VOLUMETRIC SURVEY OF LAKE WORTH

Prepared for:

City of Fort Worth

In conjunction with

United States Army Corps of Engineers

Prepared by:
Texas Water Development Board

February 4, 2002

Texas Water Development Board

Craig D. Pedersen, Executive Administrator

Texas Water Development Board

William B. Madden, Chairman Wales H. Madden Jr., Vice-Chairman
Jack Hunt Noe Fernandez
William W. Meadows

This report was prepared by staff of the Surface Water Section:

Barney Austin, Ph.D.

Duane Thomas
Randall Burns
Marc Sansom

Published and Distributed
by the
Texas Water Development Board
P.O. Box 13231
Austin, Texas 78711-3231

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LAKE WORTH
VOLUMETRIC SURVEY REPORT

INTRODUCTION

Staff of the Surface Water Section of the Texas Water Development Board (TWDB) conducted a volumetric survey of Lake Worth during the period of May 1-15, 2001. The purpose of the survey was to determine the current volume of the lake at the conservation pool elevation. This survey will establish a basis for comparison to future surveys from which the location and rates of sediment deposition in the conservation pool over time can be determined. Survey results are presented in the following pages in both graphical and tabular form.

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gage at Lake Worth (08045400 LAKE WORTH ABOVE FORT WORTH, TX). The datum for this gage is reported as mean sea level (msl) (USGS, 2000). Thus, elevations are reported here in feet (ft) above mean sea level (msl). Volume and area calculations in this report are referenced to water levels provided by the USGS gage.

Lake Worth is located on the West Fork Trinity River (Trinity River Basin) in Tarrant County within the city limits and just northwest of downtown Fort Worth, Texas (Figure 1). At conservation pool elevation the reservoir extends approximately 11 miles upstream to Eagle Mountain Dam and Spillway and has approximately 52 miles of shoreline. Records indicate the drainage area is approximately 2,064 square miles (USGS 2000).

Original design information of the dam and spillway show the crest of the uncontrolled spillway was at elevation 594.3 ft and that being the same as the conservation pool elevation (TWDB 1973). Records indicate an elevation-area-capacity (EAC) table was developed in 1968 and 1969 by a joint

effort of the U.S. Army Corps of Engineers, Fort Worth District and Freese, Nichols and Endress, Consulting Engineers, Fort Worth, Texas (1969). Although there may have been some question as to the elevation of the spillway, the 1969 elevation-area-capacity table is referenced by the USGS, City of Fort Worth and the Tarrant Regional Water District (TRWD), as the current EAC table for Lake Worth. According to Freese and Nichols Engineering Inc., a 1979 level survey was conducted on the spillway crest and elevations varied from 593.86 ft to 594.18 ft. Modifications of the dam and spillway were made in 1979 and the spillway crest was leveled to elevation 594.0 ft. The USGS refers to the conservation pool elevation as 594.0 ft (USGS 2000). According to the 1969 elevation-area-capacity table, at conservation pool elevation 594.0 ft, Lake Worth has a surface area of 3,490 acres and a capacity of 37,066 acre-feet (ac-ft).

LAKE HISTORY AND GENERAL INFORMATION

The City of Fort Worth (City) acquired water rights to Lake Worth under Certified Filing No. 757 from the State Board of Water Engineers. The water rights permit was amended several times with Certified Filing No. 757B issued May 9, 1983. The City is currently authorized under the Certificate of Adjudication No.08-3340 to maintain an existing dam and reservoir on the West Fork Trinity River, known as Lake Worth and impound therein not to exceed 38,124 ac-ft of water (Texas Water Commission 1985). The City is authorized to divert and use not to exceed 12,143 ac-ft of water per annum from Lake Worth for municipal purposes in Tarrant County, Texas. Authorization is granted to use not to exceed 1,000 ac-ft of water per annum for industrial purposes in Tarrant County, Texas. The owner of the certificate is allowed to use not to exceed 145 ac-ft of water per annum to irrigate 135 acres of land known as the Fort Worth Botanic Garden located in Tarrant County, Texas. The City is granted the right to use the impounded waters of Lake Worth for recreational purposes. Copies of the Certified Filing and Certificate of Adjudication (original and amended) may be obtained from the Texas Natural Resource Conservation Commission's Central Records

Construction on Lake Worth Dam started in 1912. Deliberate impoundment of water began June 1914 and the dam was completed in October 1914. The design engineer for the project was John

B. Hawley. The general contractor was the Underground Construction Company (November 1911 – April 1913) and the City of Fort Worth (April 1913 – October 1914). The estimated cost of the dam was $589,000.00 (not including the land).

Originally Lake Worth Dam and appurtenant structures consisted of a rolled earthfill embankment 3,200 ft in length and a maximum height of 50 ft with a crest elevation of 606.3 ft. A 700-foot long uncontrolled concrete spillway located near the center of the dam's embankment had a crest elevation of 594.3 ft.

The outlet works consist of a 48-inch diameter pipe passing through the dam and is controlled by a 36-inch valve, which can be used for downstream releases. To release water to the city of Fort Worth treating plant, there is one 48-inch diameter pipe and two 60 by 48-inch rectangle conduits controlled by three valves each 48-inches in diameter. Water supplies are also furnished to the City of River Oaks by two 16-inch diameter steel pipe siphons over the top of the dam. Lake Worth is normally a constant level riverine lake and is operated as a "pass through" reservoir. There is no design to store floodwater.

Remedial measures were taken in 1979 to modify the dam and spillway. Repairs included placing a concrete overlay on the spillway crest. This required removing some of the old concrete and replacing a minimum of 8-inch thick concrete. The design drawings called for the crest elevation to be 594.0 ft. In 1997 the crest elevation of the dam's embankment was raised to 609.5 ft. in order that the spillway be able to pass the probable maximum flood (PMF) without the dam's embankments being overtopped.

VOLUMETRIC SURVEYING TECHNOLOGY

The equipment used to perform the volumetric survey consists a 20-foot aluminum shallow-draft flat bottom SeaArk craft with cabin and equipped with one 115-horsepower Evinrude outboard motor was used. The portable data collection equipment on-board the boat included a Knudsen 320 B/P

Echosounder (depth sounder), a Trimble Navigation, Inc. AgGPS 132 GPS receiver, an OmniSTAR receiver, and a laptop computer. (Reference to brand names throughout this report does not imply endorsement by TWDB).

The GPS equipment, survey vessel, and depth sounder in combination provide an efficient hydrographic survey system. As the boat travels across the lake surface, the depth sounder takes approximately ten readings of the lake bottom each second. The depth readings are stored on the PC along with the positional data generated by the boat's GPS receiver. The daily data files collected are downloaded from the PC and brought to the office for editing after the survey is completed. During editing, poor-quality data is removed or corrected, multiple data points are averaged to get one data point per second, and average depths are converted to elevation readings based on the lake elevation recorded on the day the survey was performed. Accurate estimates of the lake volume can be quickly determined by building a 3-D model of the reservoir from the collected data.

PRE-SURVEY PROCEDURES

The reservoir's boundary was digitized using Environmental Systems Research Institute's (ESRI) ArcView from digital orthophoto quadrangle images (DOQ's). The DOQ's were produced by VARGIS of Texas LLC for the TEXAS Orthoimagery Program (TOP). The DOQ products produced for the Department of Information Resources and the GIS Planning Council under the Texas Orthoimagery Program reside in the public domain. More information can be obtained on the Internet at http://www.tnris.state.tx.us/DigitalData/doqs.htm. The map boundary was created from the LAKE WORTH, TEXAS DOQ. The lake elevation at the time the DOQ was photographed was 594.06 ft. (January 31, 1995).

The survey layout was designed by placing survey track lines at 500-foot intervals within the digitized lake boundary using HYPACK software. The survey design required the use of approximately 180 survey lines placed perpendicular to the original river channel along the length of the lake.

SURVEY PROCEDURES

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

Equipment Calibration and Operation

The depth sounder was calibrated using the bar check feature in the Knudsen software program. This was accomplished by positioning the transducer over a known (measured) depth. The speed of sound was then adjusted (either higher or lower) until the displayed depths matched the known depth. The depth was then checked manually with a stadia (survey) rod to ensure that the depth sounder was properly calibrated and operating correctly.

While surveying Lake Worth, the speed of sound in the water column ranged from 4,745 feet per second to 4,785 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 ft. An additional estimated error of $\pm$0.3 feet arises from variation in boat inclination. These two factors combine to give an overall accuracy of $\pm$0.5 ft for any instantaneous reading. These errors tend to be fairly minimal over the entire survey, since some readings are positive and some are negative. Further information on these calculations is presented in Appendix G.

During the survey, the horizontal mask setting on the on-board GPS receiver was set to 10 degrees and the PDOP (Position Dilution of Precision) limit was set to seven to maximize the accuracy of the horizontal positioning. An internal alarm sounds if PDOP rises above seven to advise the field crew that the horizontal position has degraded to an unacceptable level. Further positional accuracy is obtained through the Omnistar receiver. The lake's initialization file used by the HYPACK data

collection program was set up to convert the collected Differential GPS positions to state-plane coordinates on the fly.

Field Survey

Data were collected on Lake Worth on May 1 - 4, 14 & 15, 2001. Weather conditions included moderate temperatures and gusty winds throughout most of the data collection. Approximately 71,009 data points were collected over the approximately 116 miles traveled. These points were stored digitally on the boat's computer in 286 data files. Data were not collected in areas with significant obstructions. Figure 2 shows the actual location of all data collection points.

Data collection for Lake Worth began at Lake Worth Dam and continued upstream to near Eagle Mountain Dam and Spillway. The 180 cross-sectional lines were collected in 500 ft increments running perpendicular to the original river channel. The survey crew was able to collect data in several off-channel tributaries, Woods Creek, Live Oak Creek, and Silver Creek; upstream to the point the creeks became too narrow or shallow for the boat to maneuver. Data were also collected on 18 transects that were used to calculate sediment loads in earlier studies. The location of these transects were estimated since there were no record of endpoints (Lake Worth Clean Lakes Study, Amended February 1991).

Lake Worth is a riverine lake on the West Fork Trinity River that meanders (approximately 11 miles) through a hilly terrain in a northwest to southeast direction. The average width of the lake near Lake Worth Dam is 2,500 feet. The widest part of the lake, between Mosque Point and the mouth of Silver Creek is approximately two miles. The headwaters narrow to a width of 500 ft at Eagle Mountain Dam and Spillway. The physical topography along the perimeter of the lake consists of both deep valleys with steep-sided walls and large flat areas typical of a meandering river with cut and fill banks.

The land use along the shorelines of Lake Worth from Lake Worth Dam upstream to Greer Islands is mostly residential development excluding Naval Air Station-Joint Reserve Base, Fort Worth. Bulkheads

protect most of the lake's shoreline in the developed area. Lake front property upstream of Greer Islands to Eagle Mountain Dam and Spillway is mostly undeveloped rural land. Most of this property has been dedicated to the Fort Worth Nature Center. Some shoreline erosion was noticed in this area during the survey. There were several city parks located along the shores of Lake Worth. The City maintains these parks and also permits structures on the lake.

In the upper reaches of Lake Worth the cross-section of the channel was generally flat. As the original river channel meandered, the survey crew noted the depths to be shallow on the fill side bank and a deeper bottom with a steep sidewall on the cut bank. Often the old channel or thalweg would be noted as data was collected along transects.

Lake Worth is fairly clear of navigational hazards such as submerged stumps between Lake Worth Dam and Highway 199 bridge. The survey crew did notice in this part of the lake an aquatic reed commonly known as bulrush (scirpus spp). This plant was usually growing in shallow water (approximately two feet deep). Upstream of Highway 199 bridge, Lake Worth took on more rural river-type characteristics. As the crew collected data from the Highway 199 bridge upstream to Eagle Mountain Dam and Spillway, they encounted both exposed and submerged stumps, assorted types of aquatic plants including lily pads and multiple islands or sandbars. Data were collected in the upper reaches of Lake Worth at a much slower pace.

The collected data were stored in individual data files for each pre-plotted range line or random data collection event. These files were downloaded to diskettes at the end of each day for future processing.

Data Processing

The collected data were downloaded from diskettes onto TWDB's networked computers. 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 files. 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 pool elevation varied from 593.81 ft to 594.18 ft according to elevation data provided by the USGS. After all changes had been made to the raw data files, the edited files were saved with different extensions.
The edited files were combined into a single X, Y, Z data file, to be used with the GIS software to develop a model of the lake bottom elevation.

