LAKE LOWELL
1994 RESERVOIR SURVEY

WATER RESOURCES MANAGEMENT.....FOR THE FUTURE

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13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation surveyed the underwater area of Lake Lowell in April 1994 to compile field data for developing a reservoir topographic map and computing a present storage-elevation relationship. The 1994 bathymetric survey used sonic depth recording equipment interfaced with an automated microwave positioning system that gave continuous depth and sounding positions throughout the reservoir. The above-water reservoir area was measured from aerial photography obtained prior to the bathymetric survey. The topography was developed by a computer graphics program using the collected data. The new reservoir contour map is a combination of the aerial and underwater measured topography.

As of April 1994, at maximum reservoir elevation (feet) 2531.2, the surface area was 9024.8 acres with a total capacity of 173,043 acre-feet and an active capacity of 159,365 acre-feet.

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LAKE LOWELL RESERVOIR

1994 RESERVOIR SURVEY

by

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Denver, Colorado

September 1995

ACKNOWLEDGMENTS

The Bureau of Reclamation's Sedimentation and River Hydraulics Group of the TSC (Technical Service Center) prepared and published this report. Ronald Ferrari of the TSC conducted the hydrographic survey. Personnel from the Columbia Basin Project Office of the Pacific Northwest Region assisted during the hydrographic survey and performed the required land survey for the hydrographic and aerial data collection. Special thanks to Jack McFarlin and Doug Schmidt of the project office for their field assistance during the hydrographic survey. Ronald Ferrari completed the data processing needed to generate the new topographic map and area-capacity tables. Paul Weghorst of the TSC developed the procedures for generating the new topographic maps and computing the surface areas. James Melena performed the peer review of this documentation.

U.S. Department of the Interior
Mission Statement

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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INTRODUCTION

Lake Lowell, formally Deer Flat Reservoir, is an off-stream storage facility formed by three earth-fill dams and is one of five storage reservoirs of the Boise Project. Lake Lowell is located in Canyon County about 5 miles west of Nampa and 25 miles west of Boise, Idaho (fig. 1).

On March 27, 1905, the original Boise Project (now the Arrowrock Division) was authorized under provisions of the Reclamation Act of June 17, 1902 (32 Stat. 388). The dams of Lake Lowell consist of three zoned, rolled earthfill embankments called the Upper, Middle, and Lower Dams (fig. 2). A fourth embankment, called the East (Roadway) Dike, was completed in 1911. Little is known about the construction of the East Dike, the purpose of which is to protect farmsteads on the eastern end of the reservoir during full conditions. Construction of the structures took place between 1906 and 1911; closure and first storage took place in 1908. At elevation 2531.2, the reservoir length is 9.2 miles and average width is 0.65 mile.

The Upper Embankment was constructed from 1906 through 1908 with modifications in 1911 and 1938. The embankment has a crest length of 4,164 feet with a structural height* of 74 feet, a hydraulic height of 72 feet, and a crest elevation of 2539.2 (±0.2 ft). Near the right abutment, the Deer Flat Nampa Canal has a diversion capacity of 100 cubic feet per second; near the left abutment, the Deer Flat Caldwell Canal has a diversion capacity of 70 cubic feet per second.

The Lower Embankment was constructed from 1906 through 1908 with modifications in 1909, 1913, and 1938. The embankment has a crest length of 7,270 feet with a structural height of 46 feet, a hydraulic height of 44 feet, and a crest elevation of 2539.3 (±1.6 ft). The Low Line Canal at the left abutment has a diversion capacity of 1,200 cubic feet per second, and the Deer Flat North Canal at the right abutment has a capacity of 70 cubic feet per second.

The Middle Embankment, which has no diversion structures, was completed in 1911 and has a structural height of 16 feet, a crest length of 1,262 feet, and a crest elevation of 2536.0 (±0.1 ft). Lake Lowell is an off-stream reservoir with no spillway structure. The Middle Embankment, which was constructed with a lower crest elevation than the other embankments, has been referred to as an emergency spillway; however, no slope protection is provided for this purpose.

Lake Lowell receives the majority of its inflow from the Boise River, via the New York Canal, whose headworks is located about 5 miles east of Boise, Idaho, and about 40 channel miles from Lake Lowell. The contributing drainage area of Lake Lowell is 63.5 square miles, of which 23.3 percent is reservoir area. The drainage area's elevations range from 2,501.2 feet at the reservoir to 3,010 feet at the southern boundary. Drainage runoff enters the reservoir from small natural streams or through the basin's extensive canal system. Water is diverted from the reservoir through the four separate canal outlets located at the Upper and Lower Embankments. The total capacity of all the canal outlets is 1,440 cubic feet per second.

