OCHOCO RESERVOIR

1990 SEDIMENTATION SURVEY

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16. ABSTRACT

Ochoco Reservoir was surveyed in 1990 to compile field data for developing a reservoir topographic map and computing a present storage-elevation relationship. The data were also used to estimate the volume of sediment that has accumulated in the reservoir since dam closure in 1920. The 1990 bathymetric survey utilized 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 calculated from close interval cross sections measured from aerial photography flown in November of 1990. A new reservoir contour map was developed by the computer graphics program SURFACE II using the collected data.

As of June 1990, at reservoir spillway crest elevation (ft) 3130.6, the surface area was 1,062 acres with a total capacity of 44,918 acre-feet and an active capacity of 44,142 acre-feet. Since 1920, it is estimated that 3,082 acre-feet of sediment has accumulated below elevation 3130.6, which represents a 6.4 percent loss in storage capacity.

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b. IDENTIFIERS-- Ochoco Reservoir

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OCHOCO RESERVOIR

1990 SEDIMENTATION SURVEY

by

RONALD L. FERRARI

BUREAU OF RECLAMATION
EARTH SCIENCES DIVISION
SURFACE WATER BRANCH
SEDIMENTATION SECTION
DENVER OFFICE

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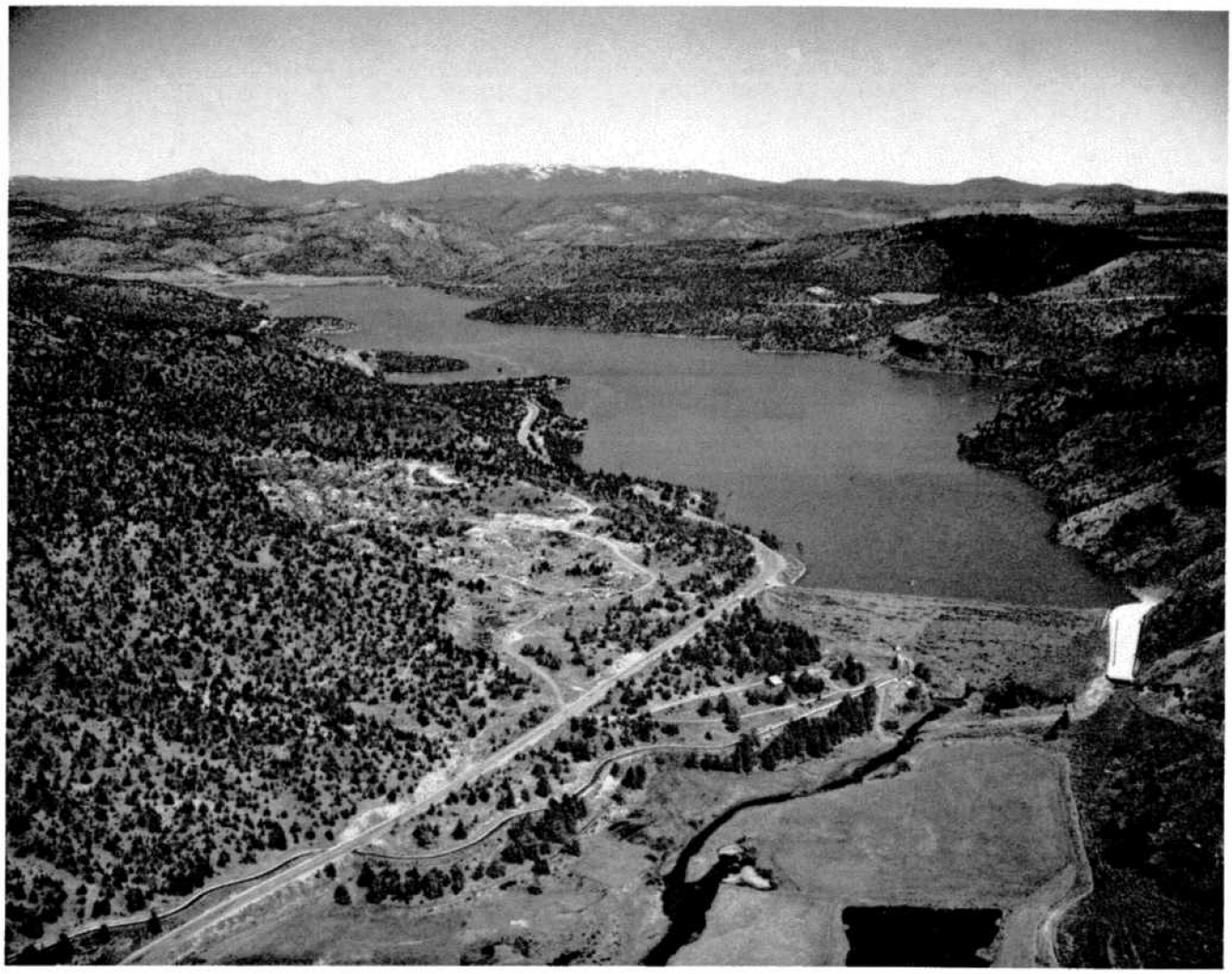

Ochoco Dam and Reservoir

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INTRODUCTION

Ochoco Dam and Reservoir, one of two water storage reservoirs of the Crooked River Project, is located on Ochoco Creek at its confluence with Mill Creek. The dam, located in west-central Crook County near the geographic center of Oregon, is about 6 river miles east of Prineville, Oregon (fig. 1).

