THEODORE ROOSEVELT RESERVOIR

1995 SEDIMENTATION SURVEY

U.S. Department of the Interior
Bureau of Reclamation

ERRATA

Theodore Roosevelt Reservoir 1995 Sedimentation Survey

Page 10, Table 1, item 9: This should read 2,100 feet rather than 2214.

Page 12, Table 1, item 47, footnote 1: [1] Modifications to Roosevelt Dam completed in 1995 raised the dam elevation and lowered the spillway sill elevation. The original dam elevation was 2142 and the spillway elevation (top of radial gates) was 2136.

Page 13. Table 2, footnote 7: Computed sediment expressed as a percentage of total computed sediment (182,185 acre-feet).

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13. ABSTRACT ***(Maximum 200 words)***

The Bureau of Reclamation (Reclamation) surveyed the area of Theodore Roosevelt Reservoir in the spring of 1995 to compile field data for developing a reservoir topographic map and computing a present storage-elevation relationship. The data were also used to calculate the volume of reservoir capacity loss attributable to sediment accumulation since dam closure in 1909. The bathymetric survey used sonic depth recording equipment interfaced with a GPS (Global Positioning System) that gave continuous sounding positions throughout Theodore Roosevelt Reservoir. The above-water reservoir area was measured from aerial photography obtained in October 1994. The reservoir topography was developed by a computer graphics program using the collected data.

As of April 1995, at top of dam elevation 2,218 feet, the reservoir surface area was 31,852 acres and total capacity was 3,432,408 acre-feet. Since the initial filling in 1909, about 182,185 acre-feet of Theodore Roosevelt Reservoir capacity have been lost below elevation 2,136 feet (top of existing active conservation capacity), resulting in a 12-percent loss in reservoir volume. Since 1909, the average annual rate of reservoir capacity lost below elevation 2,136 feet is 2,121 acre-feet per year.

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THEODORE ROOSEVELT RESERVOIR

1995 SEDIMENTATION SURVEY

by

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Technical Service Center
Denver, Colorado

May 1996

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The Bureau of Reclamation's Sedimentation and River Hydraulics Group of the TSC (Technical Service Center) prepared and published this report. Joe Lyons was the TSC team leader for the preparation of this report and Ron Ferrari conducted the hydrographic survey. Lori Lest and Norm Prince of the TSC and Rick Navratil from the Phoenix Area Office assisted in the completion of the report. Personnel from the Phoenix Area Office performed the required land survey for the hydrographic and aerial data collection. Rick Navratil conducted the aerial photography and hydrographic data interpretation needed to generate the new topographical maps and area-capacity tables. Ron Ferrari performed the peer review of this documentation.

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INTRODUCTION

Theodore Roosevelt Dam was the first major structure built by the Reclamation Service (now the Bureau of Reclamation [Reclamation]) after its formation in 1902 by the Reclamation Act. Construction of the dam began in 1903 and was completed in 1911. Located about 80 miles northeast of Phoenix, Arizona, on the Salt River, the dam is part of the multipurpose Salt River Project that controls floods, generates power, and stores irrigation water.

A modification to the structural height of Roosevelt Dam completed in 1995 raised the dam crest elevation to 2,218 feet, an increase of 77 feet above the pre-modified dam crest elevation of 2,141 feet. As recomputed in 1981 (Lara, 1982), the original (as surveyed in 1909) capacity of the lake was 1,530,499 acre-feet at elevation 2,136 feet. The surface area at elevation 2,136 feet was measured at 17,826 acres in 1909. The 1995 survey resulted in a surface area of 19,075 acres at elevation 2,136 feet and a capacity of 1,348,314 acre-feet at this elevation.

Roosevelt Dam controls runoff from the Salt River, Tonto Creek, and many smaller tributaries. The Salt River arm of the lake is about 16 miles long; the Tonto Creek arm is about 11 miles long (fig. 1). The net sediment contributing area above the reservoir is 5,709 square miles.

SUMMARY AND CONCLUSIONS

This report presents the 1995 results of the first extensive reservoir survey of Theodore Roosevelt Lake. All seven previous reservoir surveys were completed by re-surveying established range lines across the reservoir. In 1995, a complete bathymetric survey of the lake was accomplished. The primary objectives of the survey were to gather data needed to:

- develop reservoir topography to be used as the basis for computing sediment accumulation and for future surveys
- compute area-capacity relationships
- resolve conflicts about storage capacity
- estimate storage depletion caused by sedimentation deposition since closure of Theodore Roosevelt Dam

The bathymetric survey was run using sonic depth recording equipment interfaced with a DGPS (differential global positioning system) capable of determining sounding locations within the reservoir. The system continuously recorded depth and horizontal coordinates of the survey boat as it was navigated along grid lines covering Theodore Roosevelt Reservoir. The positioning system provided information to allow the boat operator to maintain course along these grid lines. Water surface elevations recorded by a Reclamation gage during the time of collection were used to convert the sonic depth measurements to true lake bottom elevations.

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* The definition of terms such as "structural height," "hydraulic height," etc., may be found in manuals such as Reclamation's *Design of Small Dams* and *Guide for Preparation of Standing Operating Procedures for Dams and Reservoirs*, or ASCE's *Nomenclature for Hydraulics*.

The above-water Theodore Roosevelt Reservoir area was measured from aerial photography obtained in October 1994. Photo interpretation produced horizontal positioning and elevations throughout the reservoir area. The new reservoir contour map is a combination of the aerial and underwater survey data. The 1995 reservoir surface areas at predetermined 5-foot contour intervals were generated by a computer graphics program using the collected data. The 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 summarizes the reservoir sedimentation and watershed characteristics for the 1995 survey. The 1995 survey determined that the reservoir has a total storage capacity of 1,348,314 acre-feet and a surface area of 19,075 acres at water surface elevation 2,136 feet. Since closure in 1909, the reservoir has accumulated an estimated volume of 182,185 acre-feet of sediment below elevation 2,136 feet during the period of 85.9 years. This volume represents a 12-percent loss in total capacity and an average annual loss of 2,121 acre-feet.

Previous estimates of reservoir area and capacity were based upon topographic mapping developed from plane table surveys accomplished in the early part of this century. The bathymetric surveying and aerial photography done for the 1995 survey resulted in a much improved (more accurate) estimate of existing reservoir area and capacity.

RESERVOIR OPERATIONS

The reservoir is a multi-use facility having (following values are from the Water Resources Management Division, PxAO-7450, Phoenix Area Office, Bureau of Reclamation):

- 1,223,169 acre-feet of surcharge storage between elevations 2,175 feet and 2,218 feet.
- 556,196 acre-feet of flood control space between elevations 2,151 feet and 2,175 feet.
- 1,634,391 acre-feet of active conservation storage space between elevations 1,989 feet and 2,151 feet.
- 18,652 acre-feet of dead storage below elevation 1,989 feet.

The capacities are dynamic in that they will undergo periodic adjustment approximately every 10 years based on a complex agreement between several valley cities, Salt River Project, and Reclamation. Some of the capacities as listed in this section are *not* the initial capacities that will be used after the dam is declared substantially complete.

Theodore Roosevelt Reservoir receives the majority of its inflow from the Salt River and Tonto Creek watersheds. Available records for calendar years 1909 through 1995 show that the average inflow into the reservoir was 752,279 acre-feet per year. This inflow computes to a mean annual runoff of 2.47 inches for the 5,709-square-mile basin. The inflow and end-of-month stage records in table 1 show the annual fluctuation of the reservoir. Project operations began in May 1907, and storage operations started 2 years later in May 1909. Available records show Theodore Roosevelt Reservoir operation ranging from elevation 1,947 feet in water year 1910 to elevation 2,139 feet in water year 1993.

HYDROGRAPHIC SURVEY EQUIPMENT AND METHOD

Survey History

The original Theodore Roosevelt Reservoir topographic map, drawing 25-P-48, dated April 1915, shows the stations of the range line endpoints in the 1915 local survey coordinates. No other information on surface area and contour development was located. It is assumed the original surface areas were mapped by a plane table survey, prior to dam closure, at a 10-foot contour accuracy. The original surface area values appear in column (2) of table 2. Column (3) of table 2 gives the original capacity of Theodore Roosevelt Reservoir recomputed in 1981 using the area-capacity computer program ACAP (Reclamation, 1985).

Boat and Shore Equipment

The hydrographic survey equipment was mounted in the cabin of a 24-foot tri-hull aluminum vessel equipped with twin in-board motors. The hydrographic system contained on the survey vessel consisted of a GPS (global positioning system) receiver with a built-in radio and omnidirectional antenna, dual frequency depth sounder, helmsman display for navigation, plotter, computer, and hydrographic system software for collecting the underwater data. Power to the equipment was supplied by an on-board generator.

The shore equipment included a second GPS receiver with a built-in radio and omnidirectional antenna. The GPS receiver and antenna were mounted on a survey tripod over a known datum point. The power for the shore units was provided by a 12-volt battery. To obtain the maximum radio transmission range, known datum points with clear line-of-sight to the survey boat were selected.

GPS Technology and Equipment

The positioning system that was used at Theodore Roosevelt Reservoir was NAVSTAR (NAVigation Satellite Timing and Ranging) GPS, an all weather, radio based, satellite navigation system that enables users to accurately determine 3-dimensional position. The NAVSTAR system's primary mission is to provide passive global positioning and navigation for land, air, and sea based strategic and tactical forces and is operated and maintained by DOD (Department of Defense). The GPS receiver measures the distances between the satellites and itself and determines the receiver's position from the intersections of the multiple range vectors. Distances are determined by accurately measuring the time a signal pulse takes to travel from the satellite to the receiver.

The NAVSTAR system consists of three segments:

- The space segment is a network of 24 satellites maintained in precise orbits, about 10,900 nautical miles above the earth, each completing an orbit every 12 hours.
- The ground control segment tracks the satellites, determines their precise orbits, and periodically transmits correction and other system data to all the satellites, which are then retransmitted to the user segment.
- The user segment is the GPS receivers, which measure the broadcasts from the satellites and calculate the position of the receivers.

The GPS receivers use the satellites as reference points for triangulating their position on earth. The position is calculated from distance measurements to the satellites that are determined by the time a radio signal takes to reach the receiver from the satellite. To calculate the receiver's position on earth, the satellite distance and the satellite's position in space are needed. The satellites transmit signals to the GPS receivers for distance measurements along with the data messages about their exact orbital location and operational status. The satellites transmit two "L" band frequencies for the distance measurement signals called L1 and L2. At least four satellite observations are required to mathematically solve for the four unknown receiver parameters (latitude, longitude, altitude, and time). The time unknown is caused by the clock error between the expensive satellite atomic clocks and the imperfect clocks in the GPS receivers. For hydrographic surveying of altitude, the Theodore Roosevelt Reservoir water surface elevation parameter was known, which realistically meant only three satellite observations were needed to track the survey vessel. During the Theodore Roosevelt Reservoir survey, at least five satellites were used for position calculations. During much of the survey, the best six available satellites were used to determine the position of the survey vessel.

The GPS receiver's absolute position is not as accurate as it appears in theory because of the function of range measurement precision and geometric position of the satellites. Precision is affected by several factors: time, because of the clock differences; and atmospheric delays caused by the effect on the radio signal by the ionosphere. GDOP (geometric dilution of precision) describes the geometrical uncertainty and is a function of the relative geometry of the satellites and the user. Generally, the closer together in angle two satellites are from the receiver, the greater the GDOP. GDOP is broken into components: PDOP is position dilution of precision (x,y,z); HDOP is horizontal dilution of precision (x,y). The components are based only on the geometry of the satellites. The PDOP and HDOP were monitored during the Theodore Roosevelt Reservoir Survey, and for the majority of the time, they were less than 3, which is well within the acceptable limits of horizontal accuracy for Class 1 and Class 2 level surveys (Corps of Engineers, 1991).

An additional and larger error source of GPS collection is caused by false signal projection, called S/A (selective availability). The DOD implements S/A to discourage the use of the satellite system as a guidance tool by hostile forces. Positions determined by a single receiver when S/A is active can have errors of up to 100 meters.

A method of collection to resolve or cancel the inherent errors of GPS (satellite position or S/A, clock differences, atmospheric delay, etc.) is called DGPS (differential GPS). DGPS was used during the Theodore Roosevelt Reservoir survey to determine positions of the moving survey vessel in real time. DGPS determines the position of one receiver in reference to another and is a method of increasing position accuracies by eliminating or minimizing the uncertainties. Differential positioning is not concerned with the absolute position of each unit, but with the relative difference between the positions of the two units, which are simultaneously observing the same satellites. The inherent errors are mostly canceled because the satellite transmission is essentially the same at both receivers.

At a known geographical benchmark, one GPS receiver is programmed with the known coordinates and stationed over the geographical benchmark. This receiver, known as the master or reference unit, remains over the known benchmark, monitors the movement of the satellites, and calculates its apparent geographical position by direct reception from the satellites. The inherent errors in the satellite position are determined relative to the master receiver's programmed position, and the necessary corrections or differences are transmitted to the mobile GPS receiver on the survey vessel. For the Theodore Roosevelt Reservoir Survey, position corrections were determined by the master receiver and transmitted via a UHF (ultra-high frequency) radio link every 3 seconds to the survey vessel mobile receiver. The survey vessel's GPS receiver used the corrections along with the satellite information it received to determine the vessel's differential location. Using DGPS resulted in positional accuracies of 1 to 2 meters for the moving vessel compared to positional accuracies of 100 meters with a single receiver.

The TSC (Technical Service Center) mobile and reference GPS units are identical in construction and consist of a 6-channel L1 C/A (coarse acquisition) code continuous parallel tracking receiver, an internal modem, and a UHF radio transceiver. The differential corrections from the reference station to the mobile station are transmitted using the industry standard RTCM (Radio Technical Commission for Maritime Services) message protocol via the UHF radio link. The programming to the mobile or reference GPS unit is accomplished by entering necessary information via a notebook computer. The TSC's GPS system has the capability of establishing or confirming the land base control points by using notebook computers for logging data and post-processing software. The GPS collection system has the capability of collecting the data in 1927 or 1983 NAD (North American Datums) in the surveyed area's state plane coordinate system's zone, which for the 1995 Theodore Roosevelt Reservoir survey was the Arizona State Plane Coordinates NAD27 Central Zone.

1995 Survey Methods

The Theodore Roosevelt Reservoir hydrographic survey was completed using the contour method as outlined by Blanton (1982). The procedure involved collecting adequate coordinate data for developing a reliable contour map by bathymetric and aerial survey methods. The bathymetric survey used sonic depth recording equipment interfaced with GPS positioning that gave continuous sounding positions throughout Theodore Roosevelt Reservoir.

Reclamation's Phoenix Area Office personnel used GPS equipment and standard land surveying methods to establish horizontal and vertical control points for the hydrographic survey.

The above-water data were collected by aerial photography obtained on October 28, 1994, at an approximate reservoir elevation of 2,087 feet. Reclamation's Phoenix Area office conducted the aerial photography interpretation and provided contour data at 5-foot intervals to define the reservoir topography.

The Theodore Roosevelt Reservoir bathymetric survey began on April 18, 1995, and concluded on April 23, 1995. During this time, the average water surface of the reservoir was 2,125.7 feet. The bathymetric survey was run using sonic depth recording equipment interfaced with a DGPS capable of determining sounding locations within the reservoir. The survey system software was capable of recording, in 1-second increments, depths and horizontal coordinates as the survey boat moved along predetermined grid lines covering the reservoir. To produce adequate data for developing contours of Theodore Roosevelt Reservoir, grid lines or transects accessible by the survey boat were collected at a spacing of 400 feet. Data were collected at an average of 2-second intervals; additional data were collected along the shore as the boat traversed to the next transect. The survey vessel's guidance system gave directions to the boat operator to assist in maintaining course along these predetermined grid lines. During each run, the depth and position data were recorded on the notebook computer hard drive for subsequent processing by TSC personnel. A graph plotter was used in the field to track the boat and ensure adequate coverage during the collection process. The underwater data set included 70,500 coordinate points. Water surface elevations recorded by a Reclamation gage at the dam were used to convert the sonic depth measurements to true lake bottom elevations.

The TSC's depth sounder has a 208-kilohertz transducer that reflects the first-encountered bottom surface which is used for sediment surveys. The bottom is determined by measuring elapsed time between the transmission of the sound pulse from the transducer to the waterway bottom and the reception of its echo at the transducer. Prior to data collection and periodically through the survey, the depth sounder was calibrated by lowering a deflector plate below the boat by cables with known depths marked by beads. The depth sounder was calibrated by adjusting the speed of sound, which can vary with water density, salinity, temperature, turbidity, and other conditions. The accuracy of an instantaneous reading from the depth finder is estimated to be ±0.5 feet, but these errors are minimized over the entire survey. The estimated accuracy takes into consideration calibration error and the collection of depth data when the boat is moving. The collected data were digitally transmitted to the computer collection system via an RS232 port. The depth sounder also produces an analog hard copy chart of the measured depths. These 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 to agree with the analog chart depth.

RESERVOIR AREA AND CAPACITY

Topography Development

The aerial photography was obtained October 28, 1994, at elevation 8,000 feet a.m.t. (above mean terrain). Fifty-eight photogrammetric maps were created from this photography. The maps were compiled at a scale of 1 inch = 200 feet with a 5-foot contour interval. The elevation range was 2,090 feet to 2,225 feet plus the water surface of 2,087.0 feet and the new top of dam elevation, 2,218.0 feet. The contours were digitized directly from the photographs using an SD2000 Stereo Plotter and DAT/EM mapping software at Reclamation's Phoenix Area Office. CADD (computer aided design and drafting) software was used to create 3-dimensional models of the reservoir. For purposes of computing areas and saving disk space, the contours were filtered to a scale of 1 inch = 500 feet. This filtering involved removing as many vertex points as possible from any given contour without changing the accuracy of the contour.

For contours below elevation 2,087 feet, the sounding information collected by Denver TSC personnel was used to develop the contour map. About 70,500 data points were collected during April 18 to 23, 1995. The water surface elevation at this time averaged 2,125.7 feet. This procedure gave a desired overlap of the aerial and underwater mapping. Sounding data points above elevation 2,087 feet were eliminated from the data set. Using the digitized water line (elevation 2,087 feet) and the remaining sounding points, contours were developed for the underwater area using TIN (triangulated irregular network) software. These contours were created every 5 feet from elevation 1,965 feet to elevation 2,085 feet. Manual editing of the contours was performed in the CADD software to eliminate inconsistencies and to produce hard copy maps. The contours were then filtered to a scale of 1 inch = 500 feet to match the above water contours.

Development of 1995 Contour Areas

The 1995 contour surface areas for Theodore Roosevelt Reservoir were computed in 5-foot intervals from elevation 1,965 feet to elevation 2,225 feet using the TIN and aerial mapping data discussed above. The areas for each elevation were computed in acres. This procedure was done using CADD software for the computation of the area of a closed, planar polygon. Deductions were made for any island contours within the main contour for a given elevation. Based on the input data, elevation 1,963 feet was determined to be the low point in the reservoir. An area was also calculated for elevation 1,964 feet. The 1995 topography for Theodore Roosevelt Reservoir is shown on figures 1a and 1b.

1995 Storage Capacity

The storage-elevation relationships based on the measured surface areas were developed using the area-capacity computer program ACAP (Reclamation, 1985). The 1995 surface areas at 5-foot contour intervals from elevation 1,965 feet to 2,225 feet, plus 1,963 feet, 1,964 feet, and 2,218 feet, were used as the control parameters for computing the Theodore Roosevelt Reservoir capacity. The program can compute an area and capacity at elevation increments of 0.01- to 1.0-foot by linear interpolation between the given contour surface areas. The program begins by testing the initial capacity equation over successive intervals to ensure that the equation fits within an allowable error limit, which was set at 0.0000001 for Theodore Roosevelt 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:

$$y = a_1 + a_2 x + a_3 x^2$$

where:

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

Results of the 1995 Theodore Roosevelt Reservoir area and capacity computations are listed in tables 1 and 2 and plotted on figure 2. A set of 1995 area and capacity tables was developed for the 0.1-foot elevation increments (Reclamation). These tables are dated November 30, 1995. Computation results are listed in columns (4) and (5) of table 2. Column (2) in the table gives the original measured contour areas used in the original area and capacity computation, and column (3) gives the original capacity recomputed using ACAP. Both the original and 1995 area and capacity curves are plotted on figure 2. As of April 1995, at the top of the existing spillway at elevation 2,136 feet, the surface area was 19,075 acres and the capacity was 1,348,314 acre-feet.

RESERVOIR SEDIMENT ANALYSES

Since Theodore Roosevelt Reservoir storage began in 1909, the computed volume difference between the original and 1995 capacities is 182,185 acre-feet below top of existing active conservation capacity elevation 2,136 feet. The average annual rate of lost capacity was 2,121 acre-feet per year, or 0.372 acre-foot per square mile per year from the sediment contributing drainage area of 5,709 square miles. The storage difference in terms of percent of original storage capacity was 88 percent.

Sediment calculations in the 1995 study were based on the difference between the original and 1995 measured reservoir capacities. This method would account for all sediment accumulation during the 85.9 years of reservoir operation, but the calculations are only as accurate as the two surveys. Based on the obvious differences in mapping accuracy for the 1995 and 1915 contour maps of the Roosevelt Lake area, the surface areas and capacities for the range of operational elevations at the lake for 1995 should be compared to earlier estimates of sedimentation at Roosevelt Lake. Table 1 contains the Theodore Roosevelt Reservoir storage calculations with differences based on the 1995 resurvey and compared to the 1981 survey. Although similar, the estimates for average annual loss in capacity to sedimentation are sufficiently different to warrant consideration in future planning and storage allocation activities.

Because future reservoir surveys will be compared to the 1995 reservoir topography, the capacity and sediment distributions computed from these data are important. For computing estimates of future sedimentation rates, the data generated from the 1981 survey may be more applicable than the estimates based upon comparison of the 1995 survey and the original topography. The 1981 survey and analysis has the advantage of adjustments to a common map base between surveys (original and 1981). In contrast, the analysis for the 1995 survey relied upon comparison of two different map bases of apparently dissimilar accuracies. The intended use of the data should be considered when choosing the sedimentation analysis results for a particular application.

Comparative analyses for all range lines established in 1909 and surveyed in 1995 are presented on figures 3 through 45. The 1995 traces for these comparisons are from the 1995 topographic map developed from the recent bathymetric survey and aerial photogrammetry. These range lines were established by locating the endpoint coordinates for each range line within the topographic map developed from the 1995 survey and producing a range line profile from the map product. The 1909 (original) cross section shape of each range line was developed from the original topography for Roosevelt Lake.

These comparative plots reveal significant differences in the above water portion of the range lines between 1909 and 1995. These differences relate to the differences in techniques used to generate these maps as well as the related map accuracy. In some cases, the original profiles do not extend to the present-day endpoints. For these profiles, only the available portion of the original is shown on the comparative plot.

Profiles of the Salt River and Tonto Creek portions of the reservoir are shown on figures 46 and 47. These profiles were developed from the thalweg elevations (original and 1995) for each range line along the two arms of the lake. Distances between the range lines were established from the 1995 topographic map of Roosevelt Lake.

The coordinates and elevations for each sedimentation survey range line endpoint at Theodore Roosevelt reservoir are shown in table 3. Future reservoir surveys will likely be conducted using these data to produce comparative plots of these range lines to monitor sedimentation within the reservoir area.

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

RESERVOIR SEDIMENT
DATA SUMMARY

Theodore Roosevelt Lake
NAME OF RESERVOIR

60-4b
DATA SHEET NO.

D A M	1. OWNER Salt River Project	2. STREAM Salt River & Tonto Creek	3. STATE Arizona
	4. SEC 20, T4N, R12E	5. NEAREST PO Globe 30 NW	6. COUNTY Gila
	7. LAT 33° 33′ 13″ LONG 111° 26′ 33″	8. TOP OF DAM ELEV. 2218	9. SPILLWAY CREST ELEV. 2214

	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
R E S E R V O I R	a. FLOOD CONTROL					May 1909
	b. MULTIPLE USE					
	c. POWER					
	d. WATER SUPPLY	2136	17,826	1,522,200	1,522,200	16. DATE NORMAL OPERATION BEGAN
	e. IRRIGATION					May 1907
	f. CONSERVATION					
	g. INACTIVE					

	17. LENGTH OF RESERVOIR 26.7		MILES	AVG. WIDTH OF RESERVOIR 1.04 MILES
B A S I N	18. TOTAL DRAINAGE AREA 5,736		SQ. MI.	22. MEAN ANNUAL PRECIPITATION 21.0 INCHES
	19. NET SEDIMENT CONTRIBUTING AREA 5,709		SQ. MI.	23. MEAN ANNUAL RUNOFF 2.39 INCHES
	20. LENGTH 117 MI.	AV. WIDTH 50	MI.	24. MEAN ANNUAL RUNOFF 726,678 AC.-FT.
	21. MAX. ELEV. 11,000 FT.	MIN. ELEV. 1929	FT.	25. ANNUAL TEMP. MEAN 56.7 RANGE 37.7 to 76.6

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
Gates Closed							
1909	0	0	Contour (D)	10-ft interval	17,785	1,530,499	2.11
Sep 1981	72.4	72.4	Range (D)	39	17,337	1,336,734	1.84
Apr 1995	13.5	85.9	Contour (D)	5-ft interval	19,075	1,348,314[7,8]	1.86

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIP.	35. PERIOD WATER INFLOW, ACRE FEET			36. WATER INFLOW TO DATE, AF	
		a. MEAN ANN.	b. MAX. ANN.	c. TOTAL	a. MEAN ANN.	b. TOTAL
Sep 1981	21.0	717,131	2,582,996	50,199,184	717,131	50,199,184
Apr 1995	22.5	1,035,485	2,744,900	14,496,790	752,279	64,695,974

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.
Sep 1981	193,765	2,676	0.469	193,765	2,676	0.469
Apr 1995	see footnote 8	see footnote 8	see footnote 8	182,185	2,121	0.372

26. DATE OF SURVEY	39. AV. DRY WT. (#/FT³)	40. SED. DEP. TONS/MI.²-YR.		41. STORAGE LOSS, PCT.		42. SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANNUAL	b. TOTAL TO DATE	a. PER.	b. TOT.
Sep 1981	49.3	504	504	0.175	12.67	3,054	3,050
Apr 1995	N/A	N/A	N/A	0.139	11.90	N/A	N/A

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

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW AND ABOVE CREST ELEVATION (2136 ft crest elevation)											
	234-206	206 - 166	166 - 126	126 - 86	86 - 36	36 - crest						
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											
April 1995	1.5	15.0	26.6	27.3	28.7	0.9						

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														
April 1995	N/A														

45. RANGE IN RESERVOIR OPERATION'

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1910	2025	1947	454,365	1952	2121.43	2009.51	286,986
1911	2069	1963	800,250	1953	2116.59	2087.03	208,666
1912	2079	2051	548,027	1954	2093.11	2077.69	491,741
1913	2069	2033	401,857	1955	2082.93	2037.40	839,302
1914	2044	2012	530,770	1956	2044.70	1972.18	548,771
1915	2127	2012	1,782,758	1957	2032.88	1986.87	491,741
1916	2127	2106	2,582,996	1958	2079.02	2000.58	839,302
1917	2127	2092	816,505	1959	2076.75	2032.20	584,771
1918	2103	2045	394,512	1960	2119.58	2077.02	737,340
1919	2073	2036	991,274	1961	2103.50	2074.60	212,370
1920	2127	2072	1,890,016	1962	2107.83	2078.68	767,021
1921	2100	2068	546,283	1963	2091.90	2057.84	446,036
1922	2103	2072	688,488	1964	2068.13	2034.54	292,497
1923	2080	2052	612,431	1965	2132.46	2048.61	1,407,435
1924	2105	2053	903,937	1966	2135.47	2123.45	756,767
1925	2066	1990	328,067	1967	2125.29	2105.35	383,794
1926	2075	1990	783,887	1968	2135.52	2114.60	1,006,598
1927	2093	2038	959,292	1969	2130.92	2114.88	617,967
1928	2068	2007	317,279	1970	2114.82	2080.46	349,271
1929	2005	1962	471,874	1971	2096.13	2068.54	471,764
1930	1995	1952	397,997	1972	2098.50	2032.45	748,406
1931	2019	1952	639,182	1973	2135.88	2096.68	1,642,102
1932	2114	1968	1,394,960	1974	2118.73	2081.88	266,586
1933	2099	2076	473,897	1975	2112.73	2086.85	621,110
1934	2076	1975	263,624	1976	2104.49	2082.44	419,679
1935	2071	1962	760,101	1977	2084.24	2015.12	211,884
1936	2070	2026	689,187	1978	2132.46	2024.05	2,037,484
1937	2107	2038	1,018,347	1979	2135.95	2117.70	1,743,995
1938	2082	2007	398,797	1980	2136.83	2118.75	1,729,915
1939	2008	1957	381,849	1981	2120.81	2088.98	340,740
1940	1991	1955	309,658	1982	2128.45	2093.86	766,700
1941	2136	1955	2,267,919	1983	2135.92	2120.63	1,660,800
1942	2131	2117	609,213	1984	2131.41	2113.10	889,400
1943	2125	2102	595,101	1985	2135.98	2118.85	1,640,700
1944	2107	2086	427,664	1986	2135.74	2115.33	683,200
1945	2098	2081	349,100	1987	2135.88	2117.55	804,570
1946	2073.49	1986.65	396,127	1988	2133.35	2118.50	775,900
1947	2032.01	1954.95	312,384	1989	2125.45	2090.58	296,080
1948	2030.58	1976.54	464,169	1990	2092.33	2065.92	220,230
1949	2069.22	1993.95	815,771	1991	2134.24	2074.20	1,249,300
1950	2060.47	1970.93	205,444	1992	2123.65	2105.51	1,055,100
1951	2025.28	1971.08	367,416	1993	2139.34	2102.09	2,744,900

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

45. RANGE IN RESERVOIR OPERATION con't.

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AF
1994	2112.82	2087.43	450,010				
1995	2130.07	2099.07	1,259,900				

46. ELEVATION - AREA - CAPACITY DATA

ELEV.	AREA	CAP.	ELEV.	AREA	CAP.	ELEV.	AREA	CAP.
1995	**Survey**							
1965	157	80						
1970	551	1,850						
1980	927	9,120						
1990	1,211	19,850						
2000	2,198	36,147						
2010	3,440	64,357						
2020	4,273	103,035						
2030	4,954	149,442						
2040	5,581	202,025						
2050	6,714	262,987						
2060	7,979	336,245						
2070	9,396	423,232						
2080	10,769	524,050						
2090	12,194	638,669						
2100	13,579	767,887						
2110	14,831	909,867						
2120	16,356	1,065,544						
2130	18,000	1,237,049						
2140	19,746	1,425,957						
2150	21,351	1,631,622						
2160	22,732	1,852,129						
2170	24,163	2,086,387						
2180	25,753	2,336,067						
2190	27,402	2,601,879						
2200	29,053	2,884,154						
2210	30,614	3,182,584						
2220	32,221	3,496,484						

47. REMARKS AND REFERENCES

[1] = Modification to Roosevelt Dam completed in 1995 raised the dam and spillway elevations. Original dam elevation was 2142 and spillway elevation was 2136.

