CEDAR BLUFF RESERVOIR
2000 RESERVOIR SURVEY

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13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation (Reclamation) surveyed Cedar Bluff Reservoir in 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 November of 1950. The underwater survey was conducted in September of 2000 near reservoir elevation 2143.7 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 Cedar Bluff Reservoir was developed from the combined 2000 underwater measured topography and the digitized USGS contours and assumed no change above elevation 2,140.0.

As of September 2000, at top of conservation water surface elevation (feet) 2,144.0, the surface area was 6,869 acres with a total capacity of 172,452 acre-feet. Since initial filling in November of 1950, about 13,044 acre-feet of sediment have accumulated in Cedar Bluff Reservoir below elevation 2,144.0, resulting in a 7.0 percent loss in reservoir volume. Since 1950, the estimated average annual rate of reservoir capacity lost to sediment accumulation is 261.9 acre-feet.

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2000 RESERVOIR SURVEY

by

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Technical Service Center
Denver, Colorado

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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

Cedar Bluff Reservoir and dam are located in Trego County on the Smoky Hill River about18 miles southwest of Ellis, Kansas (fig. 1). Cedar Bluff Reservoir as part of the Cedar Bluff Unit of the Missouri River Basin development 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.

Cedar Bluff Dam was completed in September of 1951 and is a homogeneous zoned earthfill structure whose dimensions are (fig. 2):

Hydraulic height[1]	102.0	feet[2]	Structural height	202.0	feet
Top width	30	feet	Crest length	12,560	feet
Crest elevation	2,198.0	feet			

The spillway is located on the right abutment of the dam and consists of an inlet channel, an ungated overflow crest, eight 5- by 10-foot sluice gates beneath the crest, a central 14.5- by 10-foot radial gate beneath the crest, a chute, a stilling basin, and an outlet channel. The capacity of the spillway is 91,000 cubic feet per second (cfs) at reservoir elevation 2,192.0.

A gated outlet works through the base of the dam near the left abutment consists of an approach channel, an inlet structure, a 10-foot-diameter concrete conduit, a 4- by 5-foot emergency slide gate, a gate chamber, a control house, regulating slide gate, and an outlet channel. There is a 18-inch-outside-diameter steel pipe that can send water to a fish hatchery. The outlet works has a capacity of 900 cfs at reservoir elevation 2166.0.

There is a canal outlet works that consist of a concrete conduit from the river outlet works, a control house, a 108-inch-diameter concrete pipe expansion chamber, and a 66-inch-diameter concrete pressure pipe that discharge to the Cedar Bluff Canal.

The total drainage area above Cedar Bluff Dam is 5,530 square miles as listed by the USGS Water Resources Data Book. Cedar Bluff Reservoir has an average width of 1.4 miles with a length of around 7 miles.

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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.

SUMMARY AND CONCLUSIONS

This Reclamation report presents the 2000 results of the survey of Cedar Bluff Reservoir. 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

A static GPS control survey was conducted to establish a temporary horizontal and vertical control point for the reservoir survey. 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 "X 301" located about 7.5 miles southeast of Wakeeney, Kansas. All elevations in this report are referenced to the Reclamation project datum that is tied to the NGVD29.

The underwater survey was conducted in September of 2000 near reservoir water surface elevation 2,143.7. 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 Cedar Bluff Reservoir. 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 Cedar Bluff Reservoir 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 Cedar Bluff Reservoir sedimentation and watershed characteristics for the 2000 survey. The 2000 survey determined that the reservoir has a total storage capacity of 172,452 acre-feet and a surface area of 6,869 acres at reservoir elevation 2,144.0. Since closure in September of 1950, the reservoir had an estimated volume change of 13,044 acre-feet below reservoir elevation 2,144.0. This volume represents a 7.0 percent loss in total capacity and an average annual loss of 261.9 acre-feet per year.

RESERVOIR OPERATIONS

Cedar Bluff Dam operates as part of the Cedar Bluff Project to provide flood control, irrigation water, and recreational use. The September 2000 area-capacity tables show 717,592 acre-feet of total storage below the maximum water surface elevation 2,192.0. The 2000 survey measured a minimum elevation of 2,078.2. The following values are from the September 2000 area-capacity tables:

- 353,250 acre-feet of surcharge between elevation 2,166.0 and 2,192.0.
- 191,890acre-feet of flood control storage between elevation 2,144.0 and 2,166.0.
- 143,878 acre-feet of conservation use between elevation 2,107.8 and 2,144.0.
- 24,172 acre-feet of inactive storage between elevation 2,090.0 and 2,107.8.
- 4,402 acre-feet of dead storage below elevation 2,090.0.

The Cedar Bluff Reservoir inflow and end-of-month stage records in table 1, operation period November 1950 through September 2000, show the computed inflow and annual fluctuation since dam closure. Inflow values for water years 1997 and 1998 were not available and water year 2000 reported a negative inflow. The estimated average inflow into the reservoir for this operation period was 41,930 acre-feet per year. Since 1951, the extreme storage fluctuations of Cedar Bluff Reservoir ranged from an elevation of 2,092.2 in 1992 to the maximum recorded elevation of 2,153.5 in 1957.

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 Cedar Bluff Reservoir 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 Cedar Bluff Reservoir 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 $\pm$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 Cedar Bluff Reservoir 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 are 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 that allows on-the-fly centimeter accuracy measurements.

Survey Method and Equipment

The Cedar Bluff Reservoir hydrographic survey collection was conducted September 10 through September 13 of 2000 at water surface elevation 2,143.7 (Reclamation project datum). The bathymetric survey was run using sonic depth recording equipment, interfaced with an 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.

Cedar Bluff Reservoir Datums

Prior to the underwater survey in September 2000, a static GPS survey was conducted to establish a temporary horizontal and vertical control point that overlooked Cedar Bluff Reservoir. 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 "X 301" located about 7.5 miles southeast of Wakeeney, Kansas. All vertical information in this report was referenced to the reservoir water surface gauge measurements during the time of this survey that is reference to the Reclamation project datum that is tied to the NGVD29.

RESERVOIR AREA AND CAPACITY

Topography Development

The topography of Cedar Bluff Reservoir was developed from the 2000 collected underwater data and from the USGS quad maps. The upper contours of Cedar Bluff Reservoir were developed by digitizing the contour lines of elevation 2,120.0, 2,130.0, 2,140.0, 2,144.0, 2,150.0, and 2,166.0 from the USGS quad maps that covered the Cedar Bluff Reservoir area. The USGS quad maps were developed from aerial photography dated 1973, but the underwater contours of Cedar Bluff Reservoir were imported from a U.S. Bureau of Reclamation map dated 1951. 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.