The resulting data file was imported into Environmental System Research Institute's (ESRI) Arc/Info Workstation GIS software. This software was used to convert the data to a MASS points file. The MASS points and the boundary file were then used to create a Digital Terrain Model (DTM) of the reservoir's bottom surface using Arc/Info's TIN software module. The module generates a triangulated irregular network (TIN) from the data points and the boundary file using a method known as Delauney's criteria for triangulation. A triangle is formed between three non-uniformly spaced points, including all points along the boundary. If there is another point within the triangle, additional triangles are created until all points lie on the vertex of a triangle. All of the data points are used in this method. The generated network of three-dimensional triangular planes represents the actual bottom surface. With this representation of the bottom, the software then calculates elevations along the triangle surface plane by determining the elevation along each leg of the triangle. The reservoir area and volume can be determined from the triangulated irregular network created using this method of interpolation.

Volumes and areas were calculated from the TIN for the entire reservoir at one-tenth of a foot interval from minimum elevation to conservation pool level. From elevation 566.3 ft to 594.3 ft, the surface areas and volumes the lake were computed using Arc/Info software. The computed reservoir volume table is presented in Appendix A and the area table in Appendix B. An elevation-volume graph and an elevation-area graph are presented in Appendix C and Appendix D respectively.

Other products developed from the model include a shaded relief map (Figure 3) and a shaded depth range map (Figure 4). To develop these maps, the TIN was converted to a lattice using the TINLATTICE command and then to a polygon coverage using the LATTICEPOLY command. Linear filtration algorithms were applied to the DTM to produce smooth cartographic contours. The resulting

contour map of the bottom surface at 2-foot intervals is presented in Figure 5. Finally, the location of cross-section endpoints in Appendix E and the corresponding cross-section plots in Appendix F were approximated from those sediment range lines used in previous sediment studies and the 1988 survey (Lake Worth Clean Lakes Study, Amended February 1991). No comparisons between historical sediment studies and the present lake volumetric survey were made.

RESULTS

Results from the 2001 TWDB survey indicate Lake Worth encompasses 3,458 surface acres and contains a total volume of 33,495 acre-feet at the conservation pool elevation of 594.0 feet. The shoreline at this elevation was calculated to be 51.6 miles. The deepest point physically measured during the survey was 28.02 ft (elevation 566.28 ft), and was located approximately 1,400 feet upstream of Lake Worth Dam.

SUMMARY AND COMPARISONS

Lake Worth Dam was completed in 1914 and deliberate impoundment began the same year. Several sediment surveys and studies have been performed on Lake Worth. Survey data, furnished by the U.S. Army Corps of Engineers (1969) show Lake Worth had a volume of 37,066 ac-ft of water and a surface area of 3,490 acres at conservation pool elevation 594.0 feet. A summary of the comparisons is presented in Table 1 below.

During May 1-15, 2001, TWDB staff completed a volumetric survey of Lake Worth. The 2001 survey utilized a differential global positioning system, depth sounder and geographical information system technology to create a digital model of the lake's bathymetry.

At conservation pool elevation, the current survey measured 3,458 surface acres, for a reduction of 32 surface acres compared to the 1969 United States Army Corps of Engineers (USACOE) elevation-area-capacity table.

The 2001 survey results indicate that the volume at the conservation pool elevation of 594.0 feet msl is 33,495 ac-ft. The dead pool below elevation 584.25 feet was found to be 8,995 ac-ft, and thus the conservation storage found in this survey is 24,500 acre-feet.

Comparisons between the USACOE 1969 elevation-area-capacity table and the 2001 data collection set is difficult and some apparent changes might simply be due to methodological differences. It is recommended that the similar survey be performed in five to ten years or after major flood events to monitor changes to the lake's capacity.

Table 1. Area and volume comparisons at elevation 594.0 feet msl.

Year	1969 (USAC of E)	2001 (TWDB Survey)
Area (acres)	3,490	3,458
Volume (acre-feet)	37,066	33,495

REFERENCES

1. Fort Worth District U.S. Army Corps of Engineers, City of Fort Worth. “Lake Worth Clean Lakes Study Phase I –Diagnostic/Feasibility Study”, Volume I – Diagnostic Study”. Final Report. February 1990, Amended February 1991.

2. Texas Water Commission, 1985. “Certificate of Adjudication No. 08-3340”.

3. Texas Water Development Board. 1973. “Dams and Reservoirs in Texas, Historical and Descriptive Information” Report 48.

4. Texas Water Development Board. 1966 Revised 1967. “Engineering Data on Dams and Reservoirs in Texas, Report 126 Part II”.

5. U. S. Army Corps of Engineers, Fort Worth District. February 1969. “LAKE WORTH AREA AND CAPACITY TABLES”

6.U.S. Department of the Interior, U.S. Geological Survey, 2000. “Water Resources Data Texas Water Year 2000” Volume 2 Water-Data Report TX-00-2.

Appendix A

Lake Worth

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD — May 2001 SURVEY

VOLUME IN ACRE-FEET — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
566				0	0	0	0	0	0	0
567	0	0	0	0	0	1	1	1	1	2
568	2	2	3	3	4	5	6	7	8	9
569	11	13	15	17	19	22	26	30	34	39
570	44	49	55	61	68	75	83	91	100	109
571	119	129	140	151	163	176	189	202	216	231
572	246	262	278	295	312	330	349	368	387	407
573	428	449	470	492	514	536	559	583	606	631
574	655	681	706	733	760	787	816	845	874	905
575	935	967	999	1031	1064	1097	1131	1166	1200	1236
576	1272	1308	1345	1383	1422	1461	1501	1542	1584	1627
577	1670	1715	1761	1807	1855	1904	1954	2006	2059	2113
578	2169	2226	2285	2345	2407	2471	2536	2603	2671	2740
579	2811	2884	2958	3034	3111	3190	3270	3352	3435	3520
580	3606	3694	3784	3876	3970	4066	4164	4264	4365	4469
581	4575	4683	4793	4905	5019	5136	5254	5375	5497	5621
582	5747	5874	6003	6134	6266	6400	6535	6672	6811	6951
583	7093	7237	7382	7529	7677	7827	7978	8130	8284	8439
584	8596	8754	8914	9076	9239	9404	9571	9739	9909	10081
585	10254	10429	10606	10783	10963	11143	11325	11509	11694	11881
586	12069	12258	12449	12641	12835	13030	13226	13424	13623	13824
587	14025	14228	14433	14639	14846	15055	15265	15476	15690	15905
588	16121	16339	16559	16781	17004	17230	17458	17687	17919	18153
589	18390	18629	18871	19116	19365	19617	19872	20131	20394	20659
590	20928	21201	21476	21754	22035	22319	22605	22894	23186	23481
591	23778	24078	24381	24687	24994	25304	25615	25929	26244	26561
592	26879	27198	27518	27840	28163	28487	28813	29140	29468	29797
593	30127	30458	30791	31125	31460	31796	32134	32472	32812	33153
594	33495									

