50.19", West longitude 96° 42' 57.68", and ellipsoid height of 125.80 meters. The approximate NGVD '29 elevation is 499.5 feet. Those coordinates were then entered into the shore station receiver located over TWDB #004 to fix its location and allow calculation and broadcasting of corrections through the radio and modem to the roving receiver located on the boat.

The reservoir's surface area was determined by digitizing the lake boundary from 1958 USGS quad sheets that were photo-revised in 1968 and 1973. Intergraph Microstation CADD software was used to determine the boundary based on the North American Datum of 1927 (NAD '27) used for this map. The information was then transformed to the North American Datum of 1983 (NAD '83) using Microstation Projection Manager. NAD '83, a flat projected representation of the curved earth surface, was chosen to calculate areas and volumes. The data points obtained by DGPS were also transformed from WGS '84 to NAD '83. The resulting shape was modified slightly to match information gathered in the field, resulting in 1,088 acres at the normal pool elevation.

The survey layout was pre-planned, using approximately twenty-four survey lines at a spacing of 500 feet. Additional random data were collected lengthwise along the lake. Additional data were entered into the data set utilizing the DGPS horizontal position and manually poling the depth in shallow areas where the depth was less than the minimum recordable depth of the depth sounder. Figure 2 presents the actual location of the data collection sites. Data were not collected in areas that were inaccessible due to shallow water or obstructions. The data set included approximately 10,400 data points.

Depths were transformed to elevations based on a water surface elevation of 458.57 feet. The data points were used to create a digital terrain model (DTM) of the lake's bottom surface using the Terrain Modeler product. The product uses Delauney's criteria for triangulation to produce a DTM, or a numerical representation of the actual bottom surface. From this dry lake bottom representation, the Modeler product calculates the surface area and volume of the entire lake at the specified elevations. Figure 3 is a graphical representation of a grided version of the three-dimensional DTM. Areas that were too shallow for data collection or obstructed by vegetation were estimated by the Modeler product, using a straight-line interpolation. The difference between the estimated volume and the actual volume is believed to be minor because the shallow areas do not contain significant amounts of water. Figure 4 presents a two-dimensional version of the same map, using bands of color increasing in intensity from shallow to deep water.

The DTM was then smoothed and linear smoothing algorithms were applied to the smoothed model to produce smooth contours. The following smoothing options were chosen for this model: Douglas-Peucker option with a tolerance of 0 feet, to eliminate redundant points, and Round Corners with a delta of 50 feet. Figure 5 presents a contour map and typical cross sections of the lake.

DATA

White Rock Lake is a finger-shaped lake approximately fifteen thousand feet in length. The deepest portions of the lake are found within the area immediately adjacent to the dam. The cross sections reflect a wide, flat bottom with relatively steep side slopes throughout the lake.

White Rock Lake was estimated by this survey to encompass 1,088 acres and to contain a volume of 9,004 acre-feet at the normal pool elevation of 458.0 feet. The 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. Normally the boat can negotiate in approximately 1.8 feet of water. Since the surface elevation of the lake was actually above the normal pool elevation on the date of the survey, only the upper 1.2 feet are estimated, based on a straight-line interpolation from the last data points collected to the normal pool elevation boundary as digitized. The positional data collected in the field corresponds with the boundary obtained from the photo-revised USGS map. The Board does not represent the boundary, as depicted in this report, to be a detailed actual boundary. It is an approximation of the actual boundary used to compute the volume and area within the upper elevations.

The storage volume calculated by this survey is approximately fifty-eight percent less than the original permit for the lake, and approximately sixteen percent less than the 1970 survey. The estimated surface area at normal pool elevation is approximately three percent less than the 1970 survey.

SUMMARY

The lowest elevation encountered during this survey was 435.3 feet, or 22.7 feet of depth. Based on the March 1993 survey, the conservation storage was calculated to be 9,004 acre-feet. In comparison to the 1970 survey, the estimated reduction in storage capacity is 1,736 acre-feet, or sixteen percent. It is assumed that the reduction in estimated storage is due to both a combination of sedimentation, and improved data and calculation methods, but the majority of the reduction is attributed to sedimentation. It is obvious that deposition is occurring at the point where White

Rock Creek enters the lake. Repeating this survey with the same calculation methodology in five to ten years or after major flood events should remove any noticeable error due to improved calculation techniques and will help isolate the storage loss due to sedimentation.