[2] = Storage allocation breakdown unknown.

[3] = Modification to Roosevelt Dam in 1995 raised the water supply allocation to elevation 2218 feet and the capacity to 3,432,408 acre-feet.

[4] = Date of project operation. Date of normal dam operation unavailable.

[5] = Salt River Arm = 15.8 miles; Tonto Creek Arm = 10.9 miles.

[6] = 1909 area and capacity values recomputed in 1981 by current methods for comparison with 1995 area and capacity values to compute sediment deposition.

[7] = Capacity in 1995 at elevation 2136 recomputed using map developed from 1995 surveys.

[8] = The increased intensity of bathymetry survey, along with increased map detail, results in lower sediment deposition estimates for 1995 when compared to the 1981 survey results.

[9] = Inflow, maximum, and minimum elevation data from Salt River Project files.

48. AGENCY MAKING SURVEY Bureau of Reclamation
49. AGENCY SUPPLYING DATA Bureau of Reclamation DATE. April 1996

Table 2. - Summary of 1995 survey results and sediment distribution.

(1) Elevation (ft)	(2) Original Area (acres)	(3) Original Capacity (acre-ft)	(4) 1995 Area (acres)	(5) 1995 Capacity (acre-ft)	(6) Computed Sediment Volume (acre-ft)	(7) Percent of Computed Sediment
2220			32,221	3,496,484		
2210			30,614	3,182,584		
2200			29,053	2,884,154		
2190			27,402	2,601,879		
2180			25,753	2,336,067		
2170			24,163	2,086,387		
2160			22,732	1,852,129		
2150			21,351	1,631,622		
2140			19,746	1,425,957		
2136	17,785	1,530,499	19,075	1,348,314	182,185	100.0
2130	17,203	1,425,512	18,000	1,237,049	188,463	103.5
2120	16,177	1,258,547	16,356	1,065,544	193,003	105.9
2110	15,095	1,102,215	14,831	909,867	192,348	105.6
2100	14,140	956,455	13,579	767,887	188,568	103.5
2090	13,247	819,272	12,194	638,669	180,603	99.1
2080	11,939	693,315	10,769	524,050	169,265	92.9
2070	10,638	580,590	9,396	423,232	157,358	86.4
2060	9,482	479,928	7,979	336,245	143,683	78.9
2050	8,262	391,207	6,714	262,987	128,220	70.4
2040	7,106	314,623	5,581	202,025	112,598	61.8
2030	6,216	248,009	4,954	149,442	98,567	54.1
2020	5,286	190,334	4,273	103,035	87,299	47.9
2010	4,264	142,903	3,440	64,357	78,546	43.1
2000	3,544	103,787	2,198	36,147	67,640	37.1
1990	2,744	72,347	1,211	19,850	52,497	28.8
1980	1,985	48,867	927	9,120	39,747	21.8
1970	1,428	31,935	551	1,850	30,085	16.5
1960	1,020	19,743			19,743	10.8
1950	677	11,328			11,328	6.2
1940	419	5,893			5,893	3.2
1930	227	2,735			2,735	1.5
1920	117	1,059			1,059	0.6
1910	52	211			211	0.1
1902	0	0			0	0.0

Explanation of columns:
(1) Elevation of reservoir water surface.
(2) Original reservoir surface area. Roosevelt Dam was modified, which raised the pool elevation to 2218.
(3) Original reservoir capacity. The modification increased the capacity to 3,432,408 acre-feet.
(4) Reservoir surface area determined from 1995 survey.
(5) Reservoir capacity from 1995 survey.
(6) Accumulated sediment volume = column (3) - column (5).
(7) Measured sediment expressed as percentage of total measured sediment (188,463 acre-ft).

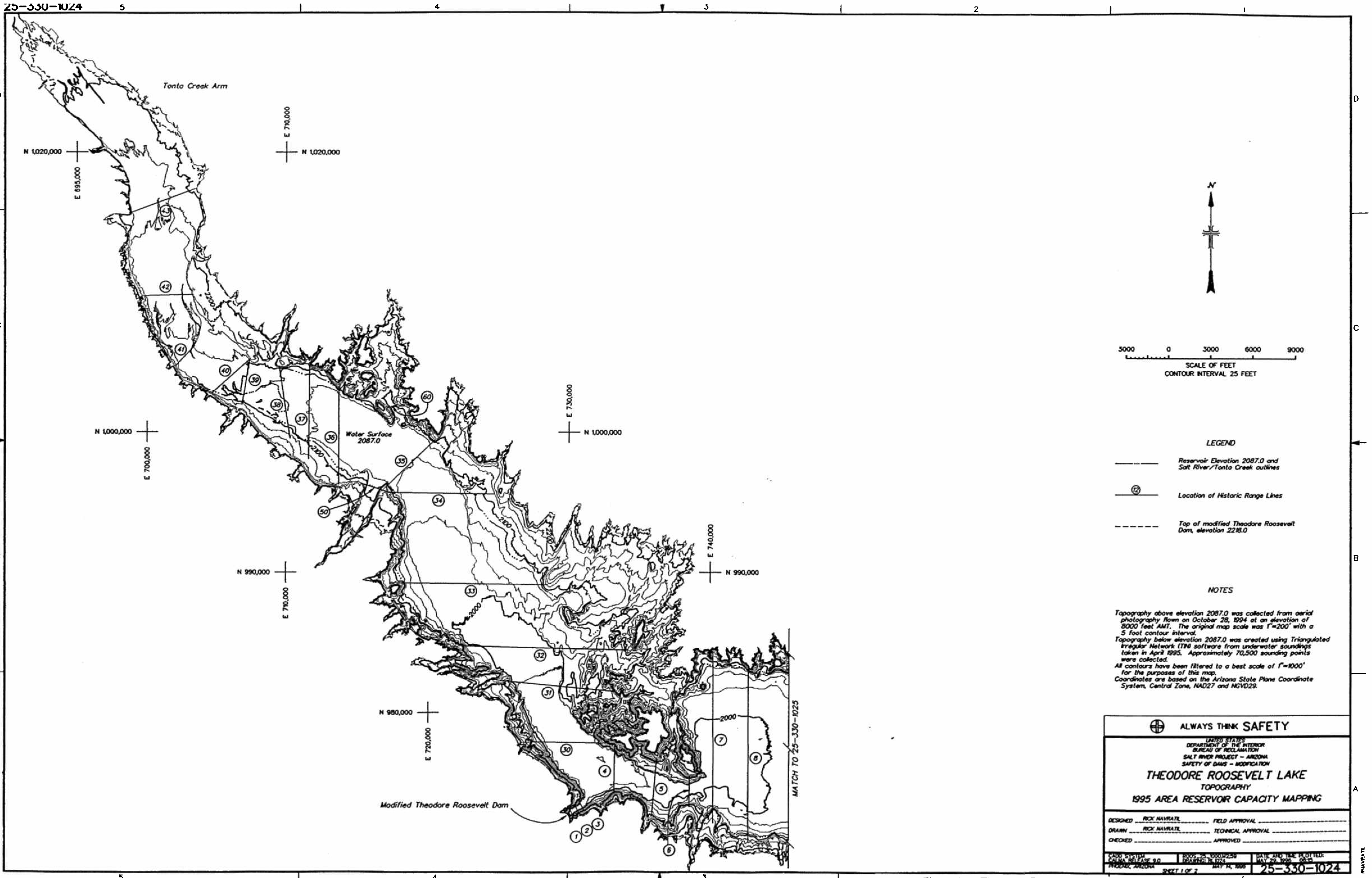
Table 3. - Roosevelt Dam range line bank stations (page 1 of 2).

Range Line	Looking Downstream	Name of Bank Station	FROM 1981 SURVEY LOCAL SYSTEM Drwg. K-653-104.1, 8/81		Elevation (feet)	FROM 1995 G.P.S. SURVEY AZ ST PLN COORD. NAD27 CENTRAL ZONE (US feet)	
			NORTHING	EASTING		NORTHING	EASTING
1	Left Bank	1A	29868.626	60414.562	2130.62	972569.798	730410.915
1	Right Bank	90C	30509.433	60040.744	2136.28	973208.396	730033.533
2	Left Bank	1B	30139.417	60782.903	2136.6	972842.629	730777.670
2	Right Bank	90B	30764.853	60440.896	2144.48	973466.038	730432.182
3	Left Bank	1C	30216.711	61206.644	2137.86	972922.305	731200.910
3	Right Bank	90A	31094.811	60708.438	2134.57	973797.457	730697.819
4	Left Bank	2	31494.845	63287.103	2132.49	974211.999	733273.832
4	Right Bank	55A	35027.557	63338.136	2146.4	977744.462	733304.899
5	Left Bank	4A	29863.893	65894.834	2131.72	972596.027	735890.381
5	Right Bank	54	33971.353	66262.610	2152.69	976704.941	736234.895
6	Left Bank	5	30529.034	68587.052	2136.62	973276.277	738578.432
6	Right Bank	53	32759.592	68609.173	2152.21	975506.621	738587.948
7	Left Bank	6	29351.071	70211.233	2137.1	972107.669	740209.021
7	Right Bank	50B	41633.824	70267.596	2170.63	984388.874	740195.983
8	Left Bank	6A	28062.925	72658.359	2141.93	970833.544	742663.053
8	Right Bank	50A	40346.408	72722.392	2142.73	983115.522	742657.679
9	Left Bank	8	28299.791	76747.093	2139	971093.474	746749.827
9	Right Bank	49	39419.342	77208.704	2135.65	982213.943	747148.547
10	Left Bank	9A	29578.614	80727.976	2146.17	972394.593	750722.880
10	Right Bank	46	34776.175	80780.304	2135.97	977591.659	750745.836
11	Left Bank	10	32633.100	81999.315	2150.88	975455.797	751976.770
11	Right Bank	45B	63652.027	82024.755	2138.01	1006470.154	751826.962
12	Left Bank	18	24741.857	86504.938	2152.3	967591.208	756526.290
12	Right Bank	43B	34125.667	86568.054	2129.49	976973.949	756536.382
13	Left Bank	20	23660.938	90435.051	2152.43	966532.657	760461.913
13	Right Bank	42B	32947.009	90646.086	2139.39	975818.509	760620.453
14	Left Bank	22	23780.458	94071.163	2151.98	966672.701	764096.797
14	Right Bank	40B	32119.804	94208.343	2146.35	975011.555	764186.842
15	Left Bank	24	21664.571	97712.843	2151.26	964577.710	767749.877
15	Right Bank	39A	29952.502	98479.852	2139.22	972868.714	768469.947
16	Left Bank	25	22362.295	100534.100	2147.2	965291.267	770566.764
16	Right Bank	38A	28671.271	100596.134	2134.94	971599.634	770593.145
17	Left Bank	26	22909.258	103230.472	2153.2	**965853.613**	**773258.830**
17	Right Bank	37A	27394.328	103298.589	2129.36	970338.153	773302.404
18	Left Bank	27	22802.779	106610.933	2134.88	965766.015	776640.185
18	Right Bank	36A	28555.258	106626.875	2197.07	971517.710	776623.625
19	Left Bank	31	19778.980	109790.050	2176.28	962760.636	779835.902
19	Right Bank	35C	27261.120	111325.890	2241.54	970250.316	781329.238
20	Left Bank	32D	17712.240	113862.220	2175.74	960717.217	783919.129
20	Right Bank	34	24944.650	113391.420	2228.96	967945.868	783407.541
21	Left Bank	32E	18511.260	115665.360	2166.7	961526.302	785717.481
21	Right Bank	33B	24423.420	114725.600	2217.19	967432.254	784744.463
22	Left Bank	32F	16382.560	116894.130	2224.83	959404.868	786958.091
22	Right Bank	32C	23335.320	118320.290	2263.21	966364.628	788344.754
23	Left Bank	32F	16382.560	116894.130	2224.83	959404.868	786958.091
23	Right Bank	32H	15678.470	120895.880	2163.18	958723.493	790963.211
24	Left Bank	32J	12512.570	118818.850	2195.89	955546.340	788904.382
24	Right Bank	32K	13820.670	121527.740	2188.43	956869.545	791605.470
30	Left Bank	56	35086.929	63018.822	2144.92	977802.021	732985.298
30	Right Bank	86A	35242.369	57371.857	2130.95	977925.535	727338.313
31	Left Bank	58C	38780.910	63408.890	2137.56	**981497.406**	**733357.813**
31	Right Bank	85A	39703.358	54404.420	2142.85	982369.081	724346.124
32	Left Bank	58B	41737.573	64305.501	2140.71	984458.924	734234.208
32	Right Bank	84	42091.377	52445.657	2125.32	984745.671	722374.167
33	Left Bank	60	46432.254	58616.916	2134.84	989120.753	728519.964
33	Right Bank	83	46596.630	48262.553	2127.44	989226.606	718166.246
34	Left Bank	63	52916.379	54881.464	2128.47	995582.789	724748.447
34	Right Bank	79A	53062.505	47385.625	2129.91	995686.545	717252.922
35	Left Bank	65	56790.569	50587.953	2127.17	999432.134	720433.701
35	Right Bank	79	53464.514	47120.942	2151.8	**996085.758**	**716986.638**
36	Left Bank	68	60623.620	43888.384	2151.73	1003226.753	713713.495
36	Right Bank	77A	53647.029	43840.019	2138.12	996250.949	713704.552
37	Left Bank	69	62181.145	41847.655	2157.73	1004772.512	711664.277

Table 3. - Roosevelt Dam range line bank stations (page 2 of 2).

Range Line	Looking Downstream	Name of Bank Station	FROM 1981 SURVEY LOCAL SYSTEM Drwg. K-653-104.1, 8/81 NORTHING	EASTING	Elevation (feet)	FROM 1995 G.P.S. SURVEY AZ ST PLN COORD. NAD27 CENTRAL ZONE (US feet) NORTHING	EASTING
37	Right Bank	76A	55482.876	41756.386	2134.05	998074.745	711610.864
38	Left Bank	70	62133.710	39703.218	2164.51	**1004712.521**	**709519.188**
38	Right Bank	75C	56951.735	40439.407	2139.48	999535.940	710285.787
39	Left Bank	71B	62627.102	37609.240	2137.81	1005194.456	707423.987
39	Right Bank	75	59367.075	37050.772	2136.56	1001931.769	706884.021
40	Left Bank	71B	62627.102	37609.240	2137.81	1005194.456	707423.987
40	Right Bank	74	60244.568	34873.547	2133.38	1002796.828	704702.170
41	Left Bank	72	63589.040	33613.170		1006133.671	703423.089
41	Right Bank	73	62162.500	32203.820		1004699.386	702022.013
42	Left Bank	72B	67272.880	33516.780	2188.16	1009816.407	703305.902
42	Right Bank	72E	67220.580	30012.350	2167.91	1009744.316	699802.300
43	Left Bank	72J	74830.830	33668.060	2207.02	1017374.063	703414.460
43	Right Bank	72H	73086.250	28940.930	2240.27	1015603.042	698697.904
60	Left Bank	66D	59334.876	47949.102	2145.08	1001961.146	717780.877
60	Right Bank	66C	59129.592	47266.743	2144.15	1001752.038	717099.782
70	Left Bank	45C	36622.358	82915.440	2143.62	979449.624	752870.218
70	Right Bank	45B	63652.027	82024.755	2138.01	1006470.154	751826.962
71	Left Bank	45E	38613.574	82355.559	2137.06	981437.375	752299.172
71	Right Bank	45D	38033.331	80523.783	2185.72	980846.871	750470.953
80	Left Bank	30B	21302.860	107993.620	2183.7	964274.136	778031.136
80	Right Bank	31	19778.980	109790.050	2176.28	962760.636	779835.902

Note: The 1981 local coordinates were converted into Arizona state plane coordinates, NAD27 Central Zone.
The bold coordinates from the 1995 GPS survey were used to correlate the state plane coordinates to the local coordinates.



LEGEND

Reservoir Elevation 2087.0 and Salt River/Tonto Creek outlines

⑫ Location of Historic Range Lines

Top of modified Theodore Roosevelt Dam, elevation 2218.0

NOTES

Topography above elevation 2087.0 was collected from aerial photography flown on October 28, 1994 at an elevation of 8000 feet AMT. The original map scale was 1"=200' with a 5 foot contour interval.
Topography below elevation 2087.0 was created using Triangulated Irregular Network (TIN) software from underwater soundings taken in April 1995. Approximately 70,500 sounding points were collected.
All contours have been filtered to a best scale of 1"=1000' for the purposes of this map.
Coordinates are based on the Arizona State Plane Coordinate System, Central Zone, NAD27 and NGVD29.

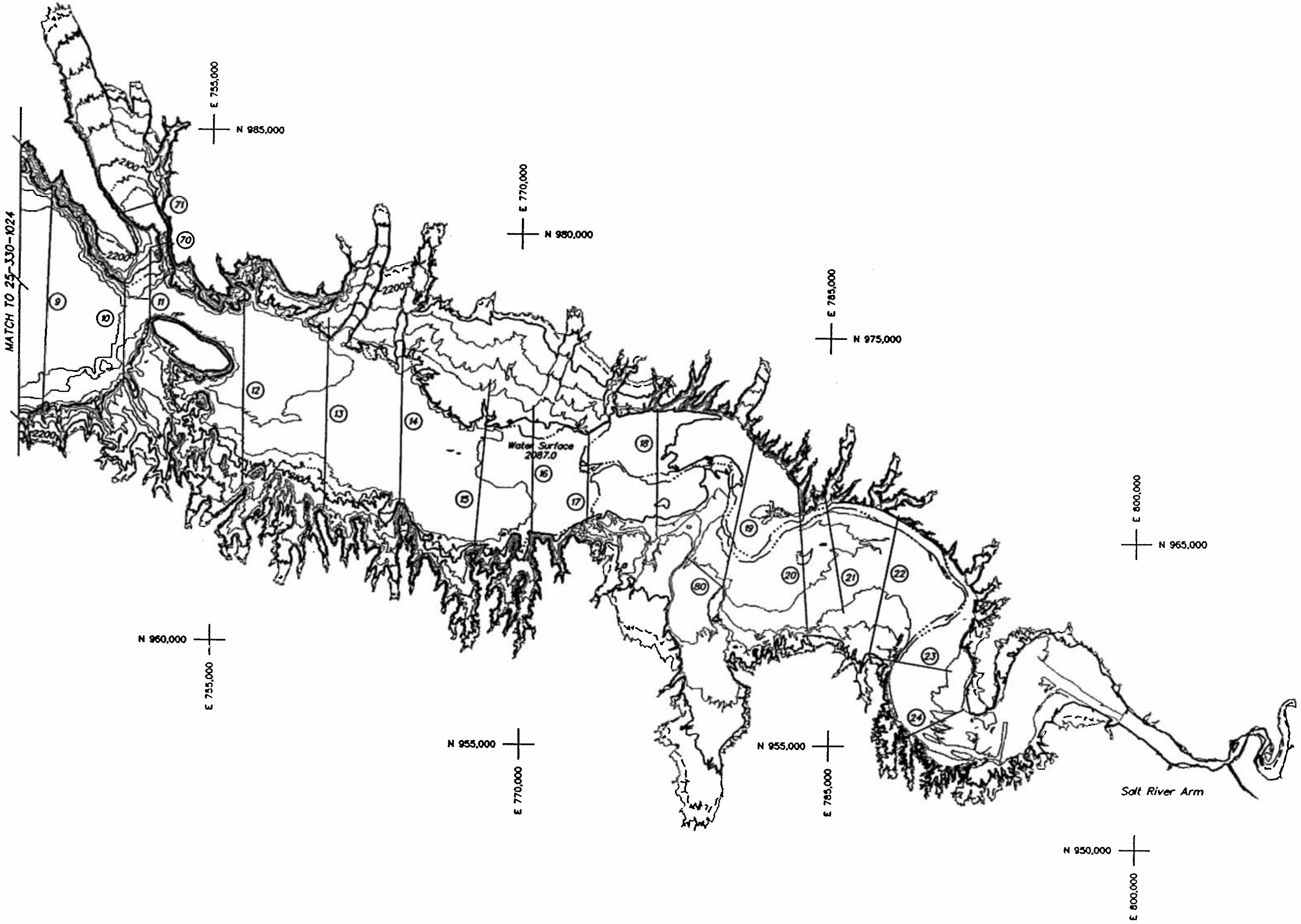
ALWAYS THINK SAFETY

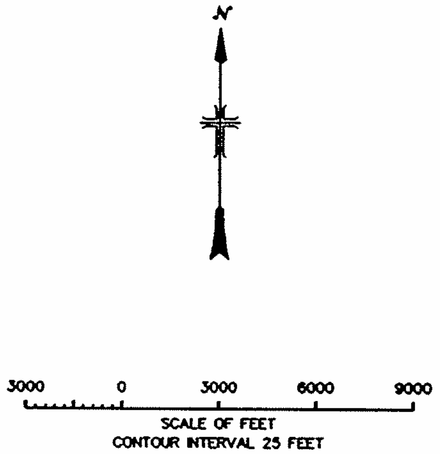
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
SALT RIVER PROJECT – ARIZONA
SAFETY OF DAMS – MODIFICATION
THEODORE ROOSEVELT LAKE
TOPOGRAPHY
1995 AREA RESERVOIR CAPACITY MAPPING

DESIGNED RICK NAVRATIL FIELD APPROVAL
DRAWN RICK NAVRATIL TECHNICAL APPROVAL
CHECKED APPROVED

CADD SYSTEM CALMA RELEASE 9.0
DATE AND TIME PLOTTED: MAY 29, 1996
PHOENIX, ARIZONA SHEET 1 OF 2 MAY 14, 1996
25-330-1024

Figure 1a. - Theodore Roosevelt Reservoir topography and location map (sheet 1 of 2).





LEGEND

—— ··· ——	Reservoir Elevation 2087.0 and Salt River/Tonto Creek outlines
⑫ ——	Location of Historic Range Lines
– – – – – –	Top of modified Theodore Roosevelt Dam, elevation 2218.0

NOTES

Topography above elevation 2087.0 was collected from aerial photography flown on October 28, 1994 at an elevation of 8000 feet AMT. The original map scale was 1"=200' with a 5 foot contour interval.

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SAFETY OF DAMS – MODIFICATION

THEODORE ROOSEVELT LAKE
TOPOGRAPHY
1995 AREA RESERVOIR CAPACITY MAPPING

DESIGNED RICK NAVRATIL FIELD APPROVAL
DRAWN RICK NAVRATIL TECHNICAL APPROVAL
CHECKED APPROVED

CADD SYSTEM CALMA RELEASE 9.0	ROOS 25 1000M259 DRAWING: TR1025	DATE AND TIME PLOTTED: MAY 29, 1996 08:15
PHOENIX, ARIZONA SHEET 2 OF 2	MAY 14, 1996	25-330-1025

RNAVRATIL

Figure 1b. - Theodore Roosevelt Reservoir topography and location map (sheet 2 of 2).