Appendix B

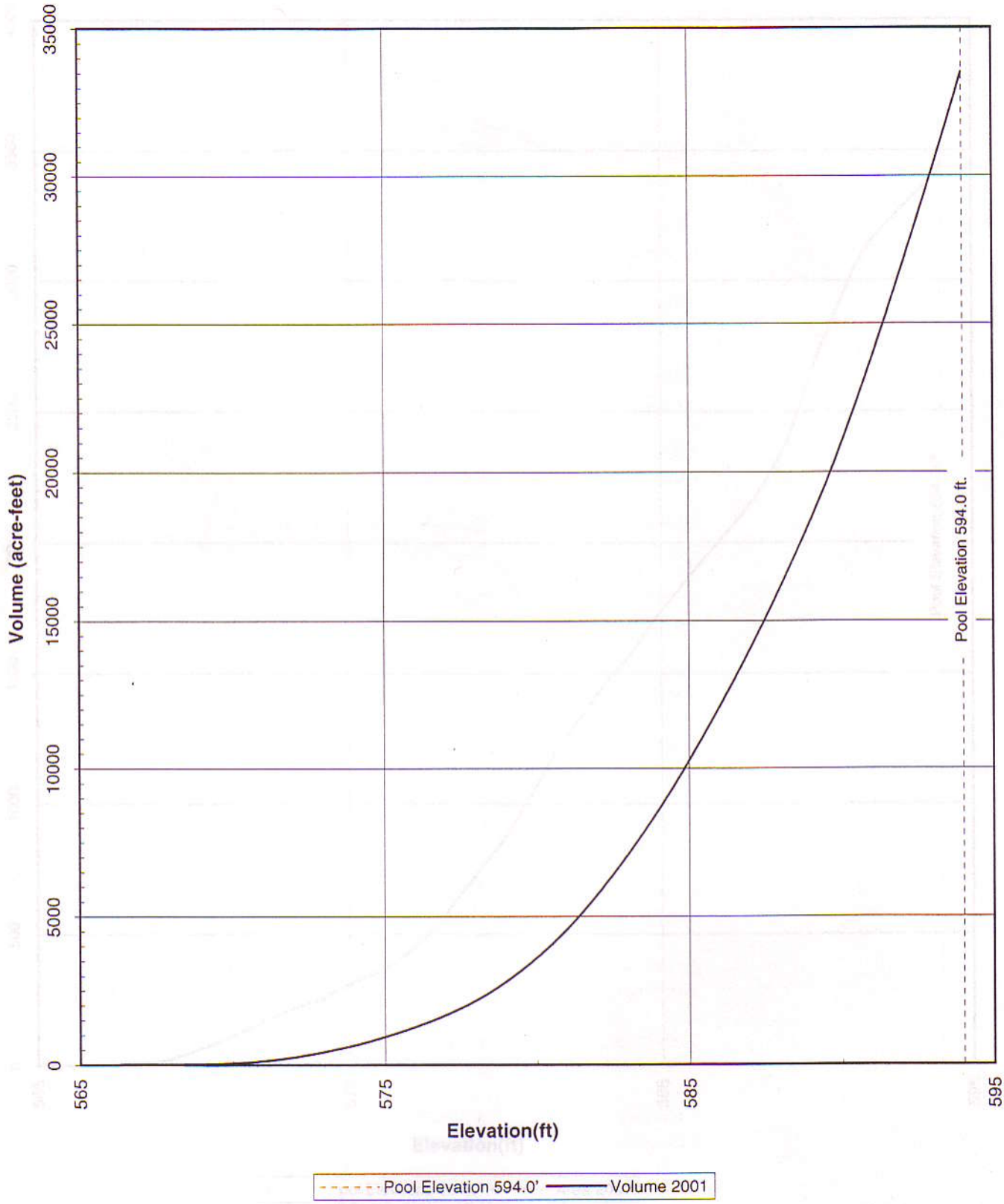
Lake Worth

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — May 2001 SURVEY

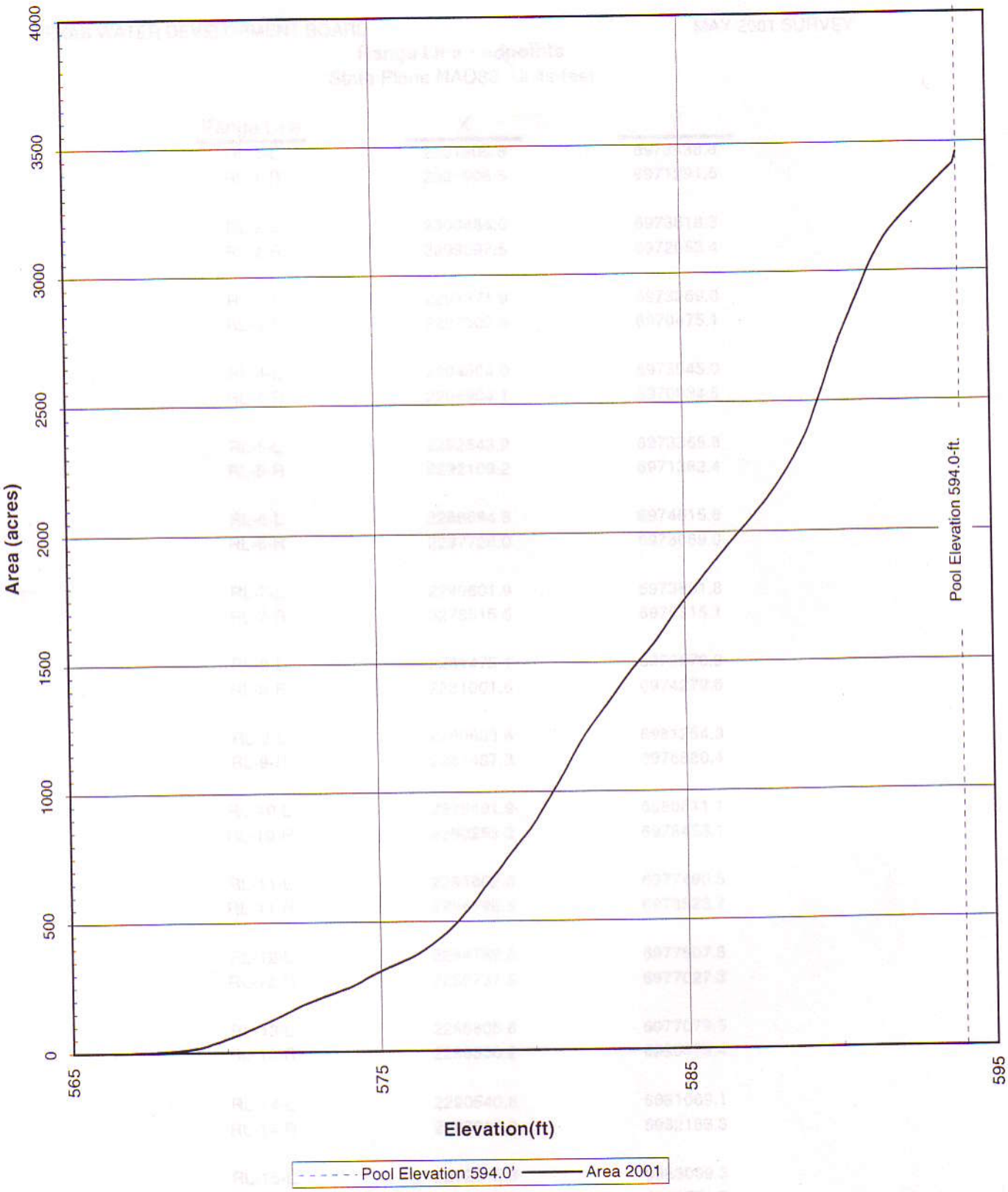
AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
566				0	0	0	0	0	0	0
567	0	1	1	1	1	2	2	2	3	3
568	4	5	5	6	7	8	9	11	13	14
569	16	19	21	25	28	33	37	40	44	48
570	53	57	61	66	70	74	80	85	90	95
571	100	105	110	116	121	126	132	138	143	149
572	155	161	166	172	178	183	188	192	197	202
573	206	211	215	219	223	227	232	236	241	245
574	249	254	260	267	273	281	288	294	299	305
575	310	316	322	327	332	336	341	346	351	356
576	362	368	375	382	389	397	406	414	423	432
577	442	451	461	472	484	496	509	523	536	550
578	563	578	595	613	629	644	659	674	688	702
579	718	735	750	766	781	796	811	825	839	854
580	871	889	909	929	949	967	988	1008	1028	1047
581	1067	1089	1112	1134	1155	1175	1195	1214	1232	1249
582	1266	1282	1298	1314	1329	1345	1361	1378	1396	1412
583	1429	1445	1461	1476	1490	1504	1517	1531	1545	1559
584	1574	1590	1607	1624	1642	1659	1677	1694	1710	1725
585	1741	1756	1771	1785	1799	1814	1829	1844	1859	1873
586	1887	1901	1915	1929	1944	1958	1972	1985	1998	2011
587	2024	2037	2051	2065	2080	2094	2109	2124	2140	2157
588	2173	2190	2208	2226	2246	2266	2286	2308	2330	2353
589	2376	2404	2438	2471	2504	2536	2570	2605	2641	2675
590	2708	2739	2768	2795	2822	2850	2878	2904	2931	2960
591	2989	3017	3042	3064	3086	3106	3126	3143	3158	3173
592	3186	3199	3212	3224	3237	3249	3261	3273	3285	3297
593	3309	3321	3333	3345	3356	3368	3380	3391	3403	3414
594	3458									



Lake Worth
May 2001
Prepared by: TWDB

Appendix C Elevation vs. Volume



Lake Worth
May 2001
Prepared by: TWDB

Appendix D Elevation vs. Area

Appendix E

Lake Worth

TEXAS WATER DEVELOPMENT BOARD MAY 2001 SURVEY

Range Line Endpoints

State Plane NAD83 Units-feet

Range Line	X	Y
RL-1-L	2301905.8	6973438.8
RL-1-R	2301006.5	6971291.5
RL-2-L	2300484.0	6973618.3
RL-2-R	2299697.5	6972053.4
RL-3-L	2297371.9	6973269.0
RL-3-R	2297300.8	6970475.1
RL-4-L	2294904.0	6973545.0
RL-4-R	2294904.1	6970834.5
RL-5-L	2292543.9	6973365.8
RL-5-R	2292109.2	6971382.4
RL-6-L	2288684.8	6974515.8
RL-6-R	2287726.0	6973069.0
RL-7-L	2289601.9	6973851.8
RL-7-R	2278515.5	6975315.1
RL-8-L	2281475.1	6976570.9
RL-8-R	2281001.6	6974279.6
RL-9-L	2280633.6	6981254.3
RL-9-R	2281487.3	6976860.4
RL-10-L	2279401.8	6980611.1
RL-10-R	2280259.3	6978433.1
RL-11-L	2284802.0	6977490.5
RL-11-R	2284798.8	6973523.7
RL-12-L	2284783.6	6977507.5
RL-12-R	2286737.5	6977027.3
RL-13-L	2286805.6	6977079.5
RL-13-R	2286330.2	6980629.4
RL-14-L	2290540.6	6981069.1
RL-14-R	2289919.0	6982183.3
RL-15-L	2292815.3	6983009.3
RL-15-R	2292069.1	6983771.9
RL-16-L	2293139.0	6985507.1
RL-16-R	2292254.0	6984877.3

Appendix E (continued)

Lake Worth

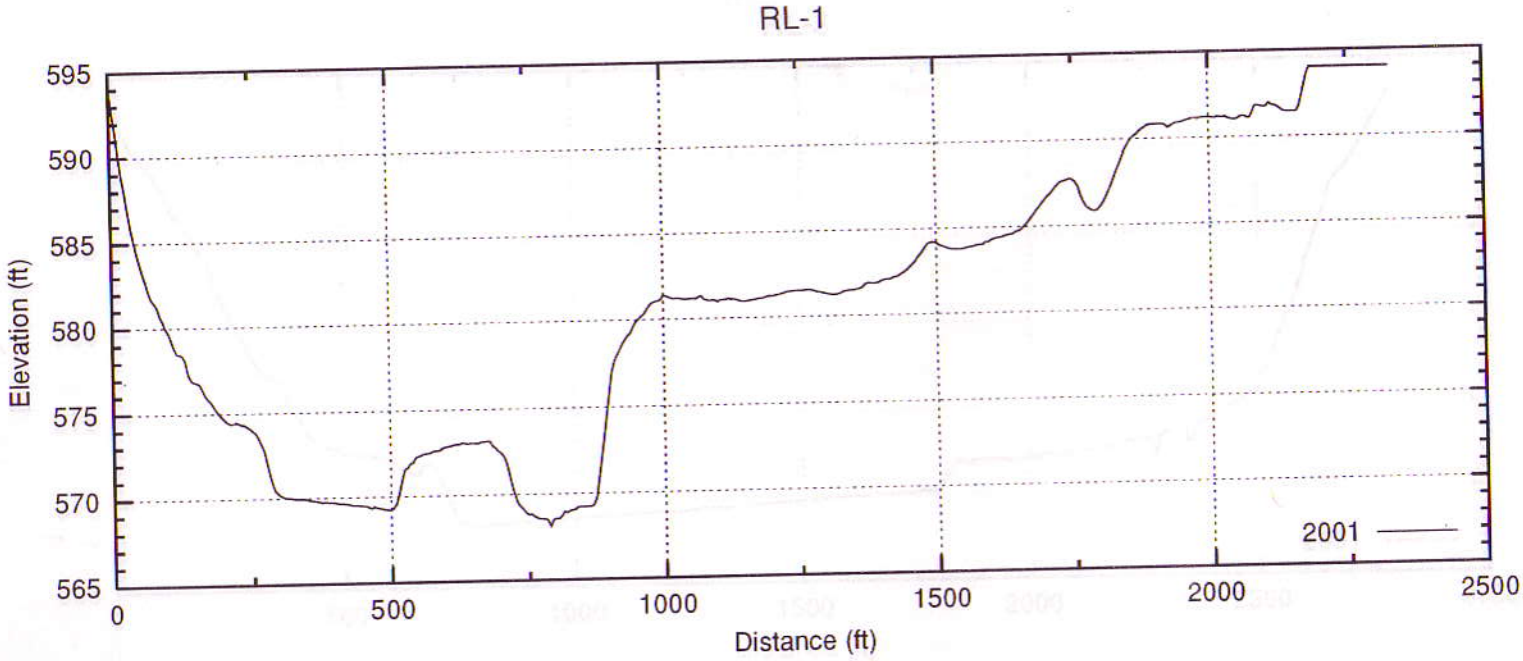
TEXAS WATER DEVELOPMENT BOARD MAY 2001 SURVEY

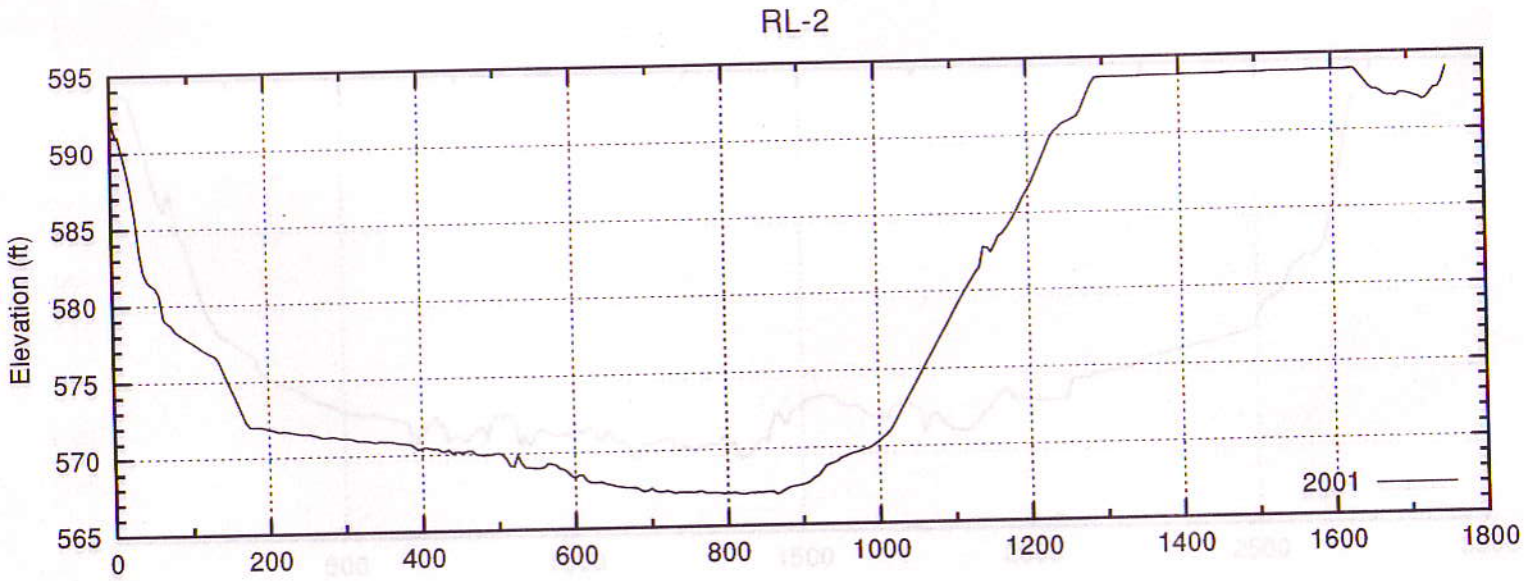
Range Line Endpoints

State Plane NAD83 Units-feet

Range Line	X	Y
RL-17-L	2288479.4	6986589.9
RL-17-R	2288537.5	6984413.4
RL-18-L	2287463.3	6990875.7
RL-18-R	2286705.1	6990335.6

