Technical Memorandum

Date:	October 17, 2016
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Subject	FINAL Los Padres Reservoir Survey Study Report

Introduction

HDR Engineering, Inc. (HDR) was retained by the Monterey Peninsula Water Management District (District) to prepare a study which evaluates the feasibility of implementing potential upstream and downstream fish passage alternatives at Los Padres Dam. As part of the background data collection effort, HDR was tasked to collect bathymetric data and interpret existing conditions in Los Padres Reservoir. This document describes the methods, results and conclusions derived from the study task.

HDR completed a single-beam echo-sounder bathymetric survey of the Los Padres Reservoir on July 27, 2016. After completion of the in-water survey, a brief topographic survey of the area upstream of the reservoir was performed on foot using Real-Time Kinematic (RTK) GPS and a survey rod. These datasets were combined with existing Light Detection and Ranging (LiDAR) elevation data of the remaining upland surfaces to create a complete digital elevation model (DEM) of the reservoir to determine reservoir capacity.

Purpose and Objectives

The objective of this study was to determine the existing bottom surface elevations of the reservoir, model the upland areas at the dam crest and around the reservoir perimeter, evaluate elevations at the upland extent of the reservoir (i.e., head of reservoir), and estimate the capacity of the existing reservoir.

The data and results presented herein are to be used by the District for the purpose of:

- Informing future water management decisions regarding reservoir stage vs. volumetric capacity;
- Providing a basis of comparison to approximate sediment accumulation rates which will inform the future long-term sedimentation study; and
- Informing the current fish passage feasibility assessment by providing insight on reservoir configuration and potential impediments to fish pathways.

Study Area

The Los Padres Reservoir is located in Carmel Valley, CA. The reservoir pool level at the time of the survey was 1034.1 ft in the National Geodetic Vertical Datum of 1929 (NGVD29), which is the presumed operational vertical datum of the reservoir (i.e., for comparison to historic measurements). Normal maximum water surface elevation (NMWSE) at the dam is approximately 1040.0 ft NGVD29.

Survey

Survey Control

On the initial July 27th site visit, HDR was unsuccessful in locating previously-established survey control (e.g., by CSUMB, 2008; and Bestor, 2010) at the project site likely due to recent construction activities occurring throughout the site. Moreover, HDR was not able to locate the spillway benchmark reported to exist along the east side of the spillway. Therefore, HDR established a temporary benchmark on the top of the dam and referenced the benchmark to a local surveyor’s control (Polaris Land Surveying).

A base station GPS was setup with a radio repeater to transmit RTK GPS corrections to a rover GPS installed on the survey vessel. The base station GPS was setup on the temporary benchmark and raw GPS data were collected throughout the survey day from this receiver. Water surface elevations were measured with the rover GPS and were confirmed with the National Weather Service water gage data at the Los Padres Dam (Station LPRC1). The base station equipment is shown in Figure 1. The temporary benchmark location is shown in Figure 2.

Figure 1. HDR temporary benchmark on the water access plate nearest the boat ramp.

Figure 2. HDR benchmark is the top of the Letter "A" located at the end of the pencil in this figure.

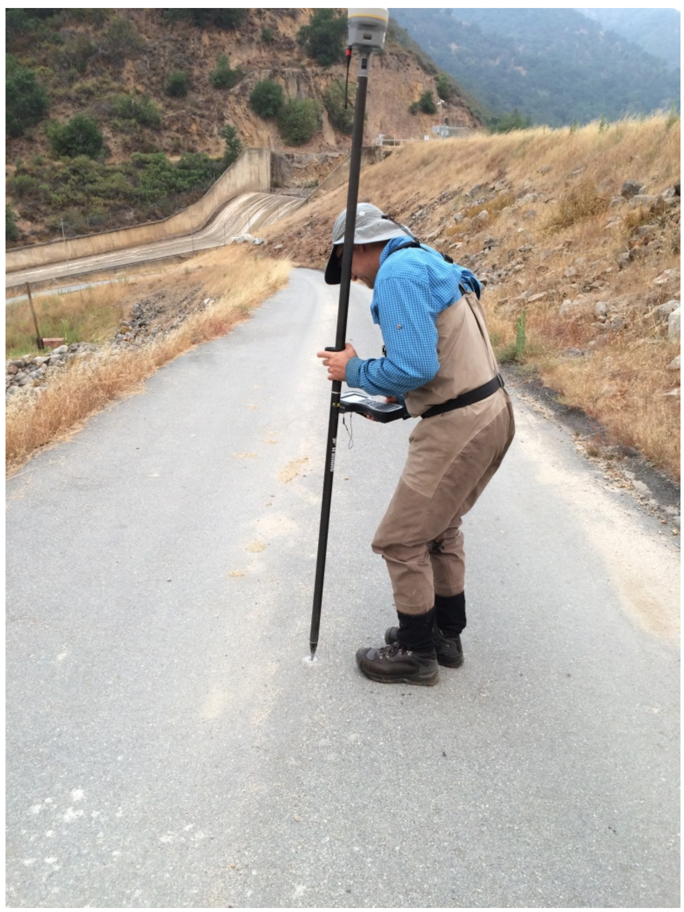

Figure 3. Location of Polaris Land Surveying control point on entrance driveway to top of dam.

Following the survey, the raw GPS data from the base station were submitted to the Online Positioning User Service (OPUS), a service maintained by the National Oceanic and Atmospheric Agency (NOAA) and the National Geodetic Survey (NGS). A coordinate solution of the true base point location was computed by the OPUS and was later applied to all the bathymetry and topographic data.

On September 15, 2016, HDR revisited the site and successfully recovered the CSUMB benchmark near the boat ramp. A level loop was completed between the CSUMB benchmark, the HDR temporary benchmark, and another control point established on the entrance roadway by Polaris Land Surveying. The level loop confirmed that CSUMB, HDR, and Polaris Land Surveying control networks resided on the same vertical datum. The location of the Polaris Land Surveying control point utilized is illustrated in Figure 3.

Survey Methods

HDR utilized a cataraft survey vessel with a rigid aluminum frame and a rear mounted motor as shown in Figure 4. The bottom elevations were determined using a Teledyne/Odom CVM, 200 kHz single-beam echosounder (SBE) and Trimble R10 for RTK GPS positioning. The SBE includes a 4-degree beam angle and is capable of measuring water depths to +/-0.05 feet (1 cm). RTK GPS positioning allows for precise horizontal and vertical positioning within 0.1-0.2 feet (3-5 cm). The SBE and GPS were co-located on a vertical pole and mounted on the bow of the survey vessel (see Figure 5).

Figure 4. HDR survey vessel mobilization.

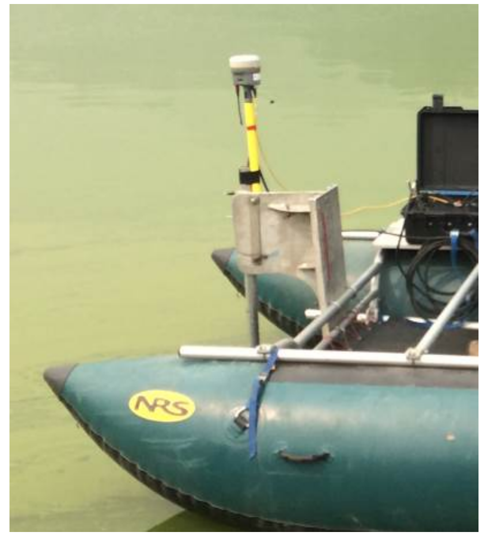

Figure 5. SBE (below water) with collocated RTK GPS (top of pole).

HDR completed sonar calibration testing following standard USACE Hydrographic Surveying protocols (e.g., USACE Hydrographic Surveying Manual, EM 1110-2-1003). A bar check was completed to verify system index offsets and sound velocity corrections to be applied to the acoustic signal. Additionally, a latency test was completed to confirm there were no delays in the equipment signals as they are reported to the field computer. Hypack 2016 Hydrographic Survey Software was used to collect the hydrographic data.

Preliminary sounding measurements were collected along a reservoir perimeter line to gain an understanding of the water depths around the reservoir and facilitate efficient data collection for the remainder of the survey. Subsequent data were collected throughout the reservoir along distinct 50-ft transect lines taken in a grid-like pattern. The bathymetry sounding transect locations from the survey are shown in Figure 6. On the day of the survey, a thick layer of algae was observed on the surface of the water which prevented visibility into the water during the survey. For safety reasons (i.e., to avoid striking potential submerged objects), HDR surveyors maintained a relatively larger distance from the shoreline than typically executed.

At the head of the reservoir, further upstream than the cataraft was able to safely navigate, the surveyors collected cross-sections of elevations across the reservoir/river channel on foot, using the RTK GPS and survey rod. Surveyors also took photographs of the channel and documented the channel conditions.

Publically-available LiDAR data collected in the fall of 2010 were downloaded from NOAA, National Ocean Service, Office for Coastal Management. The point cloud was reviewed and found to have extensive classification errors. HDR LiDAR experts reprocessed the LiDAR data in the reservoir vicinity and upslope to an elevation of 1090 ft. The LiDAR data were likely collected while the reservoir was near full pool because no data were available below the NMWSE within the reservoir boundary. The data were reported in the NAVD88 vertical datum. The ground returns from the reprocessed LiDAR data were exported to GIS for use in DEM generation.

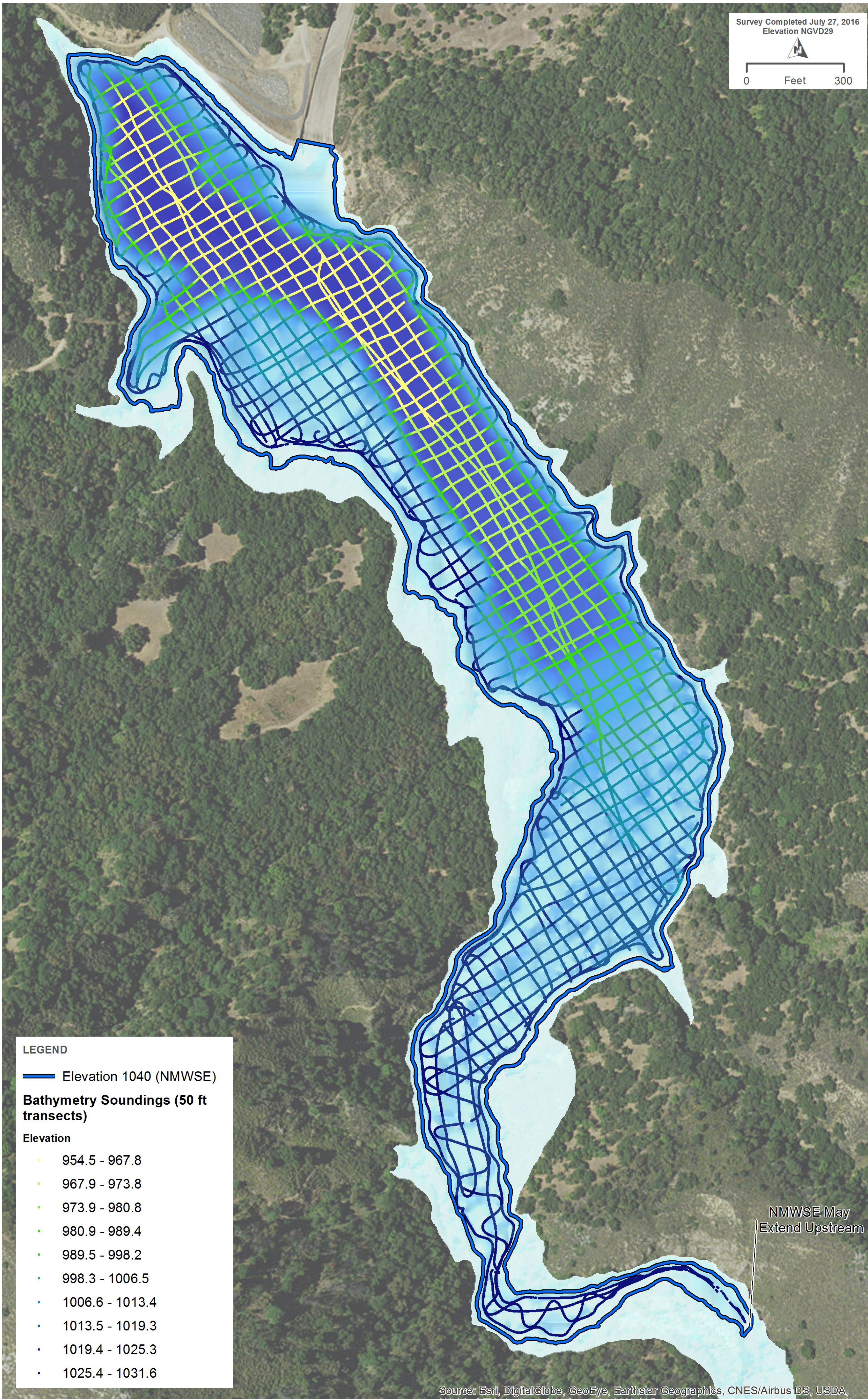

Figure 6. Survey Soundings with Sounding Elevations.

Results and Analysis

Survey Control

Although HDR was unsuccessful in locating the CSUMB benchmark during the initial survey on July 27, 2016, HDR relocated the benchmark during a subsequent site visit on September 15, 2016. The CSUMB benchmark was included in a level loop survey to determine any vertical offset between the CSUMB and HDR benchmarks.

CSUMB reported the benchmark elevation to be 1057.802 ft in the North American Vertical Datum of 1988 (NAVD88), and using Geoid 03. HDR's level loop comprised a traverse between the Polaris Land Surveying control point and the CSUMB benchmark, where the CSUMB elevation was determined to be 1057.85 feet NAVD88 (using Geoid12B). This is an approximate vertical difference of 0.05 feet, which is within the measurement accuracies of RTK GPS, and also indicates that the CSUMB, HDR, and Polaris Land Surveying control networks are on the same vertical datum. Because of this, HDR proceeded assuming the separation between the two geoids in the area of this survey to be zero.

In order to compare the HDR bathymetric survey to the previous CSUMB survey, it was necessary to shift the HDR survey datum to NGVD29. In 2008, CSUMB reported that the shift should be 2.9 ft, and HDR calculated the vertical shift from NAVD88 to NGVD29 to be 2.93 feet using NOAA's VERTCON datum conversion tool. However, CSUMB shifted the survey by a difference of 2.54 ft citing it as a locally measured difference resulting from comparison to a previous survey. The justification to shift 2.54 feet was unclear; consequently, HDR was unable to resolve the method by which CSUMB computed their final reservoir area/capacity curves.

In March 27, 1999, the District determined the elevation of the CSUMB benchmark and the dam spillway from another benchmark that was not recovered by HDR, the "shack" (Appendix A from CSUMB, 2008). The vertical offset computed between the benchmark "shack" and the CSUMB benchmark was 2.36 feet, which conflicts with the vertical shift value reported by CSUMB of 2.54 feet.

As another means of aligning the HDR dataset to previously-collected data, HDR compared elevations measured on the dam spillway. Though not as accurate as comparing benchmark elevations, the dam spillway elevations are approximately +/- 0.2 feet.

Returning to the District survey from Appendix A (CSUMB, 2008), the District estimated the top of spillway to be approximately 1039.78 to 1039.96 feet, NVGD29 measure along the very crest of the sloping ogee spillway. By applying a 2.93 foot vertical shift to the HDR spillway measurements, the resultant elevations are 1039.7 to 1039.8 feet NVGD29.

Moreover, HDR compared spillway elevations to those measured by Bestor in 2010. Values in Table 1 indicate the similarities between the two when a 2.93 foot vertical shift is applied to the HDR NAVD88 elevations.

Table 1. HDR and Bestor dam and spillway elevation comparisons.

Location	HDR Elevation (ft, NGVD29)	Bestor Elevation (ft, NGVD29)
Crest of Dam	1057.64	1057.6 ft
Crest of Spillway	1039.72	1039.7 ft

Because HDR's 2016 survey elevations were consistent with previous surveys using a 2.93 ft shift, HDR shifted the bathymetry survey data by 2.93 ft and not 2.54 ft. This process facilitated a more accurate comparison between the District's 2008 survey (CSUMB, 2008) and HDR's 2016 survey.

Head of Reservoir

The area upstream of the where the survey vessel could safely navigate and collect depths was investigated on foot with an RTK survey rover. Three transects were recorded in the channel at the approximately ~190 ft, 225ft,and 430 ft upstream of the last bathymetric survey point (Figure 7). The reach was of a consistent width for ~600ft upstream of the bathymetric survey. Accessing areas farther upstream became challenging due to the presence of standing water, deep vegetative cover, and steep hillslopes. Surveyors found a large pool of unknown depth covered by a thick canopy that blocked RTK GPS data collection. A water surface elevation point was collected at the pool (1034.1ft NGVD29) before surveyors returned to the survey vessel to complete the bathymetry survey.

Elevations measured in each transect included measurements several feet below the NMWSE, suggesting that the reservoir extends back into this reach when operating at full pool. Surveyors were unable to locate a clear hydraulic control location that would indicate the upstream extent of the full pool. Additional surveying with total stations would be required to accurately determine the upstream extent of the reservoir full pool boundary.

The survey crew found the upstream reach to be a low-gradient, braided channel with fine sandy sediment and gravel bars bordered by both thick vegetation growing in a silt substrate and bedrock/boulders. The channel width varied between approximately 50 and 60 feet within the inundated areas varying from 5 – 10 ft wide and water depths of 0.5 - 1.5 ft. Photos representative of existing conditions are provided in Figure 8 through Figure 11.

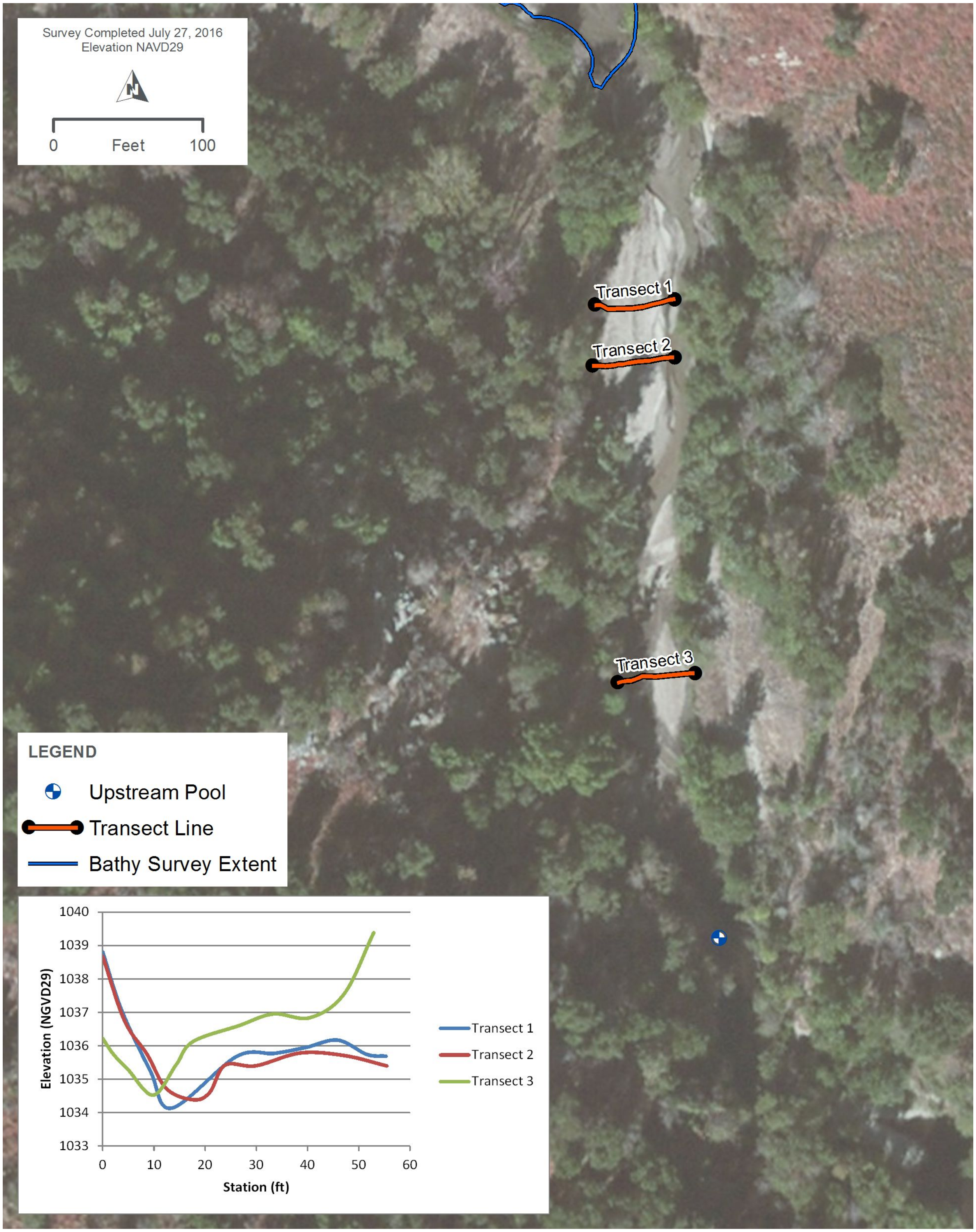

Figure 7. Map of upstream transects and pool water surface elevation survey point.

Figure 8. Transects 1 & 2: a representative photo showing fine sediment and a braided channel, looking upstream.

Figure 9. Transect 3 with fine sediment in channel and boulders along the upstream right margin, looking upstream.

Figure 10. Upstream pool with thick overhead vegetation, gravel bar, and bedrock margin looking upstream.

Figure 11. Fine sediment found in the channel.

Reservoir Volume Estimates

SBE data were processed using Hypack 2016 Hydrographic Surveying software and exported to GIS. LiDAR data were combined with the topographic and bathymetric SBE data and a DEM surface was interpolated in GIS using the ArcGIS tool “Topo to Raster”. This tool is specifically designed for the creation of hydrologically-correct DEMs. Elevation contours and an area-capacity calculation were derived from the DEM surface at five foot intervals. Additional area-capacity calculations were derived both at the NMWSE and the crest of the dam elevation. A graphic illustrating the resulting DEM and contour data, with thalweg profile inset, is provided in Figure 12. The resulting area-capacity curve is plotted in Figure 13.

The reservoir water surface elevation on the day of the survey was measured with RTK GPS both before and after the survey. Elevation readings were also available from the reservoir gauge as reported by National Weather Service via the internet. Both measurements indicated there was less than one tenth of a foot change in water surface elevation during the time of the survey. As the error band of the RTK equipment was greater than the measured change in water surface elevation, HDR assumed a static water surface elevation for calculating elevations from the depths reported by the SBE. HDR used the RTK reported elevation of 1034.1 ft NGVD29.