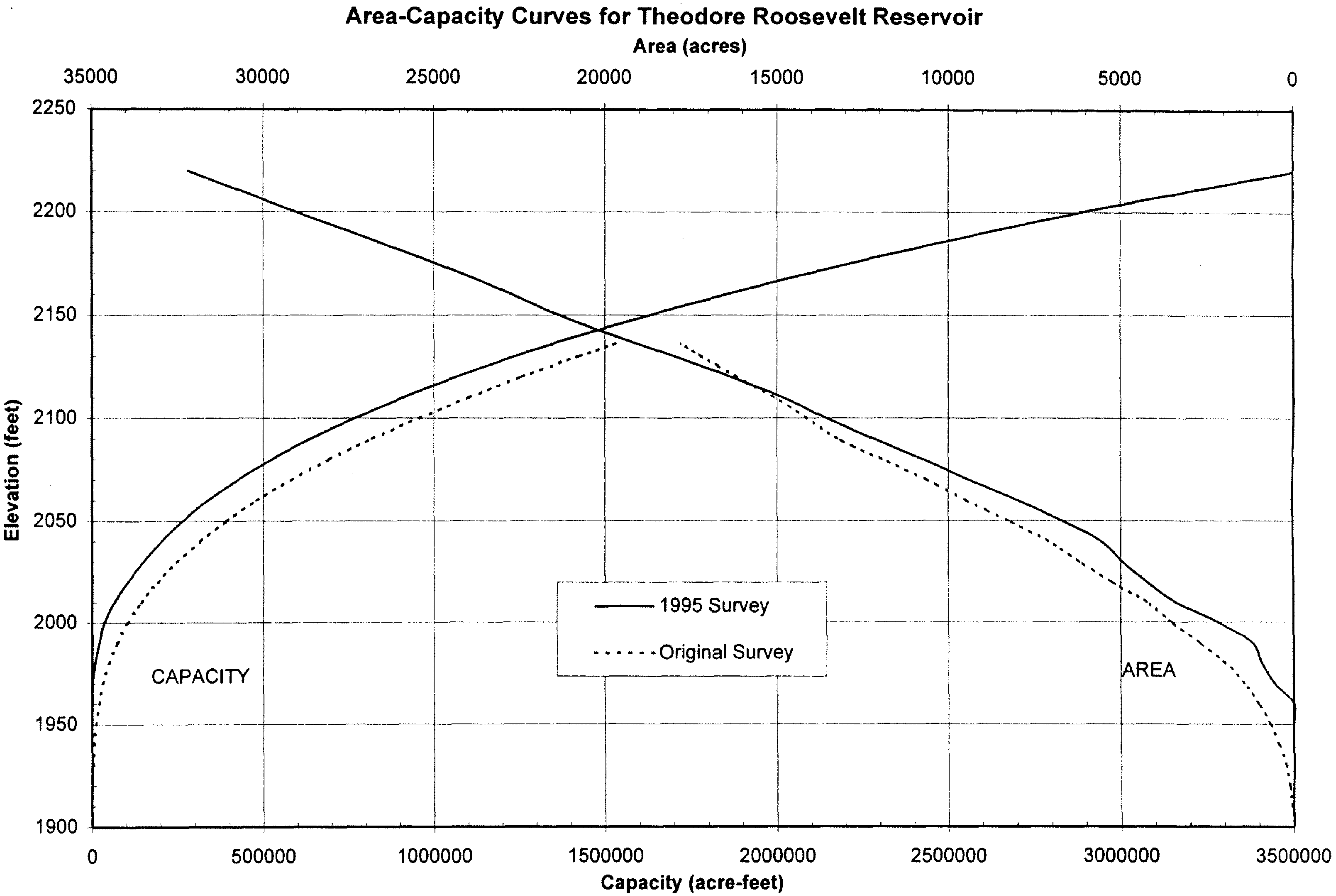
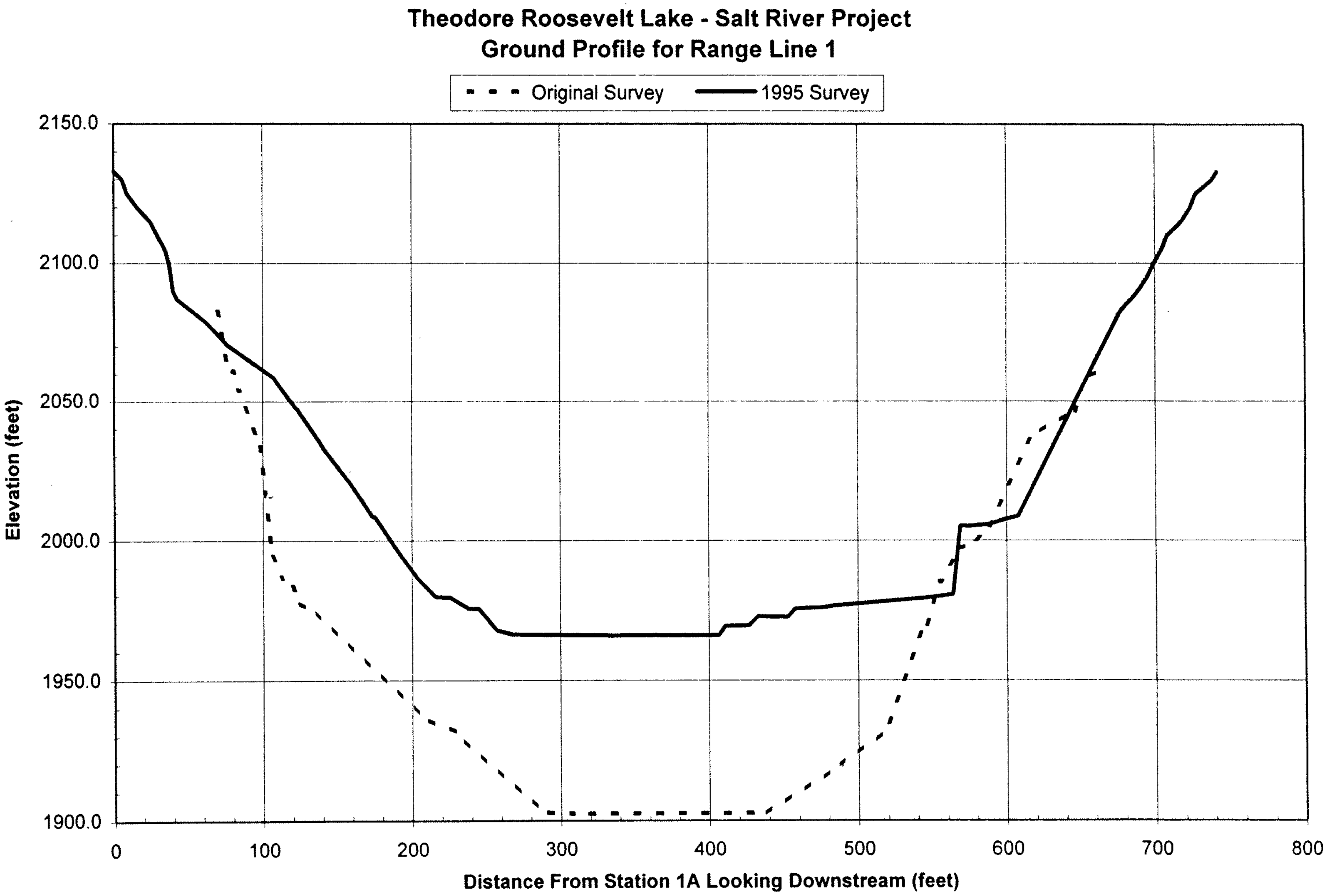


Figure 2. - 1995 area and capacity curves for Theodore Roosevelt Reservoir.



Theodore Roosevelt Lake - Salt River Project
Ground Profile for Range Line 1

Figure 3. - Theodore Roosevelt Reservoir ground profile for range line 1.

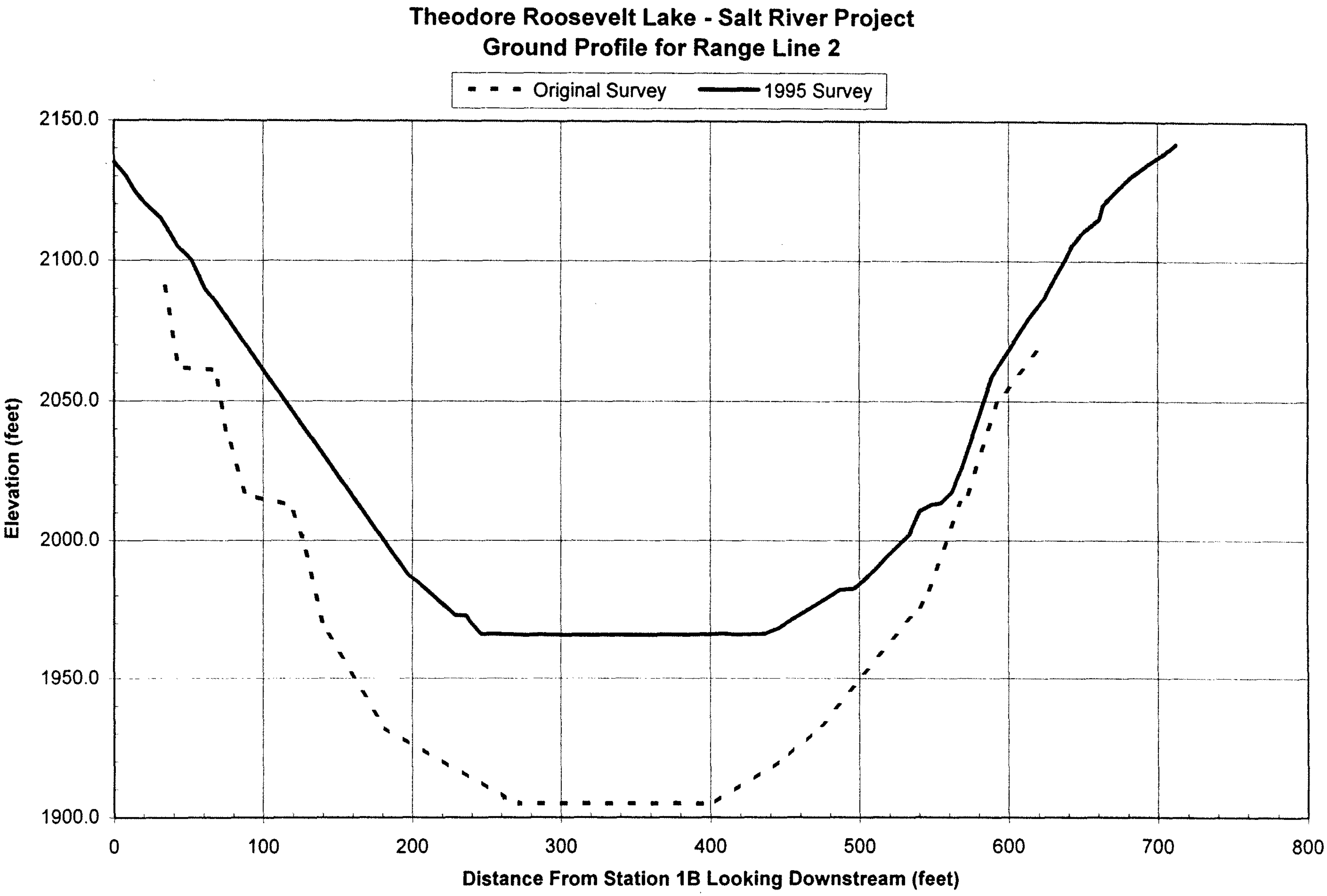


Figure 4. - Theodore Roosevelt Reservoir ground profile for range line 2.

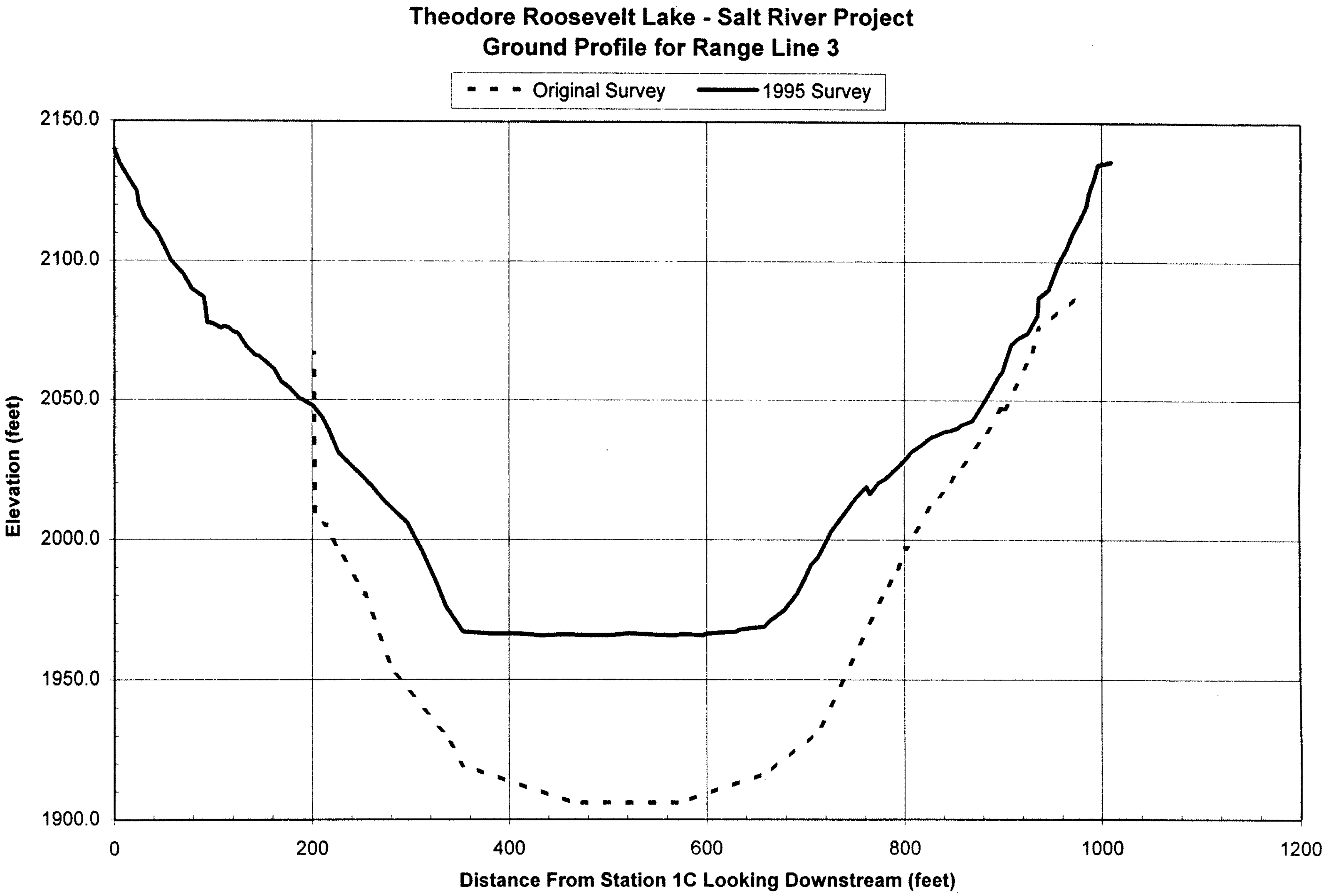


Figure 5. - Theodore Roosevelt Reservoir ground profile for range line 3.

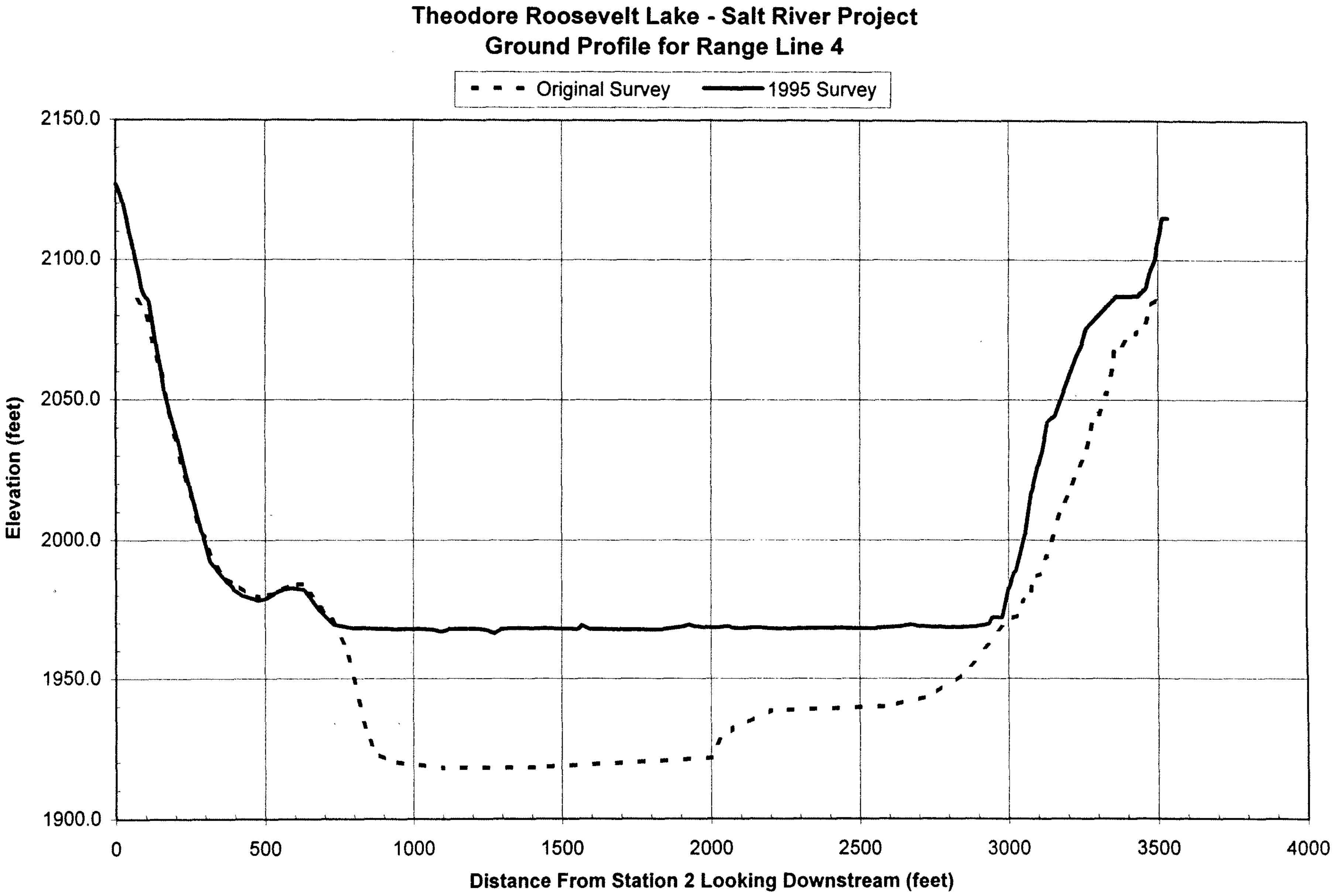


Figure 6. - Theodore Roosevelt Reservoir ground profile for range line 4.

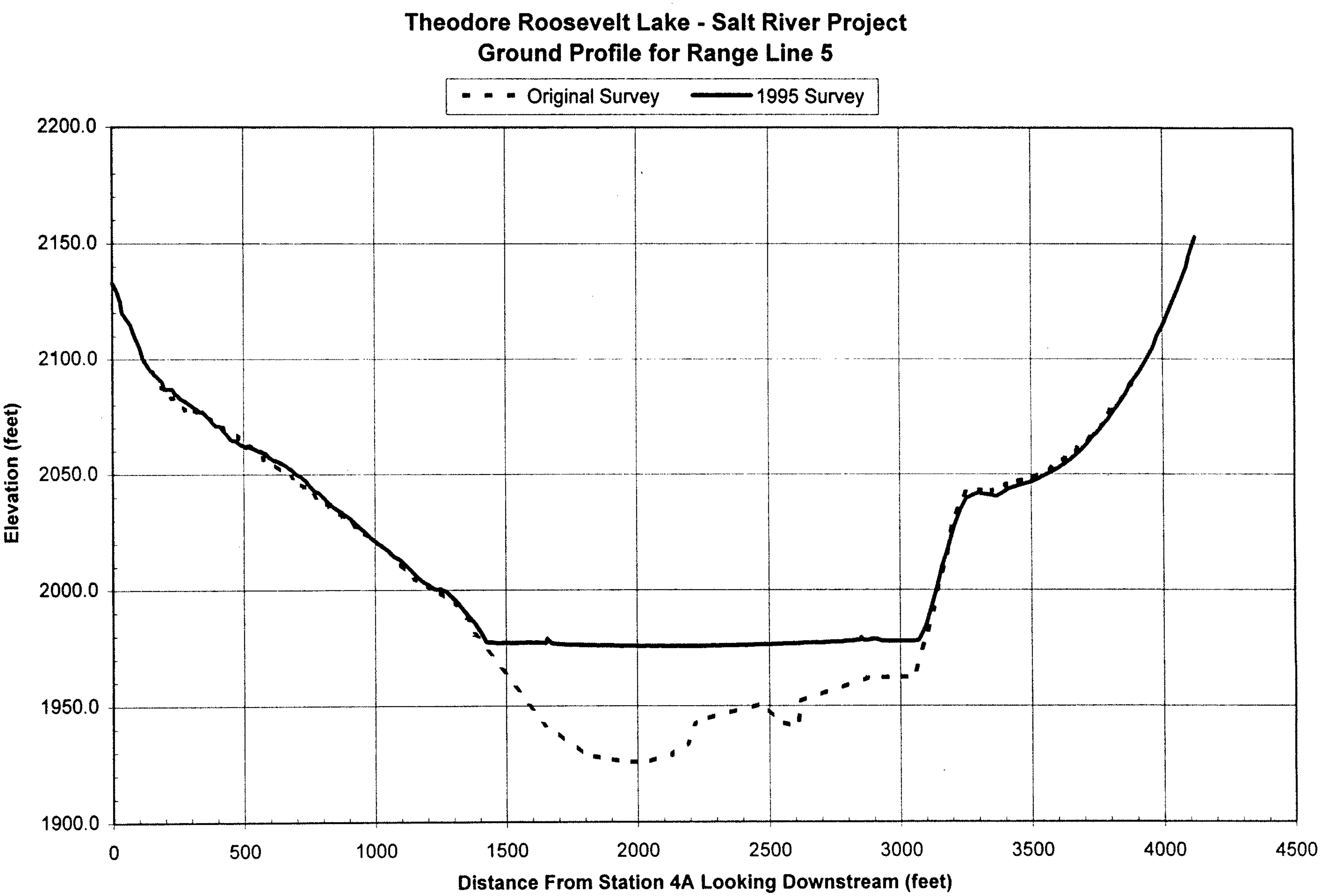


Figure 7. - Theodore Roosevelt Reservoir ground profile for range line 5.

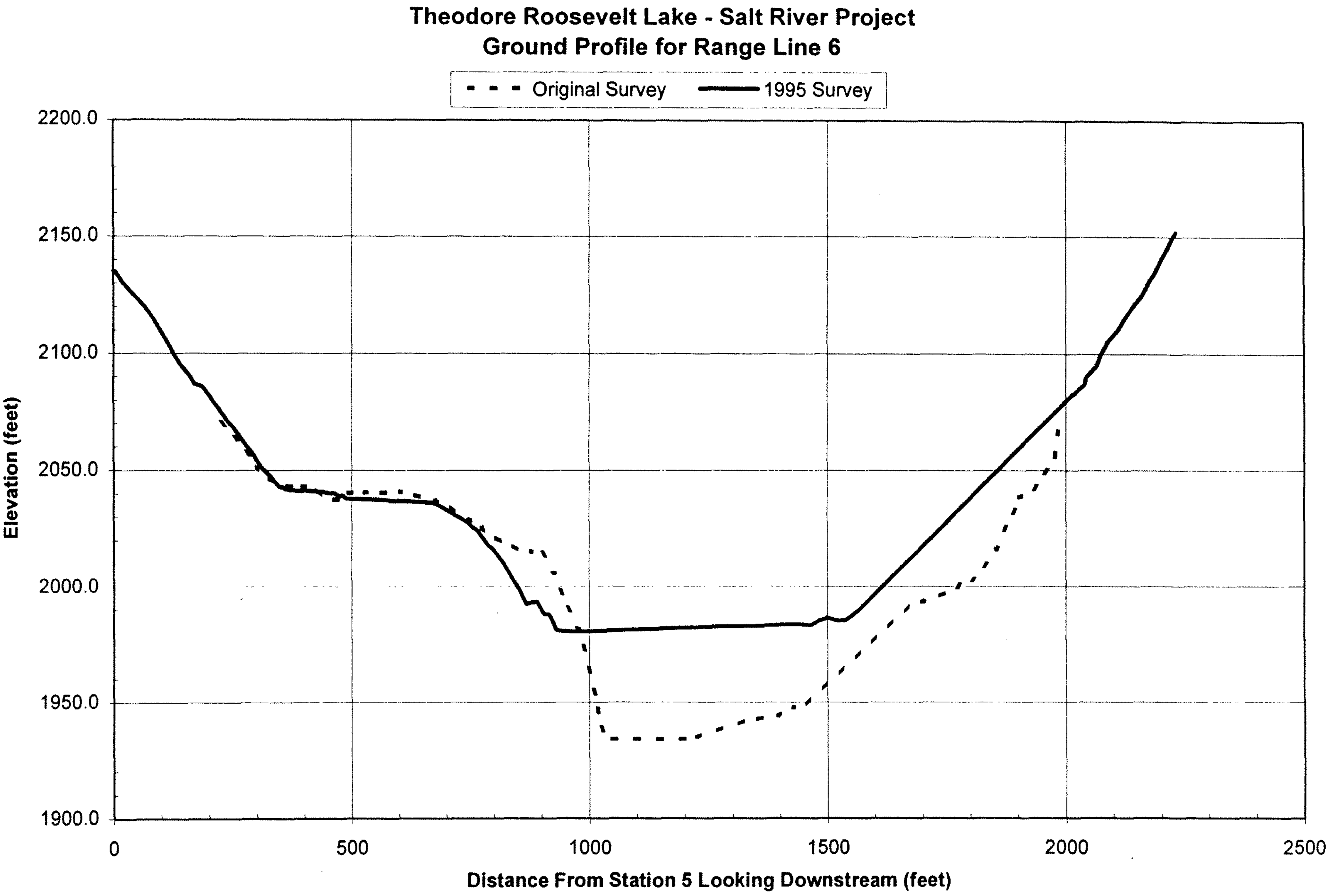


Figure 8. - Theodore Roosevelt Reservoir ground profile for range line 6.

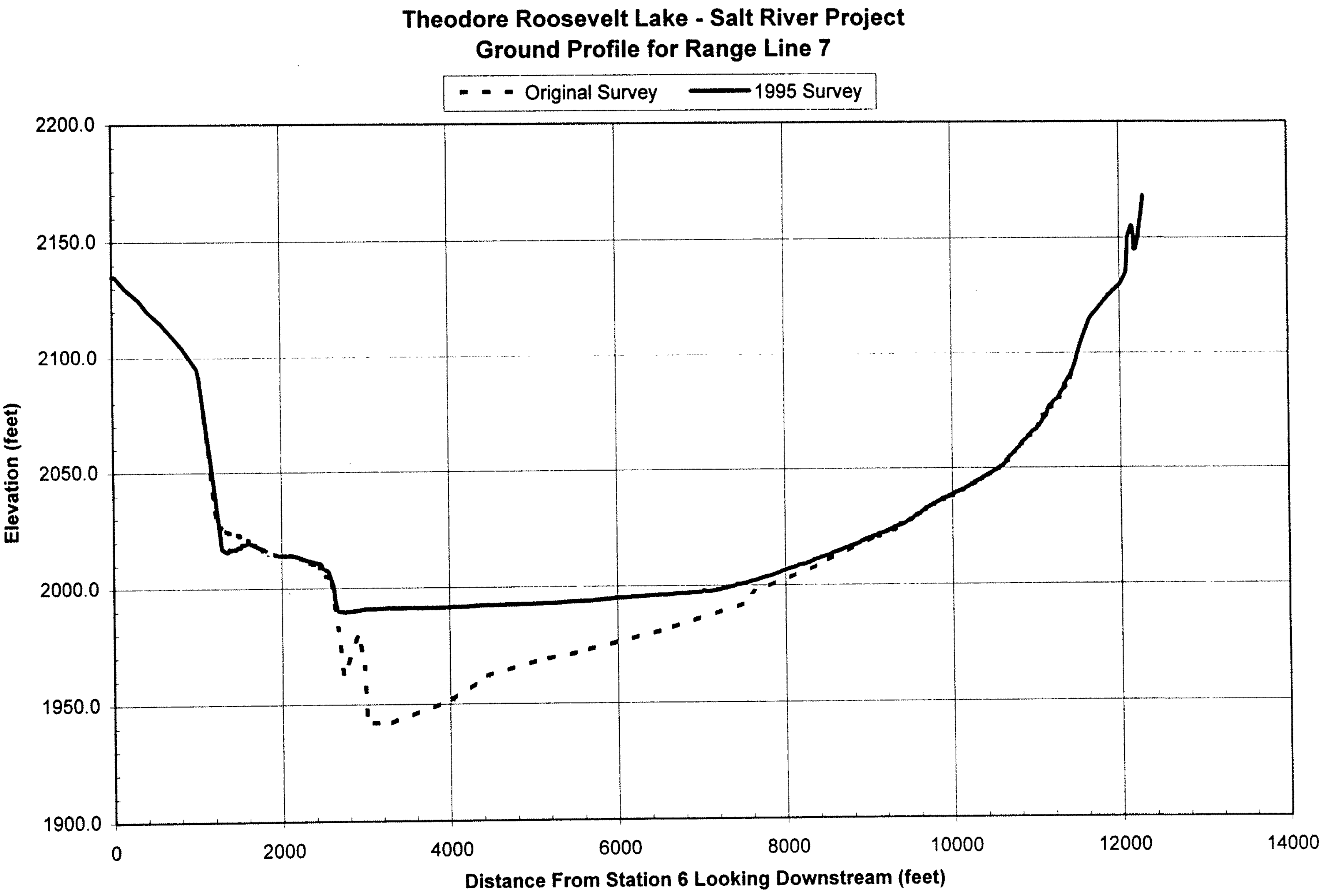


Figure 9. - Theodore Roosevelt Reservoir ground profile for range line 7.

