KEITH SEBELIUS
2000 LAKE SURVEY

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13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation (Reclamation) surveyed Keith Sebelius Lake (formerly Norton Reservoir) in July and September of 2000 to develop a topographic map and compute a present storage-elevation relationship (area-capacity tables). The data were used to calculate reservoir capacity lost due to sediment accumulation since dam closure in October of 1964. The underwater survey was conducted in the main part of the reservoir in July of 2000 and the upper portion of the reservoir in September of 2000. The surveys were conducted near reservoir elevation 2300 feet (project datum). The underwater survey used sonic depth recording equipment interfaced with a global positioning system (GPS) that gave continuous sounding positions throughout the underwater portions of the reservoir covered by the survey vessel. The above-water topography was determined by digitizing the developed contour lines from the U.S. Geological Survey quadrangle (USGS quad) maps of the reservoir area. The new topographic map of Keith Sebelius Lake was developed from the combined 2000 underwater measured topography and the digitized USGS contours and assumed no change above elevation 2,300.0.

As of September 2000, at top of conservation water surface elevation (feet) 2,304.3, the surface area was 2,181 acres with a total capacity of 34,510 acre-feet. Since initial filling in October of 1964, about 1,617 acre-feet of sediment have accumulated in Keith Sebelius Lake below elevation 2,304.3, resulting in a 4.48 percent loss in reservoir volume. Since 1964, the estimated average annual rate of reservoir capacity lost to sediment accumulation is 44.9 acre-feet.

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Keith Sebelius Lake

2000 RESERVOIR SURVEY

by

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The Bureau of Reclamation's (Reclamation) Sedimentation and River Hydraulics Group of the Technical Service Center (TSC) prepared and published this report. Jennifer Bountry, Kent Collins and Ronald Ferrari of the TSC conducted the hydrographic survey. Ronald Ferrari completed the data processing needed to generate the new topographic map and area-capacity tables. Sharon Nuanes of the TSC completed the final map development. Kent Collins of TSC performed the technical peer review of this documentation.

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to tribes.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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INTRODUCTION

Keith Sebelius Lake and Norton Dam are located in Norton County on Prairie Dog Creek about 2.5 miles upstream of Norton, Kansas (fig. 1). Keith Sebelius Lake (formerly Norton Reservoir) is part of the Almena Unit of the Missouri River Basin development that was designed to provide irrigation, municipal and industrial water, flood control, and recreation benefits. The dam and reservoir are operated and maintained by the Bureau of Reclamation.

Norton Dam was completed in December of 1964 and is a zoned rolled earthfill structure whose dimensions are (fig. 2):

Hydraulic height[1]	84.4	feet[2]	Structural height	131	feet
Top width	30	feet	Crest length	6,450	feet
Crest elevation	2,347.0	feet			

The spillway is located on the right abutment of the dam and is a gated overflow concrete structure with three 30.0- by 36.35-foot radial gates, a concrete-lined discharge channel, and stilling basin. The spillway crest elevation is 2,296.0. The capacity of the spillway is 94,600 cubic feet per second (cfs) at reservoir elevation 2,341.0.

The outlet works consist of a drop-inlet type intake structure with two high-pressure gates. The outlet works stilling basin is designed for a maximum discharge of 330 cfs at the maximum water surface elevation of 2,341.

The total drainage area above Norton Dam is 683 square miles as listed by the USGS Water Resources Data Book. Keith Sebelius Lake has an average width of 0.5 miles with a length of around 6.5 miles.

SUMMARY AND CONCLUSIONS

This Reclamation report presents the 2000 results of the survey of Keith Sebelius Lake. The primary objectives of the survey were to gather data needed to:

- develop reservoir topography
- compute area-capacity relationships
- estimate storage depletion caused by sediment deposition since dam closure

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[1]The definition of such terms as "hydraulic height," "structural height," etc. may be found in manuals such as Reclamation's *Design of Small Dams* and *Guide for Preparation of Standing Operating Procedures for Dams and Reservoirs*, or ASCE's *Nomenclature for Hydraulics*.

[2]Elevation levels are shown in feet. All elevations shown in this report are based on the original project datum established by U.S. Bureau of Reclamation which is tied to the National Geodetic Vertical Datum of 1929.

The underwater survey was conducted in July and September of 2000 near reservoir water surface elevation 2,300. The bathymetric survey was run using sonic depth recording equipment, interfaced with a differential global positioning system (DGPS), capable of determining sounding locations within the reservoir. The system continuously recorded depth and horizontal coordinates of the survey boat as it was navigated along grid lines covering Keith Sebelius Lake. The positioning system provided information to allow the boat operator to maintain a course along these grid lines. Water surface elevations recorded by the reservoir gauge (tied to the Reclamation vertical datum) during the time of collection were used to convert the sonic depth measurements to true reservoir bottom elevations. The above-water topography was determined by digitizing the developed contour lines from the U.S. Geological Survey quadrangle (USGS quad) maps of the reservoir area.

The new Keith Sebelius Lake topographic maps are a combination of the USGS quad contours and underwater survey data. The 2000 reservoir surface areas at predetermined contour intervals were generated by a computer graphics program using the collected reservoir data. The 2000 area and capacity tables were produced by a computer program that uses measured contour surface areas and a curve-fitting technique to compute area and capacity at prescribed elevation increments (Bureau of Reclamation, 1985).

Tables 1 and 2 contain a summary of the Keith Sebelius Lake sedimentation and watershed characteristics for the 2000 survey. The 2000 survey determined that the reservoir has a total storage capacity of 34,510 acre-feet and a surface area of 2,181 acres at reservoir elevation 2,304.3. Since closure in October of 1964, the reservoir had an estimated volume change of 1,617 acre-feet below reservoir elevation 2,304.3. This volume represents a 4.5 percent loss in total capacity and an average annual loss of 44.9 acre-feet per year.

RESERVOIR OPERATIONS

Norton Dam operates as part of the Almena Project to provide flood control, irrigation water, and recreational use. The September 2000 area-capacity tables show 192,027 acre-feet of total storage below the maximum water surface elevation 2,341.0. The 2000 survey measured a minimum elevation of 2,261. The following values are from the September 2000 area-capacity tables:

- 58,287 acre-feet of surcharge between elevation 2,331.4 and 2,341.0.
- 99,230 acre-feet of flood control storage between elevation 2,304.3 and 2,331.4.
- 30,517 acre-feet of conservation use between elevation 2,280.4 and 2,304.3.
- 2,357 acre-feet of inactive storage between elevation 2,275.0 and 2,280.4.
- 1,636 acre-feet of dead storage below elevation 2,275.0.

The Keith Sebelius Lake inflow and end-of-month stage records in table 1, operation period October 1964 through September 2000, show the computed inflow and annual fluctuation since dam closure. Inflow values for water years 1997 through 2000 were not available. The estimated average inflow into the reservoir for this operation period was 17,100 acre-feet per year. Since initial filling in 1967, the extreme storage fluctuations of Keith Sebelius Lake ranged from an elevation of 2,275.8 in 1981 to the maximum recorded elevation of 2,306.5 in 1997.

