NAMBE FALLS RESERVOIR
2004 SURVEY

U.S. Department of the Interior
Bureau of Reclamation

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave Blank)*	2. REPORT DATE April 2004	3. REPORT TYPE AND DATES COVERED Final

4. TITLE AND SUBTITLE Nambe Falls Reservoir 2004 Survey	5. FUNDING NUMBERS PR
6. AUTHOR(S) Ronald L. Ferrari	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Bureau of Reclamation, Technical Service Center, Denver CO 80225-0007	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Bureau of Reclamation, Denver Federal Center, PO Box 25007, Denver CO 80225-0007	10. SPONSORING/MONITORING AGENCY REPORT NUMBER DIBR

11. SUPPLEMENTARY NOTES

Hard copy available at Bureau of Reclamation Technical Service Center, Denver, Colorado

12a. DISTRIBUTION/AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The Bureau of Reclamation (Reclamation) surveyed Nambe Falls Reservoir in the spring of 2004 to develop new reservoir topography and compute a present storage-elevation relationship (area-capacity tables). The underwater survey, conducted near lake elevation 6,803 feet (project datum), 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 developed by standard land collection methods using RTK GPS and total station instrumentation. This study assumed no change, since the 1976 original reservoir survey, from elevation 6,828 (feet) and above due to the lack of detailed 2004 above water data.

As of April 2004, at spillway crest elevation 6,826.6, the surface area was 58 acres with a total capacity of 1,920 acre-feet. Since dam closure on February 23, 1976, about 106 acre-feet of estimated change has occurred below elevation 6,826.6, resulting in a 5.2 percent loss in reservoir volume. This calculated change is due to sediment inflow and accuracy differences between the surveys. The study calculated that 42.5 percent of the total change occurred below dead storage elevation 6,760.9.

14. SUBJECT TERMS reservoir area and capacity/ sedimentation/ reservoir surveys/ sonar/ sediment distribution/ contour area/ reservoir area/ sedimentation survey/ global positioning system/ lake	15. NUMBER OF PAGES
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UL	UL	UL	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18
298-102

Nambe Falls Reservoir

2004 Survey

By

Ronald L. Ferrari

Sedimentation and River Hydraulics Group
Water Resources Services
Technical Service Center
Denver, Colorado

April 2004

ACKNOWLEDGMENTS

The Bureau of Reclamation's (Reclamation) Sedimentation and River Hydraulics Group of the Technical Service Center (TSC) prepared and published this report. Anthony Lopez of the Albuquerque Area Office (AAO) was the team leader for this study. Ronald Ferrari of the TSC and Anthony Lopez and Anthony Vigil of the AAO conducted the hydrographic survey. Ron Ferrari of the TSC completed the data processing needed to generate the new topographic map and area-capacity tables. Sharon Nuanes of the TSC developed the final topographic map. Kent Collins of the TSC performed the technical peer review of this documentation.

UNITED STATES DEPARTMENT OF THE INTERIOR

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 Indian tribes and our commitments to island communities.

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.

CONTENTS

	Page
Introduction	1
Summary and Conclusions	2
Reservoir Operations	3
Hydrographic Survey Equipment and Method	3
Reservoir Area and Capacity	5
Topography Development	5
Development of 2004 Contour Areas	6
2004 Storage Capacity	6
Reservoir Sediment Analyses	7
Summary and Recommendations	9
References	9

TABLES

Table		
1	Reservoir sediment data summary (page 1 of 2)	11
1	Reservoir sediment data summary (page 2 of 2)	12
2	Summary of 2004 survey results	13

FIGURES

Figure		
1	Nambe Falls Reservoir location map	1
2	Nambe Falls Reservoir 2004 data map	15
3	Nambe Falls Reservoir topographic map	17
4	2004 area and capacity curves	19
5	Nambe Falls (After 2004 Survey)	20

INTRODUCTION

Nambe Falls Dam and Reservoir, on the Rio Nambe River, are within the boundaries of the Rio Nambe Indian Reservations in Santa Fe County. The dam, reservoir, and facilities are part of the San Juan-Chama Project and are located about 12 miles north of Santa Fe, New Mexico (fig. 1).

Figure 1 – Nambe Falls Reservoir Location Map.

The reservoir, formed by a concrete arch and earthfill dam, had initial storage on February 23 of 1976. The zoned earth embankment dam has a 673-foot long crest at elevation of 6,844.0, a structural height of 144 feet, and a hydraulic height of 127 feet. The concrete arch dam dimensions are:

Hydraulic height[1]	137	feet	Structural height	150	feet
Top width	25	feet	Crest length	320	feet
Crest elevation	6,844.0	feet[2]			

[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]Elevations are in feet. All elevations in this report are based on the original project datum established by U.S. Bureau of Reclamation that was reported to be tied to the National Geodetic Vertical Datum of 1929 (NGVD29).

The spillway is an uncontrolled overflow section in the center of the arch dam with crest elevation 6,826.6 and provides a discharge of 22,500 cubic feet per second (cfs) at maximum reservoir elevation 6,839.8. An outlet works is located through the arch dam and consists of two 18-inch-diameter and one 6-inch-diameter conduits. The inlet elevation of the outlets is 6,761.5 with a discharge capacity of 107 cfs at reservoir elevation 6,826.6.