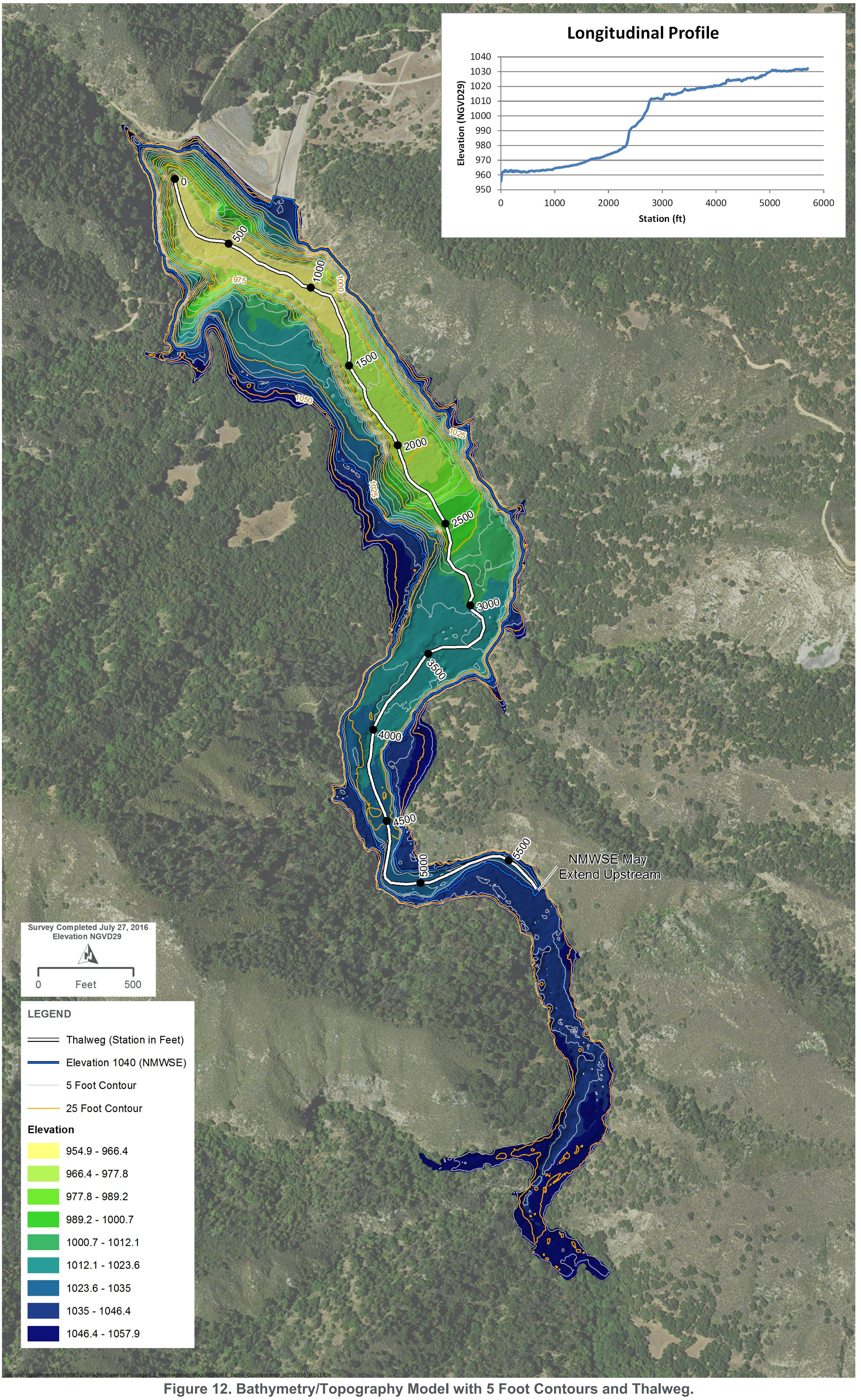

Figure 12. Bathymetry/Topography Model with 5 Foot Contours and Thalweg.

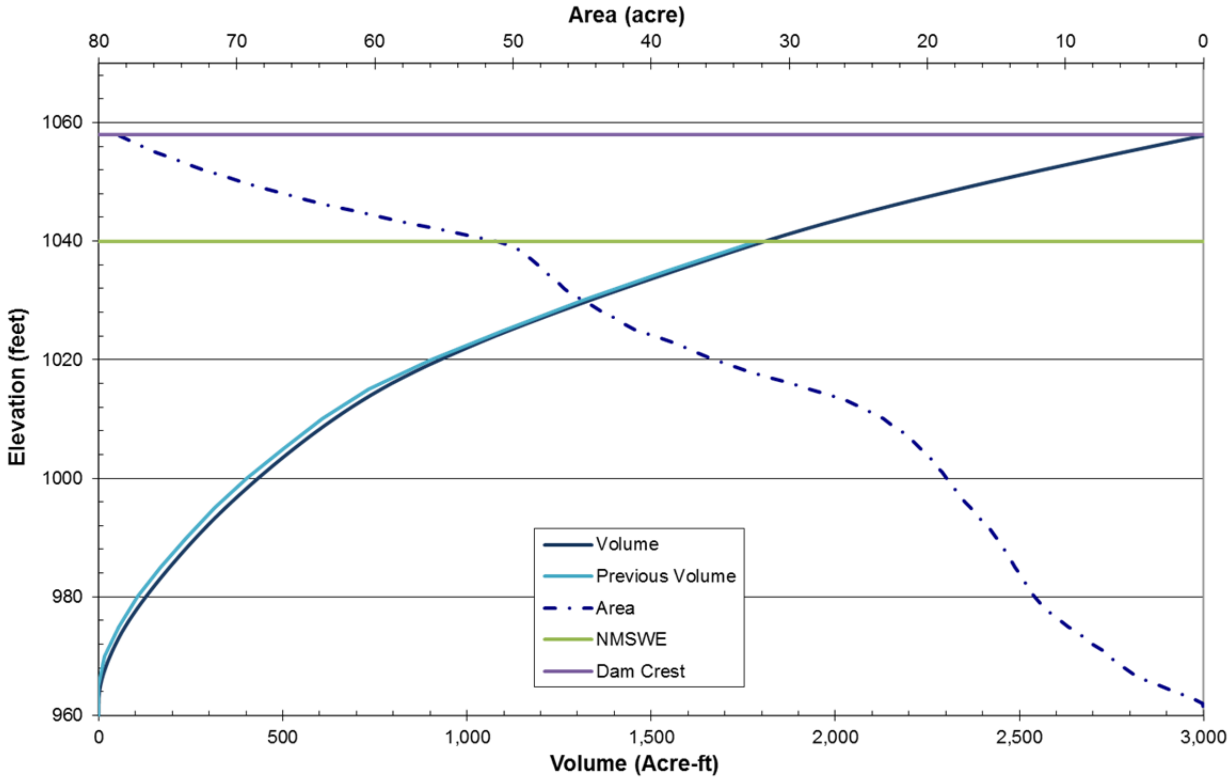

Figure 13. Area-Capacity curve for Los Padres Reservoir (as of July 27, 2016).

The CSUMB reservoir survey (2008) estimated 1,786 acre-ft of water in the reservoir at NMWSE (1040.0 NGVD29). The 2016 HDR survey estimate is 1810.1 acre-ft, which is within 1.3% (or 23.90 ac-ft) of the CSUMB value. Figure 13 shows that the 2016 area-capacity curve (“Volume”) approximates the CSUMB (“Previous Volume”) curve very closely but the 2016 curve estimates between 15 to 30 more acre-ft of storage at a given elevation.

This difference in volume has several potential causes. The 2008 survey was completed at a much lower water level and consequently, it did not appear to include the most upstream 700+ feet of channel that was included in the HDR 2016 survey. Additionally, the 2008 survey used different methods (multi-beam bathymetry and terrestrial LiDAR) which would, in theory, provide a higher resolution of data in the areas surveyed, relative to the methods employed in this survey. Additionally, the difference in the datum shifts applied between the two surveys could also contribute to some unknown level of discrepancy however the methods utilized in this survey took great care to match the elevations of major project features which should lead to a more precise comparison. It is also possible that there has been very little appreciable sediment accumulating in Los Padres Reservoir over the past 8 years which resulted in a very low change in storage volume.

Nonetheless, a difference in estimated volume at NMWSE of 1.3% is within the range of error that could be expected from a SBE survey, and considered good agreement. A tabular summary of the cumulative volume estimates are provided in Table 2 for NGVD29 elevations.

Table 2. Area-Capacity curve data

Elevation (ft, NGVD29)	Area (acres)	Volume (acre-ft)
960	0.01	0.0
965	3.17	4.6
970	6.86	31.0
975	9.78	72.4
980	12.23	128.1
985	13.64	192.8
990	14.99	264.4
995	16.90	343.9
1000	18.61	432.8
1005	20.48	530.3
1010	23.19	638.9
1015	28.51	766.3
1020	35.38	926.8
1025	41.07	1117.2
1030	44.87	1332.3
1035	47.71	1564.6
1040	**51.14**	**1809.9**
1045	61.35	2091.7
1050	69.68	2420.3
1055	75.82	2784.8
1057.9	**78.65**	**3008.9**
1058	78.65	3016.8

*Yellow shading indicates Normal Maximum Water Surface (1040 NGVD29). Red shading indicates Dam Crest Elevation (1057.9 NGVD29).

Central
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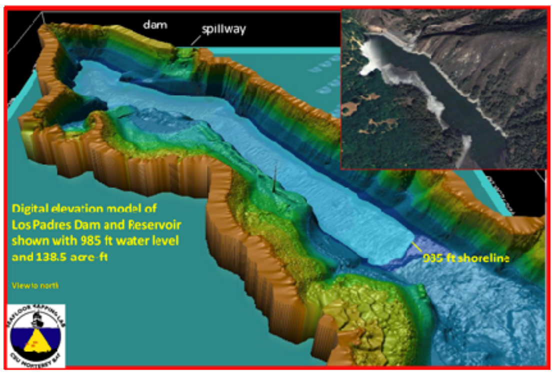

Fall 2008 Stage-Volume Relationship for Los Padres Reservoir, Carmel River, California

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Executive Summary

Los Padres Reservoir is a surface water storage facility located in the headwaters of the Carmel River Watershed. A bathymetric and topographic survey was conducted on November 5, 2008 to capture a snapshot of the reservoir capacity. The survey comprised multi-beam sonar soundings below the water line and laser scanning above the water. We report reservoir capacity of 1786 acre-feet (af), and a surface area of 49.8 acres, at a water stage of 1040 ft. This 2008 capacity calculation is higher than the capacity estimate from a survey conducted in 1998. In the absence of dredging, reservoir capacity cannot increase through time. Given the high precision of the 2008 survey, we believe that the 1998 survey erroneously underestimated the true 1998 capacity, perhaps because lead-line technology under-samples the bathymetry.

This survey acts as a baseline condition from which to accurately measure future reservoir changes. Rapid siltation and delta growth are anticipated in the years following the "Basin-Complex" fire of summer 2008. We recommend performing annual repeat surveys following the 2008-09 storm season to capture the immediate and longer-term impacts of the Basin Complex Fire.

This work was funded by contracts between the Monterey Peninsula Water Management District and 1) the University Corporation of CSU Monterey Bay and 2) Moss Landing Marine Laboratories.

This report may be cited as:

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Table of Contents

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1 Introduction

1.1 Background

Los Padres Reservoir stores surface water flowing from the upper watershed of the Carmel River in Monterey County, California (Fig. 1). A series of reservoir surveys has shown the volume of the reservoir gradually diminishing through sediment trapping (Figure 2). This report provides a fall 2008 volume estimate for the reservoir and a new volume-stage relationship.

The watershed above Los Padres Reservoir is approximately 28,700 acres (Fig. 1), and is underlain by highly erodible bedrock (Fig. 3). The watershed was burned during the summer 2008 Basin-Complex fire, leading to speculation that winter rains of 2008-2009 would lead to accelerated erosion and reservoir filling. The objectives of the 2008 survey are to:

- produce an accurate estimate of reservoir volume using high-precision bathymetry and terrestrial survey, and
- compare the present volume with past estimates in order to assess the general changes in volume.

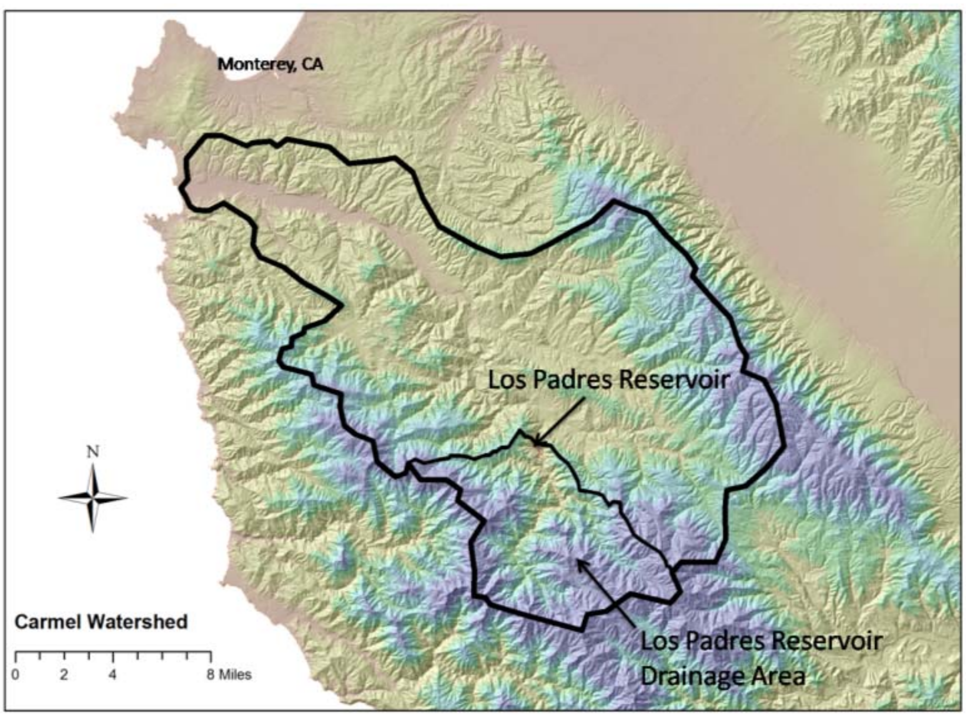


Figure 1: Study area location.

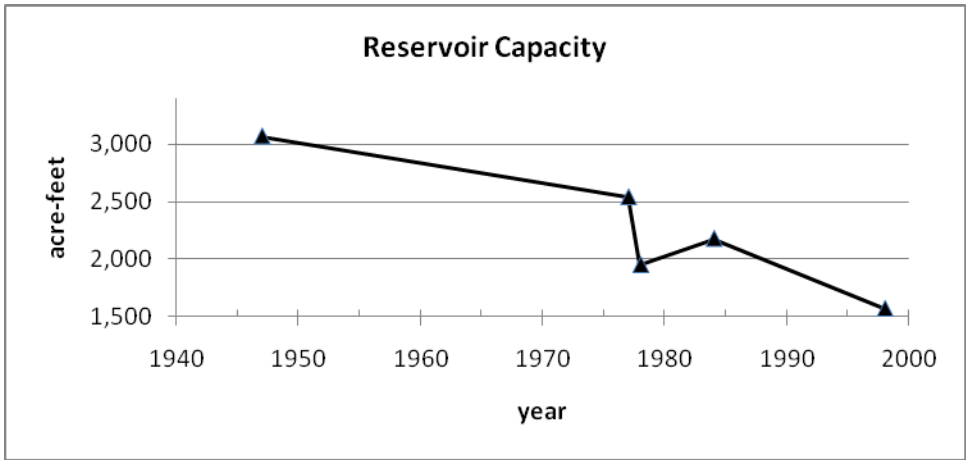


Figure 2: Capacity of Los Padres reservoir from 1946 construction through 1998 survey. Sudden drop in capacity in 1978 is the result of the Marble-Cone Fire. Increased capacity in 1984 is from sediment removal. Data summary from Monterey Peninsula Water Management District.

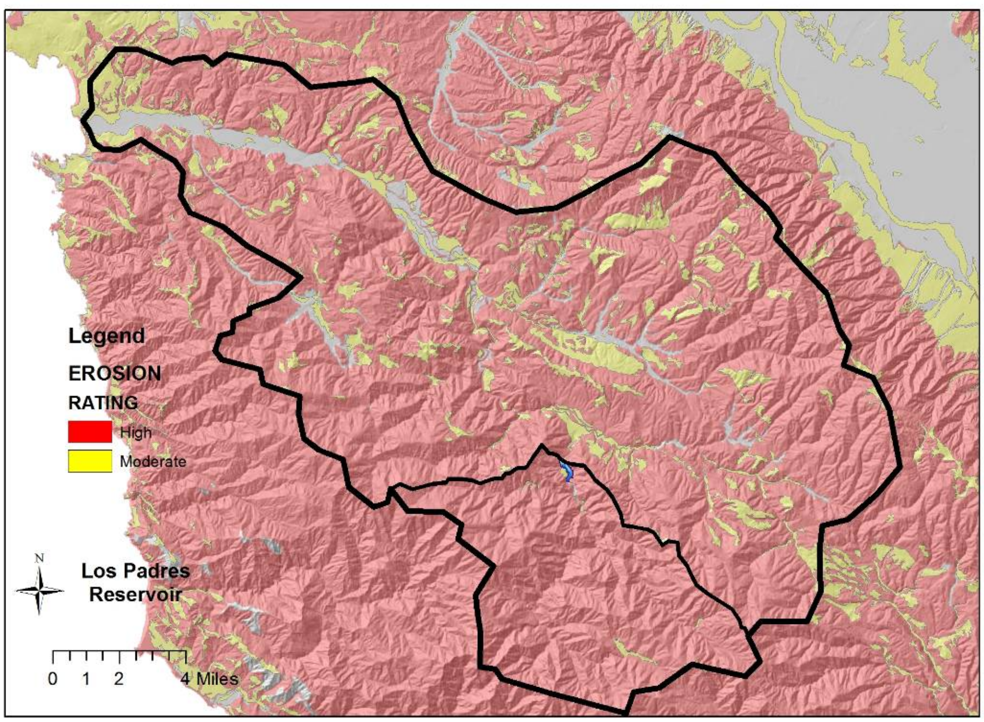


Figure 3: Erosion potential of geologic substrate in the region of the Carmel River watershed. Erosion data from Rosenberg (2001).

1.2 Basin Complex Fire and Debris-Flow Hazard

Figure 4 and Table 1 show the burn severity distribution in the Basin Complex Fire in the land draining to the Los Padres Reservoir. Cannon et al., (in press) have found that the moderate-to-high burn severity areas generate the majority of debris flows during post-fire rains events; 30% of the watershed falls in that category.

Table 1: Burn Severity in the Los Padres Reservoir watershed (GIS data from USDA (2008))

Burn Severity	Area (acres)	Watershed area %
Moderate	10653	37%
High	3061	11%
Moderate + High	13700	48%

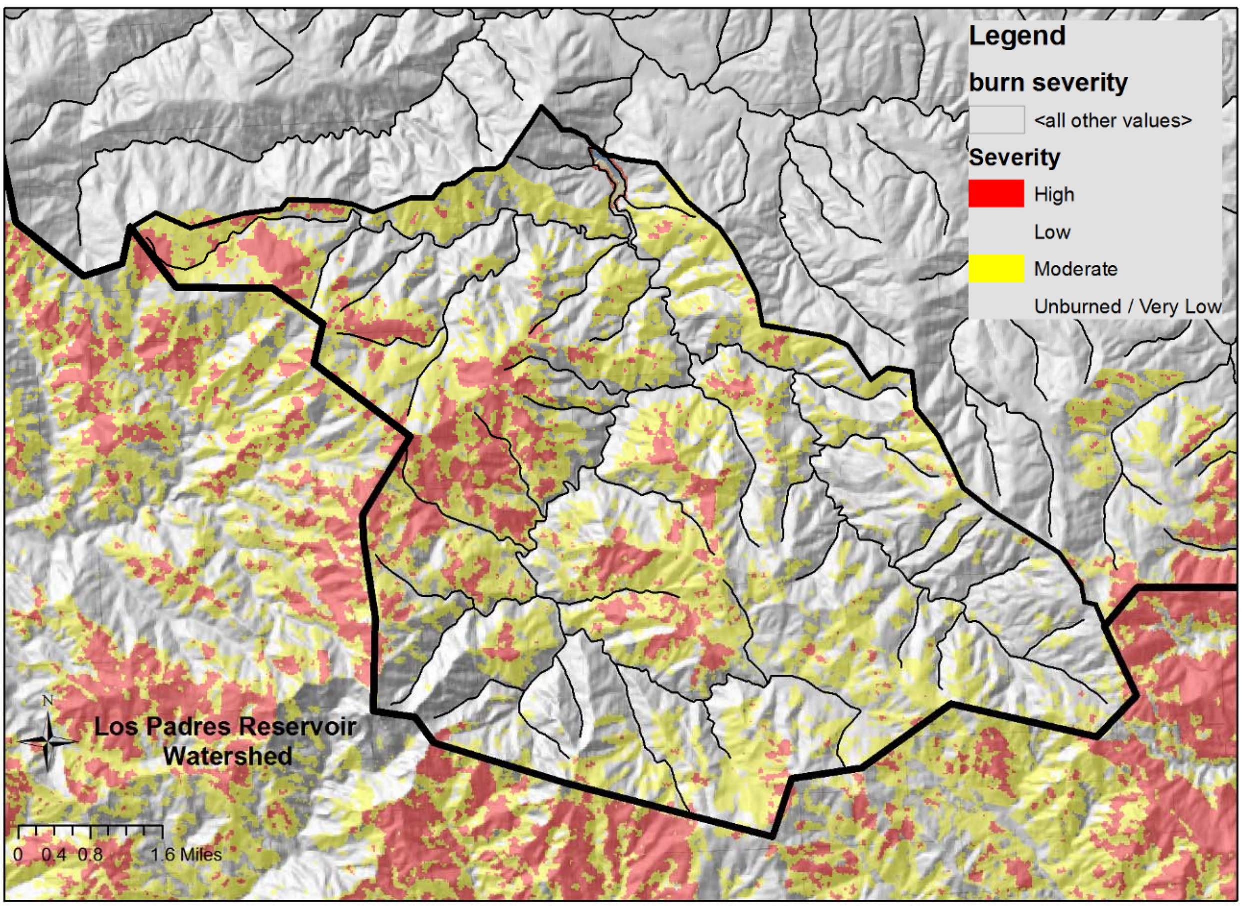


Figure 4: Distribution of Basin-Complex fire intensity in the watershed above Los Padres Reservoir. Red is high intensity; yellow is moderate intensity. Los Padres Reservoir is blue. Data from USDA.

