VOLUMETRIC SURVEY
OF
GRAPEVINE LAKE

Prepared for:

CITY OF DALLAS
CITY OF GRAPEVINE
DALLAS COUNTY PARK CITIES MUNICIPAL UTILITY DISTRICT

In Cooperation with

U. S. Army Corps of Engineers, Fort Worth District

Prepared by:
Texas Water Development Board

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INTRODUCTION

Staff of the Surface Water Section of the Texas Water Development Board (TWDB) conducted a volumetric survey of Grapevine Lake during the period of May 1 – 8, 2002. The purpose of the survey was to determine the current volume of the reservoir 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 lake elevation gage at Grapevine Lake. The station number and name is 08054500 GRAPEVINE LAKE NEAR GRAPEVINE, TX. The datum for this gage is reported as mean sea level (msl) (USGS, 2001). 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.

Grapevine Lake is located on Denton Creek, a tributary of Elm Fork Trinity River (Trinity River Basin) in Tarrant and Denton Counties, two miles northeast of Grapevine, Texas (Figure 1). At conservation pool elevation (cpe) 535.0 ft above msl, the reservoir is approximately 11 miles in length and has approximately 76 miles of shoreline. Records indicate the drainage area is approximately 695 square miles (TWDB 1973).

The original capacities of Grapevine Lake were based on a United States Army Corps of Engineers (USACE) 1946 survey and published in 1952. A revised original was published the same year. A re-survey in 1961 and 1966 was also performed by the USACE prior to the TWDB 2002 volumetric survey. These studies will be discussed in the following section.

LAKE HISTORY AND GENERAL INFORMATION

Grapevine Dam, appurtenant structures and the surrounding shoreline of Grapevine Lake (up to contour elevation 560.0 ft) are owned by the U. S. Government and operated by the USACE, Fort Worth District. The dual-purpose lake is used for flood protection and water supplies. Federal authorization for the Grapevine Lake Project was granted under the River and Harbors Act approved March 2, 1945, first session of the 77th Congress, and Public Law 14, first session of the 79th Congress (TWDB 1966).

The Cities of Dallas and Grapevine and Dallas County Park Cities Municipal Utility District (formerly Municipal Water and Improvement District No. 2) have contracted with the USACE for use of water stored in the conservation pool between elevation 535.0 ft and 500.5 ft (http://www.swf-wc.usace.army.mil/ click on Hydrologic Data, then Pertinent Data). This window of the conservation pool is known as the "active pool" for water supply storage. The rest of the conservation pool between 500.5 ft and 475.0 ft is considered inactive. The top of the conservation pool is presently at elevation 535.0 ft. The bottom elevation of the conservation pool is 475.0 ft, also being the same elevation of the invert for the lowest outlet (reference website is http://www.swf-wc.usace.army.mil/

The Texas Commission on Environmental Quality (formerly known as the Texas Water Commission (TWC)) currently adjudicates the water rights for Grapevine Lake under the following certificates:

Certificate of Adjudication 08-2362 was issued to the City of Grapevine on July 22, 1983. It allows the City of Grapevine to store 26,250 ac-ft of water between elevation 500.5 ft and 535.0 ft in Grapevine Lake and use not to exceed 26,250 ac-ft of water for municipal purposes (TWC 1983).

Certificate of Adjudication 08-2363 was issued to the Dallas County Park Cities Municipal Utility District (DCPCMUD) on July 22, 1983. The certificate authorizes the owner, DCPCMUD to store 50,000 ac-ft of water in Grapevine Lake and use not to exceed 50,000 ac-ft of water for domestic, municipal, industrial and recreational purposes (TWC 1983).

Certificate of Adjudication 08-2458 was issued to the City of Dallas on July 22, 1983. Authorization was granted to the City of Dallas to store 85,000 ac-ft of water in Grapevine Lake. Authorization was granted to divert and use not to exceed 50,005 ac-ft of water per annum for municipal purposes. Authorization was also granted to divert and use not to exceed 34,995 ac-ft of water per annum for domestic, municipal, industrial, manufacturing, pleasure and recreational purposes (TWC 1983).

Additional information on amendments to the Certificates of Adjudication and other matters relating to the water rights of Grapevine Lake can be found at the Records Division of the Texas Commission on Environmental Quality.

Construction started on Grapevine Dam in January 1948 and was completed in July 1952. Deliberate impoundment of water began July 3, 1952 and the conservation pool filled for the first time on May 4, 1957. The U. S. Army Corps of Engineers was the design engineer. T. L. James, Inc. and Guilliam Brothers, Ruston, Louisiana were the general contractors. The estimated project cost was $11,753,000.00.

Original design information shows Grapevine Dam (embankment) is 12, 850 ft long and rises approximately 137 ft above the original streambed to a crest elevation of 588.0 ft. The earthen embankment is composed of mostly impervious material and has rock riprap on the upstream face for erosion control. FM 2499 (a two-lane asphalt road) occupies the dam's crest. Modifications were made to the downstream face of the embankment in 1985.

The spillway for Grapevine Lake consists of an approach channel, an uncontrolled ogee crest, discharge channel and stilling basin. This structure is located on the north (left) abutment of the dam. The approach channel bottom is at elevation 550.0 ft and is 500 ft wide. The ogee crest is an uncontrolled concrete weir, 500 ft in length at elevation 560.0 ft. Flows are discharged into a 500 ft wide trapezoid-shape concrete channel for a length of approximately 500 ft and empties into the stilling basin. Modifications were made to the spillway system in 1985.

The outlet works are designed with an intake tower (located immediately upstream of the dam), a 13-ft diameter conduit that discharges through the dam, a stilling basin, and a discharge channel. The outlet works serves for primarily water supply releases but can also be used for flood releases. The invert elevation for the lowest outlet located at the base of the intake tower is 475.0 ft. There are two 6.5 ft by 13.0 ft broom-type service gates that control the flow through the discharge conduit and they are also located at the base of the inlet tower. These service gates can open 0.2 of a foot per minute via electric wire rope hoist. The controls and hoists are located on the operation deck of the intake tower.

The low-flow system is housed in the intake tower and consists of two wet wells and two 30-inch diameters welded steel pipes that are located in the base of the 13-ft diameter conduit. There are multiple openings at different elevations in the tower to allow for water quality and temperature controlled releases. These openings are controlled by 3.0-ft by 5.0-ft emergency sluice gates located on the exterior wall of the intake structure. The sluices that lead to the north wet well have invert elevations of 520.0 ft and 500.5 ft. The openings for the south well of the intake structure have invert elevations of 512.0 ft and 500.5 ft. There are service sluice gates (3.0 ft by 3.0 ft) located on the interior wall of the intake structure and at the base of the wet wells that control flows into the 30-inch diameter steel discharge pipes.

Both the City of Dallas and DCPCMUD withdraw their permitted water downstream of Lake Grapevine. The City of Grapevine usually withdraws water from the outlet works at the downstream stilling basin. The City of Grapevine also has the option to withdraw water directly from the south 30-inch diameter steel pipe by closing a valve near the stilling basin and redirecting the discharge flow to a pump station.

The original capacity for Grapevine Lake was based on a 1946 survey by the USACE. The initial capacity was adjusted after the construction of Grapevine Dam in order to consider the volume of borrowed material taken from the lake area to use for the dam's embankment. According to the "1952 original area and capacity datum", the storage capacity 188,543 ac-ft below cpe 535.0 ft. There was a 1952 revised original datum calculated after 41 sediment range lines were established on Grapevine Lake. There were two re-surveys and sedimentation reports published by the USACE of Grapevine Lake in 1961 and 1966. The 1966 re-survey showed the storage capacity below conservation pool elevation 535.0 ft would be 181,109 ac-ft (USACE 1966). Please refer to Table 2 for more information on the area and capacity of Grapevine Lake based on the past sedimentation studies and the 2002 volumetric survey results. The following table summarizes information for Grapevine Dam and Grapevine Lake.

Table 1. Grapevine Dam and Grapevine Lake Pertinent Data

Owner of Grapevine Dam and Facilities

United States of America

Operator of Grapevine Dam and Facilities

U. S. Army Corps of Engineers, Fort Worth District

Engineers and General Contractors

U. S. Army Corps of Engineers (Design)

T. L. James, Inc. and Guilliam Brothers, Ruston, Louisiana

Location

On Denton Creek, a tributary of Elm Fork Trinity River (Trinity River Basin) in Tarrant and Denton Counties, two miles northeast of Grapevine, Texas.

Drainage Area

695 square miles

Dam

Type	Earthfill
Length (total)	12,850 ft (including 500 ft spillway)
Maximum Height	137 ft
Top width	28 ft

Spillway

Type	Ogee (Concrete)
Length	500 ft
Crest elevation	560.0 ft
Control	None

Outlet Works

Type	1 conduit
Size	13-ft diameter with two inlets
Control	2 gates, each 6.5-ft by 13-ft
Invert elevation	475.0 ft above msl

Authorization

Federal: River and Harbors Act approved March 2, 1945, first session of the 77th Congress, and Public Law 14, first session of the 79th Congress

State: Permit No. 1465 (Application No. 1573) August 19, 1948, to allow Dallas County Park Cities Municipal Water Control and Improvement District No.2 to divert 50,000 ac-ft of water per annum for municipal, industrial, recreational and manufacturing uses. Certificate of Adjudication 08-2363 was issued to the Dallas County Park Cities Municipal Utility District (DCPCMUD) on July 22, 1983.

Permit No. 1464 (Application No. 1572) August 19, 1948, to allow the City of Dallas to divert 85,000 ac-ft of water annually for municipal, manufacturing, recreational, and industrial purposes. Certificate of Adjudication 08-2458 was issued to the City of Dallas on July 22, 1983.

Permit No. 1603 (Application No. 1728) November 23, 1951, to allow the City of Grapevine to divert 1,250 ac-ft of water per annum for municipal use. Certificate of Adjudication 08-2362 was issued to the City of Grapevine on July 22, 1983 to allow the City of Grapevine to divert 26,250 ac-ft of water per annum for municipal use.

Reservoir Data (Based on TWDB 2002 volumetric survey)

Feature	Elevation (Above msl)	Capacity (Acre-feet)	Area (Acres)
Conservation Pool Elevation (Conservation Storage)	535.0	164,702	6,893
Active Pool for Water Supply (Between elev. 535.0 ft – 500.5 ft)	535.0	147,042	6,893
Dead Pool (Invert lowest outlet)	475.0	1	1

VOLUMETRIC SURVEYING TECHNOLOGY

The equipment used to perform the latest volumetric survey consisted of a 23-foot aluminum tri-hull SeaArk craft with cabin, equipped with twin 90-Horsepower Honda outboard motors. (Reference to brand names throughout this report does not imply endorsement by TWDB). Installed within the enclosed cabin are a Coastal Oceanographics' Helmsman Display (for navigation), an Innerspace Technology Model 449 Depth Sounder and Model 443 Velocity Profiler, Trimble Navigation, Inc. AG132 GPS receiver with Omnistar differential GPS correction signal and a pc. A water-cooled 4.5 kW generator provides electrical power through an in-line uninterruptible power supply. In shallow areas and where navigational hazards such as stumps were present, a 20-foot aluminum shallow-draft flat bottom SeaArk craft with cabin and equipped with one 100-horsepower Yamaha 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. AG132 GPS receiver with Omnistar differential GPS correction signal and a laptop computer.

The GPS equipment, survey vessel, and depth sounder in combination provide an efficient hydrographic survey system. As the boat travels across the pre-plotted transect lines, the depth sounder takes approximately ten readings of the lake bottom each second. The depth readings are stored on the computer along with the positional data generated by the boat's GPS receiver. The data files collected are downloaded from the computer 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 one data point per second, and the average depths are converted to elevation readings based on the water-level elevation recorded at the time the data was collected. 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 lake'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 lake's boundary was created by digitizing the LEWISVILLE WEST, GRAPEVINE and ARGYLE, TEXAS DOQ's. The lake elevations, at the time the DOQ's were photographed (January 19, 1995, January 31, 1995, and January 11, 1996) were 534.65 ft, 534.86 ft, and 530.24 ft. respectively. These photographs (DOQ's) were used to digitize lines around the boundary of the lake and were given elevations corresponding to the date of the photo. The lake elevations varied between elevation 538.91 ft and 539.14 ft during the survey. In order to utilize all the data collected from the survey boat, the 540 ft contour from the USGS 7.5 minute quadrangle maps was used as the elevation for the lake boundary. The TWDB Staff utilized this updated boundary and the lines digitized from the above DOQ's at their respective elevations in the model for the current study.

The survey layout was designed by placing survey track lines at 500-foot intervals within the digitized reservoir boundary using HYPACK software. The survey design required the use of approximately 217 survey lines placed perpendicular to the original creek channel and tributaries along the length of the reservoir. The design also included approximately 18 of the 41 original sediment range lines that were established by the USACE in 1952.

SURVEY PROCEDURES

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

Equipment Calibration and Operation

While onboard the Hydro-survey boat and prior to collecting data, the depth sounder was calibrated with the Innerspace 443 Velocity Profiler, an instrument used to measure the variation in the speed of sound at different depths in the water column. The average speed of sound through the entire water column below the boat was determined by averaging local speed-of-sound measurements collected through the water column. The velocity profiler probe was first placed in the water to acclimate the probe. The probe was next raised to the water surface where the depth was considered zero. The probe was then gradually lowered on a cable to a depth just above the lake bottom, and then raised again to the surface. During this lowering and raising procedure, local speed-of-sound measurements were collected, from which the average speed was computed by the velocity profiler. This average speed of sound was entered into the ITI449 depth sounder, which then provided the depth of the lake bottom. The depth was then checked manually with a measuring tape to ensure that the depth sounder was properly calibrated and operating correctly.

Onboard the River-runner (shallow draft) boat, 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.

The speed of sound in the water column ranged from 4,872 feet per second to 4,890 feet per second during the Grapevine Lake survey. 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 ft 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 errors 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 onboard 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 reservoir'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

TWDB staff collected data at Grapevine Lake for approximately five days during the period of May 1 – 8, 2002. The USACE were able to maintain the water level elevations during the survey at a fairly constant level between elevation 538.91 ft and 539.14. The water level elevations were approximately four feet higher than conservation pool elevation thus allowing the survey crew to collect data in most areas of the lake that would not be inundated at conservation pool elevation 535.0 ft.

The survey crew experienced typical Spring-like weather conditions while surveying Grapevine Lake. Temperatures ranged in the mid 80's to low 90's with winds generally blowing 10 to 20 mph. The crew experienced favorable conditions each day except on Tuesday, May 7th, when the winds were 15 to 25 mph and gusting to 30 mph. The crew suspended data collection for that day and instead performed data collection demonstrations for the lake owners in protected areas of the lake.

The geographical feature of Grapevine Lake is unique in that the catchment basin is in a valley where Denton Creek meanders through canyon-type terrain with steep banks bordering most of the lake. Denton Creek flows in a northwest to southeast direction with Grapevine Dam being at the southeast end of the lake.

Data collection began at the dam and parallel lines were driven in increments of 500 ft as the crew worked upstream. Data were also collected on perpendicular lines in the coves along the north and south shores that were formed by contributing creeks. Steep slopes with sandstone outcrops were noted all along the shoreline in this area. The bathymetry of the lake bottom was consistent with the surrounding terrain as noted on the depth sounder's analog chart. Distinguishable features that were observed during the data collection phase included the old Denton Creek Channel and other tributaries that flow into Grapevine Lake.

Grapevine Lake is located in a very populated area that continues to grow. The USACE owns the surrounding shoreline of Grapevine Lake to contour elevation 560.0 ft with a flood easement to elevation 575.0 ft. The survey crew noted some residential housing around the lake but appeared to be above the easement contour. Several large floating marinas were located in the protective coves and approximately one dozen parks were noted along the shoreline of Grapevine Lake.

As the survey crew collected data upstream of Rocky Park (on the north shore) and Walnut Grove Park (on the south shore), the terrain became less steep. The canyon-type shoreline turned gradually into prairie land with gentle contours which is more common for that area. The headwater of Grapevine Lake is near the confluence of Marshall Creek and Denton Creek. It was in this area that the survey crew noted a large delta occupied by 20+ ft tall willow trees. A large amount of floating debris and submerged logs and stumps hampered data collection in this area. Data collection continued upstream in Denton Creek in a zigzag pattern to a point upstream of US Highway 377 where the crew considered Denton Creek to be unaffected by the back waters of Grapevine Lake.