The drainage area above Nambe Falls Dam is approximately 34.1 square miles with all considered sediment contributing. The drainage area is orientated east to west on the western slope of the Sangre de Christo Mountains and ranges from elevation 6826.6, at the spillway crest, to over 12,600 feet along the eastern rim of the basin. In June 2003, a major basin fire affected about 1.5 square miles or 4.4 percent of the basin (Bureau of Indian Affairs, September 2003). The reservoir is about 0.7 miles in length with an average width of around 0.13 miles.

SUMMARY AND CONCLUSIONS

This Reclamation report presents the 2004 results of the survey of Nambe Falls Reservoir. The primary objective of the survey was to gather data needed to:

- develop reservoir topography
- compute area-capacity relationships
- estimate sediment deposition since dam closure in 1976

The hydrographic survey crew used the horizontal and vertical control that was previously established as part of the Nambe Dam settlement and deflection network. The GPS base was set over monument "G" (located on the downstream face of the earthen portion of the dam) that was last surveyed in April of 2003. The horizontal control was in the New Mexico state plane central coordinate zone in the North American Datum of 1927 (NAD27) and the vertical control was tied to the National Geodetic Vertical Datum of 1929 (NGVD29). All elevations in this report are in feet and referenced to the Reclamation project vertical datum that is reported to be tied to NGVD29.

The underwater survey, conducted on March 30 and 31 of 2004, was between reservoir elevations 6,803.1 and 6,803.4. The bathymetric survey used sonic depth recording equipment interfaced with a RTK GPS capable of determining sounding locations within the reservoir. The system continuously recorded depth and horizontal coordinates of the survey boat as it navigated along grid lines covering Nambe Falls 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 Reclamation's reservoir gauge, 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 standard land collection methods using RTK GPS and total station instrumentation. For final map development, a digitized the water surface contour from the U.S. Geological Survey quadrangle (USGS quad) map of the reservoir area was utilized.

The 2004 Nambe Falls Reservoir topographic map is a combination of the above and under water 2004 collected data and the digitized USGS quad contour. A computer graphics program generated the 2004 reservoir surface areas at predetermined contour intervals from the collected reservoir data.
The 2004 area and capacity tables were generated 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 Nambe Falls Reservoir and watershed characteristics for the 2004 survey. The 2004 survey determined that the reservoir has a storage capacity of 1,920 acre-feet and a surface area of 58 acres at spillway crest elevation 6,826.6. Since closure on February 23, 1976, the reservoir has an estimated volume change of 106 acre-feet below reservoir elevation 6,826.6. This volume represents a 5.2 percent loss in total capacity at this elevation.

RESERVOIR OPERATIONS

Nambe Falls Reservoir is part of the San Juan-Chama Project that provides a water supply to the middle Rio Grand Valley for municipal, domestic, and industrial uses. The April 2004 capacity table shows 2,792 acre-feet of total storage below the maximum water surface elevation 6,839.8. The 2004 survey measured a minimum lake bottom elevation of 6,740.5. The following values are from the April 2004 capacity table:

- 872 acre-feet of surcharge elevation 6,826.6 and 6,839.8.
- 1,618 acre-feet of active conservation use between elevation 6,780.0 and 6,826.6.
- 224 acre-foot of inactive storage between elevation 6,760.9 and 6,780.0.
- 78 acre-foot of dead storage below 6,760.9.

Nambe Falls Reservoir available inflow and end-of-month stage records are listed on table 1 for operation period 1976 through 2004. The inflow values are from the USGS gauging station "Rio Nambe below Nambe Falls Dam." This station is located below the dam, but was the only available information during preparation of this report. The average runoff at this gauge for water years 1979 through 2001 was 10,310 acre-feet per year. The table shows the extreme annual fluctuation of the reservoir as the water surface exceeded spillway crest elevation 6,826.6 many years. The maximum-recorded elevation was 6,827.2 in 1979 with the minimum elevation of 6,778.8 in 1996.

HYDROGRAPHIC SURVEY EQUIPMENT AND METHOD

The survey of Nambe Falls Reservoir was first planned for spring 2003, but was delayed because the 2003 low runoff did not provide full reservoir conditions. Full reservoir conditions are ideal for a hydrographic survey, if dense above water collection will not be conducted, because the survey vessel can cover the underwater portion in a more efficient manner than standard land methods. During the summer of 2003, an extensive drainage basin fire occurred and the resulting runoff deposited material within the reservoir boundary. During the winter of 2003, the reservoir was lowered to excavate the exposed sediments. In January of 2004, a request was made to conduct the hydrographic survey at an extremely low lake level, near elevation 6,786, but icy conditions made collection very hazardous so it was delayed until late March of 2004. In March, the lake had risen to elevation 6,803, but still required much above water collection. During collection, the hydrographic crew found some of the excavated reservoir material deposited in mounds within the reservoir boundary with some completely exposed and some just below the water surface. Limited data was collected on and around these deposits for future reference. It is predicted that much of this material will be eroded over time from its present location and will deposit in lower elevations of the reservoir.