Sediment erosion rates are typically elevated following fires. Debris flows are the greatest potential source of reservoir-filling sediment in the steep erodible sub-watersheds above Los Padres Reservoir. The elevated risk of slope failure and debris-flow generation diminishes in the first few years following a fire. Hecht (1981) found that stream channels above Los Padres Reservoir regained their original morphology within three years following the Marble Cone fire. Both debris-flow generation and stream recovery may have been amplified and accelerated by the heavy winter rains on the portion of the watershed burned in the Marble Cone fire.

Debris flow risk has been modeled in other parts of the country with reasonable success (Cannon et al. in press). Cannon (2008) modeled the debris flow probability and volume of over 850 sub-watersheds of the Basin Complex fire. The modeled triggering event was a 10-year, 3 hour duration storm delivering about 0.6 in/hr intensity. Cannon estimated both the % chance of debris flow generation and the approximate volume of the debris flow for each sub-watershed. A "Combined Relative Hazard Ranking" that uses both probability and volume provides a single number of relative risk for each basin. The numbers range from 0 to 9, with 9 representing the riskiest combination of flow probability and debris volume.

Cannon (personal communication, 2008) supplied model data in GIS format so that we could illustrate risks within sub-regions of the Basin Complex Fire perimeter. Table 2 and Figure 5 show the combined hazard index above the Los Padres Reservoir. 54% of the watershed has a ranking of 7 or above. The model figures might underestimate the true risk because the region is underlain by naturally weak substrate of the northern Santa Lucia Range (Fig. 3).

Increased soil loss and increased debris flow frequency can persist for up to three years following watershed fire events (Cannon 2008; Cannon et al., in press). We provide a baseline study from which to calculate the reservoir capacity reduction anticipated to occur in the years following the Basin-Complex fire.

Table 2: Debris Flow Risk in the Carmel River Watershed (GIS data from Cannon (2008); Risk method from Cannon et al. (in press)).

Combined relative Hazard Ranking (Fig. 5)	Volume (m^3)	% chance of event	Number of sub-basins	Area (acres)	Watershed area %
7	1,001-10,000	>80%	77	6610	14%
8	10,001 - 100,000	>80%	26	18170	40%
			Total area	24779	54%

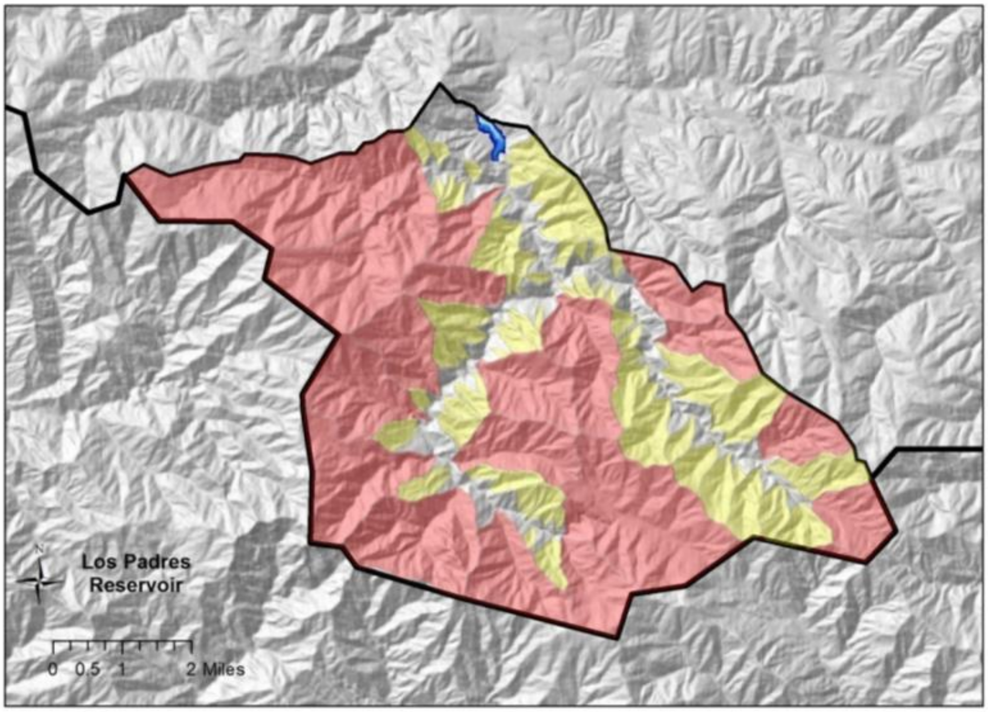


Figure 5: "Combined Relative Hazard Ranking" index of debris-flow hazard in the watershed above Los Padres Reservoir. Yellow is an index of 7; red is index of 8. Los Padres Reservoir is blue. Debris flow hazard data from Cannon 2008).

2 Methods

2.1 Goals and Approach

The primary goal of our work is to produce an accurate estimate of the volume of the reservoir at various stages. We combined geospatial data from the following sources to produce a high-resolution bathymetric model of the reservoir.

1. Shore-based GPS station
2. Vessel-mounted high-frequency interferometric sidescan sonar bathymetry for subaqueous soundings
3. Vessel-mounted terrestrial LiDAR scanner for the portion of the reservoir above the water line
4. Tripod-based total station to fill in data gaps and establish vertical framework adjustments

Hydrographic and LiDAR data were collected on November 5, 2008 under clear skies with light wind. The data were cleaned and combined using standard hydrographic software (Caris Hips, Fledermaus, ArcGIS) to produce a "bare-earth" digital elevation model of the reservoir that extends several meters above the present spillway elevation.

Those data were augmented by shore-based scanning total station data described in a separate report from Moss Landing Marine Laboratories.

2.2 Positioning

The bench mark for the 2008 survey data is a large hex head bolt set in concrete with a small hole drilled off-center in its top. The small drill hole is the reference position for vertical and horizontal surveys. The benchmark is located near the boat ramp on the east side of the dam (Figs. 6 and 7).

Figure 6: General location of SFML benchmark (arrow), located below GPS antenna and positioning base station. See Figure 7 for benchmark detail.

Figure 7: SFML benchmark showing drill hole used as horizontal and vertical reference.

The multi-hour, time-averaged GPS position of the benchmark is:
UTM WGS-84 Zone 10
Easting [meters] 619388.986
Northing [meters] 4027605.397

NAVD 88 (Computed using GEOID03)
Elevation [meters] 322.418

The L1/L2 static GPS data was collected at 1hz over a 7.3 h period with a Trimble NetR5 survey grade receiver and Zephyr GNSS Model 2 geodetic antenna (sn 55971.00). These data were processed using the National Geodetic Survey (NGS) Static Online Positioning User Service (OPS) at: http://www.ngs.noaa.gov/OPUS/. (See appendix B for OPUS solution.)
In practice, such measurements are repeatable to within 0.01 m.

2.3 Multibeam Bathymetry

A SwathPlus interferometric sidescan sonar bathymetry system was used to obtain soundings throughout the wetted part of the reservoir, as close as safe navigation would allow (Fig. 8). This system obtained bank to bank coverage of the entire wetted area except for a narrow band in front of the shallow delta at the extreme upper end where water depths of < 0.50 m restricted boat access. The sonar system was used to gather millions of individual depth soundings of the reservoir. Each sounding was precisely located to geographic xyz coordinates using onboard GPS, a highly accurate attitude sensing system (Aplannix POS/MV 320v4), and post-processing using the base station on shore. Each sounding has a vertical precision of approximately 0.2 m (Fig. 9). These soundings were cleaned by hand in Fledermaus software to remove outliers and soundings associated with subaqueous snags and vegetation.

Figure 8: Photo from instrumented survey vessel to spillway crest.

The remaining high-quality soundings were averaged into a 1 m X 1 m grid in IVS Fledermaus for further geospatial analysis in ArcGIS. Each grid node elevation results from averaging a great number of nearby independent soundings, so the grid vertical precision is higher than the precision of individual soundings. The resulting grid represents the equivalent of 201,052 lead-line soundings, one sounding every 1 m, across the entire reservoir bottom.

2.4 LiDAR

A Reigl LMS-Z420i mobile laser scanning system was used to capture millions of individual laser returns from the subaerial part of the reservoir that was visible by boat. The system is designed to be used on a moving platform (such as a boat) via supplemental position (GPS) and attitude (IMU) sensors. The system is configured to achieve decimeter accuracy with sub-meter resolution at a 1 kilometer range. These data were merged with the bathymetry data following the same quality-control procedures that removed both spurious data and vegetation.

A detailed view of the merged LiDAR and sonar data shows that the two independent data sets match very well at the shoreline (Fig. 9), providing a high degree of confidence in geographic positioning and elevation soundings.

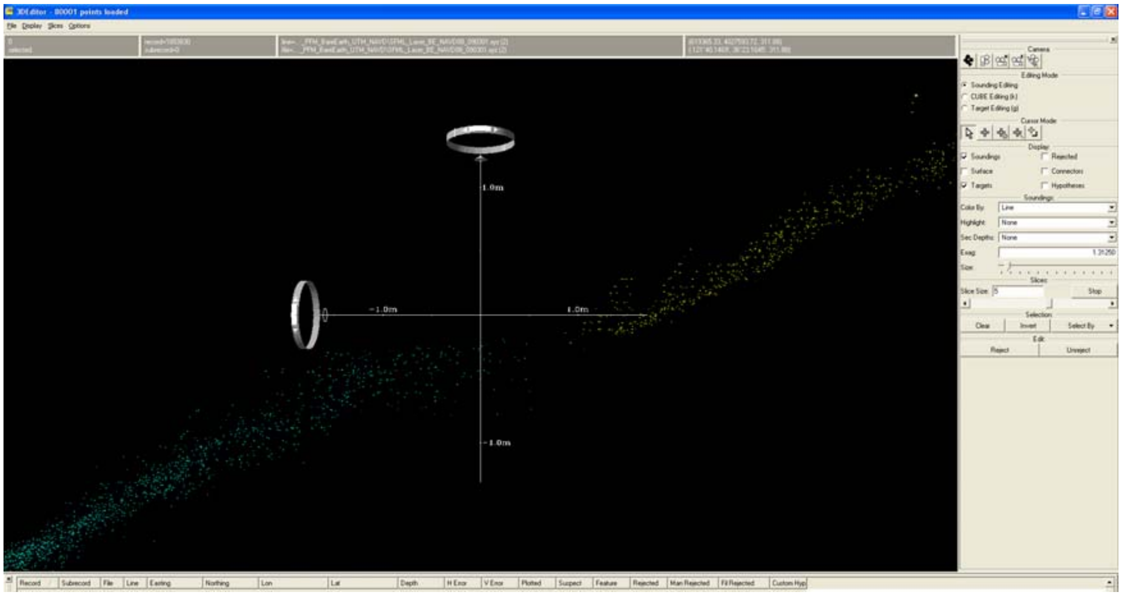


Figure 9: Screen grab from Fledermaus shows a vertical cross section through the raw soundings (blue) and subaerial laser returns (yellow) where they meet at the shoreline (approximately in center of image). Tick marks on vertical and horizontal axes are 1.0 m. The image illustrates the typical high data density within a small region of the reservoir. Vertical scatter of points represents precision of individual soundings (approximately 0.2 m). Averaging the data on a scale of 1 m produces a grid of well-defined elevation nodes throughout the reservoir.

2.5 Land-based Total Station

Moss Landing Marine Laboratories provided data collected by a robotic, automated Trimble VX Spatial Station c, based upon the SFML benchmark described above. Data from that system did not precisely align with the vessel-collected data, but several data holes were filled using carefully-selected points and point clouds.

2.6 Data Processing

Approximately 5 million individual xyz soundings from vessel-mounted and land-based systems were combined into one 1 m X 1 m grid file using the Fledermaus avggrid program. Remaining data gaps were filled using interpolation in the Fledermaus “DMagic” program. Interpolation was guided by the judicious addition of synthetic soundings. Textured and colored oblique images of the reservoir model were created in Fledermaus. A final ASCII ArcGIS elevation grid was exported from D-Magic for analysis in ArcGIS. The ASCII grid was converted to a floating point raster and projected to UTM WGS-84 zone 10 in ArcMap.

Contour maps and maps with regional context were created in ArcMap. Volume and surface area calculations were made at a variety of elevations using 3D analyst tools in ArcMap.

2.7 Vertical Adjustments

The elevations determined in the survey were vertically shifted to align with previous surveys of the reservoir. This vertical shift does not correspond to a simple geodetic conversion between NAVD-88 (GEIOD03) used in our survey and NAVD-1929, the putative datum for prior reservoir surveys. A simple conversion between datums would call for us to lower our survey elevations by 0.894 m (2.93 ft). However, the surveyed difference in elevations is 0.773 m (2.54 ft). The discrepancy indicates that either the previously used benchmarks, or the present survey is not true to its stated datum. We adjusted the digital elevation model by 2.54 ft to align with previous reservoir surveys.

Given the above vertical adjustment, and recent surveys of the edge of the spillway crest,, a water stage of 1040.00 ft is approximately 0.22 ft above the crest of the spillway, and 1.1 ft above the bottom of the notch in the spillway (Fig. 10). Previous surveys may have made that same estimate. Alternatively, previous surveyors may have called the elevation of the spillway crest “1040 ft,” with the attendant low precision correctly implied by the lower number of significant digits. The “full” reservoir volume is significantly different at these different representative stages (1040.00, spillway crest, notch). We have provided reservoir capacity results for all three “full” stages.

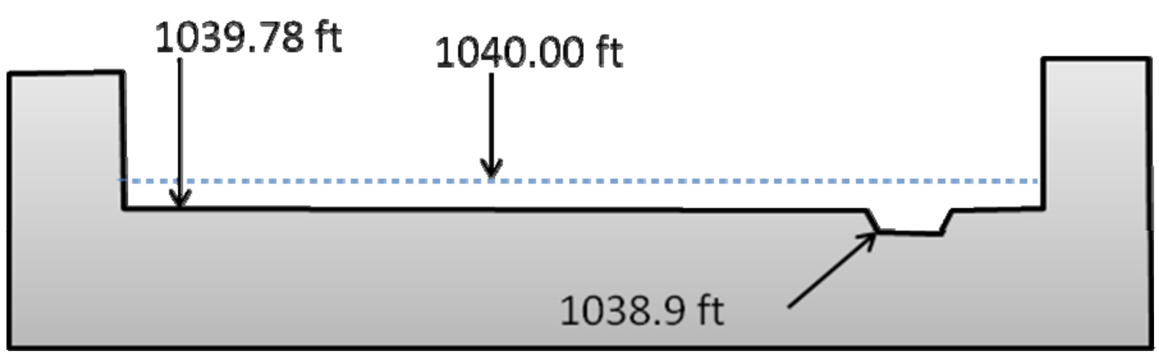


Figure 10: Schematic illustration of the three “full” elevations on Los Padres dam.

2.8 Technology Comparison

Differences between historic volumes and the 2008 survey may arise from real differences, or differences in survey technology. Because we have digitized the entire reservoir, we have the luxury of sub-sampling the digital data in a simulation of lead-line survey technology. This work was accomplished by georeferencing the transect positions from the 1998 lead-line survey (Fig. 11) so that the 1998 transect positions could guide a simulated lead-line survey through the 2008 data. A synthetic sounding was taken at the two shoreline positions of each transect and at intervals of approximately 60 to 75 ft along the transects. This sparse subsampling of bathymetry was used to generate a 3 m grid of elevations in ArcMap. Reservoir volume calculations were made using this grid. And the results were compared to the more accurate assessment using the entire data set.

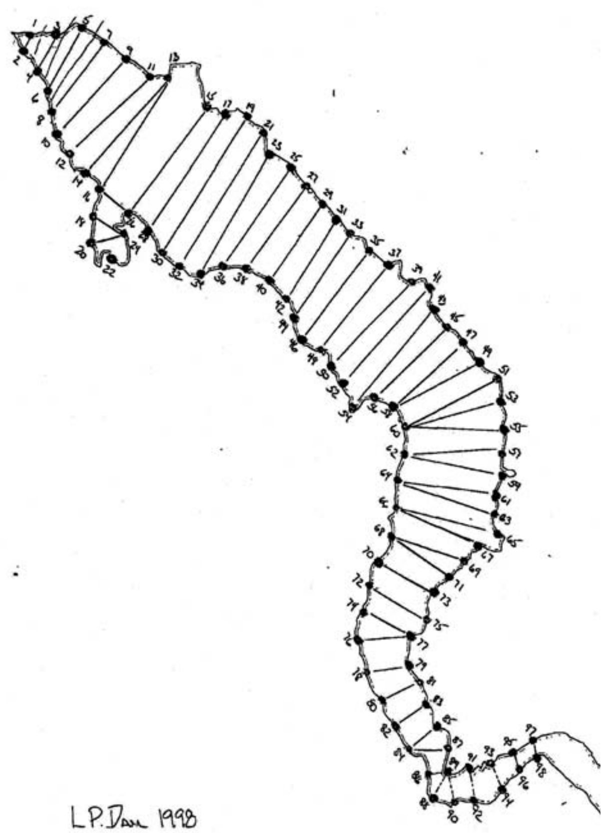


Figure 11: 1998 sounding transect positions (Los Padres Silt Study, California American Water, 1999)

2.9 Horizontal and Vertical Precision and Accuracy

According to OPUS processing (Appendix B) the RMS error on base station positioning was 0.009 m. This result is in keeping with our past experience using multi-hour GPS averaging. The accuracy of the positioning is based upon several factors including the quality of the GEOID-03 conversion to NAVD 88 vertical reference.

3 Results

3.1 Digital Elevation Model of Los Padres Reservoir

This project includes several electronic files that can be used in further analysis and for creating a variety of terrain views (e.g., Figs. 12 through 15).

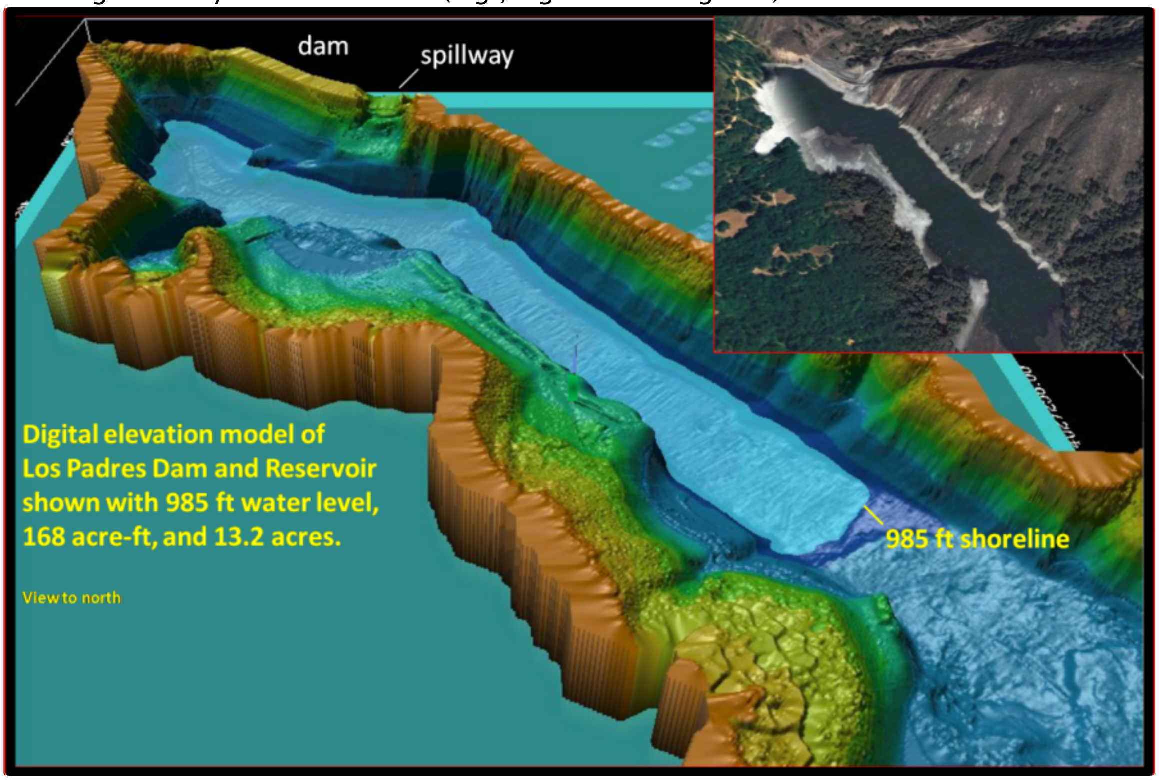


Figure 12: Fall 2008 colored hillshade of digital elevation model of Los Padres Reservoir filled to 985 ft. Rendering has 2X vertical exaggeration.

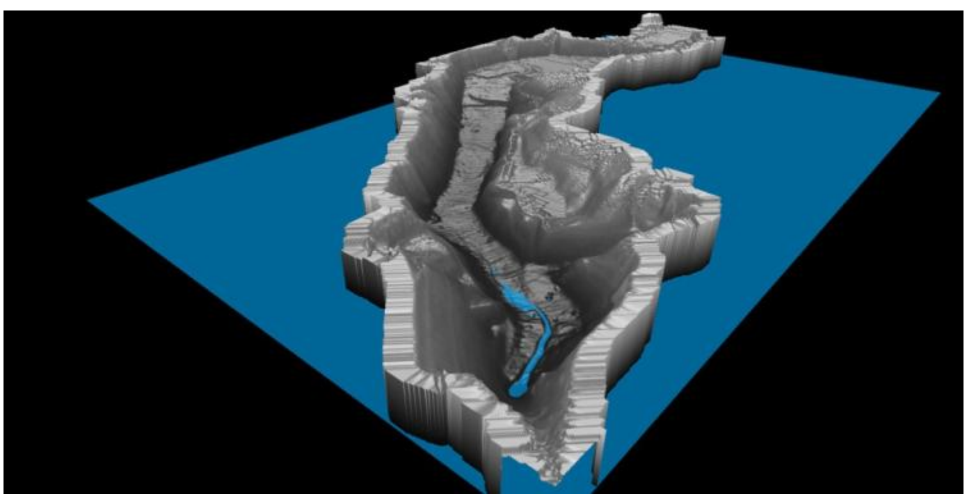


Figure 13:Hillshade of digital elevation model with water surface elevation of 965 ft (blue). Rendering has 2X vertical exaggeration with oblique southern perspective.