Ochoco Dam was constructed between 1917 and 1921 as part of the Veterans Farm Settlement Program undertaken by the Ochoco Irrigation District, which was organized by the state of Oregon. The dam was constructed by hydraulic fill methods with a foundation cutoff trench. Reservoir storage was first recorded in January 1920. Due to safety concerns, the dam was rehabilitated by the Bureau of Reclamation in 1949 and 1950. The rehabilitation was authorized in the Interior Department Appropriation Act of June 29, 1948, and involved:

- blanketing seepage areas on the right abutment
- improving upstream riprap
- adding zone 1, 2, and 3 materials to the top and downstream face of the dam, which raised the crest of the dam 5 feet.

The Crooked River Project, which incorporated the Ochoco Project, was authorized by Congress on August 6, 1956, under Public Law 992, 84th Congress, 2d session.

Since construction of Ochoco Dam, much confusion has occurred due to the use of different datums for surveys of reservoir features. Reclamation's 1949 rehabilitation of Ochoco Dam used a datum that established the spillway crest as elevation (feet) 3130.9. Reclamation's capacity table, labeled 1959, used a datum referred to as the project datum that established the spillway crest as elevation 3130.2. Since 1980, a datum based on mean sea level by the U.S. Coast and Geodetic Survey, labeled CY 63 Oregon State, has been used for all surveys including the 1990 reservoir survey. This datum established a spillway crest elevation of 3130.56 feet. All elevations in this report are referenced to the mean sea level datum labeled CY 63. To simplify the figures in this report all elevations were rounded to the nearest tenth of a foot.

Ochoco Dam (fig. 2) has a structural height of 125 feet, a hydraulic height of 112.9 feet, a top crest width of 30 feet, and a crest length of 1,350 feet at dam crest elevation 3,142.7. The spillway, located at the left abutment, has a curved, uncontrolled overflow crest, 275 feet in length at the spillway crest elevation of 3130.6 and a 410-foot-long concrete- and mortar-lined chute. The design capacity of the spillway is 11,200 ft^3/s (cubic feet per second) at water surface elevation 3135.9. The outlet works, located right of center of the dam, consists of:

- an intake tower containing a 6-foot-square cast iron slide gate
- a concrete conduit through the base of the dam housing a 44-inch steel pipe
- a 3.25-foot-square slide gate
- a stilling basin downstream from the regulating gate
- a waterway downstream from the stilling basin

The hydraulic capacity of the outlet works is 490 ft^3/s at reservoir elevation 3130.6.

The original surface area of Ochoco Reservoir was 1,100 acres and capacity was 48,000 acre-feet at the spillway crest elevation of 3130.6. The 1990 survey measured a surface area of 1,062 acres and a capacity of 44,918 acre-feet at the same reservoir elevation, indicating an estimated capacity loss of 3,082 acre-feet during the 70.4 years (January 1920 to June 1990) since dam closure.

SUMMARY AND CONCLUSIONS

This report presents the 1990 results of the first extensive sedimentation survey of Ochoco Reservoir by the Bureau of Reclamation since construction of Ochoco Dam. The primary objectives of the survey were to:

- gather data needed to develop new reservoir topography
- compute area-capacity relationships
- estimate storage depletion caused by sedimentation deposition since closure of Ochoco Dam.

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 near the dam. 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 steered across 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 1990 surface areas at predetermined 5-foot contour intervals were generated by a computer graphics program that produced a new contour map of the reservoir (fig. 3). The revised 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.

Table 1 contains a summary of reservoir watershed characteristics and sediment data for the 1990 survey. The 1990 survey determined that the reservoir has a storage capacity of 44,918 acre-feet and a surface area of 1,062 acres at the spillway crest elevation of 3130.6. Since closure in 1920, the reservoir has accumulated a volume of 3,082 acre-feet of sediment below elevation 3130.6. This volume represents a 6.4 percent loss in total capacity and an average annual loss of 44 acre-feet. Because of the small amount of sediment estimated to have accumulated in the reservoir since the original survey, a resurvey of Ochoco Reservoir should not be necessary unless major sediment inflow occurs in the future.

DESCRIPTION OF WATERSHED

The drainage area of the Ochoco Reservoir basin (above the dam) is 291 square miles (fig. 4). It lies on the western slope of the mountains separating the Deschutes and John Day River basins. The elevation of the basin ranges from elevation 3049.0 at the intake gate of the outlet works to mountain peaks nearly 7000 feet in elevation.