The bathymetric or underwater water survey equipment was mounted on a small boat with an outboard motor. The hydrographic system included a RTK GPS receiver with a built-in radio, a depth sounder, a computer, hydrographic system software for collecting the underwater data, and 12-volt batteries to power the instrumentation. The shore equipment included a second RTK GPS receiver with an external radio powered by a 12-volt battery. The GPS antenna was mounted on a survey tripod over the known datum point "G".

The Sedimentation and River Hydraulics Group uses RTK GPS. The major benefit of RTK GPS is precise height measurement in real time to monitor water surface elevation changes. The basic outputs from a 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 New Mexico's NAD27 central state plane coordinates. The RTK GPS system employs two receivers that track the same satellites simultaneously just like with differential GPS.

Nambe Falls Reservoir hydrographic survey was conducted on March 30 and 31 between water surface elevations 6,803.1 and 6,803.4 (Reclamation project datum). The bathymetric survey used sonic depth recording equipment, interfaced with a RTK GPS, capable of determining sounding locations within the reservoir. The survey system software continuously recorded reservoir depths and horizontal coordinates as the survey boat moved across closely spaced grid lines covering the reservoir area. Most transects (grid lines) were run in a perpendicular alignment of the reservoir at around a 50-foot spacing. Data also was collected along the shore as the boat traversed between transects. Extensive amounts of surface debri hindered full access by the survey boat near the concrete portion of the dam. 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 collected data was digitally transmitted to the computer collection system via a RS-232 port.

The underwater collected data was processed using the same hydrographic system software that was used for the onboard data collection. The analysis included applying all measurements, such as vessel location, and corrections that included the sound velocity of the reservoir water column, and converting all depth data points to elevations using the measured water surface elevation at the time of collection. The depth sounder produced digital charts of the measured depths that were analyzed during post-processing for correcting errors in the computer recorded bottom depths. The water surface elevations at the dam, recorded by a Reclamation gauge and confirmed by the RTK GPS ground survey, were used to convert the sonic depth measurements to true lake-bottom elevations. The underwater data set from the single beam depth sounder included around 18,000 data points.

The above water area of the reservoir was surveyed by standard land collection methods using both a RTK GPS rover and total station instrumentation. Since there was only one rover available, a total station was used when the RTK GPS rover was being utilized for the underwater collection. The above water data set included about 4,000 data points.

All data was tied to the existing Nambe Falls Reservoir control network that was last surveyed in April of 2003. The horizontal control was in the New Mexico state plane central coordinate zone in the North American Datum of 1927 (NAD27) and the vertical control was tied to the National Geodetic Vertical Datum of 1929 (NGVD29). During the RTK GPS collection, the base was set over point "G" and checked on other network points such as "F" and "K". Following are coordinates for points used during the 2004 reservoir survey:

	F	G	K
East	602,383.60	602,301.04	602,328.98
North	1,762,850.56	1,762,975.14	1,762,886.70
Elevation	6,842.436	6,843.971	6,841.275

RESERVOIR AREA AND CAPACITY

Topography Development

The topography of Nambe Falls Reservoir was developed from the 2004 collected data and the digitized contour from the USGS quad maps. The digitized USGS contour line was the Nambe Falls Reservoir contour that outlined the reservoir boundary and was developed from imagery taken in 1996. ARC/INFO V7.0.2 geographic information system software was used to digitize the USGS quad contour. The digitized contours were transformed to New Mexico's NAD 1927 state plane coordinates, central zone, using the ARC/INFO PROJECT command.

The digitized contour line was used to perform a clip of the Nambe Falls Reservoir triangular irregular network (TIN) such that interpolation was not allowed to occur outside the enclosed polygon. The selected contour was the closest available data to the actual reservoir water surface. This clip was performed using the hardclip option of the ARC/INFO CREATETIN command. Using ARCEDIT, the 2004 collected data and digitized contours from the quad maps were plotted. The plot showed that the underwater data did not lie completely within this clip, which required modifications to include the entire underwater data set within the enclosed polygon. Modified areas included some of the shoreline and small inlets not shown on the USGS quad. Using SELECT and MOVE commands within ARCEDIT, the vertices of the clip were shifted to fit all the 2004 collected reservoir data. This hardclip was assigned an elevation of 6,828 to reflect the original surface area of this developed polygon. A plot of the 2004 collected data and the generated contour, elevation 6,826, are shown on figure 2.

Contours for the reservoir below elevation 6,828.0 were computed from the 2004 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 Nambe Falls Reservoir TIN. The areas of the enclosed contour polygons at one-foot increments were developed from the survey data for elevations 6,842.0 through elevation 6,828.0. The 2004 study assumed no change in area since the original survey for elevation 6,828.0 and above. The contour topography at 2-foot intervals is presented on figure 3.

Development of 2004 Contour Areas

The 2004 contour surface areas for Nambe Falls Reservoir were computed at 1-foot increments from elevation 6,841.0 to 6,828.0. The 2004 underwater survey measured a minimum reservoir bottom elevation of 6,740.5. 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. For the purpose of this study, the measured 2004 survey areas at 2-foot increments from elevation 6,842.0 through 6,824.0 were used to compute the new area and capacity tables. Due to the limited amount of 2004 above water data, this study assumed no change from the original surveyed areas at elevation 6,828.0 and above.

