RECLAMATION

Managing Water in the West

Pishkun Reservoir
2002 Survey

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

August 2005

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13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation (Reclamation) surveyed Pishkun Reservoir in June 2002 to develop new reservoir topography and compute a present storage-elevation relationship (area-capacity tables). The underwater survey was conducted at reservoir water surface elevation 4,369.9 feet (project datum). The survey used sonic depth recording equipment interfaced with a real-time kinematic (RTK) global positioning system (GPS) that gave continuous sounding positions throughout the underwater portion of the reservoir covered by the survey vessel. The above-water topography was determined by digitizing the developed reservoir contour line from the U.S. Geological Survey quadrangle (USGS quad) maps of the reservoir area. The new topographic map of Pishkun Reservoir was developed from the combined digitized USGS quad contour and June 2002 underwater measured topography. This study assumed no change from elevation 4,370.0 (feet) and above. As of June 2002, at water surface elevation 4,370.0, the surface area was 1,522 acres with a total capacity of 46,694 acre-feet. This study found little change from the original published values. It is assumed the calculated changes are due to accuracy difference between the two surveys and expected small sediment inflow to the offstream reservoir.

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Pishkun Reservoir 2002 Survey

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UNITED STATES DEPARTMENT OF THE INTERIOR

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BUREAU OF RECLAMATION

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

Pishkun Reservoir, an offstream storage reservoir, is part of the Sun River Project located near Augusta, west central Montana and about 15 miles northeast of Gibson (figure 1). Eight earthfill dikes form the reservoir with heights ranging from 12 to 50 feet, crest widths of 20 feet, and an overall crest length of 9,050 feet. The outlet for the reservoir is a 12-foot diameter concrete conduit through Dike Number 4. The downstream canal has a maximum capacity of 1,600 cubic feet per second (cfs). The capacity of the outlet works is 1,850 cfs at reservoir elevation 4,371.2 feet[1]. There is no spillway for the reservoir.

Figure 1 – Pishkun Dikes Location

The Sun River Project uses the waters of the Sun River and its tributaries that is stored and regulated by Gibson, Pishkun, and Willow Creek Reservoirs for irrigating about 93,000 acres of land lying along the Sun River. Water stored in Gibson Reservoir is released into the river for diversion downstream into the Pishkun Supply Canal, Willow Creek Feeder Canal, or the Fort Shaw Canal. The Pishkun Supply Canal, heading at Sun River Diversion Dam, conveys water to Pishkun or Willow Creek Reservoirs through the Willow Creek Feeder Canal, which stems from the Pishkun Supply Canal and empties into a natural channel to the reservoir. Water released from Pishkun Reservoir enters the Sun River Slope Canal, which branches into several main canals for distribution to about 81,000 acres in the Greenfields Division. The drainage area above Pishkun Dikes Reservoir is 9.7 square miles with all considered sediment contributing.

[1]Elevations in feet. Unless noted, all elevations in report based on the original project datum established by U.S. Bureau of Reclamation. The 2002 survey found project datum to be 6.4 feet lower than the North American Vertical Datum of 1988 (NAVD88).

system continuously recorded depth and horizontal coordinates of the survey boat as it was navigated along grid lines covering Pishkun 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 reservoir contour line from the U.S. Geological Survey quadrangle (USGS quad) maps of the reservoir area.

The 2002 Pishkun Reservoir topographic map is a combination of the USGS quad contour and the underwater survey data. A computer graphics program generated the 2002 reservoir surface areas at predetermined contour intervals from the collected data. The 2002 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 summaries of the Pishkun Reservoir and watershed characteristics for the 2002 survey. The 2002 survey determined that the reservoir has a total storage capacity of 46,694 acre-feet and a surface area of 1,522 acres at active conservation elevation 4,370.0.

RESERVOIR OPERATIONS

The Sun River Project uses the waters of the Sun River and its tributaries, stored and regulated by Gibson, Pishkun, and Willow Creek Reservoirs, for irrigating about 93,000 acres of land lying along the Sun River. Water stored in Gibson Reservoir is released into the river for diversion downstream into the Pishkun Supply Canal, Willow Creek Feeder Canal, or the Fort Shaw Canal. The Pishkun Supply Canal, heading at Sun River Diversion Dam, conveys water to Pishkun or Willow Creek Reservoirs through the Willow Creek Feeder Canal, which stems from the Pishkun Supply Canal and empties into a natural channel to the reservoir. Water released from Pishkun Reservoir enters the Sun River Slope Canal, which branches into several main canals for distribution to about 81,000 acres in the Greenfields Division.