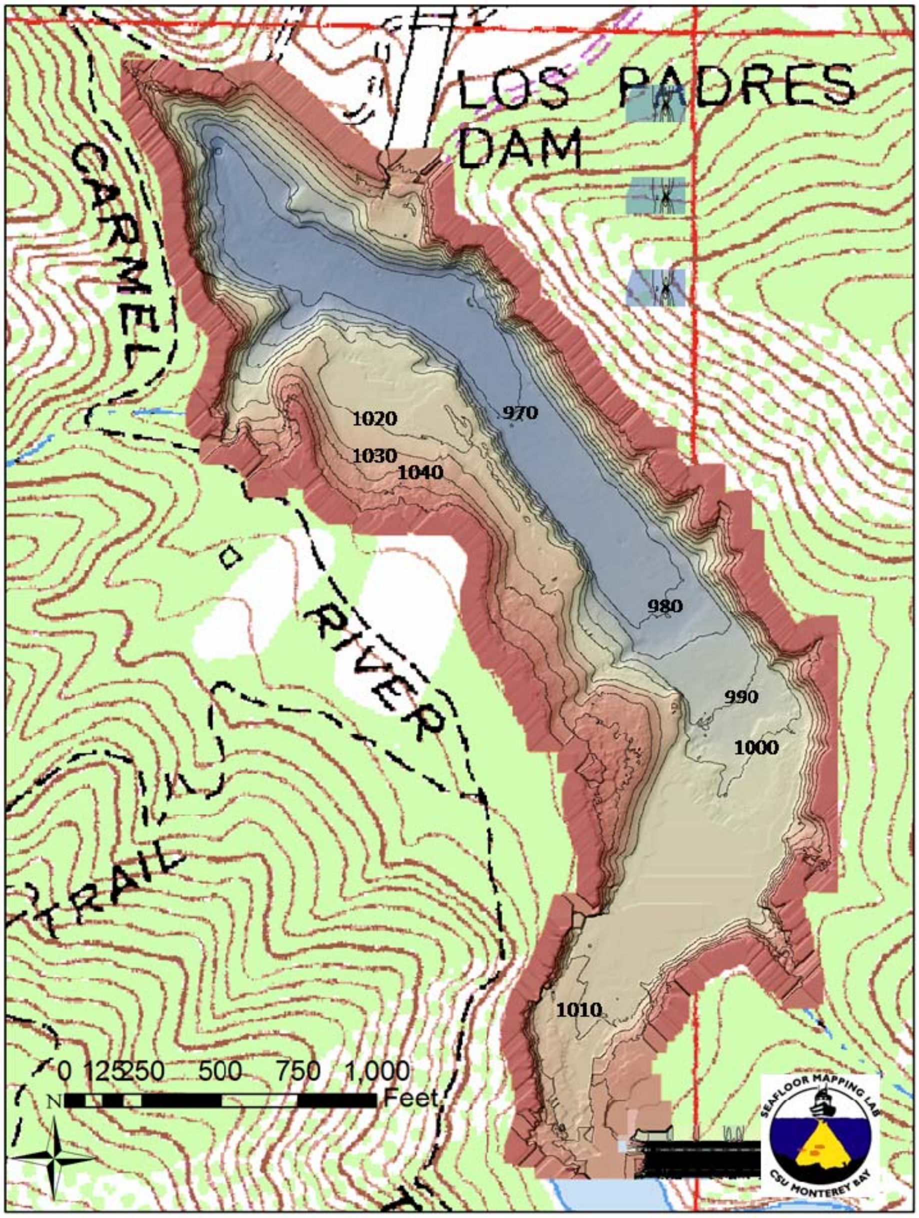


Figure 14: Topographic contours shown on hillshade of digital elevation model. Contour interval 10 ft, starting at 960 ft.

Digital elevation models can be used for reconnaissance inspection of dam-face integrity in reservoirs where draw-down does not expose the dam toe (Fig 15).

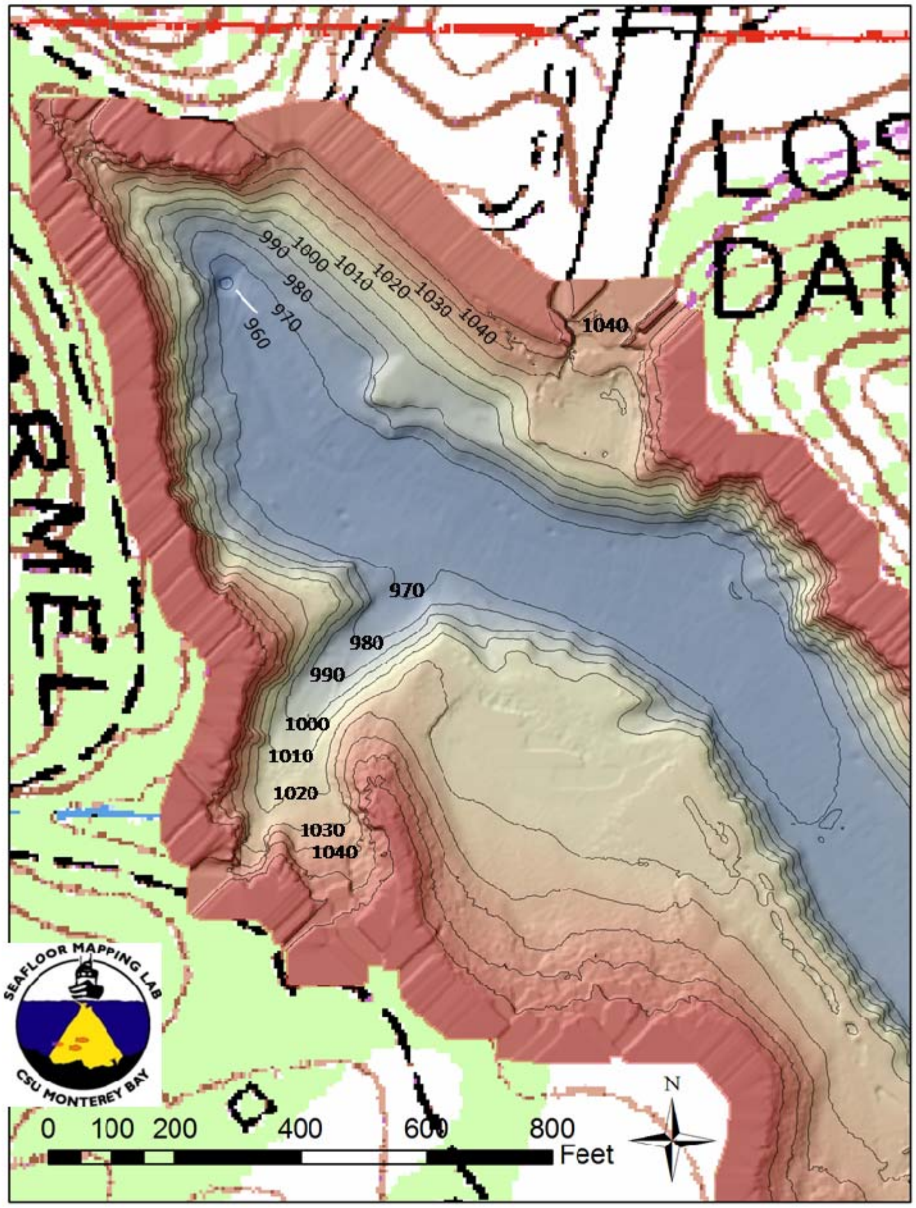


Figure 15: Detailed view of interior dam face and toe.

3.2 Reservoir Capacity in fall 2008

Reservoir volume and surface area calculations were made using the "surface volume" tool in ArcMap (Table 3; Fig. 16). These results provide an accurate base-line for measuring future change.

Table 3: Capacity of Los Padres Reservoir

Stage (ft)	Volume (acre-ft)	Area (acres)	Note
960	0	0.02	
965	0	0.3	
970	17	5.8	
975	54	8.8	
980	105	11.7	
985	168	13.2	
990	238	14.6	
995	315	16.5	
1000	403	18.6	
1005	501	20.6	
1010	608	22.6	
1015	734	30.2	
1020	903	37.2	
1025	1100	41.3	
1030	1316	44.5	
1035	1544	46.9	
1038.90	1731	48.9	notch elevation
1039.78	1774	49.7	spillway elevation
1040.00	1786	49.8	

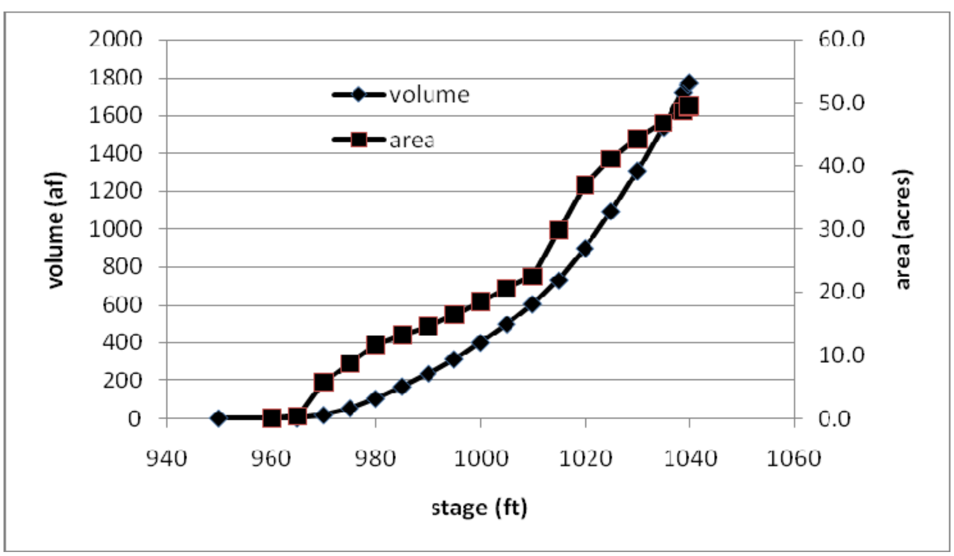


Figure 16: Fall 2008 stage, area, and volume in Los Padres Reservoir

3.3 Past Surveys

3.3.1 Historic Capacity Trends

The historic survey data for the Los Padres Reservoir includes the "as-built" estimate of initial volume in 1947, and five subsequent "lead-line" bathymetric surveys, with the most recent survey in 1998 (Table 4; Fig. 2). This project adds the most recent volume estimate using modern sonar and laser equipment (Table 3 and 4).

Table 4: Los Padres Reservoir capacity (1040 ft). Historic data provided by Larry Hampson, 2008.

Year	1947	1977	1978	1984[a]	*1998* [b]	2008
Capacity (acre-ft)	3070	2540	1950	2179[a]	*1569* [b]	1785

a) Increase in capacity between 1978 and 1984 is by sediment removal.
b) Discussion below suggests that data from the 1998 survey are suspect.

According to available data, Los Padres Reservoir lost approximately 610 acre-ft (44 af/yr) capacity between 1984 and 1998, years without major fire impacts (Fig. 2; Table 4). Based upon that historic data, we would anticipate approximately 440 acre-ft capacity loss, rather than the 216 acre-ft capacity gain between 1998 and 2008 (Table 4). Although the Kirk-Complex fire (1999) burned through a significant portion of the watershed above Los Padres Reservoir (primarily in the Miller Fork watershed), the burn intensity was low relative to both the Marble-Cone and Basin Complex fires. Furthermore, according to the observations of local resource managers, little or no fire impacts were realized between 1998 and the 2008 survey[1], so we might anticipate lower than average capacity loss during that span. Nevertheless, given the typical monotonic trend for reservoirs to diminish in volume with time, the increase in volume indicated between 1998 and 2008 cannot be real. The reservoir was not dredged in the last decade, so the differences might be influenced by differences in technology or questionable surveys that led to underestimated capacity in 1998.

[1] Don Lingenfelter, the dam tender for California American Water, stated that he observed little or no sediment deposition in Los Padres Reservoir after 1998 (interview with Larry Hampson, MPWMD, March 27, 2009). Similarly, Greg James, MPWMD Senior Hydrographer, noted that the channel in the vicinity of the MPWMD gaging station on the main stem above Los Padres Reservoir changed little during the same time period (interview with Larry Hampson, MPMWD, May 5, 2009).

3.3.2 *Synthetic Lead-line Surveys*

We synthesized lead-line sounding surveys to assess the possibility that lead-line surveying can underestimate reservoir volume estimates. We synthesized lead-sounding surveys by sub-sampling the 2008 high-resolution bathymetry (Fig. 17; Table 5). It is apparent that the lead-line subsampling overestimates depth (and therefore volume) in some areas and underestimates it in others (Fig. 17), but the net result is a loss of cross sectional area with fewer soundings.

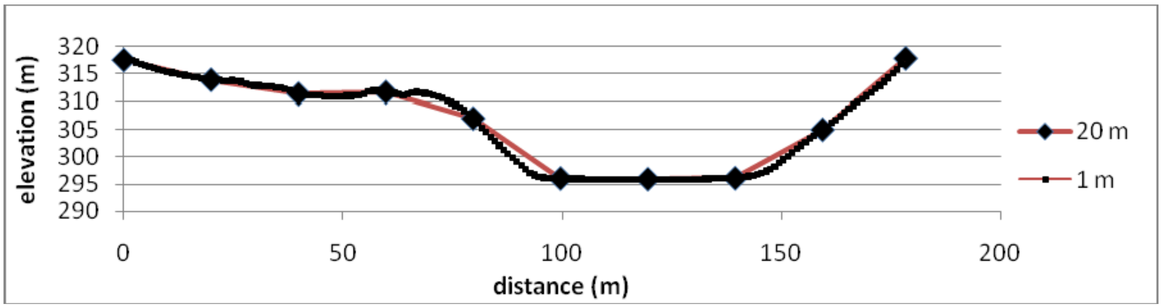


Figure 17: Cross section of 1998 transect line 25-36 (Fig. 11) plotted using 1 m spacing (small symbols) and 20 m spacing (larger symbols). See Table 5 for comparison of cross sectional area.

Table 5: Cross sectional area as a function of sounding spacing along transect 25-36. See Figure 17 for reference.

Sounding spacing (m)	Soundings used	Cross- sectional area (m^2)	Cross- sectional area (ft^2)
1	178	2115	22770
20	8	2071	22290

Figure 18 shows the site-specific elevation difference between surveys when the entire set of 1998 survey transects (Fig. 11) were used to resample the full 2008 bathymetric model at an average sounding spacing of 20 m.

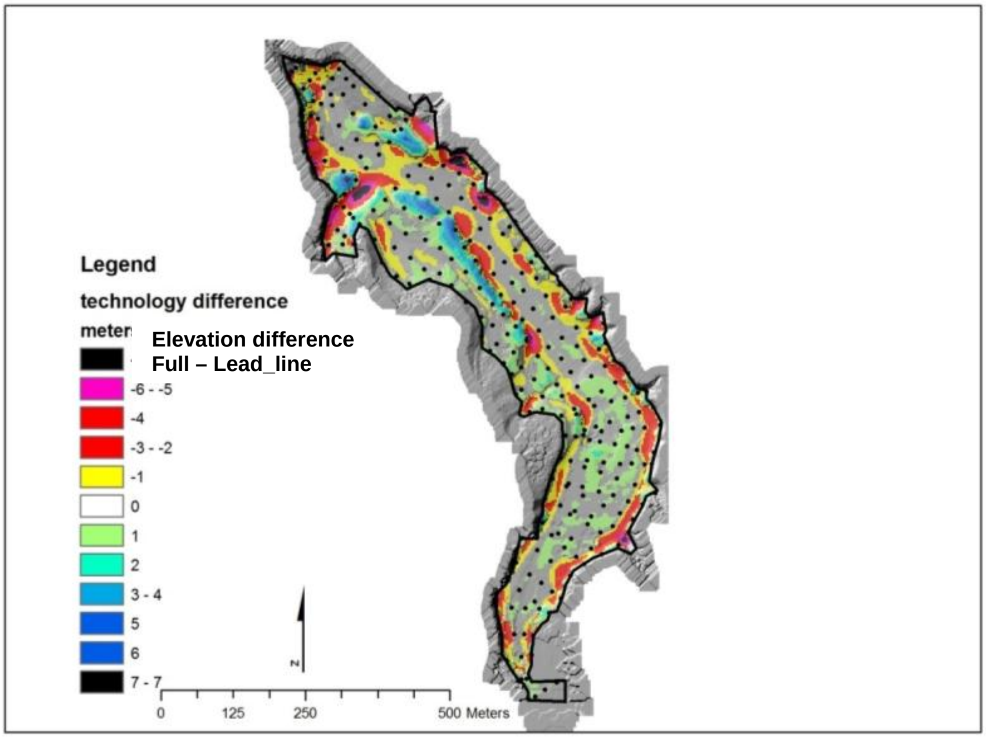


Figure 18: Elevation differences between full 2008 survey and synthetic lead-line survey through 2008 bathymetric data. Warm colors indicate regions where lead-line survey underestimated elevation (volume); cool colors are regions where lead-line survey overestimated elevation (volume); black dots are synthetic lead-line soundings aligned with 1998 transects (Fig.11).

The resulting total synthetic lead-line survey yielded an a 1040.00 ft stage capacity of 1660 acre-ft, 126 acre-ft fewer than the high resolution 2008 survey (Table 3). It is clear that greater and lesser differences would result from using different sub-sampling strategies.

Finally, four reservoir-wide synthetic surveys were performed to assess the more general effect of sparse soundings. When the total number of soundings used in synthetic lead-line transects is reduced, the resulting 1040.00 ft stage capacity is reduced as well (Fig. 19). A sharp reduction in apparent capacity was found when there were fewer than approximately 280 soundings used. The paradoxical rise in reservoir capacity between 1998 and 2008 can be explained by a difference in technology if the 1998 survey employed fewer than 200 soundings (Fig. 19), or if the 1998 survey was flawed for some other reason. The 2008 survey provides a new level of accuracy for future comparisons.

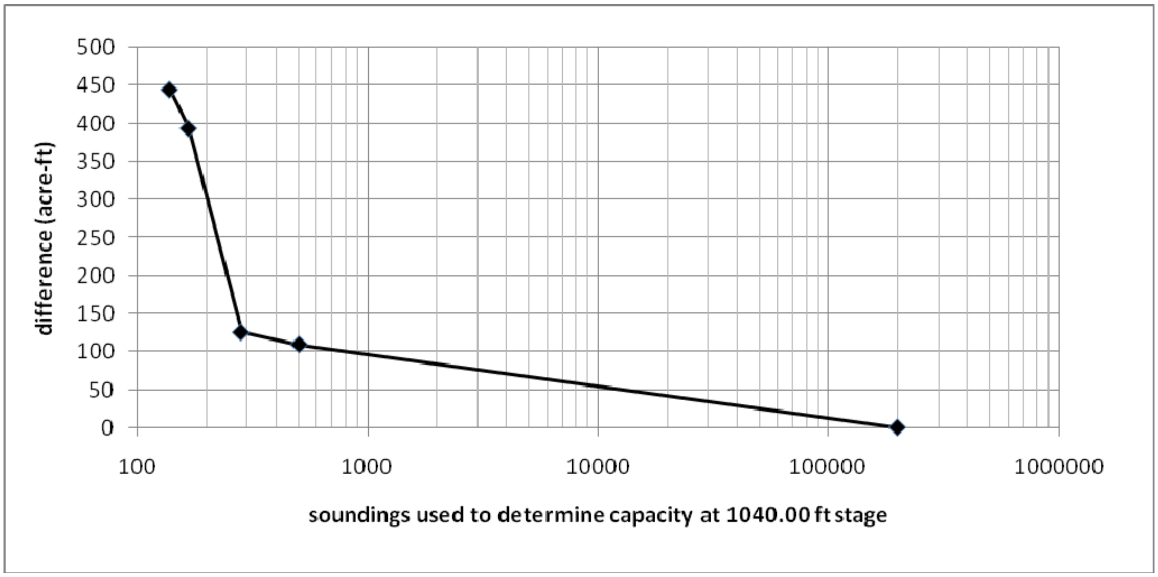


Figure 19: Difference from fall 2008 capacity as a function of number of soundings used to survey the reservoir.

3.3.3 Spillway Elevation

In past studies, "1040 ft" is the highest water surface elevation for which volume is computed. The spillway and water surface elevations from past surveys are referenced to a local benchmark presumed to be at an elevation of 1059.3 (APPENDIX A). Our assumed vertical datum for that elevation is National Geodetic Vertical Datum of 1929 (NGVD 29). A recent resurvey of the spillway, using the same reference benchmarks as the historic surveys, indicates that the actual spillway crest is lower than 1040.00 ft. The general spillway crest is approximately 1039.78 ft, and the bottom of a notch cut into the spillway is 1038.90 ft (Fig. 10). This discrepancy leaves at least two interpretations of the maximum volume reported in previous studies. Either the highest volumes are overestimates of the non-spilling volume of the reservoir, or the crest elevation was rounded to 1040 ft, with a lower implied precision. Each tenth of a foot stage difference, in the vicinity of 1040 ft, corresponds to a volume estimate difference of over 4.5 acre-ft. The stage difference between 1040.00 ft and the actual spillway crest corresponds to a capacity difference of 12 acre-ft. The stage difference between 1040.00 ft and the notch corresponds to capacity differences of 43 acre-ft.

4 References

California American Water, 1999, 1998 Los Padres Silt Study Summary, 4 pp.

Cannon, S.H. (2008) Geologic Hazards Team. Letter to Monterey County Office of Emergency Services, Rob Clyburn.

Cannon, S.H., Gartner, M.G., Rupert, M.G., Michael, J.A., Rea, A.H., Parrett, C. (in press) Predicting the probability and volume of post-wildfire debris flows in the intermountain Western U.S. : Bulletin of the Geological Society of America.