HYDROGRAPHIC SURVEY EQUIPMENT AND METHOD

The hydrographic survey equipment was mounted in the cabin of a 24-foot trihull aluminum vessel equipped with twin in-board motors. The hydrographic system contained on the survey vessel consisted of a GPS receiver with a built-in radio and an omnidirectional antenna, a depth sounder, a helmsman display for navigation, a computer, and hydrographic system software for collecting underwater data. Power to the equipment was supplied by an on-board generator.

The shore equipment included a second GPS receiver with an external radio and an omnidirectional antenna. The GPS receiver and antenna were mounted on a survey tripod over a known datum point. To obtain the maximum radio transmission range, known datum points with clear line-of-sight to the survey boat were selected. The power for the shore unit was provided by a 12-volt battery.

GPS Technology and Equipment

The hydrographic positioning system used at Keith Sebelius Lake was Navigation Satellite Timing and Ranging (NAVSTAR) GPS, an all-weather, radio-based, satellite navigation system that enables users to accurately determine three-dimensional position. The NAVSTAR system's primary mission is to provide passive global positioning and navigation for land-, air-, and sea-based strategic and tactical forces and is operated and maintained by the Department of Defense (DOD). The GPS receiver measures the distances between the satellites and itself and determines the receiver's position from intersections of the multiple-range vectors. Distances are determined by accurately measuring the time a signal pulse takes to travel from the satellite to the receiver.

The NAVSTAR system consists of three segments:

- The space segment is a network of 24 satellites maintained in a precise orbit about 10,900 nautical miles above the earth, each completing an orbit every 12 hours.

- The ground control segment tracks the satellites, determining their precise orbits. Periodically, the ground control segment transmits correction and other system data to all the satellites, and the data are then retransmitted to the user segment.

- The user segment includes the GPS receivers which measure the broadcasts from the satellites and calculate the position of the receivers.

The GPS receivers use the satellites as reference points for triangulating their position on earth. The position is calculated from distance measurements to the satellites that are determined by how long a radio signal takes to reach the receiver from the satellite. To calculate the receiver's position on earth, the satellite distance and the satellite's position in space are needed. The satellites transmit signals to the GPS receivers for distance measurements along with the data messages about their exact orbital location and operational status. The satellites transmit two "L" band frequencies (called L1 and L2) for the distance measurement signal. At least four satellite observations are required to mathematically solve for the four unknown receiver parameters (latitude, longitude, altitude, and time); the time unknown is caused by the clock error between the expensive satellite atomic clocks and the imperfect clocks in the GPS receivers.

The GPS receiver's absolute position is not as accurate as it appears in theory because of the function of range measurement precision and the geometric position of the satellites. Precision is affected by several factors--time, because of the clock differences, and atmospheric delays caused by the effect of the ionosphere on the radio signal. Geometric dilution of precision (GDOP) describes the geometrical uncertainty and is a function of the relative geometry of the satellites and the user. Generally, the closer together in angle two satellites are from the receiver, the greater the GDOP. GDOP is broken into components: position dilution of precision (x,y,z) (PDOP), and horizontal dilution of precision (x,y) (HDOP). The components are based only on the geometry of the satellites. The PDOP and HDOP were monitored at the survey vessel's GPS receiver during the Keith Sebelius Lake Survey, and for the majority of the time they were less than 3, which is within the acceptable limits of horizontal accuracy for Class 1 and 2 level surveys (Corps of Engineers, 1994).

An additional and larger error source in GPS collection is caused by false signal projection, called selective availability (S/A). The DOD implements S/A to discourage the use of the satellite system as a guidance tool by hostile forces. Positions determined by a single receiver when S/A is active can have errors of up to 100 meters. In May of 2000 the use of S/A was discontinued, but the errors of a single receiver are still around ±10 meters.

A method of collection to resolve or cancel the inherent errors of GPS is called differential GPS (DGPS). DGPS is used during the reservoir survey to determine positions of the moving survey vessel in real time. DGPS determines the position of one receiver in reference to another and is a method of increasing position accuracies by eliminating or minimizing the uncertainties. Differential positioning is not concerned with the absolute position of each unit but with the relative difference between the positions of two units, which are simultaneously observing the same satellites. The inherent errors are mostly canceled because the satellite transmission is essentially the same at both receivers.

At a known geographical benchmark, one GPS receiver is programmed with the known coordinates and stationed over the geographical benchmark. This receiver, known as the master or reference unit, remains over the known benchmark, monitors the movement of the satellites, and calculates its apparent geographical position by direct reception from the satellites. The inherent errors in the satellite position are determined relative to the master receiver's programmed position, and the necessary corrections or differences are transmitted to the mobile GPS receiver on the survey vessel.

For the Keith Sebelius Lake survey, position corrections were determined by the master receiver and transmitted via an ultra-high frequency (UHF) radio link every second to the survey vessel mobile receiver. The survey vessel's GPS receiver used the corrections along with the satellite information it received to determine the vessel's differential location. Using DGPS can result in sub-meter positional accuracies for the survey vessel.

The Sedimentation and River Hydraulics Group conducts their bathymetric surveys using Real-time Kinematic (RTK) GPS. The major benefit of RTK versus DGPS is that precise heights can be measured in real time for monitoring water surface elevation changes. The basic outputs from an RTK receiver are precise 3D coordinates in latitude, longitude, and height with accuracies on the order of 2 centimeters horizontally and 3 centimeters vertically. The output is on the GPS datum of WGS-84 which the hydrographic collection software converted into the Kansas's NAD83 state plane north coordinate system. The system employs two receivers, like with DGPS, that collect additional satellite data which allows on-the-fly centimeter accuracy measurements.

Survey Method and Equipment

The Keith Sebelius Lake hydrographic survey collection was conducted in July and September of 2000 near water surface elevation 2,300 (Reclamation project datum). The bathymetric survey was run using sonic depth recording equipment, interfaced with a RTK GPS, capable of determining sounding locations within the reservoir. The survey system software continuously recorded reservoir depths and horizontal coordinates as the survey boat moved across close-spaced grid lines covering the reservoir area. Most of the transects (grid lines) were run somewhat in a north or south direction of the reservoir at a 300-foot spacing. Data was also collected along the shore as the boat traversed between transects. The survey vessel's guidance system gave directions to the boat operator to assist in maintaining the course along these predetermined lines. During each run, the depth and position data were recorded on the notebook computer hard drive for subsequent processing.

The 2000 underwater data were collected by a depth sounder that was calibrated by lowering a deflector plate below the boat by cables with known depths marked by beads. The depth sounder was calibrated by adjusting the speed of sound, which can vary with density, salinity, temperature, turbidity, and other conditions. The collected data were digitally transmitted to the computer collection system via a RS-232 port. The depth sounder also produces an analog hard-copy chart of the measured depths. These graphed analog charts were printed for all survey lines as the data were collected and recorded by the computer. The charts were analyzed during post-processing, and when the analog charted depths indicated a difference from the recorded computer bottom depths, the computer data files were modified. The water surface elevations at the dam, recorded by a Reclamation gauge were used to convert the sonic depth measurements to true lake-bottom elevations.