The June 2002 capacity table shows 54,852 acre-feet of total storage below the maximum water surface elevation 4,375.0. The 2002 survey measured a minimum lake bottom elevation of 4290.5. The following values are from the June 2002 capacity table:

- 8,158 acre-feet of surcharge between elevation 4,370.0 and 4,375.0.
- 30,686 acre-feet of conservation use between elevation 4,342.0 and 4,370.0.
- 16,008 acre-foot of dead storage below 4,342.0.

Pishkun Reservoir readily available inflow and end-of-month stage records in table 1, operation period 1947 through 2002, show the calculated inflow and annual fluctuation for these years of operation. The computed average inflow into the reservoir for these years was 227,240 acre-feet per year. The maximum-recorded elevation was 4371.2 in 1949 and the minimum recorded was 4316.4 in 1991.

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 (figure 4). The hydrographic survey system included a GPS receiver with a built-in radio, a depth sounder, a helmsman display for navigation, a computer, and hydrographic system software for collecting the underwater data. An on-board generator supplied power to all the equipment. The shore equipment included a second GPS receiver with an external radio powered by a 12-volt battery. The GPS antenna and receiver were mounted on a survey tripod over a known datum point. The equipment was also mounted in a pontoon raft to collect data in the shallow water areas along the shoreline and around the numerous islands.

Figure 4 - Survey vessel with mounted hydrographic equipment on Jackson Lake in Wyoming

The Sedimentation and River Hydraulics Group uses Real-time Kinematic (RTK) GPS with the major benefit being precise heights measured in real time to monitor 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 that the hydrographic collection software converted into Montana's NAD83 state plane coordinate system. The RTK GPS system employs two receivers that track the same satellites simultaneously just like with differential GPS.

The Pishkun Reservoir hydrographic survey was conducted from June 13 through 15 of 2002 near water surface elevations 4,369.6 (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 closely spaced grid lines covering the reservoir area. Most of the transects (grid lines) were run somewhat in a northeast alignment on the reservoir at around 200-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 2002 underwater data were collected by a depth sounder that was calibrated by lowering a weighted cable below the boat with beads marking known depths. 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.

Pishkun Datum

Upon completion of the underwater survey, a RTK GPS survey was conducted to tie the horizontal and vertical control of the hydrographic survey temporary point and the reservoir water surface to the NGS control point "Choteau". The 2002 RTK GPS survey determined the Reclamation vertical datum to be around 6.4 feet lower than NGVD88. Note that all elevations in this report are tied to the Reclamation vertical elevations that were measured by the Reclamation gauge during the time of collection.

RESERVOIR AREA AND CAPACITY

Topography Development

The topography of Pishkun Reservoir was developed from the 2002 collected underwater and a digitized contour from the USGS quad map. The digitized USGS contour line was the Pishkun Reservoir water surface labeled elevation 4,370.0. The USGS quad maps were developed from aerial photography dated 1982. This study found the enclosed digitized contour area, with the island surfaces removed, to be slightly less than the original surface area at elevation 4370. ARC/INFO V7.0.2 geographic information system software was used to digitize the USGS quad contour. The digitized contours were transformed to Montana's NAD 1983 state plane coordinates using the ARC/INFO PROJECT command.

The digitized contour line was used to perform a clip of the Pishkun Reservoir triangular irregular network (TIN) such that interpolation was not allowed to occur outside the enclosed polygon. This contour was selected since it was the only available data to represent the reservoir water surface at the time the survey was conducted (near reservoir elevation 4,370). This clip was performed using the hardclip option of the ARC/INFO CREATETIN command. Using ARCEDIT, the underwater collected data and digitized contours from the quad maps were plotted. Using select and move commands within ARCEDIT, the vertices of the clip were

shifted to fit all the collected underwater data. The clip was assigned an elevation of 4,370.0 to reflect the original area of the developed polygons.