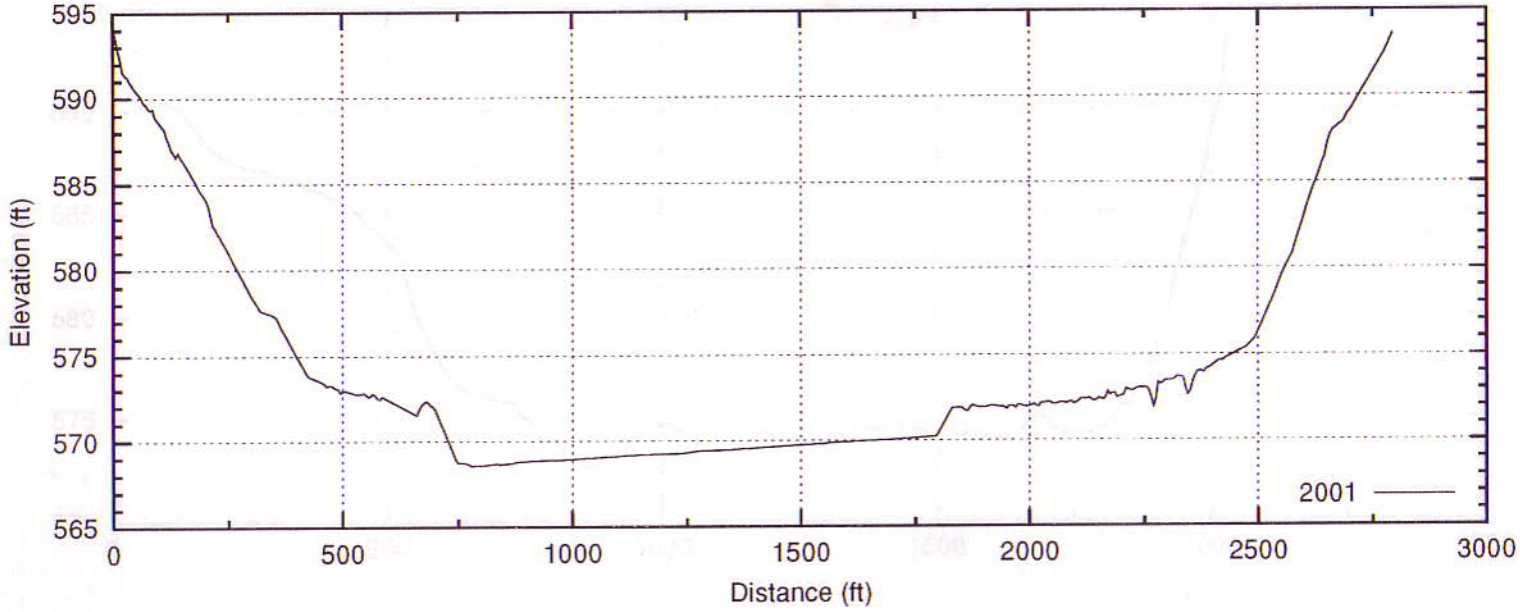
Lake Worth


RL-1
595
590
585
580
575
570
565
Elevation (ft)
0
500
1000
1500
2000
2500
Distance (ft)
2001

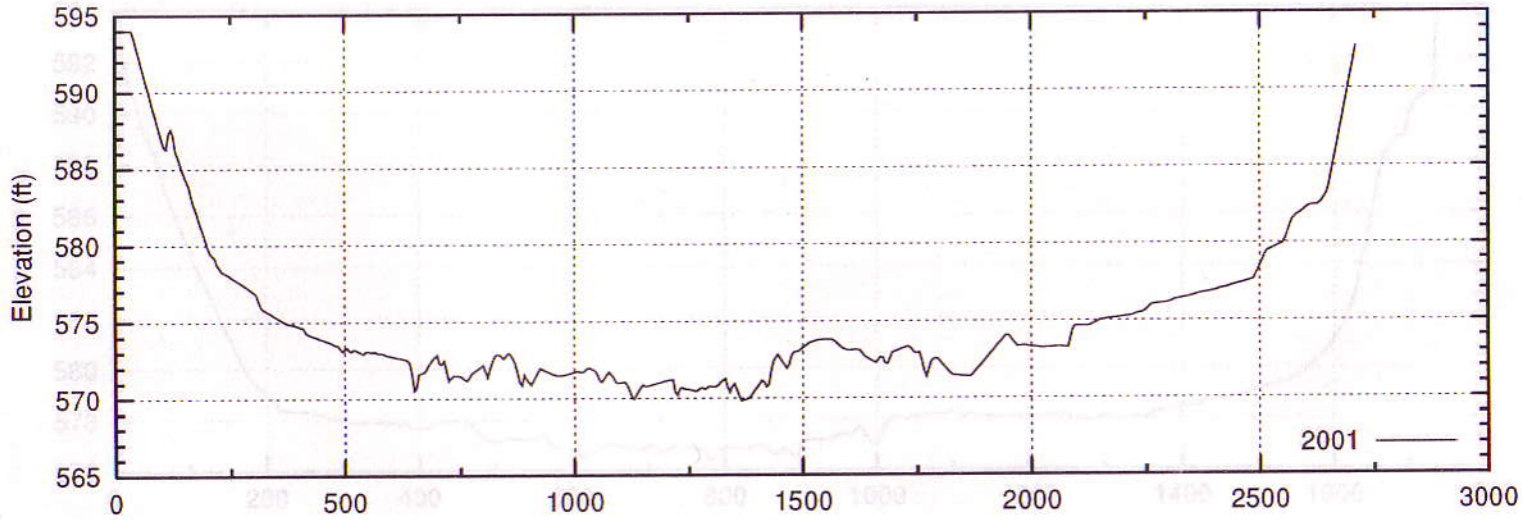

RL-2
595
590
585
580
575
570
565
Elevation (ft)
0
200
400
600
800
1000
1200
1400
1600
1800
Distance (ft)
2001