Keith Sebelius Lake Datums

Prior to the underwater survey in September 2000, a RTK GPS survey was conducted to establish a temporary horizontal and vertical control point that overlooked Keith Sebelius Lake. The horizontal control was established in Kansas state plane north coordinates in the North American Datum of 1983 (NAD83). The GPS control was conducted with the base set on the NGS datum point "NORTONPORT 2" located at the Norton Municipal Airport. All vertical information in this report was referenced to the reservoir water surface gauge measurements during the time of this survey. Gauge measurements are referenced to the Reclamation project datum which is tied to the NGVD29.

RESERVOIR AREA AND CAPACITY

Topography Development

The topography of Keith Sebelius Lake was developed from the 2000 collected underwater data and from the USGS quad maps. The upper contours of Keith Sebelius Lake were developed by digitizing the contour lines of elevation 2,280.0, 2,290.0, 2,300.0, 2,304.0, 2,310.0, 2,320 and 2,331 from the USGS quad maps that covered the Keith Sebelius Lake area. The USGS quad maps were developed from aerial photography dated 1974, but the underwater contours of Keith Sebelius Lake were imported from a U.S. Bureau of Reclamation map dated 1956. ARC/INFO V7.0.2 geographic information system software was used to digitize the USGS quad contours. The digitized contours were transformed to Kansas's NAD 1983 north state plane coordinates using the ARC/INFO PROJECT command.

The elevation 2,300.0 contour digitized from USGS quad maps was used to perform a clip of the Keith Sebelius Lake TIN such that interpolation was not allowed to occur outside of the 2,300.0 contour. This complete contour was selected since it was the closest elevation to enclose the 2000 underwater data that was collected near reservoir elevation 2,300. This clip was performed using the hardclip option of the ARC/INFO CREATETIN command. Using ARCEDIT, the underwater collected data and the digitized contours from the USGS quad maps were plotted. The plot found that the underwater data completely lied within the elevation 2,300.0 clip.

For developing the 2000 Keith Sebelius contour map and calculating the surface areas there was a need for data in the underwater reservoir areas not surveyed in 2000. Using ARCEDIT, the digitized USGS quad contours and the 2000 underwater collected data layers were overlaid or plotted on-screen. The 2,290 contour was chosen as a pattern to add some data points to the underwater data set. This was needed due to thick tree growth around the reservoir which did not allow survey boat access near the shoreline, shallow water areas in the main body, and many of the coves and inlets of the reservoir. In some areas the growth was so thick the survey vessel ended the collection in 10 to 20 feet of water.

Contours for the reservoir below elevation 2,300.0 were computed from the underwater data set using the triangular irregular network (TIN) surface modeling package within ARC/INFO. A TIN is a set of adjacent, non-overlapping triangles computed from irregularly spaced points with x,y coordinates and z values. TIN was designed to deal with continuous data such as elevations. The TIN software uses a method known as Delaunay's criteria for triangulation where triangles are formed among all data points within the polygon clip. The method requires that a circle drawn through the three nodes of a triangle will contain no other point, meaning that sample points are connected to their nearest neighbors to form triangles using all collected data. This method preserves all collected survey points. Elevation contours are then interpolated along the triangle elements. The TIN method is discussed in greater detail in the ARC/INFO V7.0.2 *Users Documentation,* (ESRI, 1992).

The linear interpolation option of the ARC/INFO TINCONTOUR command was used to interpolate contours from the Keith Sebelius Lake TIN. In addition, the contours were generalized by eliminating certain vertices along the contours. This generalization process improved the presentability of the resulting contours by removing very small variations in the contour lines. This generalization had no bearing on the computation of surface areas and volumes for Keith Sebelius Lake since the areas were calculated from the developed TIN. The areas of the enclosed contour polygons developed from the survey data were completed for elevations 2,261 through elevation 2,300.0.

The contour topography at 5-foot intervals is presented on figures 3 through 7, drawing numbers 492-D-365 through 492-D-369.

Development of 2000 Contour Areas

The 2000 contour surface areas for Keith Sebelius Lake were computed at 1-foot increments, from elevation 2,262 to 2,290, using the Keith Sebelius Lake TIN discussed above. The 2000 survey measured the minimum reservoir as elevation 2,261 feet. These calculations were performed using the ARC/INFO VOLUME command. This command computes areas at user specified elevations directly from the TIN and takes into consideration all regions of equal elevation. As discussed in the survey method and equipment section there were large areas of the underwater portion of the reservoir not surveyed due to the thick tree growth. This accounts for the fact that the 2000 areas were only computed for elevation 2,290 and below. Due to the lack of 2000 survey data in the tree-covered areas, the final 2000 area computations assumed no change in the original measured surface area from elevation 2,300.0 and above.

2000 Storage Capacity

The storage-elevation relationships based on the measured surface areas were developed using the area-capacity computer program ACAP85 (Bureau of Reclamation, 1985). Computed surface areas from the developed TIN, at 2-foot contour intervals, from reservoir elevation 2,262 to elevation 2,290 were used as the control parameters for computing the Keith Sebelius Lake capacity. Since this study did not collect any above water data the original areas from elevation 2,300.0 and above were used to complete the table. The program can compute an area and capacity at elevation increments 0.01- to 1.0-foot by linear interpolation between the given contour surface areas. The program begins by testing the initial capacity equation over successive intervals to ensure that the equation fits within an allowable error limit. The error limit was set at 0.000001 for Keith Sebelius Lake. The capacity equation is then used over the full range of intervals fitting within this allowable error limit. For the first interval at which the initial allowable error limit is exceeded, a new capacity equation (integrated from basic area curve over that interval) is utilized until it exceeds the error limit. Thus, the capacity curve is defined by a series of curves, each fitting a certain region of data. Final area equations are derived by differentiating the capacity equations, which are of second order polynomial form:

$$y = a_1 + a_2x + a_3x^2$$

where:
y = capacity
x = elevation above a reference base
a_1 = intercept
a_2 and a_3 = coefficients

Results of the 2000 Keith Sebelius Lake area and capacity computations are listed in table 1 and columns 4 and 5 of table 2. On table 2, columns 2 and 3 list the original surface areas and recomputed capacities. A separate set of 2000 area and capacity tables has been published for the 0.01, 0.1 and 1-foot elevation increments (Bureau of Reclamation 2000). A description of the computations and coefficients output from the ACAP85 program is included with these tables. Both the original and 2000 area-capacity curves are plotted on figure 8. As of September 2000, at maximum reservoir water surface elevation 2,341.0, the surface area was 6,713 acres with a total capacity of 192,027 acre-feet.

RESERVOIR SEDIMENT ANALYSES

Figure 8 is a plot of Keith Sebelius Lake's original area data versus the 2000 measured areas. This illustrates the difference between the original and the 2000 measured surface areas. Since Norton Dam closure in October 1964, the measured total volume change at reservoir elevation 2,304.3 was estimated to be 1,617 acre-feet. The estimated average annual rate of capacity lost for this time period (36.0 years) was 44.9 acre-feet per year. The storage loss in terms of percent of original storage capacity was 4.48 percent. Tables 1 and 2 contain the Keith Sebelius Lake sediment accumulation and water storage data based on the 2000 resurvey.