In total, approximately 77,100 data points were collected over the 192 miles traveled. The crew collected data on 204 of the 236 pre-plotted transects that were designed for the survey. Data were also collected on 18 of the 41 USACE sediment range lines that were established 1952. These points were stored digitally on the boat's computer in 312 data files. Random data were collected in those areas where the crew could not navigate the boat to stay on course. Data were not collected in areas with significant obstructions or where the depths were too shallow to navigate. Figure 2 shows the actual location of all data points collected.

Data Processing

The collected data were downloaded from diskettes onto TWDB's network 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 level elevation varied from 538.91 ft on May 1, 2002 to 539.14 ft on May 6, 2002 according to the USGS gage. After all changes had been made to the raw data files, the edited files were saved.

The edited files were then 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 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 the lowest elevation to the contour used for the lake boundary during the 2002 survey. From elevation 473.6 ft to 540.0 ft, the surface areas and volumes of 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 5-ft 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 established by the USACE in 1952.

RESULTS

Results from the 2002 TWDB survey indicate Grapevine Lake encompasses 6,893 surface acres and contains a total volume of 164,703 ac-ft at the conservation pool elevation of

535.0 ft. The shoreline at this elevation was calculated to be 76 miles whereas the digitized 540.0 ft boundary measures 80 miles. The deepest point physically measured during the survey was at elevation 473.62 ft and was located approximately 1,700 feet upstream of Grapevine Dam.

SUMMARY AND COMPARISONS

Grapevine Dam was completed in 1952 and deliberate impoundment began the same year. Several sediment surveys and studies have been performed on Grapevine Lake. Original design information was furnished from a 1946 USACE survey. The most recent Sediment Survey Report on Grapevine Lake was published by the USACE in 1971 and based on a 1966 re-survey. Records indicate that Grapevine Lake had a total volume of 181,109 ac-ft of water and a surface area of 7,276 acres at conservation pool elevation 535.0 feet based on the 1966 sediment survey. A summary of the comparisons is presented in Table 2.

During the period of May 1 - 8, 2002 TWDB staff completed a volumetric survey of Grapevine Lake. The 2002 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 535.0 ft, the current survey measured 6,893 surface acres, for a reduction of 383 surface acres compared to the 1966 USACE Sediment Survey. The 2002 survey results indicate that the total volume at the conservation pool elevation of 535.0 ft is 164,703 ac-ft. The dead pool below elevation 475.0 feet was found to be 1 ac-ft, and thus the conservation storage found in this survey is 164,702 acre-feet of water. The 1966 sediment survey results showed the conservation storage capacity to be 181,012; thus, there is a reduction of 16,310 ac-ft of water or approximately 9% reduction in conservation storage capacity since 1966. Grapevine Lake lost 22,057 ac-ft of water or 11.8 % in conservation storage compared to the 1952 revised capacity datum.

Comparisons between the USACE historical Sediment Surveys and the TWDB 2002 Volumetric Survey is difficult and some apparent changes might simply be due to methodological differences. It is recommended that another survey utilizing modern methods be performed in five to ten years or after major flood events to monitor changes to the lake's capacity.

Table 2. Area and Volume Comparisons Grapevine Lake

	USACE (Original Capacity)	USACE (Revised)	USACE (Re-survey)	USACE (Re-survey)	TWDB (Volumetric)
Year	**1952**	**1952**	**1961**	**1966**	**2002**
Area (acres) (At cpe 535.0 ft)	7,377	7,414	7,302	7,276	6,893
Total Volume (ac-ft) (At cpe 535.0 ft)	188,543	187,551	183,639	181,109	164,703
Conservation Storage (ac-ft) (Between elev. 535.0 ft-475.0 ft)	187,698	186,759	183,455	181,012	164,702
Active Pool for Water Supply (ac-ft) (Between elev. 535.0 ft – 500.5 ft)	--	--	--	--	147,042
Inactive Pool (ac-ft) (Between elev. 500.5 ft – 475.0 ft)	--	--	--	--	17,660
Dead Storage (ac-ft) (Below lowest invert elev. 475.0 ft)	845	792	184	97	1

Information based on data from the USACE 1966 Re-survey Sedimentation Report (USACE 1971, p.23) and the TWDB 2002 Volumetric Survey results.

REFERENCES

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Appendix A

Grapevine Lake

RESERVOIR VOLUME TABLE

TEXAS WATER DEVELOPMENT BOARD — MAY 2002 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
473							0	0	0	0
474	0	0	0	0	0	0	0	0	0	1
475	1	1	1	1	1	1	2	2	2	2
476	3	3	4	4	4	5	5	6	6	7
477	8	8	9	10	11	12	13	14	15	16
478	17	18	20	21	22	24	25	27	29	31
479	32	34	36	39	41	43	46	48	51	54
480	57	61	65	68	73	77	82	88	93	99
481	106	113	121	129	137	146	156	167	178	190
482	202	216	230	245	261	277	295	313	332	352
483	372	393	415	437	461	485	510	536	562	589
484	618	647	677	707	739	772	806	840	875	911
485	948	985	1023	1062	1102	1142	1183	1224	1267	1310
486	1354	1399	1444	1490	1536	1583	1631	1679	1728	1777
487	1827	1878	1929	1981	2034	2087	2141	2196	2251	2307
488	2364	2421	2479	2538	2598	2658	2719	2780	2843	2906
489	2969	3034	3099	3165	3232	3300	3368	3437	3507	3578
490	3649	3721	3793	3867	3941	4016	4091	4168	4245	4323
491	4401	4481	4562	4643	4726	4809	4893	4979	5065	5153
492	5242	5332	5423	5516	5609	5704	5800	5898	5996	6095
493	6195	6296	6399	6502	6606	6712	6818	6926	7035	7145
494	7257	7371	7485	7601	7718	7837	7957	8079	8203	8329
495	8456	8585	8716	8848	8981	9116	9253	9391	9531	9672
496	9815	9959	10105	10251	10399	10548	10698	10850	11002	11156
497	11311	11468	11625	11784	11945	12106	12269	12433	12599	12767
498	12936	13107	13279	13453	13629	13807	13987	14168	14351	14535
499	14721	14908	15096	15286	15476	15669	15862	16057	16253	16451
500	16649	16849	17050	17253	17456	17661	17867	18073	18281	18490
501	18699	18910	19122	19335	19549	19764	19980	20197	20414	20633
502	20853	21073	21295	21518	21742	21967	22194	22422	22651	22881
503	23112	23345	23578	23812	24047	24283	24521	24759	24999	25239
504	25481	25724	25968	26213	26459	26706	26954	27203	27453	27704
505	27955	28209	28463	28719	28976	29234	29494	29755	30018	30283
506	30549	30816	31086	31358	31632	31907	32185	32464	32745	33027
507	33311	33597	33883	34171	34461	34752	35044	35338	35634	35931
508	36230	36530	36831	37134	37438	37744	38052	38361	38672	38985
509	39301	39619	39938	40259	40582	40907	41234	41562	41892	42223
510	42556	42891	43227	43564	43902	44242	44583	44926	45270	45616
511	45963	46312	46661	47011	47363	47716	48069	48424	48779	49136
512	49494	49853	50213	50574	50936	51299	51663	52029	52395	52762
513	53130	53498	53869	54240	54612	54985	55359	55734	56110	56488
514	56866	57245	57625	58007	58389	58773	59158	59544	59931	60320
515	60710	61102	61495	61890	62286	62683	63082	63483	63884	64287
516	64692	65098	65506	65915	66326	66738	67151	67566	67981	68398
517	68816	69235	69655	70076	70499	70923	71348	71774	72201	72631
518	73061	73492	73925	74359	74795	75232	75670	76110	76550	76993
519	77436	77881	78327	78774	79222	79672	80122	80574	81027	81480
520	81935	82391	82847	83305	83764	84223	84684	85145	85608	86072
521	86536	87002	87469	87937	88406	88876	89347	89820	90294	90769
522	91245	91723	92202	92682	93164	93646	94130	94614	95100	95587
523	96076	96565	97055	97547	98040	98534	99029	99525	100023	100522
524	101022	101523	102026	102530	103036	103542	104050	104559	105070	105582
525	106094	106609	107124	107641	108160	108679	109200	109723	110247	110773
526	111299	111828	112358	112889	113421	113955	114490	115027	115565	116104
527	116645	117186	117730	118274	118820	119367	119915	120465	121016	121569
528	122123	122678	123235	123793	124352	124913	125474	126038	126602	127168
529	127735	128303	128873	129443	130016	130590	131165	131741	132319	132898

Grapevine Lake
RESERVOIR VOLUME TABLE (continued)

TEXAS WATER DEVELOPMENT BOARD MAY 2002 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
530	133479	134061	134645	135230	135817	136405	136994	137586	138178	138773
531	139368	139965	140565	141165	141768	142372	142978	143585	144194	144805
532	145418	146032	146648	147265	147885	148505	149128	149752	150378	151007
533	151636	152267	152901	153536	154174	154813	155455	156099	156744	157392
534	158042	158694	159348	160005	160664	161325	161988	162654	163330	164015
535	164703	165394	166087	166781	167478	168177	168878	169581	170286	170993
536	171701	172411	173123	173836	174551	175268	175986	176707	177428	178152
537	178877	179604	180333	181063	181795	182528	183263	184000	184738	185479
538	186220	186964	187709	188456	189204	189954	190706	191459	192214	192971
539	193729	194489	195251	196014	196779	197545	198313	199083	199854	200627
540	201402									

Appendix B

Grapevine Lake

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD MAY 2002 SURVEY

AREA IN ACRES ELEVATION INCREMENT IS ONE TENTH FOOT

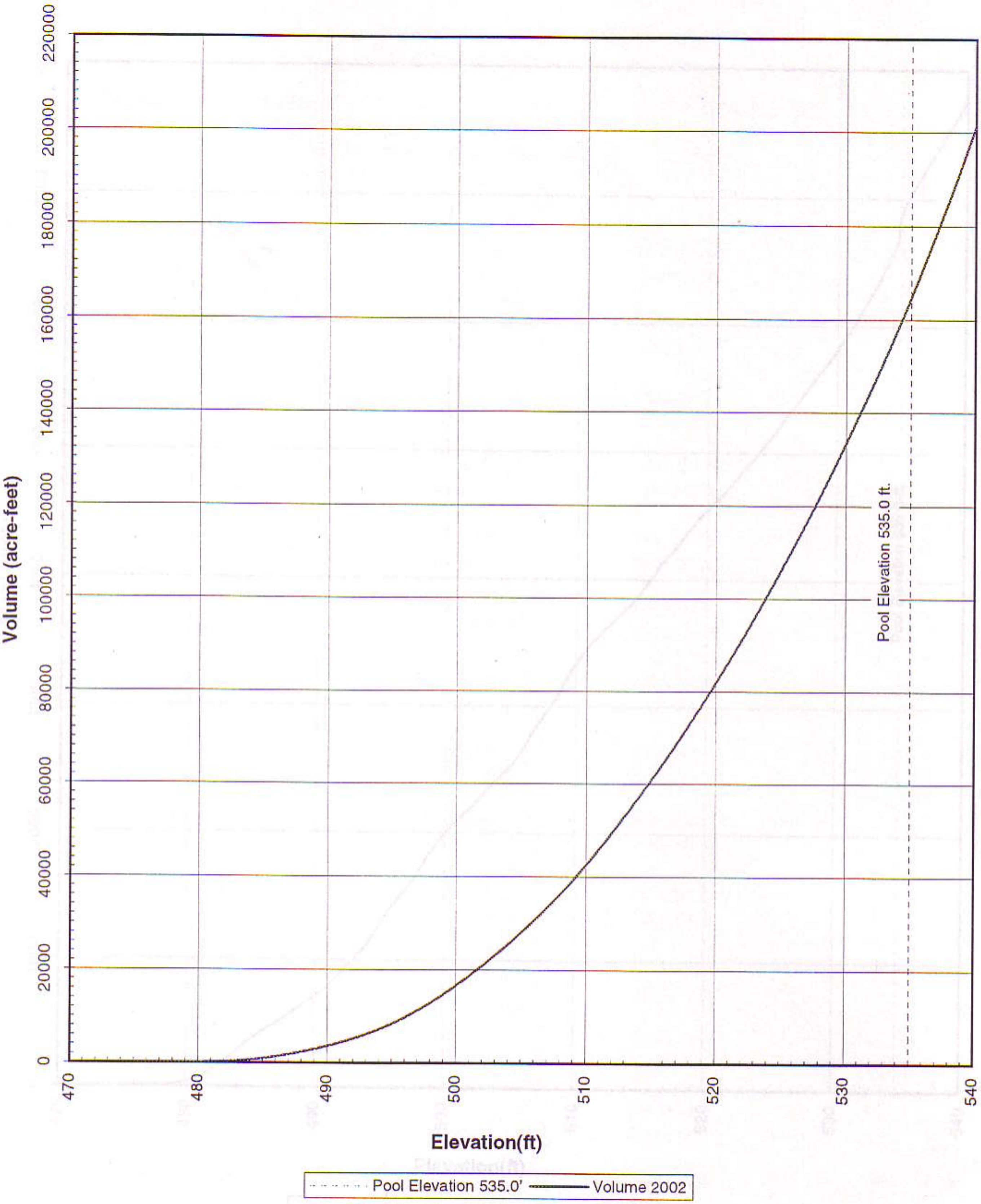
ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
473							0	0	0	0
474	0	0	0	0	0	1	1	1	1	1
475	1	1	2	2	2	2	2	3	3	3
476	3	4	4	4	4	5	5	5	6	6
477	7	7	8	8	9	9	10	10	11	12
478	12	13	13	14	15	15	16	17	17	18
479	19	20	21	22	23	24	26	27	29	32
480	34	36	38	41	44	48	51	55	59	64
481	68	73	78	83	89	95	101	107	115	123
482	130	138	146	154	162	170	178	185	193	200
483	207	214	222	229	237	246	254	262	269	277
484	286	295	304	313	322	331	340	349	356	362
485	369	376	385	392	399	406	413	420	428	435
486	443	450	456	462	467	473	479	485	491	497
487	503	509	516	523	530	537	543	550	557	564
488	571	578	585	592	598	605	612	619	626	633
489	641	649	657	665	673	680	687	695	702	709
490	716	723	730	737	745	752	760	767	775	783
491	792	801	810	820	829	839	849	860	872	883
492	894	905	918	930	943	956	967	977	987	997
493	1007	1017	1027	1038	1048	1060	1072	1084	1098	1112
494	1125	1139	1153	1166	1180	1195	1212	1230	1248	1265
495	1281	1296	1311	1327	1343	1360	1375	1391	1406	1422
496	1435	1447	1459	1471	1483	1495	1508	1521	1533	1545
497	1557	1570	1584	1596	1610	1623	1637	1651	1667	1683
498	1699	1716	1733	1752	1770	1787	1805	1820	1835	1849
499	1862	1877	1890	1902	1915	1927	1941	1955	1969	1981
500	1994	2006	2018	2030	2041	2051	2061	2072	2082	2093
501	2103	2114	2124	2134	2144	2153	2163	2173	2182	2192
502	2202	2212	2223	2234	2246	2259	2273	2285	2296	2307
503	2317	2327	2337	2347	2357	2368	2380	2390	2400	2411
504	2422	2434	2445	2456	2466	2475	2484	2494	2503	2514
505	2525	2537	2550	2564	2578	2592	2606	2621	2635	2651
506	2669	2689	2708	2726	2746	2766	2784	2802	2817	2832
507	2846	2861	2874	2887	2901	2917	2933	2948	2964	2979
508	2994	3008	3022	3036	3052	3067	3084	3101	3121	3143
509	3166	3186	3204	3221	3239	3257	3275	3291	3307	3322
510	3337	3352	3365	3378	3391	3405	3420	3435	3450	3465
511	3477	3489	3499	3510	3520	3530	3540	3551	3562	3573
512	3585	3596	3606	3616	3626	3636	3646	3656	3665	3675
513	3685	3695	3705	3716	3727	3737	3746	3756	3766	3777
514	3787	3798	3809	3820	3832	3843	3854	3867	3880	3895
515	3910	3925	3939	3954	3968	3983	3996	4009	4024	4040
516	4055	4071	4086	4100	4113	4126	4139	4151	4162	4173
517	4184	4195	4207	4219	4231	4243	4256	4269	4283	4296
518	4309	4322	4335	4348	4362	4377	4390	4402	4416	4428
519	4441	4453	4466	4478	4489	4500	4511	4521	4531	4542
520	4552	4562	4572	4581	4591	4601	4611	4621	4631	4642
521	4652	4663	4674	4685	4696	4708	4719	4731	4744	4757
522	4772	4785	4796	4807	4819	4831	4842	4853	4864	4876
523	4888	4899	4910	4922	4933	4945	4957	4970	4982	4995
524	5009	5022	5034	5047	5060	5073	5086	5099	5111	5123
525	5136	5149	5163	5177	5190	5204	5218	5233	5248	5263
526	5278	5291	5304	5318	5331	5345	5358	5372	5386	5399
527	5412	5425	5438	5451	5464	5478	5492	5505	5519	5533
528	5546	5560	5573	5586	5599	5612	5625	5637	5650	5663
529	5676	5690	5703	5717	5730	5744	5758	5772	5786	5800