2004 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 2004 surveyed surface areas at 2-foot contour intervals,from reservoir elevation 6,742.0 to elevation

6,824.0 were used as the control parameters for computing the 2004 Nambe Falls Reservoir capacity. The original computed survey area at elevation 6,828.0 and the original surveyed surface areas at 5-foot contour intervals from elevation 6,830.0 to 6,840.0 were used to complete the area and capacity tables. 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 Nambe Falls 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. Differentiating the capacity equations, which are of second order polynomial form, derives final area equations:

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

where:

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

Results of the Nambe Falls 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 original capacities. A separate set of 2004 area and capacity tables has been published for the 0.01, 0.1 and 1-foot elevation increments (Bureau of Reclamation 2004). A description of the computations and coefficients output from the ACAP85 program are included with these tables. Both the original and 2004 area-capacity curves are plotted on figure 4. As of April 2004, at maximum reservoir elevation 6,839.8, the surface area was 74 acres with a total capacity of 2,792 acre-feet.

RESERVOIR SEDIMENT ANALYSES

Figure 4 is a plot comparison of the surface areas and capacities of Nambe Falls Reservoir's original and 2004 survey results. For calculating the 2004 sediment accumulation, the original capacities were recomputed using ACAP85. ACAP85 was also used to compute the 2004 capacities. Using the same program removes the small computation differences that occur between programs. Since Nambe Dam closure in 1976, the measured total volume change at reservoir elevation 6,826.6 is 106 acre-feet. The estimated average annual rate of capacity lost for the 28.1-year operation period was 3.8 acre-feet per year. The storage loss in terms of percent of original storage capacity was 5.2 percent at elevation 6,826.6.

The original survey measured a minimum elevation of 6,667 and the 2004 survey measured the minimum at the dam as elevation 6,740.5. This indicates over 70 feet of sediment deposition at the dam, but it must be noted the original survey only measured a surface area of 0.1 acres at elevation 6,710 and 1.1 acres at elevation 6,735. Of the total measured sediment in 2004, about 9.4 percent has deposited from elevation 6,735 and below and about 42.5 percent has deposited in the dead storage area below elevation 6,760.9. Figure 5 illustrates the 2004 sediment accumulation in relation to the outlet location and the reservoir pool elevations.

The Nambe Falls reservoir capacity allocation sheet lists the 100-year sediment deposition to be a total of 400 acre-feet below elevation 6,826.6 of which 230 acre-feet, or 57.5 percent, is projected to deposit below elevation 6,780.0. The 100-year estimate equates to 4 acre-feet per year, which is close to the 2004 survey result of 3.8 acre-feet per year. The 2004 survey results measured a normal accumulation pattern compared to the 100-year projections, but the June 2003 drainage fire could affect the sediment accumulation over the next few years.

As indicated previously, the 2004 area and capacity tables were generated assuming no change in area and capacity, since the 1976 original survey, from elevation 6,828 and above due to the lack of above water detailed survey data. This is in all probability not the case, but from the 2004 collected data and visual observation, it appears there has been minimal change at the upper reservoir elevations since 1976. The 2004 above water survey collected data along the visual high water mark where it could be safely accessed around the lake. This data was used along with the USGS digitized contour to generate a hardclip around the reservoir perimeter. This enclosed clip was assigned elevation 6,828 because it was near the original surface area for this elevation.

The 2004 survey noted a minimal sediment delta in the upper reservoir area and only a minor amount of shoreline erosion. The delta that previously existed was excavated in the winter of 2003 and some of this material was deposited within the reservoir boundaries below the spillway crest elevation of 6,826.6. The land excavation of the reservoir area was conducted when the water surface was below elevation 6,790. It appears a large portion of the reservoir bottom was disturbed and a large amount of reservoir bottom material moved and deposited in the eastern and northern portions of the reservoir. During the 2004 survey, data was collected on land and underwater to map the locations of these deposits. Most of these spoils will be completely submerged when the reservoir becomes full and it is predicted that over time the majority of this material will be redistributed in the lower elevations of the reservoir due to wind and wave actions.

SUMMARY

A resurvey of Nambe Falls Reservoir should be conducted in the near future if major sediment inflow events are observed or after several years of normal runoff. Since the basin fire of 2003 changed the stability of the drainage area, the survey should be scheduled to include major runoff events, but not until the sediment accumulates within the reservoir. If possible, the survey should be schedule when the reservoir level is nearly full to minimize the need and time required for the above water collection. Range lines could be surveyed to monitor change over time, but the small reservoir size allows a complete underwater survey, with 50-foot spacing between cross sections, to be conducted in less than 2-days. The 2004 survey was conducted over a four-day period, with over fifty percent of that time spent on the above water collection because the reservoir level was over 20 feet below full. Even though the 2004 land survey only accounted for about twenty percent of the total data set, it is felt that there was adequate data for the 2004 results to be used as a base for future comparisons. Some of the 2004 upper elevation points could be used as a base for future surveys.

As noted previously, there was excavation of some of the reservoir area in the winter of 2003 with some of the excavated bottom material deposited within the reservoir boundary. Some of this deposited material consisted of large rock indicating that areas of original landscape were disturbed, possibly making it more prone to shoreline erosion. It is felt that over time much of this spoiled material will be eroded and deposited in the lower elevations of the reservoir. Any future excavation should remove the material from the reservoir area.