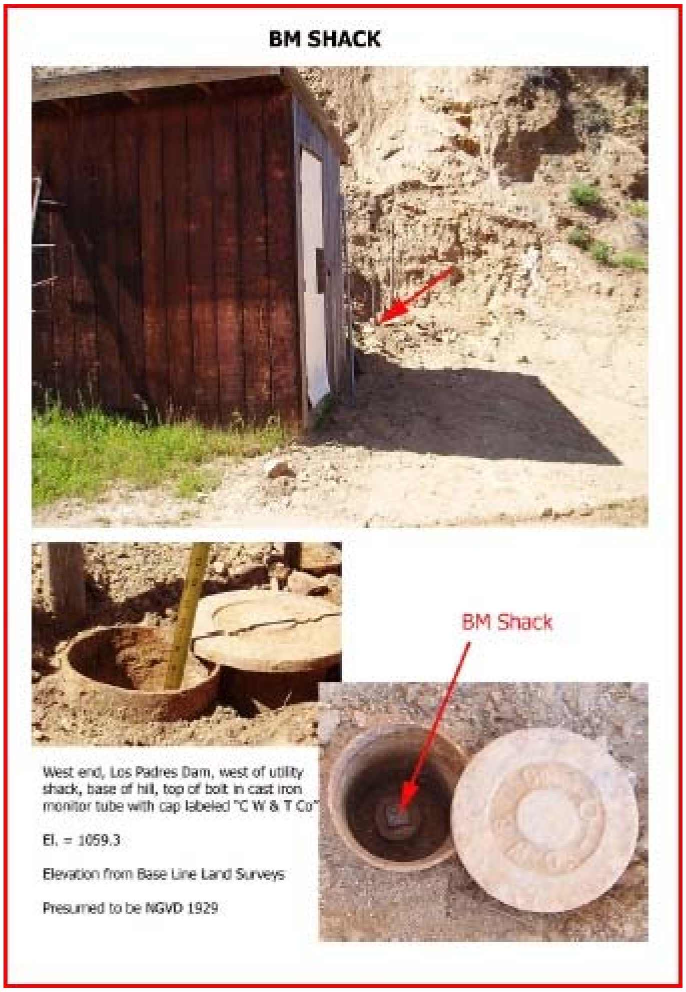
Hecht, B. (1981) Sequential changes in bed habitat conditions in the upper Carmel River following the Marble-Cone fire of August 1977, in Warner, R.E. and Hendrix, K.M., eds., California riparian systems: ecology, conservation and productive management. University of California Press, 134-141.

Rosenberg, L. 2001. Geologic resources and constraints Monterey county California. County of Monterey Environmental Resource Policy Department.

[USDA] United States Department of Agriculture United States Forest Service. Los Padres National Forest. (2008) Executive Summary: Basin Complex Fire/Indians Fire BAER Initial Assessment. Internet Resource: www.fs.fed.us/r5/lospadres/fire/baer/gallery/basin-indian-baer-initial.pdf

5 APPENDIX A

Survey field notes of Larry Hampson (MPWMD) from March 27, 2009. BM Shack was used to shift the 2008 bathymetric survey to the reference frame of Los Padres Reservoir stage.



6 APPENDIX B

National Geodetic Survey On-line Positioning User Service solution report for the SFML benchmark used to survey the reservoir in 2008

- FILE: 4819K55871200811051640.08o 000465967
-
- NGS OPUS SOLUTION REPORT
- ========================
-
- All computed coordinate accuracies are listed as peak-to-peak values.
- For additional information: www.ngs.noaa.gov/OPUS/Using_OPUS.html#accuracy
-
- USER: rikk_kvitek@csumb.edu DATE: November 06, 2008
- RINEX FILE: 4819310q.08o TIME: 20:02:35 UTC
-
-
- SOFTWARE: page5 0810.20 master12.pl 081023 START: 2008/11/05 16:40:00
- EPHEMERIS: igr15043.eph [rapid] STOP: 2008/11/05 23:59:00
- NAV FILE: brdc3100.08n OBS USED: 16298 / 16345 : 100%
- ANT NAME: TRM55971.00 NONE # FIXED AMB: 46 / 51 : 90%
- ARP HEIGHT: 1.114 OVERALL RMS: 0.009(m)
-
-
- REF FRAME: NAD_83(CORS96)(EPOCH:2002.0000) ITRF00 (EPOCH:2008.8466)
-
- X: -2699033.367(m) 0.015(m) -2699034.209(m) 0.015(m)
- Y: -4375426.494(m) 0.018(m) -4375424.986(m) 0.018(m)
- Z: 3762945.597(m) 0.021(m) 3762945.762(m) 0.021(m)
-
- LAT: 36 23 10.23945 0.023(m) 36 23 10.25996 0.023(m)
- E LON: 238 19 52.14169 0.019(m) 238 19 52.08118 0.019(m)
- W LON: 121 40 7.85831 0.019(m) 121 40 7.91882 0.019(m)
- EL HGT: 289.372(m) 0.008(m) 288.793(m) 0.008(m)
- ORTHO HGT: 322.418(m) 0.105(m) [NAVD88 (Computed using GEOID03)]
-
- UTM COORDINATES STATE PLANE COORDINATES
- UTM (Zone 10) SPC (0404 CA 4)
- Northing (Y) [meters] 4027605.397 620151.628
- Easting (X) [meters] 619388.986 1760588.267
- Convergence [degrees] 0.78976463 -1.59220133
- Point Scale 0.99977562 0.99994946
- Combined Factor 0.99973021 0.99990405
-

- US NATIONAL GRID DESIGNATOR: 10SFF1938927605(NAD 83)
-
-
-
- BASE STATIONS USED
- PID DESIGNATION LATITUDE LONGITUDE DISTANCE(m)
- DH3876 P171 SANTALUCIACN2004 CORS ARP N362907.865 W1214733.006 15638.4
- DI7526 P210 ELKHRNSLGHCN2005 CORS ARP N364858.073 W1214354.570 48045.5
- DH7214 P284 AVILARANCHCN2005 CORS ARP N355559.715 W1205424.579 85018.3
-
- NEAREST NGS PUBLISHED CONTROL POINT
- GU3700 TULARCITOS N362524.930 W1213931.424 4262.5
-
- This position and the above vector components were computed without any
- knowledge by the National Geodetic Survey regarding the equipment or

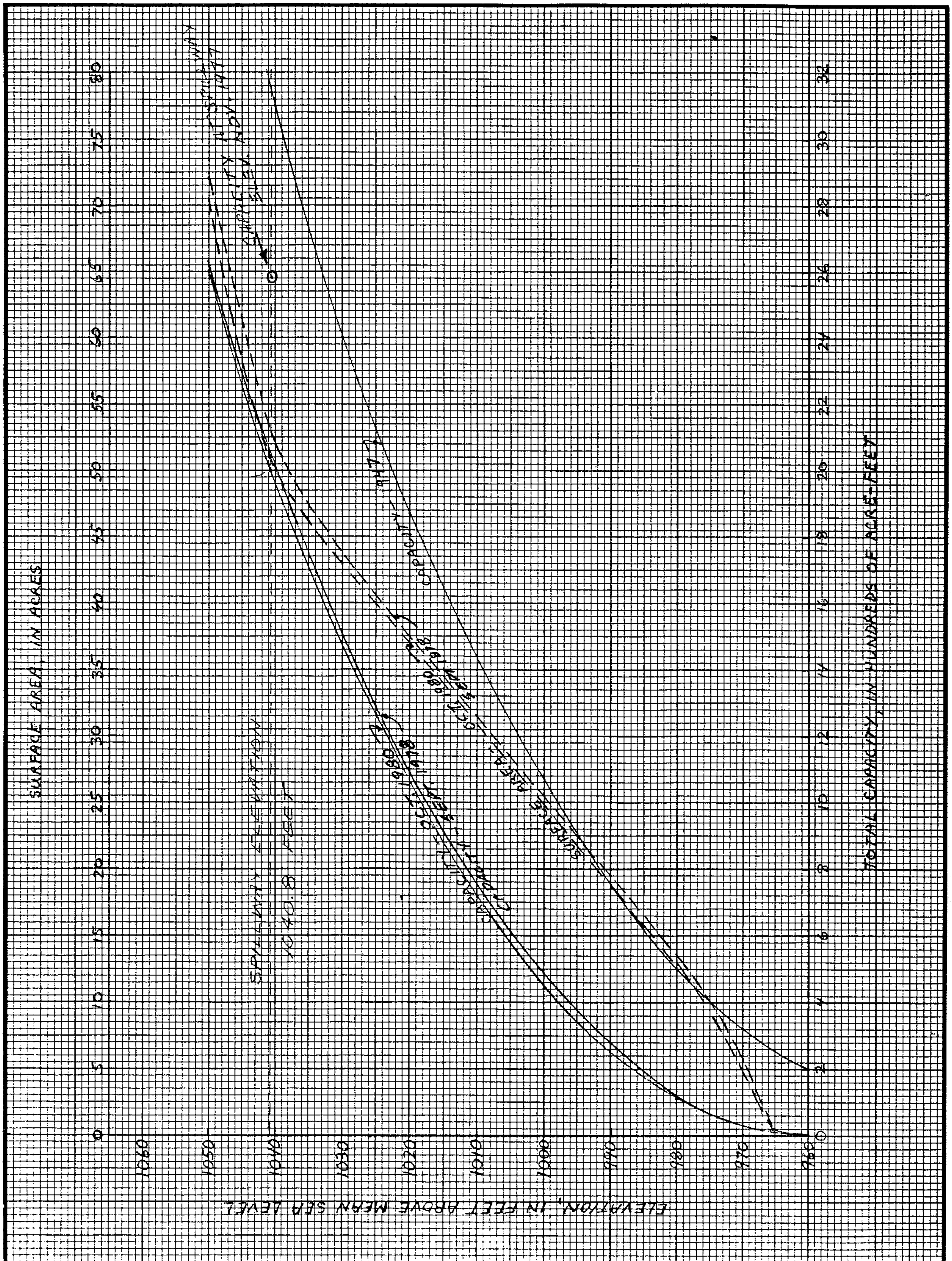
field operating procedures used.

9-213-E
(March 1949)
Cross-Section

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File ____________

SURFACE-AREA AND CAPACITY CURVES, LOS PADRES RESERVOIR



GPO : 1977 O - 229-010

Sheet No. ______ of ______ Sheets. Prepared by LET Date 3/16/79 Checked by ____________ Date ______

Los Padres Reservoir Silt Study - 1998
Summary

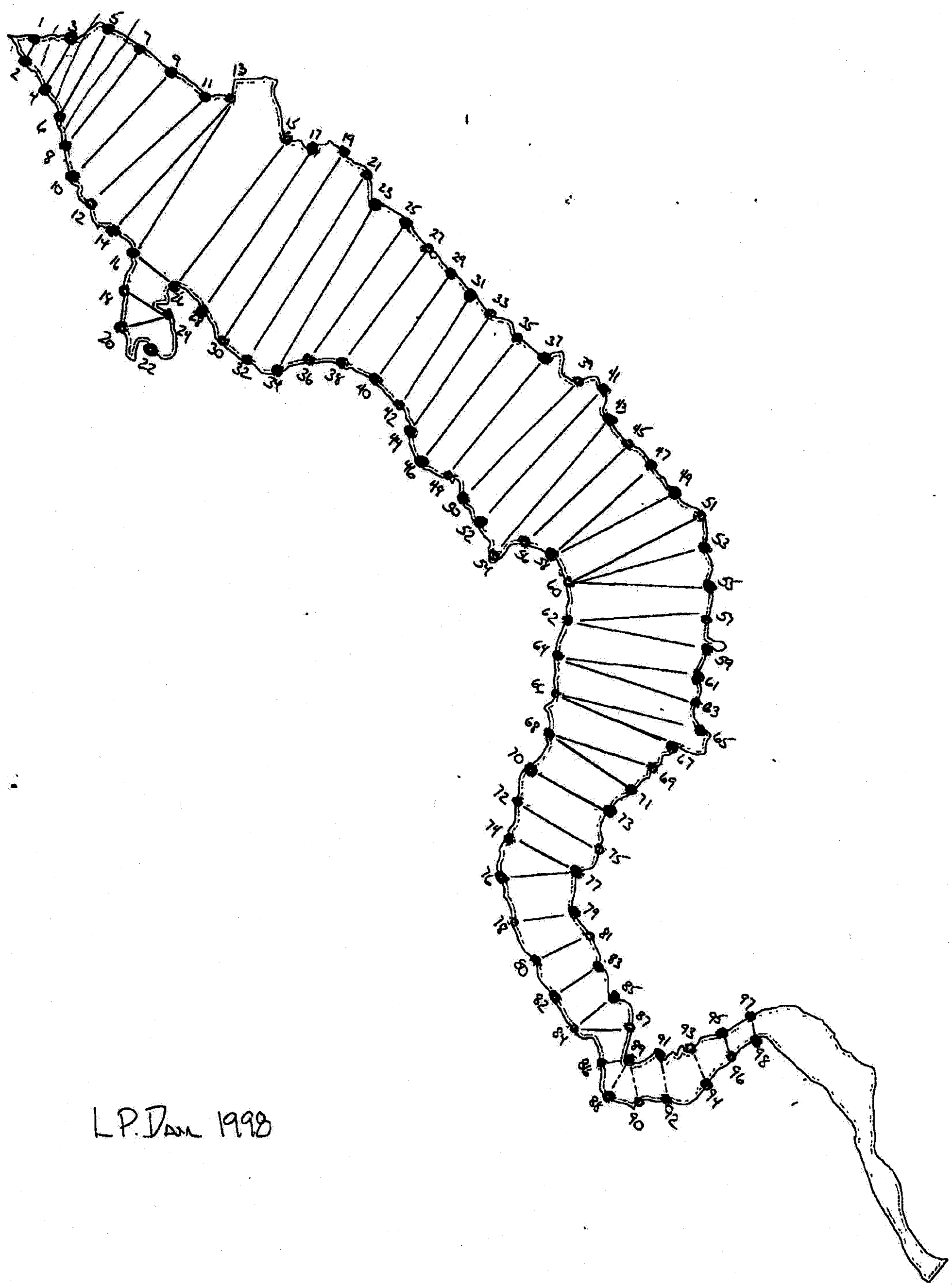
For a gauge height of 1040 the capacity of Los Padres Reservoir is:

68,361,025	cu. ft.
511,374,648	gallons
1,569.4	acre-ft.

Los Padres Reservoir Silt Study - 1998

Sounding Route from points...	Distance Between Points (in feet)	- VOLUME - cu. ft.	gallons	acre ft.
1 - 2	100	155,550	1,163,592	3.6
3 - 4	210	770,600	5,764,473	17.7
5 - 6	380	1,594,000	11,923,917	36.6
7 - 8	460	2,124,000	15,888,582	48.8
9 - 10	540	2,687,000	20,100,104	61.7
11 - 12	600	2,748,000	20,556,414	63.1
13 - 14	660	2,037,000	15,237,779	46.8
13 - 16	690	2,004,900	14,997,654	46.0
16 - 26	200	566,000	4,233,963	13.0
18 - 24	190	403,000	3,014,642	9.3
20 - 24	140	331,200	2,477,542	7.6
15 - 26	700	2,577,000	19,277,249	59.2
17 - 28	730	3,126,200	23,385,539	71.8
19 - 30	840	3,169,000	23,705,705	72.8
21 - 32	830	2,844,500	21,278,282	65.3
23 - 34	730	2,678,000	20,032,779	61.5
25 - 36	640	2,558,600	19,139,607	58.7
27 - 38	550	2,148,000	16,068,114	49.3
29 - 40	500	1,989,000	14,878,715	45.7
31 - 42	500	1,870,000	13,988,535	42.9
33 - 44	530	1,914,200	14,319,173	43.9
35 - 46	590	2,117,000	15,836,219	48.6
37 - 48	570	2,279,000	17,048,060	52.3
39 - 50	620	2,248,800	16,822,148	51.6
41 - 52	700	2,504,200	18,732,668	57.5
43- 54	670	2,303,400	17,230,584	52.9
45 - 56	530	1,516,000	11,340,438	34.8
47 - 58	500	1,047,750	7,837,694	24.1
49 - 58	520	1,075,050	8,041,912	24.7
51 - 60	570	1,237,050	9,253,753	28.4
53 - 60	540	719,550	5,382,594	16.5
55 - 60	540	1,025,100	7,668,261	23.5

Sounding Route from points...	Distance Between Points (in feet)	- VOLUME - cu. ft.	gallons	acre ft.
57 - 62	520	983,700	7,358,568	22.6
59 - 62	530	901,425	6,743,110	20.7
61 - 64	550	884,400	6,615,754	20.3
63 - 64	560	973,500	7,282,267	22.3
65 - 66	570	1,010,700	7,560,541	23.2
67 - 66	490	832,050	6,224,150	19.1
69 - 68	410	592,650	4,433,318	13.6
71 - 68	380	559,800	4,187,584	12.9
73 - 70	340	628,800	4,703,738	14.4
75 - 72	350	578,600	4,328,217	13.3
77 - 74	290	335,550	2,510,082	7.7
77 - 76	280	306,600	2,293,521	7.0
79 - 78	220	292,800	2,190,290	6.7
81 - 80	210	268,200	2,006,270	6.2
83 - 82	200	220,400	1,648,702	5.1
85 - 84	190	160,050	1,197,254	3.7
87 - 84	210	109,950	822,481	2.5
89 - 86	90	47,100	352,332	1.1
89 - 88	140	47,400	354,576	1.1
89 - 90	120	59,400	444,342	1.4
91 - 92	150	92,400	691,198	2.1
93 - 94	130	63,000	471,272	1.4
95 - 96	100	26,500	198,233	0.6
97 - 98	80	17,400	130,161	0.4
	TOTALS :	68,361,025 cu. ft.	511,374,648 gallons	1569.4 acre-ft.



L.P. Dam 1998

IMPACT OF THE MARBLE CONE FIRE OF AUGUST 1977 ON THE SEDIMENTATION OF LOS PADRES RESERVOIR

Project Proposal

Prepared by
L. F. Trujillo
U.S. Geological Survey
Water Resources Division
Menlo Park, California

July 1978

IMPACT OF THE MARBLE CONE FIRE OF AUGUST 1977 ON THE SEDIMENTATION OF LOS PADRES RESERVOIR

NEED FOR STUDY

The large-scale destruction of ground cover during the Marble Cone Fire of August 1977 has left many areas susceptible to accelerated erosion. One area of special interest is the upper Carmel River basin located on the northern slope of the Santa Lucia Range in Monterey County (fig. 1). Over 95 percent of the Carmel River basin above Los Padres dam was burned by the Marble Cone Fire (fig. 2). The upper Carmel River and its tributaries carry runoff from the burn areas of this basin into Los Padres Reservoir (45 mi^2 D. A.), located upstream from the town of Carmel Valley.

Because erosion rates and, therefore, sediment yields often increase significantly after a fire (Krammes, 1965), a study documenting the changes in sediment deposition and loss in storage capacity of Los Padres Reservoir will be useful in future planning for the Carmel River basin and for the operation of this reservoir. Results of this study will also be useful in predicting sediment runoff and basin recovery time for other basins experiencing similar vegetation losses.

In anticipation of increased sediment yields after the Marble Cone Fire, a reservoir survey was made on November 21, 1977, before winter runoff began. Two cross sections (Nos. 10 and 11), located near the center of the reservoir, were rerun on June 13, 1978, after the unusually large storms in January through March. Data from these cross sections indicate that sediment was deposited to depths of over 40 feet, resulting in cross-sectional area losses of 75 percent in section 10 and 40 percent in section 11 (figs. 3 and 4). Further investigation, therefore, seems warranted.

OBJECTIVES

The objectives of the proposed study are to determine the immediate effects of the fire on the storage capacity of the reservoir and to document postfire rates of reservoir deposition as the vegetation in the burned area recovers. An estimate of the reservoir's trap efficiency, as described by Brune (1953), will also be made.

APPROACH

Since sediment runoff entering the reservoir after the Marble Cone Fire and before the November 21 survey is considered insignificant, the preburn storage capacity of the reservoir will be based on the November survey. A second reservoir survey, to be run in October or November 1978, will be used to compute the current storage capacity of the reservoir. The volume of sediment deposited in Los Padres Reservoir since the August 1977 fire will then be computed by subtracting the preburn storage capacity from the current storage capacity.

The reservoir will be resurveyed at one or two year intervals, depending on climatic conditions and results of a yearly reconnaissance. The storage capacity and changes in volume and distribution of deposited sediment will be computed for each survey and will be used to relate sediment runoff to degree of vegetation recovery and to yearly or storm rainfall amounts.

Infrared photographs of the upper basin will be examined on a yearly basis to monitor rates of revegetation. Infrared photographs taken by NASA 3 weeks after the fire are available from the U.S. Forest Service.

A split core sampler will be used to obtain bed sediment samples at selected cross sections for each survey. The samples will be analyzed for particle size distribution and specific weight, so that the total weight of deposited sediment and weight per square mile of drainage can be determined. The particle size analyses will also give an indication of the variation in particle size along the length of the reservoir bed.

Periodic surface-water measurements and sediment samples will be taken at the outlet of the dam to investigate possible changes in sediment concentration of the release water as the storage capacity of the reservoir decreases.

REPORT PLANS

A report summarizing the results of each reservoir survey will be completed in March of the year following each survey. The first report will summarize the results of the first two surveys and will be completed by March 1979.