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* The definition of terms such as "structural height," "hydraulic 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*.

SUMMARY AND CONCLUSIONS

This report presents the 1994 results of the first extensive reservoir survey of Lake Lowell Reservoir by the Bureau of Reclamation since construction of the dams. The primary objectives of the survey were to:

- gather data needed for developing new reservoir topography
- compute area-capacity relationships
- resolve the issue of the reservoir's elevation datum.

Standard land surveying methods were used to establish horizontal and vertical control points for the aerial and hydrographic surveys. A horizontal grid system was established for both surveys using monumented control points located in the reservoir area. The bathymetric survey was run using sonic depth recording equipment interfaced with an automated survey system consisting of a line-of-sight microwave positioning unit capable of determining sounding locations within the reservoir. The system continuously recorded reservoir depth and horizontal coordinates as the survey boat was navigated along close spaced gridlines covering the reservoir area. The positioning system provided information to allow the boat operator to maintain course along these gridlines. Water surface elevations measured by the land surveyors at the time of data collection were used to convert the sonic depth measurements to true lake bottom elevations.

The 1994 underwater surface areas at predetermined 2-foot contour intervals were generated by a computer graphics program using the collected data. The above-water reservoir area was measured from aerial photography obtained on January 26, 1994, at approximate water surface elevation 2515.0. The new reservoir contour map is a combination of the aerial and underwater topography and is drawn at 5-foot contour intervals for clarity (fig. 3). The revised area and capacity tables were produced by a computer program that used the measured contour surface areas and a curve-fitting technique to compute area and capacity at prescribed elevation increments.

Table 1 contains a summary of results for the 1994 reservoir survey. The 1994 survey determined that the reservoir has a total storage capacity of 173,043 acre-feet and a surface area of 9024.8 acres at reservoir elevation 2531.2. No sediment calculations are given because of the unknown original capacity of Lake Lowell.

RESERVOIR OPERATIONS

The reservoir is primarily an irrigation facility having no flood control storage (the following values are from April 1994 area-capacity tables):

- 159,365 acre-feet of active conservation storage between elevations 2504.2 and 2531.2.

- 5,823 acre-feet of inactive storage between elevations 2501.2 and 2504.2 (the inactive storage is required for proper outlet works discharge).

- 7,855 acre-feet of dead storage below elevation 2501.2.

Lake Lowell is an off-stream reservoir that receives the majority of its inflow from Boise River diversions. Available records for years 1949 through 1994 show that the average unregulated inflow into the reservoir was 248,570 acre-feet per year. This value would compute to a mean annual runoff of 73.4 inches for the 63.5-square-mile basin. The inflow and end-of-month stage records in table 1 show the annual fluctuation of the reservoir. The end-of-month elevation records were measured from different datums, and it is assumed that they would have to be adjusted +0.7 feet to be tied to the mean sea level datum. The available records show Lake Lowell operation ranging from elevation 2506.2 in 1992 to elevation 2531.2, which occurred from 1957 through 1959.

SURVEY METHOD AND EQUIPMENT

The Lake Lowell hydrographic survey was completed using the contour method as outlined by Blanton (1982). The procedure involved collecting adequate coordinate data for developing a reliable contour map by photogrammetric and bathymetric survey methods. Standard land surveying methods were used by Columbia Basin Project Office personnel to establish horizontal and vertical control points for both survey methods. A horizontal grid system was established for both surveys using monumented points, with state plane coordinates, located in the reservoir area. The vertical control for the study was based on Bureau of Reclamation vertical datum. The above water data were collected by aerial photography obtained on January 26, 1994, at approximate reservoir elevation 2515.0. The field survey work for the bathymetric survey involved establishing a triangulation network around the reservoir to provide horizontal and vertical control for all required gridlines and shore stations. No range lines had been previously established on the lake, and it was decided not to establish permanent range lines during this survey. Because of the size and shape of the reservoir, any future survey would also employ the contour method; therefore, permanent range line end markers were not necessary.