Following are the ARC/INFO resulting digitized areas from the USGS quads versus the original reported areas:

(1) USGS digitized 2,120 contour area was 3,177 acres, 99.1% of the original 3,207 acres
(2) USGS digitized 2,130 contour area was 4,422 acres, 98.3% of the original 4,495 acres
(3) USGS digitized 2,140 contour area was 6,137 acres, 98.6% of the original 6,225 acres
(4) USGS digitized 2,144 contour area was 6,744 acres, 98.1% of the original 6,869 acres
(5) USGS digitized 2,150 contour area was 7,527 acres, 96.3% of the original 7,814 acres
(6) USGS digitized 2,166 contour area was 10,459 acres, 96.9% of the original 10,790 acres

It is assumed that the area differences are due to the quad scale and the different methods of digitizing the contour areas. These areas are only provided as information, none of the digitized measured surface areas from the USGS quads were used to develop the new area and capacity tables.

The elevation 2,130.0 contour digitized from USGS quad maps was used to perform a clip of the Cedar Bluff Reservoir TIN such that interpolation was not allowed to occur outside of the 2,130.0 contour. This complete contour was selected since it was the closest elevation to enclose the September 2000 underwater data that was collected at reservoir elevation 2,143.7. 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 majority of the underwater data completely lied within the elevation 2,130.0 clip. The upstream end of the 2,130 clip was adjusted to account for changes due to sediment deposition. This was completed using the underwater survey data to interpolate where the upstream end of the 2,130 contour line would occur due to the sediment delta formation.

The 2,130 contour was chosen 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 (around bottom elevation 2,120 to 2,130). For developing the 2000 Cedar Bluff Reservoir contour map and calculating the surface areas there was a need for data of the underwater reservoir areas not surveyed in September of 2000. Using ARCEDIT, the digitized elevation 2,120 USGS quad contour and the September 2000 underwater collected data layers were overlaid or plotted on-screen. Using ARCEDIT, elevation points were added in areas not surveyed to complete the development of the reservoir contours for elevation 2,130 and below. Locations of these points were determined by using the 2,120 contour as a pattern for locating the individual data points in areas not accessible during the September 2000 survey.

Contours for the reservoir below elevation 2,130.0 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 Cedar Bluff Reservoir TIN. In addition, the contours were generalized by filtering 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 Cedar Bluff Reservoir 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 2,079.0 through elevation 2,130.0. The contour topography at 5-foot intervals is presented on figures 3 through 8, drawing numbers 372-D-411 through 372-D-416.

Development of 2000 Contour Areas

The 2000 contour surface areas for Cedar Bluff Reservoir were computed at 1-foot increments, from elevation 2,079.0 to 2,130.0, using the Cedar Bluff Reservoir TIN discussed above. The 2000 survey measured the minimum reservoir as elevation 2,078.2 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 2,130.0 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 2,140.0 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 5-foot contour intervals, from reservoir elevation 2,080.0 to elevation 2,125.0 were used as the control parameters for computing the Cedar Bluff Reservoir capacity. The surface area for elevation 2,130.0 was computed from the digitized USGS contour of elevation 2,130 which was adjusted in the upstream end to account for measured sediment inflow. Since this study did not collect any above water data the original areas from elevation 2,140.00 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 Cedar Bluff Reservoir. 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 Cedar Bluff Reservoir 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 9 As of September 2000, at maximum reservoir water surface elevation 2,192.0, the surface area was 16,510 acres with a total capacity of 717,592 acre-feet.

RESERVOIR SEDIMENT ANALYSES

Figure 9 is a plot of Cedar Bluff Reservoir's original area data versus the 2000 measured areas. This illustrates the difference between the original and the 2000 measured surface areas. Since Cedar Bluff Dam closure in August November 1950, the measured total volume change at reservoir elevation 2,144.0 was estimated to be 13,044 acre-feet. The estimated average annual rate of capacity lost for this time period (49.8 years) was 261.9 acre-feet per year. The storage loss in terms of percent of original storage capacity was 7.03 percent. Tables 1 and 2 contain the Cedar Bluff Reservoir sediment accumulation and water storage data based on the 2000 resurvey.

The original 100 year sediment inflow estimate used during the design of Cedar Bluff Reservoir was 26,000 acre-feet for an average annual rate of capacity loss of 260 acre-feet. This is compared to the 2000 survey results of 261.9 acre-feet. It must be noted that the 2000 area and capacity table were generated using measured surface areas from elevation 2,130 and below. The original surface areas from elevation 2,140 and above were used to complete the new area and capacity table. This assumed no surface area change from elevation 2,140 and above which in all probability is not the case. The only means to measure this would be to conduct an aerial survey, but since the maximum water surface elevation since 1957 was 2,153.5 and the majority of the years the reservoir has operated at a much lower elevation than this, any change above elevation 2130 due to sediment accumulation is probably minimal. A resurvey of Cedar Bluff Reservoir 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 of the majority of the trees that are now located throughout the present underwater shoreline areas of the reservoir.

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RESERVOIR SEDIMENT
DATA SUMMARY

Cedar Bluff Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation	2. STREAM Smoky Hill River	3. STATE Kansas
	4. SEC. 36 TWP. 14 S RANGE 22 W	5. NEAREST P.O. Ellis	6. COUNTY Trego
	7. LAT 38° 47' 24" LONG 99° 43' 13"	8. TOP OF DAM ELEVATION 2198.0	9. SPILLWAY CREST EL 2166.0[1]

RESERVOIR	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	2192.0	16,510	353,230	730,180	
	b. FLOOD CONTROL	2166.0	10,790	191,860	376,950	11/50
	c. POWER					
	d. JOINT USE					16. DATE NORMAL OPERATION BEGAN
	e. CONSERVATION	2144.0	6,869	149,770	185,090	
	f. INACTIVE	2107.8	2,086	27,059	35,320	
	g. DEAD	2090.0	909	8,261	8,261	11/50
	17. LENGTH OF RESERVOIR	7.9 MILES		AVG. WIDTH OF RESERVOIR 1.4 MILES		

BASIN	18. TOTAL DRAINAGE AREA 5,530 SQUARE MILES	22. MEAN ANNUAL PRECIPITATION 23.1[2] INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 5,530 SQUARE MILES	23. MEAN ANNUAL RUNOFF 0.14[3] INCHES
	20. LENGTH MILES / AV. WIDTH MILES	24. MEAN ANNUAL RUNOFF 41,930[4] ACRE-FEET
	21. MAX. ELEVATION / MIN. ELEVATION	25. ANNUAL TEMP. MEAN 53°F RANGE -23°F to 112°F[2]