There are three distinct zones in the basin. The lower zone has a sparse cover of juniper and grass, low hills with steep side slopes, shallow soil cover, and numerous rock outcroppings. The middle zone has larger trees, primarily ponderosa pine, and better grass cover. The soil is deeper than in the lower zone, but still fairly shallow. The upper zone has a heavy forest cover, a good grass cover, and some rock outcroppings are visible. The soil mantle is deeper than in the lower two zones and the side slopes are not as steep.

The valley of Ochoco Creek has been eroded in rocks of volcanic origin. The rocks consist primarily of tuffs and lava flows of basalt, andesite, and rhyolite. Where soft tuffs are present in the canyon walls beneath thick lava flows, conditions conducive to landsliding exist. Many landslides have occurred along Ochoco Creek, but none are known to be active at the present time. One of these slides constitutes the right abutment and part of the foundation of Ochoco Dam.

RESERVOIR OPERATIONS

The reservoir is operated for flood control as set forth in "Flood Control Regulations" dated August 1969, Corps of Engineers. Regulations provide capacity for flood control from November 15 through January 31 between reservoir

elevations 3113.6 and 3130.6. After February 1, the capacity reserved for flood control is based on runoff forecasts. The reservoir is a multiuse facility having (following values are from June 1990 area-capacity tables):

- 5,901 acre-feet of surcharge capacity between elevations 3130.6 and 3135.9
- 16,041 acre-feet of multiple-use storage (flood control and irrigation) between elevations 3113.6 and 3130.6
- 28,098 acre-feet of irrigation storage between elevations 3048.7 and 3113.6
- 779 acre-feet of dead capacity between elevations 3025.6 and 3048.7

Records for Ochoco Reservoir show an average unregulated inflow of 45,300 acre-feet per year. The estimated mean annual runoff from the basin is 2.92 inches. Ochoco Reservoir operation ranged from a minimum elevation of 3047.0 feet, which occurred several times in the 1920's and 1930's, to a maximum elevation of 3132.0 in April 1928. The monthly inflow and end-of-month stage records in table 1 show the extreme annual fluctuation of the reservoir.

SURVEY METHOD AND EQUIPMENT

The Ochoco Reservoir survey was completed using the contour method as outlined by Blanton [1]*. 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 Crooked River 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 located in the reservoir area. The above-water data was collected by aerial photography in November 1990 at water surface elevation 3050.5. 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 grid lines and shore stations. There were no previously established range lines on the lake and it was decided not to establish permanent range lines during this survey. Because of the size and shape of the lake, any future survey would employ the contour method. Therefore, permanent range line end markers were not necessary.

The hydrographic survey took place June 4 through June 5, 1990, with the reservoir at water surface elevation 3092.3. 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

* Numbers in brackets refer to bibliography.

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. To produce adequate data for developing contours of Ochoco Reservoir, grid spacings of 200 to 300 feet were selected. 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 Denver Office 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.

SEDIMENT ANALYSES

The 1990 survey results estimate a deposit of 3,082 acre-feet of sediment below elevation 3130.6 since closure in January 1920. Of the 3,082 acre-feet of deposited sediment, 2,341 acre-feet were deposited in the active pool and 741 acre-feet in the inactive pool storage areas. The average annual rate of sediment deposition in the 70.4 year period between closure and June 1990 was 44 acre-feet per year or 0.15 acre-foot per square mile of contributory drainage area. The storage loss represents a 6.4 percent loss in total capacity. Table 1 contains the Ochoco Reservoir sediment accumulation and water storage data based on the 1990 survey.

Due to the small amount of sediment that is estimated to have accumulated in the reservoir since the original survey, a resurvey of Ochoco Reservoir should not be necessary unless major sediment inflow occurs in the future.

RESERVOIR AREA AND CAPACITY

Original Capacity

The original Ochoco Reservoir capacity table used by Reclamation was dated 1959. For this study, it was assumed that the 1959 table represented the original conditions when reservoir storage began in January 1920. These capacity table values differ slightly from the values in Reclamation's published allocation sheets and the State of Oregon capacity table because of datum discrepancies and dam modifications. The surface areas used to develop Reclamation's 1959 capacity table are not available, which precludes regeneration and verification of the table. Previous research has concluded that the 1959 table was adequate pending development of the new area-capacity table. Because the values in the 1959 table cannot be verified, all storage losses due to sediment accumulation are labeled as estimates. The reported original surface area of Ochoco Reservoir was 1,100 acres and capacity was 48,000 acre-feet at the spillway crest elevation of 3130.6.

Development of 1990 Contour Areas

The 1990 contour surface areas for Ochoco Reservoir were developed by generating a contour map from the collected aerial and underwater coordinate data. Five-foot contour intervals of the lake area were created by a computer graphics software program [2]. A modification of this program by the Denver Office calculated surface areas of the closed contours of the generated map. The final reservoir map shown on figure 3 was prepared by the Denver Office Computer Drafting Unit of the Drafting Section. The map has a scale of 1 inch equals 500 feet and 5-foot contour intervals.