The hydrographic survey was run from April 20 through 22, 1994, with the reservoir at water surface elevation 2526.95, 2526.80, and 2526.64 respectively. The bathymetric survey was run using sonic depth recording equipment interfaced with an automated survey system consisting of a line-of-sight microwave positioning unit capable of determining sounding locations within the reservoir. This positioning system transmitted line-of-sight microwave signals to fixed shore stations and converted the reply time to range distances, which were used by the system data logger to compute the coordinate position of the sounding boat. The survey system continuously recorded reservoir depth and horizontal coordinates as the survey boat moved across close-spaced gridlines covering the reservoir area. An average grid spacing of 400 feet was selected to produce adequate data for developing contours of Lake Lowell. The system gave directions to the boat operator to assist in maintaining course along the close-spaced gridlines. During each run, the depth and position data were recorded on a floppy disk for subsequent processing by Technical Service Center personnel. A graph plotter was used in the field to track the boat and ensure adequate coverage during the collection process. Water surface elevations surveyed at the time of collection were used to convert the sonic depth measurements to true lake bottom elevations.

RESERVOIR AREA AND CAPACITY

Original Capacity

The original area-capacity curves for Lake Lowell reported the total capacity as 190,000 acre-feet with a surface area of 9,840 acres at a reservoir elevation of 2530.5. The original capacity curves (drawing number 4-100-215) note that the dead storage was 13,000 acre-feet but give no additional information. The drawing also notes that the capacity curve represents visual capacity. These values do not compare very well with the 1994 measured surface areas and computed capacity values, which questions the accuracy of the original data. A plot of the original area data versus the 1994 measured areas showed near mirror images of each other; the elevation datum difference varied between 2.2 and 2.8 feet. The difference between the original and 1994 surface areas is caused by the datum difference. A comparison between the original and 1994 capacity for computing sediment volumes is not possible because limited information is available on the original dead portion of the reservoir.

1994 Topography Development

The topography of Lake Lowell was developed from collected aerial and underwater coordinate data. To develop the contours around the three embankment dams, the contour elevation 2540.0 was digitized from the United States Geological Survey 7.5 Minute Quadrangle (USGS Quads) Maps that cover the Lake Lowell area. These maps were dated 1958 with photorevisions in 1971. ARC/INFO V7.0.2 Geographic Information System software was used to digitize the contours. The digitized contours were transformed to Idaho West Zone State Plane Coordinates using the North American Datum of 1927 (NAD 1927). These transformations were performed using the ARC/INFO PROJECT command.

Contours for elevations below elevation 2540.0 feet were computed from collected underwater data using the TIN (triangular irregular network) surface modeling package within ARC/INFO. The aerial and underwater survey data were collected in the Idaho West Zone State Plane Coordinates in NAD 1927. The collected data ranged in elevation from 2469.4 to 2582.4 feet. 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 know as Delaunay's criteria for triangulation. Triangles are formed between all data points including all boundary points. This method preserves all collected survey points. The method requires that a circle drawn through the three nodes of a triangle will contain no other point. This requirement means that sample points are connected to their nearest neighbors to form triangles. Elevation contours are then interpolated along the triangle elements. The TIN method is discussed in great detail in the ARC/INFO V7.0.2 User's Documentation.

The elevation 2540.0-foot contour that was digitized from USGS Quads was used to perform a clip of the Lake Lowell TIN such that interpolation was not allowed to occur outside of the 2540.0 contour. This method was necessary to force closure of the contours on the reservoir side of the three embankment dams. This clip was performed using the hardclip option of the ARC/INFO CREATETIN command. In creating the TIN, points that fell within a set distance of each other were weeded out to eliminate flat triangular elements. Flat triangles occur where all three points making up a triangle have the same elevation. Elimination of redundant points helped to improve the performance of the contouring process as well as helped to create more continuous contours in the lower elevations of the reservoir.

The linear interpolation option of the ARC/INFO TINCONTOUR command was used to interpolate contours from the Lake Lowell TIN. In addition, the contours were generalized by weeding out 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 areas and volumes for Lake Lowell. The contour topography at 5-foot intervals is presented on figure 3.

Development of 1994 Contour Areas

The 1994 contour surface areas for Lake Lowell were computed in 1-foot intervals from elevation 2484.0 to 2540.0 using the Lake Lowell TIN discussed above. The 1994 survey measured the minimum reservoir as elevation 2483.6 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.