It must be noted that the 2000 area and capacity table were generated using measured surface areas from elevation 2,290 and below. The original surface areas from elevation 2,300 and above were used to complete the new area and capacity table. This assumed no surface area change from elevation 2,300 and above which in all probability is not the case. The only means to measure this would be to conduct an aerial survey. The maximum water surface elevation since 1964 was 2,306.5 and the majority of the years the reservoir has operated at a much lower elevation than this, therefore any change above elevation 2300 due to sediment accumulation is probably minimal. A resurvey of Keith Sebelius Lake should be considered in the future if major sediment inflow events are observed, or if the average annual rate of sediment accumulation requires further clarification. If an aerial survey is conducted, it should be scheduled when the lake level drops enough to expose the surface area under the majority of the trees that are now located throughout the reservoir.

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RESERVOIR SEDIMENT DATA SUMMARY

Keith Sebelius Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

D A M	1. OWNER Bureau of Reclamation	2. STREAM Prairie Dog Creek	3. STATE Kansas
	4. SEC. 8 TWP. 3 S RANGE 23 W	5. NEAREST P.O. Norton	6. COUNTY Norton
	7. LAT 39° 48' 27" LONG 99° 56' 04"	8. TOP OF DAM ELEVATION 2347.0	9. SPILLWAY CREST EL 2296.0[1]

R E S E R V O I R	10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, AC	13. ORIGINAL CAPACITY, AF	14. GROSS STORAGE ACRE- FEET	15. DATE STORAGE BEGAN
	a. SURCHARGE	2341.0	6,713	58,285	193,023	
	b. FLOOD CONTROL	2331.4	5,316	98,803	134,738	10/64
	c. POWER					
	d. JOINT USE					16. DATE NORMAL OPERATION BEGAN
	e. CONSERVATION	2304.3	2,181	30,651	35,935	
	f. INACTIVE	2280.4	589	2,566	5,284	
	g. DEAD	2275.0	391	2,718	2,718	10/64
	17. LENGTH OF RESERVOIR 6.5 MILES			AVG. WIDTH OF RESERVOIR 0.5 MILES		

B A S I N	18. TOTAL DRAINAGE AREA 683 SQUARE MILES		22. MEAN ANNUAL PRECIPITATION 21[2] INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 683 SQUARE MILES		23. MEAN ANNUAL RUNOFF 0.47[3] INCHES
	20. LENGTH MILES	AV. WIDTH MILES	24. MEAN ANNUAL RUNOFF 17,100[4] ACRE-FEET
	21. MAX. ELEVATION	MIN. ELEVATION	25. ANNUAL TEMP. MEAN 53°F RANGE -27°F to 116°F[2]

S U R V E Y D A T A	26. DATE OF SURVEY	27. PER. YRS.	28. ACCL. YRS.	29. TYPE OF SURVEY	30. NO. OF RANGES OR INTERVAL	31. SURFACE AREA, AC.	32. CAPACITY ACRE-FEET	33. C/I RATIO AF/AF
	10/64			Contour (D)	2-ft	2,181[5]	36,127[5]	2.11
	9/00		36.0	Contour (D)	2-ft	2,181[6]	34,510[6]	2.02

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIP.	35. PERIOD WATER INFLOW, ACRE FEET			WATER INFLOW TO DATE, AF	
		a. MEAN ANN.	b. MAX. ANN.	c. TOTAL	a. MEAN ANN.	b. TOTAL
9/00		17,100[7]	29,500	273,400	17,100	273,400

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SEDIMENT DEPOSITS TO DATE, AF		
	a. TOTAL	b. AV. ANN.	c. /MI.²-YR.	a. TOTAL	b. AV. ANNUAL	c. /MI.²-YR.
9/00	1,617[8]	44.9	0.066	1,617	44.9	0.066

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		42. SEDIMENT	
		a. PERIOD	b. TOTAL TO	a. AV.	b. TOTAL TO	a.	b.
9/00				0.12[9]	4.48[9]		

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE BY RESERVOIR ELEVATION											
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											
9/00												

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR														
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-105	105-110	110-115	115-120	120-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														

Table 1. - Reservoir sediment data summary (page 1 of 2).

45. RANGE IN RESERVOIR OPERATION[7]

YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
				1965	2,298.2	2,257.4	29,500
1966	2,302.6	2,300.9	19,500	1967	2,304.6	2,299.5	18,000
1968	2,300.6	2,293.6	11,200	1969	2,298.5	2,292.1	14,800
1970	2,293.2	2,284.4	9,500	1971	2,289.1	2,278.1	8,400
1972	2,284.8	2,284.8	9,800	1973	2,287.0	2,277.6	7,000
1974	2,283.0	2,276.9	6,600	1975	2,290.8	2,277.0	18,000
1976	2,288.6	2,284.6	6,100	1977	2,280.5	2,284.4	11,200
1978	2,285.7	2,283.9	5,200	1979	2,282.6	2,278.3	5,100
1980	2,282.3	2,277.0	2,500	1981	2,277.7	2,276.2	1,900
1982	2,278.5	2,275.8	2,500	1983	2,281.7	2,277.1	3,700
1984	2,282.2	2,278.9	3,400	1985	2,281.4	2,279.4	3,200
1986	2,283.0	2,279.4	5,300	1987	2,286.2	2,279.3	9,300
1988	2,286.9	2,283.2	6,500	1989	2,284.0	2,281.2	4,900
1990	2,283.9	2,278.5	7,600	1991	2,280.7	2,278.2	2,700
1992	2,289.1	2,277.7	8,300	1993	2,297.1	2,286.3	3,700
1994	2,300.6	2,297.0	4,200	1995	2,302.4	2,298.4	5,200
1996	2,306.2	2,298.2	18,600	1997	2,306.5	2,302.0	[7]
1998	2,304.3	2,303.4	[7]	1999	2,303.3	2,300.5	[7]
2000	2,301.2	2,299.3	[7]				

46. ELEVATION - AREA - CAPACITY DATA FOR **2000 CAPACITY**[10]

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
2261	0	0	2265	34	43	2070	160	494
2275	317	1,636	2280	553	3,767	2280.4	575	3,993
2285	775	7,146	2290	1,071	11,644	2295	1,429	17,896
2300	1,787	25,936	2304.3	2,181	34,510	2305	2,256	36,063
2310	2,820	48,685	2315	3,345	64,098	2320	3,834	82,065
2325	4,419	102,705	2330	5,076	126,465	2331.4	5,316	133,740
2335	5,953	154,024	2340	6,588	185,376	2341	6,713	192,027

47. REMARKS AND REFERENCES

1 Top of spillway crest is elevation 2,296.0.
2 Bureau of Reclamation Project Data Book, 1981.
3 Calculated using mean annual runoff value of 17,100 AF, item 24.
4 Computed annual inflows from 10/64 through 9/96. (Missing values for water years 1997 through 2000).
5 Original recomputed surface area and capacity at el. 2,304.3. For sediment computation purposes the original area and capacity was recomputed by the Reclamation ACAP program using the original 2-foot increment surface areas.
6 Surface area & capacity at el. 2,304.3 computed by ACAP program.
7 Inflow values in acre-feet and maximum and minimum elevations in feet by water year from 10/64 through 9/00. Missing inflow values for water years 1997 through 2000.
8 Computed sediment volume at elevation 2,304.3.
9 Storage losses at elevation 2,304.3.
10 Capacities computed by Reclamation's ACAP computer program.