Contours for the reservoir below elevation 4,370.0 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 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 Pishkun Reservoir TIN. In addition, the contours were generalized by filtering 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 surface areas and volumes for Pishkun Reservoir since the areas were calculated from the developed TIN. The areas of the enclosed contour polygons at one-foot increments were developed from the survey data for elevations 4,291.0 through 4,370.0. The contour topography at two-foot intervals is presented on figure 5.

Development of 2002 Contour Areas

The 2002 contour surface areas for Pishkun Reservoir were computed at one-foot increments from elevation 4,291.0 to 4,370.0. The 2002 underwater survey measured a minimum reservoir bottom elevation of 4,290.5. 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 indicated above, the 2002 underwater survey data was collected near reservoir elevation 4,369.9. For the purpose of this study, the measured 2002 survey areas at one-foot increments from elevation 4,291.0 through 4,370.0 were used to compute the new area and capacity tables. This study assumed no change in original volume from elevation 4,370.0 and above. The area and capacity program was adjusted to reflect this assumption for the computations between elevation 4,370 and 4,375.

2002 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). The 2002 surveyed surface areas at one-foot contour intervals from reservoir elevation 4,291.0 to elevation 4,370.0 were used as the control parameters for computing the 2002 Pishkun Reservoir capacity. A surface area was interpolated at elevation 4,375.0 to compute the volumes between elevations 4,370 through 4,375 with the assumption there has been little change since the original computations.

The ACAP85 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 Pishkun 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. By differentiating the capacity equations, which are of second order polynomial form, the final area equations are derived:

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

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

Results of the Pishkun Reservoir area and capacity computations are listed in table 1 and columns 4 and 5 of table 2. On table 2, column 3 lists the original capacities. A separate set of 2002 area and capacity tables has been published for the 0.01, 0.1 and 1-foot elevation increments (Bureau of Reclamation, June 2002). A description of the computations and coefficients output from the ACAP85 program is included with these tables. Both the original and 2002 area-capacity curves are plotted on figure 6. As of June 2002, at elevation 4,375.0, the surface area was projected to be 1,741 acres with a total computed capacity of 54,852 acre-feet.

2004 RESERVOIR ANALYSES

Results of the 2002 Pishkun Reservoir area and capacity computations are listed in table 1 and columns 4 and 5 of table 2. Column 3 of table 2 lists the original capacity values for Pishkun Reservoir and column 6 lists the capacity differences between the original and 2002 computations. Figure 6 is a plot of the Pishkun Reservoir capacity values for the two surveys and illustrates the very small differences. These comparisons show that the total reservoir capacity in 2002 is slightly greater in volume than the original published volume.

Research into the original values found surface areas and capacity curves along with an active storage table dated June 6, 1940. The curves are presented on drawing number 28-600-1 dated August 28 of 1942. Notes on the drawing indicate the curves represent visual capacity values with a dead storage of 16,250 acre-feet. No other history on how these values were developed was located.

The 2002 investigation found that the total drainage area into Pishkun Reservoir is around 9.7 square miles and all considered sediment contributing. The main source of water inflow is from diversions and it is assumed this also contributes a small amount of sediment inflow. Due to the unknowns of the original values, there are no means from the 2002 survey results to estimate how much sediment has deposited within the reservoir since dam closure.

It is the general conclusion the small difference between the original and 2002 surveys is more due to the differences in the detail of the two surveys and than due to sediment inflow. The 2002 survey is of sufficient detail in the underwater portion to represent the current volumes, but if a more accurate representation is needed for the total reservoir, then more detailed collection is needed in the above water area above elevation 4,370.

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RESERVOIR SEDIMENT
DATA SUMMARY

Pishkun Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM

1. OWNER Bureau of Reclamation	2. STREAM Off Stream	3. STATE Montana
4. SEC. 10 TWP. 22 N RANGE 7 W	5. NEAREST P.O. Augusta	6. COUNTY Teton
7. LAT 47° 40' 35" LONG 112° 29' 48"	8. TOP OF DAM ELEVATION 4,380.0[2]	9. SPILLWAY CREST EL NA[2]

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					
b. FLOOD CONTROL					1/30
c. POWER					
d. JOINT USE					16. DATE NORMAL OPERATION BEGAN
e. CONSERVATION	4,370.0[2]	1,550	30,420	46,670	
f. INACTIVE					
g. DEAD	4,342.0		16,250	16,250	1/30