The 2004 survey measured a minimum elevation of 6,740.5; around twenty feet lower than the inlet elevation of the outlet works. One concern will be the future impact of sediment accumulation on the outlet works. Future surveys will monitor this change, but other means of measurement should also be considered. A depth sounder on a boat is one means. Lowering a weighted marked line tag from the dam might be possible if the deepest portion of the reservoir is accessible from the abutments. With the top of the parapet wall at elevation 6,844.0, the tag line would need to be around 110 feet in length.

RECOMMENDATIONS

Due to the June 2003 basin fire, there are concerns of sediment runoff impacting Nambe Reservoir. Following are recommendations to monitor possible increase in sediment accumulation for the next few years.

1. Visual observation of sediment accumulation. During low reservoir stage and during or after major runoff events a site visit should be conducted to visually document possible changes. Someone familiar with the reservoir such as the dam tender or local office could conduct this site visit. A trip report with photographs should be filed.

2. If there are concerns from the visual observations, the sediment accumulation impact to the outlet works may be monitored by lowering a tagline into the deepest portions of the reservoir near the dam. It may be possible to do this from the dam with a tagline that is 110 feet in length. The tagline could also be lowered from a boat, but a depth sounder as simple as a fish finder could also be used. The dam tender or local office can perform these tasks seasonally or as concerns warrant.

3. If it is determined a resurvey is needed, then it should be scheduled when the reservoir is near full conditions. During the planning of the 2004 survey, several above water

methods were researched, but time and funding did not allow their use. These methods included aerial survey, land base lidar, and additional GPS rovers.

REFERENCES

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

Bureau of Indian Affairs, September 2003. ***Molina Complex, Burned Area Emergency Stabilization and Rehabilitation Plan,*** Interagency Burned Area Emergency Response Team, Nambe Pueblo, New Mexico.

Bureau of Reclamation, 1981. ***Project Data,*** Denver Office, Denver CO.

Bureau of Reclamation, 1985. Surface Water Branch, ***ACAP85 User's Manual***, Technical Service Center, Denver CO.

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

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

Bureau of Reclamation, April 2004. Denver Office, ***Nambe Falls Reservoir Area and Capacity Tables, San Juan – Chama Project***, Upper Colorado River Region, Salt Lake City, UT.

Corps of Engineers, January 2002. *Engineer and Design* - ***Hydrographic Surveying,*** EM 1110-2-1003, Department of the Army, Washington DC, (www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-1003/toc.htm).

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

RESERVOIR SEDIMENT
DATA SUMMARY

Nambe Falls Reservoir
NAME OF RESERVOIR

1
DATA SHEET NO.

DAM	1. OWNER Bureau of Reclamation	2. STREAM Rio Nambe	3. STATE New Mexico
	4. SEC. 29 TWP. 19 N RANGE 10 E	5. NEAREST P.O. Nambe Pueblo	6. COUNTY Santa Fe
	7. LAT 35° 50' 46" LONG 105° 54' 17"	8. TOP OF DAM ELEVATION 6,840.0[1]	9. SPILLWAY CREST EL 6,826.6[2]

RESERVOIR	10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, ACRES	13. ORIGINAL CAPACITY, ACRE-FEET	14. GROSS STORAGE ACRE-FEET	15. DATE STORAGE BEGAN
	a. SURCHARGE	6,839.8[3]	74	872	2,898	
	b. FLOOD CONTROL					2/23/76
	c. POWER					
	d. JOINT USE					16. DATE NORMAL OPERATION BEGAN
	e. CONSERVATION	6,826.6	59	1,666	2,026	
	f. INACTIVE	6,780.0	18	237	360	
	g. DEAD	6,760.9	8	123	123	2/1976
	17. LENGTH OF RESERVOIR 0.7[4] MILES			AVG. WIDTH OF RESERVOIR 0.13 MILES		

BASIN		
	18. TOTAL DRAINAGE AREA 34.1[5] SQUARE MILES	22. MEAN ANNUAL PRECIPITATION 8-30[6] INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 34.1[5] SQUARE MILES	23. MEAN ANNUAL RUNOFF [7] INCHES
	20. LENGTH 151 AV. WIDTH 129	24. MEAN ANNUAL RUNOFF 10,310[8] ACRE-FEET
	21. MAX. ELEVATION 10,274 MIN. ELEVATION 4,508	25. ANNUAL TEMP. MEAN °F RANGE -30°F to 105°F[6]

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
2/23/76			Contour (D)	5-ft	59	2,026	0.20
4/1/04	28.1	28.1	Contour (D)	2-ft	58[9]	1,920[9]	0.19

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
		10,310[10]				

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.
4/1/04	106[11]	3.8	0.111	106	3.8	0.111

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		42.	
		a. PERIOD	b. TOTAL TO	a. AV.	b. TOTAL TO	a.	b.
4/1/04				0.19[11]	5.2[11]		

26. DATE SURVEY	43. DEPTH DESIGNATION RANGE FEET BELOW, AND ABOVE, CREST ELEVATION											
	6697-6760.9	6760-6770	6770-6780	6780-6790	6790-6800	6800-6810	6810-6820	6820-CREST				
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											
2004	42.5	2.8	9.4	9.5	7.5	11.3	10.4	6.6				