SURVEY DATA

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
11/50			Contour (D)	5-ft	6,869[5]	185,496[5]	4.42
9/00		49.8	Contour (D)	5-ft	6,869[6]	172,452[6]	4.11

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		41,930[7]	432,400	1,962,400	41,930	1,962,400

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	13,044[8]	261.9	0.047	13,044	261.9	0.047

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT^3)	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				0.141[9]	7.03[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
				1951	2,151.3	2,078.6	432,400
1952	2,143.5	2,134.2	29,600	1953	2,133.6	2,131.8	12,500
1954	2,132.1	2,128.9	12,400	1955	2,136.7	2,127.4	59,700
1956	2,136.1	2,133.8	27,200	1957	2,153.5	2,133.0	224,400
1958	2,146.5	2,144.2	82,800	1959	2,144.6	2,143.1	11,900
1960	2,148.2	2,143.4	108,900	1961	2,146.9	2,143.9	106,100
1962	2,144.8	2,143.3	76,100	1963	2,143.8	2,142.0	41,600
1964	2,145.0	2,140.2	50,900	1965	2,142.4	2,139.8	50,700
1966	2,144.9	2,140.1	52,100	1967	2,142.4	2,138.4	41,300
1968	2,139.4	2,135.0	22,900	1969	2,137.0	2,134.4	46,900
1970	2,137.5	2,133.4	23,000	1971	2,133.0	2,128.4	15,700
1972	2,130.5	2,127.7	38,900	1973	2,136.1	2,129.9	62,400
1974	2,136.8	2,131.3	21,400	1975	2,134.4	2,130.8	35,800
1976	2,130.4	2,124.1	16,400	1977	2,124.3	2,118.4	15,200
1978	2,118.7	2,107.7	10,700	1979	2,108.4	2,106.5	9,153
1980	2,106.6	2,102.6	9,579	1981	2,101.2	2,100.7	6,849
1982	2,105.5	2,100.4	14,200	1983	2,104.0	2,101.3	3,508
1984	2,103.0	2,100.6	7,010	1985	2,100.8	2,098.9	5,178
1986	2,098.8	2,096.0	2,899	1987	2,106.7	2,095.9	24,488
1988	2,105.8	2,102.7	2,919	1989	2,102.2	2,099.2	1,595
1990	2,099.1	2,097.3	3,798	1991	2,098.9	2,093.9	1,774
1992	2,093.9	2,092.2	2,597	1993	2,119.8	2,219.3	60,721
1994	2,122.2	2,119.7	3,788	1995	2,128.4	2,120.4	24,409
1996	2,138.1	2,126.7	41,518	1997	2,141.0	2,140.0	[7]
1998	2,145.3	2,140.4	[7]	1999	2,144.5	2,143.5	6,474
2000	2,144.7	2,143.3	[7]				

46. ELEVATION - AREA - CAPACITY DATA FOR **2000 CAPACITY**[10]								
ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
2078.2	0	0	2080	52.8	53	2085	465.8	1,349
2090	755.3	4,402	2095	1,115.5	9,079	2100	1,450.2	15,493
2105	1,739.7	23,468	2107.8	1,907.0	28,574	2110	2,039.3	32,916
2115	2,447.3	44,132	2120	3,018.0	57,795	2125	3,550.0	74,215
2130	4,273.1	93,773	2135	5,249	117,578	2140	6,225	146,264
2144	6,869.0	172,452	2145	7,017	179,395	2150	7,814	216,472
2155	8,677	257,700	2160	9,557	303,285	2165	10,590	353,652
2166	10,790	364,342	2170	11,680	409,282	2175	12,690	470,207
2180	13,770	536,357	2185	14,860	607,932	2190	16,000	685,082
2192	16,510	717,592						

47. REMARKS AND REFERENCES

[1] Top of spillway weir crest is elevation 2,166.0, top of weir is elevation 2,144.0, and top of sluices elevation 2,134.8.
[2] Bureau of Reclamation Project Data Book, 1981.
[3] Calculated using mean annual runoff value of 41,930 AF, item 24.
[4] Computed annual inflows from 11/50 through 9/00. (Missing values for water years 1997, 1998, and 2000).
[5] Original recomputed surface area and capacity at el. 2,144.0. For sediment computation purposes the original area and capacity was recomputed by the Reclamation ACAP program using the original 5-foot increment surface areas.
[6] Surface area & capacity at el. 2,144.0 computed by ACAP program.
[7] Inflow values in acre-feet and maximum and minimum elevations in feet by water year from 11/50 through 9/00. Missing inflow values for water years 1997, 1998, and 2000.
[8] Computed sediment volume at elevation 2,144.0.
[9] Storage losses at elevation 2,144.0.
[10] Capacities computed by Reclamation's ACAP computer program.

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

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

1	2	3	4	5	6	7	8
Elevations (feet)	**Original Survey (acres)**	**Original Capacity (acre-feet)**	**2000 Survey (acres)**	**2000 Survey (acre-feet)**	**2000 Sediment Volume (acre-feet)**	**2000 Percent of Sediment**	**Percent of Reservoir Depth**
2,192.0	16510.0	730636	16510.0	717592			100.0
2,190.0	16000.0	698126	16000.0	685082			98.4
2,185.0	14860.0	620976	14860.0	607932			94.5
2,180.0	13770.0	549401	13770.0	536357			90.6
2,175.0	12690.0	483251	12690.0	470207			86.7
2,170.0	11680.0	422326	11680.0	409282			82.8
2,166.0	10790.0	377386	10790.0	364342			79.7
2,165.0	10590.0	366696	10590.0	353652			78.9
2,160.0	9557.0	316329	9557.0	303285			75.0
2,155.0	8677.0	270744	8677.0	257700			71.1
2,150.0	7814.0	229516	7814.0	216472			67.2
2,145.0	7017.0	192439	7017.0	179395			63.3
2,144.0	6869.0	185496	6869.0	172452	13044	100.0	62.5
2,140.0	6225.0	159308	6225.0	146264	13044	100.0	59.4
2,135.0	5353.0	130363	5249.0	117578	12785	98.0	55.5
2,130.0	4495.0	105743	4273.1	93773	11970	91.8	51.6
2,125.0	3828.0	84935	3550.0	74215	10720	82.2	47.7
2,120.0	3207.0	67348	3018.0	57795	9553	73.2	43.8
2,115.0	2668.0	52660	2447.3	44132	8528	65.4	39.8
2,110.0	2271.0	40313	2039.3	32916	7397	56.7	35.9
2,107.8	2112.0	35492	1907.0	28574	6918	53.0	34.2
2,105.0	1909.0	29863	1739.7	23468	6395	49.0	32.0
2,100.0	1607.0	21073	1450.2	15493	5580	42.8	28.1
2,095.0	1274.0	13870	1115.5	9079	4791	36.7	24.2
2,090.0	909.0	8413	755.3	4402	4011	30.7	20.3
2,085.0	605.0	4628	465.8	1349	3279	25.1	16.4
2,080.0	399.0	2118	52.8	53	2065	15.8	12.5
2,078.2	324.0	1467	0.0	0	1467	11.2	11.1
2,075.0	191.0	643	0.0	0	643	4.9	8.6
2,070.0	30.0	90	0.0	0	90	0.7	4.7
2,064.0	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 13,044.
8	Depth of reservoir expressed in percentage of total depth of 128 feet.