FIGURE 1

WHITE ROCK LAKE

LOCATION MAP

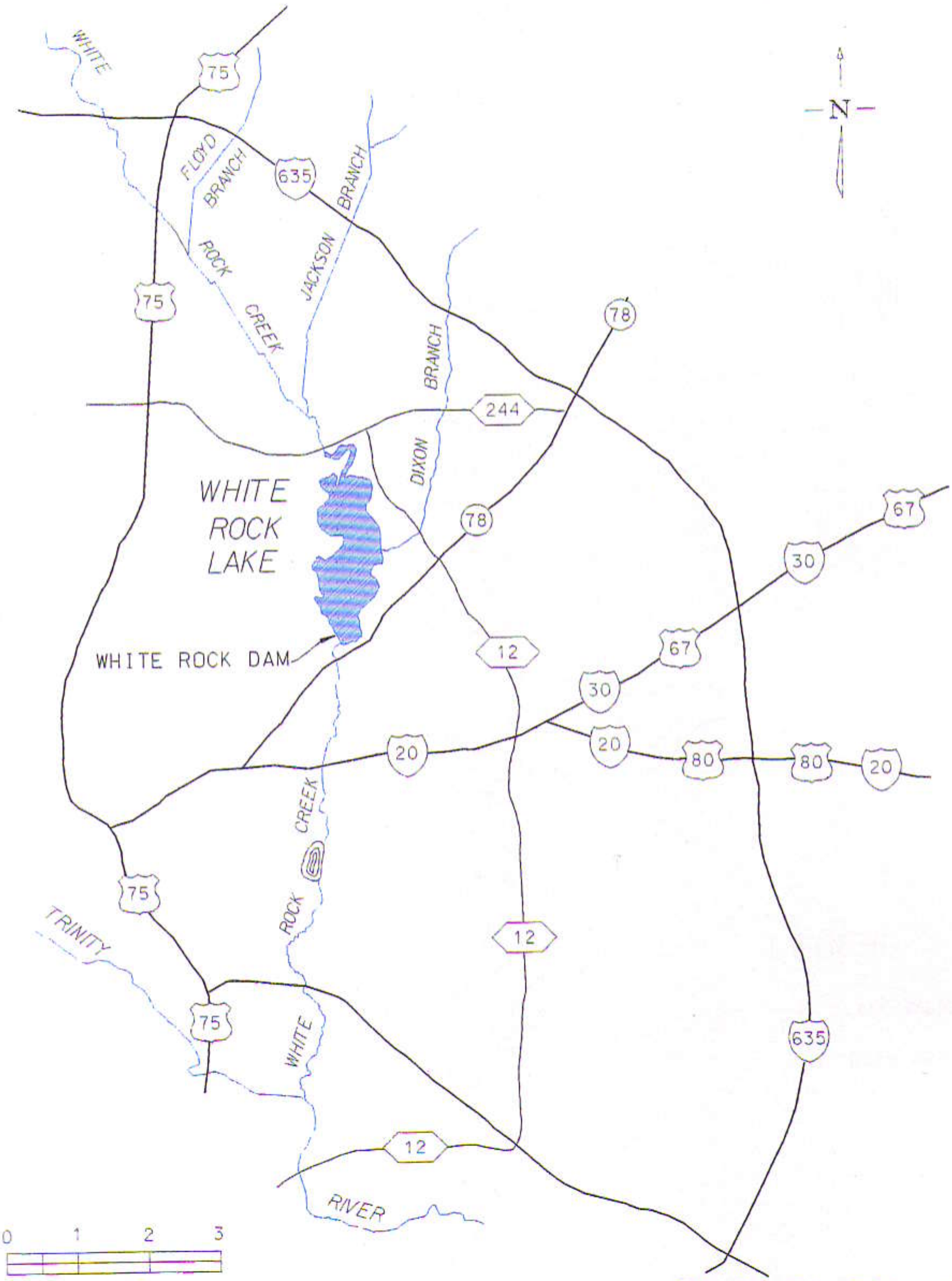

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FIGURE 2