An additional clip was digitized to account for the area removed by the fourth embankment dam, called the East (Roadway) Dike. The purpose of the East Dike is to protect farmsteads on the eastern end of the reservoir during full conditions. Using the methods described above, a second TIN was created of Lake Lowell for computing the surface areas of the reservoir only. Comparing the area computations of both TINs found that farmstead protection from the East Dike occurs when the reservoir water surface reaches elevation 2523.0 and above.

The contour surface areas of elevations 2518.0 and 2531.0 were measured from the USGS Quads of Lake Lowell to further verify the 1994 study datum adjustments and the measured surface areas. The measured surface areas of the two contours from the USGS Quads were within 0.5 percent of the computed 1994 surface areas for the same contour elevation.

1994 Storage Capacity

The storage-elevation relationships based on the measured surface areas were developed using the area-capacity computer program ACAP85 (Reclamation, 1985). Surface areas at 2-foot contour intervals from minimum reservoir elevation 2483.6 to maximum active conservation storage elevation 2531.2 were used as the control parameters for computing the Lake Lowell capacity. The program can compute an area and capacity at elevation increments of 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, which was set at 0.000001 for Lake Lowell. This 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 the basic area curve over that interval) tests the fit until it also 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:

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

where:

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

Results of the 1994 Lake Lowell area and capacity computations are listed in table 1. A separate set of 1994 area and capacity tables has been published for the 0.01-, 0.1-, and 1-foot elevation increments (Reclamation, 1994). A description of the computations and coefficients output from the ACAP85 program is included with these tables. The 1994 area-capacity curves are plotted on figure 4. As of April 1994, at reservoir elevation 2531.2, the surface area was 9,024.8 acres with a total capacity of 173,043 acre-feet and an active capacity of 159,365 acre-feet. The active capacity is considered from elevation 2504.4 to top of conservation storage elevation 2531.2. Top of dead storage elevation is 2501.2, but to obtain proper outlet works discharge there is inactive storage between elevations 2501.2 to 2504.4.

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American Society of Civil Engineers, *Nomenclature for Hydraulics*, ASCE Headquarters, New York, 1962.

Blanton, J.O. III, *Procedures for Monitoring Reservoir Sedimentation: Technical Guideline for Bureau of Reclamation*, Denver Office, Denver, CO, October 1982.

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Bureau of Reclamation, *Guide for Preparation of Standing Operating Procedures for Bureau of Reclamation Dams and Reservoirs*, U.S. Government Printing Office, Denver, CO, 1987a.

Bureau of Reclamation, *Design of Small Dams*, U.S. Government Printing Office, Denver, CO, 1987b.

Bureau of Reclamation, Technical Service Center, *Lake Lowell Area and Capacity Tables, Boise Project,* Pacific Northwest Region, Denver, CO, May 1995.

Environmental Systems Research Institute, Inc., *ARC Command References*, 1992.

RESERVOIR SEDIMENT DATA SUMMARY

Lake Lowell
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation	2. STREAM offstream[1]	3. STATE Idaho
	4. SEC. 19 TWP. 3N RANGE 3W	5. NEAREST P.O. Caldwell	6. COUNTY Canyon
	7. LAT 43° 33' 30" LONG 116° 38' 55"	8. TOP OF DAM ELEVATION 2538.0[2]	9. SPILLWAY CREST 2537.5[3]

RESERVOIR	10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL[4]	12. ORIGINAL SURFACE AREA, Ac	13. ORIGINAL CAPACITY, AF	14. GROSS STORAGE ACRE- FEET	15. DATE STORAGE BEGAN / 16. DATE NORMAL OPERATION BEGAN
	a. SURCHARGE					15. 1908
	b. FLOOD CONTROL					
	c. POWER					
	d. WATER SUPPLY					16. 1908
	e. CONSERVATION	2530.5[4]	9,840[5]	169,000[5]	190,000	
	f. INACTIVE	2503.5[6]	2,775	8,000	21,000	
	g. DEAD	2500.5[6]	1,960	13,000	13,000	
	17. LENGTH OF RESERVOIR 9.2 MILES			AVG. WIDTH OF RESERVOIR 0.65 MILES		

BASIN	18. TOTAL DRAINAGE AREA 63.5 SQUARE MILES		22. MEAN ANNUAL PRECIPITATION 11.7[7] INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 63.5 SQUARE MILES		23. MEAN ANNUAL RUNOFF 73.4[1,8] INCHES
	20. LENGTH MILES	AV. WIDTH MILES	24. MEAN ANNUAL RUNOFF 248,570[1,9] ACRE-FEET
	21. MAX. ELEVATION 3,010	MIN. ELEVATION 2,501.2	25. ANNUAL TEMP. MEAN 52°F RANGE -23°F to 108°F[7]