1990 Revised Storage Capacity

The storage-elevation relationships based on the 1990 aerial and underwater survey data were developed using the area-capacity computer program ACAP85 [3]. Surface areas at 5-foot contour intervals computed from the aerial and underwater survey data were used as the control parameters for computing reservoir capacity. The program computes an area at elevation increments of 0.01- to 1.0-foot by linear interpolation between the 5-foot contour intervals. 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 Ochoco Reservoir. 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:

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

where:

y = capacity,

x = elevation above a reference base,

a_1 = intercept, and

a_2 and a_3 = coefficients

Results of the 1990 Ochoco Reservoir area and capacity computations are listed in table 1 and plotted on figure 5. A separate set of 1990 area and capacity tables has been published for the 0.01-, 0.1-, and 1-foot elevation

increments [4]. As of June 1990, at reservoir spillway crest elevation 3130.6, the surface area was 1,062 acres with a total capacity of 44,918 acre-feet and an active capacity of 44,142 acre-feet.

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[2] Sampson, Robert J., *Surface II Graphics System*, Kansas Geological Survey, Lawrence, Kansas, 1978.

[3] *ACAP85 User's Manual*, Bureau of Reclamation, Surface Water Branch, Denver Office, Denver, Colorado, 1985.

[4] *Crooked River Project Ochoco Reservoir Oregon Area and Capacity Tables*, Bureau of Reclamation, Boise, Idaho, June 1990.

RESERVOIR SEDIMENT
DATA SUMMARY

Ochoco Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation		2. STREAM Ochoco Creek		3. STATE Oregon	
	4. SEC 5 T 15 S R 17 E		5. NEAREST PO Prineville		6. COUNTY Crook	
	7. LAT 44°18'09" LONG 120°43'00"		8. TOP OF DAM 3142.7[1]		9. SPILLWAY CREST 3130.6[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. FLOOD CONTROL	3135.9[1]	1,180[2]	6,000[2]	54,000[2]	
	b. MULTIPLE USE	3130.6[1]	1,100	16,500	48,000	Jan. 1920
	c. POWER					
	d. WATER SUPPLY					16. DATE NORMAL OPERATION BEGAN
	e. IRRIGATION	3113.6[1]	870	29,980	31,500	
	f. CONSERVATION					
	g. INACTIVE	3048.7[1]	130	1,520	1,520	Jan. 1920
	17. LENGTH OF RESERVOIR 4 MILES			AVG. WIDTH OF RESERVOIR 0.43 MILES		
BASIN	18. TOTAL DRAINAGE AREA 291 SQ. MI.			22. MEAN ANNUAL PRECIPITATION 10.5[3] IN.		
	19. NET SEDIMENT CONTRIBUTING AREA 291 SQ. MI.			23. MEAN ANNUAL RUNOFF 2.92[4] IN.		
	20. LENGTH 22.8 MI	AV. WIDTH 12.8 MI		24. MEAN ANNUAL RUNOFF 45,300[5] AC.-FT.		
	21. MAX. ELEV. 6750	MIN. ELEV. 3048.7		25. ANNUAL TEMP. MEAN 47.0[3] RANGE -34 to 105[6]		

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
	Jan 1920			Contour(D)	5-ft	1,100[2] (1,180)[7]	48,000[2] (54,000)[7]	1.06 (1.19)
	June 1990	70.4	70.4	Contour(D)	5-ft	1,062 (1,162)	44,918 (50,819)	0.99 (1.12)

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
June 1990	10.5[3]	45,300[5]	115,200	3,189,120[8]	45,300	3,189,120

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.
June 1990	3,082[9] (3,181)	43.8[9] (45.2)	0.15[9] (0.16)	3,082[9] (3,181)	43.8[9] (45.2)	0.15[9] (0.16)

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANNUAL	b. TOTAL TO DATE	a. PER.	b. TOT.
June 1990	Unknown	Unknown	Unknown	0.09 (0.08)	6.42 (5.89)	Unk.	Unk.

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW AND ABOVE CREST ELEVATION											
	112.9-81.9	81.9-17.0	17-Crest	Crest-+5.3								
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											
1990	23.3	59.2	14.4	3.1								

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 (2 pages).