Table 2. - Summary of 2000 survey results

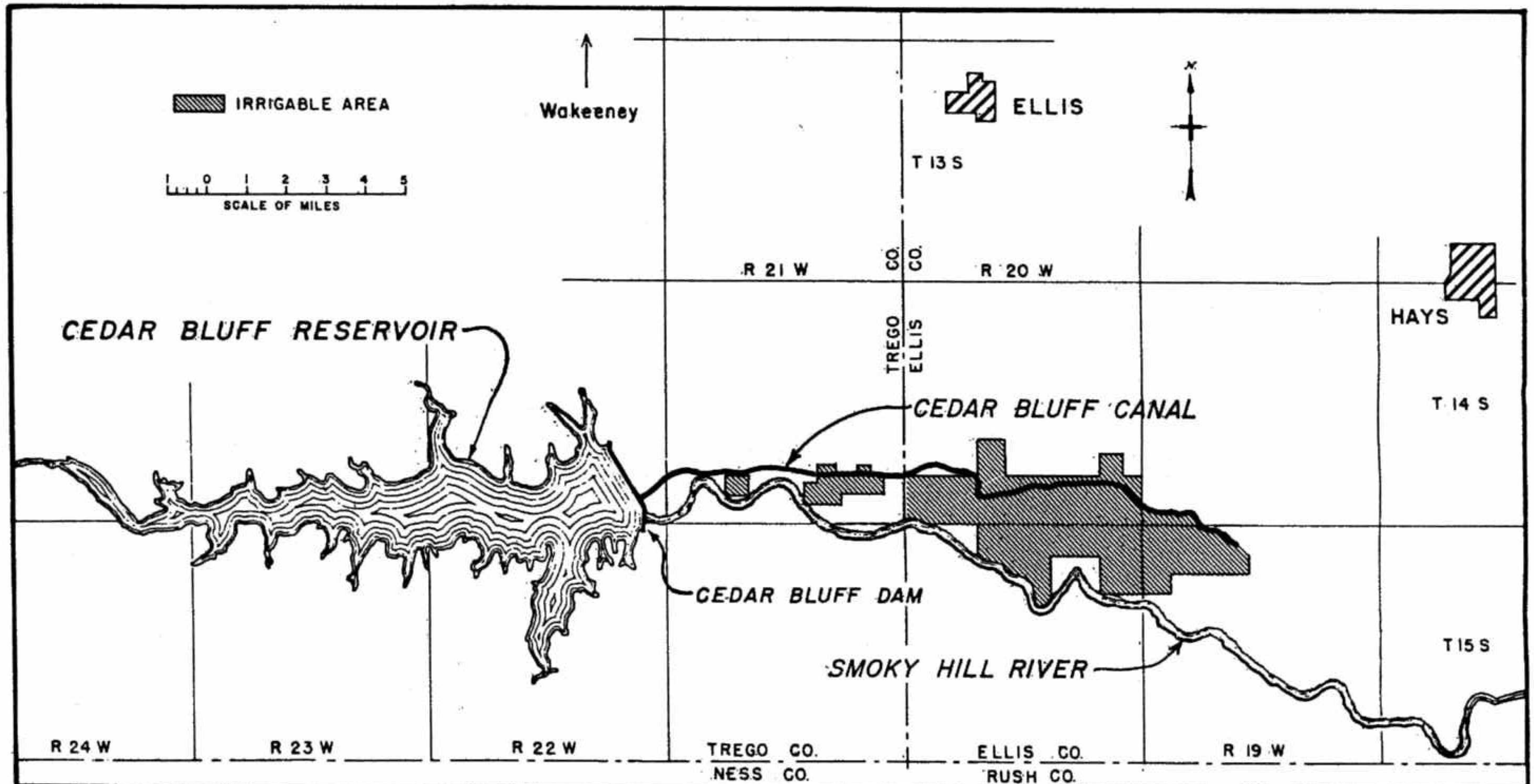

Figure 1. - Cedar Bluff Reservoir location map.