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
1908			Contour (R)		[5]	[5]	
4/94	96	96	Contour(D)	2-ft	9,024.8	173,034	

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
4/94	11.7	248,5708[8]	408,500[8]	-	248,570[8]	-

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.
	[10]			[10]		

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		42. SEDIMENT INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANNUAL	b. TOTAL TO DATE	a. PER.	b. TOT.

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW, AND ABOVE, SPILLWAY CREST ELEVATION											
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											
	N/A											

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														
	N/A														

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

45. RANGE IN RESERVOIR OPERATION [9,11]

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1948				1949	2528.5	2509.4	
1950	2530.4	2510.6		1951	2529.8	2515.0	
1952	2530.3	2513.6		1953	2530.8	2514.7	
1954	2529.1	2514.5		1955	2529.1	2508.6	
1956	2528.4	2513.9		1957	2530.5	2510.4	
1958	2530.5	2518.7		1959	2530.5	2511.0	
1960	2529.6	2509.0		1961	2529.7	2516.2	
1962	2530.2	2517.2		1963	2529.3	2521.3	215,700
1964	2529.6	2520.5	308,700	1965	2530.1	2525.2	320,400
1966	2527.4	2510.2	167,500	1967	2529.5	2511.8	364,400
1968	2527.8	2522.4	258,100	1969	2529.3	2520.2	272,400
1970	2529.7	2516.5	250,900	1971	2528.0	2517.4	264,700
1972	2527.4	2513.0	224,200	1973	2529.0	2510.3	266,700
1974	2528.1	2510.2	320,000	1975	2529.7	2515.6	272,900
1976	2529.0	2515.5	299,500	1977	2524.0	2507.8	110,900
1978	2530.4	2510.7	408,500	1979	2528.5	2511.8	202,400
1980	2529.9	2516.7	280,500	1981	2529.9	2514.9	207,500
1982	2529.2	2520.9	297,700	1983	2529.3	2521.0	249,300
1984	2529.3	2518.3	253,900	1985	2526.7	2513.2	244,800
1986	2528.2	2515.3	285,700	1987	2526.9	2514.3	134,600
1988	2523.4	2513.9	213,710	1989	2525.8	2513.2	276,830
1990	2522.4	2510.6	167,940	1991	2523.0	2512.0	-
1992	2515.9	2505.5	68,230	1993	2523.4	2507.0	-
1994	2525.5	2511.3					

46. ELEVATION - AREA - CAPACITY DATA FOR **1994 TOTAL CAPACITY** [12]

ELEV.	AREA	CAP.	ELEV.	AREA	CAP.	ELEV.	AREA	CAP.
2483.6	0	0	2485	4.8	3	2487	61.3	69
2489	145.1	276	2491	260.2	681	2493	441.7	1,383
2495	626.1	2,451	2497	762.9	3,840	2499	904.9	5,508
2500	983.5	6,452	2501.2	1,355.7	7,855	2503	2,091.0	10,957
2505	2,678.5	15,727	2507	3,195.3	21,601	2509	3,724.1	28,520
2511	4,262.0	36,506	2513	4,812.1	45,580	2515	5,366.9	55,759
2517	5,948.1	67,074	2519	6,383.5	79,406	2521	6,797.1	92,587
2523	7,184.4	106,568	2525	7,633.5	121,386	2527	8,075.9	137,095
2529	8,545.2	153,716	2531.2	9,024.8	173,043			

47. REMARKS AND REFERENCES

[1] Water diverted from Boise River through New York Canal.

[2] Reservoir formed by three earthfill dams, (Upper, Lower, and Middle). A fourth dike called East Roadway protects farmsteads when reservoir water content is near full.

[3] Offstream reservoir with no spillway structure. Middle embankment is 0.5 feet lower than other two dikes and serves as emergency spillway.

[4] Original elevations prior to datum adjustments. Many survey datums have been done throughout the history of Lake Lowell. A 1990 survey measured the maximum conservation water surface elevation as 2,531.2 feet (mean sea level).