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1920	3095.9[10]	3049.6	-	1959	3118.3	3065.1	18,100
1921	3129.7	3049.7	-	1960	3100.7	3048.8	22,780
1922	3130.0	3087.5	44,830	1961	3111.5	3049.4	37,330
1923	3116.4	3048.4	40,500	1962	3130.5	3070.4	53,580
1924	3088.0	3047.4	14,080	1963	3128.8	3100.5	49,730
1925	3119.2	3047.1	45,500	1964	3118.0	3092.0	23,440
1926	3094.4	3047.0	13,800	1965	3130.5	3092.2	90,930
1927	3119.3	3047.0	51,050	1966	3120.6	3082.6	23,140
1928	3132.2	3079.9	-	1967	3122.2	3081.8	39,990
1929	3086.0	3047.0	7,790	1968	3098.8	3055.1	5,030
1930	3067.7	3047.0	4,510	1969	3119.0	3055.3	44,830
1931	3074.0	3047.0	6,410	1970	3130.1	3096.6	42,442
1932	3110.1	3047.0	37,420	1971	3128.9	3103.2	54,230
1933	3103.4	3058.6	22,860	1972	3130.0	3105.9	71,110
1934	3065.0	3047.0	2,740	1973	3111.1	3054.3	8,470
1935	3089.7	3047.0	18,250	1974	3130.6	3049.0	72,710
1936	3103.8	3048.5	25,480	1975	3127.9	3100.7	36,970
1937	3097.7	3050.8	27,150	1976	3130.3	3108.0	41,730
1938	3130.6	3068.1	-	1977	3107.2	3059.7	3,370
1939	3112.3	3067.1	14,110	1978	3130.8	3059.5	66,570
1940	3109.0	3062.1	25,100	1979	3129.1	3103.2	51,500
1941	3091.8	3052.4	19,160	1980	3130.4	3101.5	55,050
1942	3124.2	3057.5	51,080	1981	3130.4	3106.8	37,800
1943	3130.1	3094.6	99,190	1982	3129.6	3105.8	115,200
1944	3108.6	3048.0	11,070	1983	3129.5	3107.0	107,800
1945	3116.2	3049.2	41,360	1984	3130.2	3105.3	105,300
1946	3130.5	3089.6	106,760	1985	3127.6	3099.4	-
1947	3120.1	3085.7	22,430	1986	3130.3	3097.4	-
1948	3130.6	3085.7	92,700	1987	3129.9	3097.8	-
1949	3122.8	3048.0	65,430	1988	3109.4	3056.8	-
1950	3124.0	3050.8	-	1989	3129.2	3050.2	-
1951	3130.4	3099.0	95,540	1990	3094.1	3055.8	-
1952	3129.4	3099.2	72,580				
1953	3130.7	3097.6	70,410				
1954	3130.4	3103.7	50,830				
1955	3112.0	3067.7	17,230				
1956	3130.3	3067.7	95,780				
1957	3130.2	3096.6	-				
1958	3130.2	3096.8	84,150				

46. ELEVATION - AREA - CAPACITY DATA FOR Original and 1990 Surveys

ELEV.	AREA	CAP.	ELEV.	AREA	CAP.	ELEV.	AREA	CAP.
Original	Survey		1990	Survey		3095	598	15,488
3017.7	0	0	3025.6	0	0	3105	728	22,151
3048.7	130	1,520	3035	18	66	3113.6	835	28,877
3113.6	870	31,500	3048.7	100	779	3115	852	30,057
3130.6	1,100	48,000	3055	140	1,547	3125	979	39,212
3135.9	1,180	54,000	3065	218	3,255	3130.6	1062	44,918
			3075	346	6,096	3135.9	1162	50,819
			3085	467	10,144			

47. REMARKS AND REFERENCES

[1] All elevations based or adjusted to Oregon State datum CY 63, tied to mean sea level.
[2] All original values from Bureau of Reclamation publications, may differ slightly from other sources.
[3] Climatography of the United States, 1941-70 and 1951-80, No. 81, NOAA.
[4] Calcaulated from mean annual runoff value, 45,300 ac-ft, Item 24.
[5] Unregulated monthly inflow records for water years 1920-84. Several years not used due to missing records.
[6] Project Data, Crooked River Project, USBR, 1981.
[7] All values enclosed in parenthesis are flood control values at elevation 3135.9.
[8] Computed from mean annual runoff times 70.4 years. Several years of missing records.
[9] Sediment storage losses are estimates due to uncertainties of original capacity values.
[10] Computed from end-of-month reservoir content and Bureau of Reclamation's 1959 capacity table.