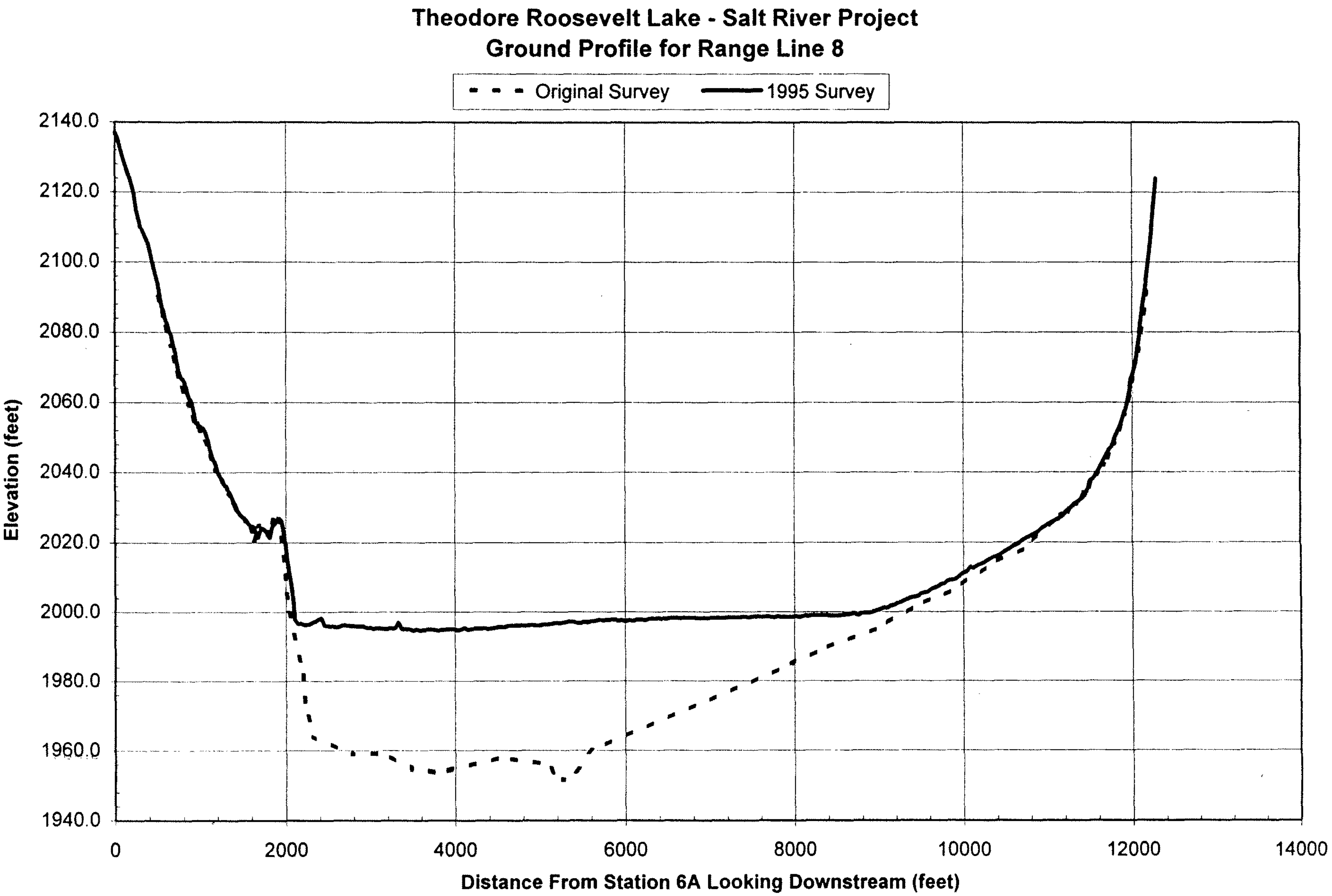


Figure 10. - Theodore Roosevelt Reservoir ground profile for range line 8.

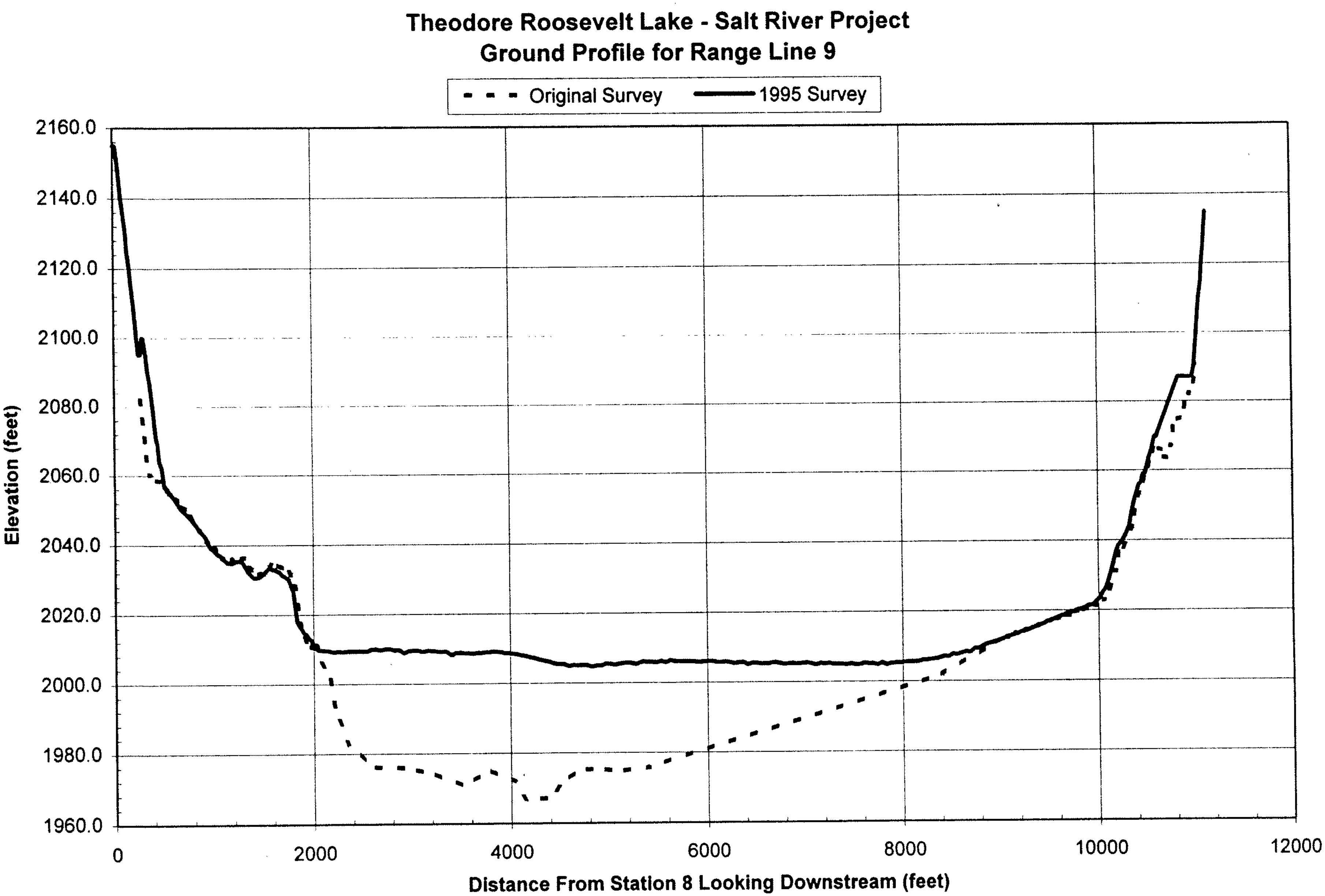


Figure 11. - Theodore Roosevelt Reservoir ground profile for range line 9.

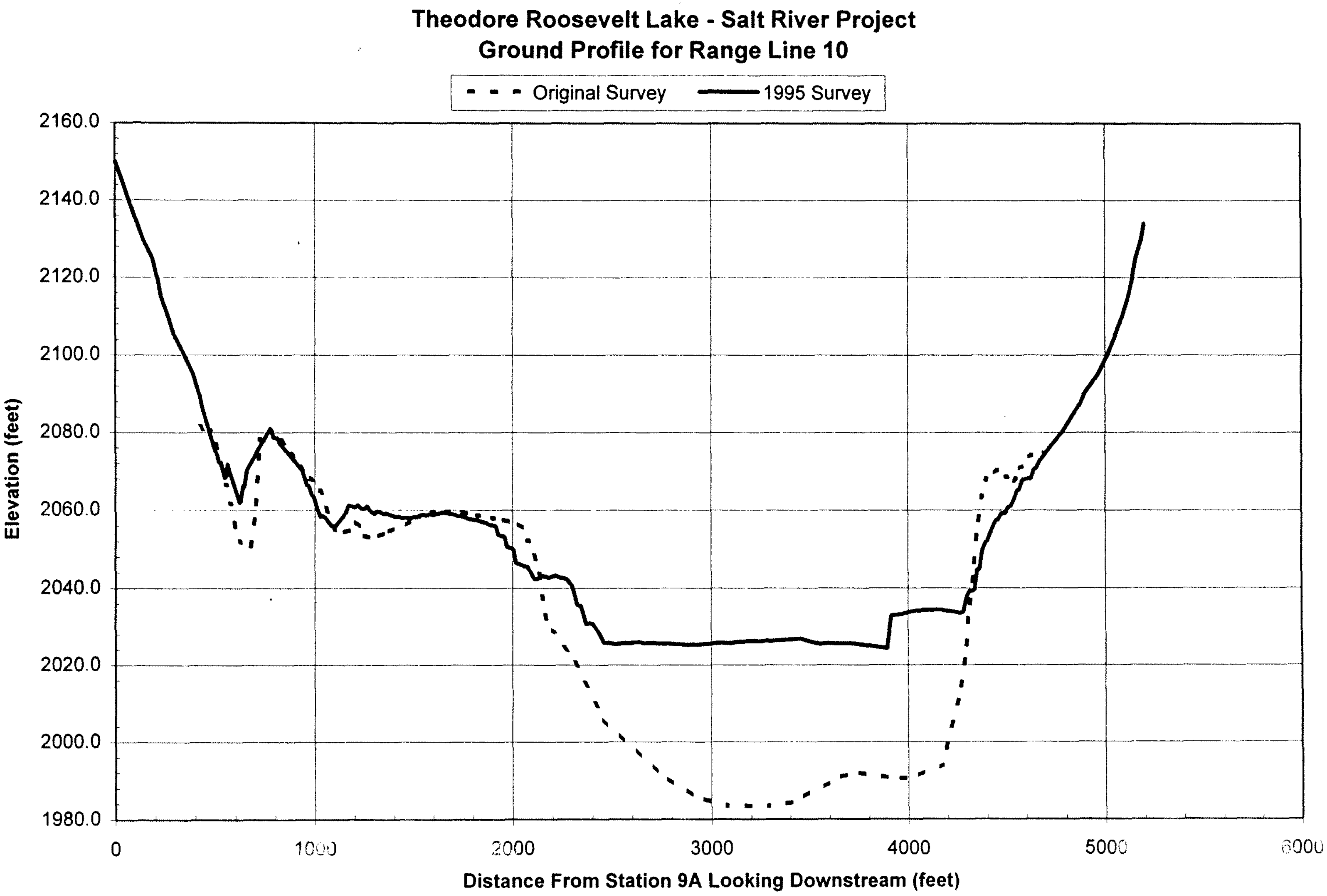


Figure 12. - Theodore Roosevelt Reservoir ground profile for range line 10.

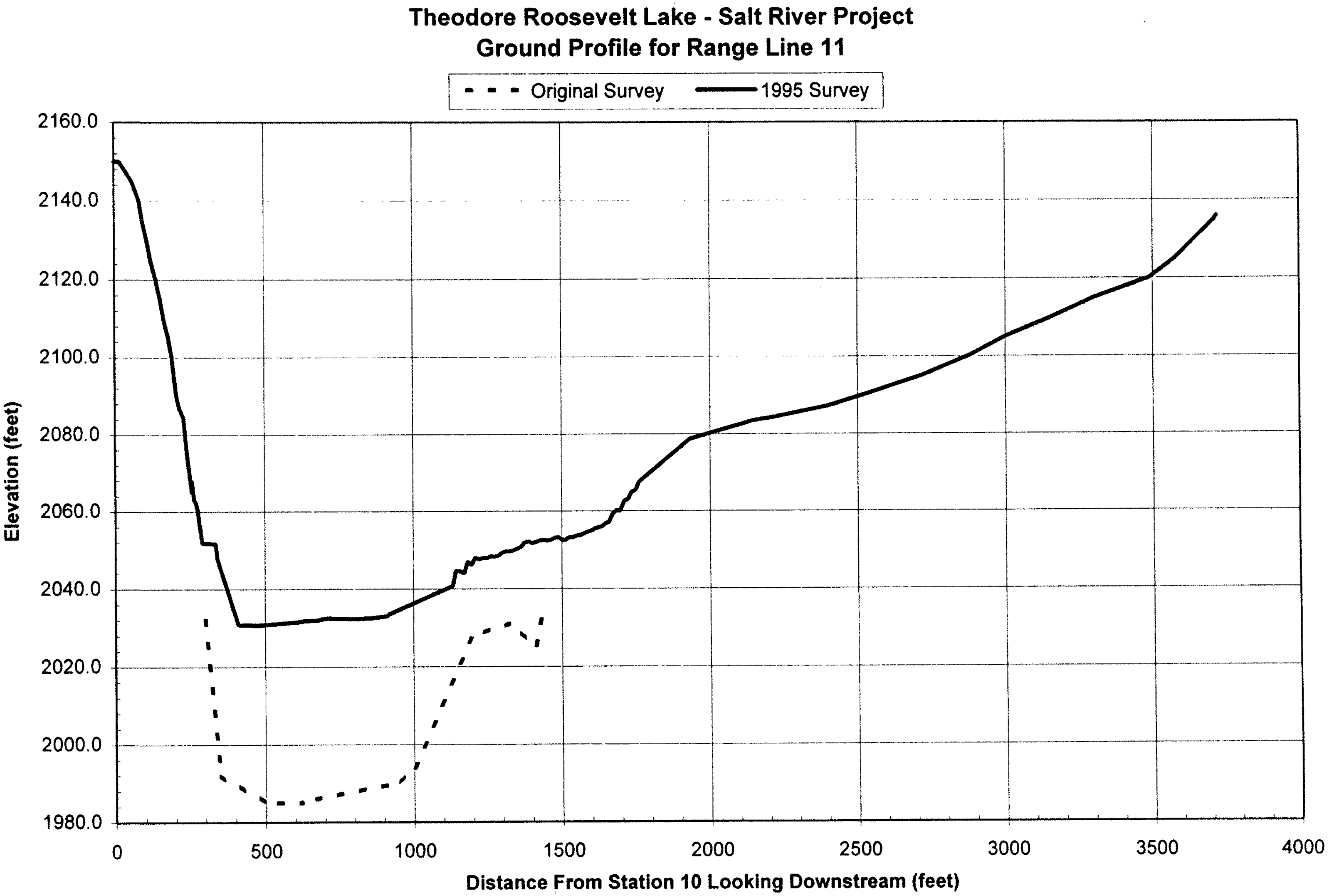


Figure 13. - Theodore Roosevelt Reservoir ground profile for range line 11.

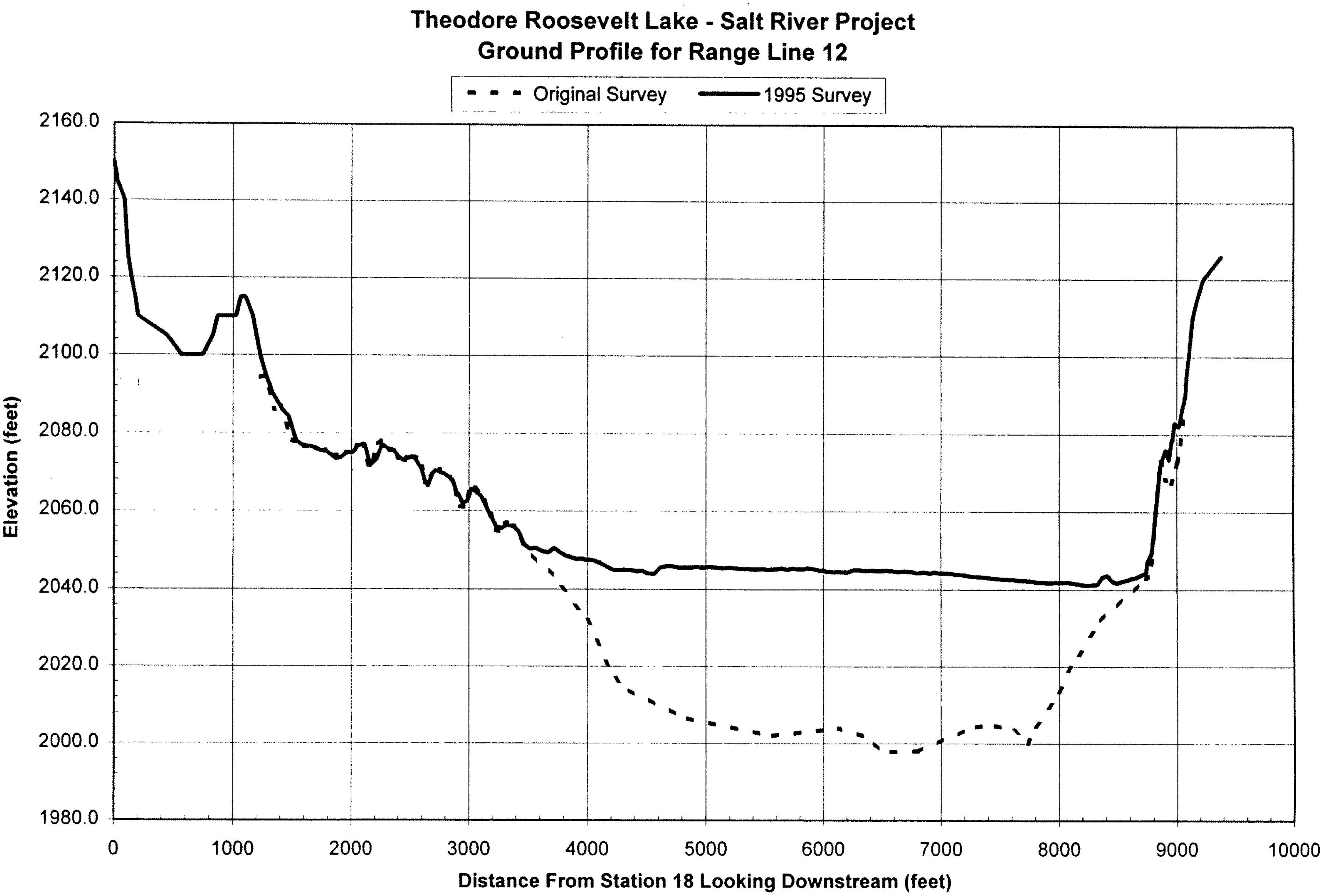


Figure 14. - Theodore Roosevelt Reservoir ground profile for range line 12.

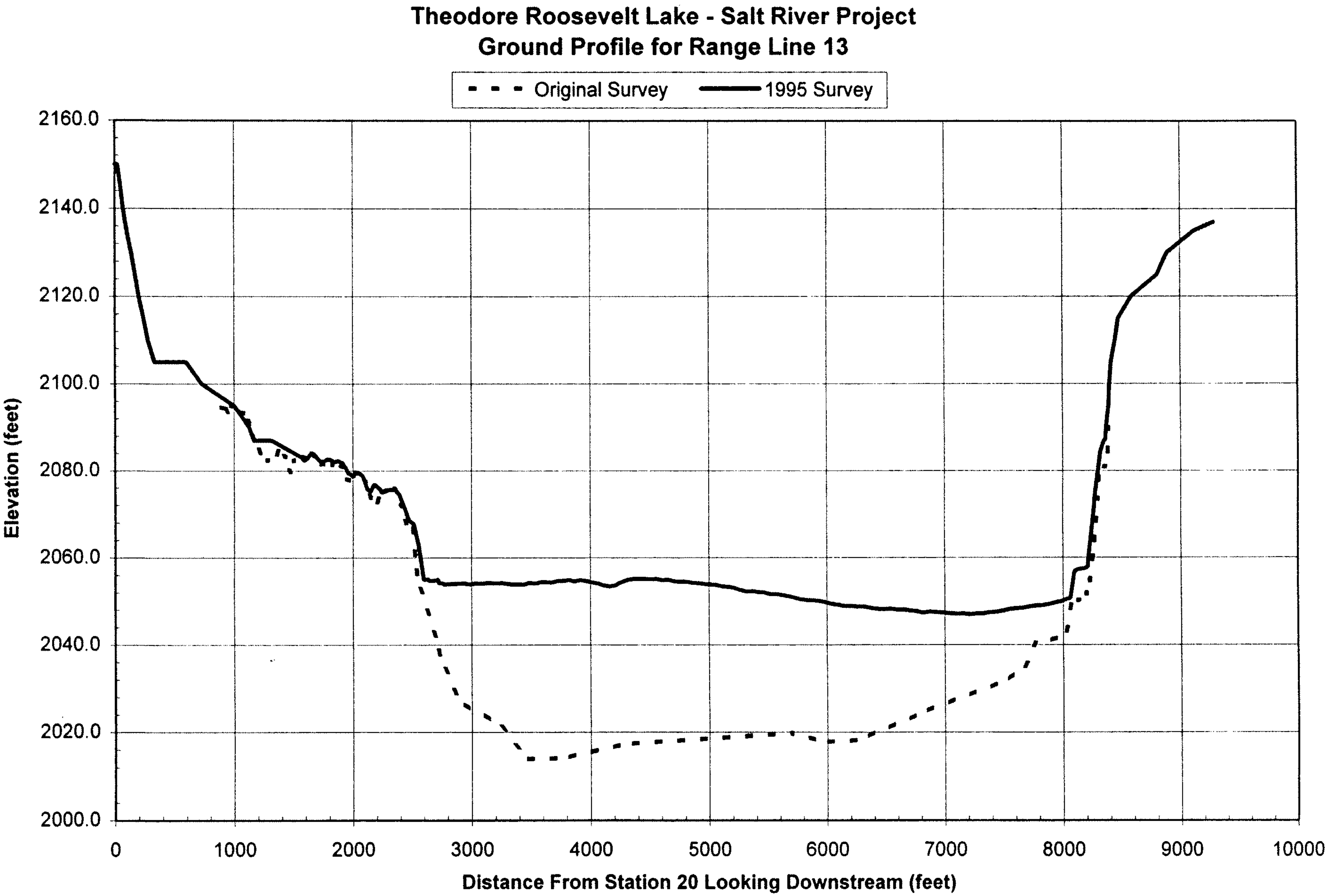


Figure 15. - Theodore Roosevelt Reservoir ground profile for range line 13.

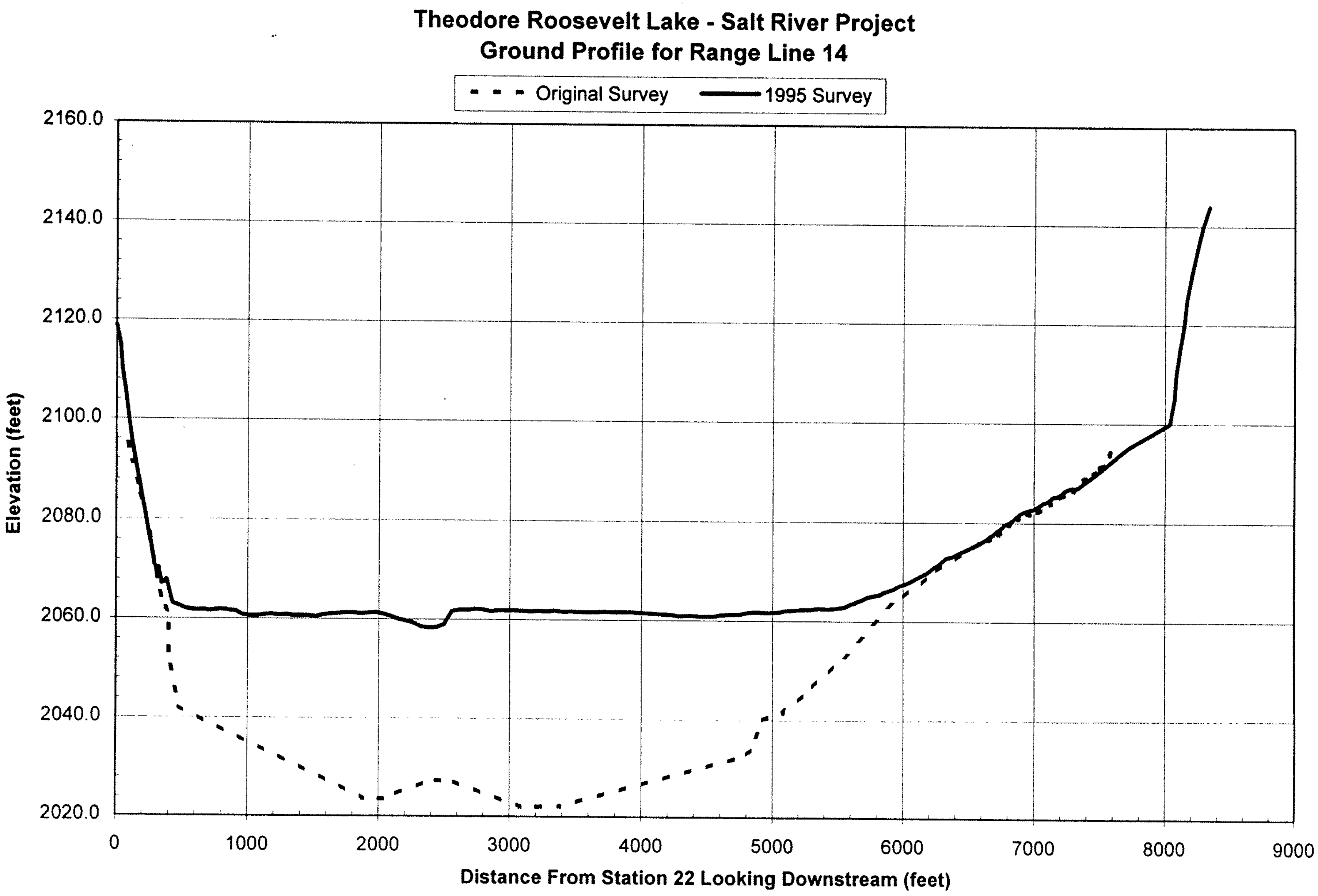


Figure 16. - Theodore Roosevelt Reservoir ground profile for range line 14.

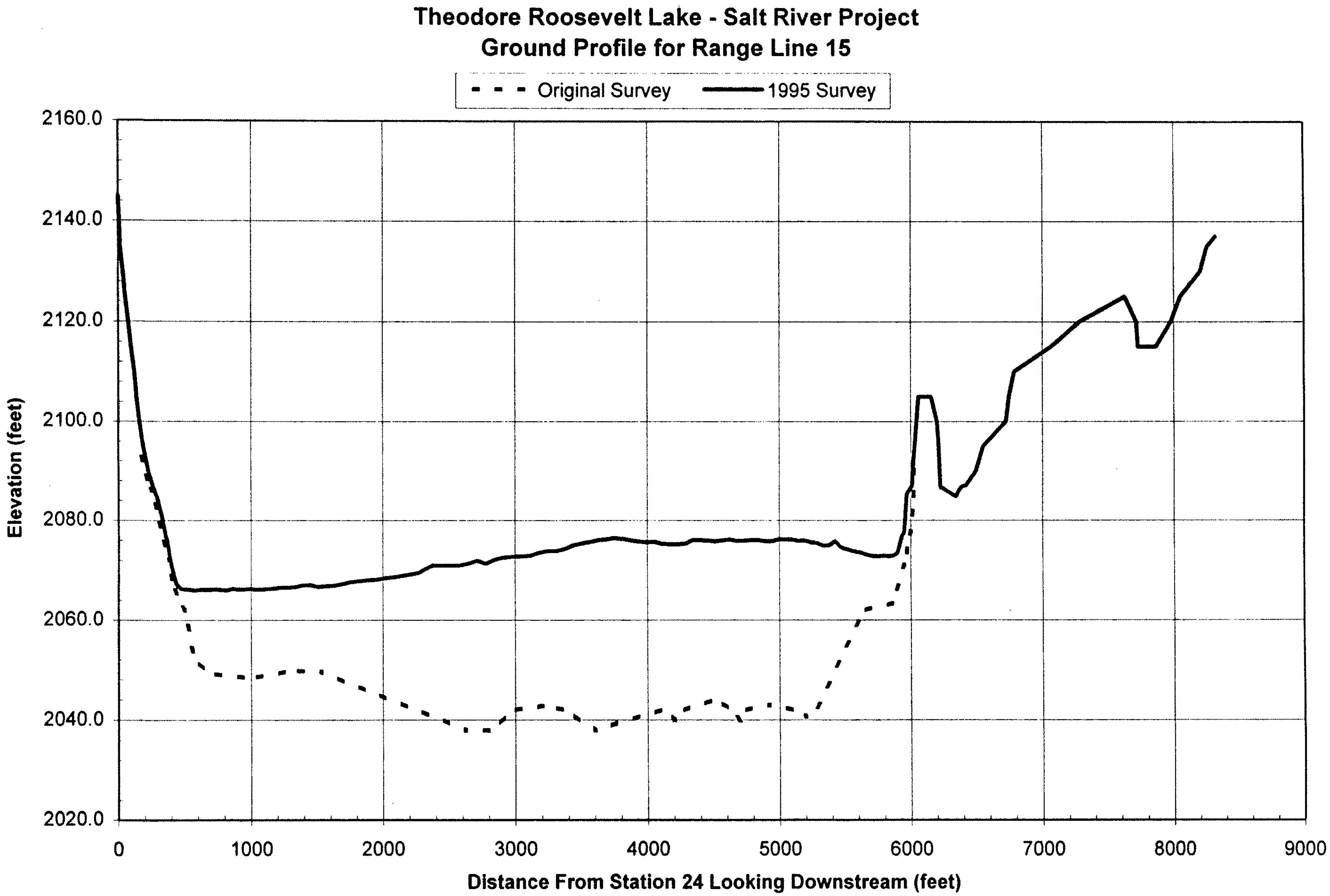


Figure 17. - Theodore Roosevelt Reservoir ground profile for range line 15.