[5] Original area and capacity values from Reclamation reservoir allocation sheet which reference area-capacity curves dated 2/15/31 (drawing number 4-100-215). Many questions on accuracy of original area and capacity values and datum elevation to use. No surface area data available on dead storage portion of lake.

[6] 1990 survey determined top of inactive elevation 2504.2 and top of dead elevation 2501.2. The inactive storage is required for proper outlet works discharge.

[7] Bureau of Reclamation *Project Data Book* of Boise Project, 1966 - 80.

[8] Calculated using mean annual runoff value of 248,570 acre-ft (item 24).

[9] Calculated unregulated monthly inflows for available reservoir operation records, 1963 through 1994. Missing records for water years 1991 and 1993.

[10] There are many questions as to validity of original area-capacity data. Original values are needed to accurately compute capacity loss caused by sediment since 1908.

[11] End-of-month maximum and minimum reservoir elevations for indicated water years. For water year 1994, data through April 1994. Elevation not adjusted for the many different datums that were used.

[12] 1994 total capacity computed by Bureau of Reclamation program ACAP using 1994 measured areas.

48. AGENCY MAKING SURVEY Bureau of Reclamation

49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE May 1995

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

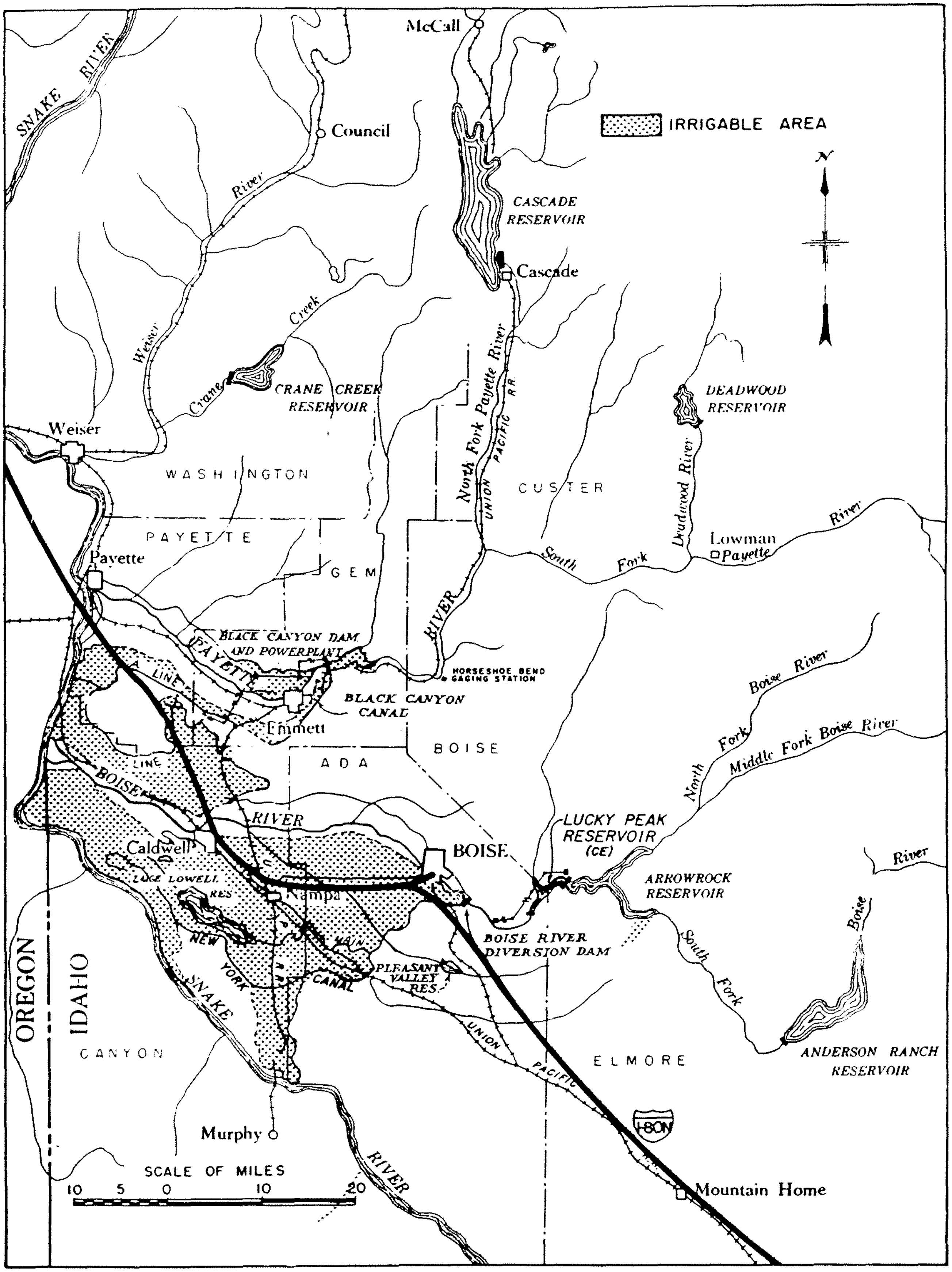

Figure 1. - Lake Lowell location map.