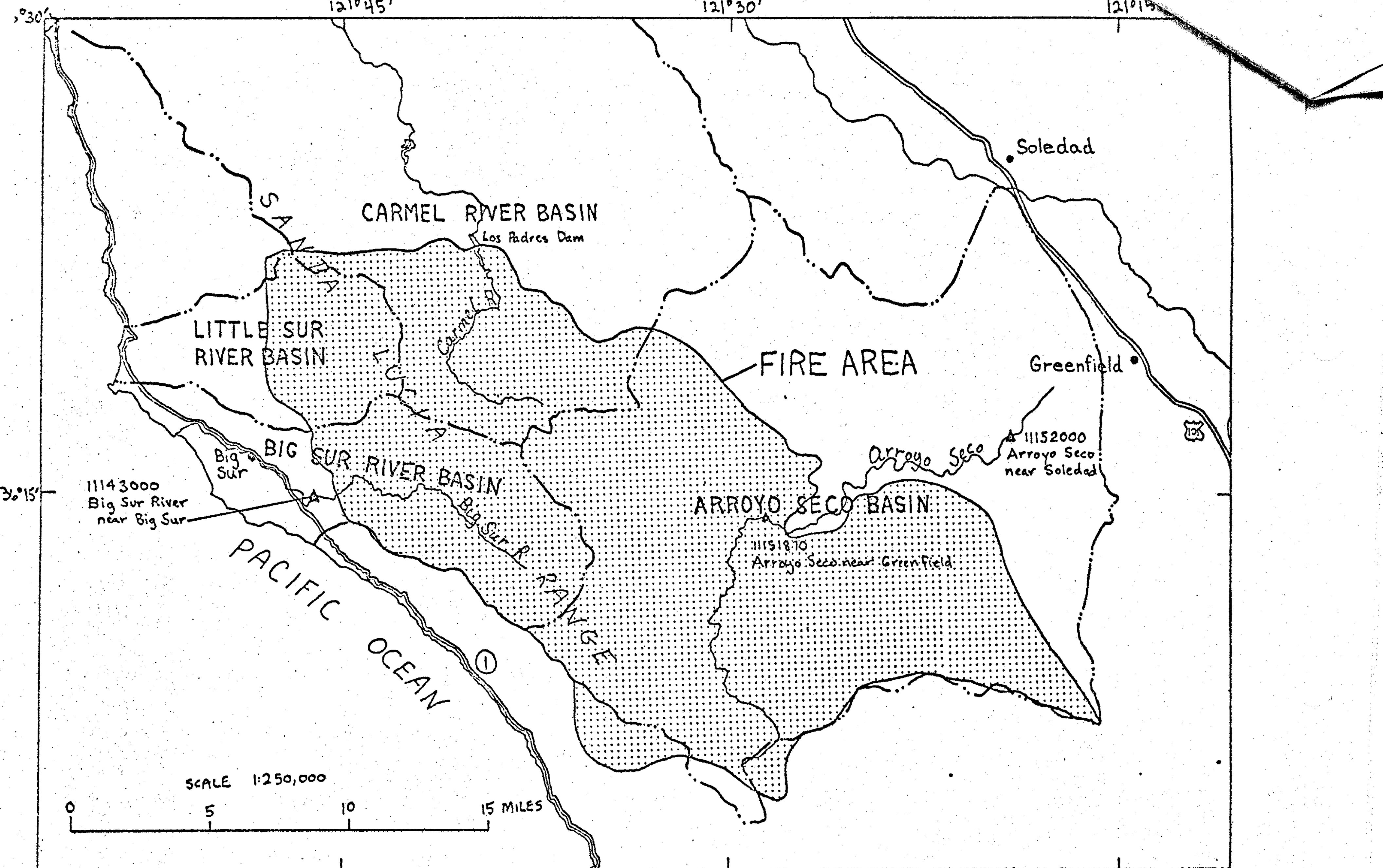


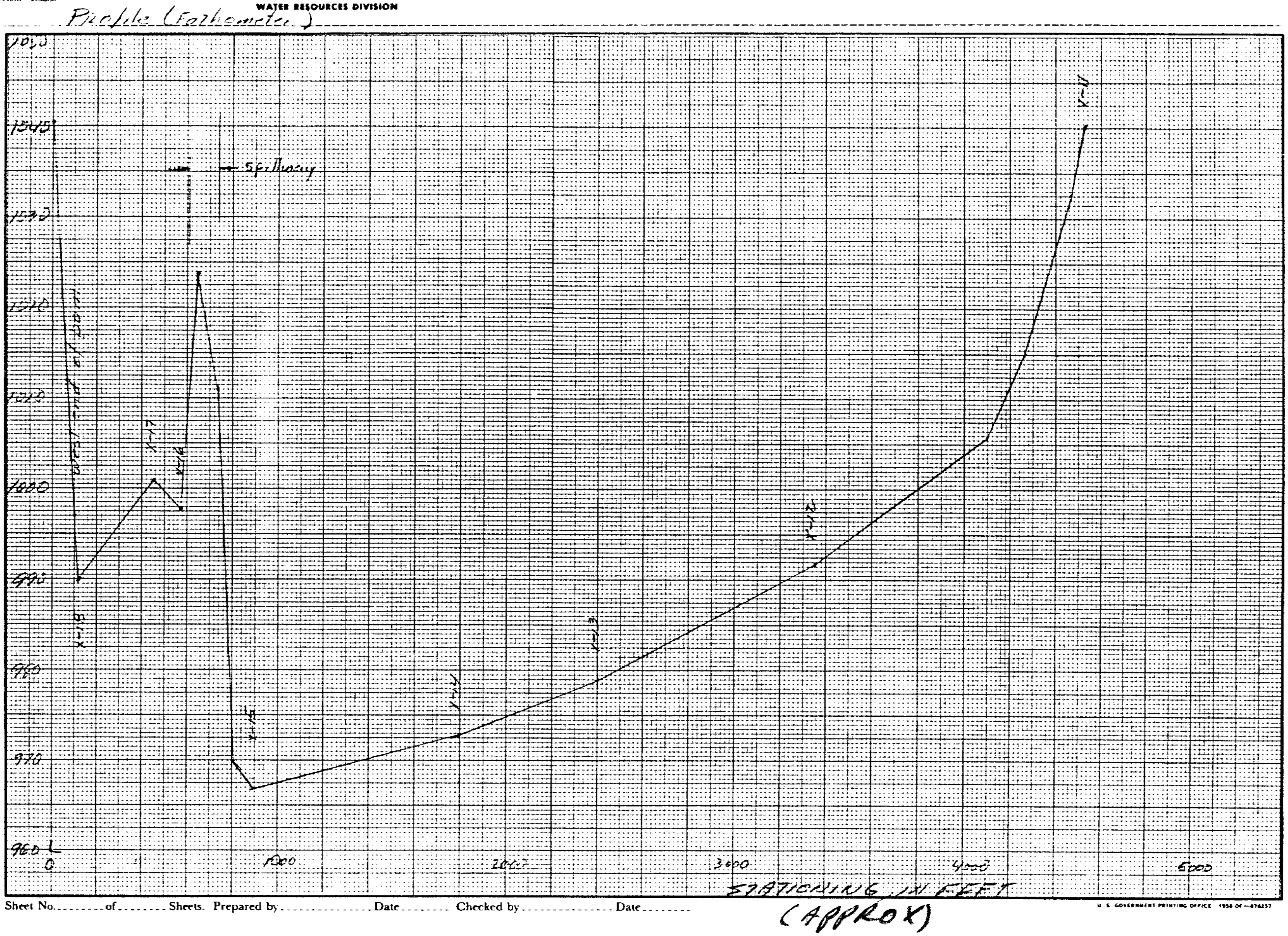
FIGURE 2.--EXTENT OF MARBLE CONE FIRE, MONTEREY COUNTY, 1977

1978 x sect data
1977 data (recovered)
N
T18S R3E
SEC 5 SEC 4
SEC 8 SEC 9
DAM
1040' (USGS)
LOS PADRES RESERVOIR
CARMEL
RIVER
CREEK
DANISH
1" = 300'

(March 1949)
Cross Section - Double

GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File............



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Longitudinal profile

(March 1949)
Cross Section Double

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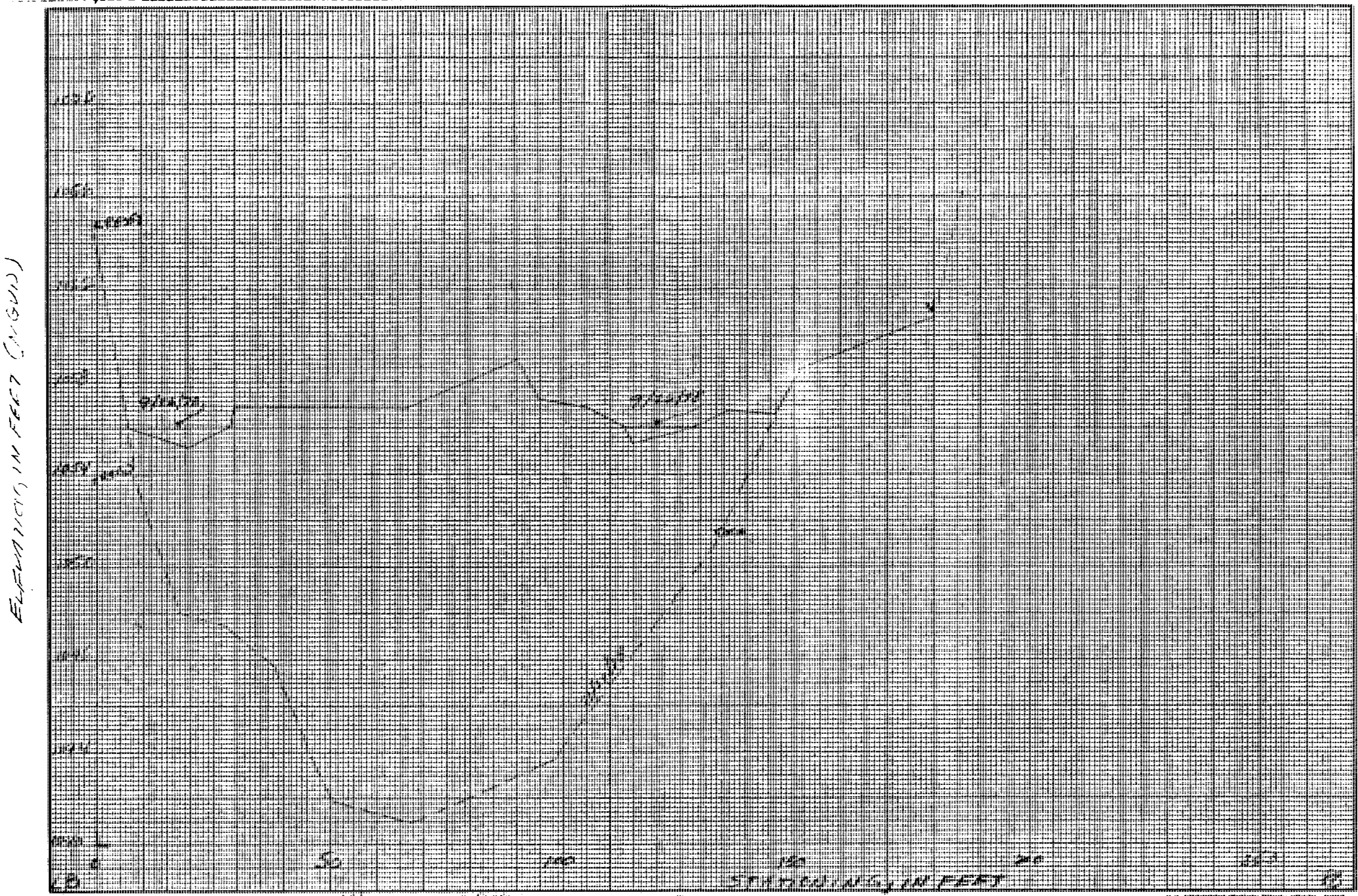

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(March 1949)
Cross-Section - Double

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WATER RESOURCES DIVISION

File

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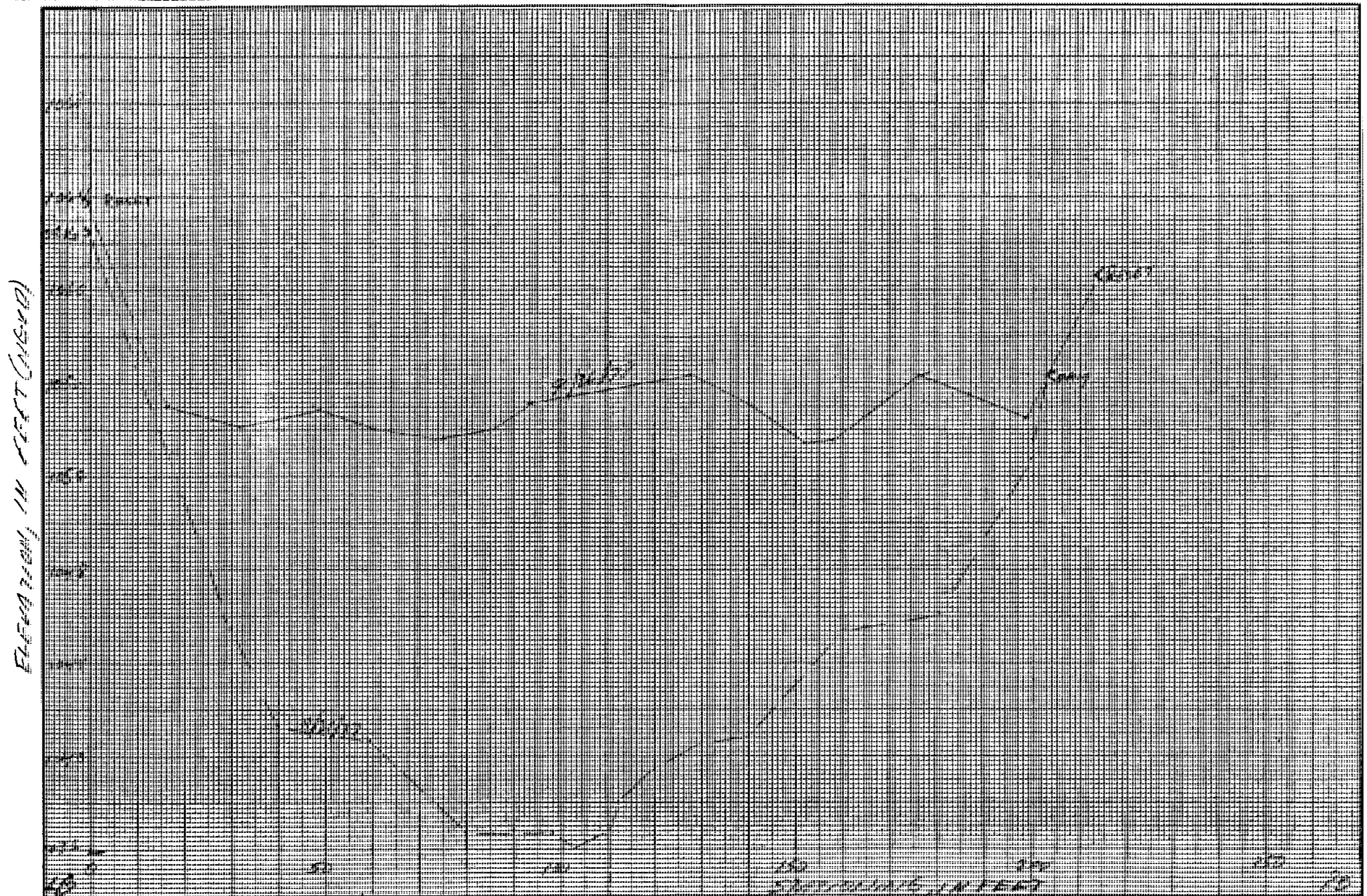

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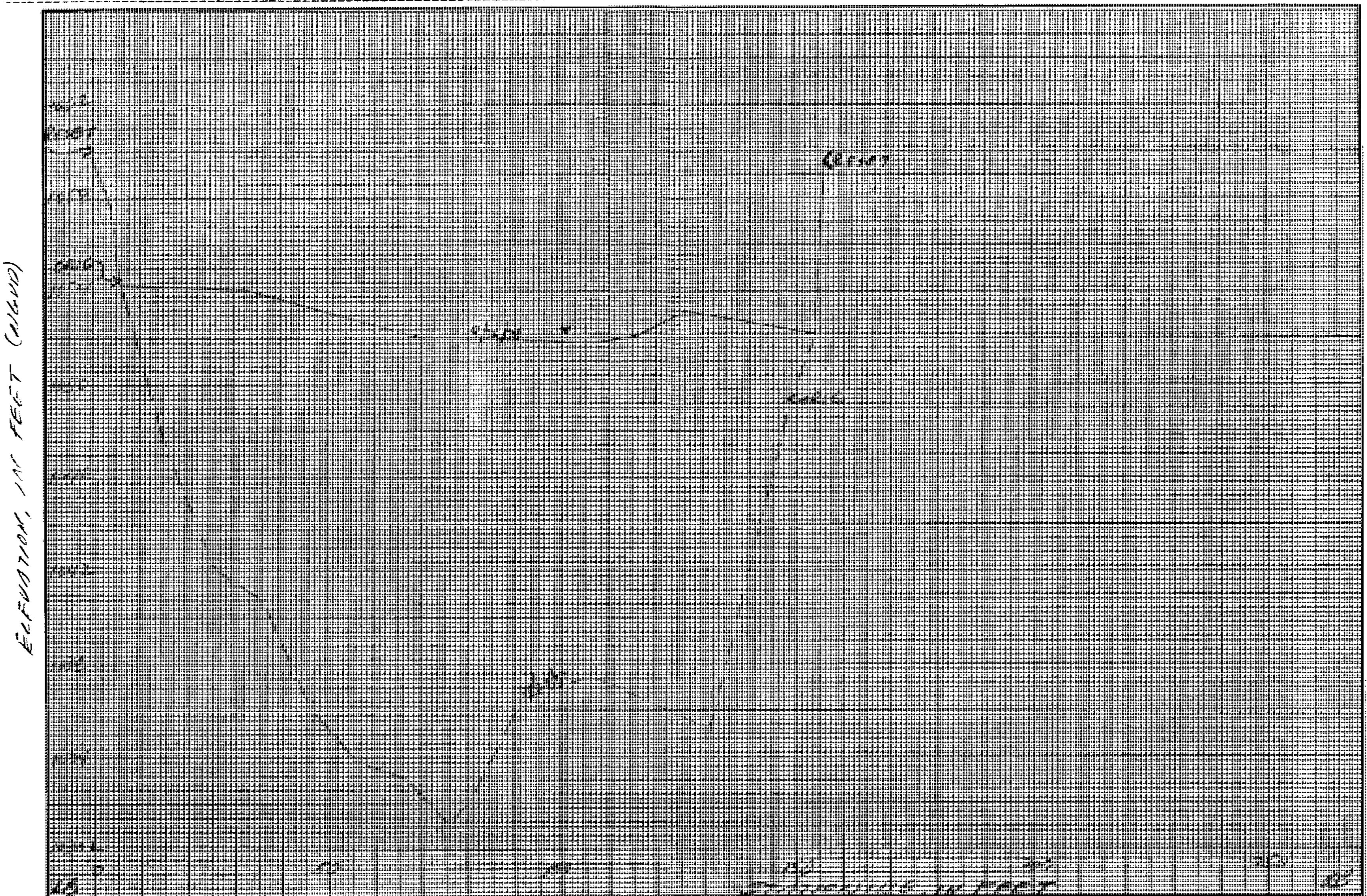
(March 1949)
Cross-Section—Double

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File LOS PADRES RES.

X-SECTION 3



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WATER RESOURCES DIVISION

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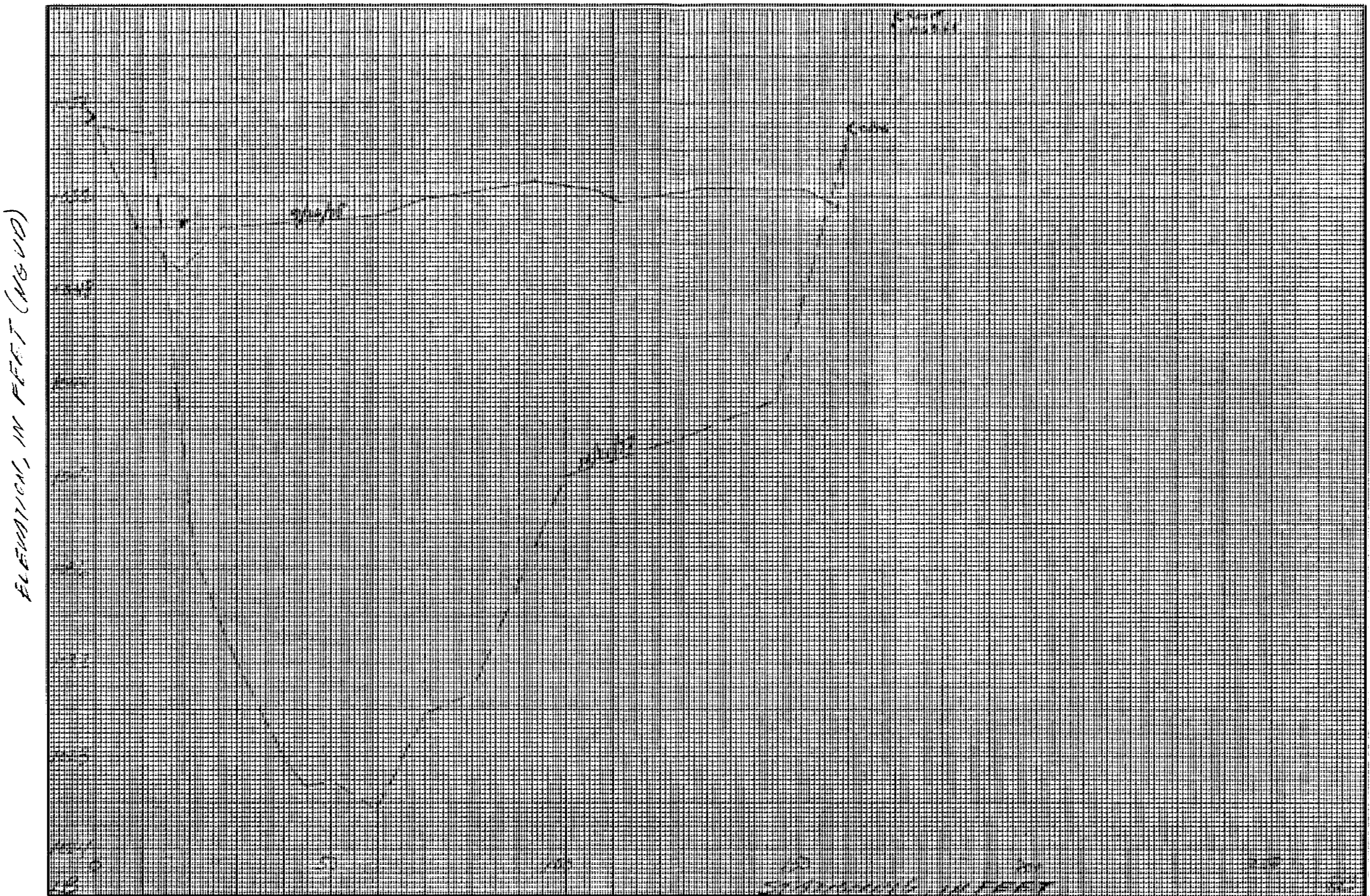