26. DATE 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 [8, 10]

YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1976				1977	6,809.5	6,780.6	4,470
1978	6,826.8	6,786.3	6,800	1979	6,827.2	6,798.9	6,600
1980	6,826.9	6,807.8	16,600	1981	6,818.8	6,781.3	3,920
1982	6,817.1	6,785.6	4,280	1983	6,827.1	6,817.1	18,130
1984	6,826.9	6,807.7	12,390	1985	6,827.0	6,814.9	18,640
1986	6,826.7	6,820.2	14,000	1987	6,827.0	6,814.9	15,200
1988	6,826.8	6,814.9	14,000	1989	6,826.6	6,801.4	7,600
1990	6,826.7	6,802.7	6,390	1991	6,827.0	6,826.7	11,730
1992	6,826.8	6,812.4	15,760	1993	6,827.0	6,810.7	11,560
1994	6,827.0	6,804.6	12,370	1995	6,826.9	6,808.3	10,390
1996	6,825.2	6,778.8	5,100	1997	6,826.8	6,789.0	5,200
1998	6,826.8	6,806.4	9,800	1999	6,826.9	6,807.3	9,400
2000				2001	6,826.9	6,802.8	7,090
2002				2003			
2004							

46. ELEVATION - AREA - CAPACITY DATA FOR **(BY INDICATED YEARS) CAPACITY**[12]

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY
1976	**SURVEY**		6,667	0	0	6,710	0.1	1
6,715	0.2	1	6,725	0.2	3	6,730	0.6	5
6,735	1.1	10	6,740	2.1	18	6,745	2.9	30
6,750	5.9	50	6,755	6.5	79	6,760	8.0	115
6,760.9	8	123	6,765	9.4	159	6,770	11.2	210
6,775	15.3	277	6,780	17.9	360	6,785	20.5	456
6,790	24.1	567	6,795	27.0	695	6,800	31.3	841
6,805	35.9	1,009	6,810	42.1	1,204	6,815	45.7	1,423
6,820	50.7	1,664	6,825	56.9	1,933	6,826.6	59	2,026
6,830	62.1	2,331	6,835	68.2	2,556	6,839.8	74	2,898
6,840	74.4	2,913						
2004	**SURVEY**							
6,740.5	0	0	6,745	1.6	3	6,750	3.4	16
6,755	5.7	39	6,760	7.4	72	6,760.9	8	78
6,765	8.9	112	6,770	11.1	162	6,775	14.0	225
6,780	16.8	302	6,785	19.6	393	6,790	22.9	499
6,795	26.4	622	6,800	30.7	765	6,805	35.1	928
6,810	39.8	1,116	6,815	45.0	1,328	6,820	50.0	1,565
6,826.6	58	1,920	6,830	62.1	2,124	6,835	68.2	2,450
6,839.8	74	2,792	6,840	74.4	2,807			

47. REMARKS AND REFERENCES

1 All elevations are in feet based on the original project datum that appears to be tied to NGVD29. Top of earth embankment and parapet wall are at elevation 6844.0.

2 Uncontrolled spillway.

3 Original values recomputed from 5-foot contours with Reclamation's ACAP program.

4 Length with side tributary.

5 From USGS water year records, 2001. Drainage runoff affected by major fire, June 2003. Estimated 4.4% of drainage basin affected, 982 acres (1.5 square miles). From report: "Molina Complex," BIA, 9/2003.

6 Bureau of Reclamation Project Data Book, 1981. Values for San Juan - Chama Project.

7 Calculated using mean annual runoff value of 10,310 AF, item 24. 1979 through 2001 average value from USGS gage "Rio Nambe Below Nambe Falls Dam." Flows controlled by Nambe Falls Dam.

8 1979 through 2001 average value from USGS gage "Rio Nambe Below Nambe Falls Dam." Flows affected by Nambe Falls Dam. Values in item 45 from USGS water reports.

9 Surface area & capacity at elevation 6,826.6, spillway crest elevation.

10 See remarks # 7 and 8. Maximum and minimum elevations from available USGS records by water year.

11 Total sediment inflow by comparing 2004 survey with recomputed capacity from original survey. Some computed change due to different methods of survey. 2004 bathymetric collection at water surface elevation 6803. Above water data collected by land survey methods using RTK GPS and total station instruments. During winter of 2003, land equipment excavate reservoir bottom. Some material removed from reservoir area with some stock piled within reservoir area.

12 All capacities computed by Reclamation's ACAP computer program. The 1976 or original capacity values were recomputed by ACAP for purpose of computing sediment accumulation values. 2004 survey assumed no change from elevation 6,828 and above since original survey.