48. AGENCY MAKING SURVEY Bureau of Reclamation
49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE July 2001

Table 1. - Reservoir sediment data summary (page 2 of 2).

1	2	3	4	5	6	7	8
					2000	2000	Percent of
Elevations	Original	Original	2000	2000	Sediment	Percent of	Reservoir
	Survey	Capacity	Survey	Survey	Volume	Sediment	Depth
(feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acre-feet)		
2,341.0	6713.0	193644	6713.0	192027	1617		100.0
2,340.0	6588.0	186994	6588.0	185376	1618		98.9
2,335.0	5953.0	155641	5953.0	154024	1617		93.6
2,331.4	5316.0	135357	5316.0	133740	1617		89.8
2,330.0	5076.0	128082	5076.0	126465	1617		88.3
2,325.0	4419.0	104322	4419.0	102705	1617		83.0
2,320.0	3834.0	83682	3834.0	82065	1617		77.7
2,315.0	3345.0	65715	3345.0	64098	1617		72.3
2,310.0	2820.0	50302	2820.0	48685	1617		67.0
2,305.0	2260.0	37680	2256.0	36063	1617		61.7
2,304.3	2181.0	36127	2181.0	34510	1617	100.0	61.0
2,300.0	1787.0	27553	1787.0	25936	1617	100.0	56.4
2,295.0	1438.0	19484	1429.0	17896	1588	98.2	51.1
2,290.0	1117.0	13279	1071.0	11644	1635	101.1	45.7
2,285.0	807.0	8558	775.0	7146	1412	87.3	40.4
2,280.4	589.0	5323	575.0	3993	1330	82.3	35.5
2,280.0	568.0	5092	553.0	3767	1325	81.9	35.1
2,275.0	391.0	2745	317.0	1636	1109	68.6	29.8
2,270.0	235.0	1122	160.0	494	628	38.8	24.5
2,265.0	89.0	302	34.0	43	259	16.0	19.1
2,261.0	31.0	62	0.0	0	62	3.8	14.9
2,260.0	19.0	62	0.0	0	62	3.8	13.8
2,255.0	2.0	9	0.0	0	9	0.6	8.5
2,250.0	1.0	2	0.0	0	2	0.1	3.2
2,247.0	0.0	0	0.0	0	0	0.0	0.0
1	Elevation of reservoir water surface.						
2	Original reservoir surface area.						
3	Original reservoir capacity recomputed using ACAP.						
4	Reservoir surface area from 2000 survey.						
5	Reservoir capacity computed using ACAP.						
6	Measured sediment volume = column (3) - column (5).						
7	Measured sediment expressed in percentage of total sediment 1,617.						
8	Depth of reservoir expressed in percentage of total depth of 94 feet.						

Table 2. - Summary of 2000 survey results

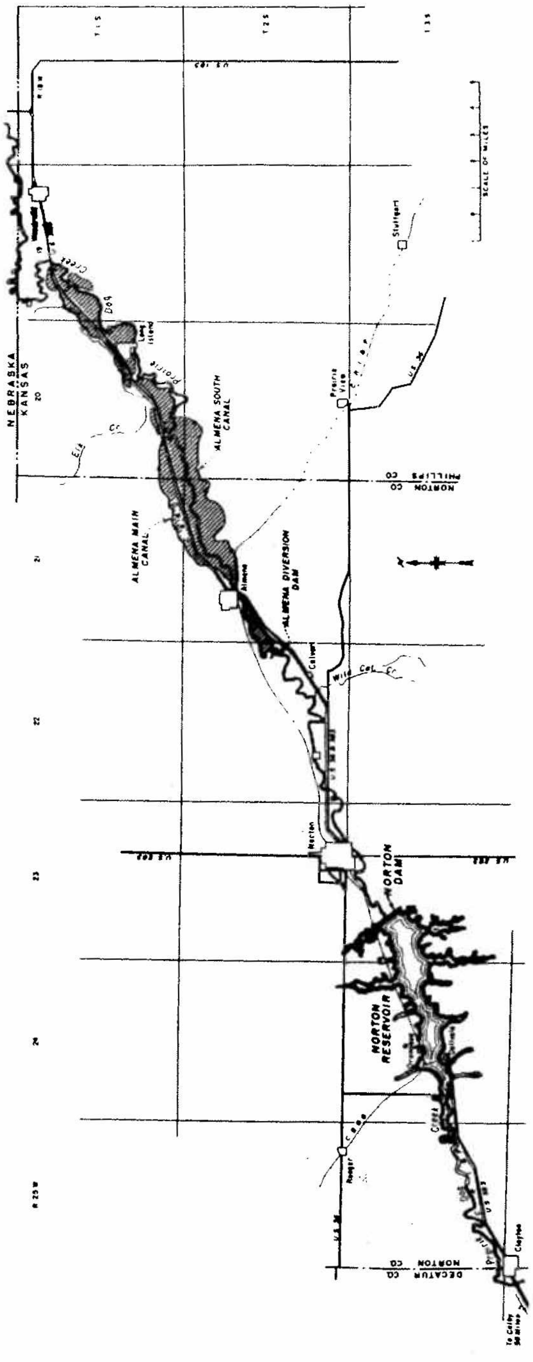

Figure 1. - Keith Sebelius Lake location map.