Grapevine Lake
RESERVOIR AREA TABLE (continued)

TEXAS WATER DEVELOPMENT BOARD — MAY 2002 SURVEY

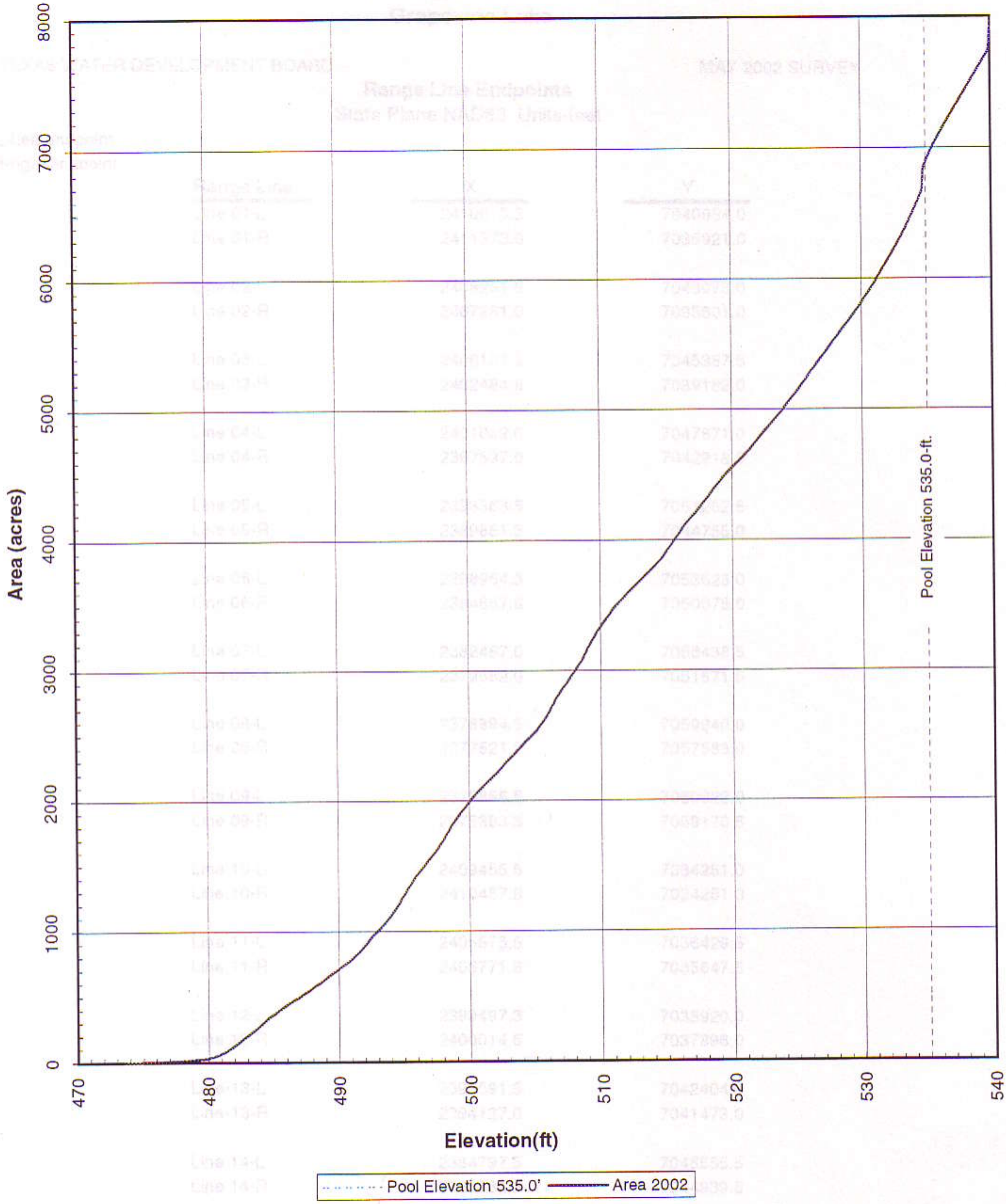
AREA IN ACRES — ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
530	5815	5830	5844	5859	5874	5889	5904	5919	5934	5950
531	5966	5982	5999	6016	6033	6050	6066	6083	6100	6116
532	6133	6150	6167	6184	6201	6218	6235	6253	6270	6288
533	6306	6324	6344	6363	6384	6405	6426	6447	6468	6489
534	6511	6532	6554	6576	6599	6622	6646	6673	6842	6868
535	6893	6916	6938	6959	6980	7000	7020	7039	7057	7074
536	7092	7109	7126	7143	7160	7176	7193	7210	7227	7243
537	7260	7277	7293	7310	7327	7343	7360	7376	7393	7410
538	7426	7443	7459	7476	7492	7509	7525	7542	7558	7574
539	7591	7607	7624	7640	7656	7673	7689	7706	7722	7738
540	7917									



Lake Grapevine
May 2002
Prepared by: TWDB

Appendix C Elevation vs. Volume



Grapvine Lake
May 2002
Prepared by: TWDB

Appendix D Elevation vs. Area

Appendix E

Grapevine Lake

TEXAS WATER DEVELOPMENT BOARD MAY 2002 SURVEY

Range Line Endpoints

State Plane NAD83 Units-feet

L-Left endpoint
R-right endpoint

Range Line	X	Y
Line 01-L	2410615.3	7040954.0
Line 01-R	2411373.0	7035921.0
Line 02-L	2408291.5	7043078.0
Line 02-R	2407281.0	7035601.0
Line 03-L	2406101.3	7045387.5
Line 03-R	2402484.8	7039182.0
Line 04-L	2401082.0	7047871.0
Line 04-R	2397537.0	7042218.5
Line 05-L	2393363.5	7051252.5
Line 05-R	2389881.3	7044755.0
Line 06-L	2388954.3	7053628.0
Line 06-R	2384667.8	7050078.0
Line 07-L	2382487.0	7056438.5
Line 07-R	2379682.0	7051871.5
Line 08-L	2378894.5	7059940.0
Line 08-R	2377521.8	7057583.0
Line 09-L	2375858.5	7060922.0
Line 09-R	2375383.3	7059170.5
Line 10-L	2409455.5	7034251.0
Line 10-R	2410457.8	7034251.0
Line 11-L	2405575.5	7036429.5
Line 11-R	2406771.8	7035647.5
Line 12-L	2399497.3	7038920.0
Line 12-R	2400014.5	7037896.0
Line-13-L	2393091.5	7042404.0
Line-13-R	2394127.0	7041473.0
Line 14-L	2384797.5	7045555.5
Line 14-R	2385332.3	7044939.5
Line 15-L	2384723.8	7057079.0
Line 15-R	2383944.5	7057346.0

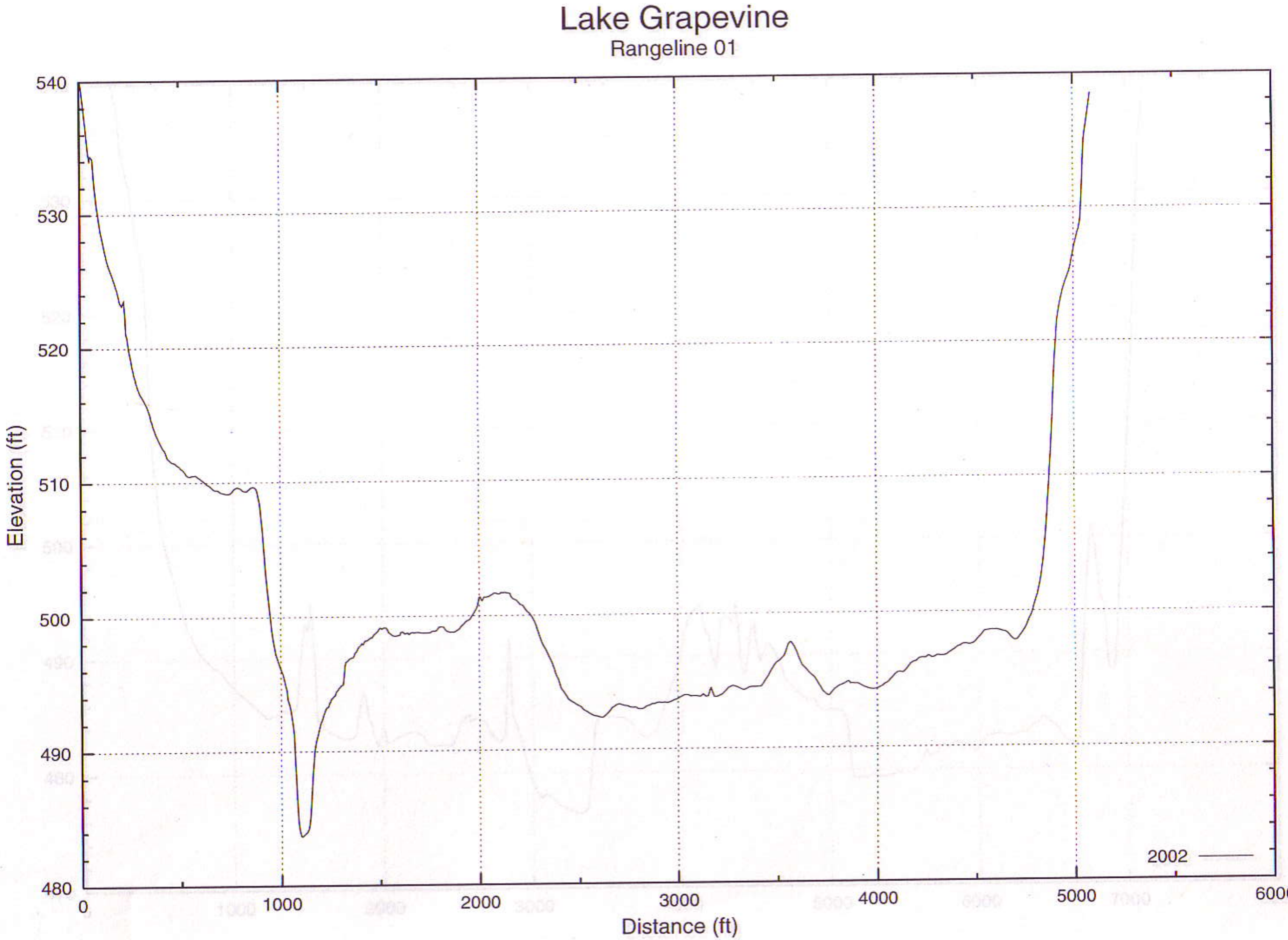
Appendix E (Continued)
Grapevine Lake

TEXAS WATER DEVELOPMENT BOARD MAY 2002 SURVEY

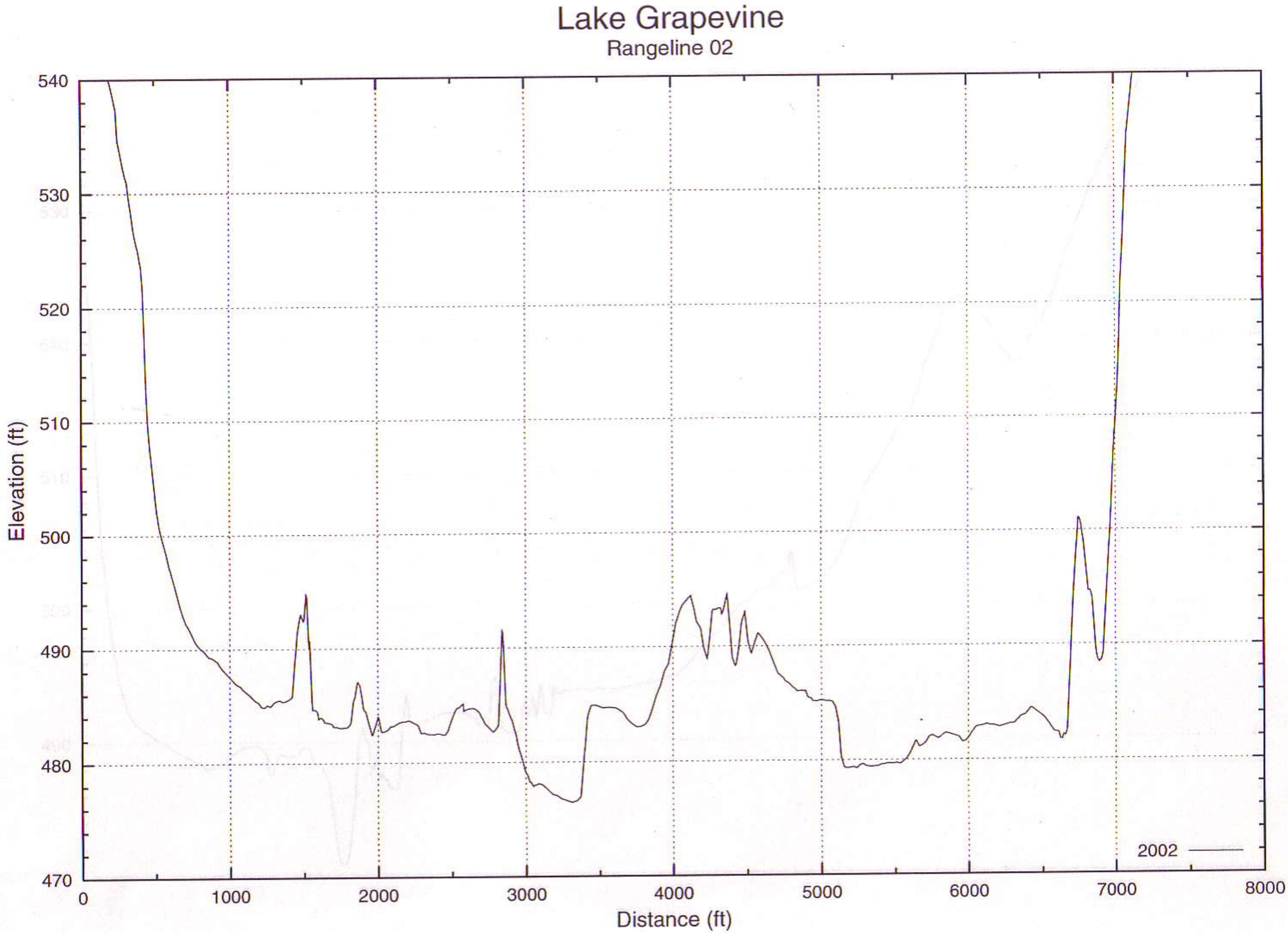
Range Line Endpoints
State Plane NAD83 Units-feet

L-Left endpoint
R-right endpoint

Range Line	X	Y
Line 16-L	2395755.3	7051455.0
Line 16-R	2395375.8	7051442.0
Line 17-L	2397402.8	7051506.0
Line 17-R	2396683.5	7051483.5
Line 18-L	2403543.0	7047716.0
Line 18-R	2402839.8	7048534.5