Lake Worth

RL-3

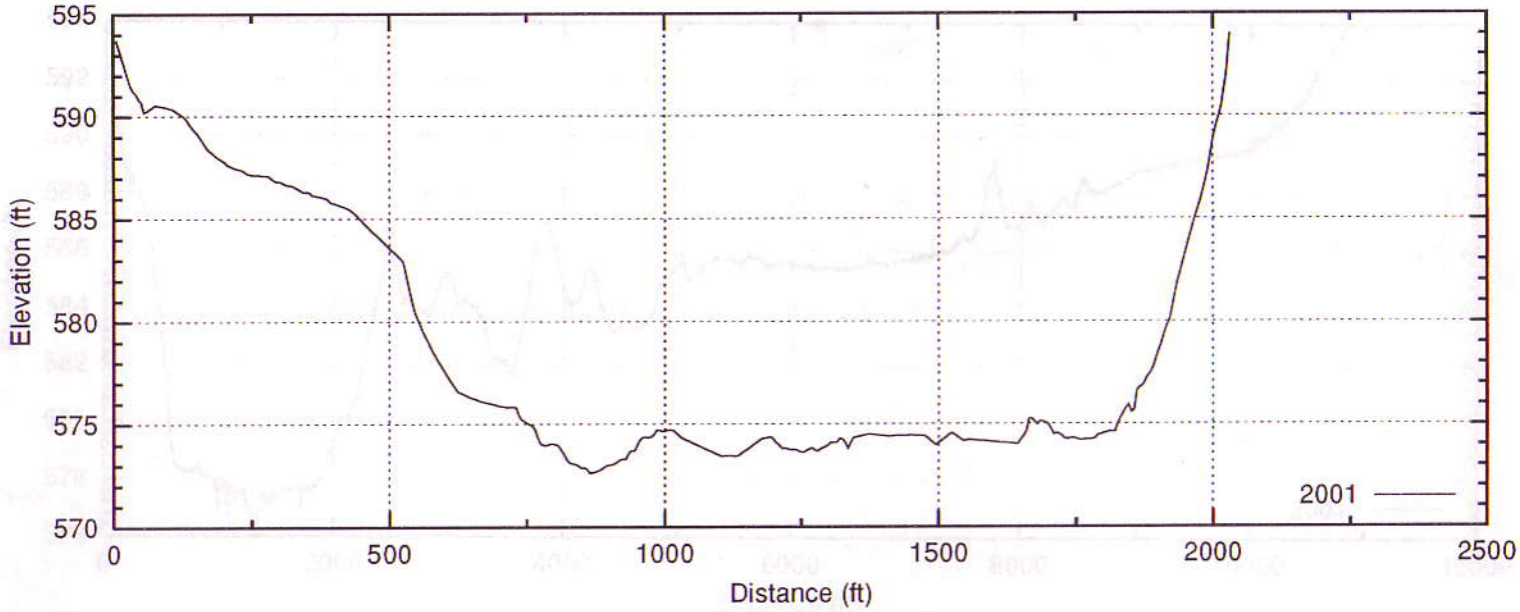


RL-4

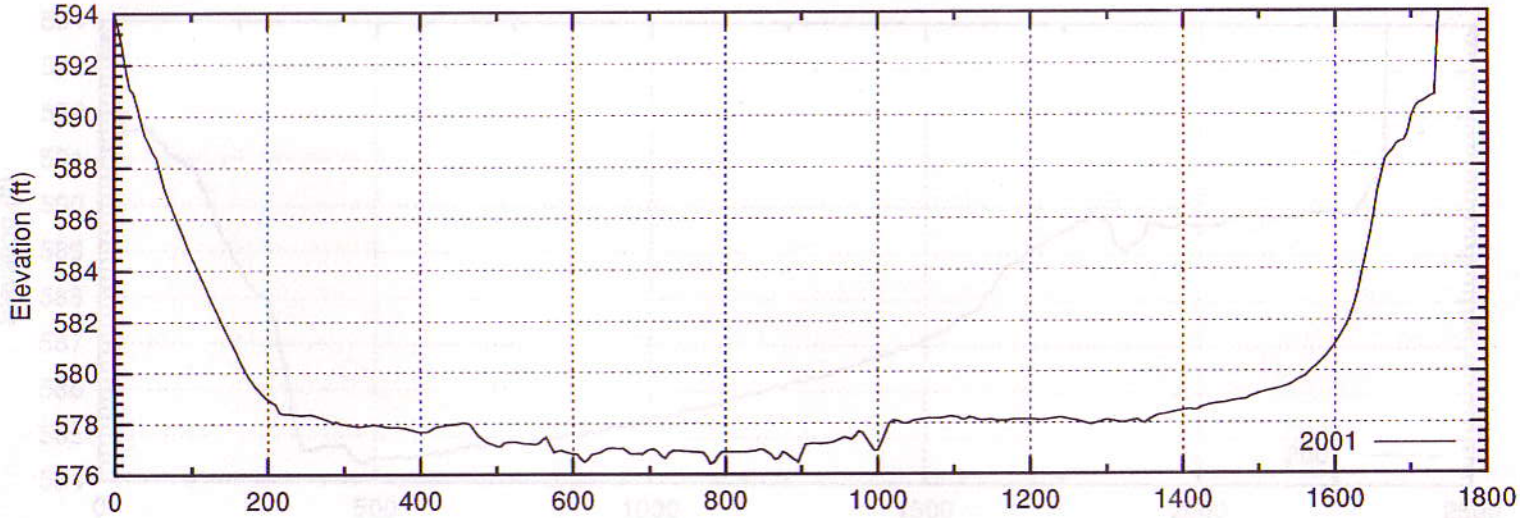


Lake Worth

RL-5

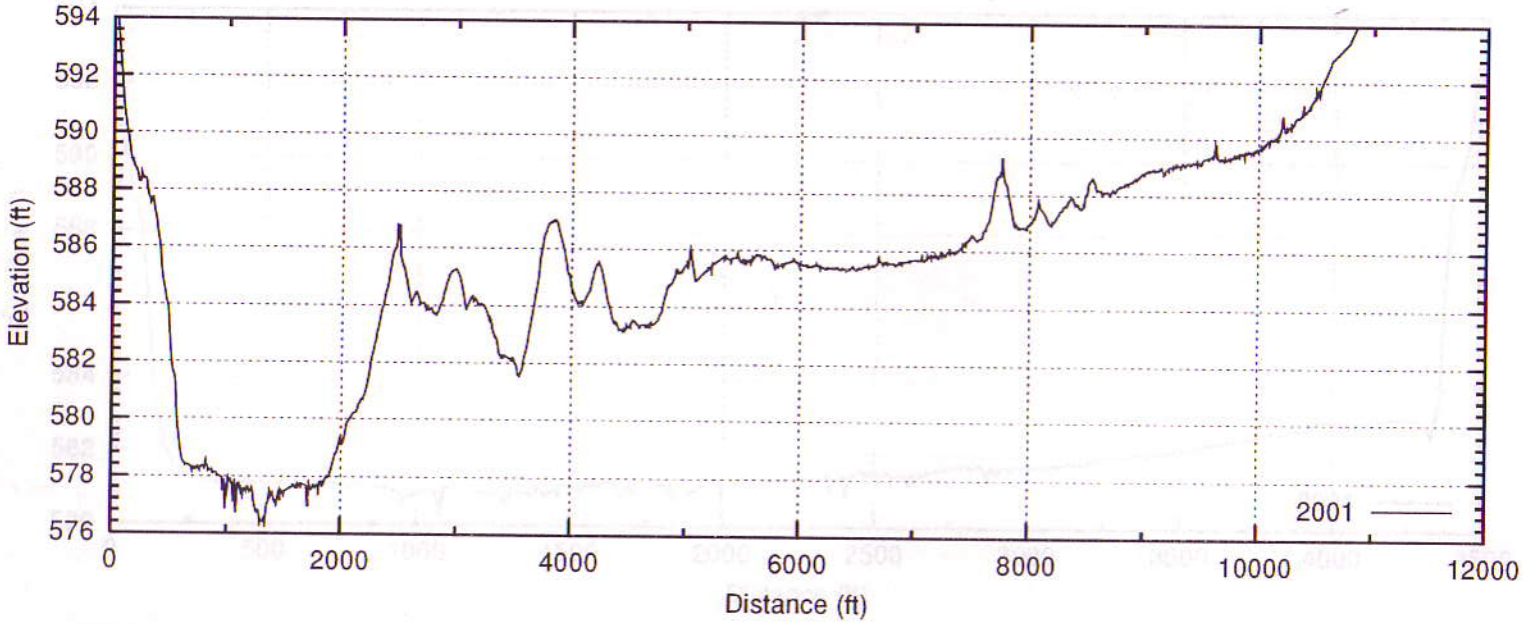


RL-6

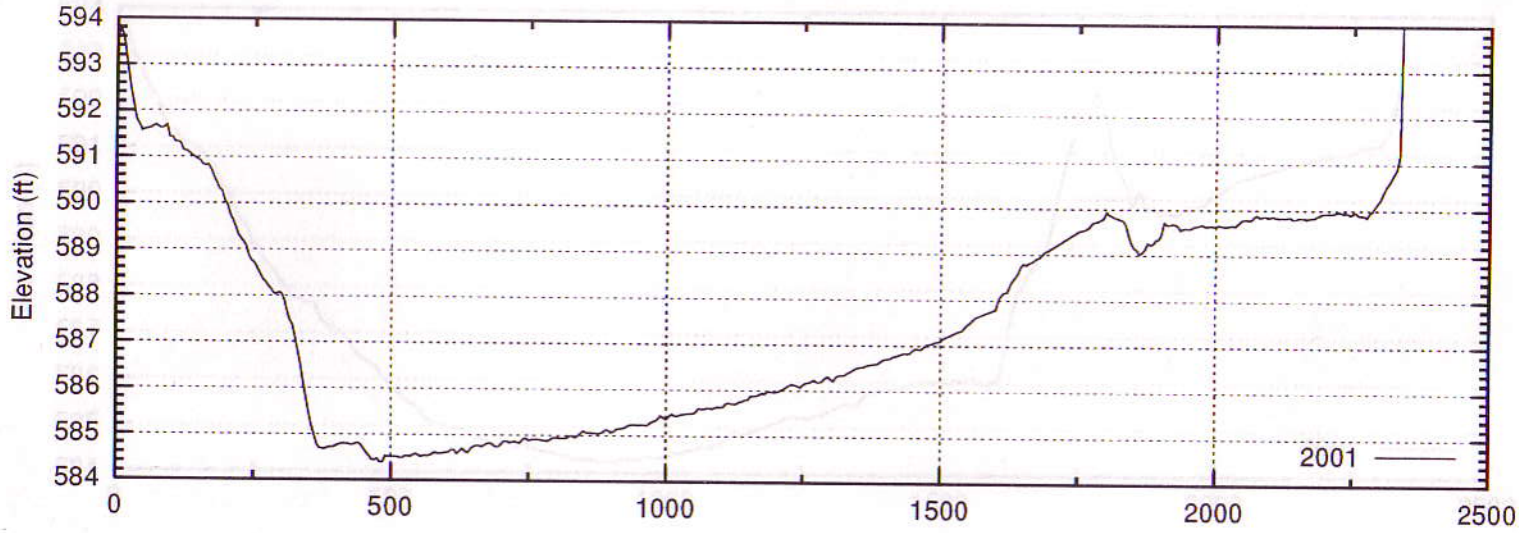


Lake Worth

RL-7

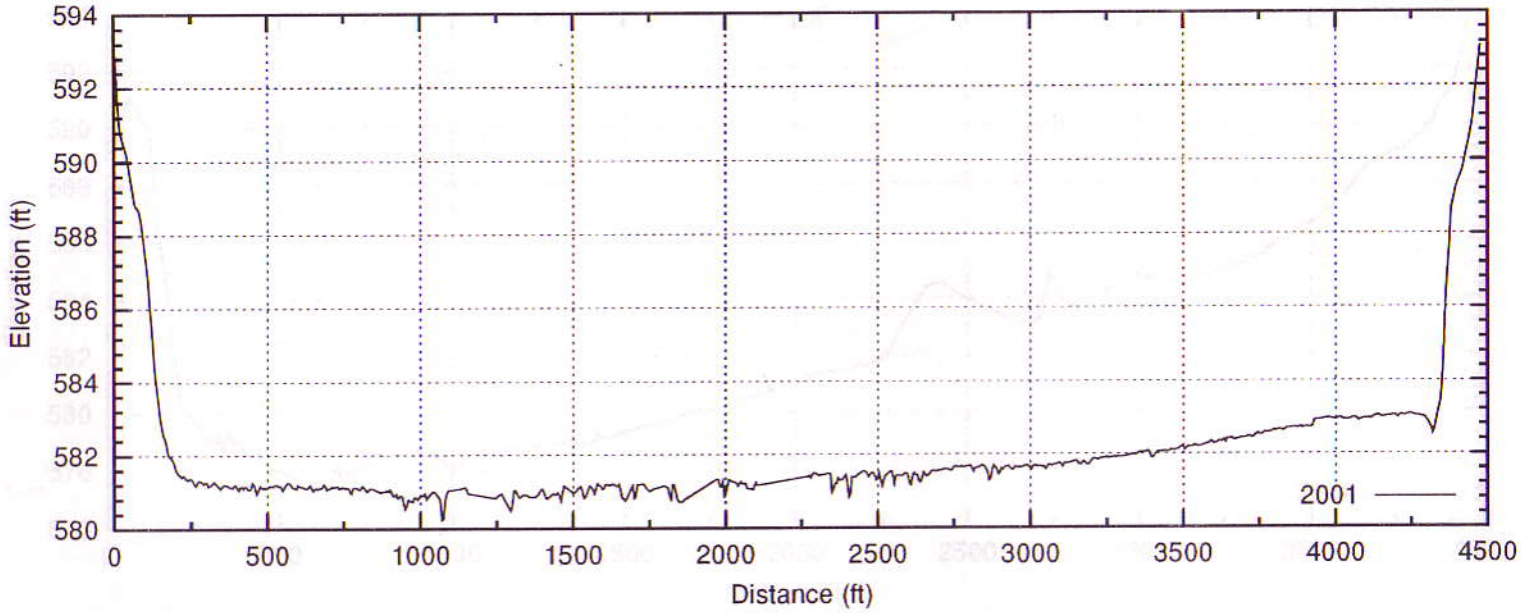


RL-8

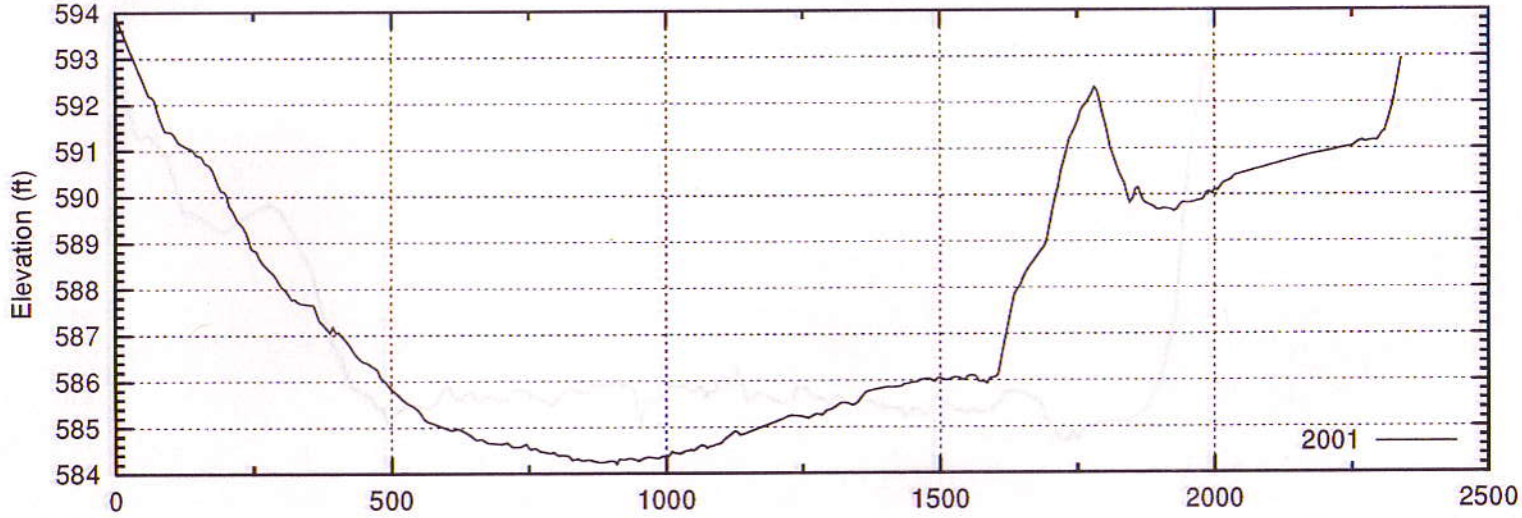


Lake Worth

RL-9

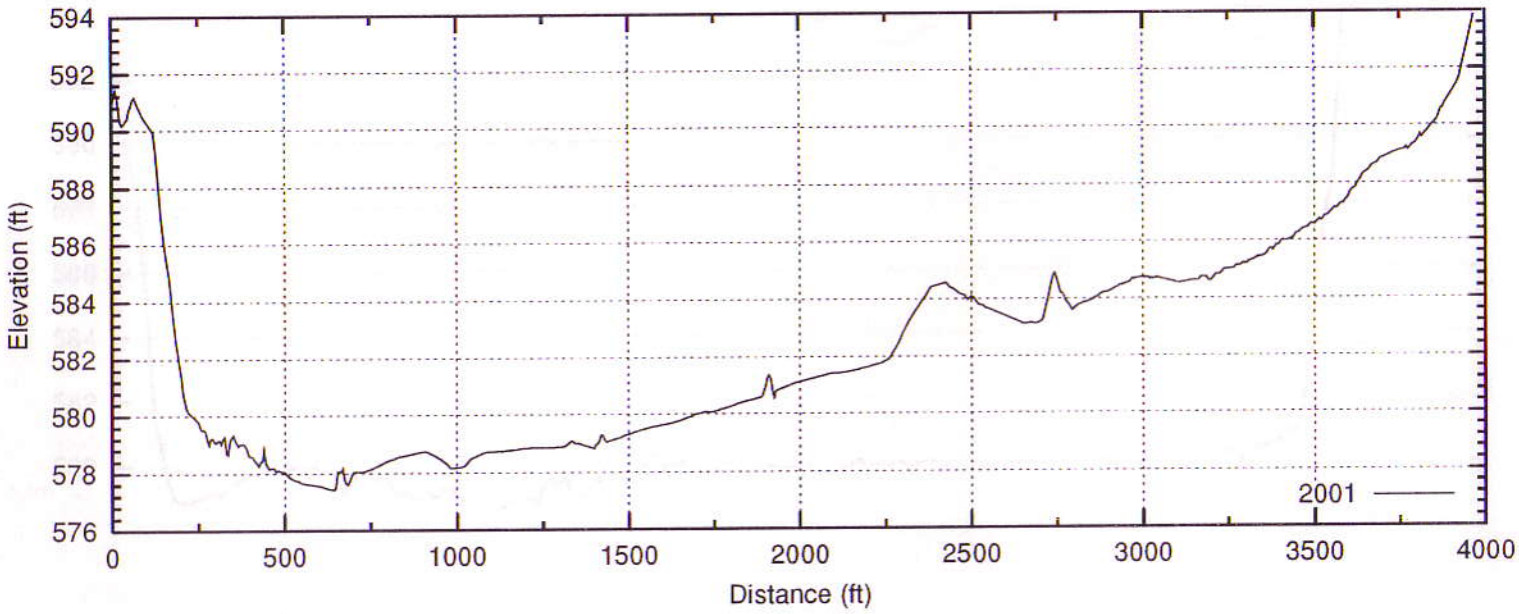


RL-10

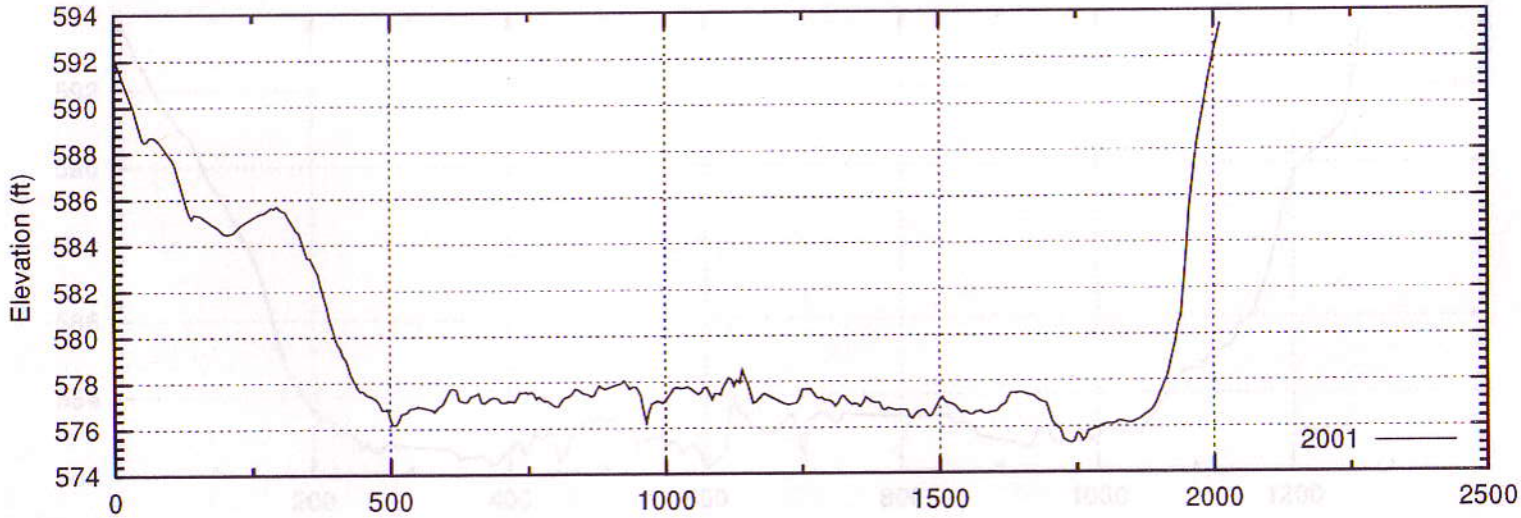


Lake Worth

RL-11

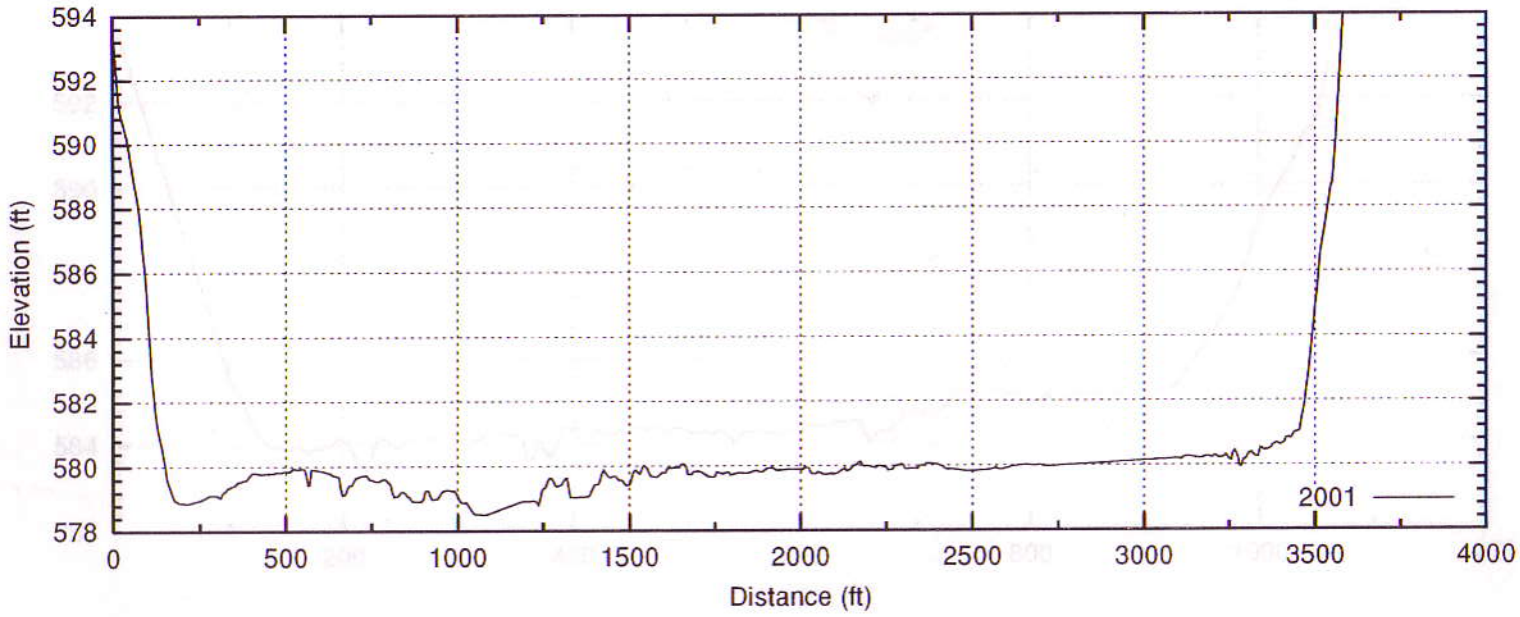


RL-12

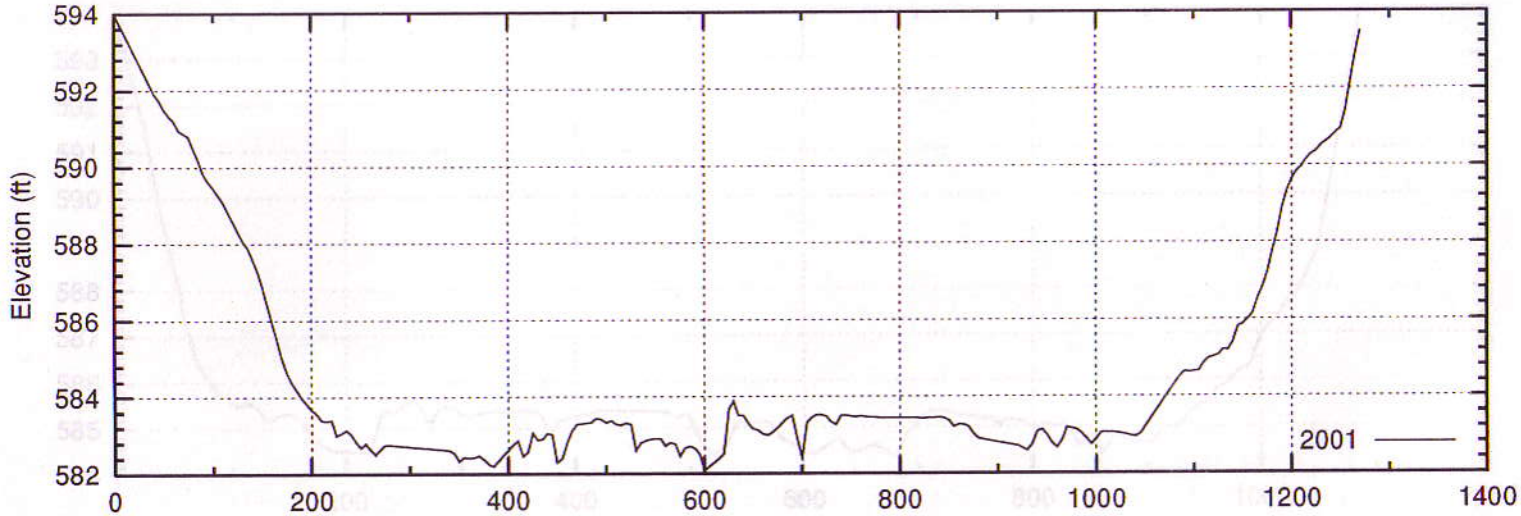


Lake Worth

RL-13

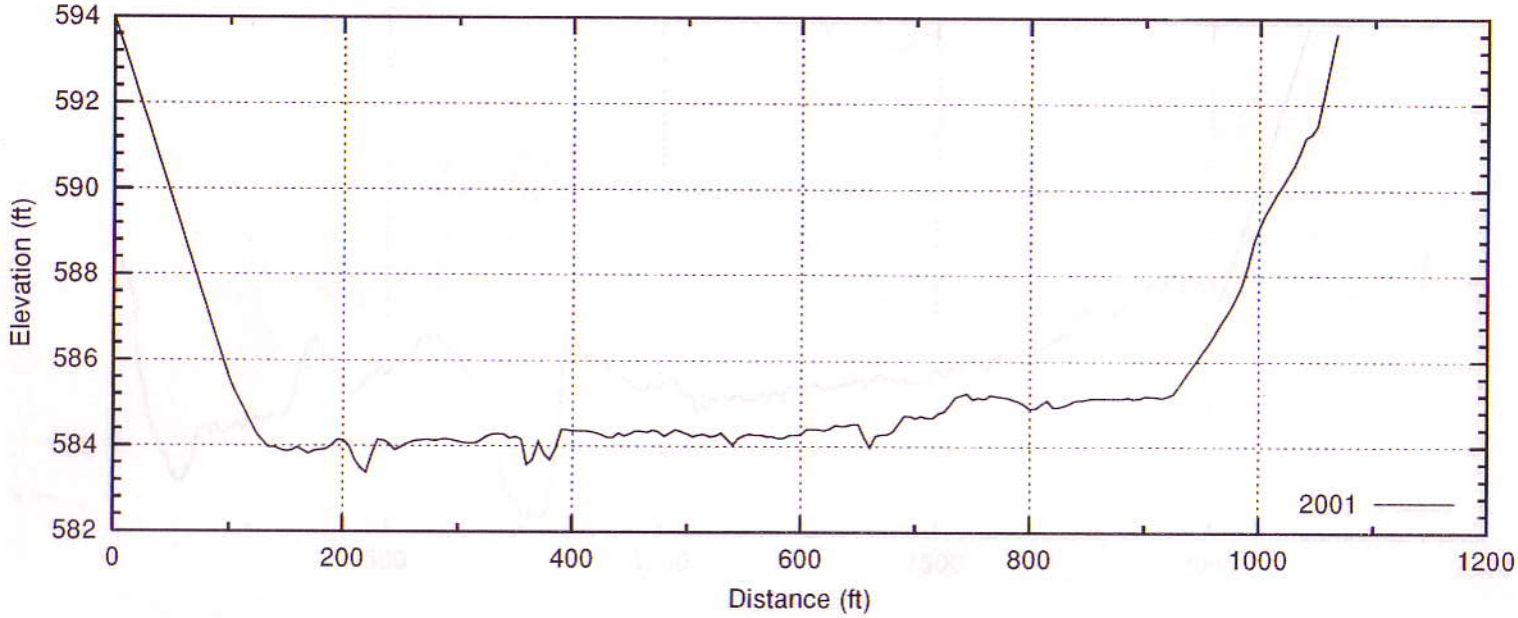


RL-14

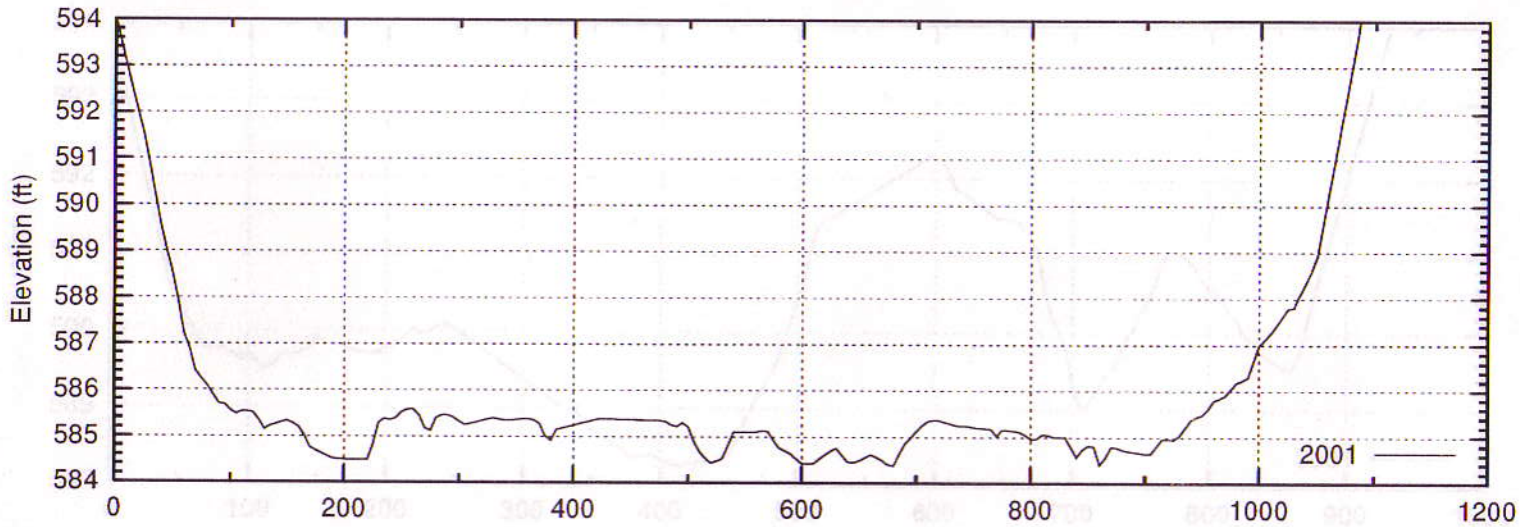


Lake Worth

RL-15

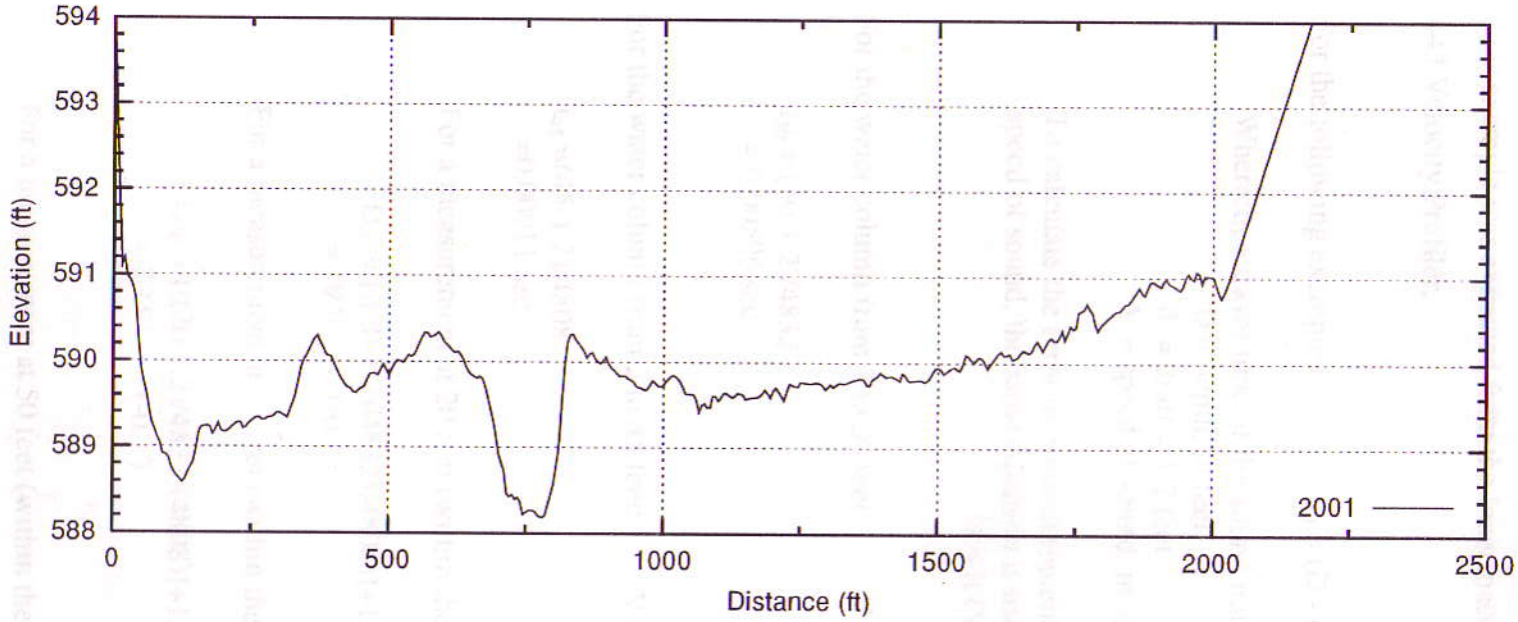


RL-16

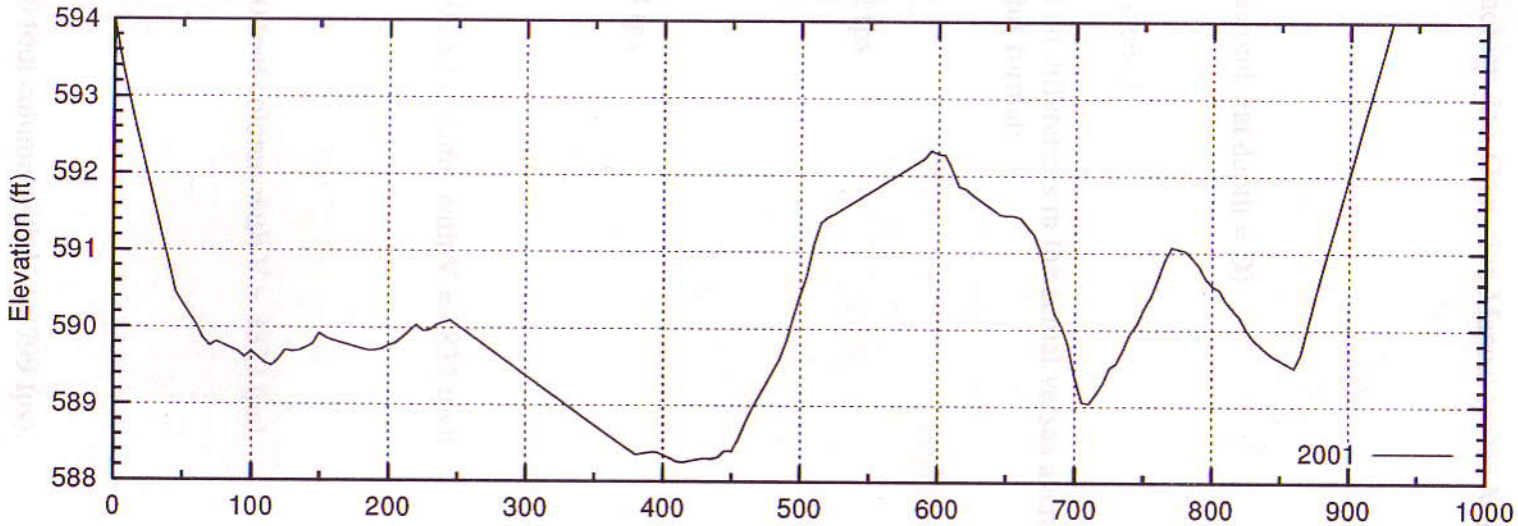


Lake Worth

RL-17



RL-18



APPENDIX G - DEPTH SOUNDER ACCURACY