17. LENGTH OF RESERVOIR 1.7 Miles — AVG. WIDTH OF RESERVOIR 1.4 MILES

BASIN

18. TOTAL DRAINAGE AREA 9.7 SQUARE MILES	22. MEAN ANNUAL PRECIPITATION 17.74[4] INCHES
19. NET SEDIMENT CONTRIBUTING AREA 9.7 SQUARE MILES	23. MEAN ANNUAL RUNOFF [5] INCHES
20. LENGTH MILES — AV. WIDTH	24. MEAN ANNUAL RUNOFF 227,240[6] ACRE-FEET
21. MAX. ELEVATION — MIN. ELEVATION	25. ANNUAL TEMP. MEAN 45°F RANGE -49°F to 106°F[4]

SURVEY DATA

26. DATE OF SURVEY	27. PER.	28. ACCL	29. TYPE OF SURVEY	30. NO. OF RANGES OR	31. SURFACE AREA, AC.	32. CAPACITY ACRE-FEET	33. C/I RATIO
April, 1940					1,550[3]	46,670	0.2
6/02			Contour (D)	1-ft	1,522[7]	46,694[7]	0.2

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
6/02		227,240[6]	322,888	12,725,500	227,240	12,725,500

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.
6/02	[9]					

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT^3)	40. SED. DEP. TONS/MI.^{2}-YR.		41. STORAGE LOSS, PCT.		42.	
		a. PERIOD	b. TOTAL TO	a. AV.	b. TOTAL TO	a.	b.
6/02				[9]	[9]		

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

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 3).

45. RANGE IN RESERVOIR OPERATION[9]

YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1946				1947	4371.0	4360.5	182,930
1948	4370.1	4360.0	116,107	1949	4371.2	4360.5	220,479
1950	4370.0	4360.0	157,727	1951	4370.9	4361.8	153,356
1952	4368.9	4360.5	210,961	1953	4371.1	4356.0	160,020
1954	4367.4	4362.4	226,145	1955	4368.1	4360.2	166,923
1956	4368.6	4359.7	197,060	1957	4370.2	4356.5	205,233
1958	4370.0	4358.9	183,251	1959	4369.6	4355.2	197,142
1960	4369.5	4349.7	229,238	1961	4368.2	4358.7	275,720
1962	4368.7	4360.1	250,475	1963	4370.2	4360.8	763,416
1964	4370.5	4359.9	260,338	1965	4370.3	4352.4	214,628
1966	4369.6	4355.2	269,930	1967	4371.1	4351.0	217,554
1968	4370.5	4359.7	279,359	1969	4370.1	4359.5	292,238
1970	4370.8	4355.7	273,119	1971	4370.5	4360.1	322,888
1972	4370.9	4360.5	303,857	1973	4370.9	4347.0	246,037
1974	4371.0	4346.7	305,862	1975	4371.0	4359.9	183,987
1976	4369.8	4358.7	268,424	1977	4370.6	4354.4	197,889
1978	4370.8	4361.6	212,457	1979	4370.0	4362.2	253,364
1980	4370.8	4350.8	204,935	1981	4370.3	4362.1	241,006
1982	4370.1	4359.1	196,993	1983	4370.0	4355.9	228,313
1984	4369.6	4356.7	254,164	1985	4370.8	4356.4	230,172
1986	4369.4	4357.6	216,442	1987	4371.1	4360.5	218,437
1988	4368.0	4344.5	227,391	1989	4367.8	4351.4	191,043
1990	4370.1	4361.2	239,904	1991	4370.2	4316.4	235,949
1992	4369.0	4361.2	251,897	1993	4369.6	4353.5	152,653
1994	4368.9	4342.0	219,889	1995	4370.3	4342.0	216,032
1996	4369.9	4357.5	259,579	1997	4370.9	4360.0	239,947
1998	4370.9	4361.7	263,155	1999	4370.37	4357.8	270,251
2000	4370.6	4361.8	263,573	2001	4370.86	4359.9	224,711
2002	4370.2	4356.5	234,896				