Space intentionally left blank due to security concerns

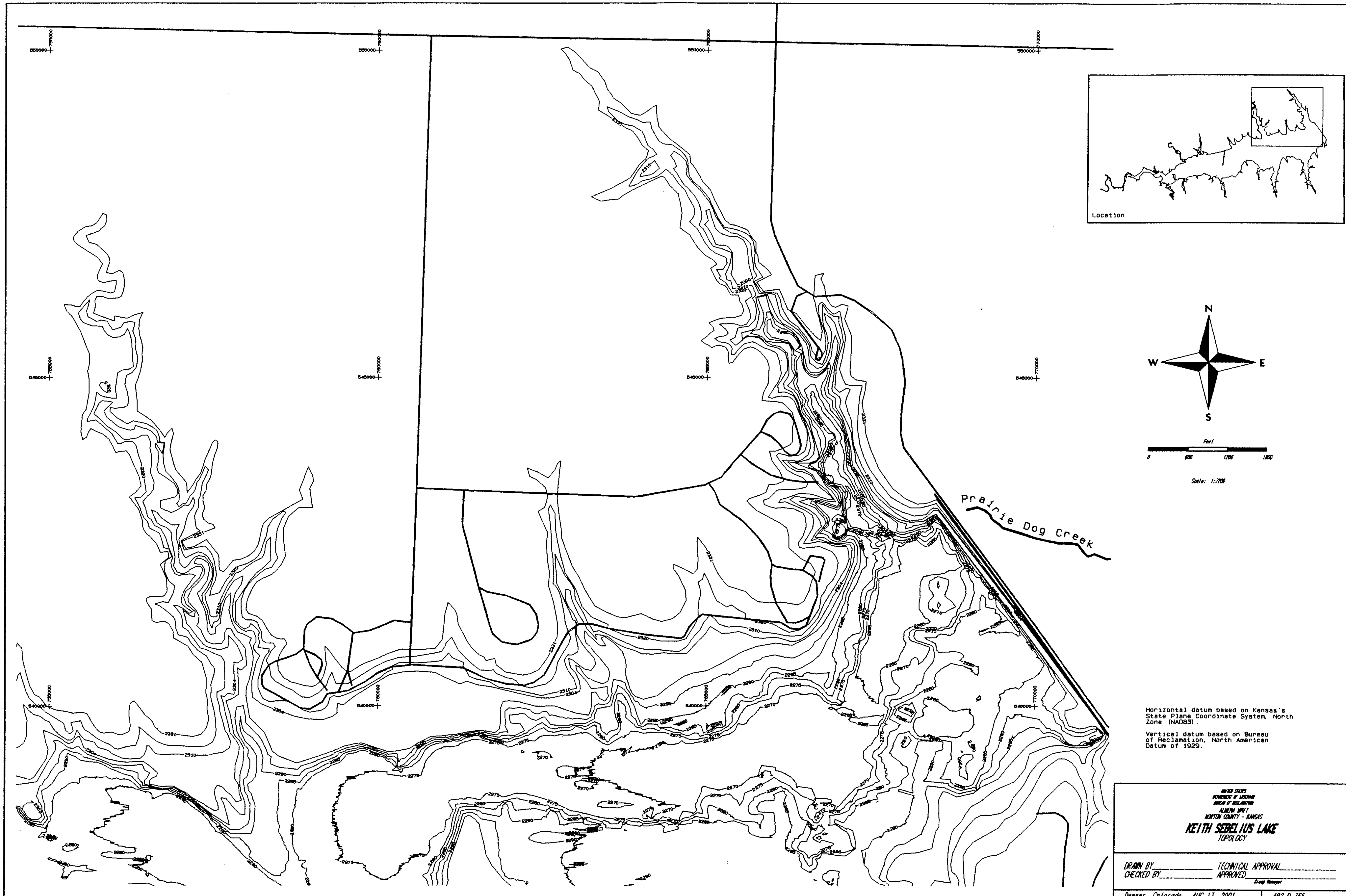

Figure 3. - Keith Sebelius Lake topographic map, No. 492-D-365

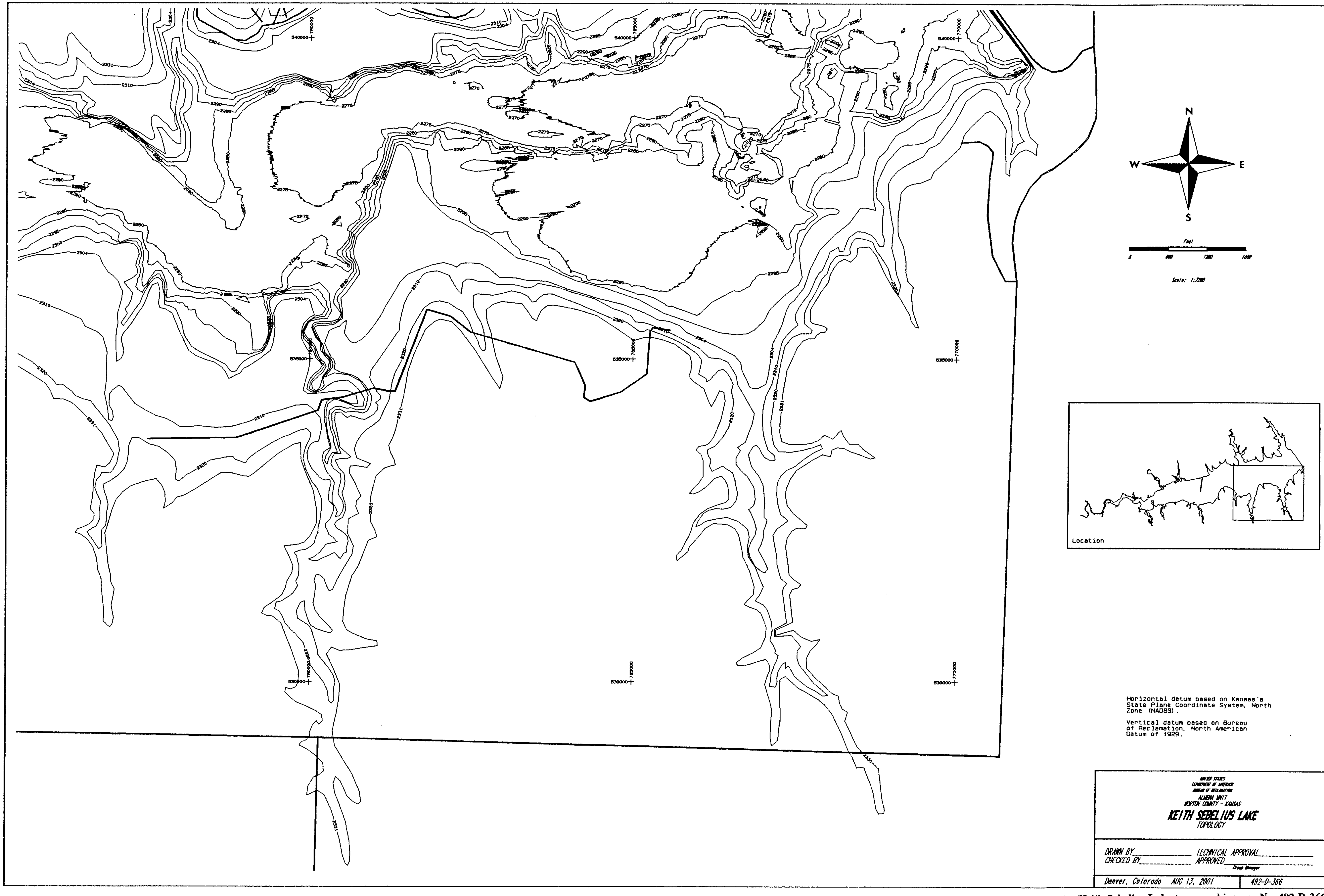

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Figure 4. - Keith Sebelius Lake topographic map, No. 492-D-366