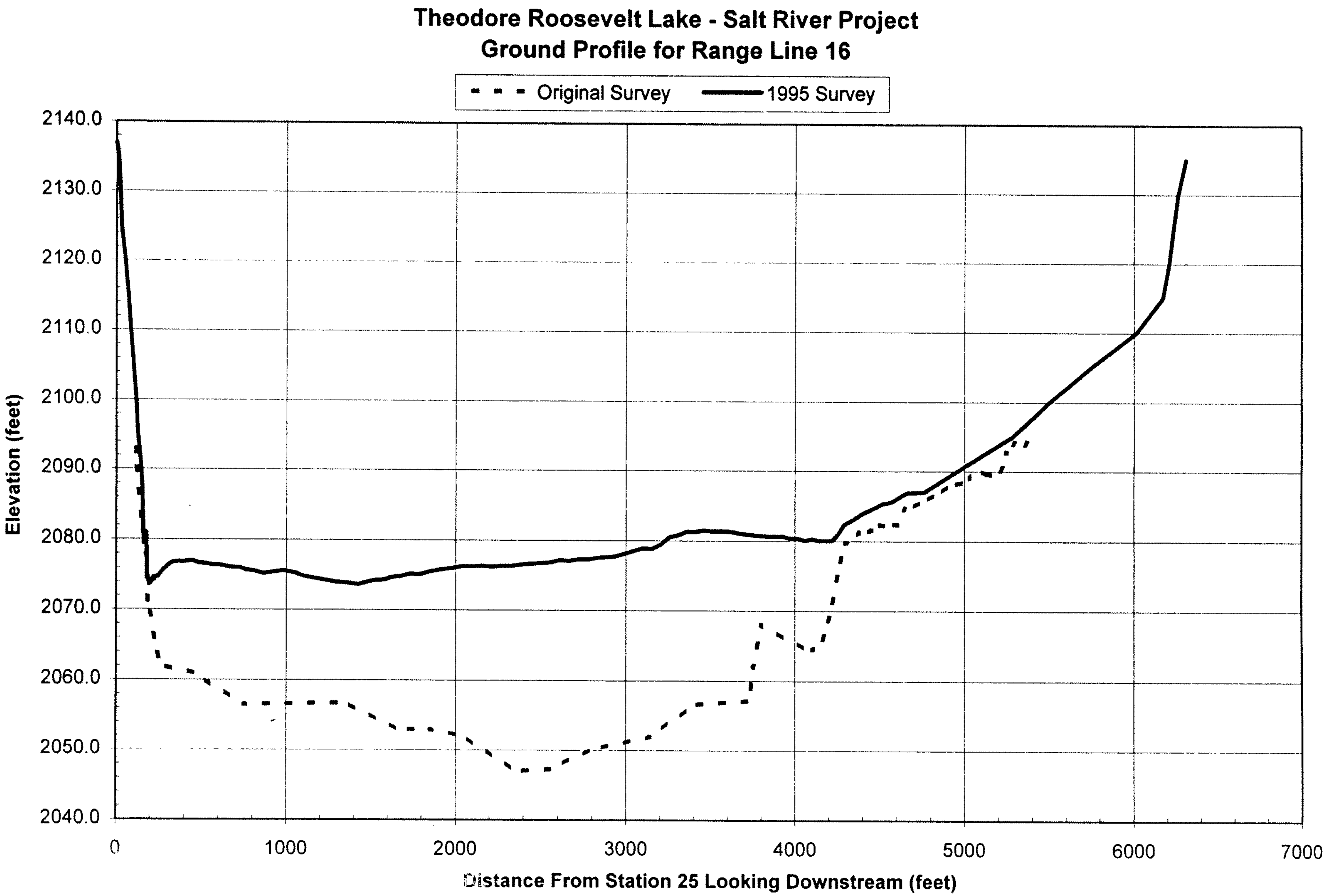


Figure 18. - Theodore Roosevelt Reservoir ground profile for range line 16.

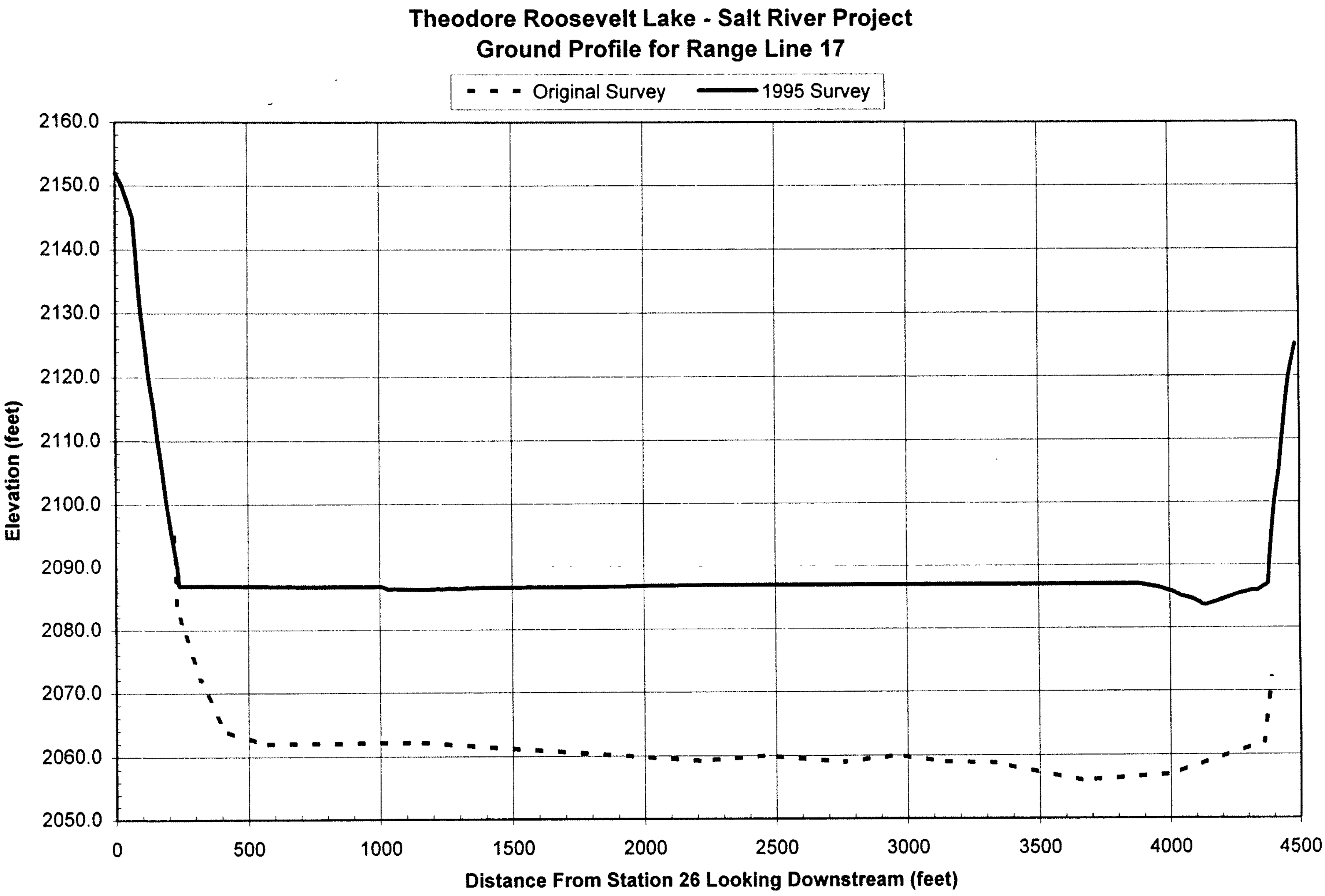


Figure 19. - Theodore Roosevelt Reservoir ground profile for range line 17.

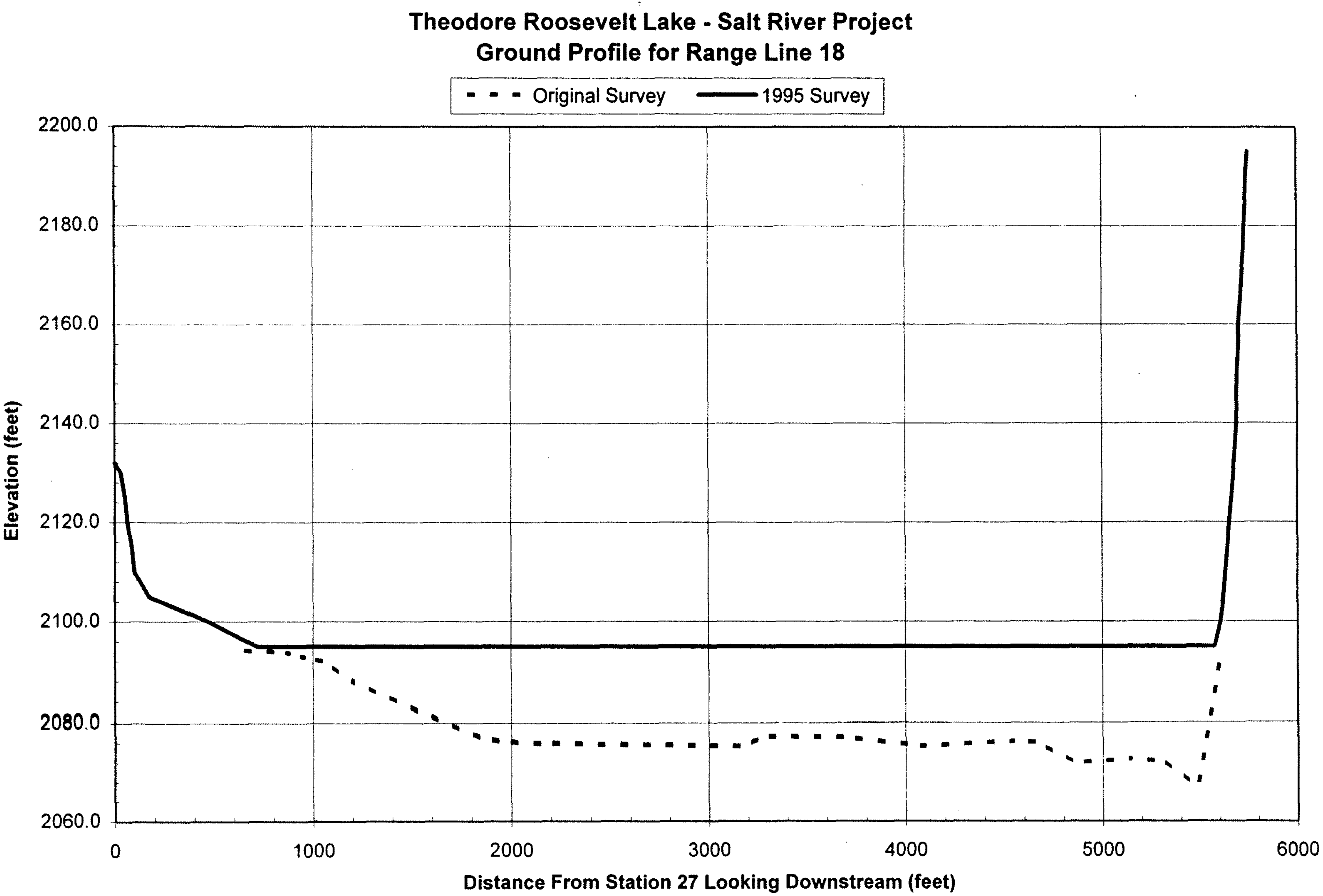


Figure 20. - Theodore Roosevelt Reservoir ground profile for range line 18.

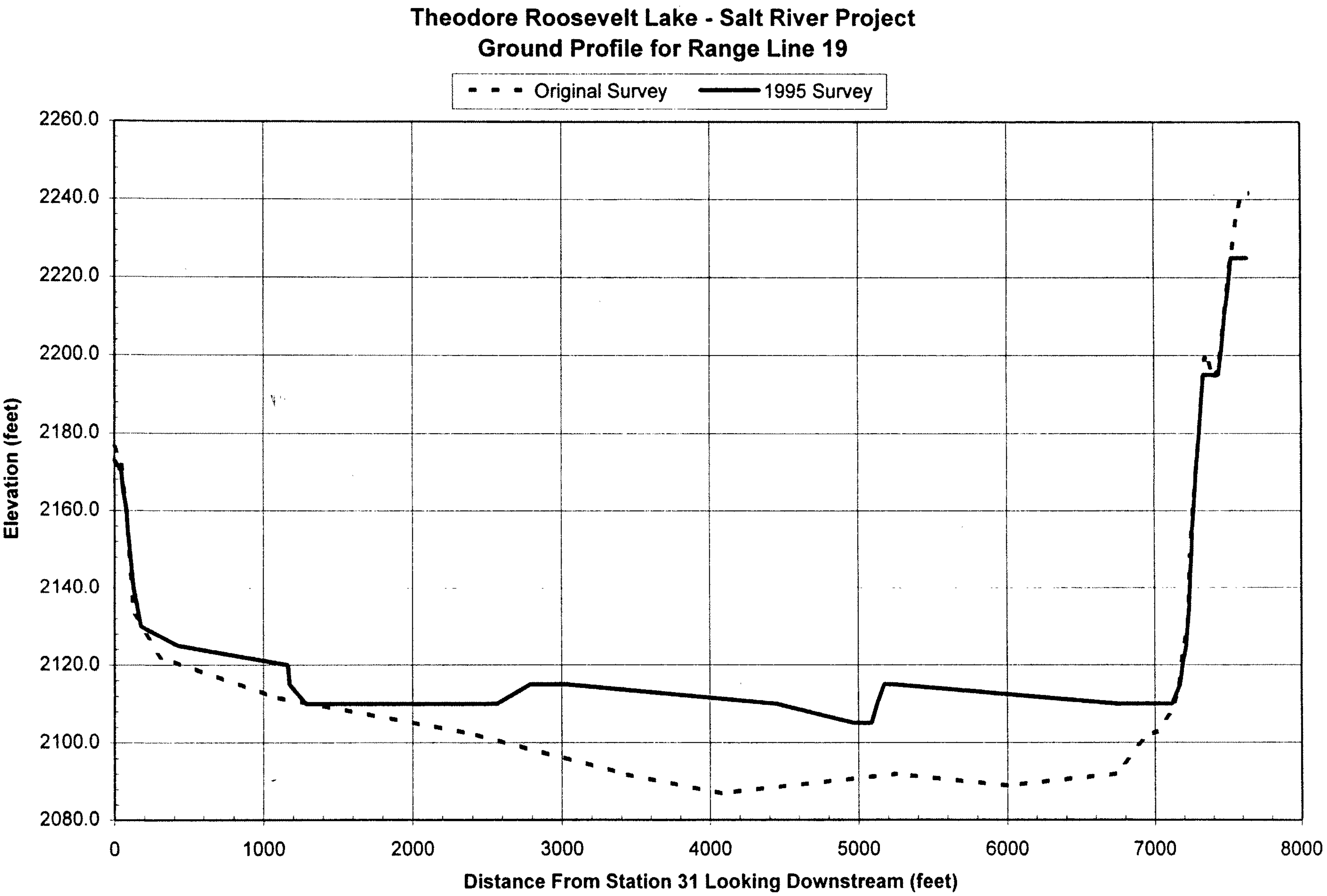


Figure 21. - Theodore Roosevelt Reservoir ground profile for range line 19.

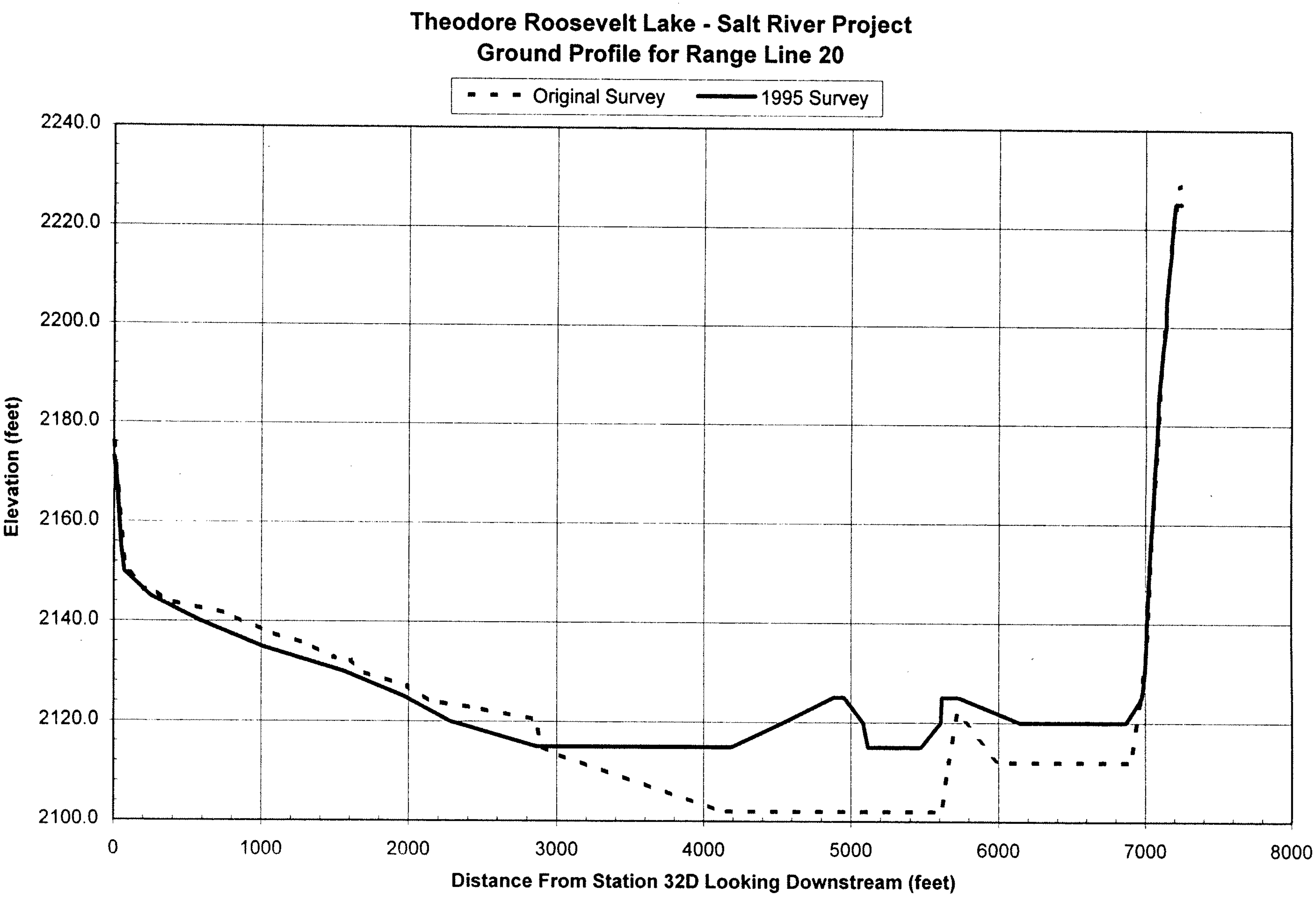


Figure 22. - Theodore Roosevelt Reservoir ground profile for range line 20.

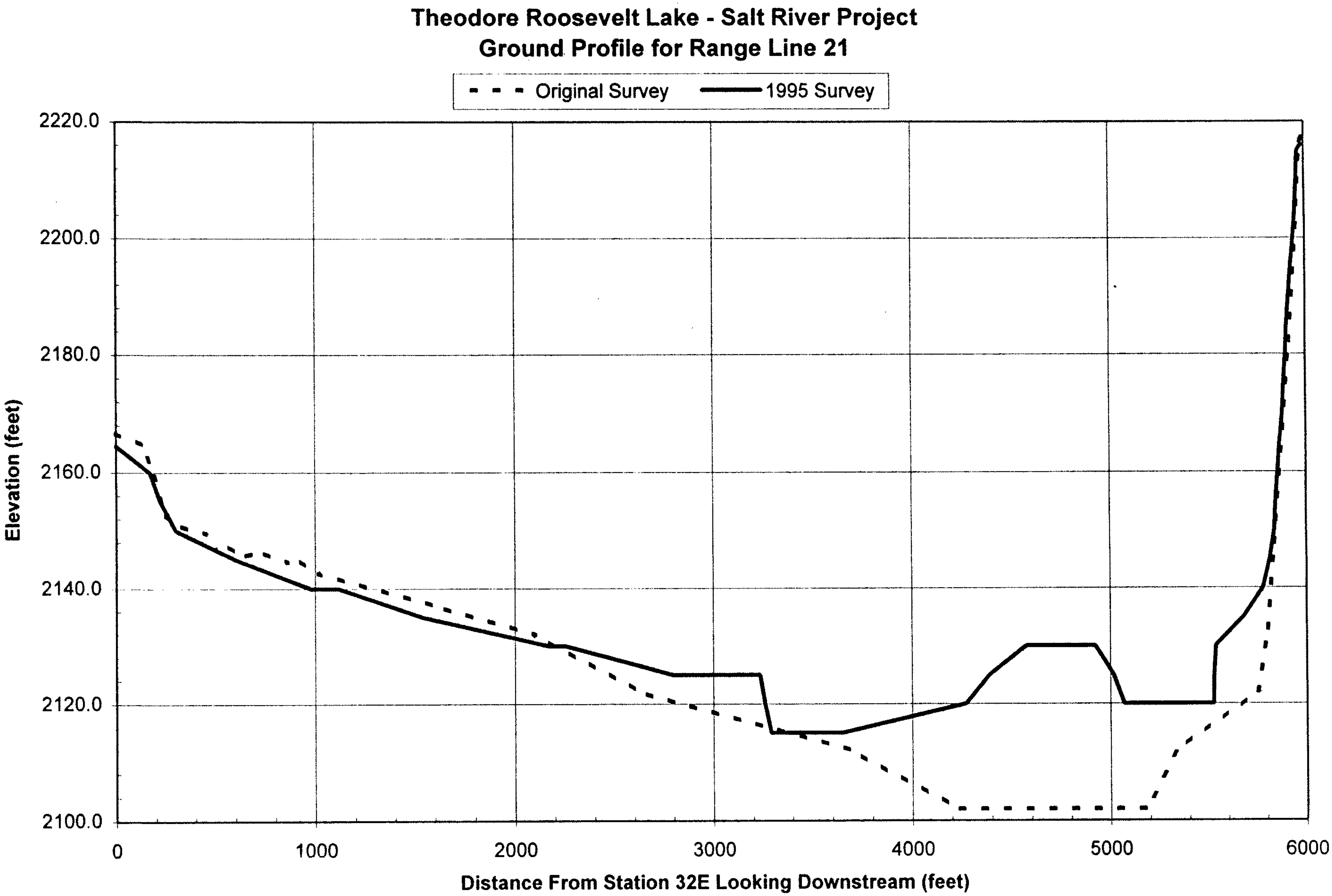


Figure 23. - Theodore Roosevelt Reservoir ground profile for range line 21.

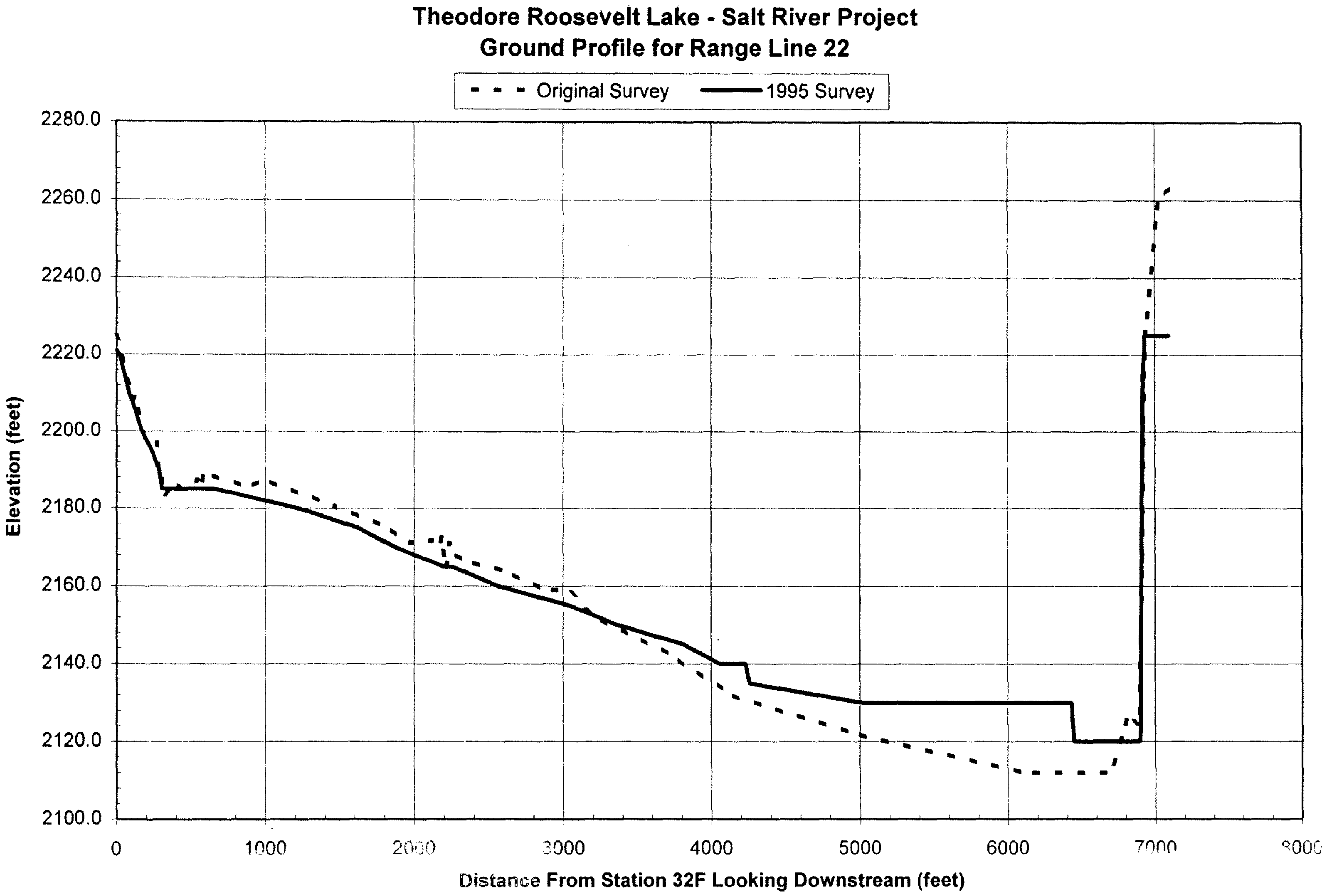


Figure 24. - Theodore Roosevelt Reservoir ground profile for range line 22.