Space intentionally left blank due to security concerns

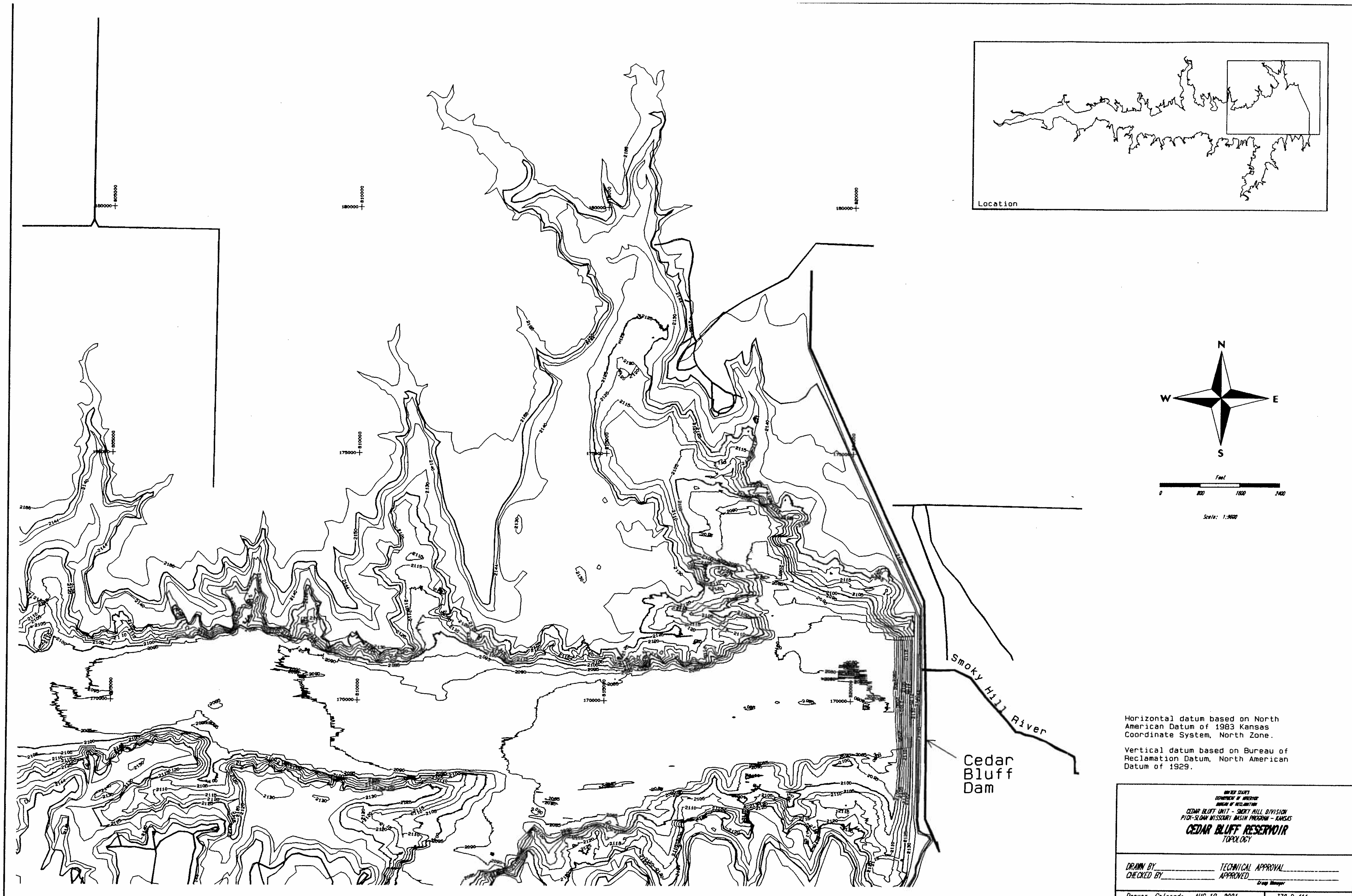

Figure 3. - Cedar Bluff Reservoir topographic map, No. 372-D-411

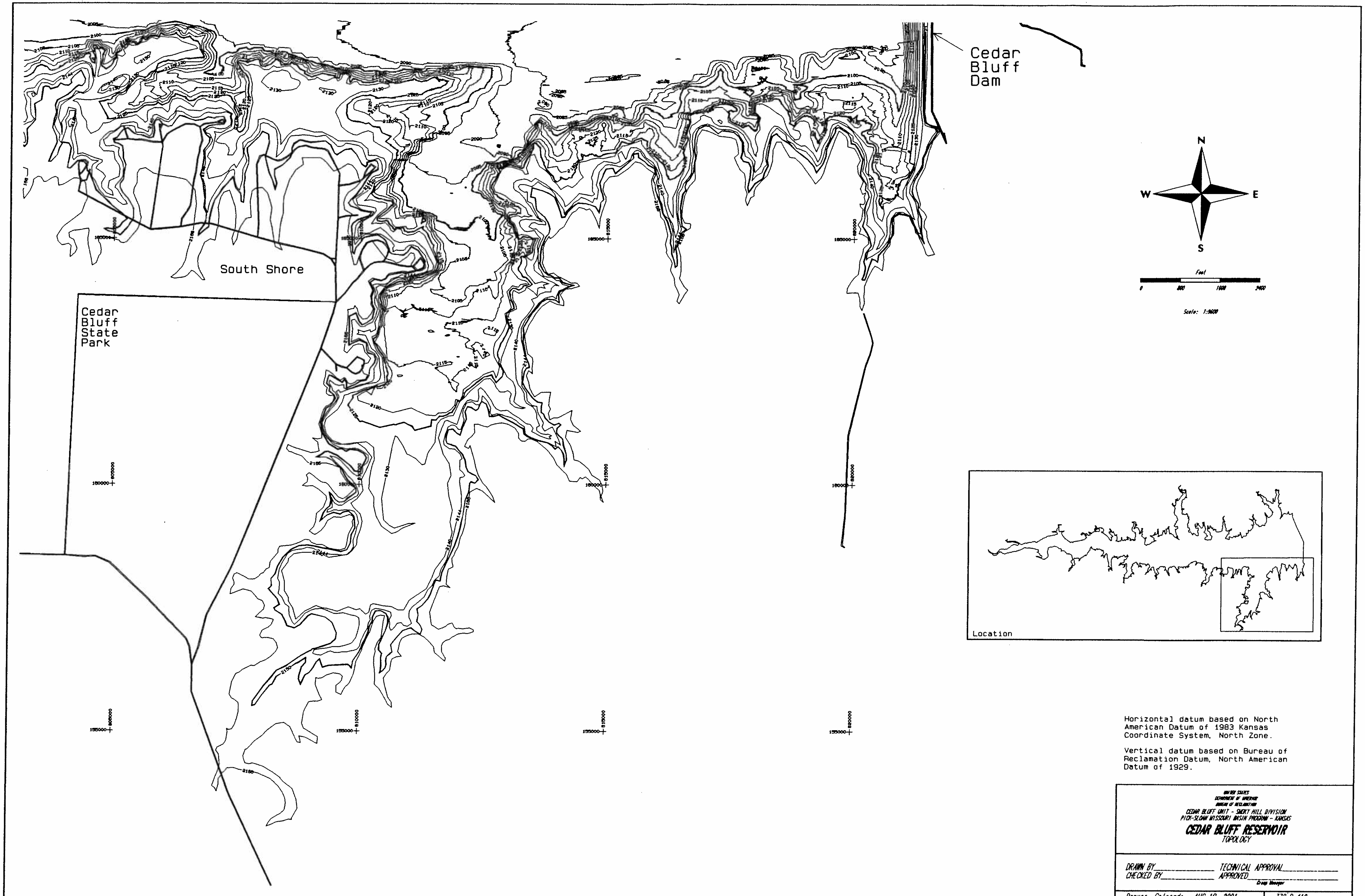