48. AGENCY MAKING SURVEY Bureau of Reclamation

49. AGENCY SUPPLYING DATA Bureau of Reclamation | DATE April 2004

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

1	2	3	4	5	6	7	8
					2004	2004	Percent of
Elevations	Original	Original	2004	2004	Sediment	Percent of	Reservoir
	Survey	Capacity	Survey	Survey	Volume	Sediment	Depth
(feet)	(acres)	(acre-feet)	(acres)	(acre-feet)	(acre-feet)		
6,840.0	74.4	2913	74.4	2807	106		
6,839.8	74	2898	74	2792	106		100.0
6,835.0	68.2	2556	68.2	2450	106		96.6
6,830.0	62.1	2231	62.1	2124	107		93.1
6,828.0	60	2109	60.0	2002	107		91.7
6,826.6	59	2026	58	1920	106	100.0	90.8
6,820.0	50.7	1664	50.0	1565	99	93.4	86.1
6,815.0	45.7	1423	45.0	1328	95	89.6	82.6
6,810.0	42.1	1204	39.8	1116	88	83.0	79.1
6,805.0	35.9	1009	35.1	928	81	76.4	75.6
6,800.0	31.3	841	30.7	765	76	71.7	72.1
6,795.0	27.0	695	26.4	622	73	68.9	68.6
6,790.0	24.1	567	22.9	499	68	64.2	65.1
6,785.0	20.5	456	19.6	393	63	59.4	61.6
6,780.0	17.9	360	16.8	302	58	54.7	58.1
6,775.0	15.3	277	14.0	225	52	49.1	54.6
6,770.0	11.2	210	11.1	162	48	45.3	51.1
6,765.0	9.4	159	8.9	112	47	44.3	47.6
6,760.9	8	123	8	78	45	42.5	44.7
6,760.0	8.0	115	7.4	72	43	40.6	44.1
6,755.0	6.5	79	5.7	39	40	37.7	40.6
6,750.0	5.1	50	3.4	16	34	32.1	37.1
6,745.0	2.9	30	1.6	3	27	25.5	33.6
6,740.0	2.1	18	0.0	0	18	17.0	30.1
6,735.0	1.1	10	0	0	10	9.4	26.6
6,730.0	0.6	5	0	0	5	4.7	23.1
6,725.0	0.2	3	0	0	3	2.8	19.6
6,715.0	0.2	1	0	0	1	0.9	12.6
6,710.0	0.1	1	0	0	1	0.9	9.1
6,697.0	0.0	0	0	0	0	0.0	0.0

1	Elevation of reservoir water surface.
2	Original reservoir surface areas from 4/1/1976 memorandum.
3	Original capacity recomputed using ACAP to compute sediment accumulation.
4	Reservoir surface area from 2004 survey.
5	Reservoir capacity computed using ACAP.
6	Measured sediment volume = column (3) - column (5).
7	Measured sediment expressed in percentage of total sediment 106 acrea-feet.
8	Depth of reservoir expressed in percentage of total depth of 142.8 feet.

Table 2. - Summary of 2004 survey results

Figure 2. – Nambe Falls Reservoir 2004 underwater data.

Figure 3. – Nambe Falls Reservoir topographic map.