WHITE ROCK LAKE

LOCATION OF SURVEY DATA

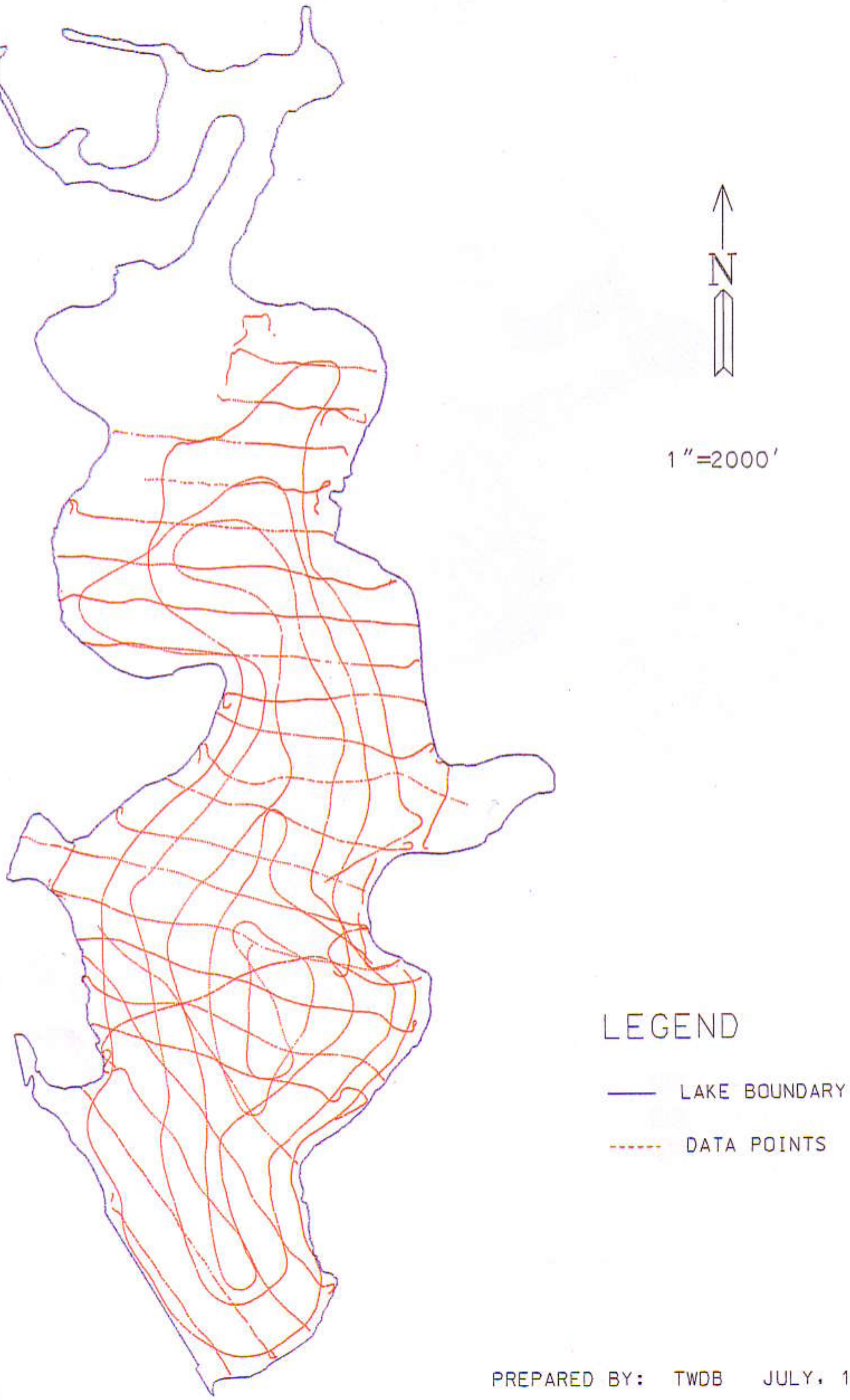

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FIGURE 3