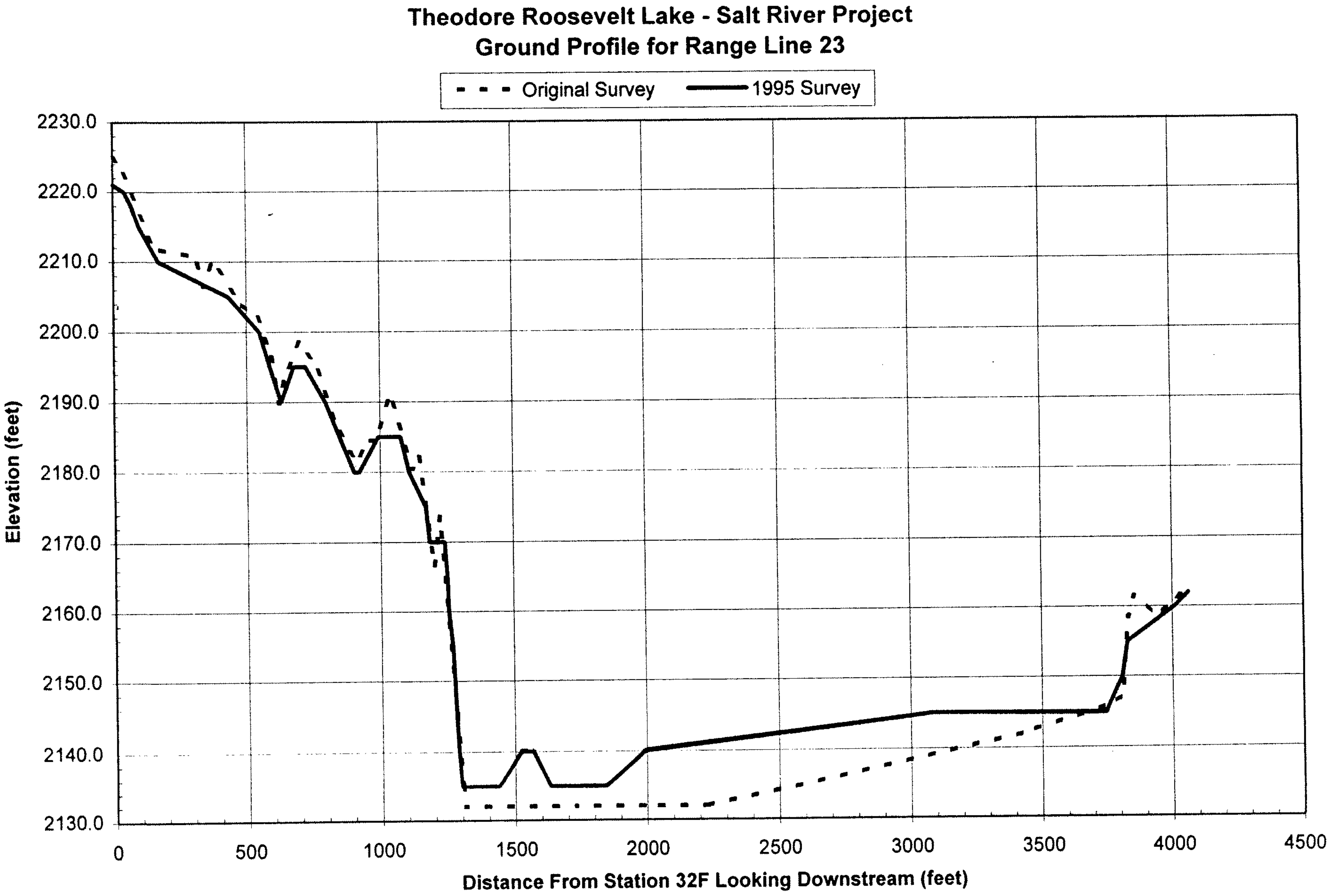


Figure 25. - Theodore Roosevelt Reservoir ground profile for range line 23.

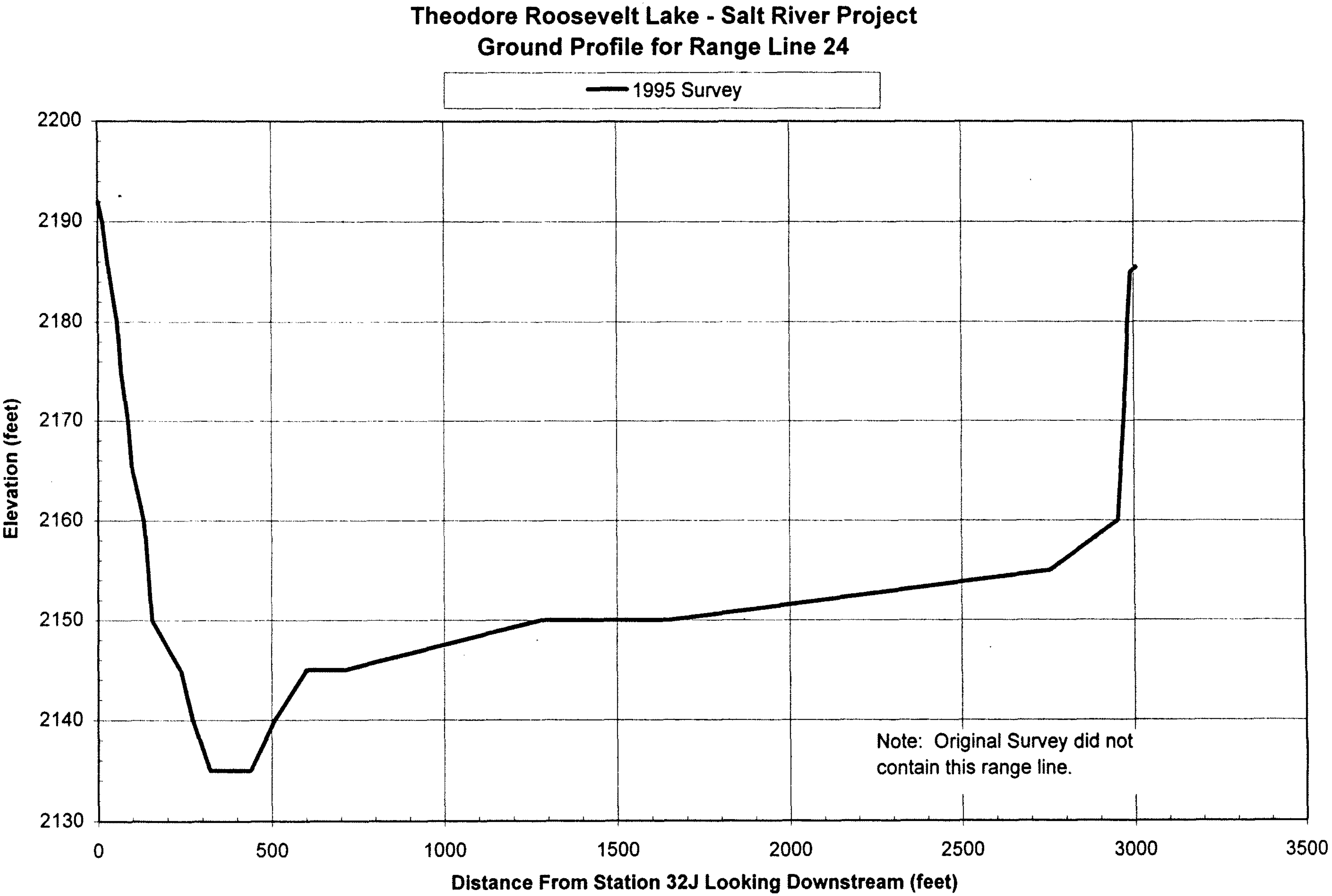


Figure 26. - Theodore Roosevelt Reservoir ground profile for range line 24.

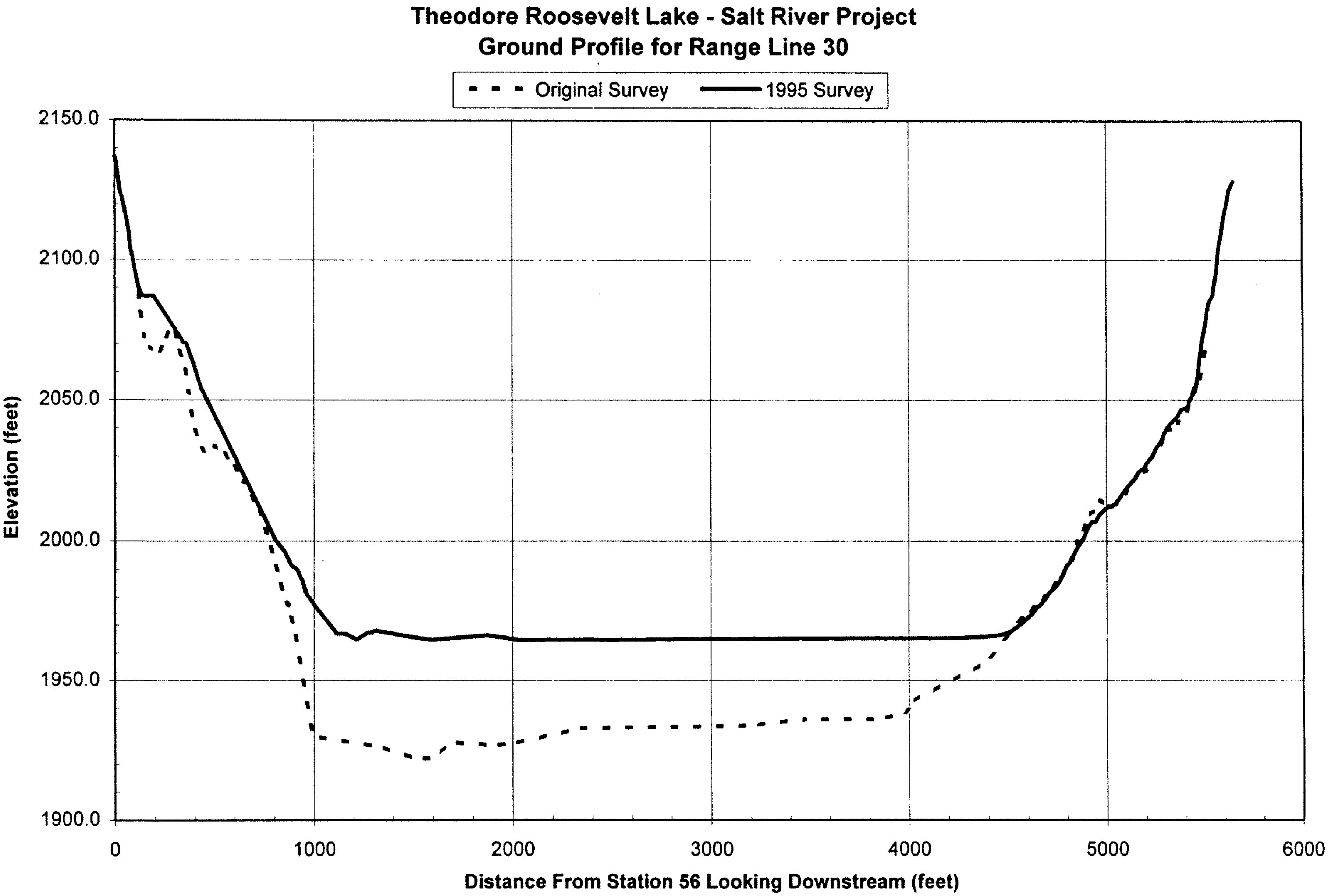


Figure 27. - Theodore Roosevelt Reservoir ground profile for range line 30.

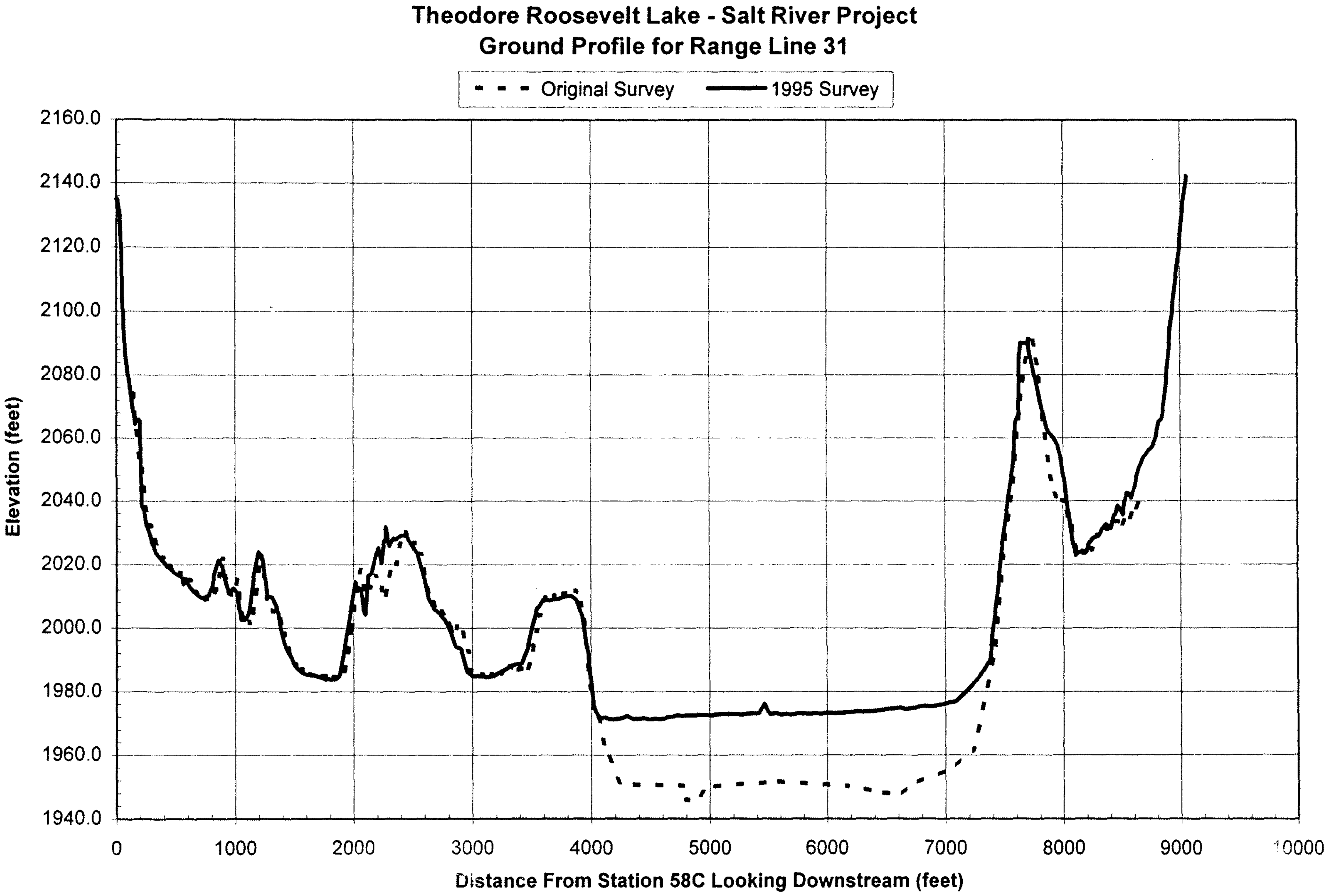


Figure 28. - Theodore Roosevelt Reservoir ground profile for range line 31.

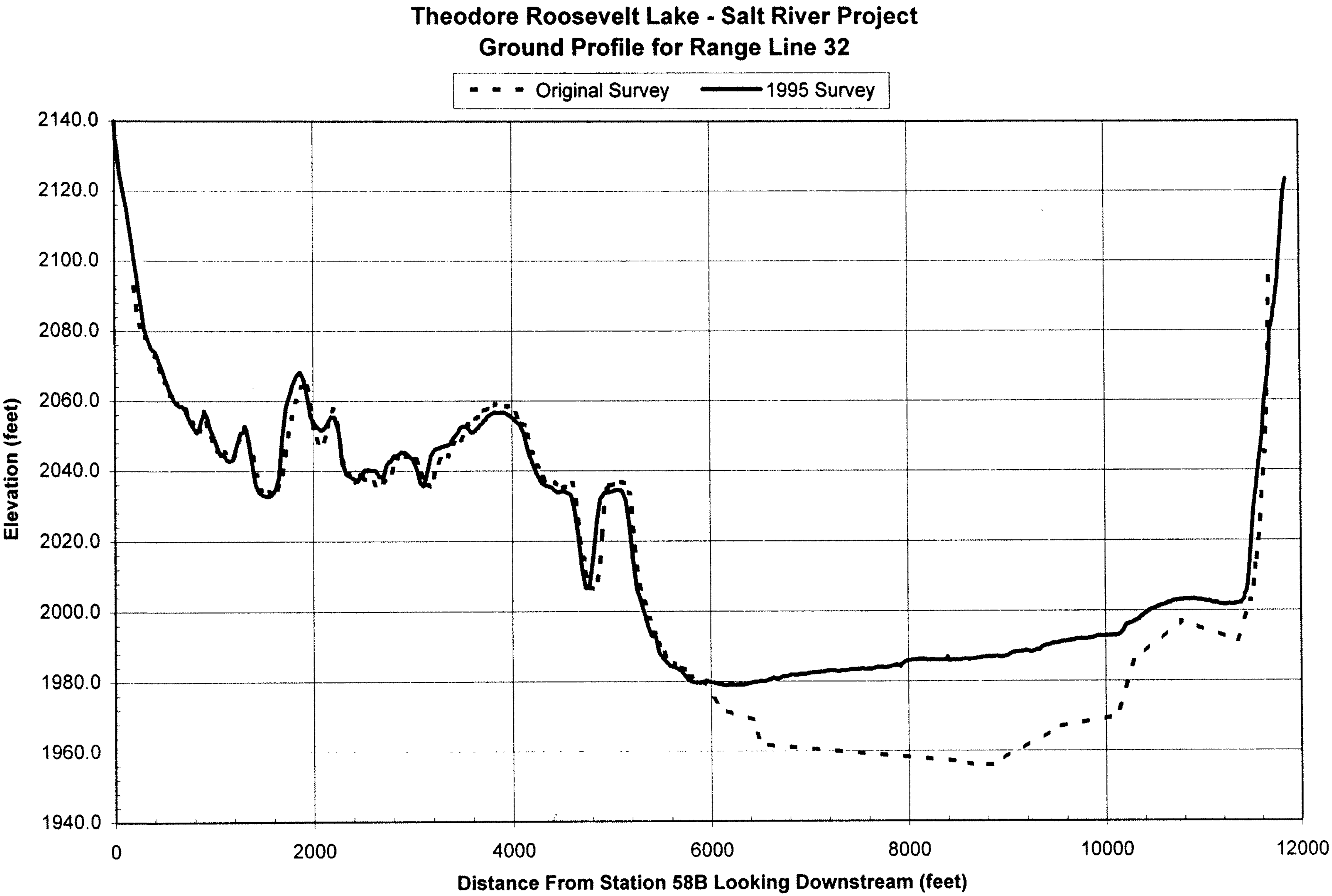


Figure 29. - Theodore Roosevelt Reservoir ground profile for range line 32.

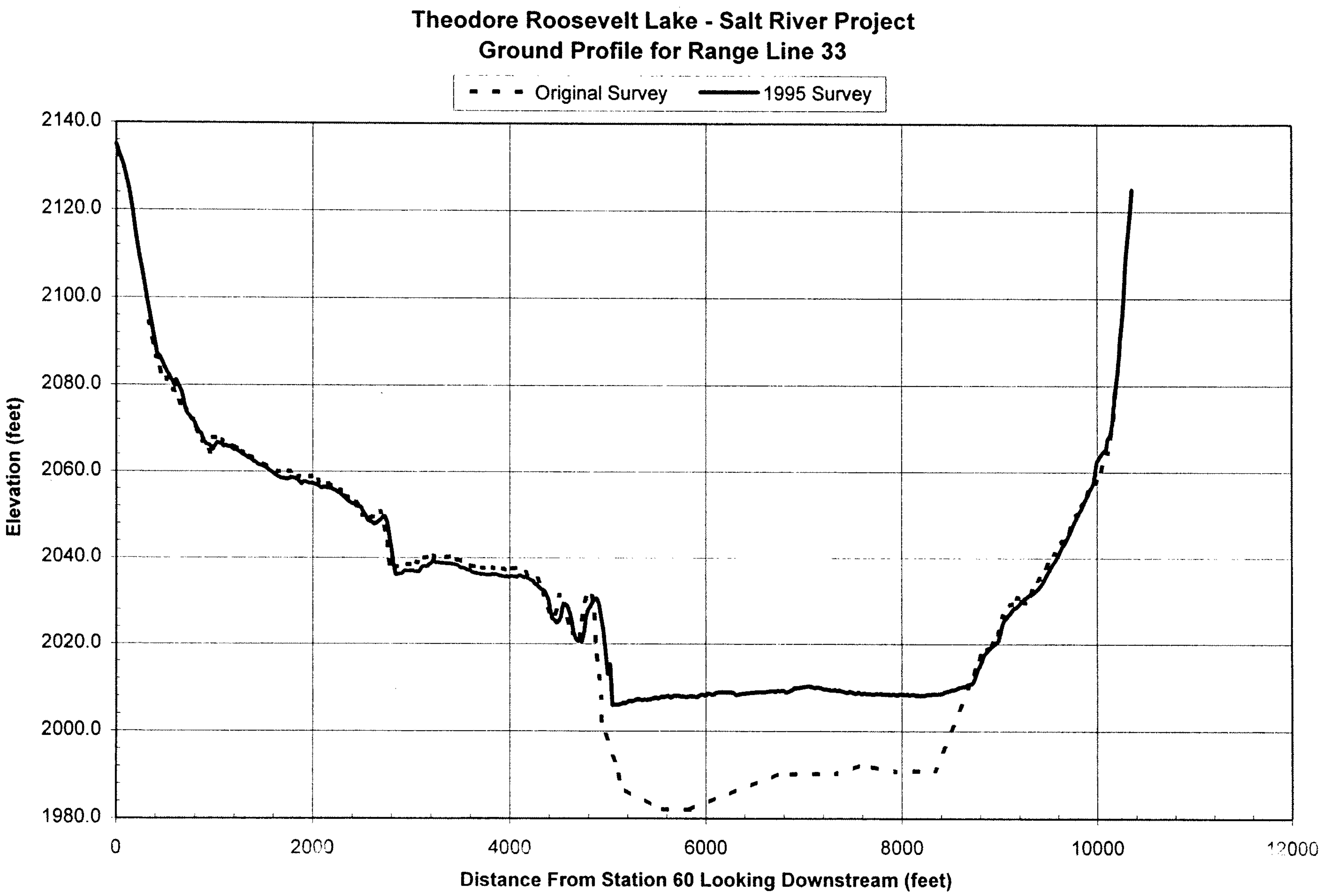


Figure 30. - Theodore Roosevelt Reservoir ground profile for range line 33.

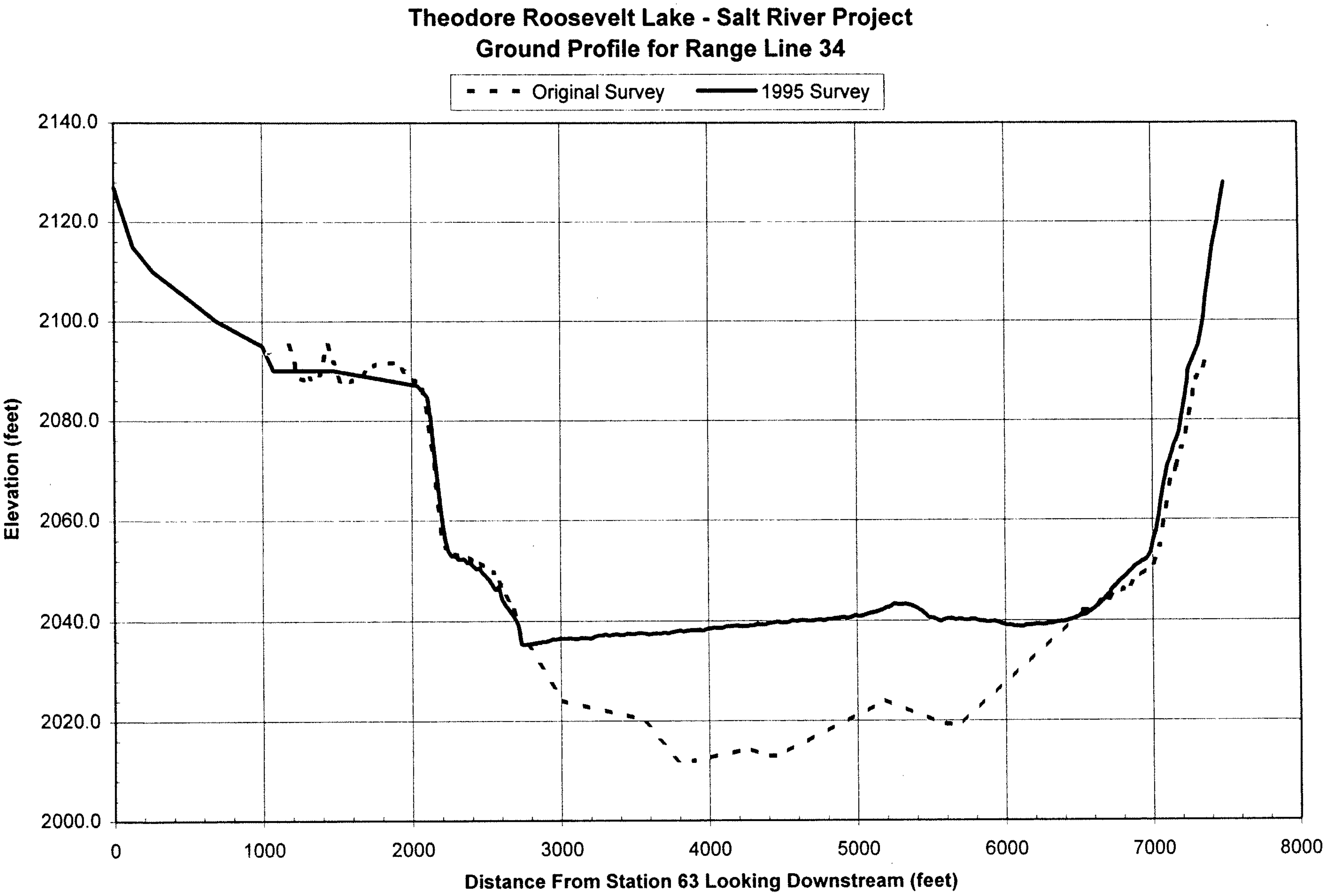


Figure 31. - Theodore Roosevelt Reservoir ground profile for range line 34.

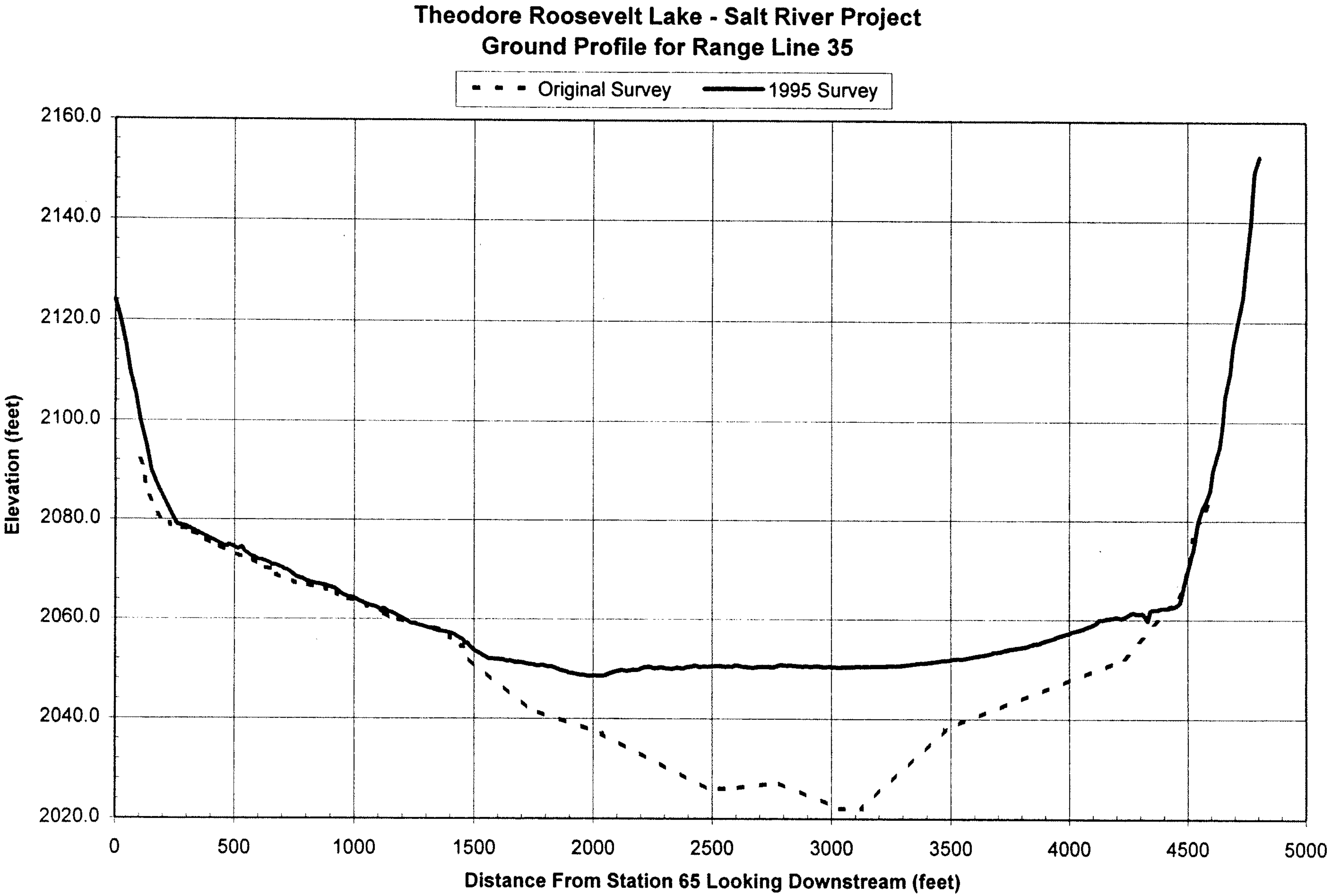


Figure 32. - Theodore Roosevelt Reservoir ground profile for range line 35.