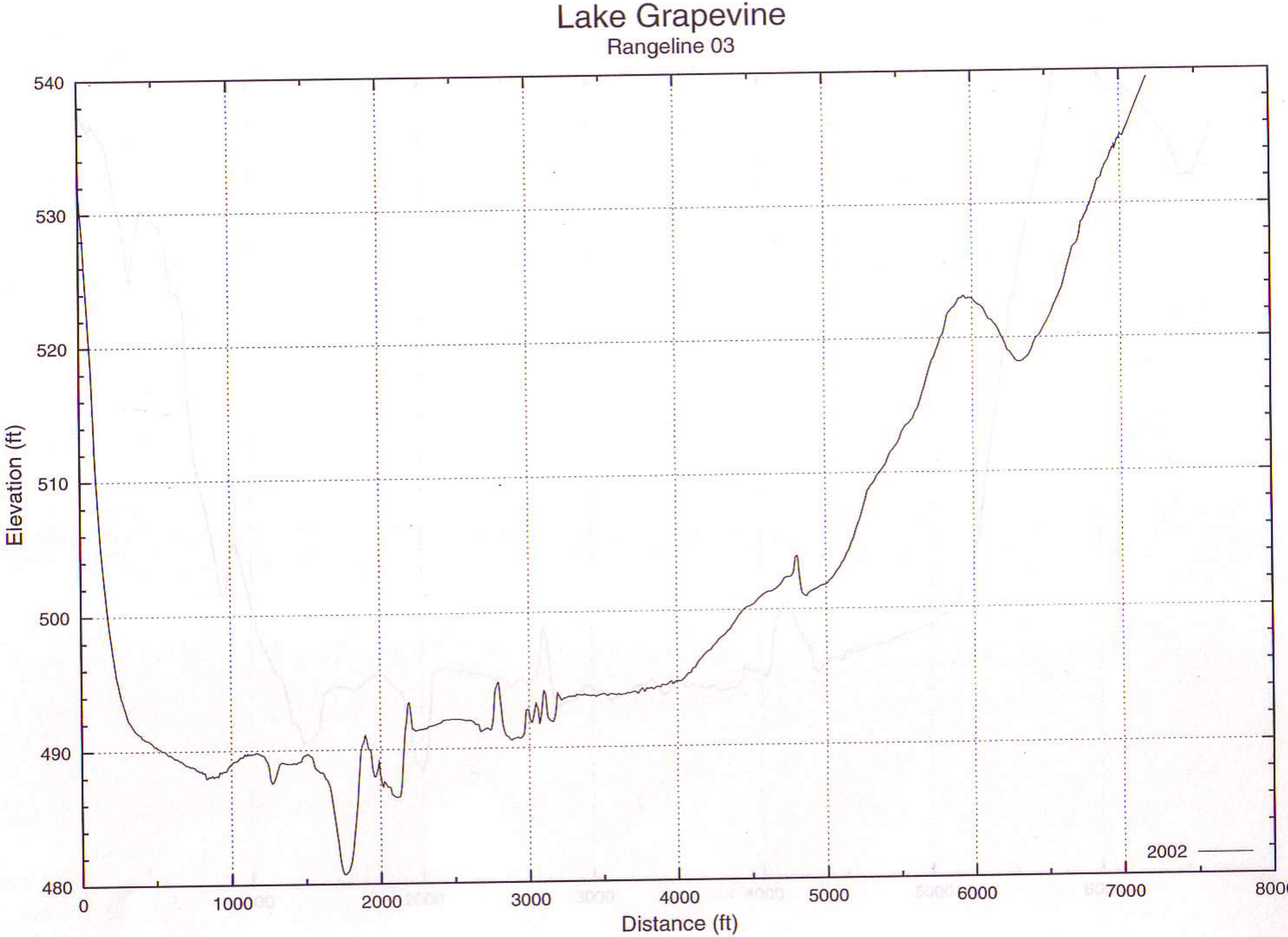


Lake Grapevine
Rangeline 01
Elevation (ft)
540
530
520
510
500
490
480
Distance (ft)
0
1000
2000
3000
4000
5000
6000
2002

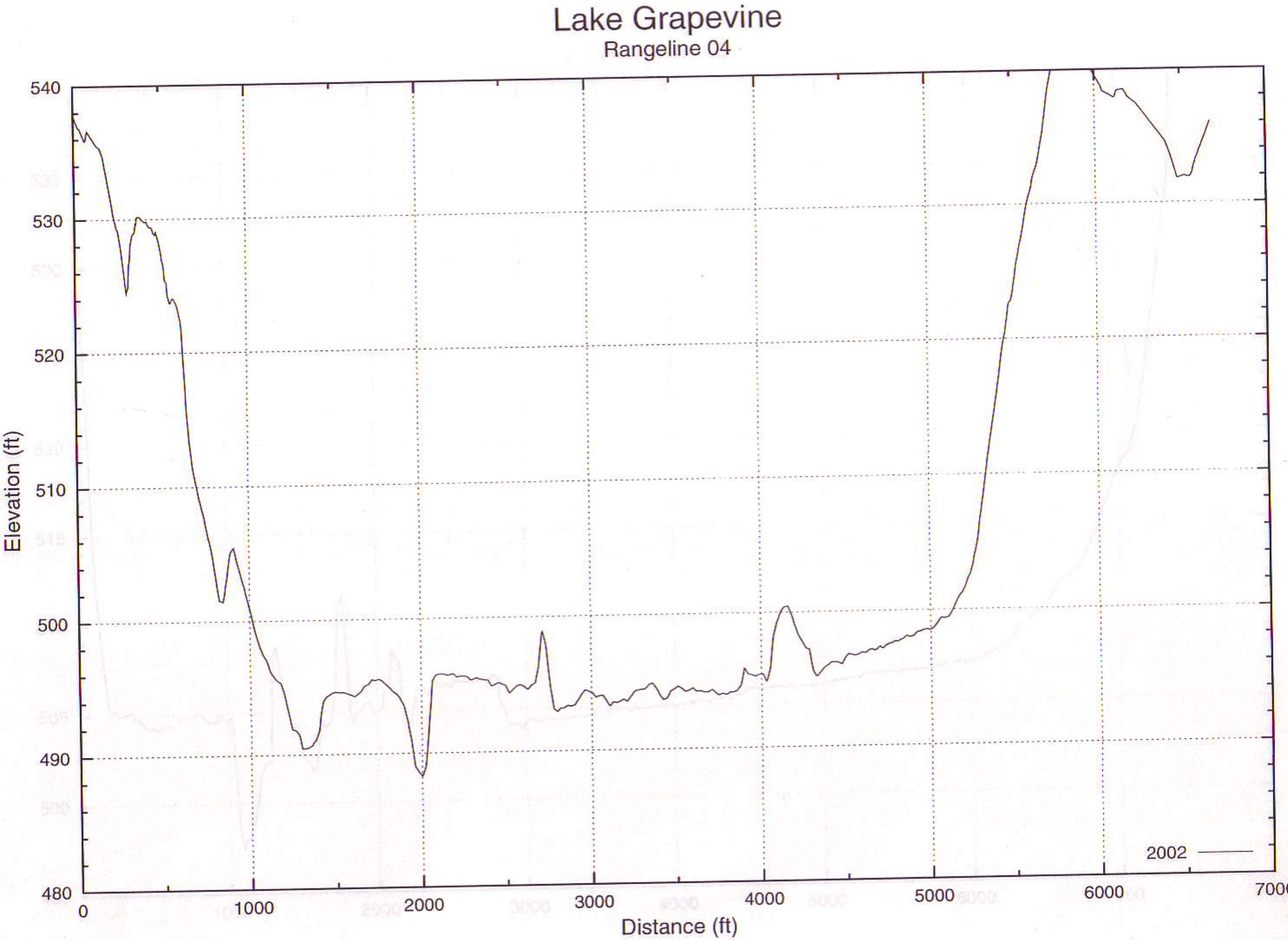


Lake Grapevine
Rangeline 02
540
530
520
510
500
490
480
470
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
Distance (ft)
2002

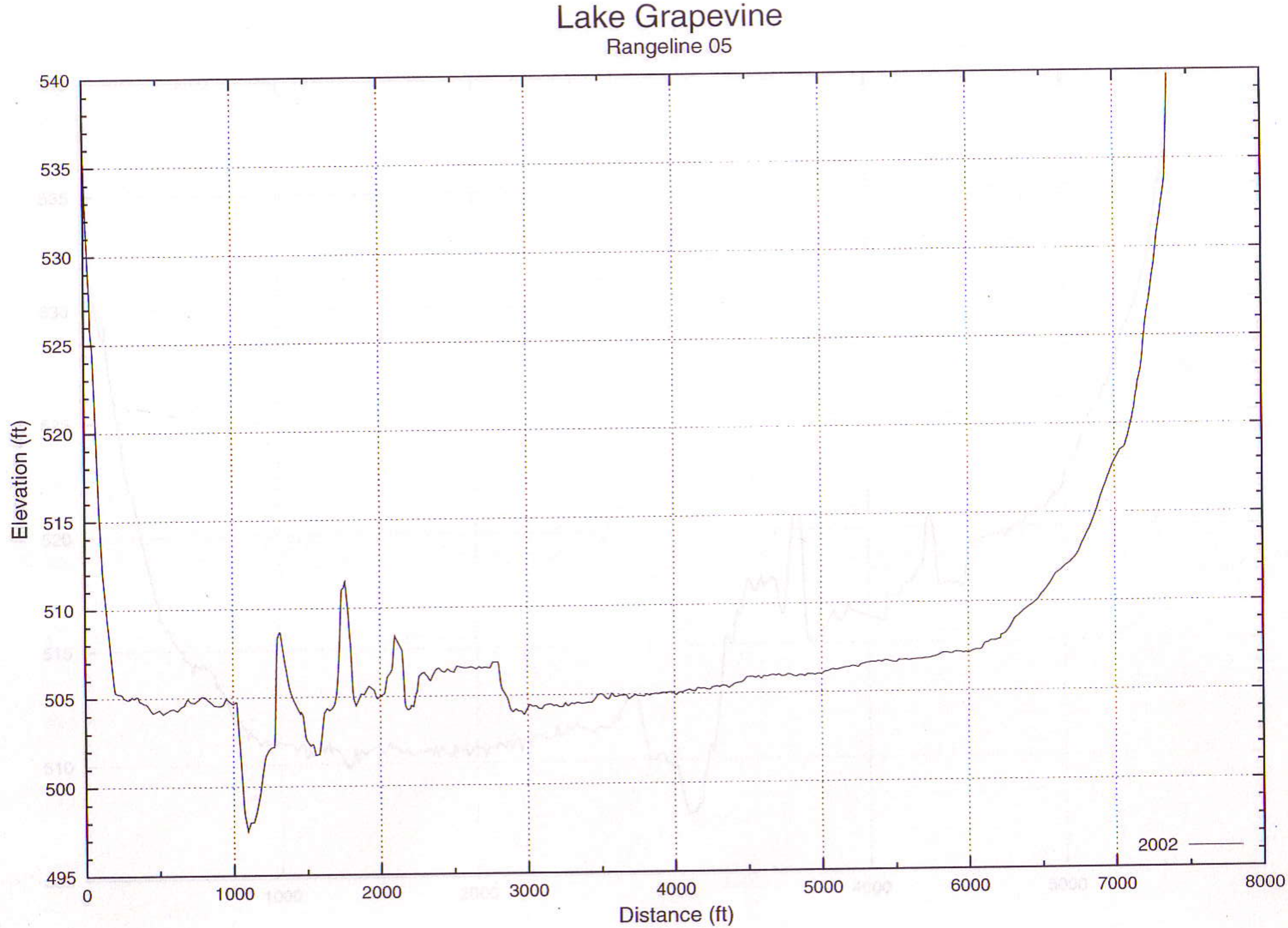
Appendix F

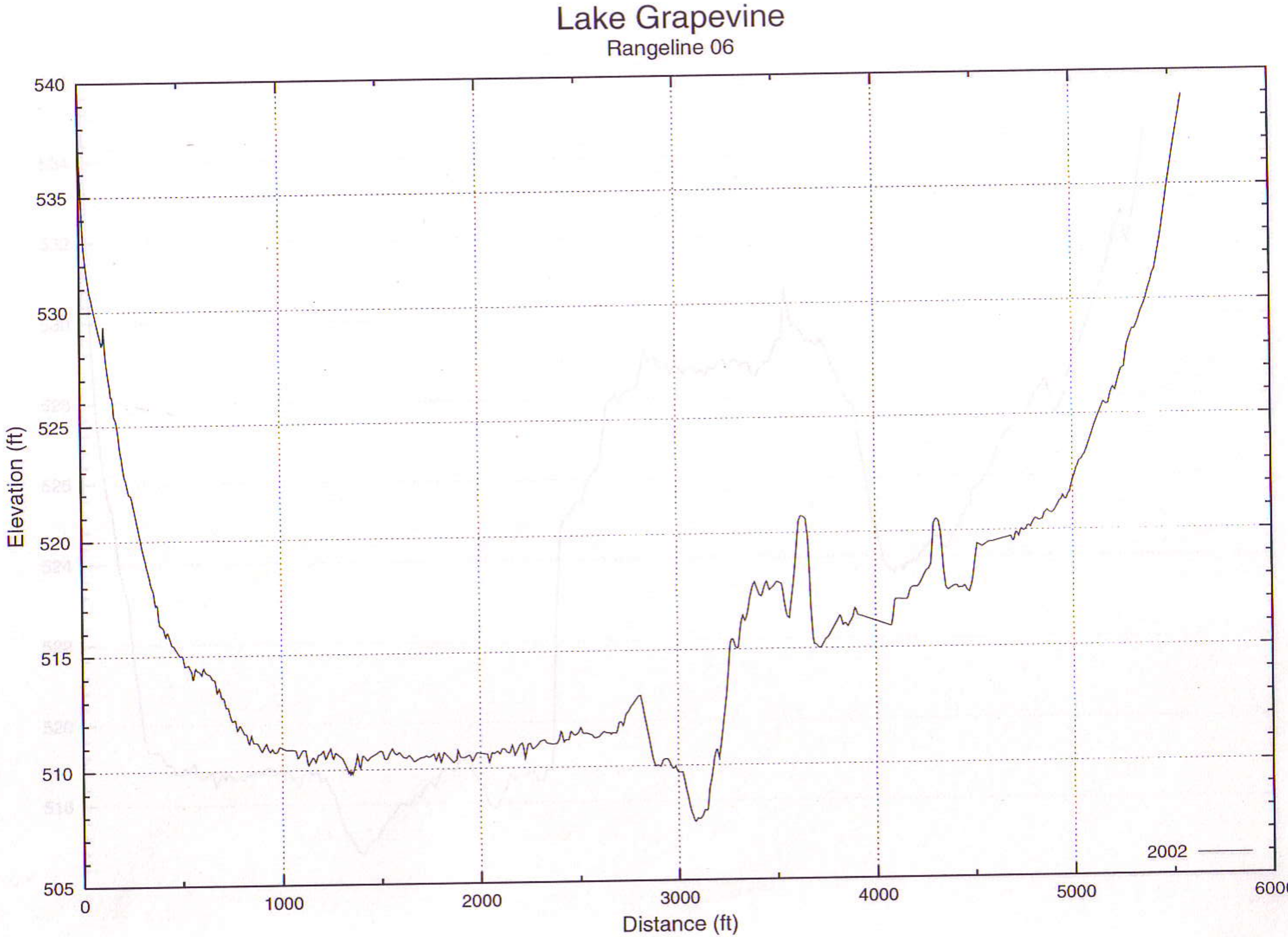

Lake Grapevine
Rangeline 03
540
530
520
510
500
490
480
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
Distance (ft)
2002

Appendix F


Lake Grapevine
Rangeline 04
540
530
520
510
500
490
480
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
7000
Distance (ft)
2002