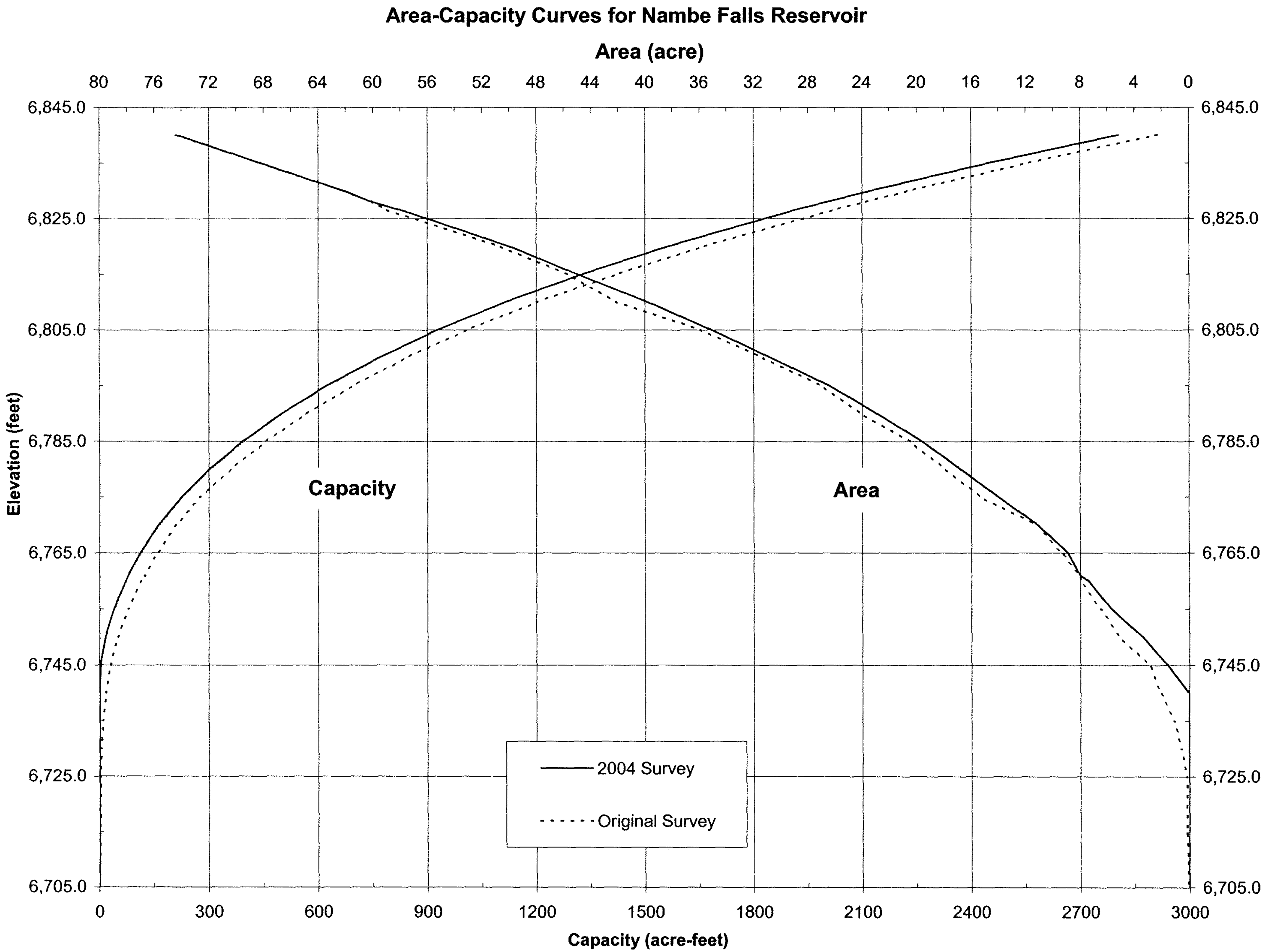

Figure 4. - 2004 area and capacity curves.

Nambe Falls (After 2004 Survey)

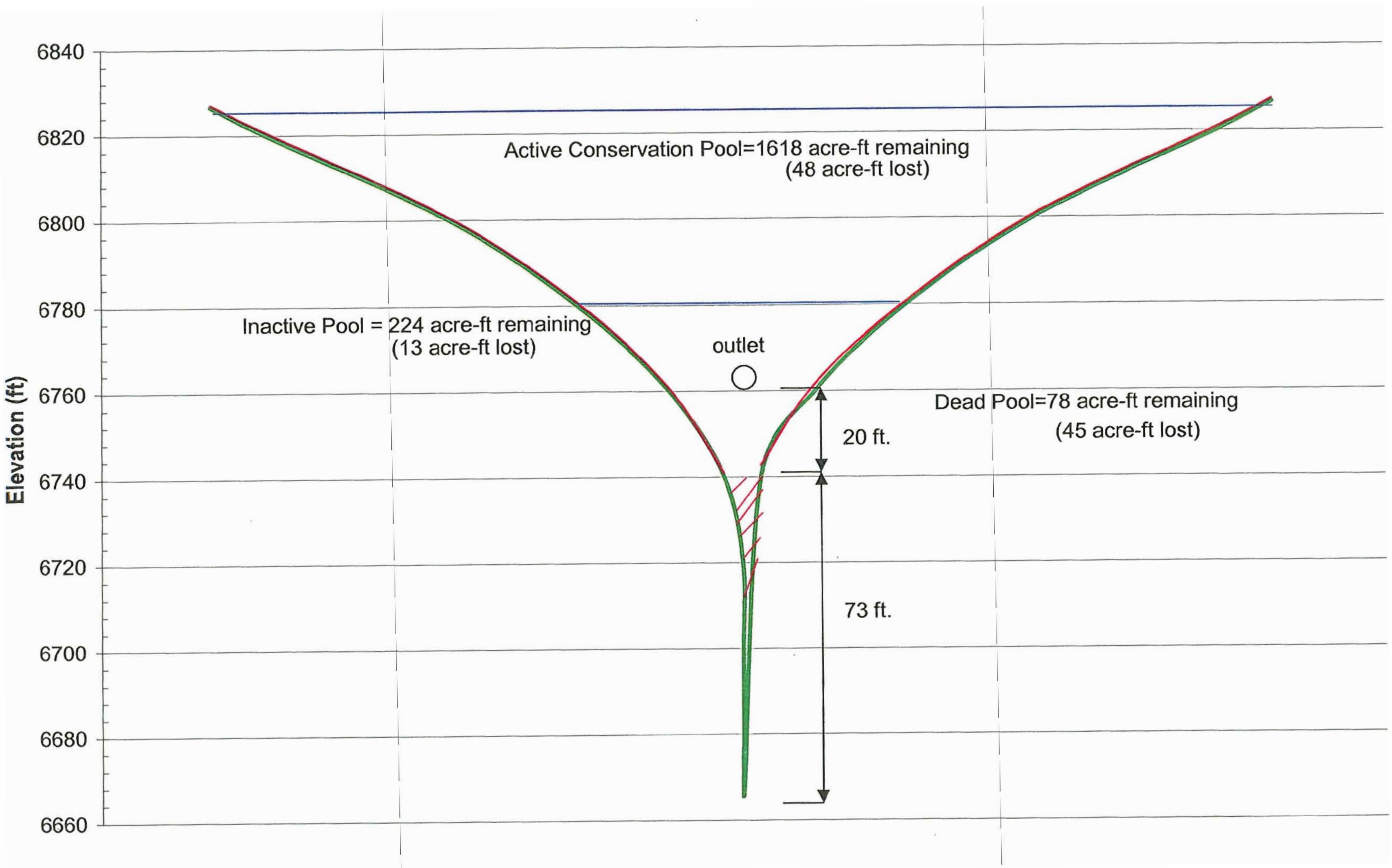

Figure 5 – Nambe Falls (After 2004 Survey)