WHITE ROCK LAKE

3-D BOTTOM SURFACE

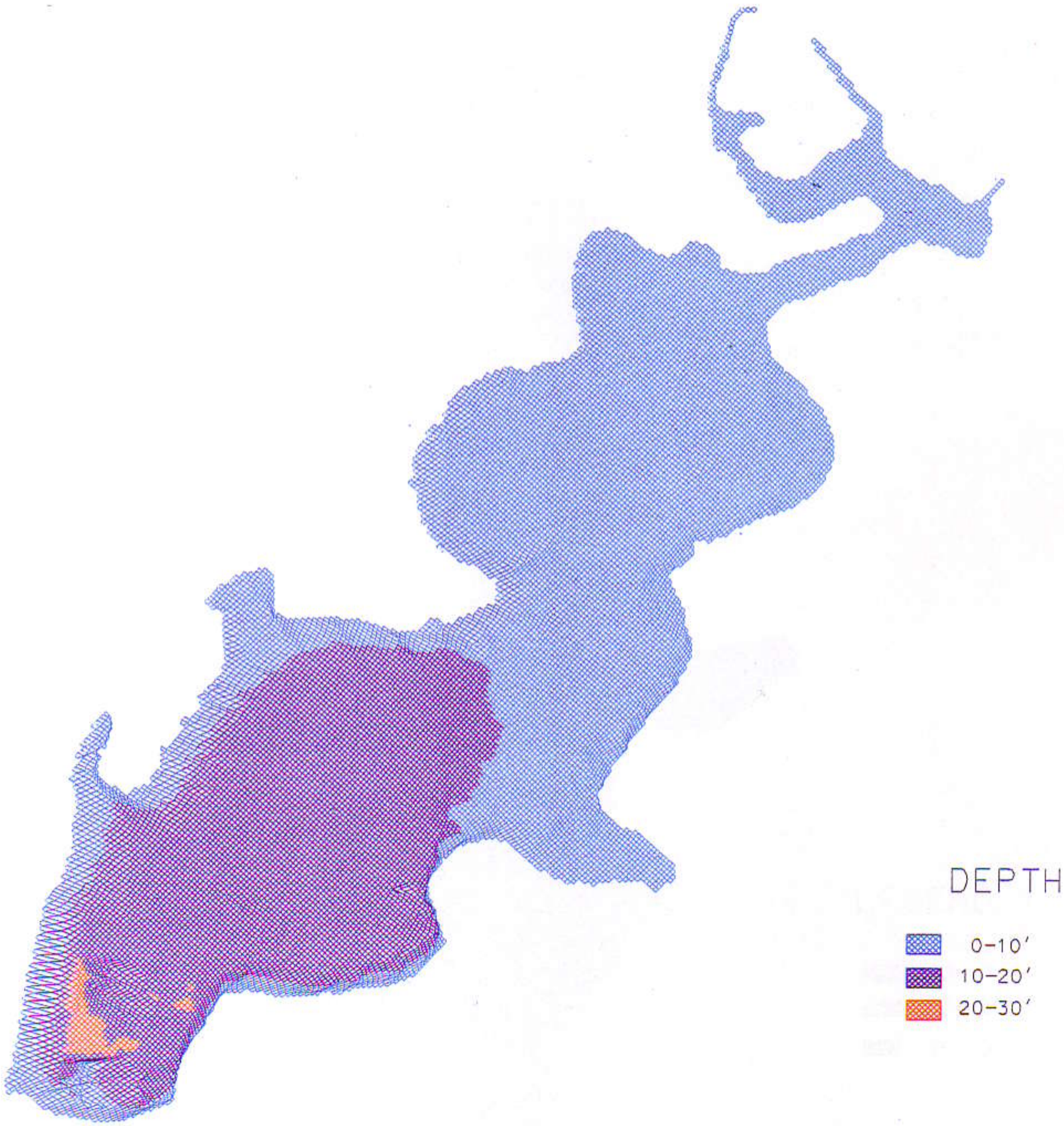

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