Appendix F

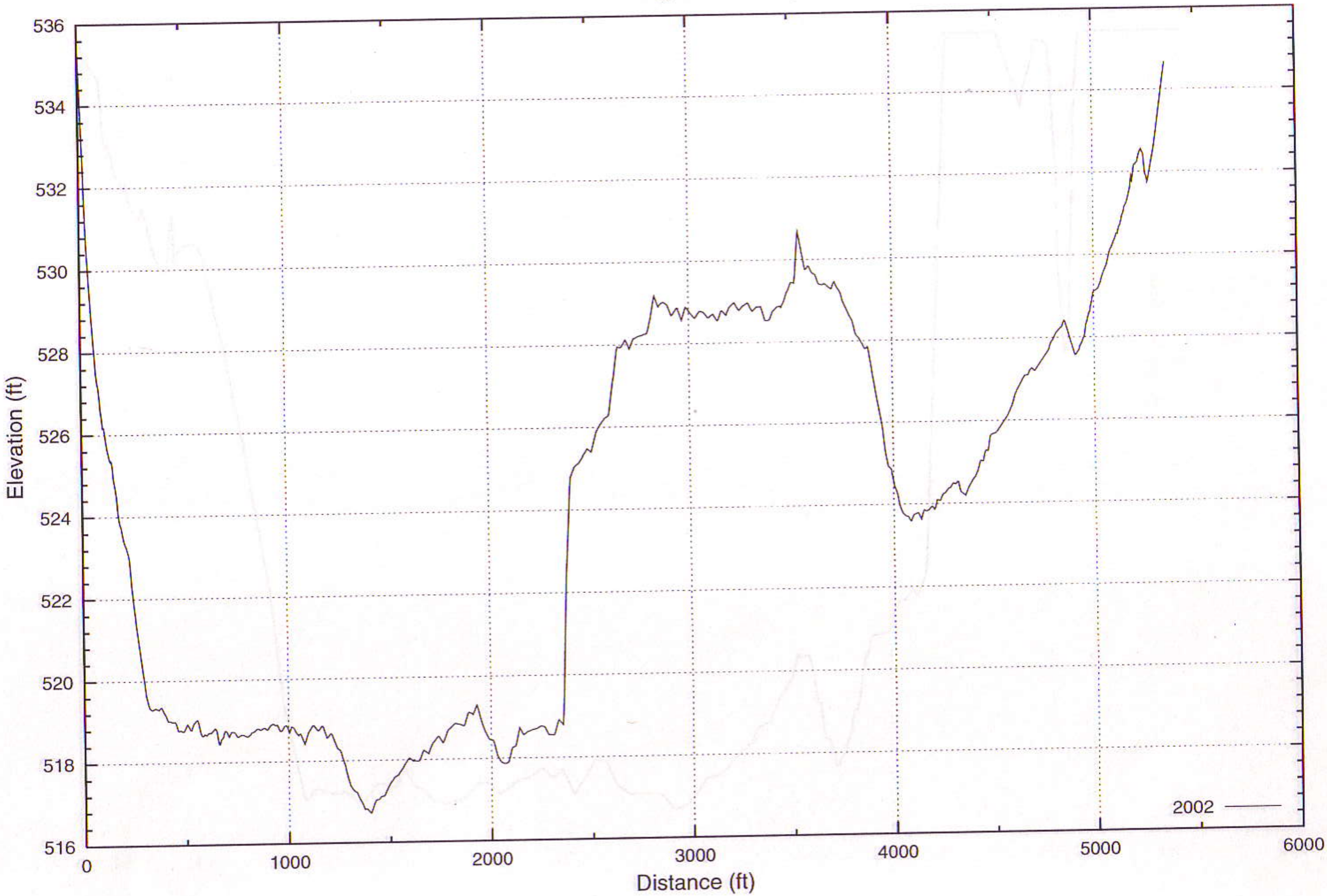

Lake Grapevine
Rangeline 05
Elevation (ft)
540
535
530
525
520
515
510
505
500
495
Distance (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
2002

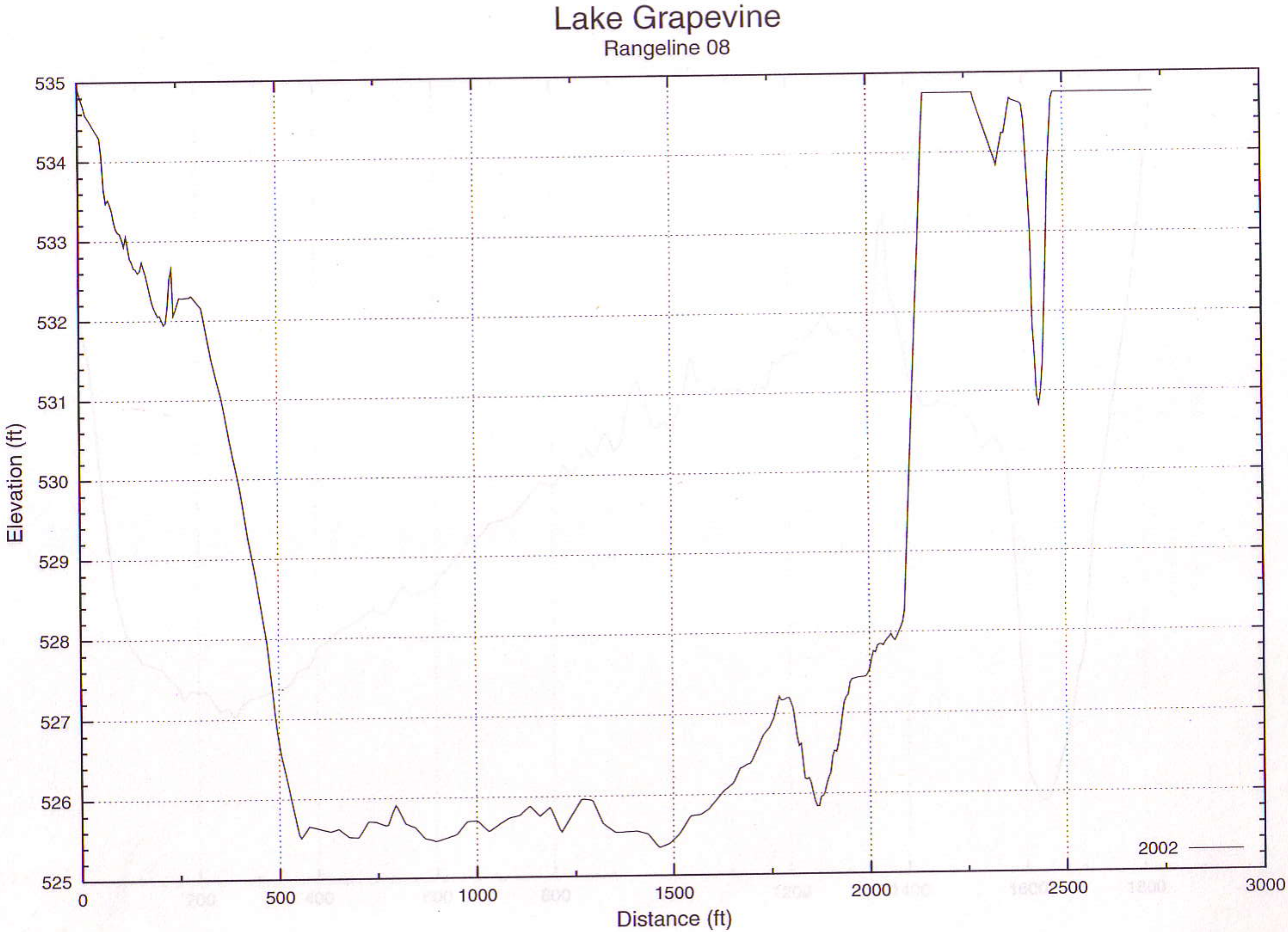

Lake Grapevine
Rangeline 06
Elevation (ft)
540
535
530
525
520
515
510
505
0
1000
2000
3000
4000
5000
6000
Distance (ft)
2002

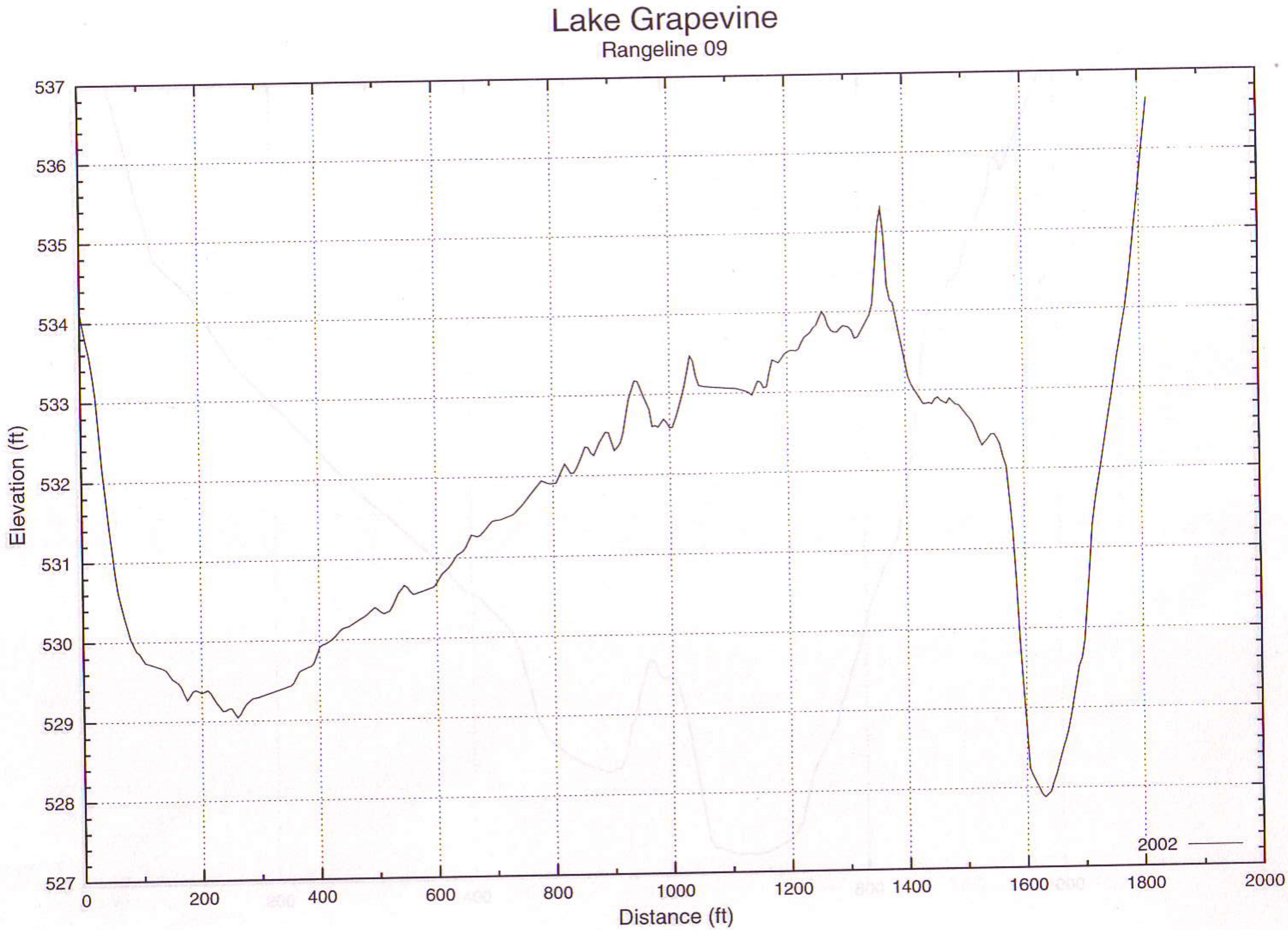
Appendix F

Lake Grapevine

Rangeline 07

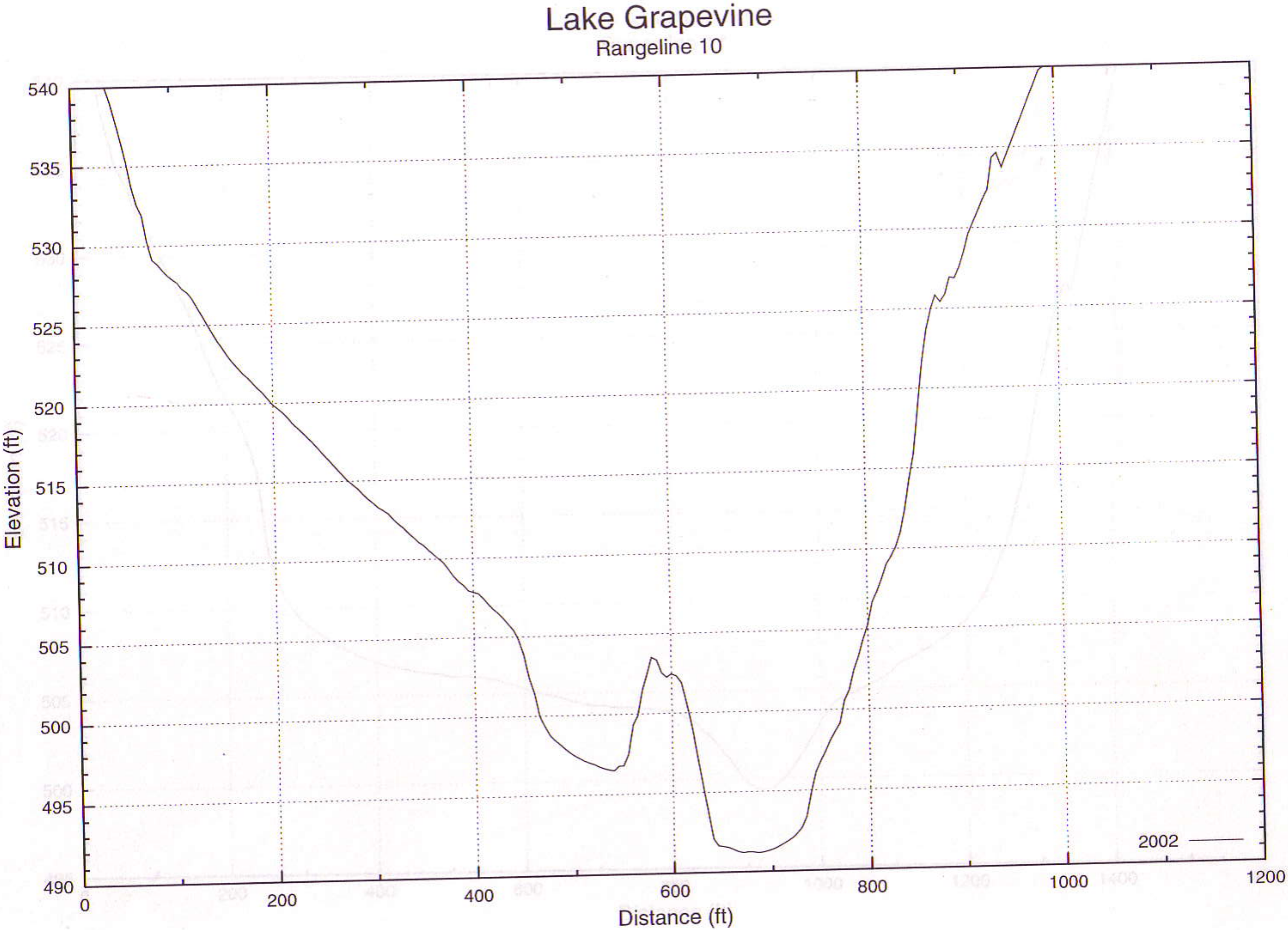


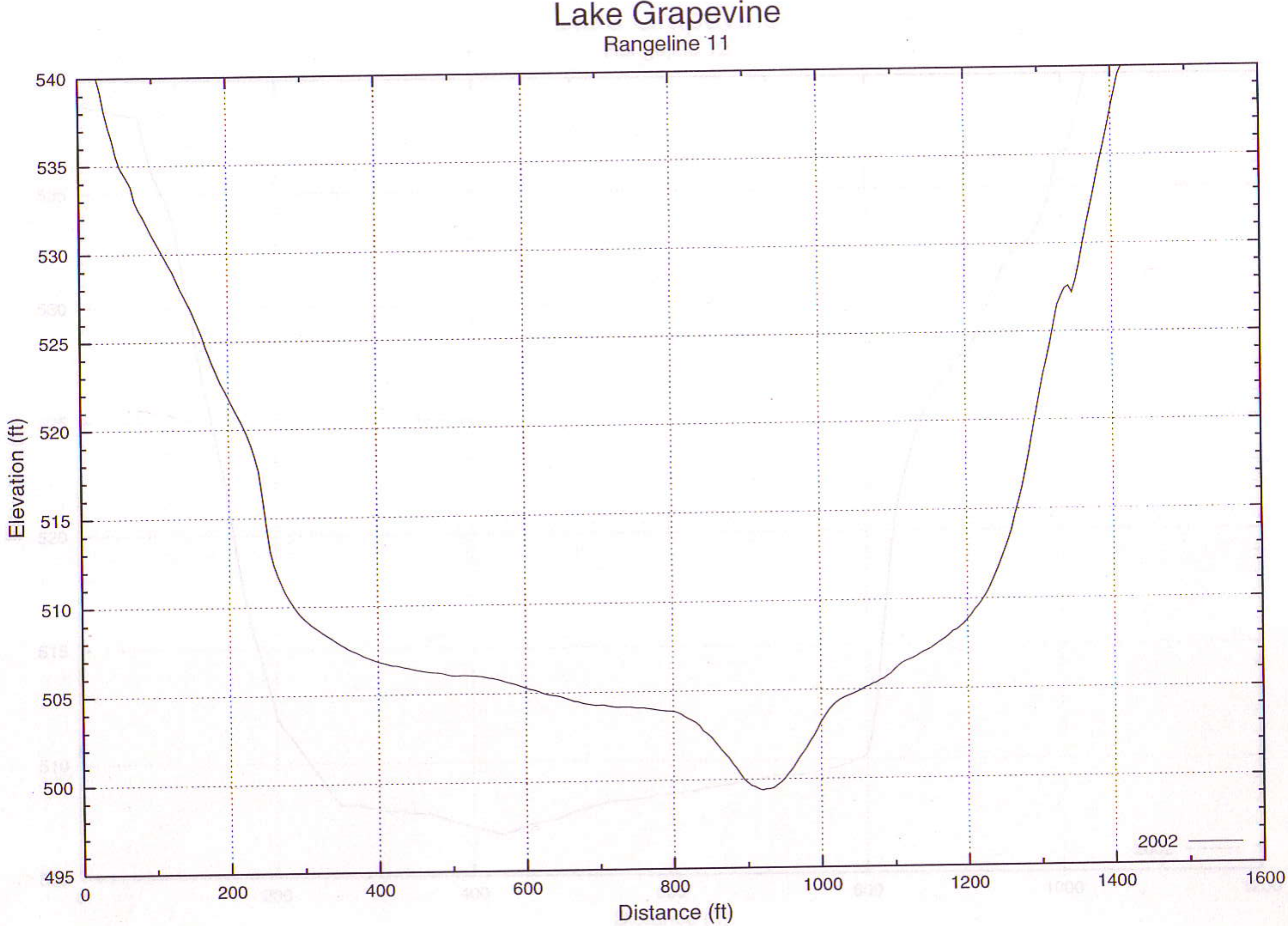

Lake Grapevine
Rangeline 08
Elevation (ft)
535
534
533
532
531
530
529
528
527
526
525
Distance (ft)
0
500
1000
1500
2000
2500
3000
2002