46. ELEVATION - AREA - CAPACITY DATA FOR **2002 CAPACITY**[10]

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
4,290	0	0	4,291	5	3	4,292	47	29
4,293	57	80	4,294	64	141	4,295	71	209
4,296	78	283	4,297	84	364	4,298	89	451
4,299	94	542	4,300	100	640	4,301	106	742
4,302	111	850	4,303	118	965	4,304	124	1,085
4,305	134	1,214	4,306	143	1,353	4,307	152	1,500
4,308	161	1,657	4,309	170	1,822	4,310	180	1,997
4,311	189	2,182	4,312	199	2,376	4,313	210	2,580
4,314	221	2,795	4,315	234	3,023	4,316	248	3,264
4,317	261	3,519	4,318	277	3,788	4,319	292	4,072
4,320	327	4,382	4,321	348	4,719	4,322	366	5,076
4,323	382	5,451	4,324	400	5,842	4,325	417	6,250
4,326	434	6,676	4,327	453	7,120	4,328	472	7,582
4,329	494	8,065	4,330	516	8,569	4,331	536	9,095
4,332	552	9,640	4,333	566	10,199	4,334	580	10,772
4,335	598	11,361	4,336	619	11,969	4,337	639	12,598
4,338	656	13,246	4,339	675	13,911	4,340	691	14,594
4,341	707	15,293	4,342	723	16,008	4,343	739	16,739
4,344	756	17,486	4,345	776	18,252	4,346	797	19,039
4,347	816	19,845	4,348	836	26,672	4,349	857	21,518
4,350	882	22,388	4,351	906	23,282	4,352	930	24,200
4,353	956	25,143	4,354	988	26,115	4,355	1,023	27,120
4,356	1,061	28,162	4,357	1,100	29,242	4,358	1,142	30,363
4,359	1,187	31,528	4,360	1,230	32,736	4,361	1,273	33,988
4,362	1,316	35,283	4,363	1,355	36,618	4,364	1,385	37,988
4,365	1,408	39,385	4,366	1,428	40,803	4,367	1,447	42,241
4,368	1,466	43,700	4,369	1,497	45,185	4,370	1,522	46,694
4,375	1,741	54,852						

Table 1. - Reservoir sediment data summary (page 2 of 3).

47. REMARKS AND REFERENCES

1 All elevations of dikes are in feet and based on the original project datum established by Reclamation that were found during 2002 survey to be around 6.4 feet less then the NAVD88. Original construction 1930-31. Enlarged in 1940.

2 An offstream reservoir with no spillway.

3 Original visual capacity based on enlargement of the reservoir completed in April 1940. 2002 area and capacity from 2002 underwater survey. 2002 surface area at elevation 4370 from a digitized USGS quad map.

4 Western Regional Climate Center Data for Station 243489 Gibson Dam, Montana

5 No calculation since majority of inflow from diversions. (See remark #6).

6 Annual computed inflows by water year, from 1947 through 2002. Inflows from Pishkun drainage and diverted flows from the Sun River through the Willow Creek Feeder Canal which stems from the Pishkun Supply Canal.

7 Surface area & capacity computed by ACAP program. Area and capacity values above elevation 4370 were interpolated using original capacity values.

8 Annual Reclamation computed inflows by water year, from 1947 through 2002. Inflows from Pishkun drainage and diverted flows from the Sun River through the Willow Creek Feeder Canal. Maximum and minimum elevations available from Reclamation end of the month water year records.

9 No computed volume change. Difference due to some sediment inflow and different method of surveys. Expect little change due to sediment inflow since Pishkun is an offstream reservoir.

10 Capacities computed by Reclamation's ACAP computer program.

48. AGENCY MAKING SURVEY Bureau of Reclamation

49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE June 2005

Table 1. - Reservoir sediment data summary (page 3 of 3).

Table 2. - Summary of 2002 survey results

1	2	3	4	5	6	7
Elevations (feet)	Original Survey (acres)	Original Capacity (acre-feet)	2002 Survey (acres)	2002 Survey (acre-feet)	2002 Volume Change	Percent of Reservoir Depth
4375		54827	1741	54852	-25	100.0
4370	1550	46670	1522	46694	-24	94.1
4365		39289	1408	39385	-96	88.2
4360		32833	1230	32736	97	82.4
4355		27349	1023	27120	229	76.5
4350		22624	882	22388	236	70.6
4345		18496	776	18252	244	64.7
4342		16250	723	16008	242	61.2
4340			691	14594		58.8
4335			598	11361		52.9
4330			516	8569		47.1
4325			417	6250		41.2
4320			327	4382		35.3
4315			234	3023		29.4
4310			180	1997		23.5
4305			134	1214		17.6
4300			100	640		11.8
4295			71	209		5.9
4290.5			0	0		0.6