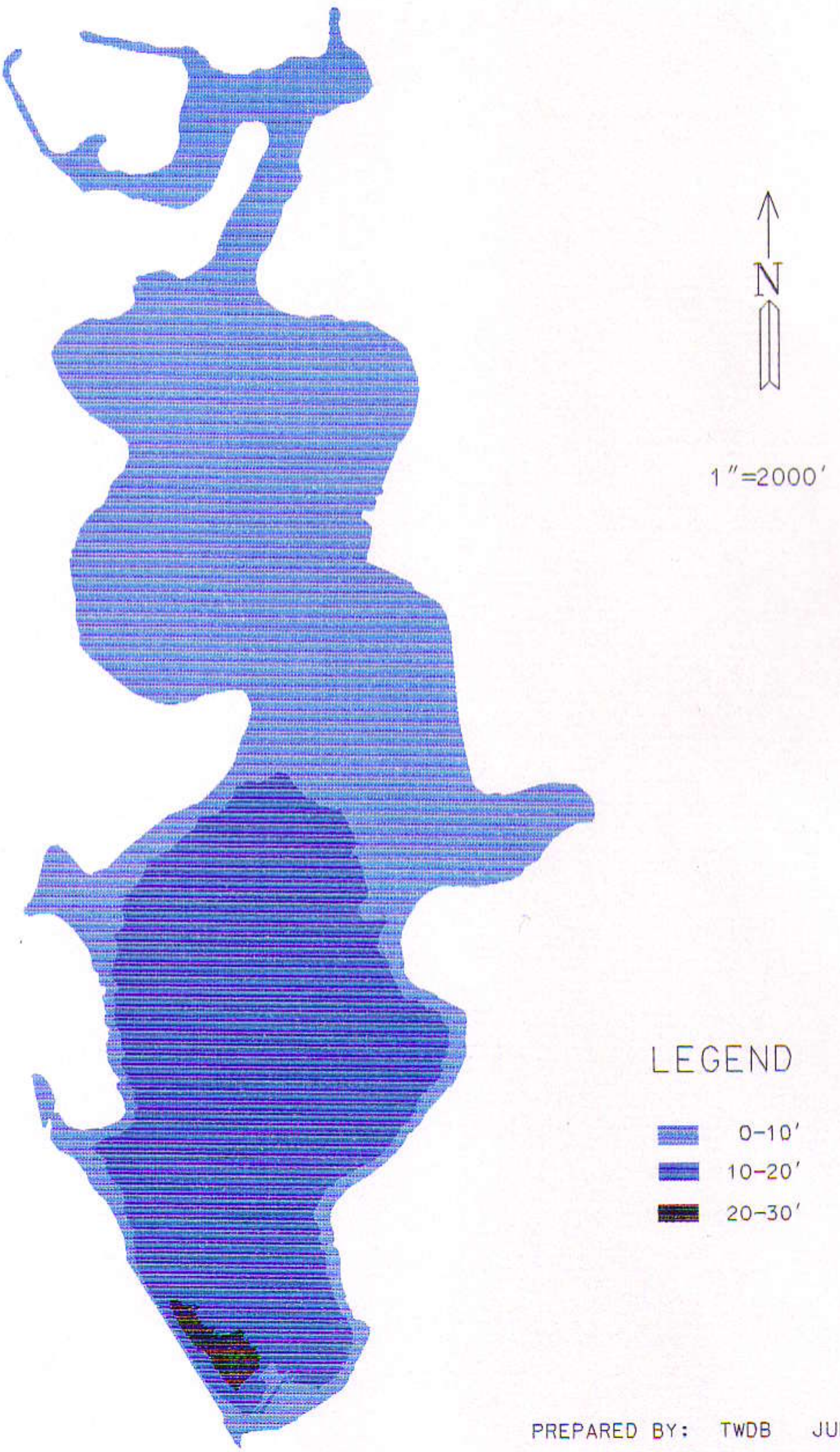
FIGURE 4

WHITE ROCK LAKE

DEPTH RANGES



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