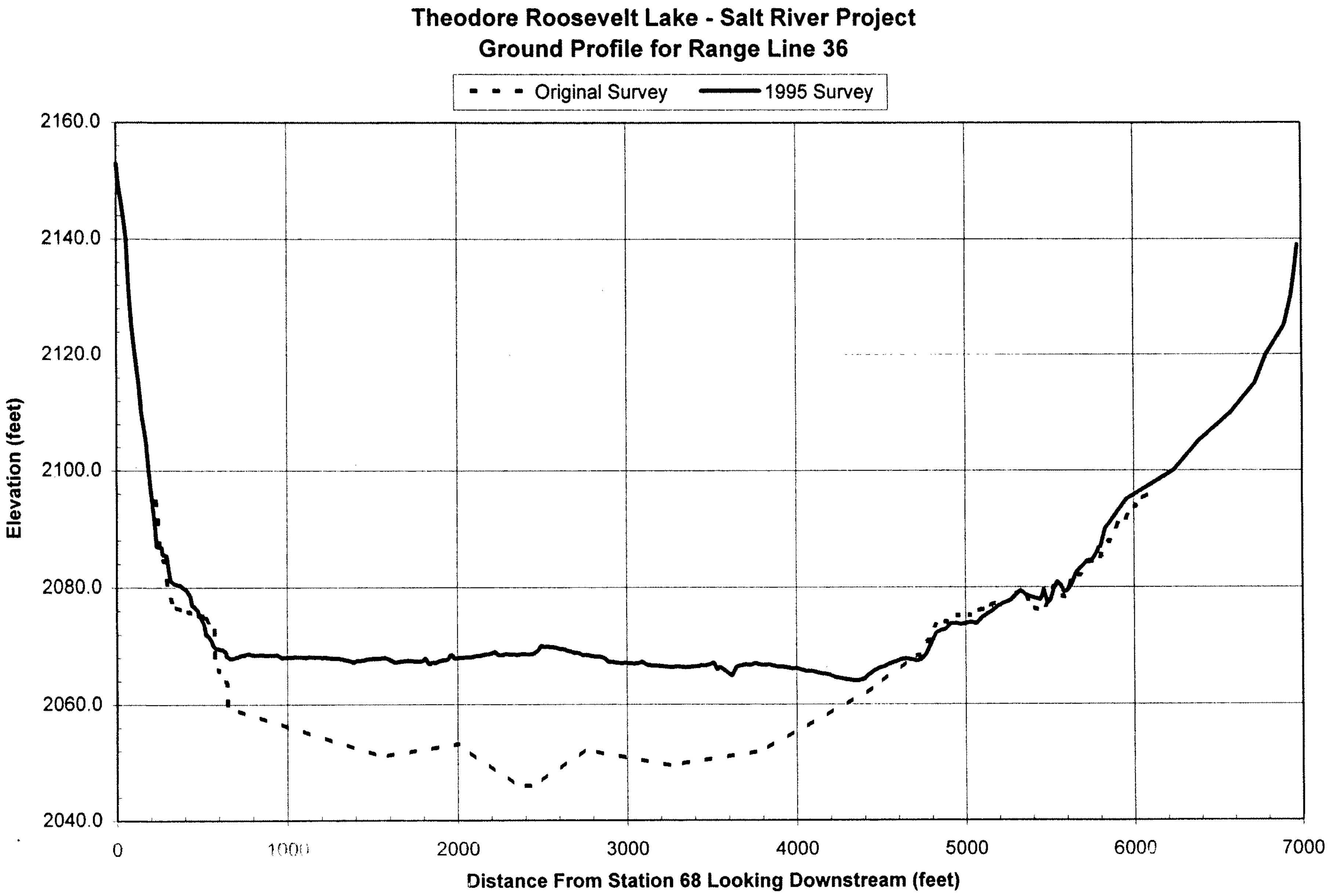


Figure 33. - Theodore Roosevelt Reservoir ground profile for range line 36.

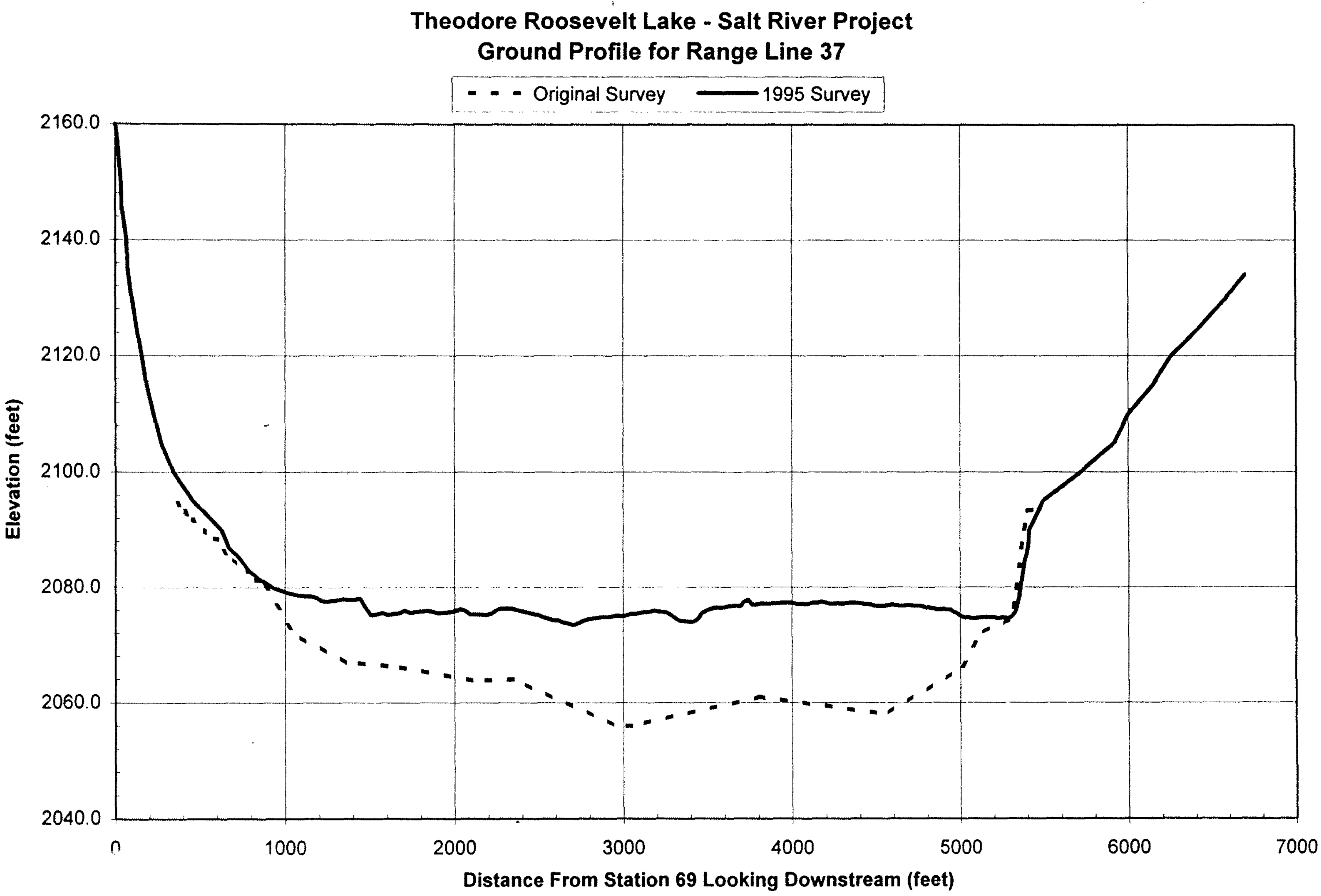


Figure 34. - Theodore Roosevelt Reservoir ground profile for range line 37.

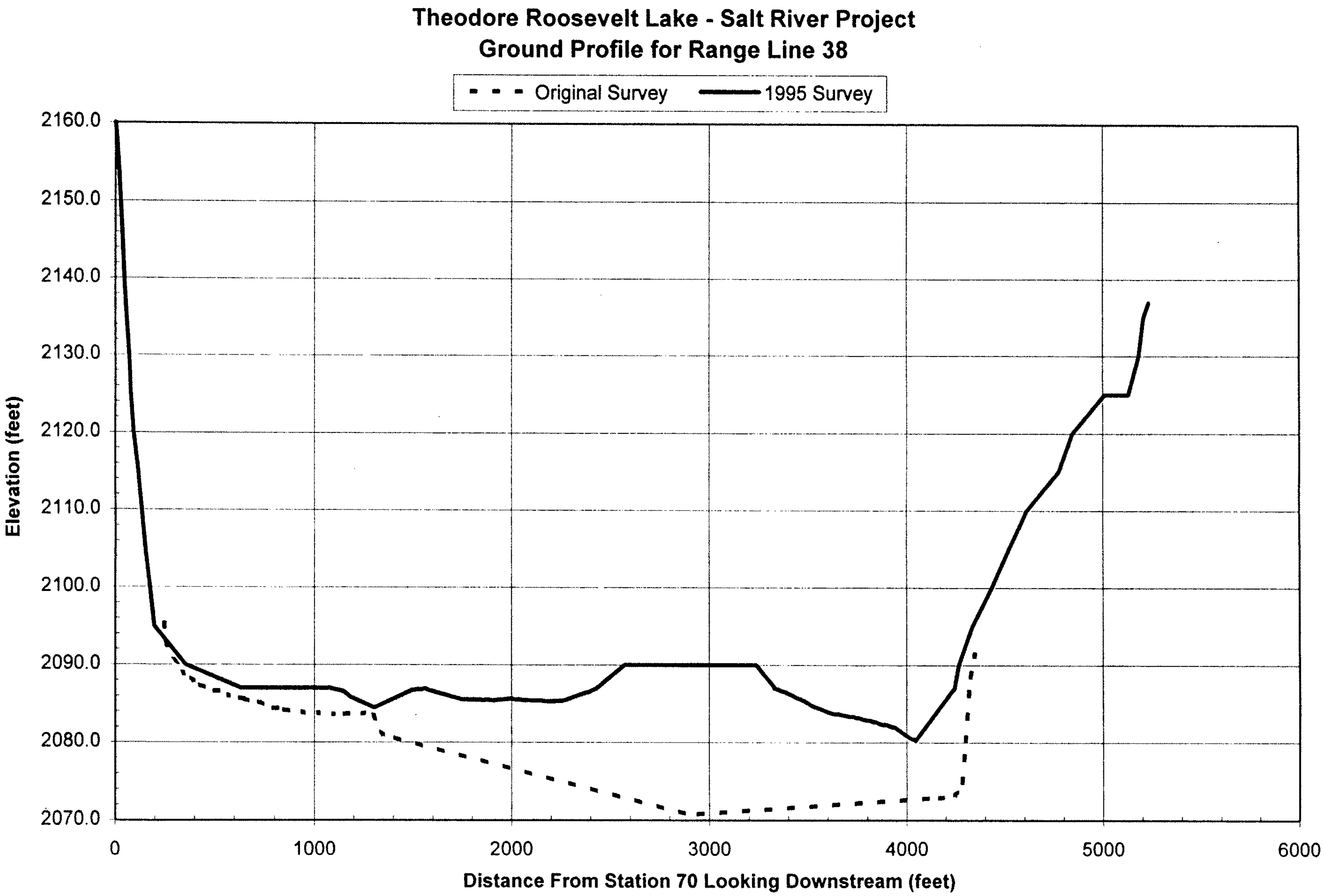


Figure 35. - Theodore Roosevelt Reservoir ground profile for range line 38.

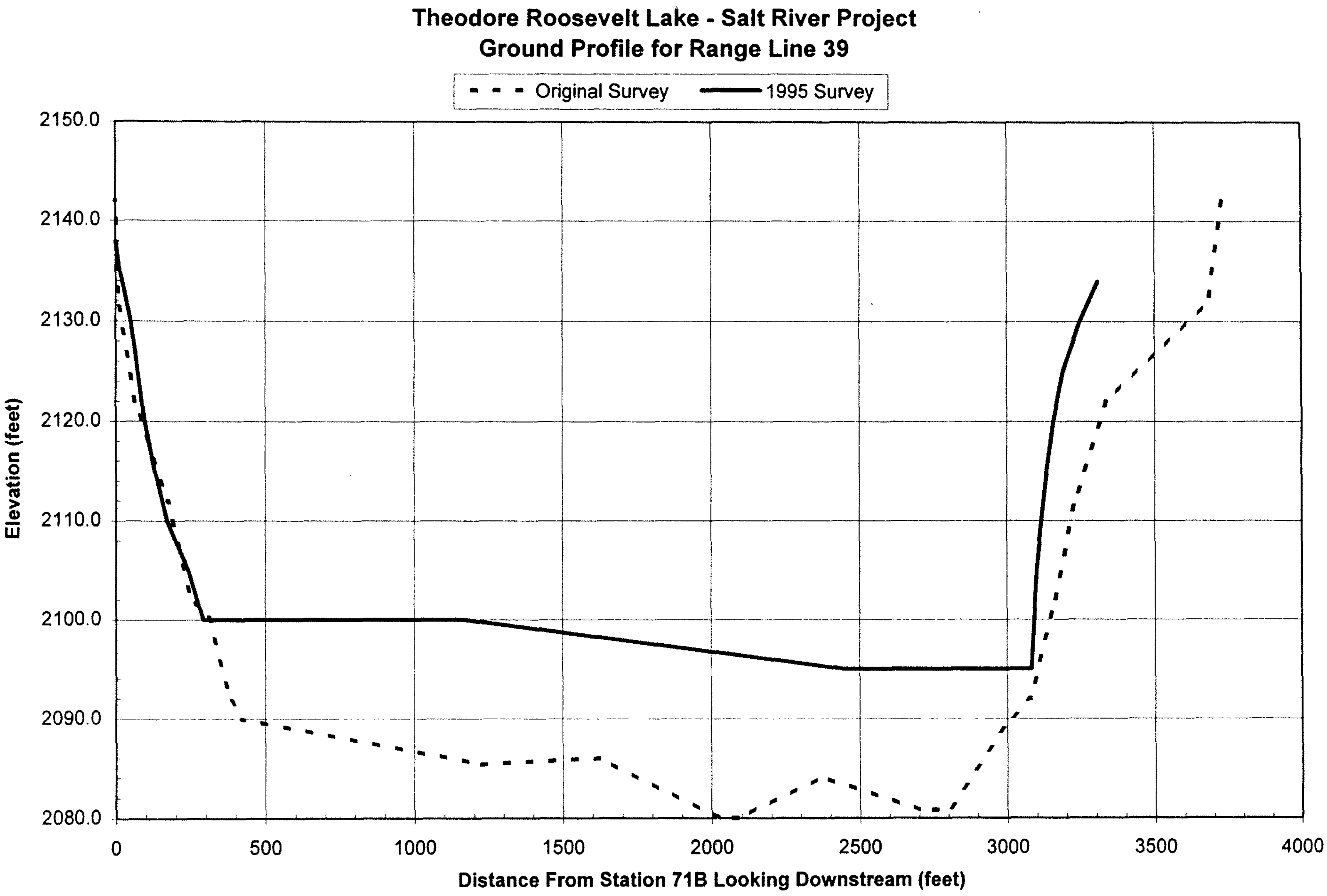
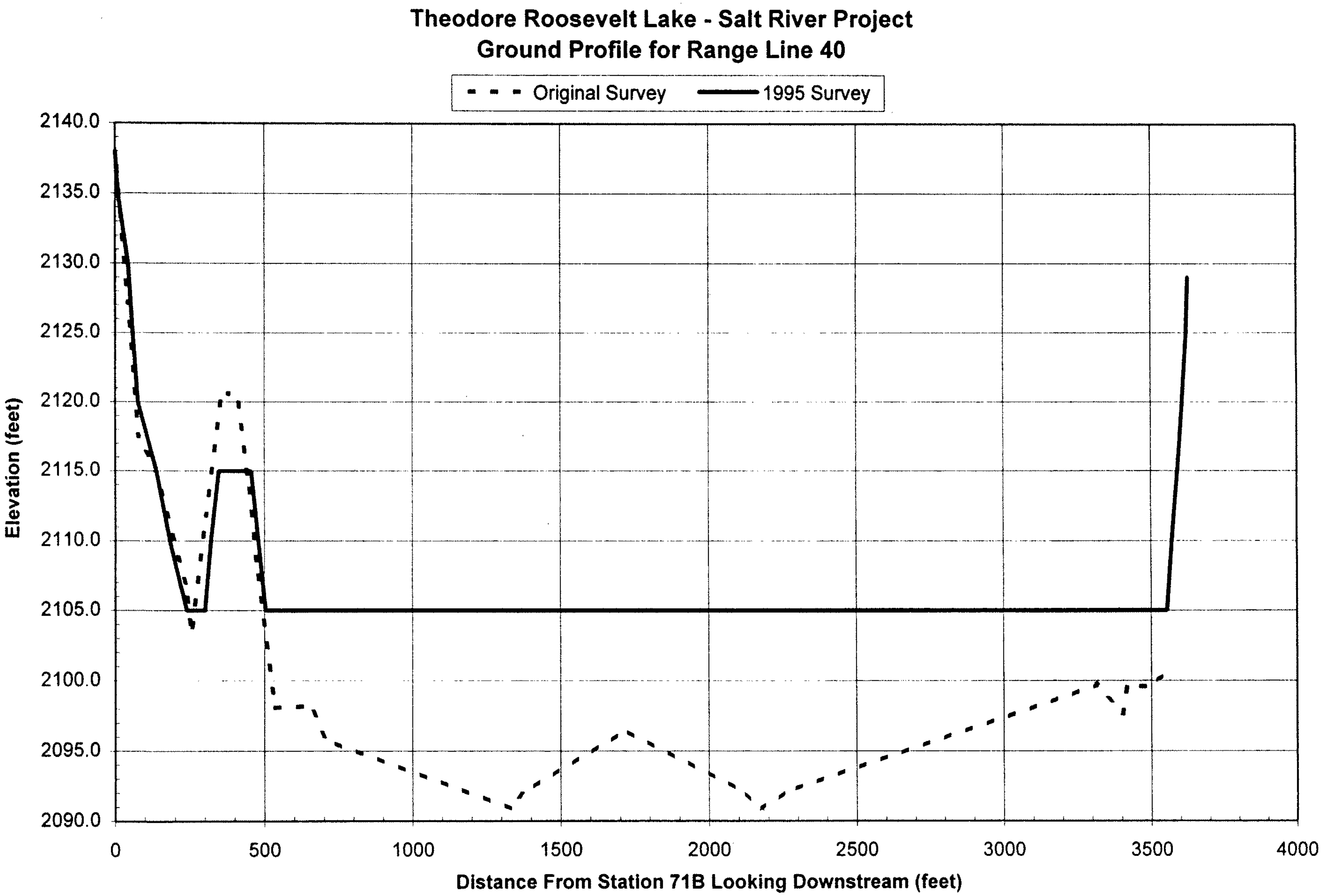


Figure 36. - Theodore Roosevelt Reservoir ground profile for range line 39.



Theodore Roosevelt Lake - Salt River Project
Ground Profile for Range Line 40

Figure 37. - Theodore Roosevelt Reservoir ground profile for range line 40.

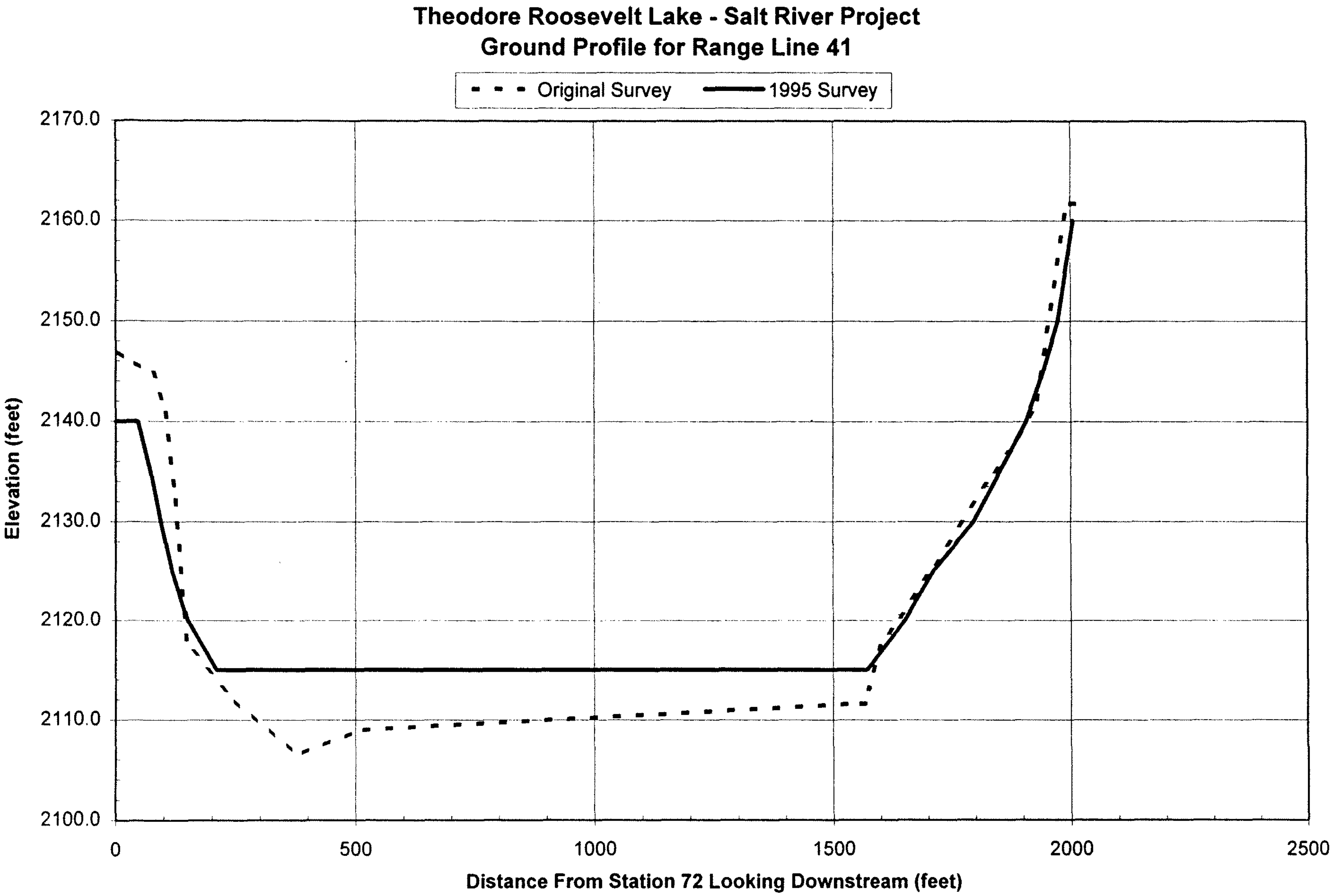


Figure 38. - Theodore Roosevelt Reservoir ground profile for range line 41.

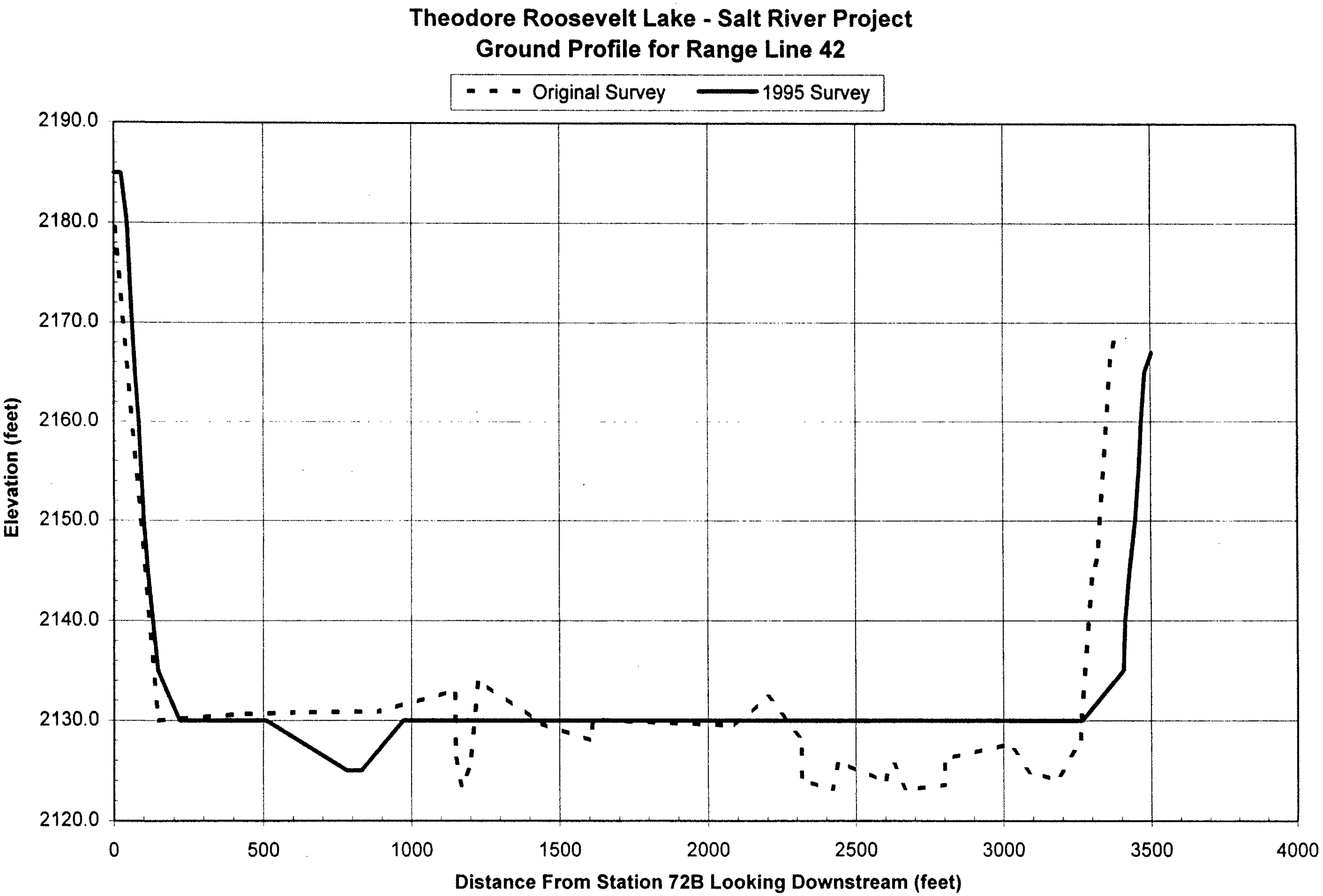


Figure 39. - Theodore Roosevelt Reservoir ground profile for range line 42.

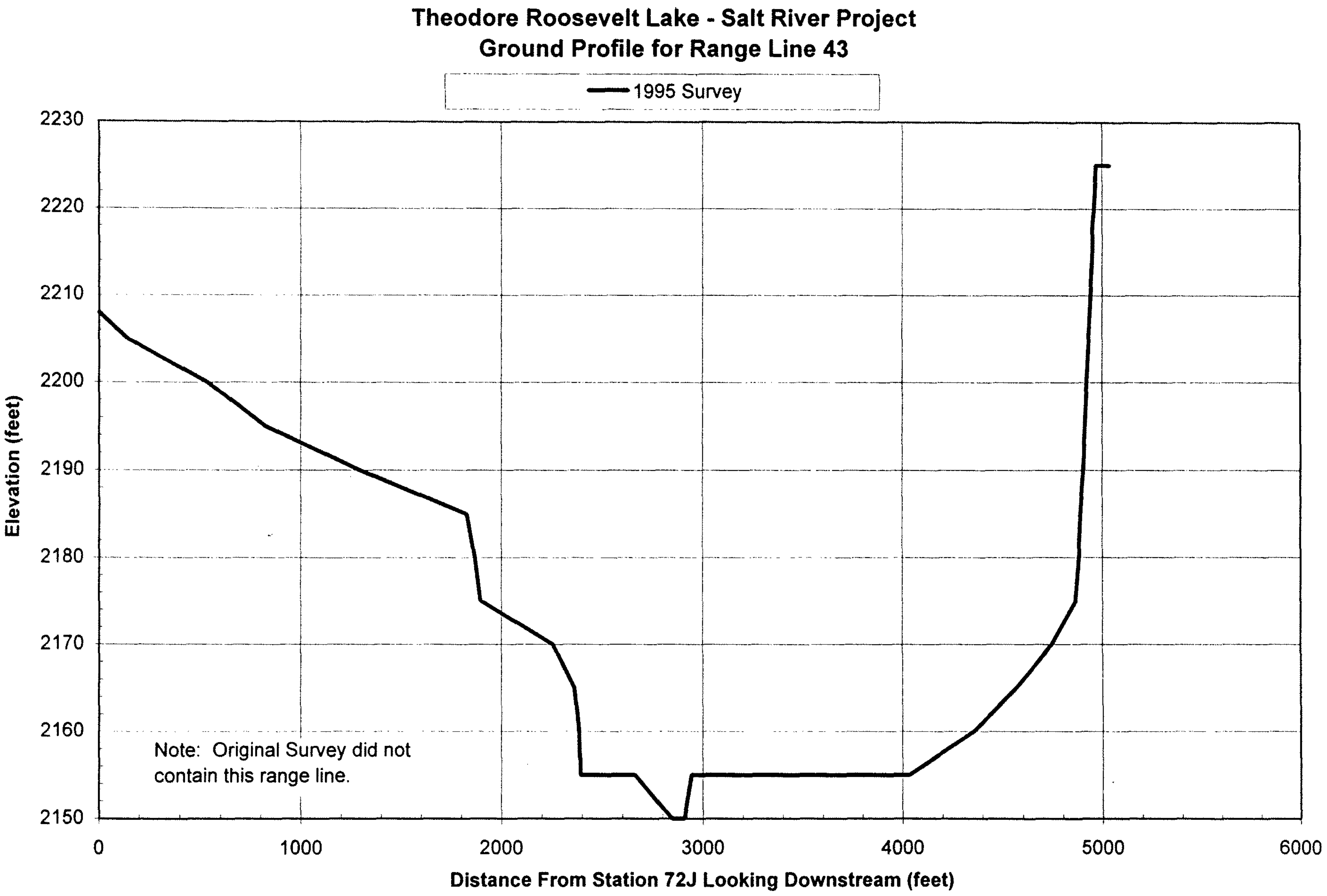


Figure 40. - Theodore Roosevelt Reservoir ground profile for range line 43.