1	Elevation of reservoir water surface.
2	Original surface area values for complete reservoir not located. Drawing No. 28-600-1, Pishkun Reservoir Area and Capacity Curves.
3	Original reservoir capacity from June 1940 capacity table (16,250 AF Inactive storage).
4	Reservoir surface area from 2002 survey.
5	Reservoir capacity computed from 2002 surface areas using ACAP.
6	Measured volume difference = column (3) - column (5).
7	Depth of reservoir expressed in percentage of total depth of 79 feet.

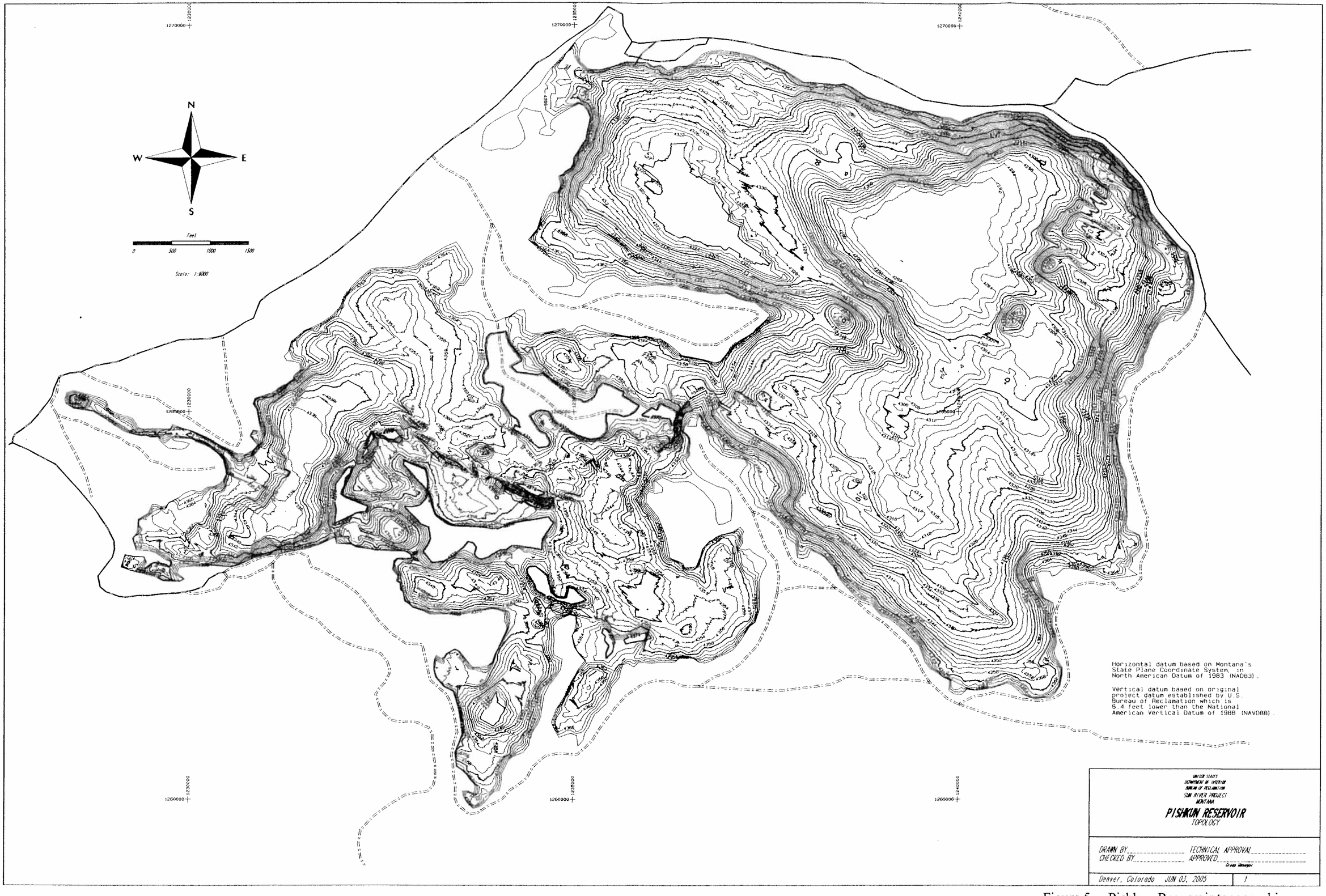

Figure 5. – Pishkun Reservoir topographic map.