48. AGENCY MAKING SURVEY Bureau of Reclamation
49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE July 1991

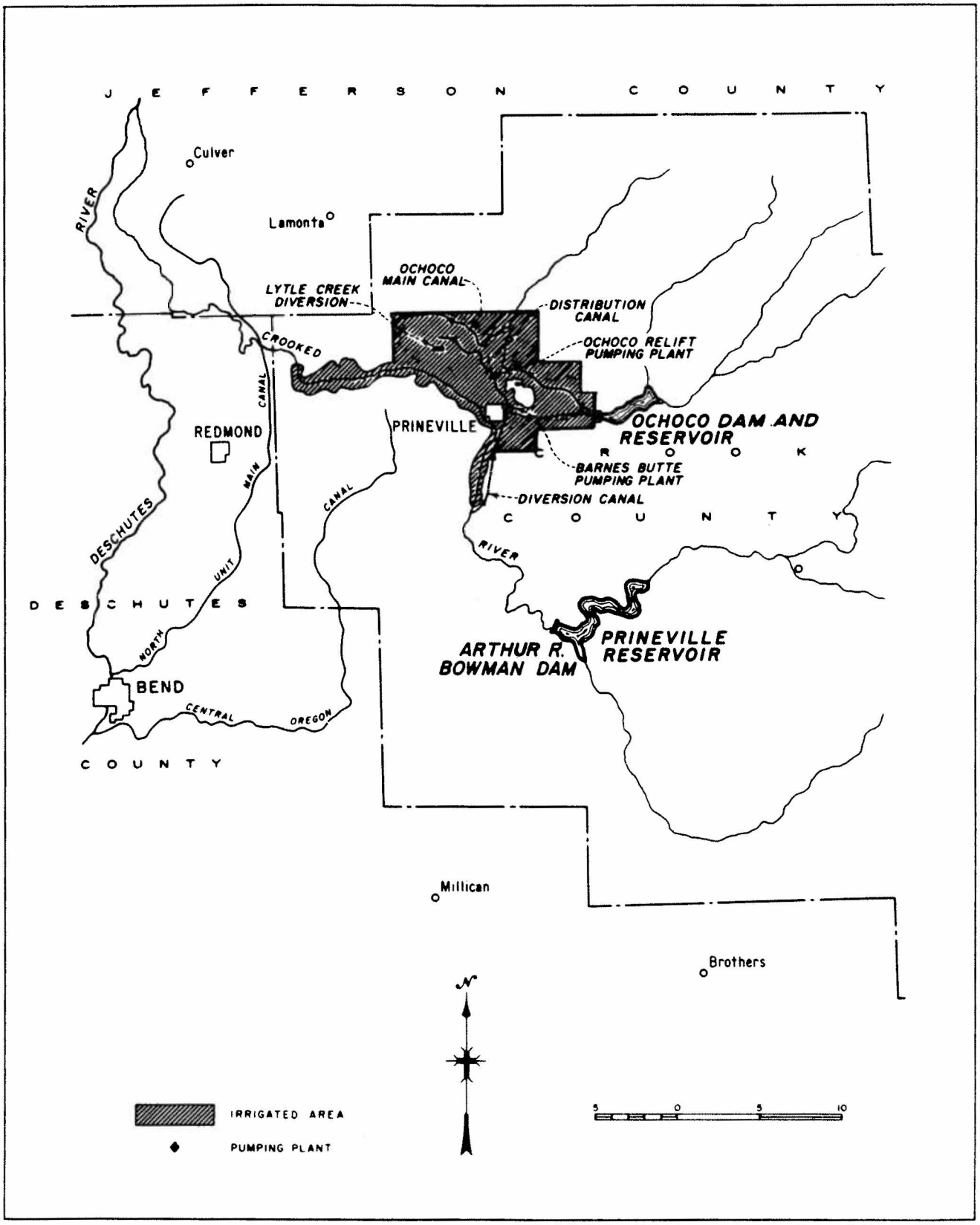

Figure 1. - Ochoco Dam and Reservoir location map—Crooked River Project.

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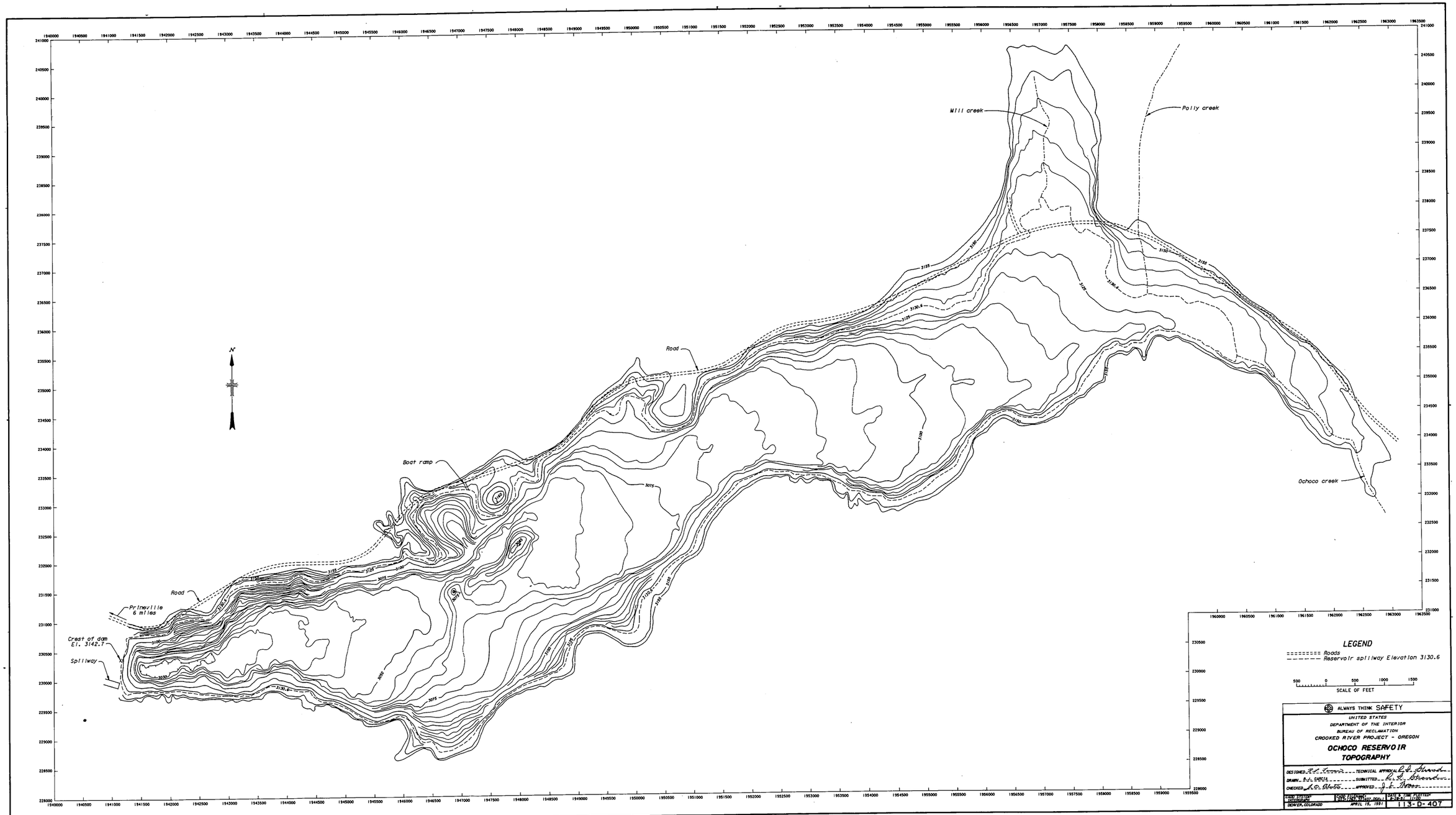
Mill creek
Polly creek
Road
Boat ramp
Ochoco creek
Road
Prineville
6 miles
Crest of dam
El. 3142.7
Spillway
N
LEGEND
Roads
Reservoir spillway Elevation 3130.6
SCALE OF FEET
ALWAYS THINK SAFETY
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CROOKED RIVER PROJECT - OREGON
OCHOCO RESERVOIR
TOPOGRAPHY
DESIGNED R.F. Tomm
TECHNICAL APPROVAL R.A. Strand
DRAWN R.J. LaDUE
SUBMITTED R.A. Strand
CHECKED R.O. Gist
APPROVED J.E. Allen
DENVER, COLORADO
APRIL 15, 1991
113-D-407