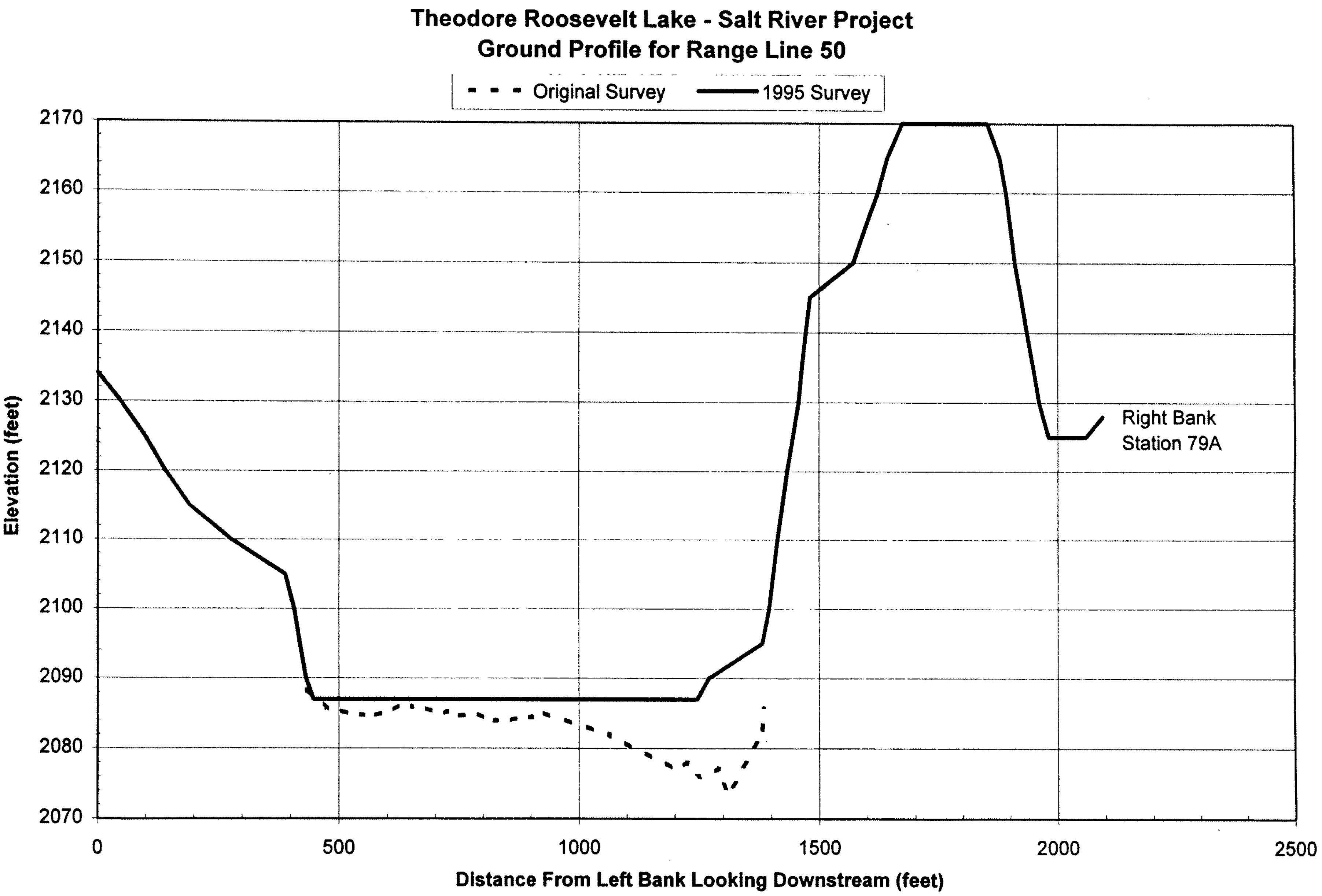
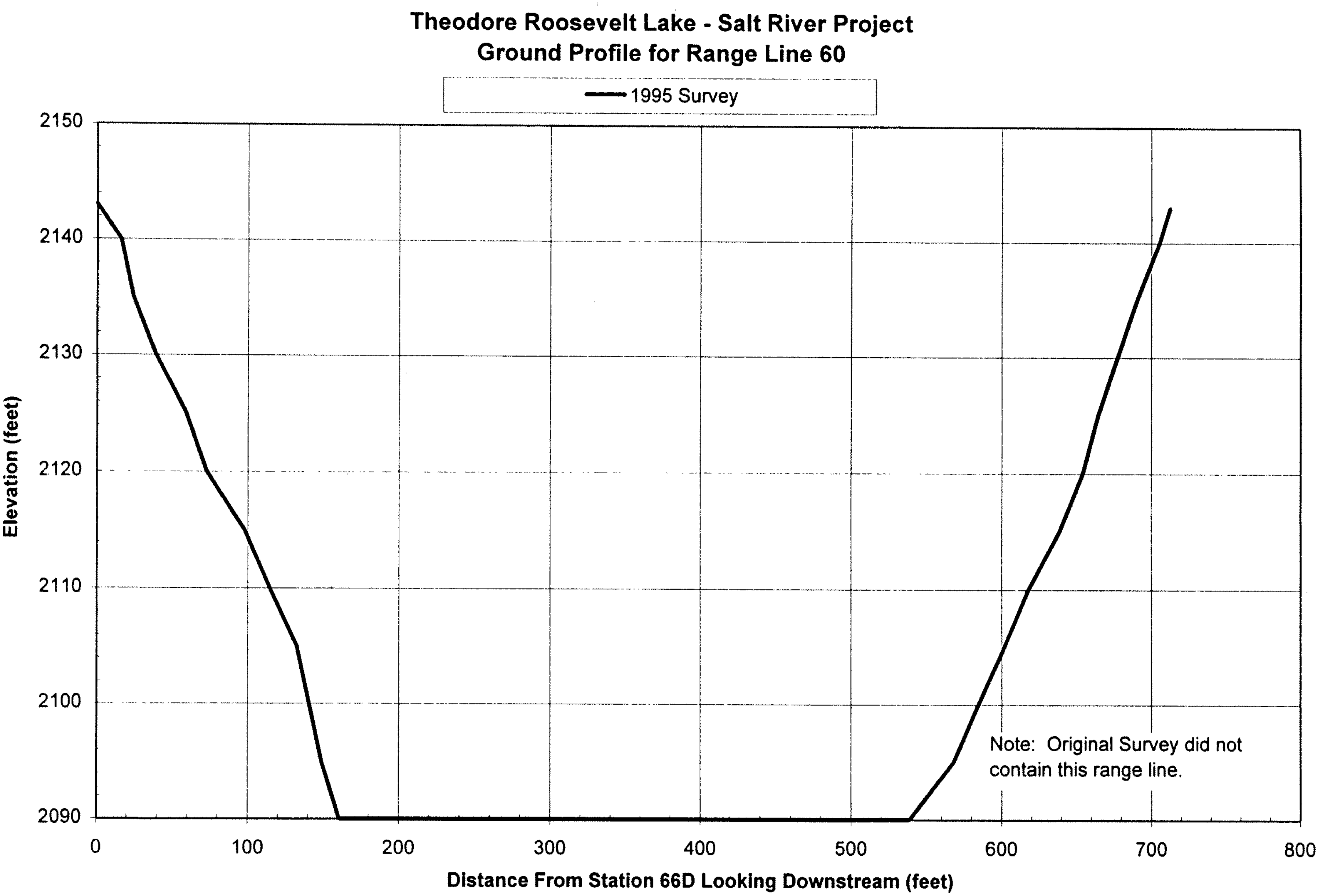


Figure 41. - Theodore Roosevelt Reservoir ground profile for range line 50.



Note: Original Survey did not contain this range line.

Figure 42. - Theodore Roosevelt Reservoir ground profile for range line 60.

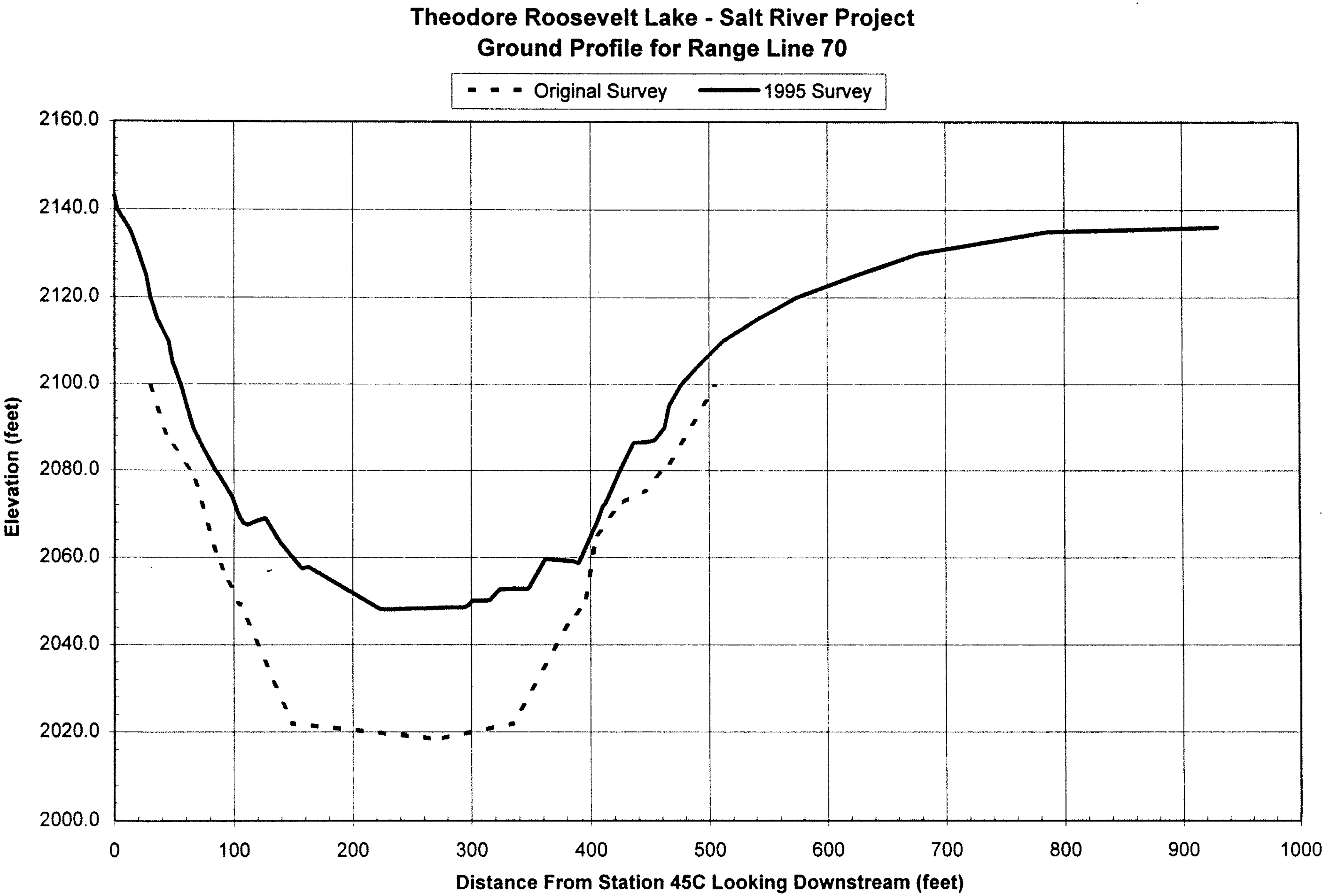


Figure 43. - Theodore Roosevelt Reservoir ground profile for range line 70.

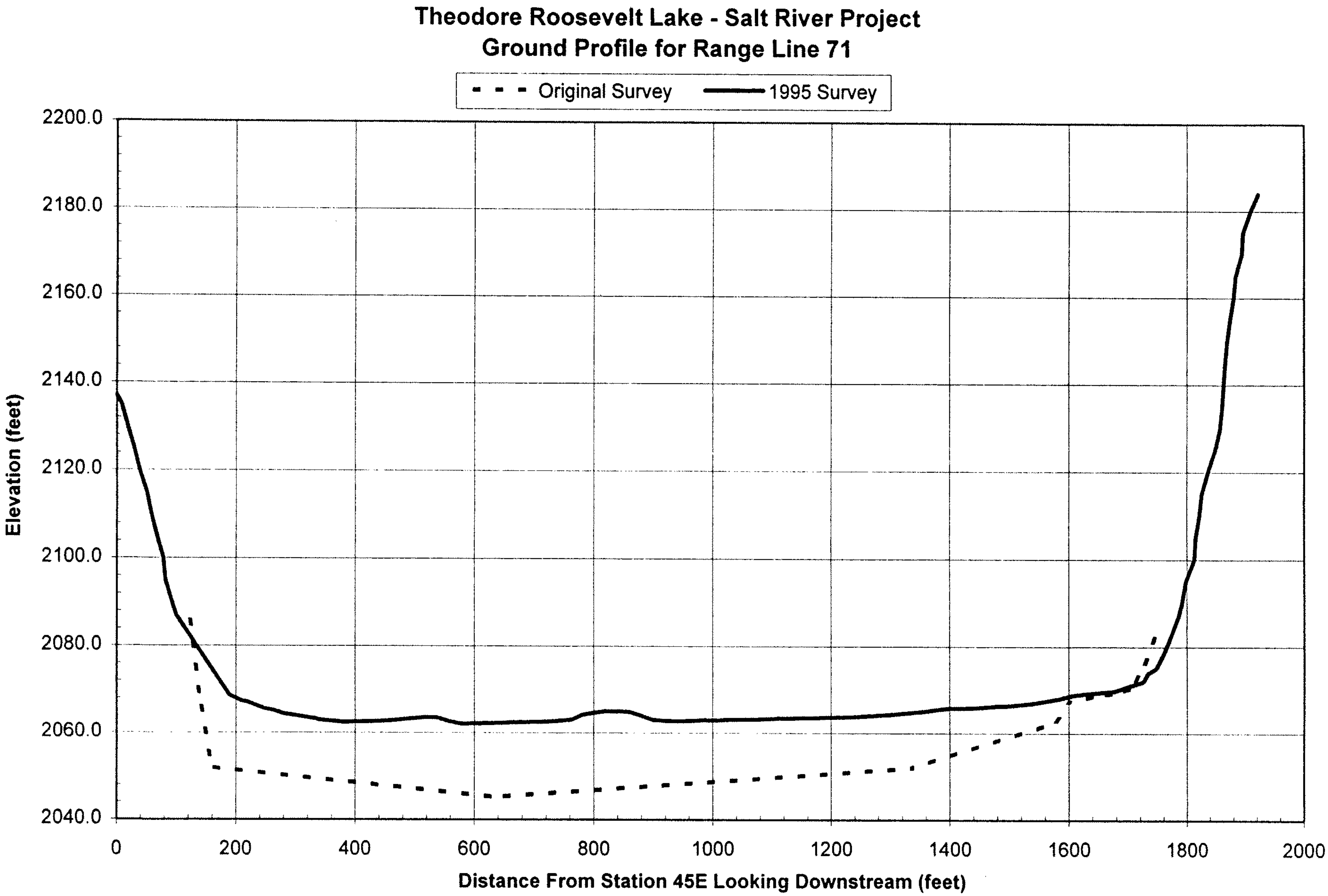


Figure 44. - Theodore Roosevelt Reservoir ground profile for range line 71.

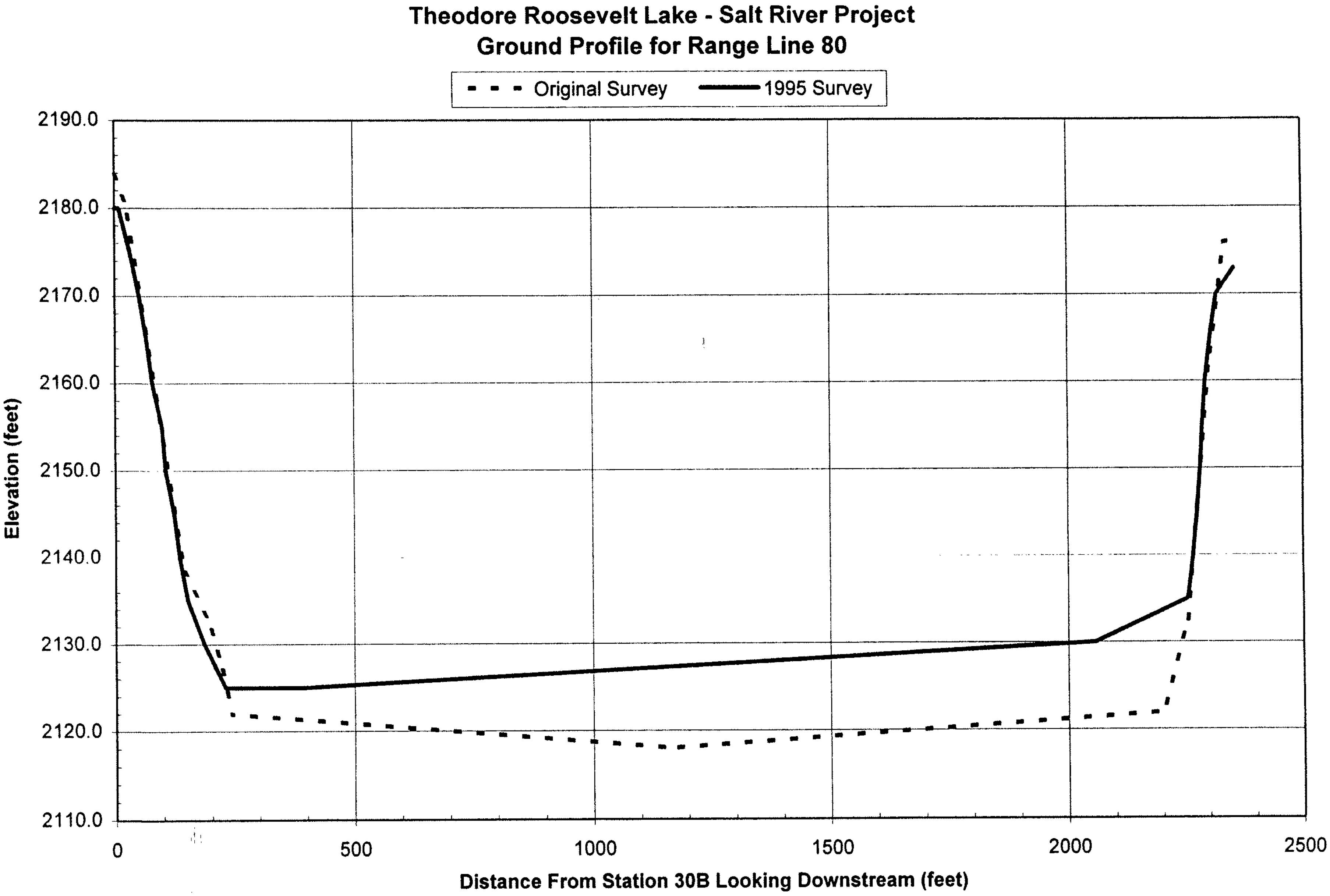


Figure 45. - Theodore Roosevelt Reservoir ground profile for range line 80.

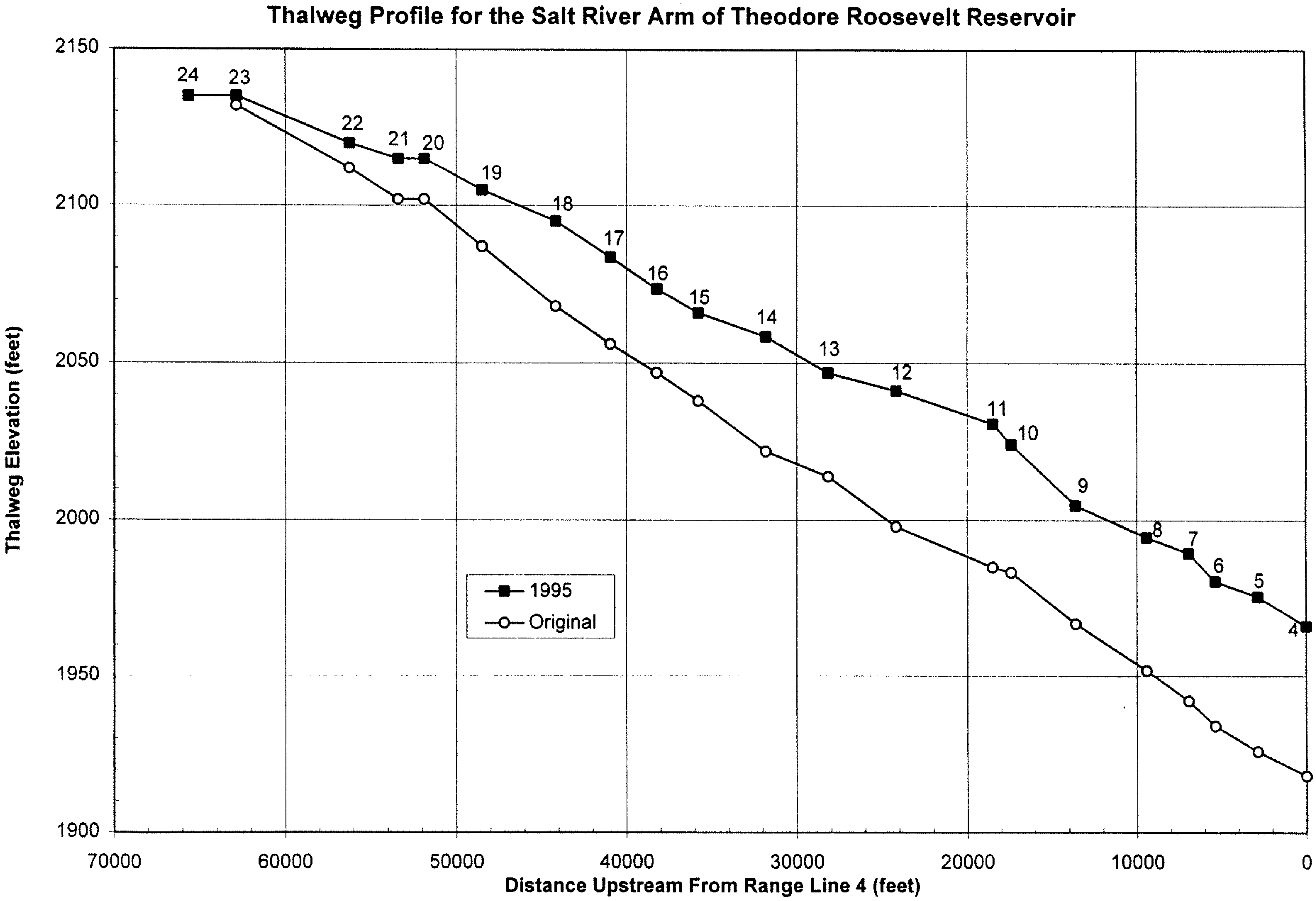


Figure 46. - Thalweg profile for the Salt River Arm of Theodore Roosevelt Reservoir.

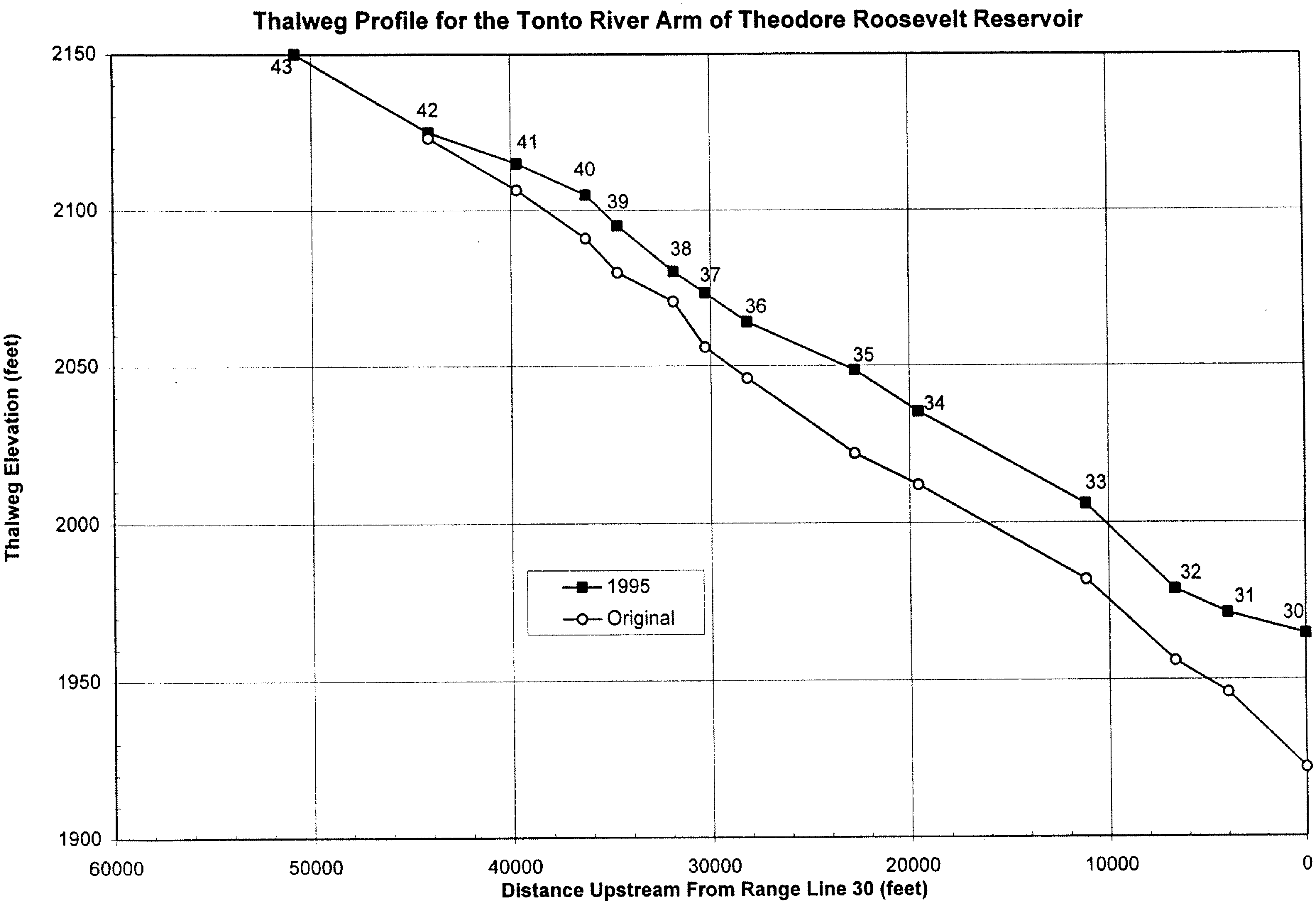


Figure 47. - Thalweg profile for the Tonto River Arm of Theodore Roosevelt Reservoir.

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American Public.