Figure 4. - Cedar Bluff Reservoir topographic map, No. 372-D-412

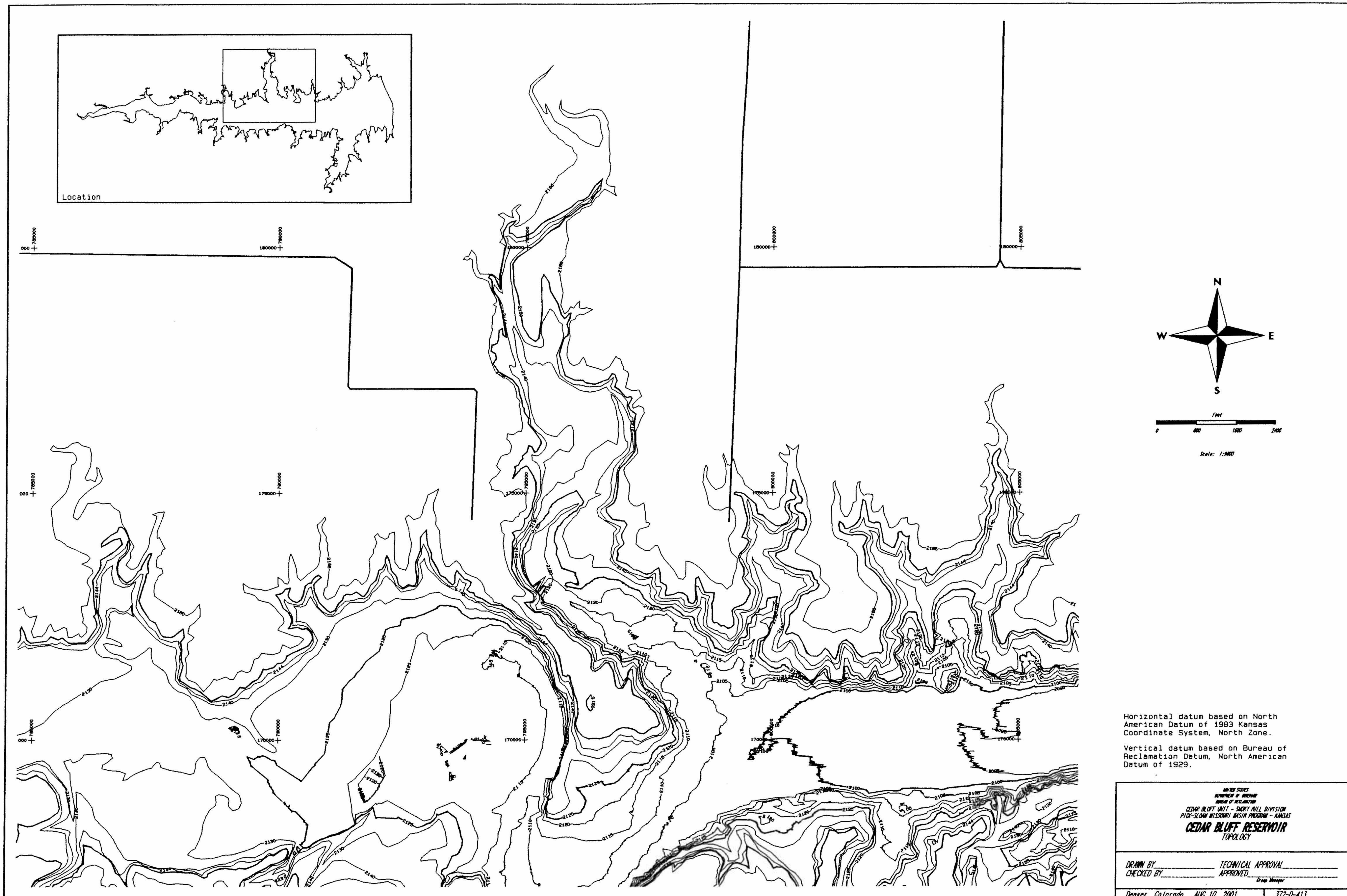

Figure 5. - Cedar Bluff Reservoir topographic map, No. 372-D-413