Space intentionally left blank due to security concerns

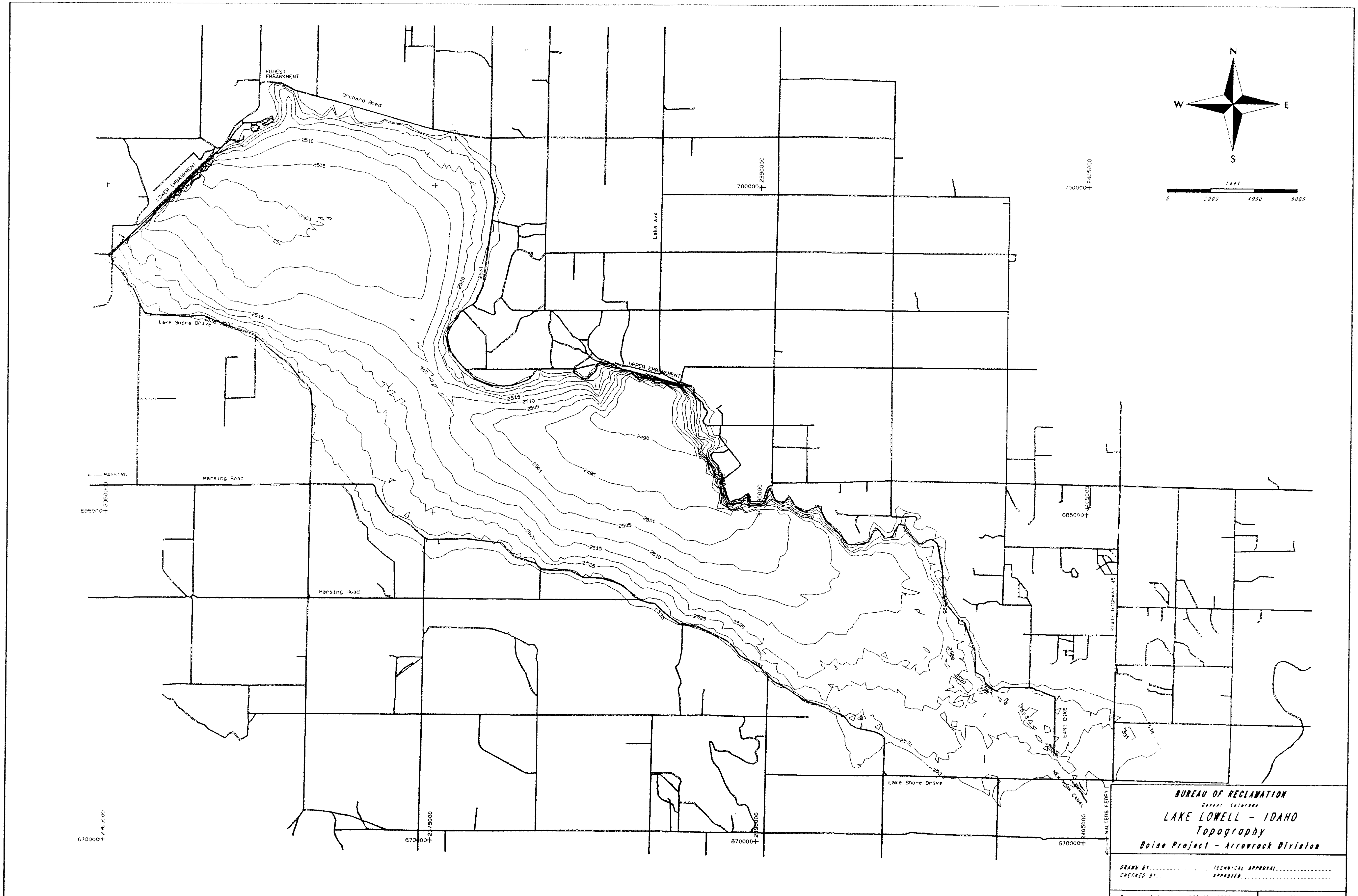

Figure 3. Lake Lowell topographic map