Lake Grapevine
Rangeline 09
537
536
535
534
533
532
531
530
529
528
527
Elevation (ft)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Distance (ft)
2002

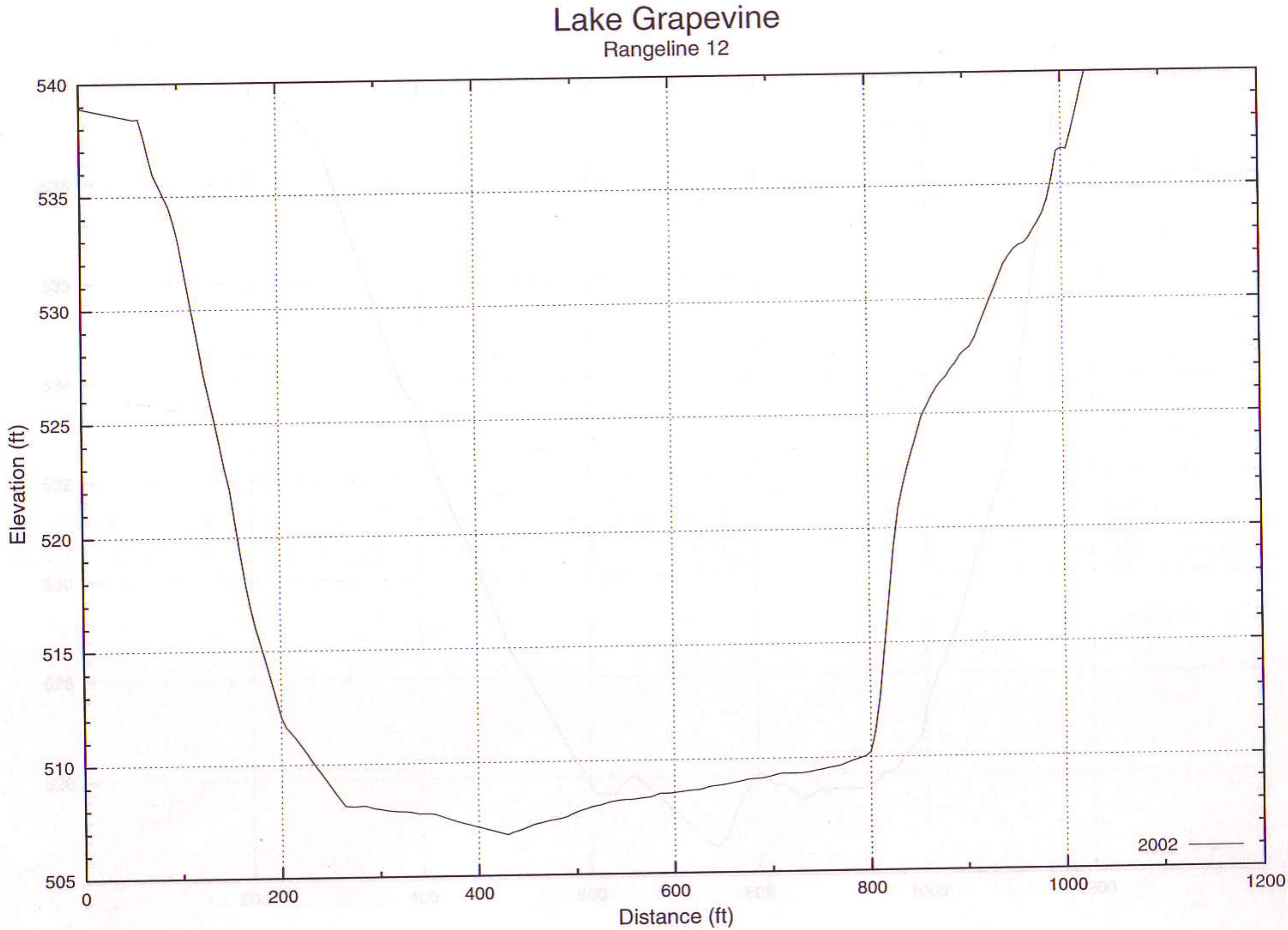
Appendix F


Lake Grapevine
Rangeline 10
Elevation (ft)
540
535
530
525
520
515
510
505
500
495
490
0
200
400
600
800
1000
1200
Distance (ft)
2002



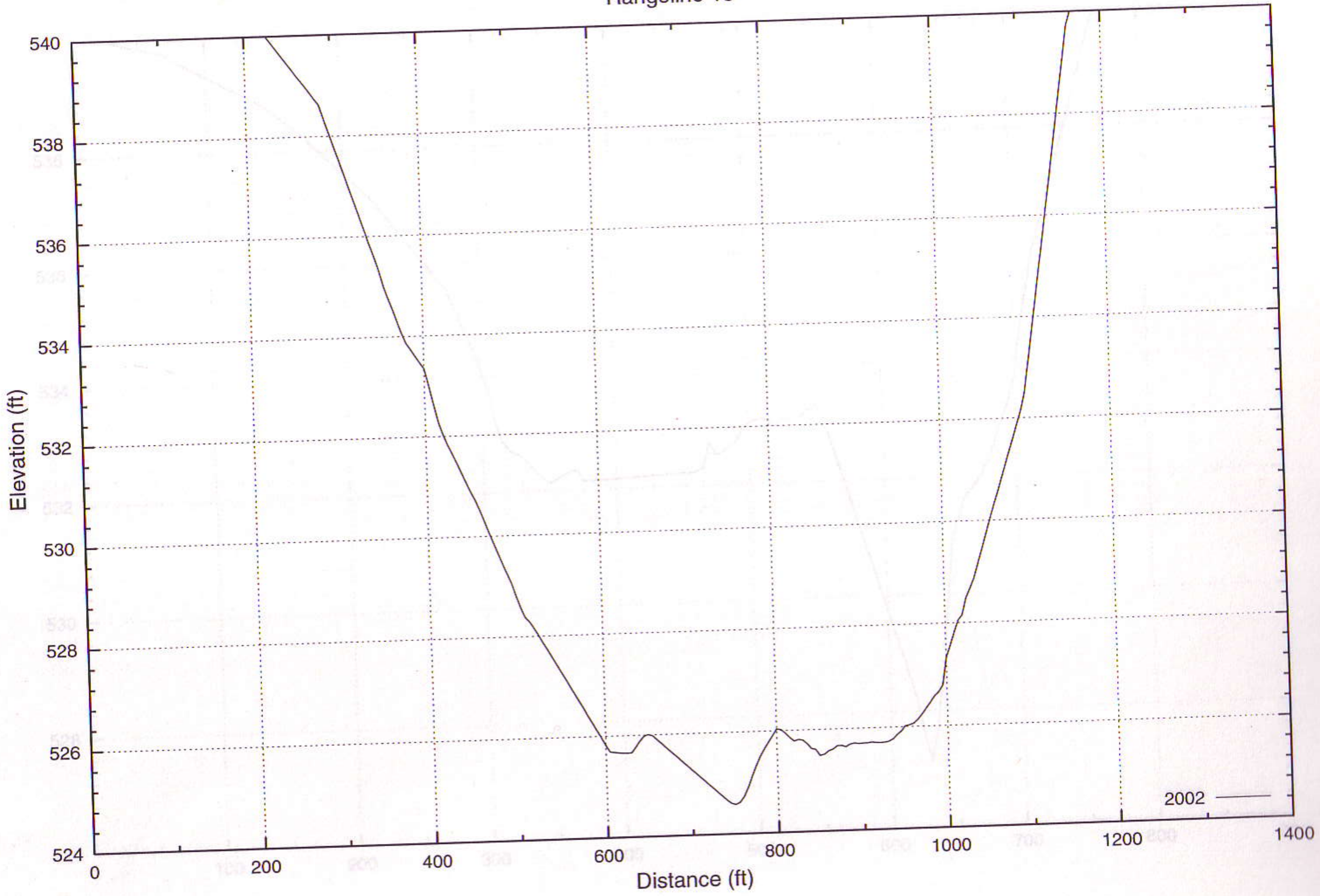
Lake Grapevine
Rangeline 11
Elevation (ft)
540
535
530
525
520
515
510
505
500
495
0
200
400
600
800
1000
1200
1400
1600
Distance (ft)
2002

Appendix F

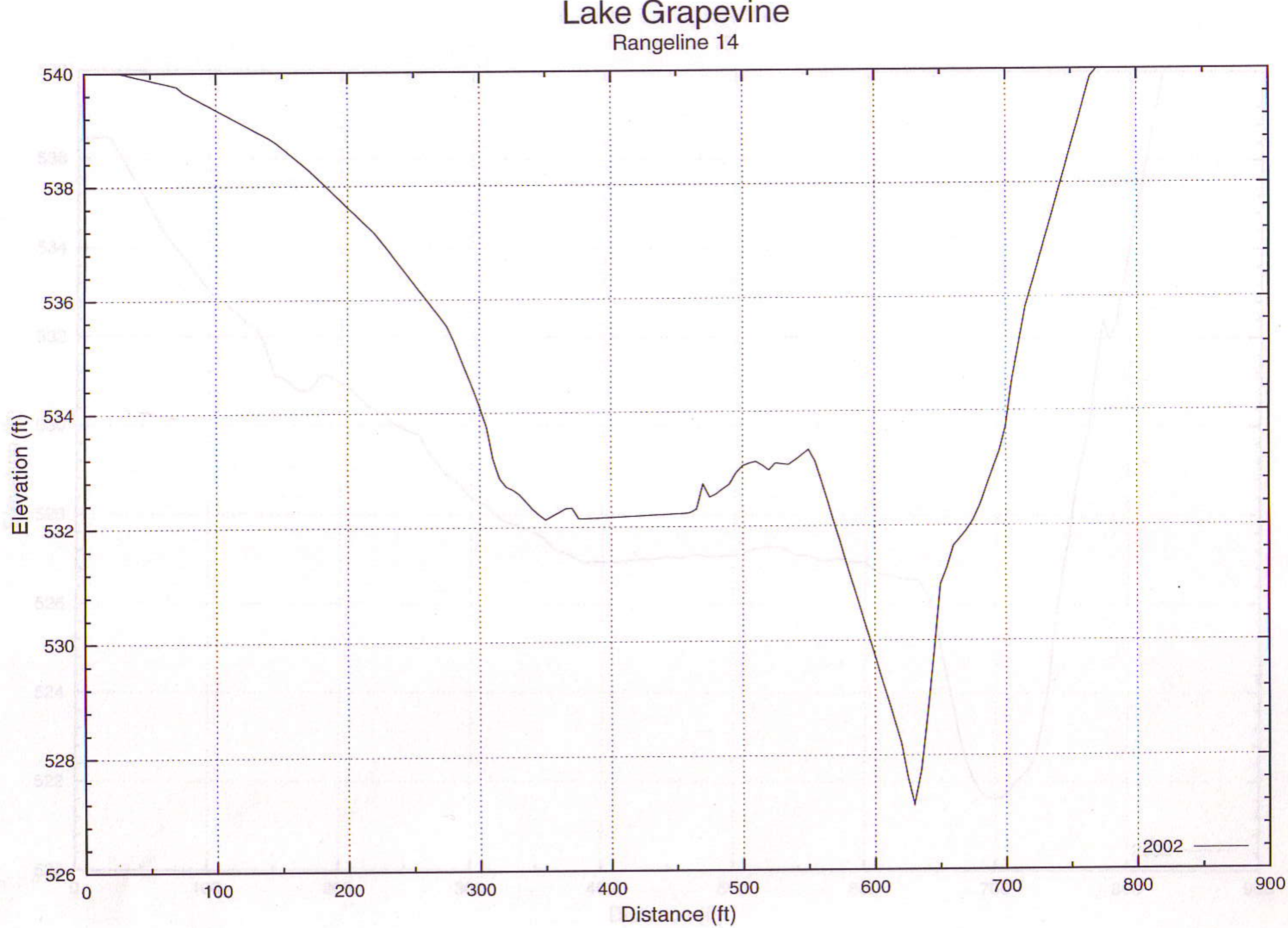

Lake Grapevine
Rangeline 12
540
535
530
525
520
515
510
505
Elevation (ft)
0
200
400
600
800
1000
1200
Distance (ft)
2002