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

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

Where: t_D = travel time of the sound pulse, in seconds (at depth = D)
D = depth, in feet
d = draft = 1.2 feet
V = speed of sound, in feet per second

To calculate the error of a measurement based on differences in the actual versus average speed of sound, the same equation is used, in this format:

$$D = [t (V)]+d$$

For the water column from 2 to 30 feet: V = 4832 fps

$t_{30} = (30-1.2)/4832$
$= 0.00596$ sec.

For the water column from 2 to 45 feet: V = 4808 fps

$t_{45} = (45-1.2)/4808$
$= 0.00911$ sec.

For a measurement at 20 feet (within the 2 to 30 foot column with V = 4832 fps):

$D_{20} = [((20-1.2)/4832)(4808)]+1.2$
$= 19.9'$ (-0.1')

For a measurement at 30 feet (within the 2 to 30 foot column with V = 4832 fps):

$D_{30} = [((30-1.2)/4832)(4808)]+1.2$
$= 29.9'$ (-0.1')

For a measurement at 50 feet (within the 2 to 60 foot column with V = 4799 fps):

D_{50} = [((50-1.2)/4799)(4808)]+1.2
= 50.1' (+0.1')

For the water column from 2 to 60 feet: V = 4799 fps Assumed V_{80} = 4785 fps

t_{60} =(60-1.2)/4799
=0.01225 sec.

For a measurement at 10 feet (within the 2 to 30 foot column with V = 4832 fps):

D_{10} = [((10-1.2)/4832)(4799)]+1.2
= 9.9' (-0.1')

For a measurement at 30 feet (within the 2 to 30 foot column with V = 4832 fps):

D_{30} = [((30-1.2)/4832)(4799)]+1.2
= 29.8' (-0.2')

For a measurement at 45 feet (within the 2 to 45 foot column with V = 4808 fps):

D_{45} = [((45-1.2)/4808)(4799)]+1.2
= 44.9' (-0.1')

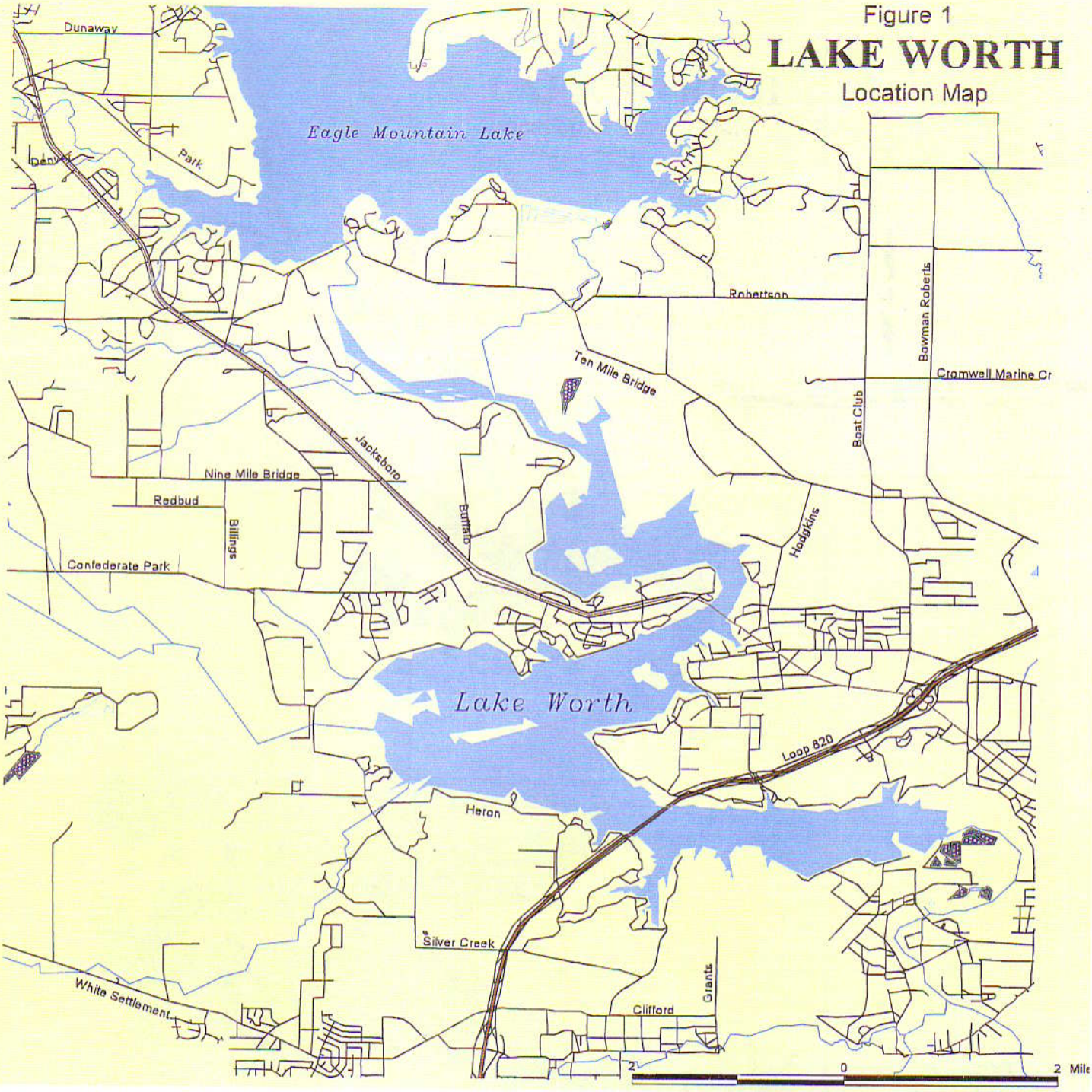
For a measurement at 80 feet (outside the 2 to 60 foot column, assumed V = 4785 fps):