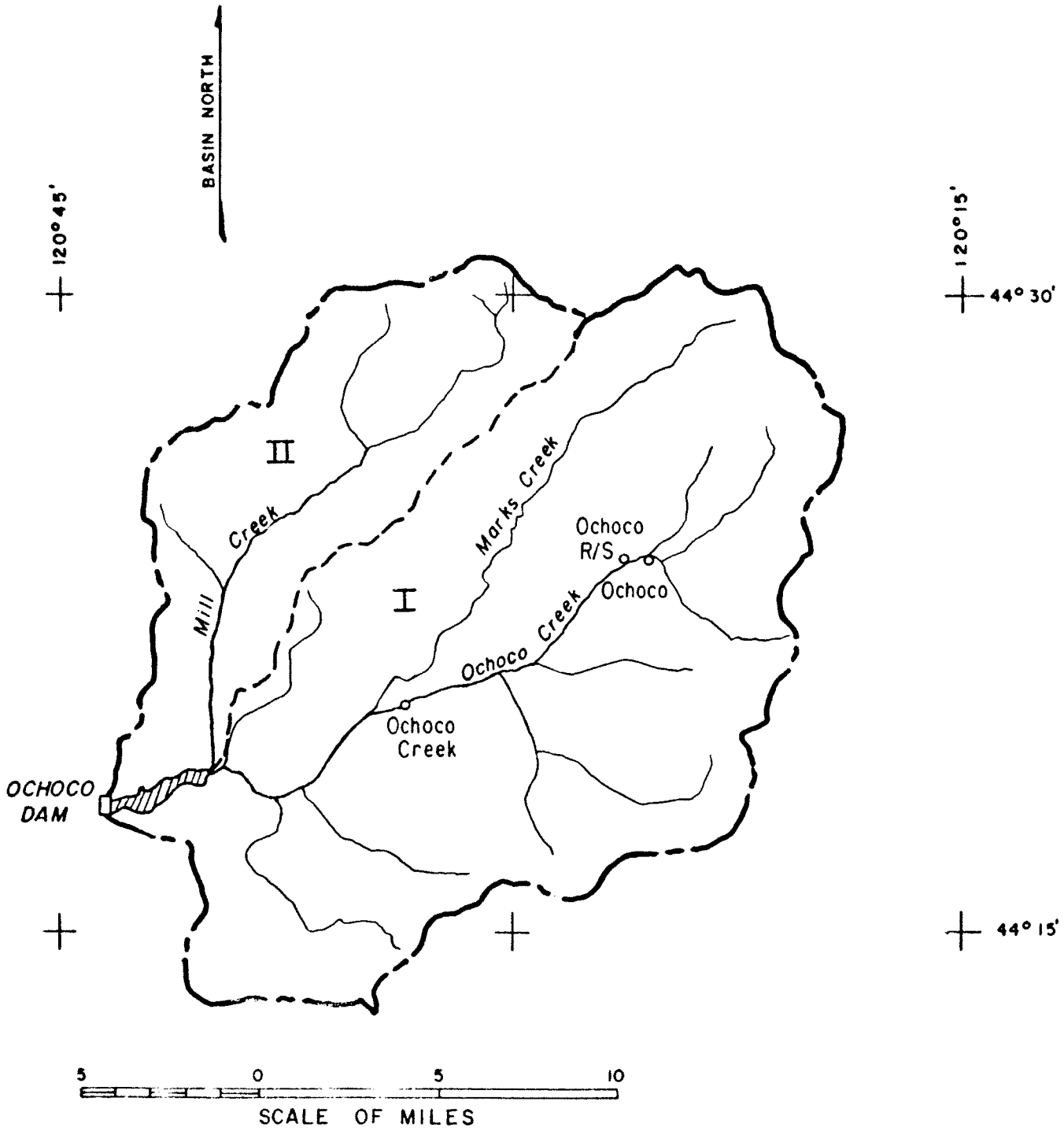

Figure 4. - Basin outline—Ochoco Dam, Crooked River Project.

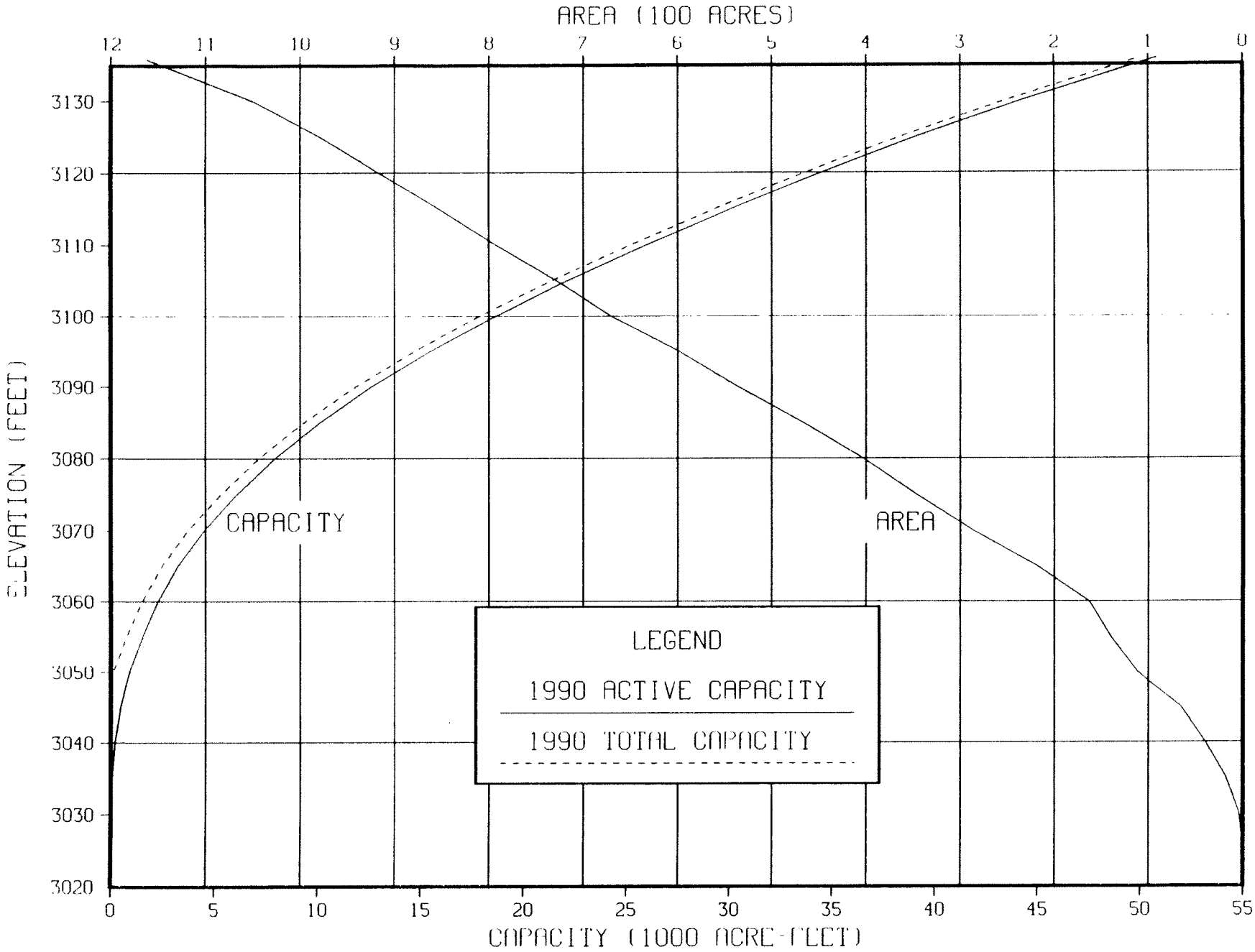

Figure 5. - Area and capacity curve, Ochoco Dam—1990.

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