Lake Grapevine

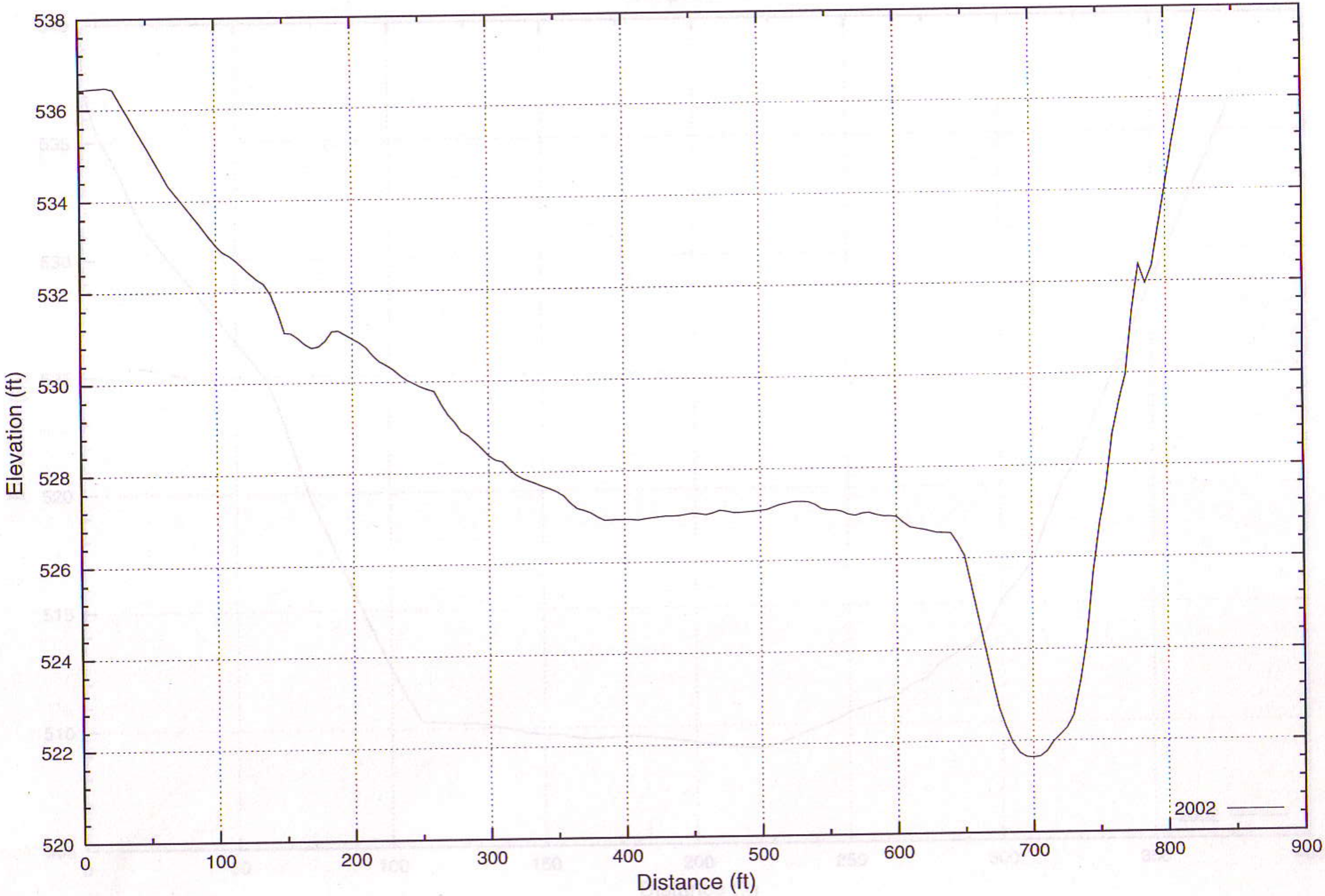
Rangeline 13



Appendix F

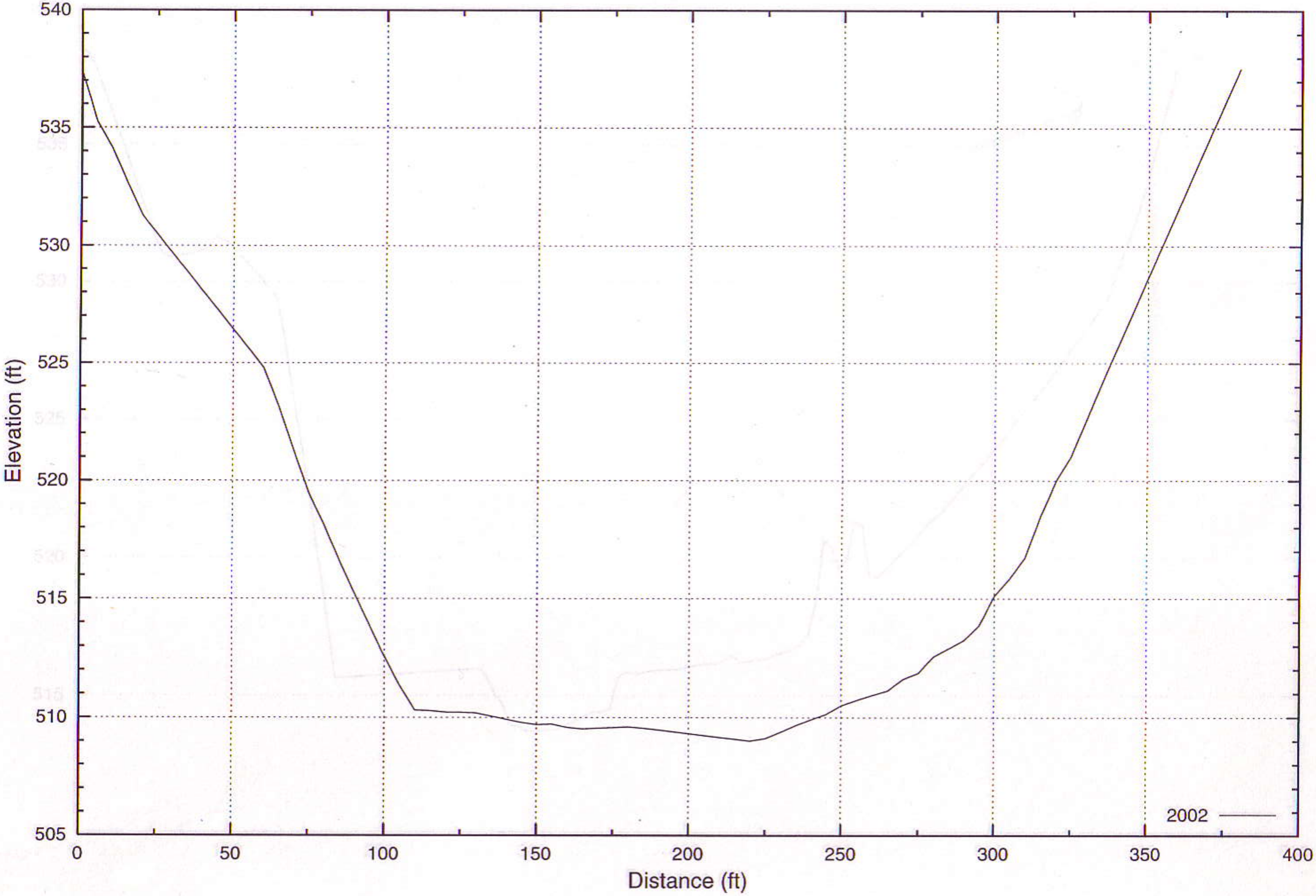

Lake Grapevine
Rangeline 14
Elevation (ft)
540
538
536
534
532
530
528
526
0
100
200
300
400
500
600
700
800
900
Distance (ft)
2002

Lake Grapevine
Rangeline 15



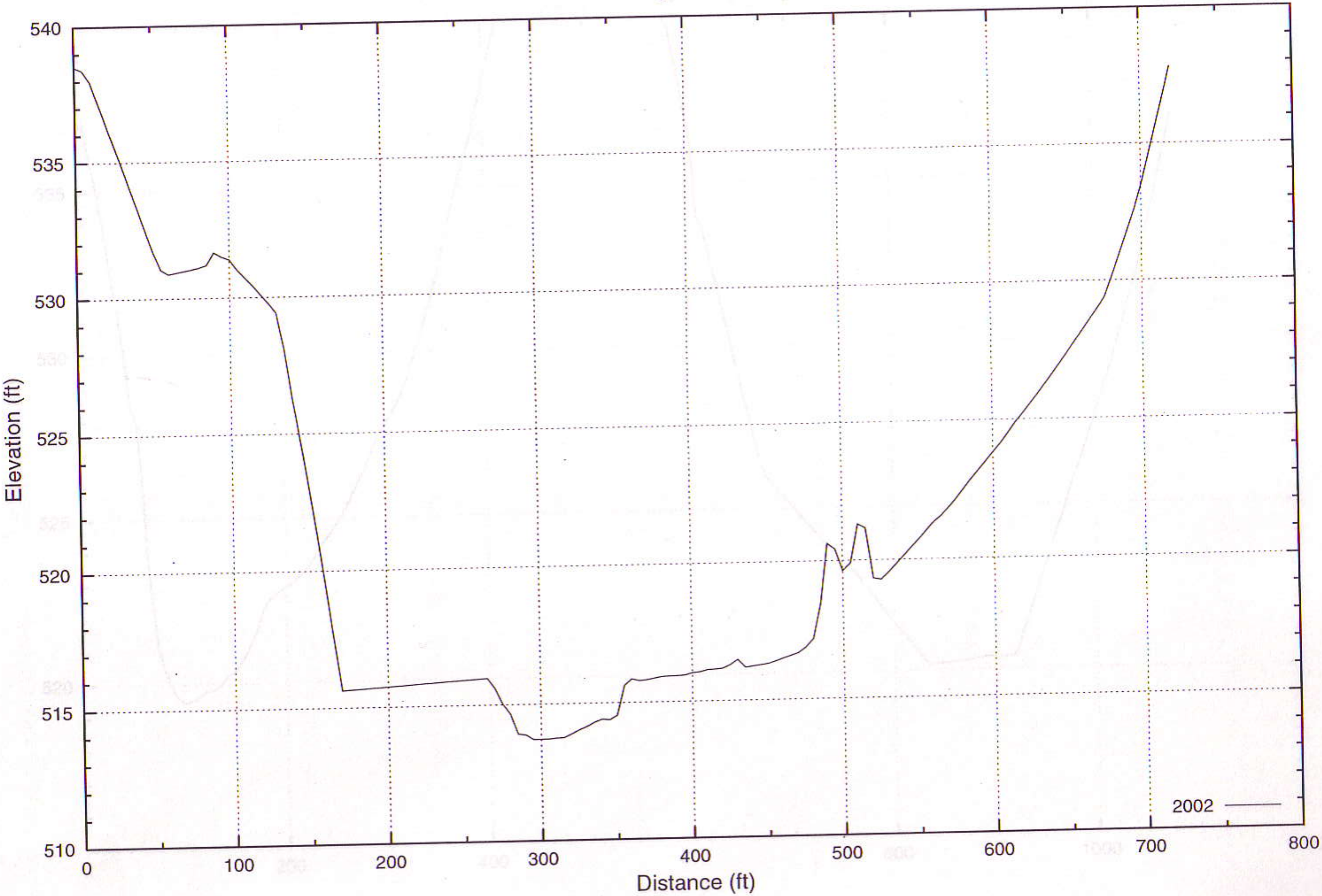
Appendix F

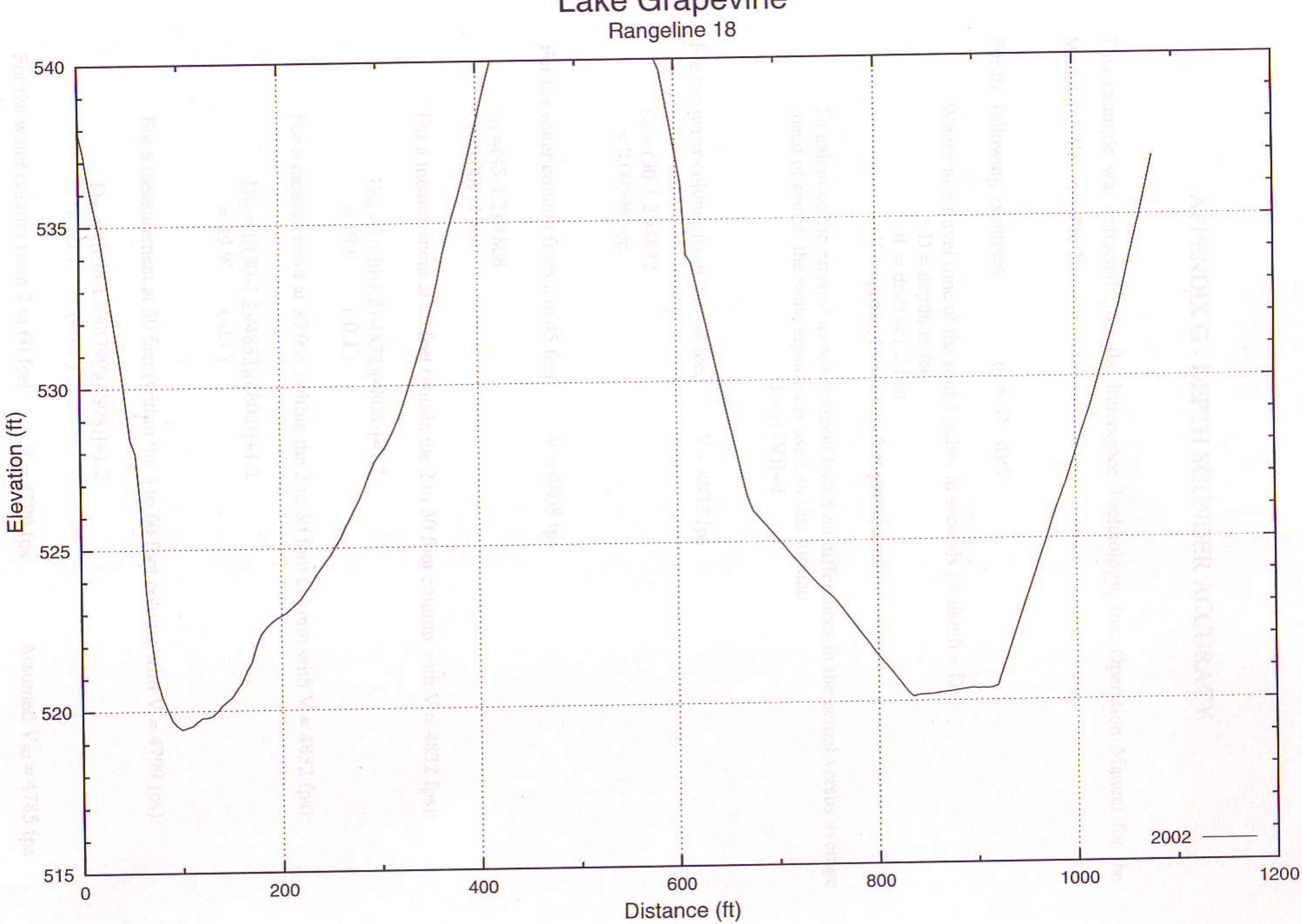
Lake Grapevine
Rangeline 16



Lake Grapevine

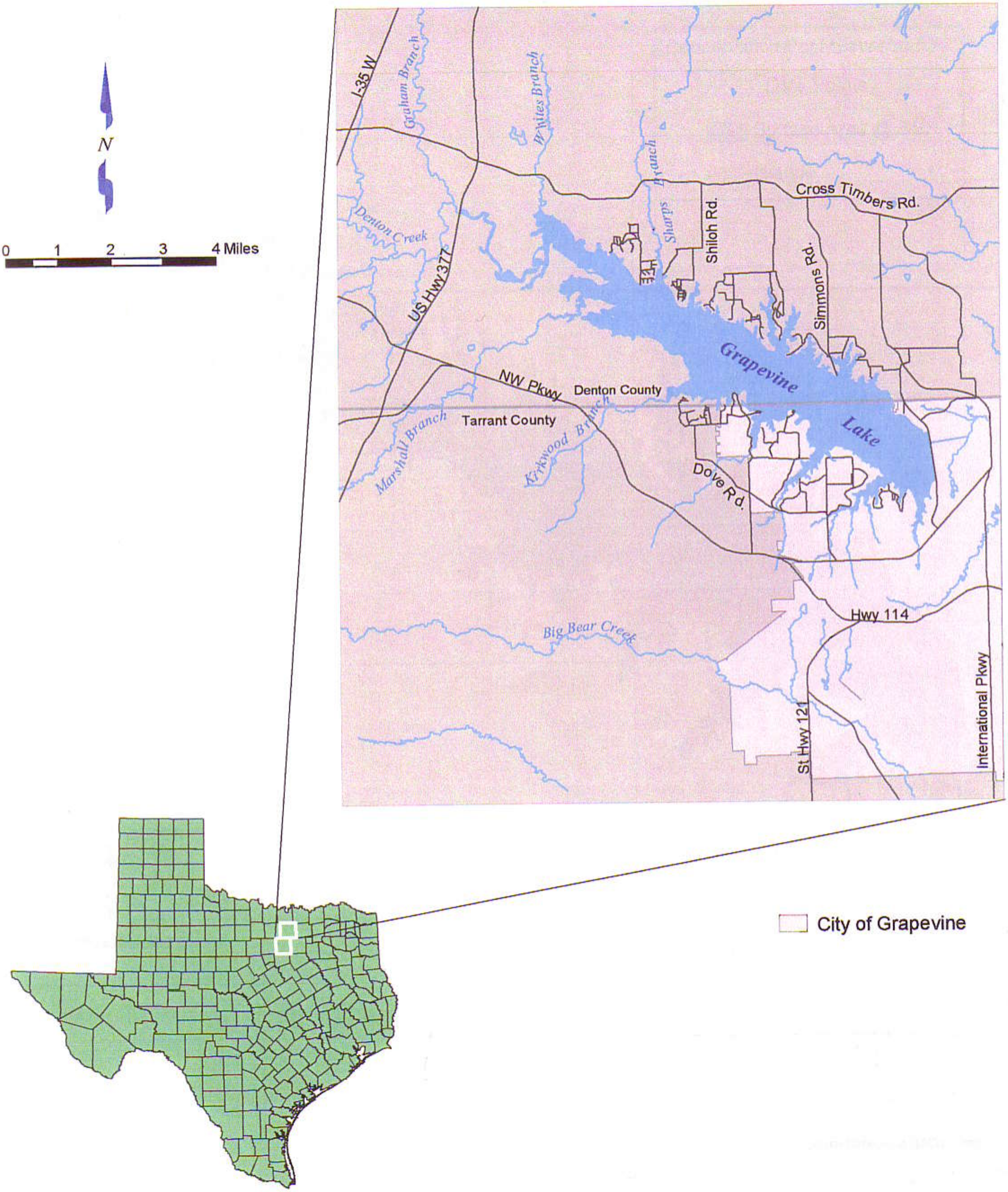
Rangeline 17





Lake Grapevine
Rangeline 18
540
535
530
525
520
515
Elevation (ft)
0
200
400
600
800
1000
1200
Distance (ft)
2002