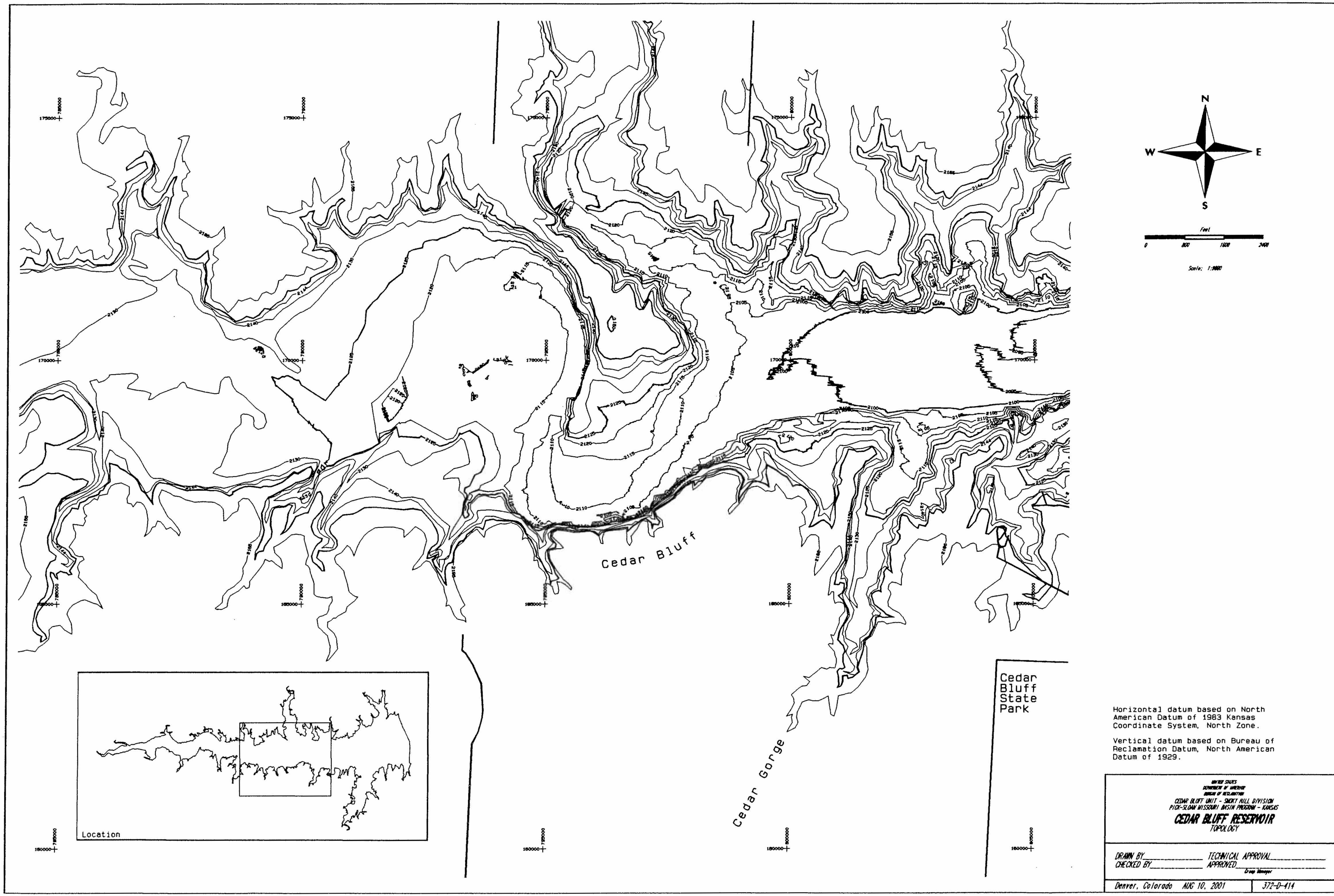

Figure 6. - Cedar Bluff Reservoir topographic map, No. 372-D-414

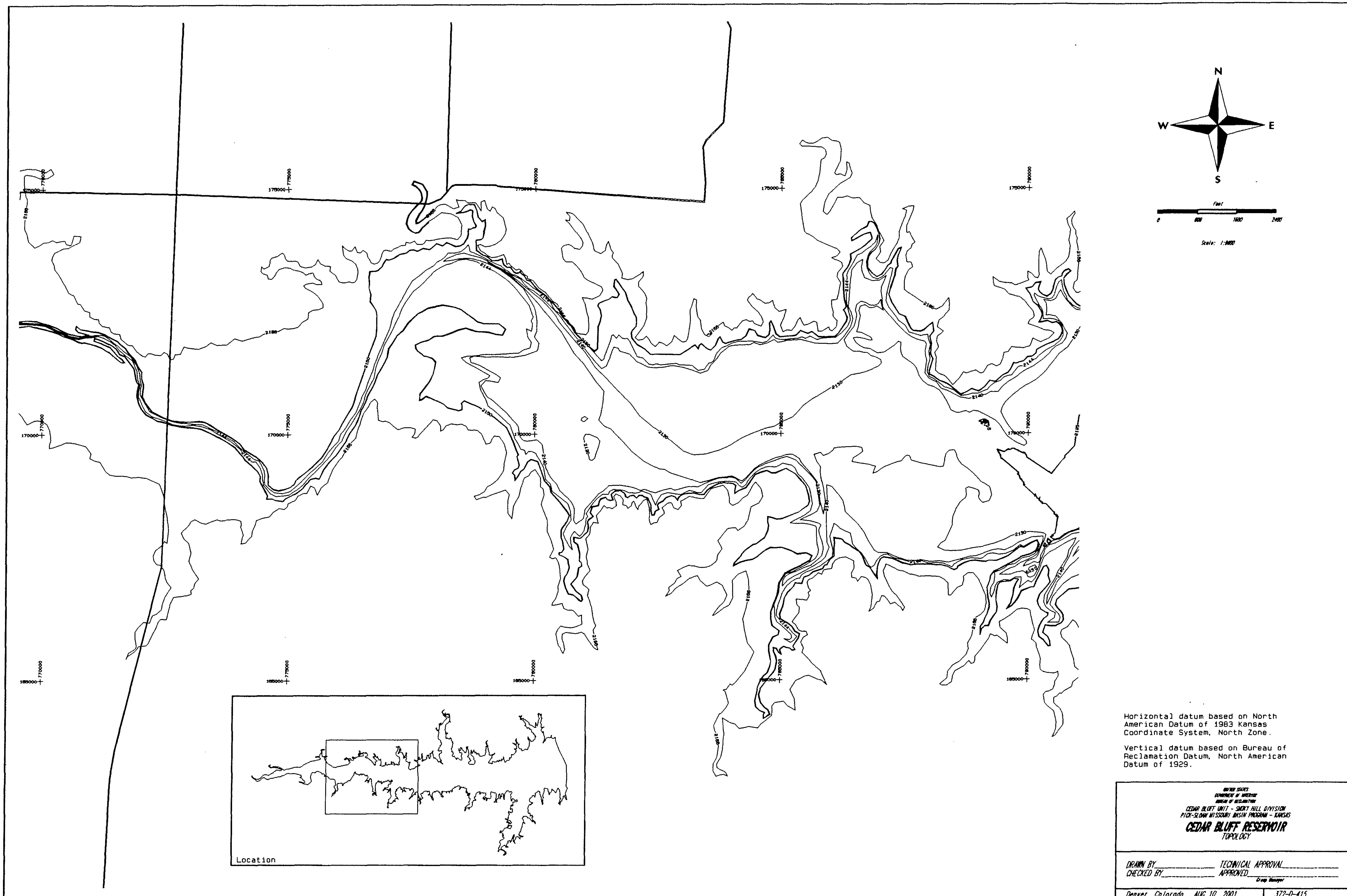

Figure 7. - Cedar Bluff Reservoir topographic map, No. 372-D-415