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Cross-Section—Double

UNITED STATES DEPARTMENT OF THE INTERIOR
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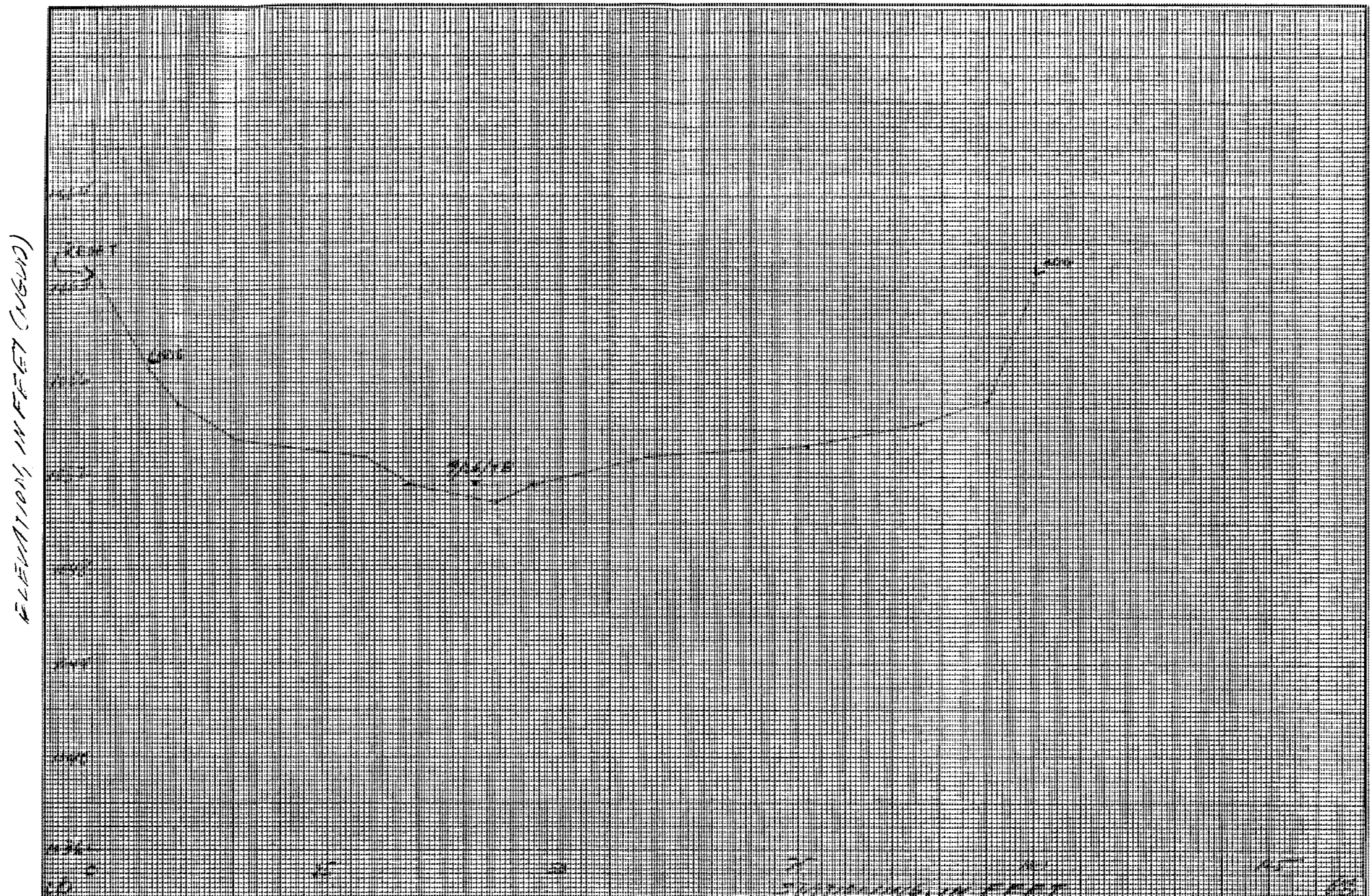
WATER RESOURCES DIVISION

File LOS PADRES RES

X-SECTION 5 DANISH CREEK



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WATER RESOURCES DIVISION

File

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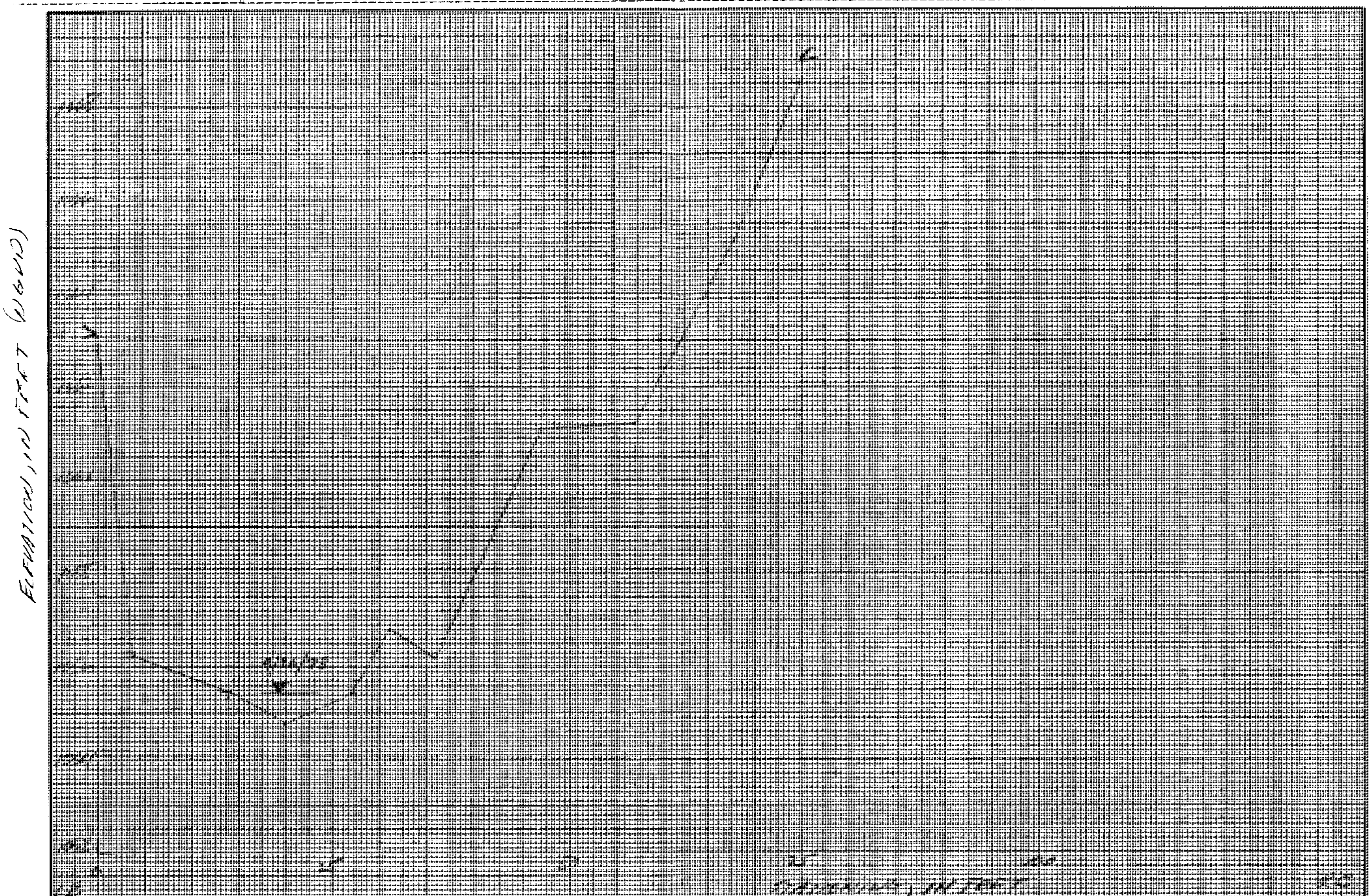

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Cross Section - Double

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WATER RESOURCES DIVISION

File

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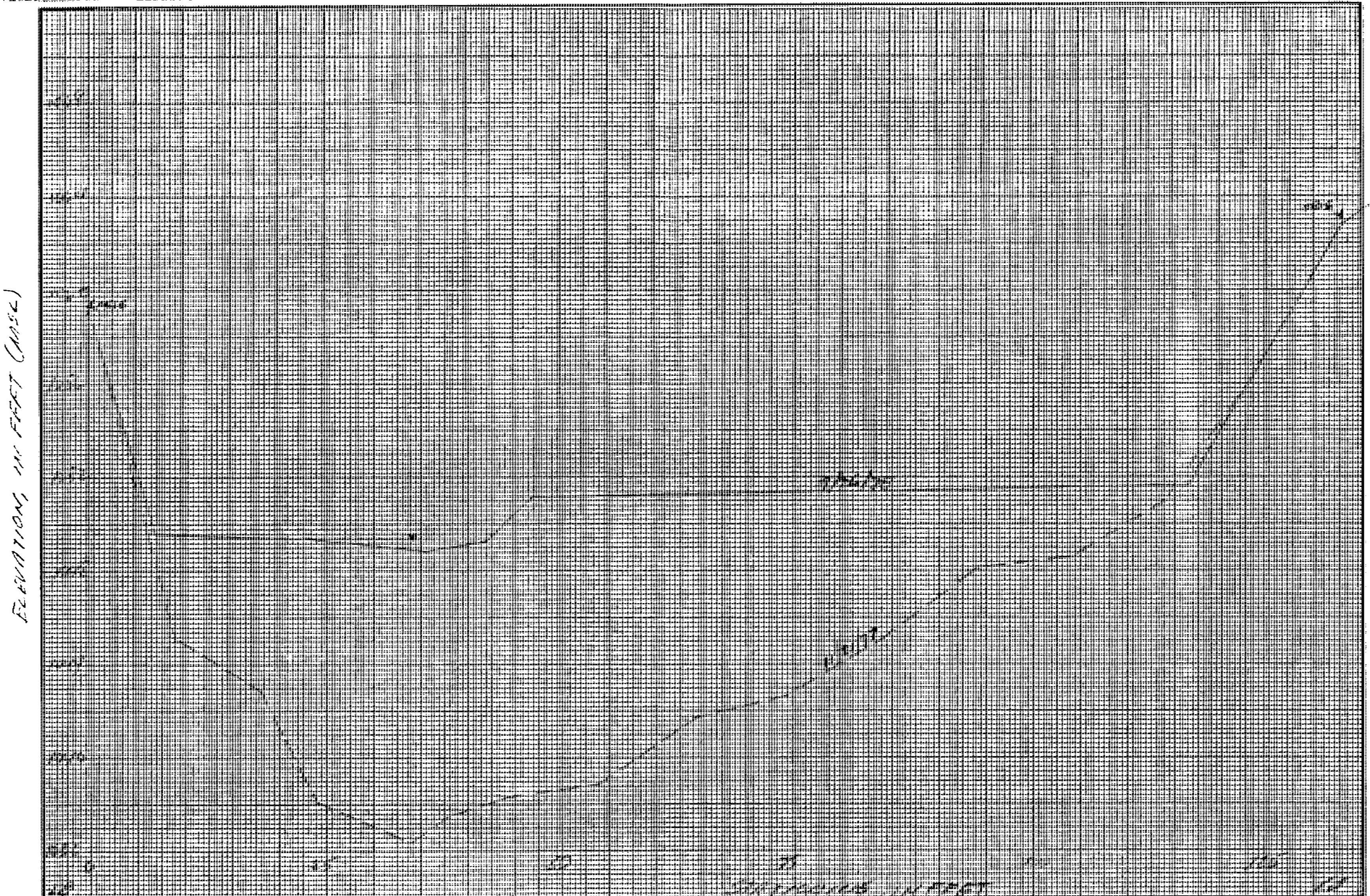

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March 1949; Cross-Section Double

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

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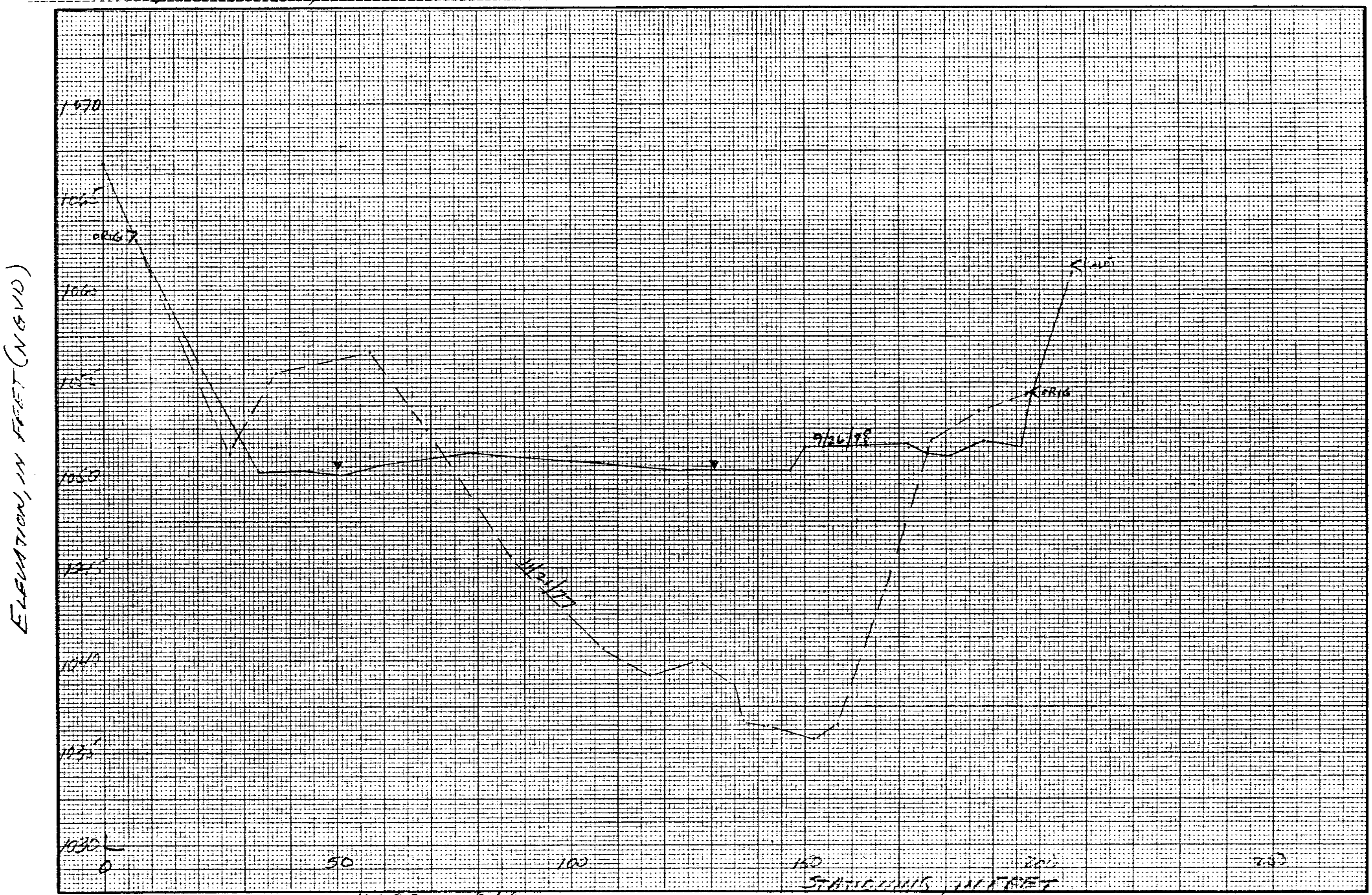

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WATER RESOURCES DIVISION

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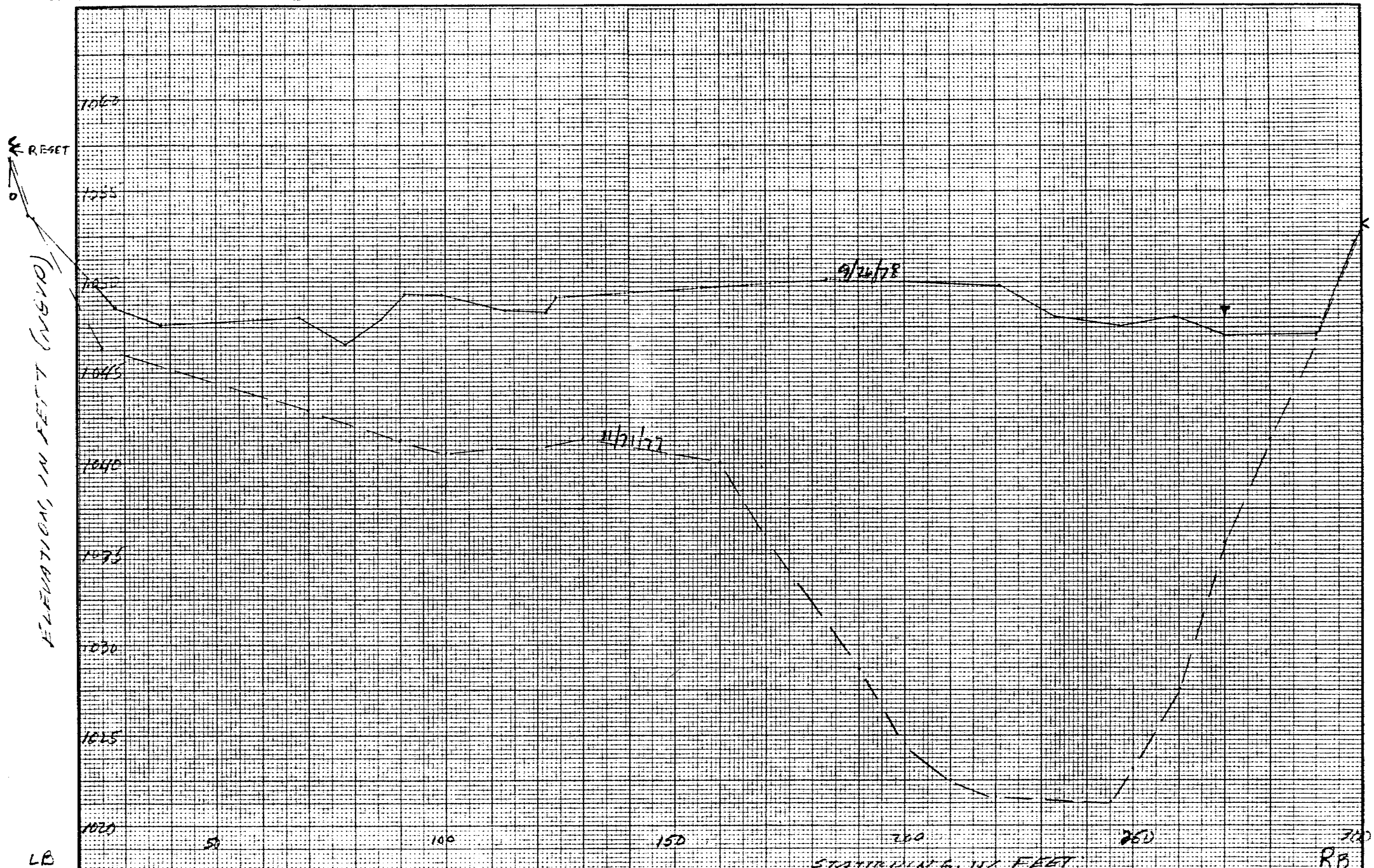
X-SECTION E



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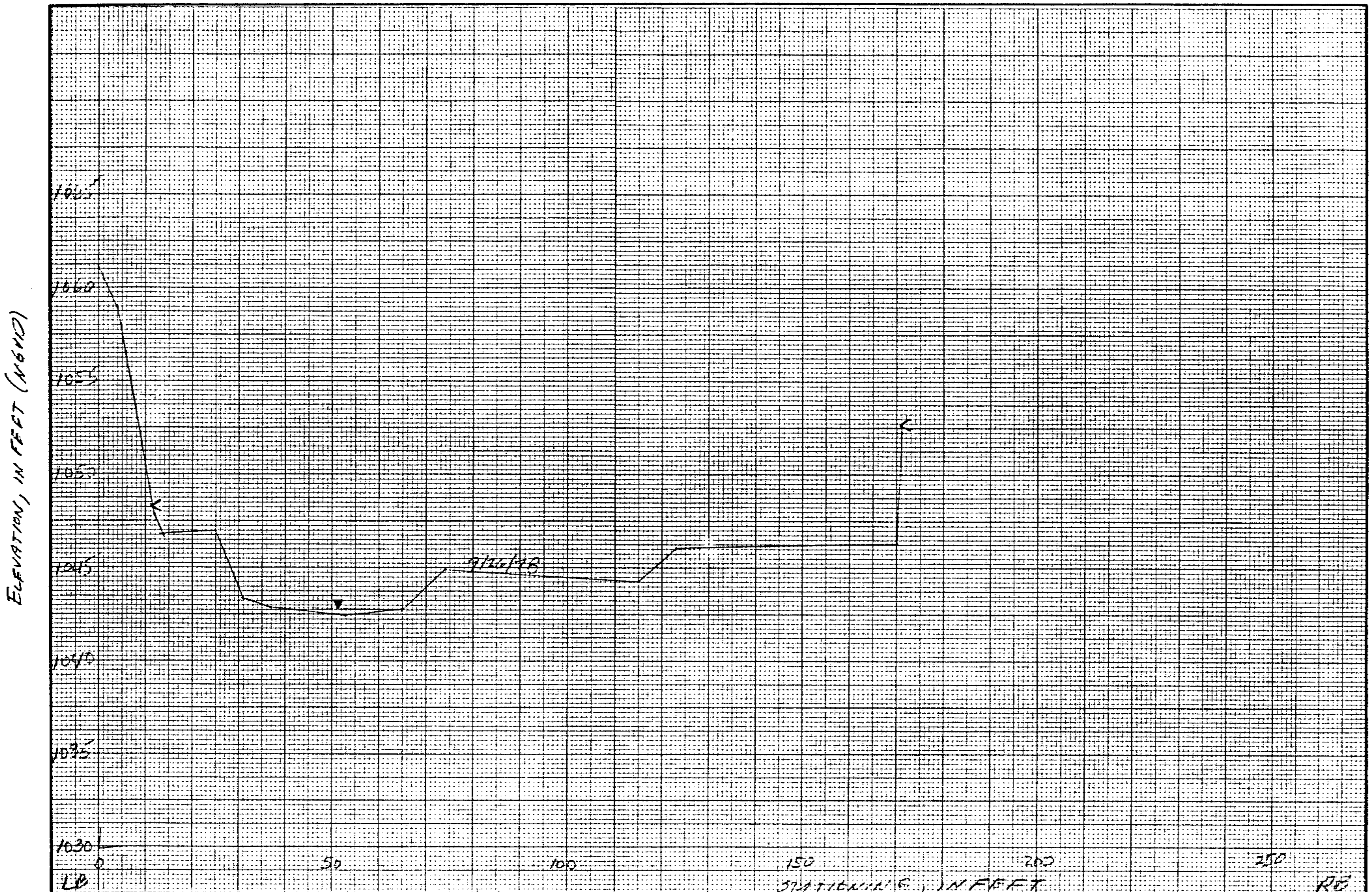