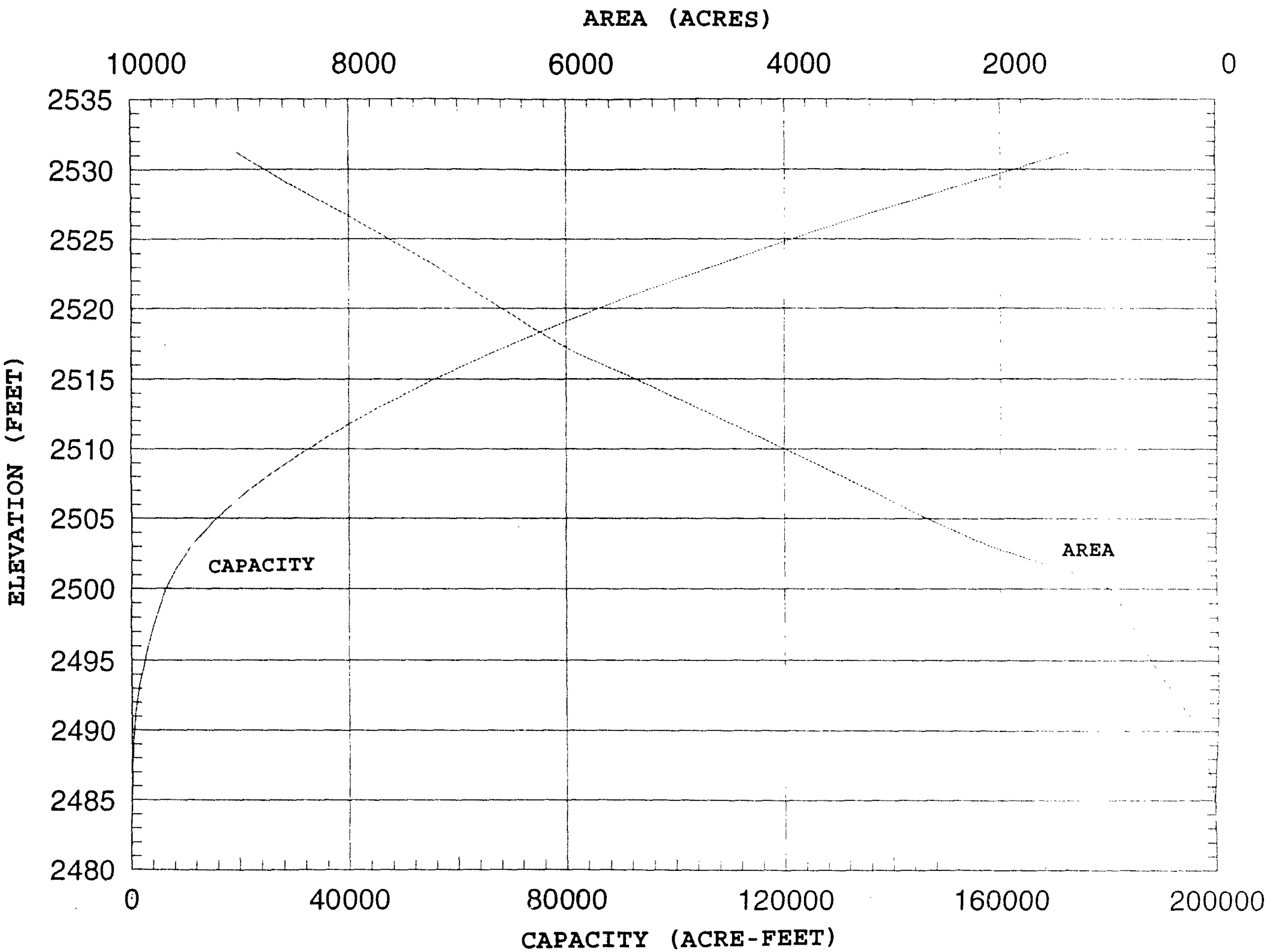

Figure 4. - 1994 area and capacity curves—Lake Lowell.

Mission

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.