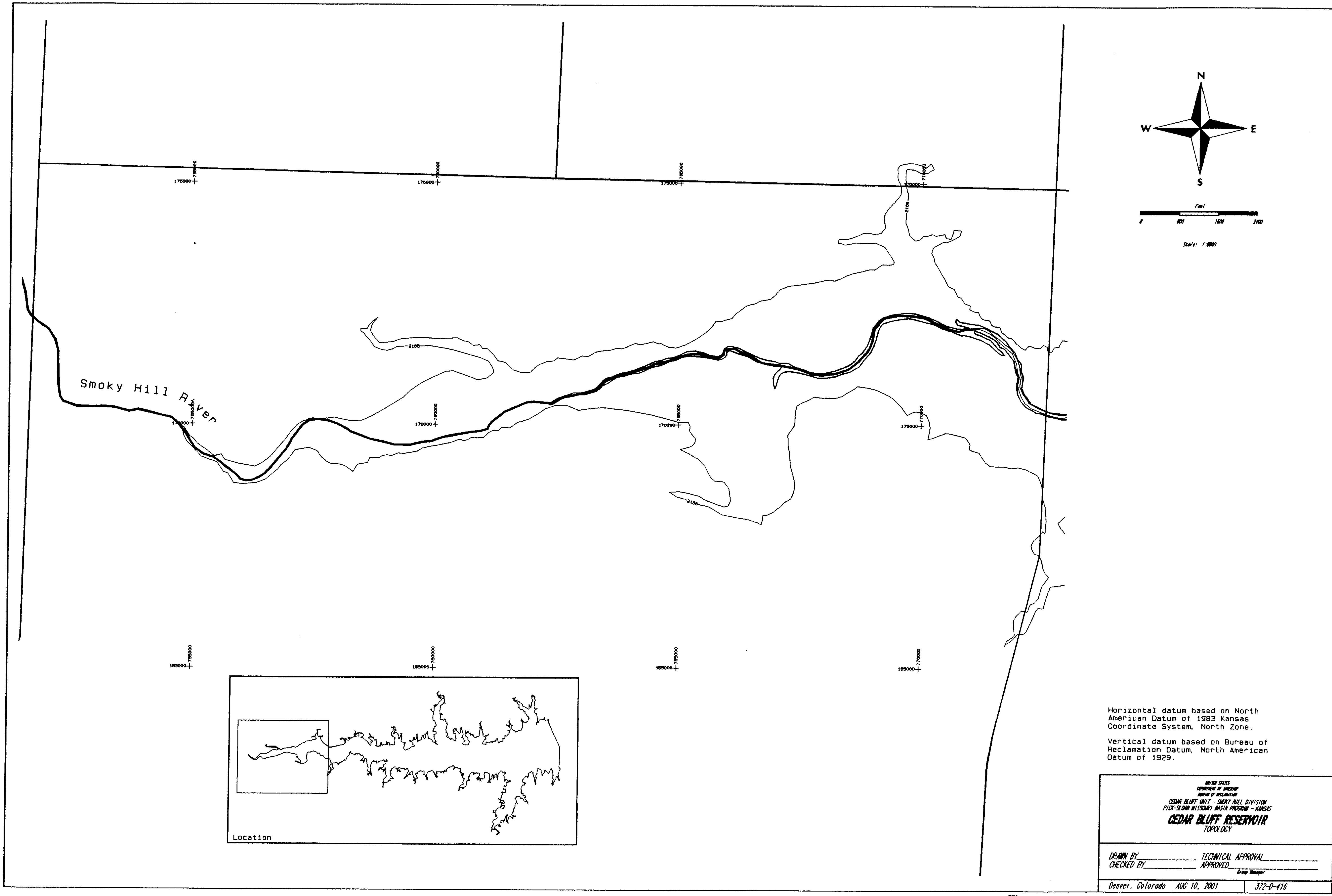

Figure 8. - Cedar Bluff Reservoir topographic map, No. 372-D-416

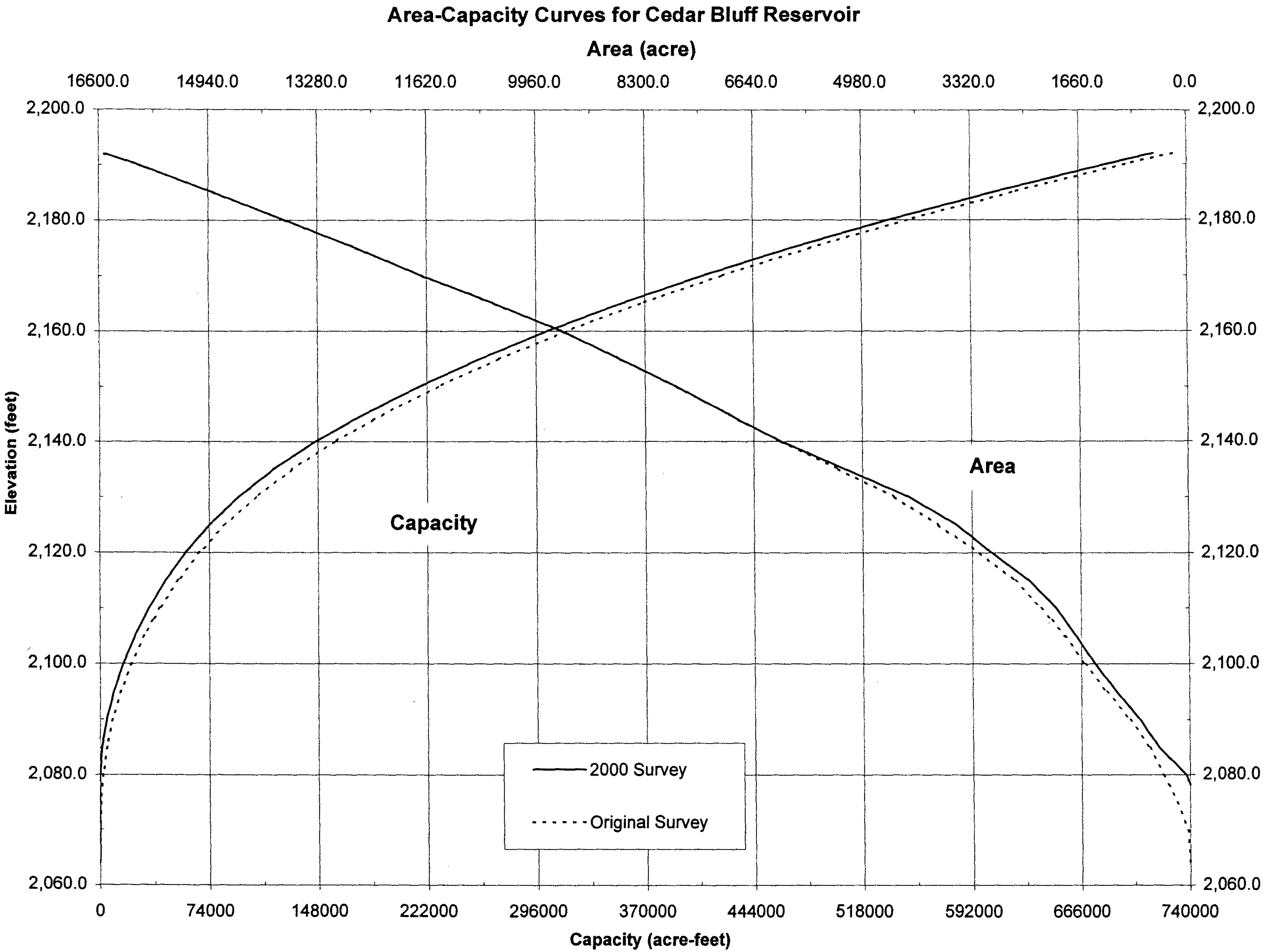

Figure 9 - 2000 area and capacity curves