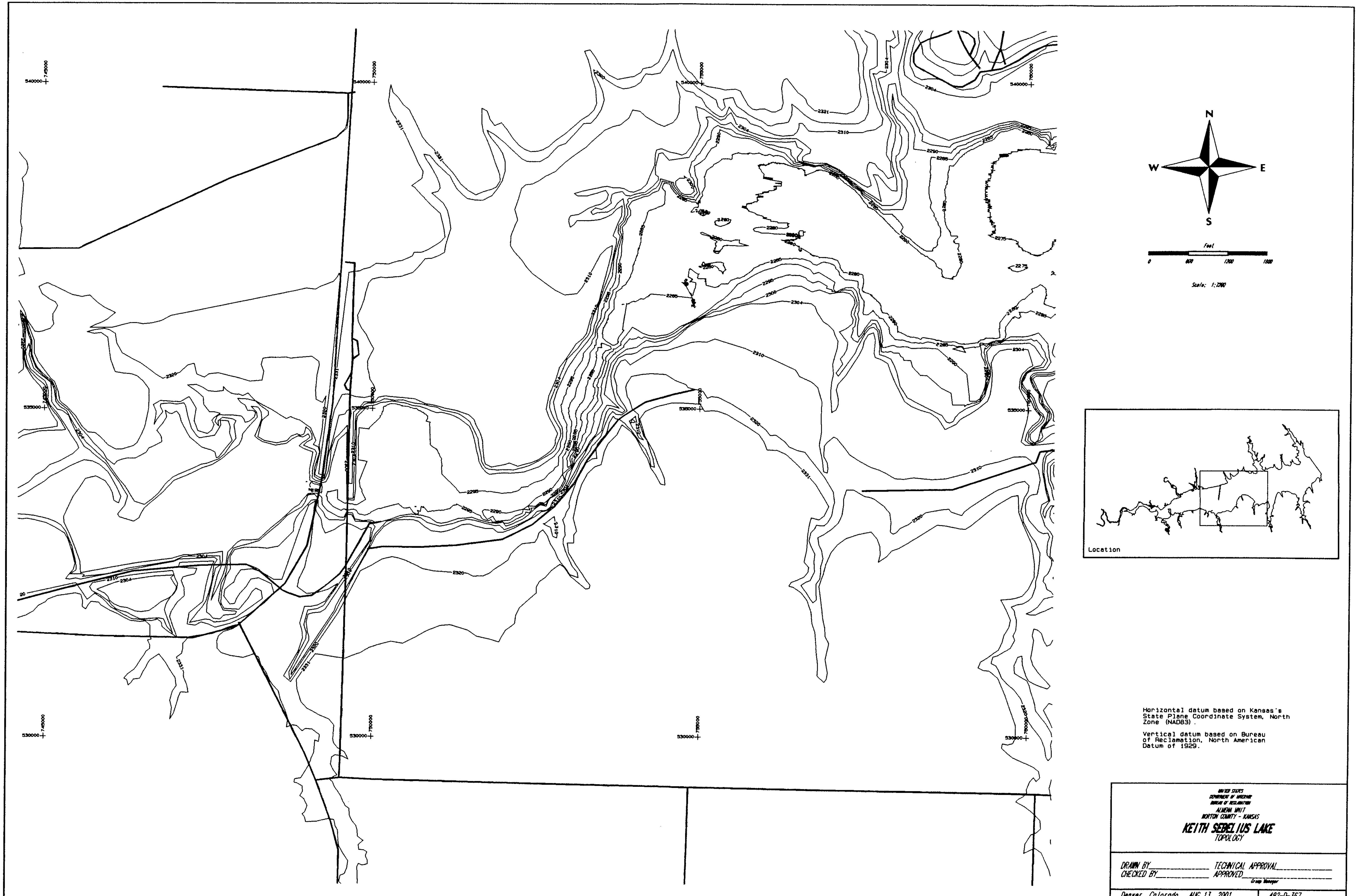

Figure 5. - Keith Sebelius Lake topographic map, No. 492-D-367

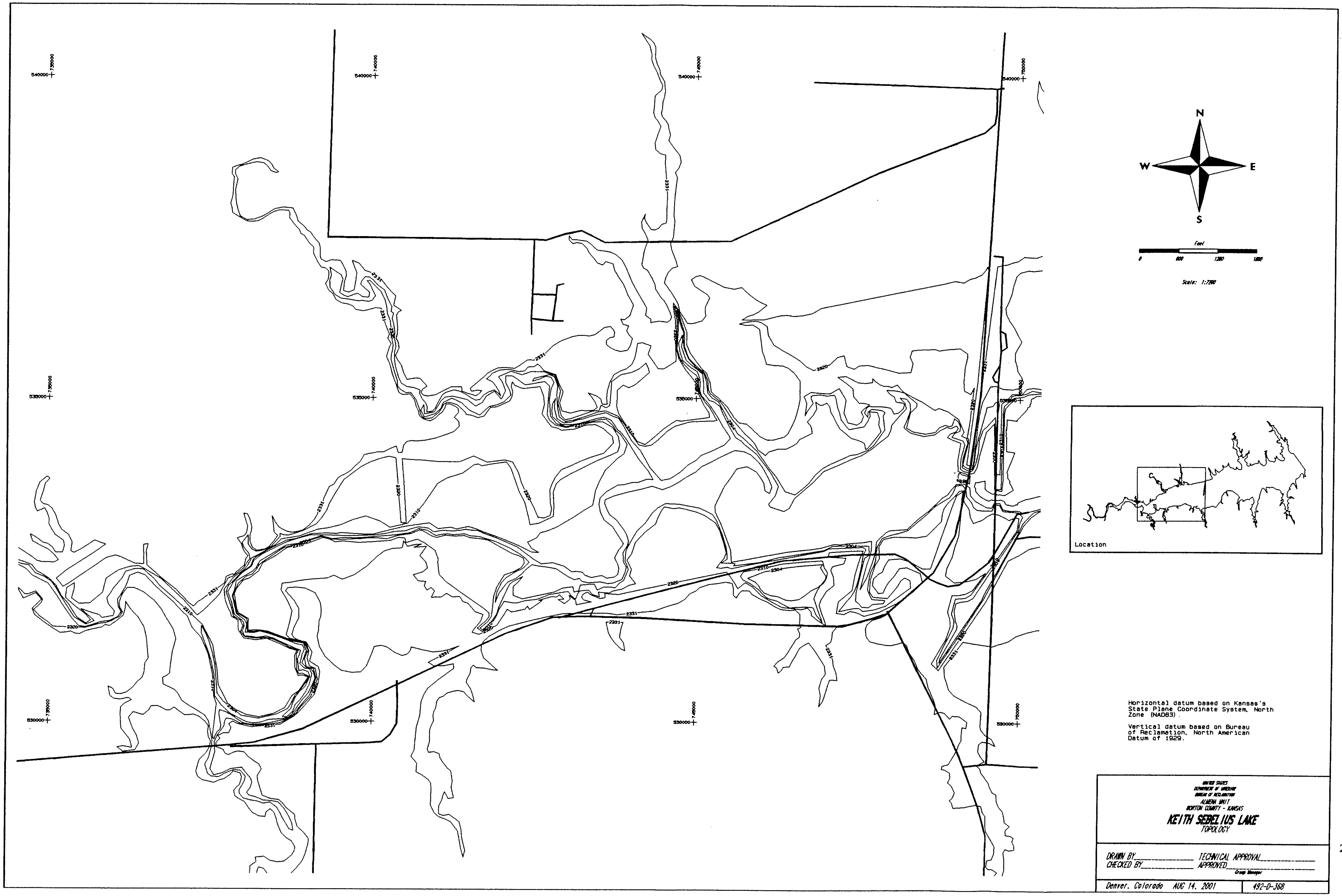

Figure 6. - Keith Sebelius Lake topographic map, No. 492-D-368