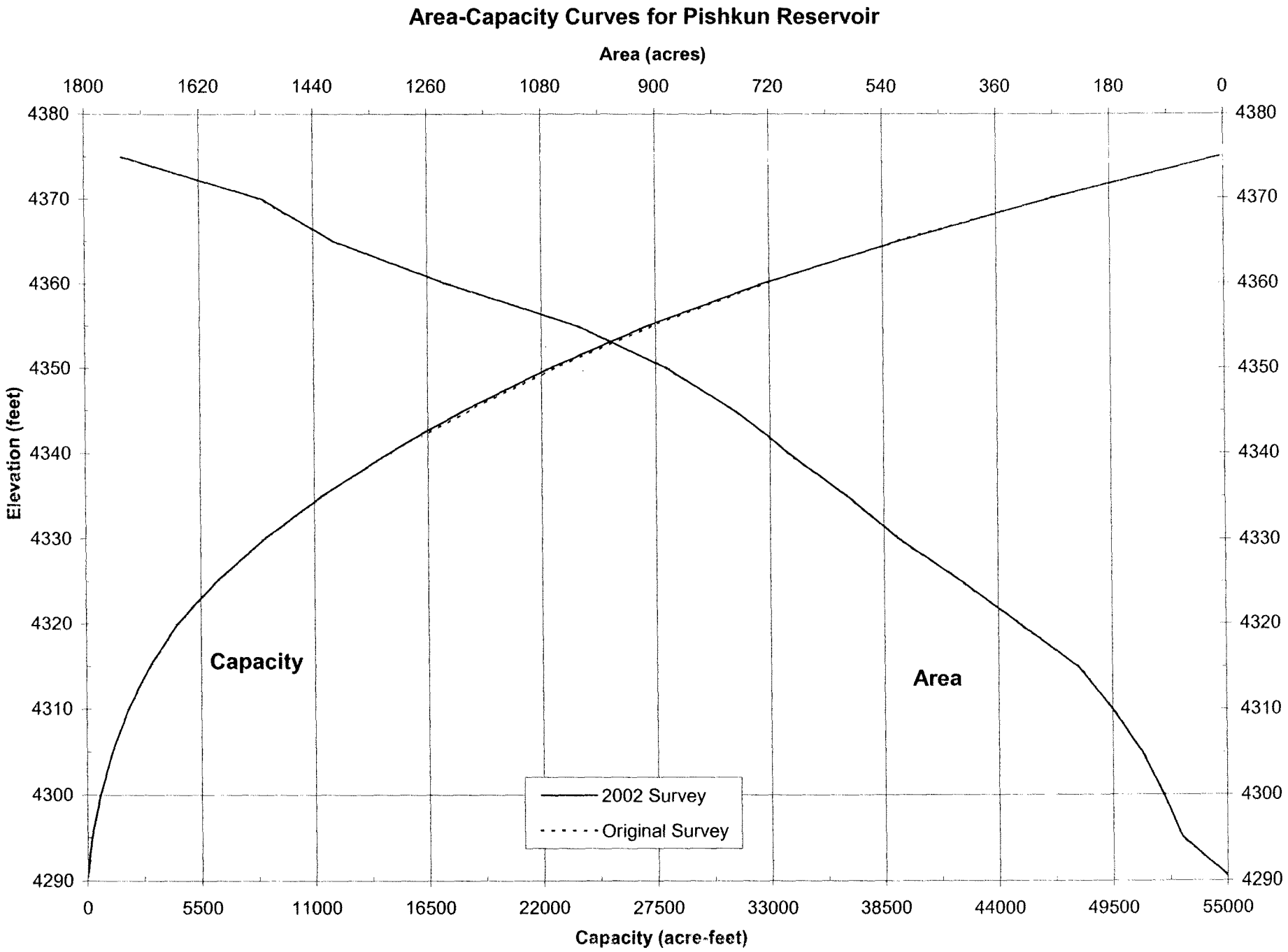

Figure 6. - 2002 area and capacity curves