Figure 1
GRAPEVINE LAKE
Location Map



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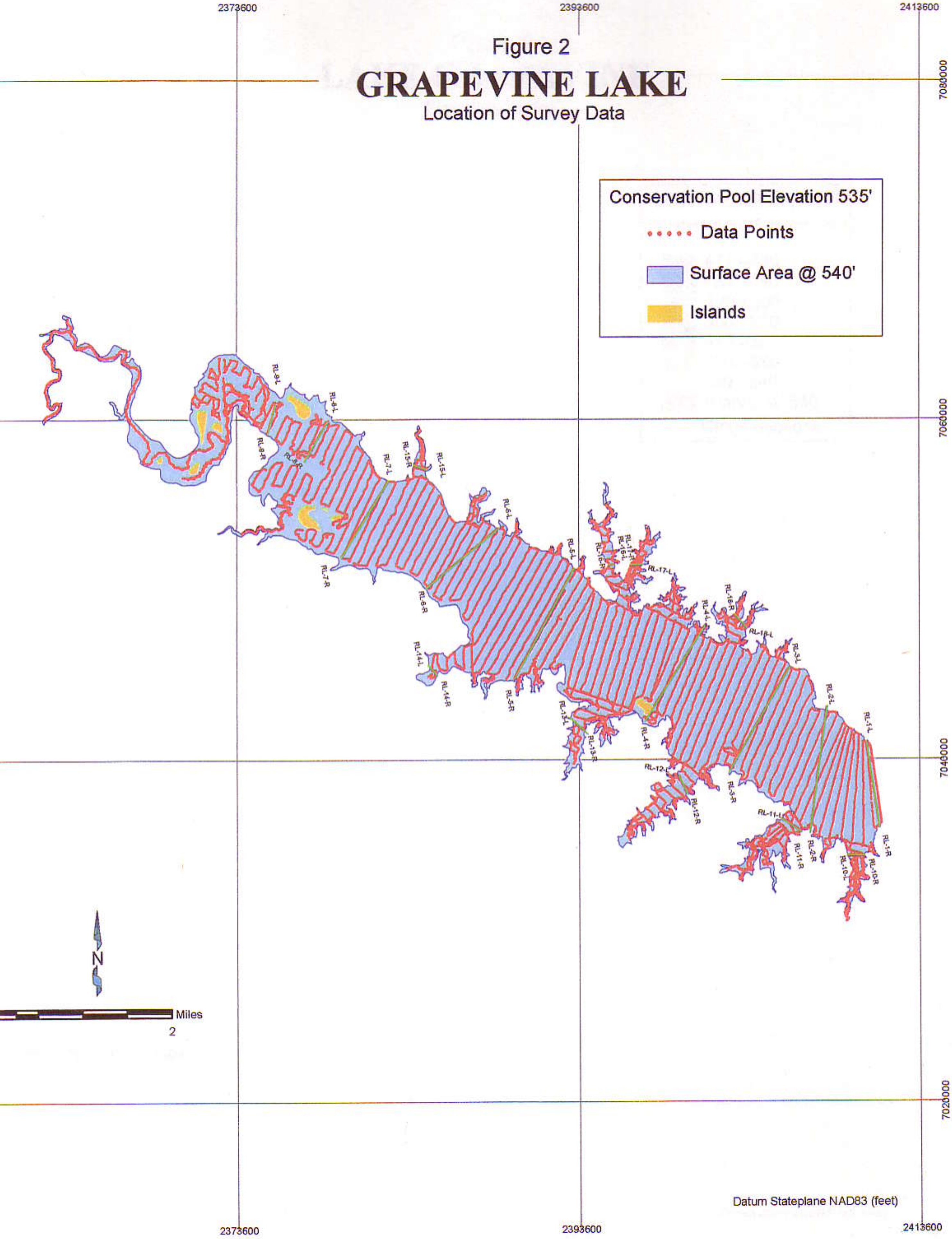

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Figure 3

LAKE GRAPEVINE

Elevation Relief

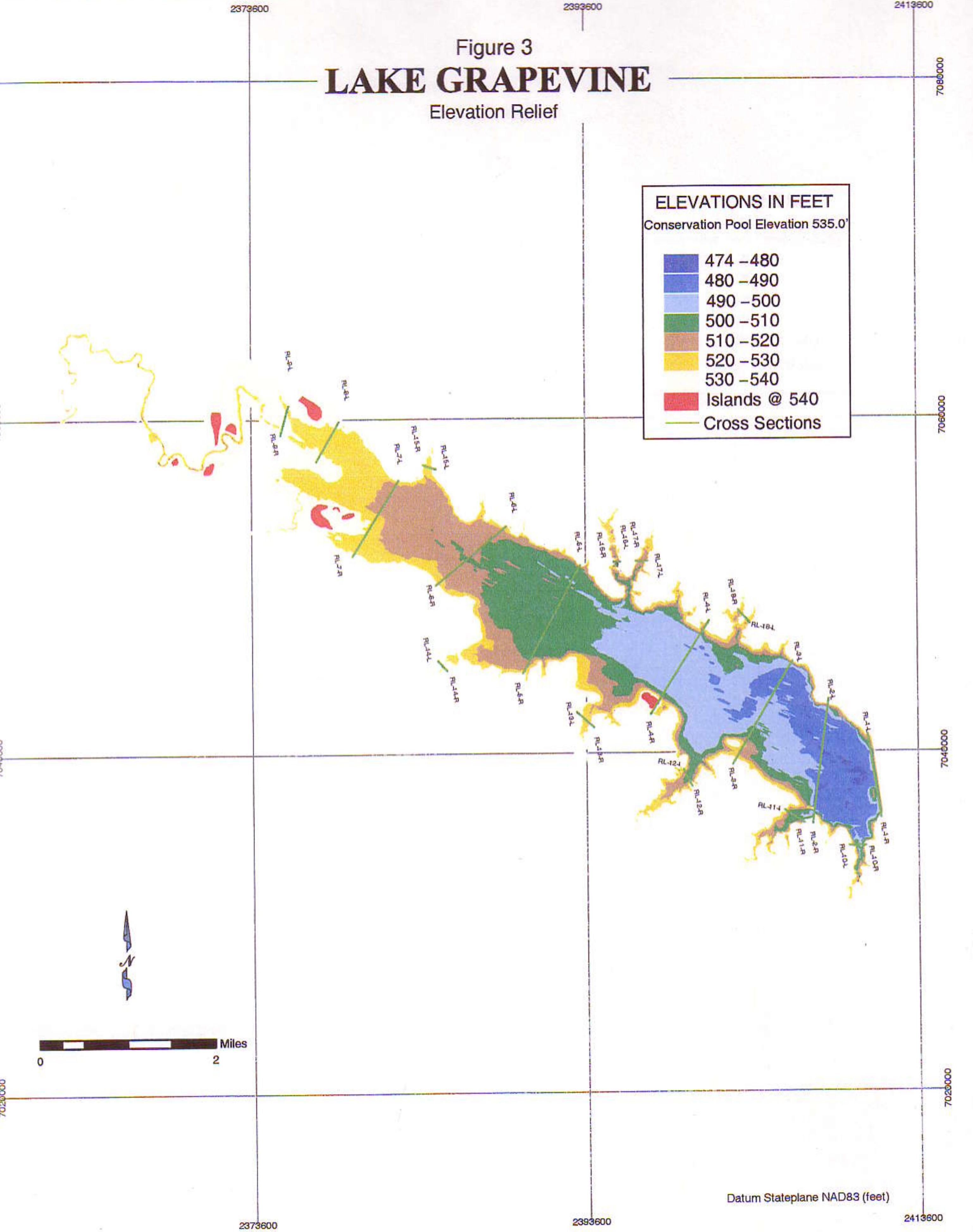

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Figure 4
LAKE GRAPEVINE
Depth Ranges

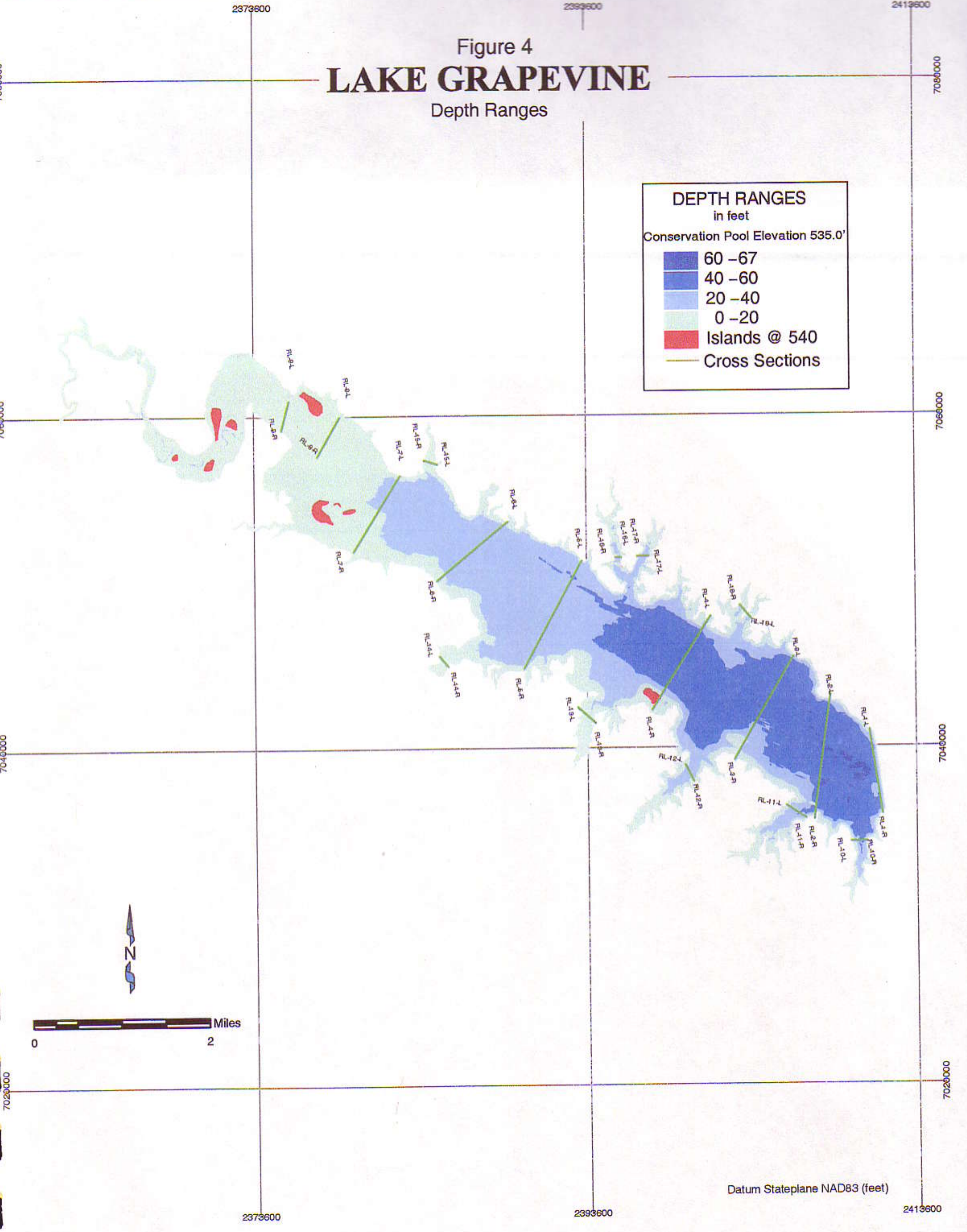

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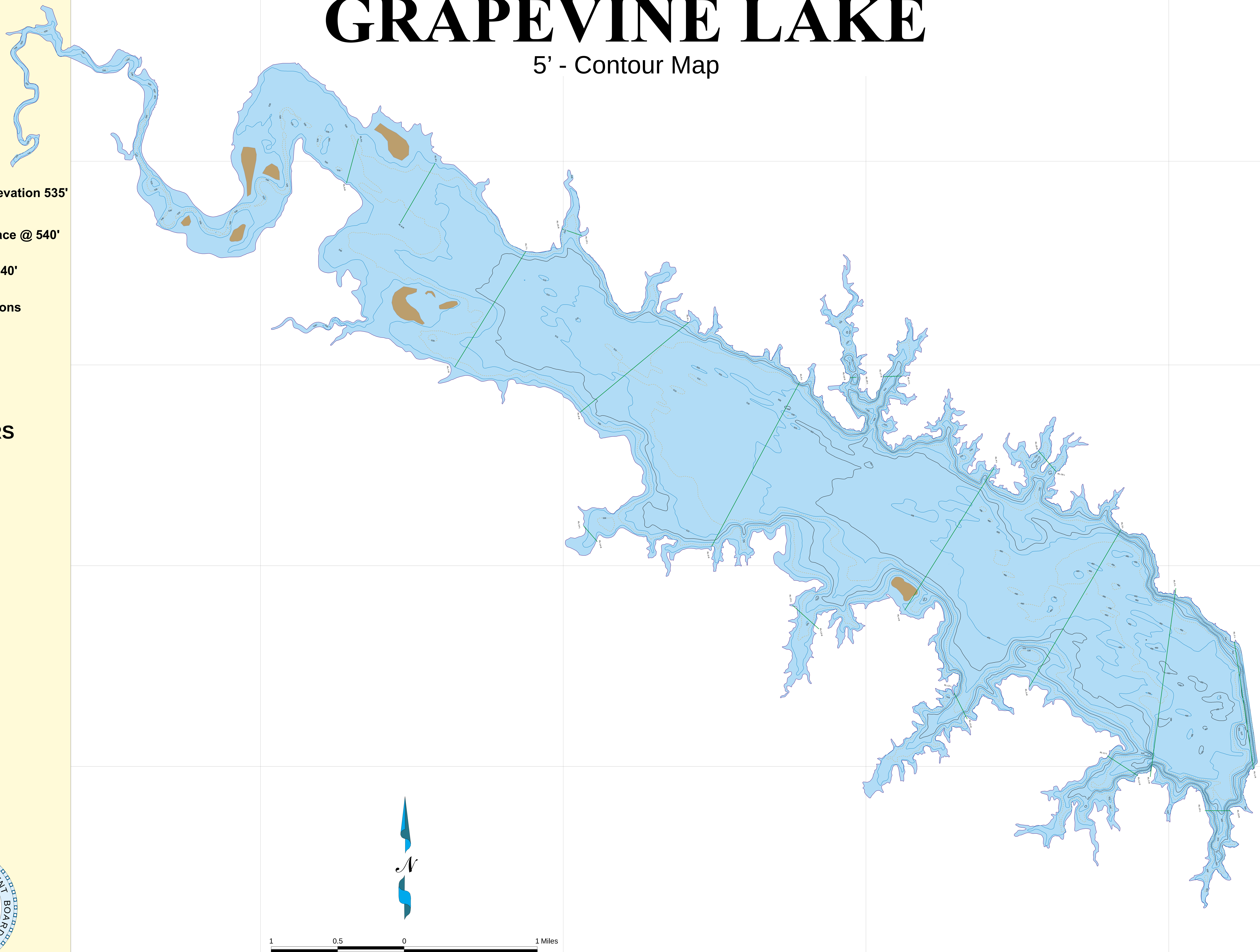
Figure 5

GRAPEVINE LAKE

5' - Contour Map



Conservation Pool Elevation 535'

- Water Surface @ 540'
- Islands @ 540'
- Cross Sections

CONTOURS

475
480
485
490
495
500
505
510
515
520
525
530
535

This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Grapevine Lake. The Texas Water Development Board makes no representations or assumes any liability.

Prepared by : TEXAS WATER DEVELOPMENT BOARD MAY 2002