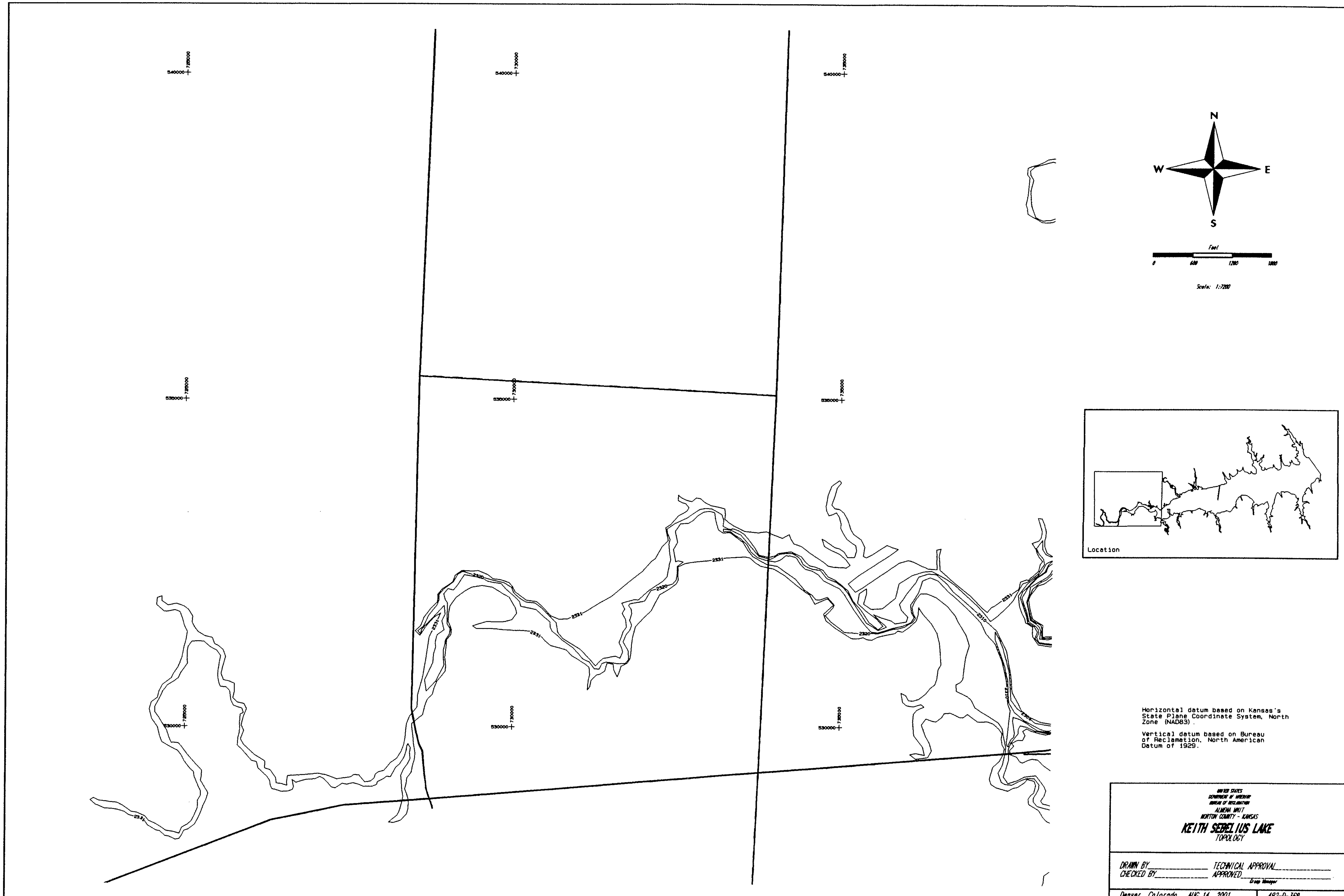

Figure 7. - Keith Sebelius Lake topographic map, No. 492-D-369

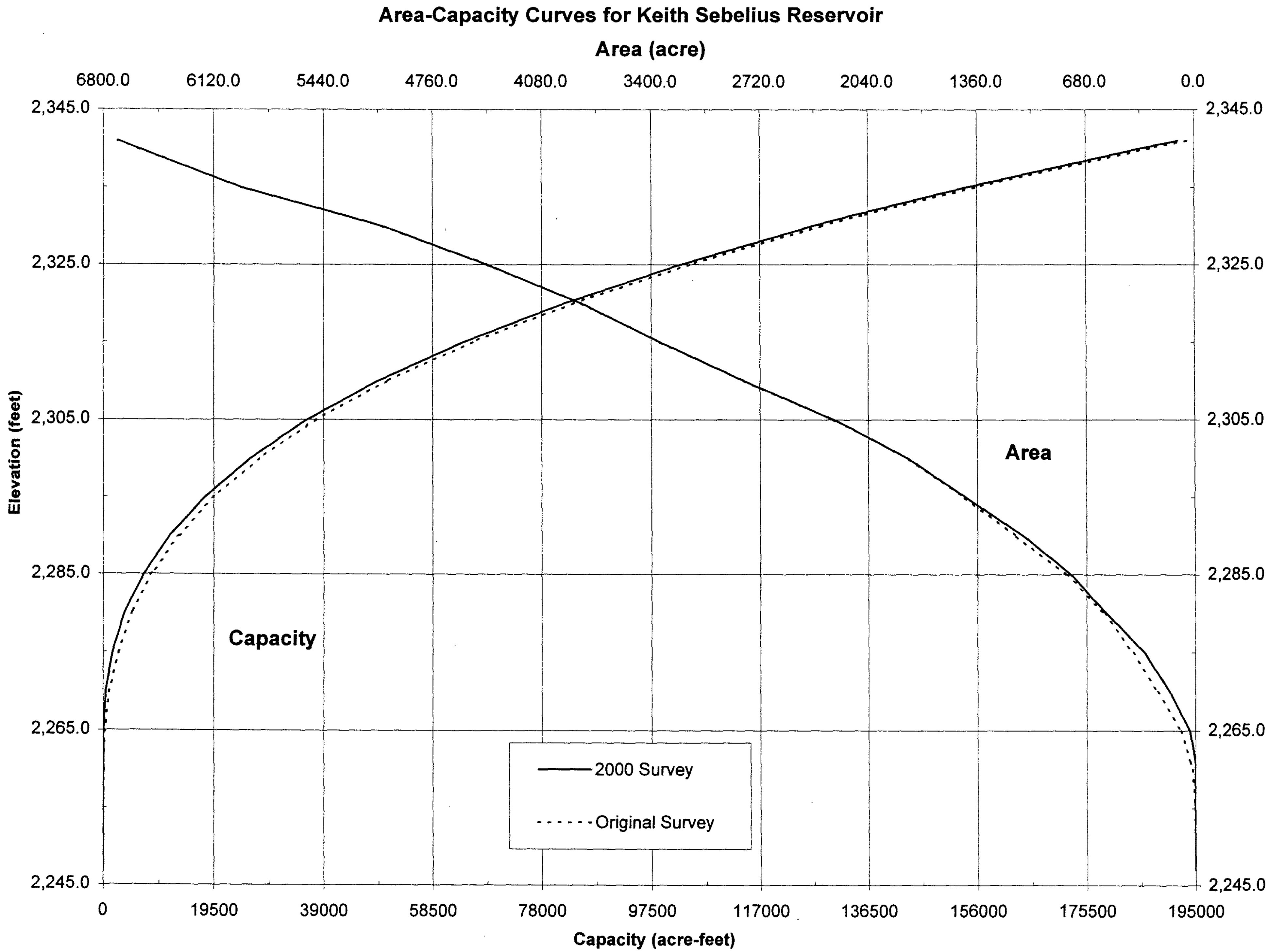

Figure 8. - 2000 area and capacity curves