D_{80} = [((80-1.2)/4785)(4799)]+1.2
= 80.2' (+0.2')

Figure 1

LAKE WORTH

Location Map

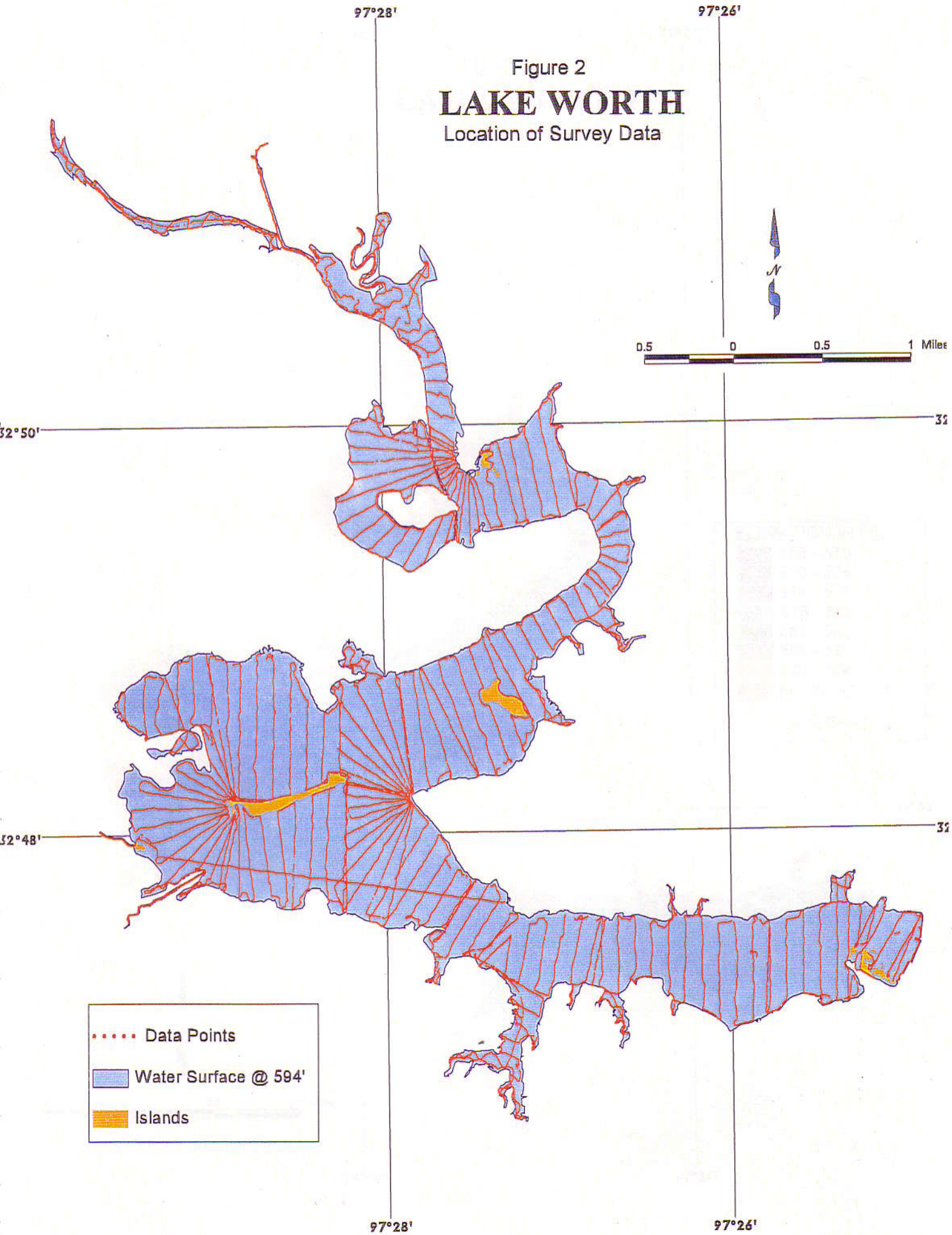


TWDB Survey May 2001

Figure 2

LAKE WORTH

Location of Survey Data

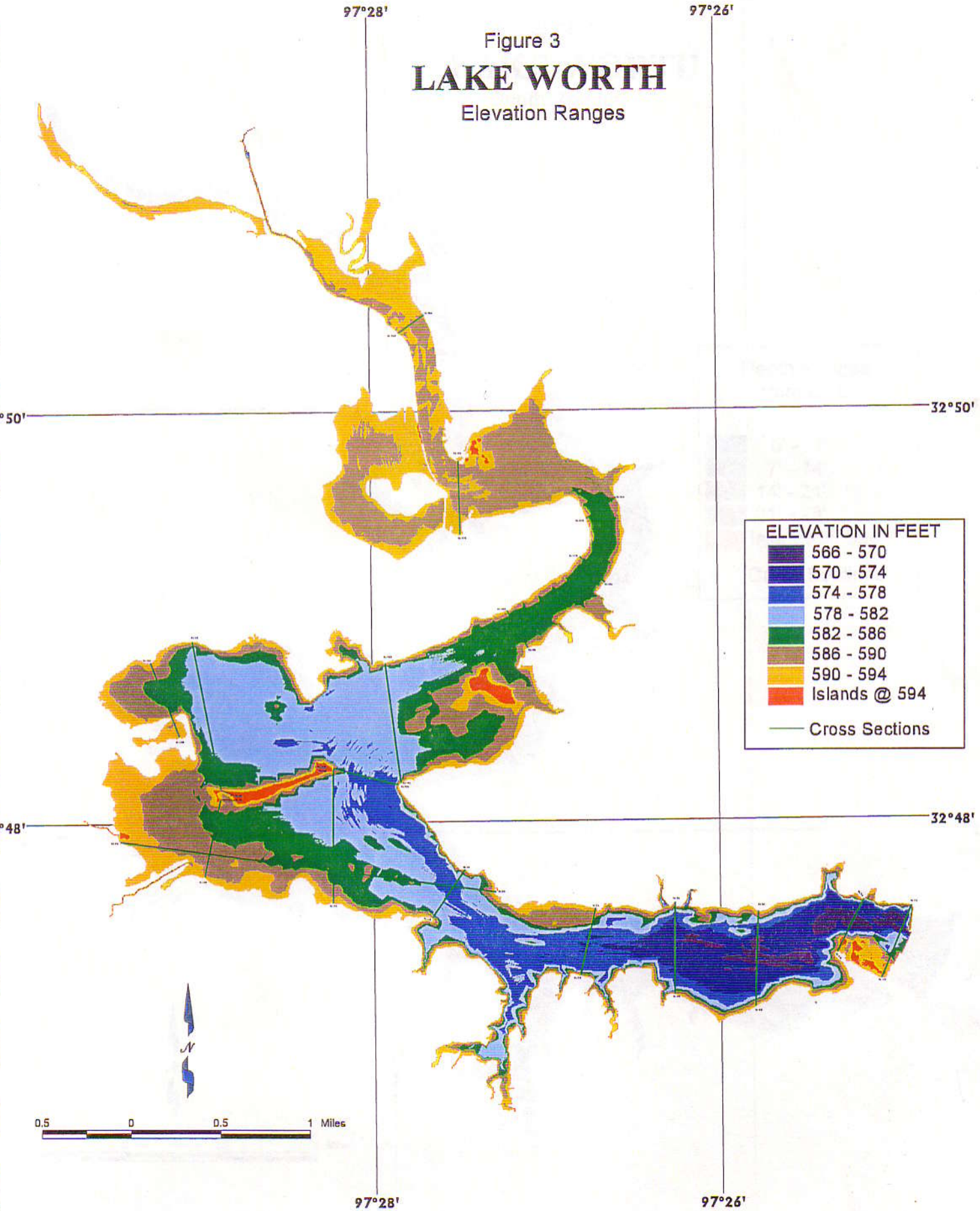


TWDB Survey May 2001

Figure 3

LAKE WORTH

Elevation Ranges

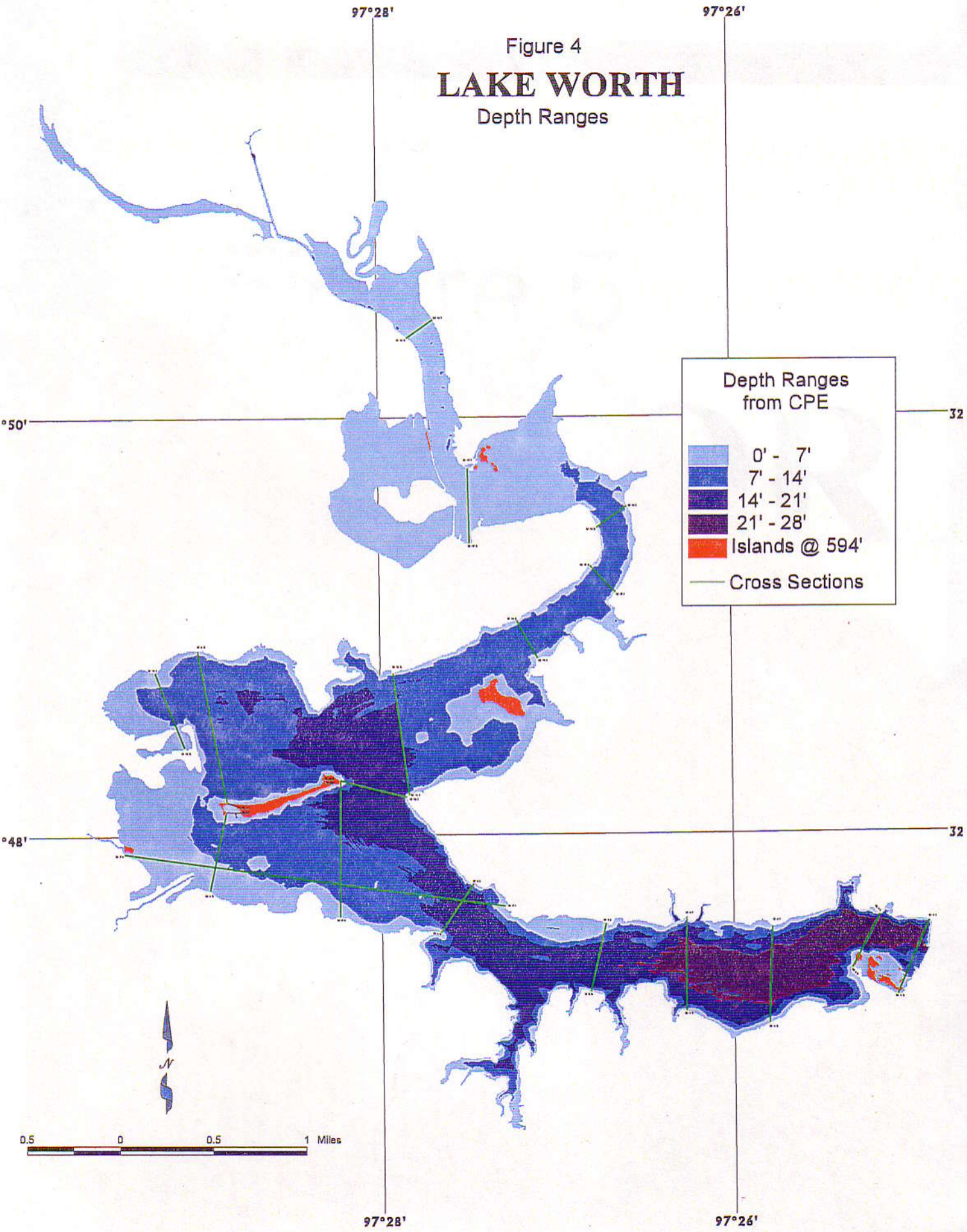


TWDB Survey May 2001

Figure 4

LAKE WORTH

Depth Ranges



TWDB Survey May 2001