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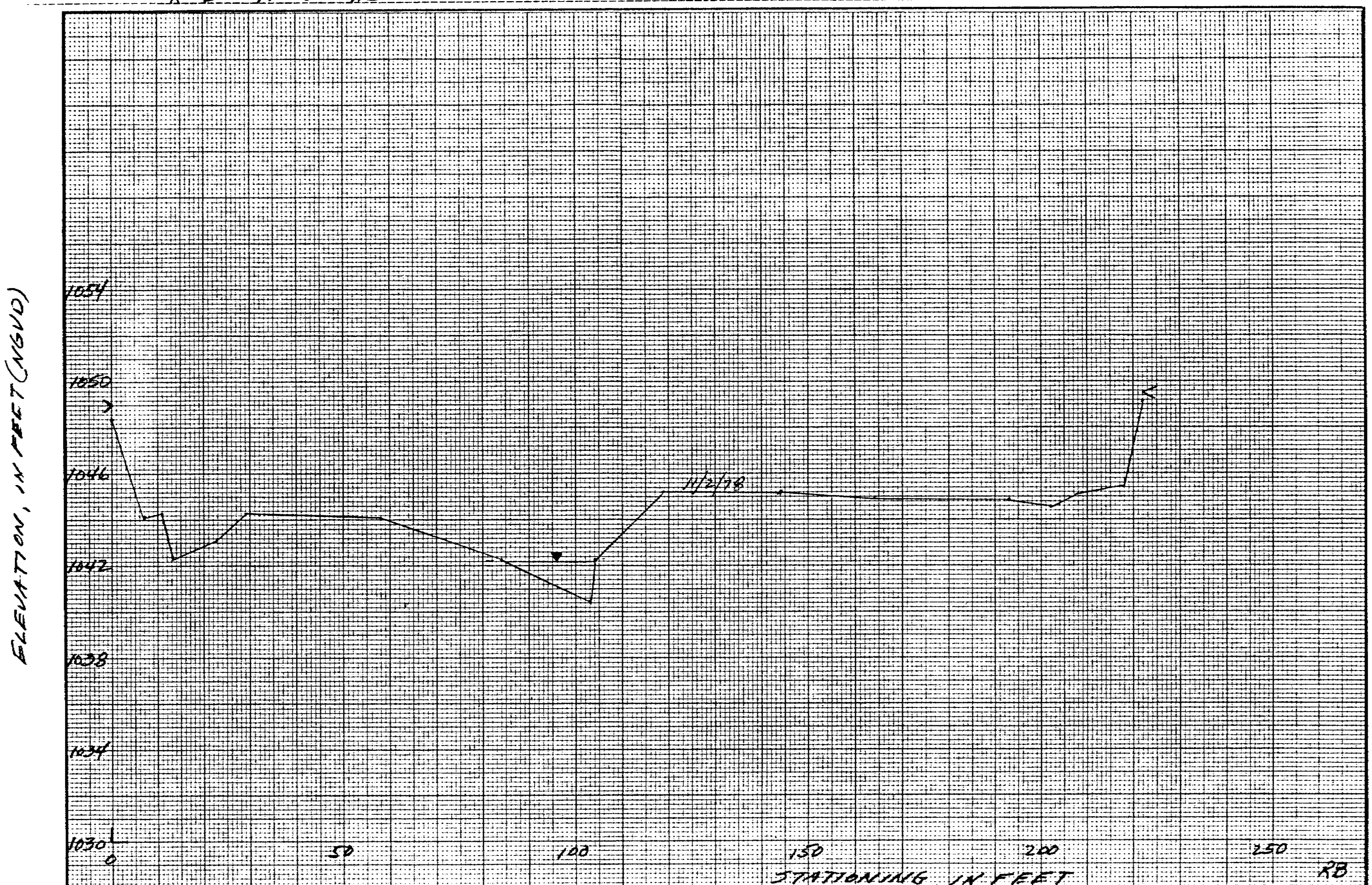

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Cross Section—Double

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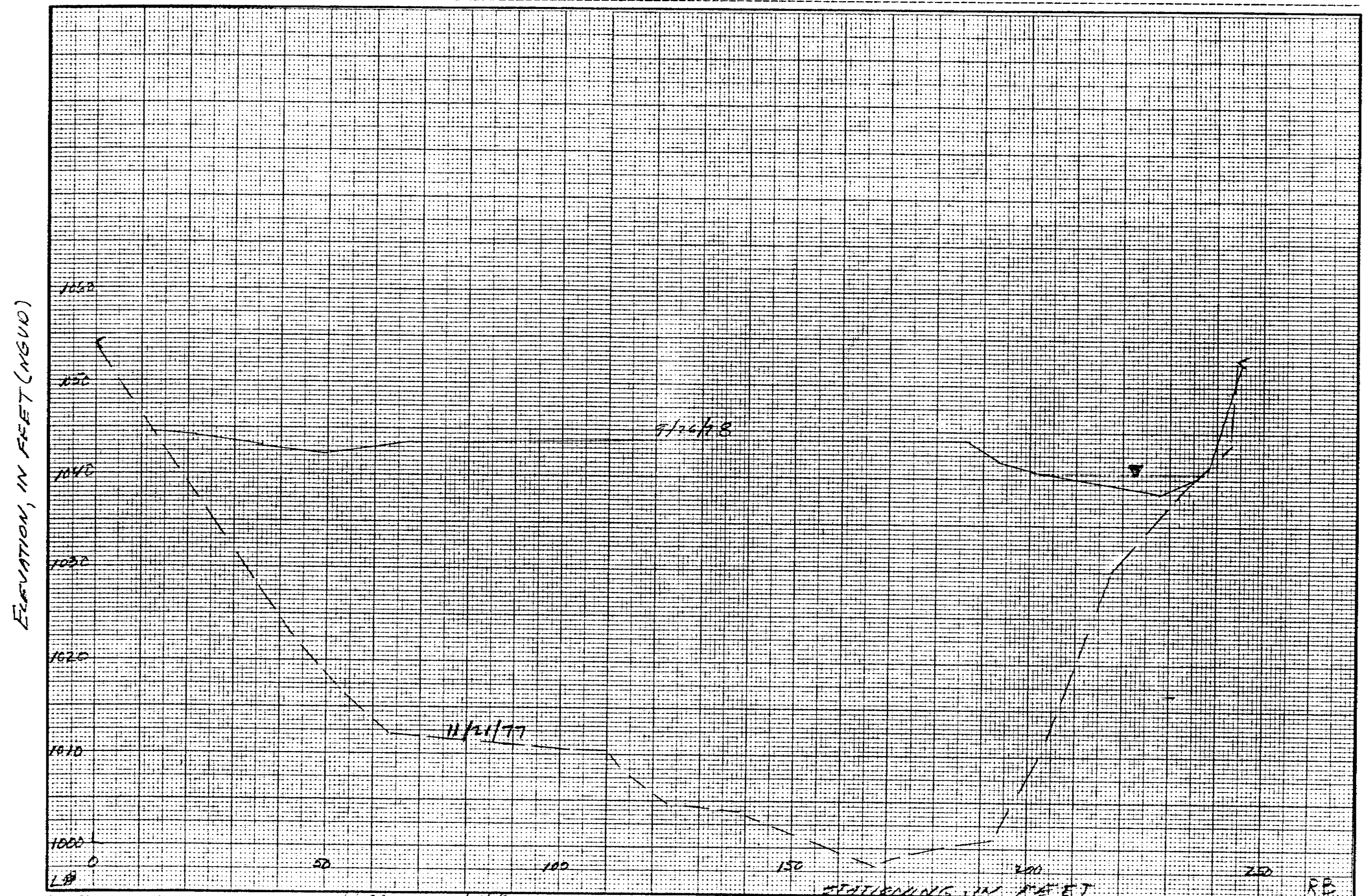

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WATER RESOURCES DIVISION

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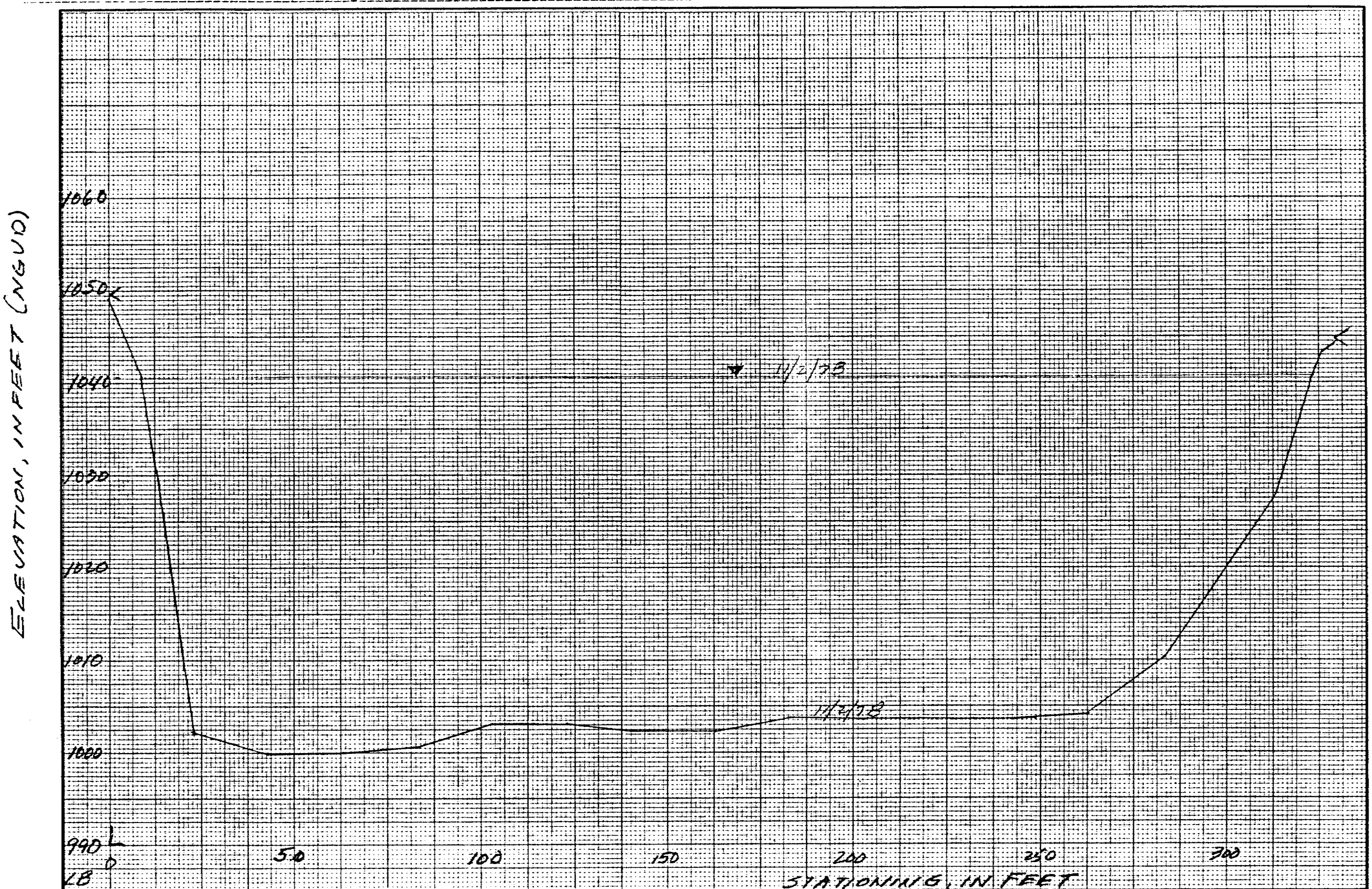

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WATER RESOURCES DIVISION

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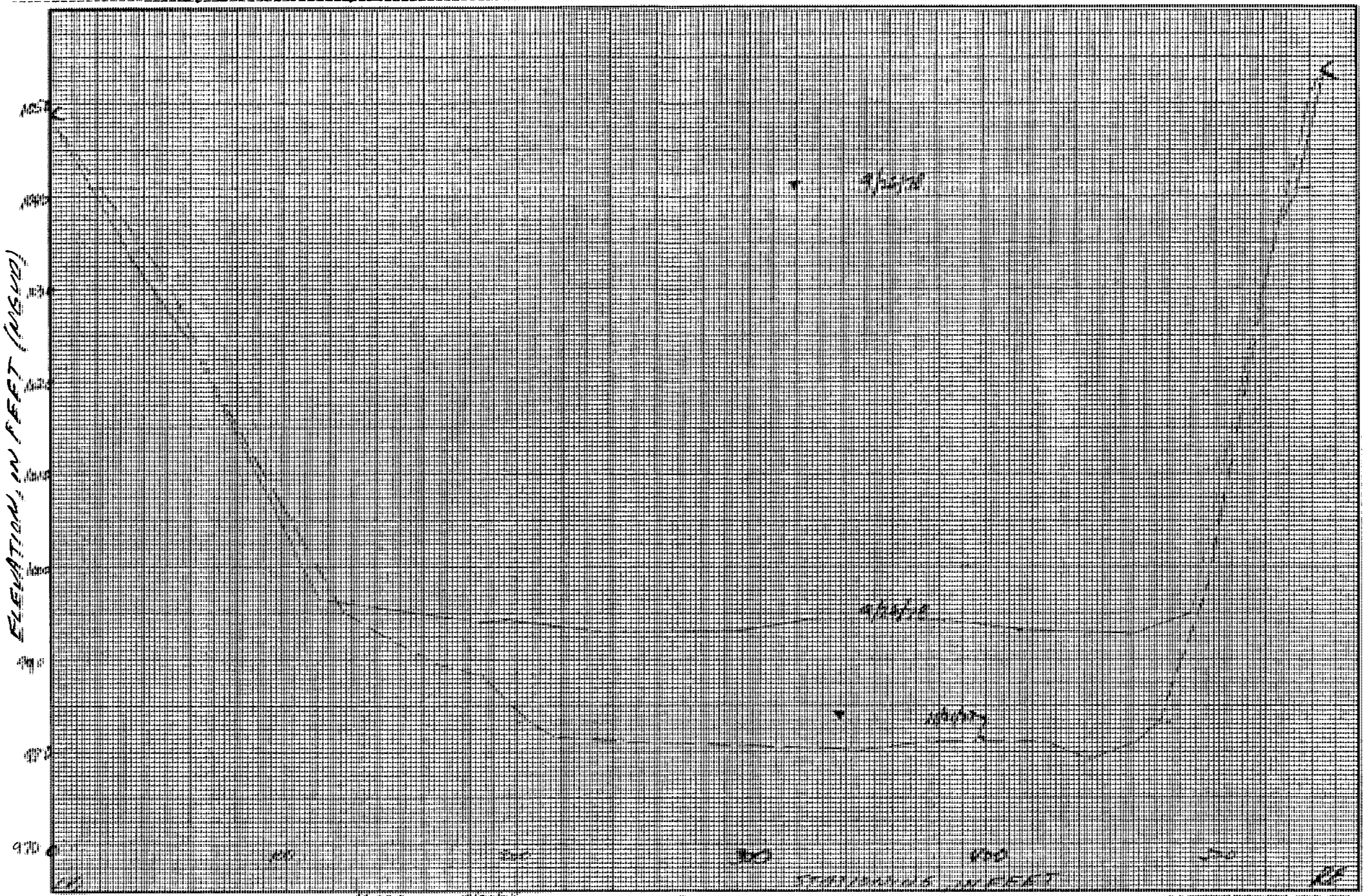

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WATER RESOURCES DIVISION

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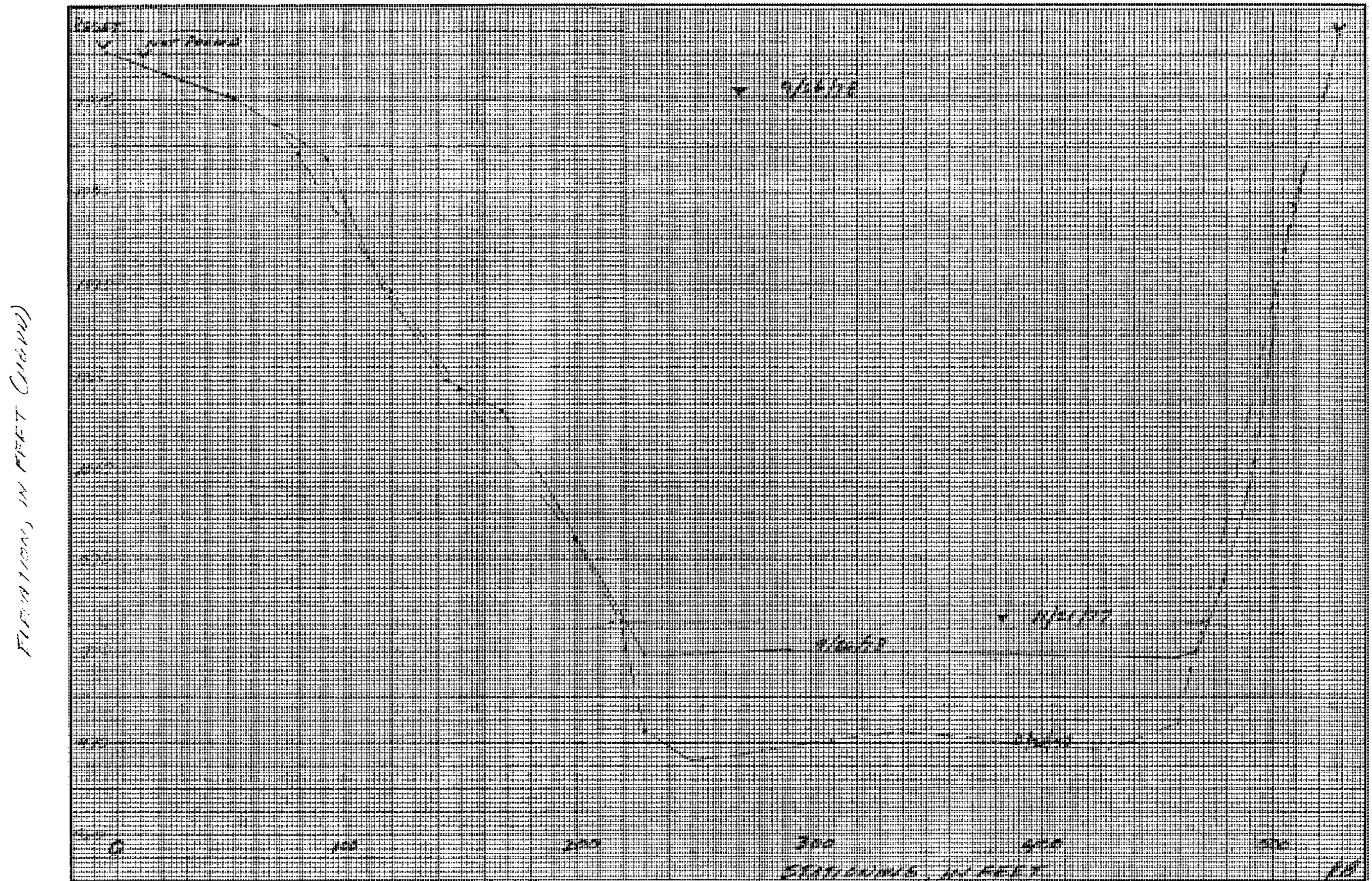

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WATER RESOURCES DIVISION

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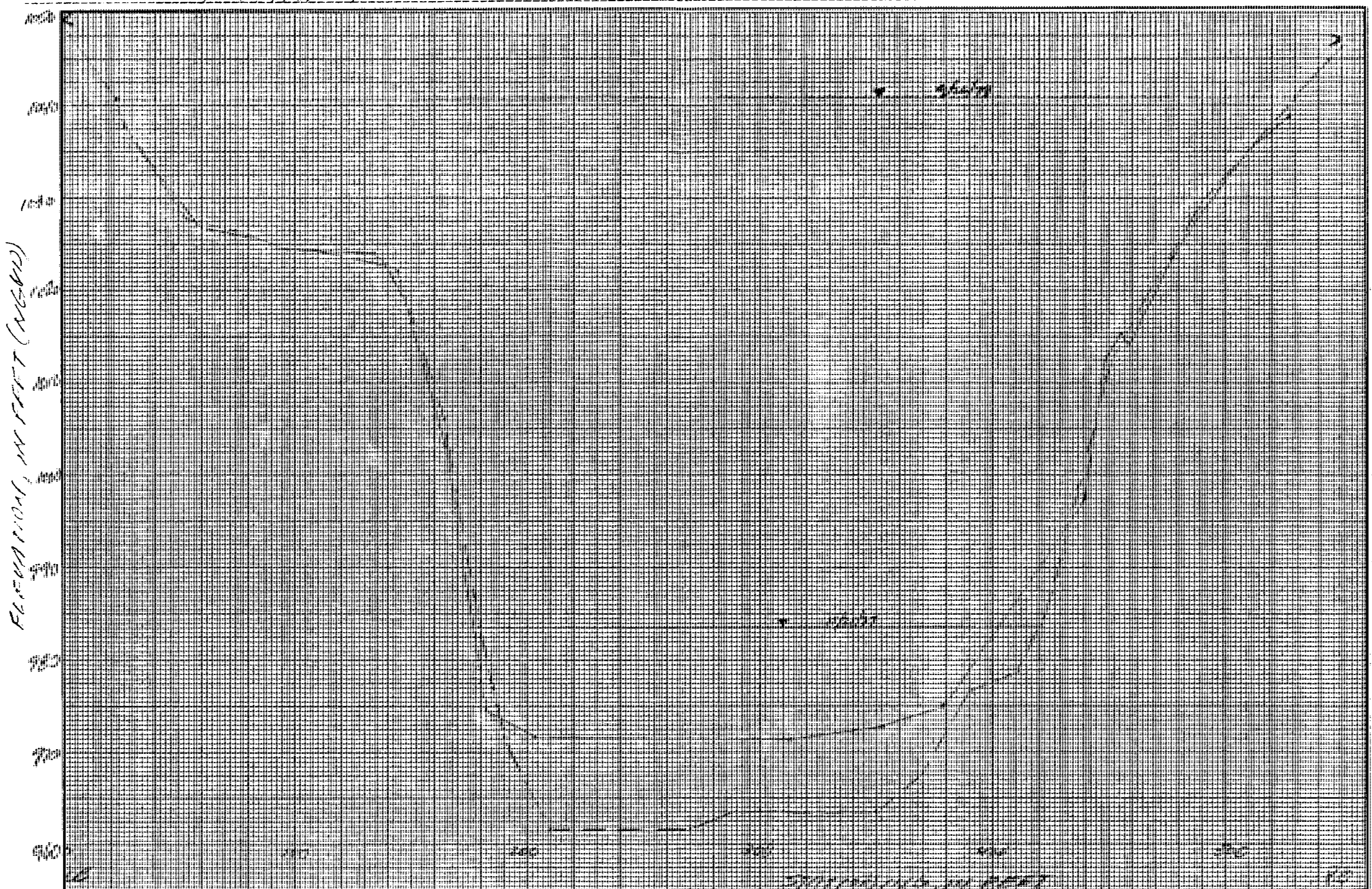

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WATER RESOURCES DIVISION

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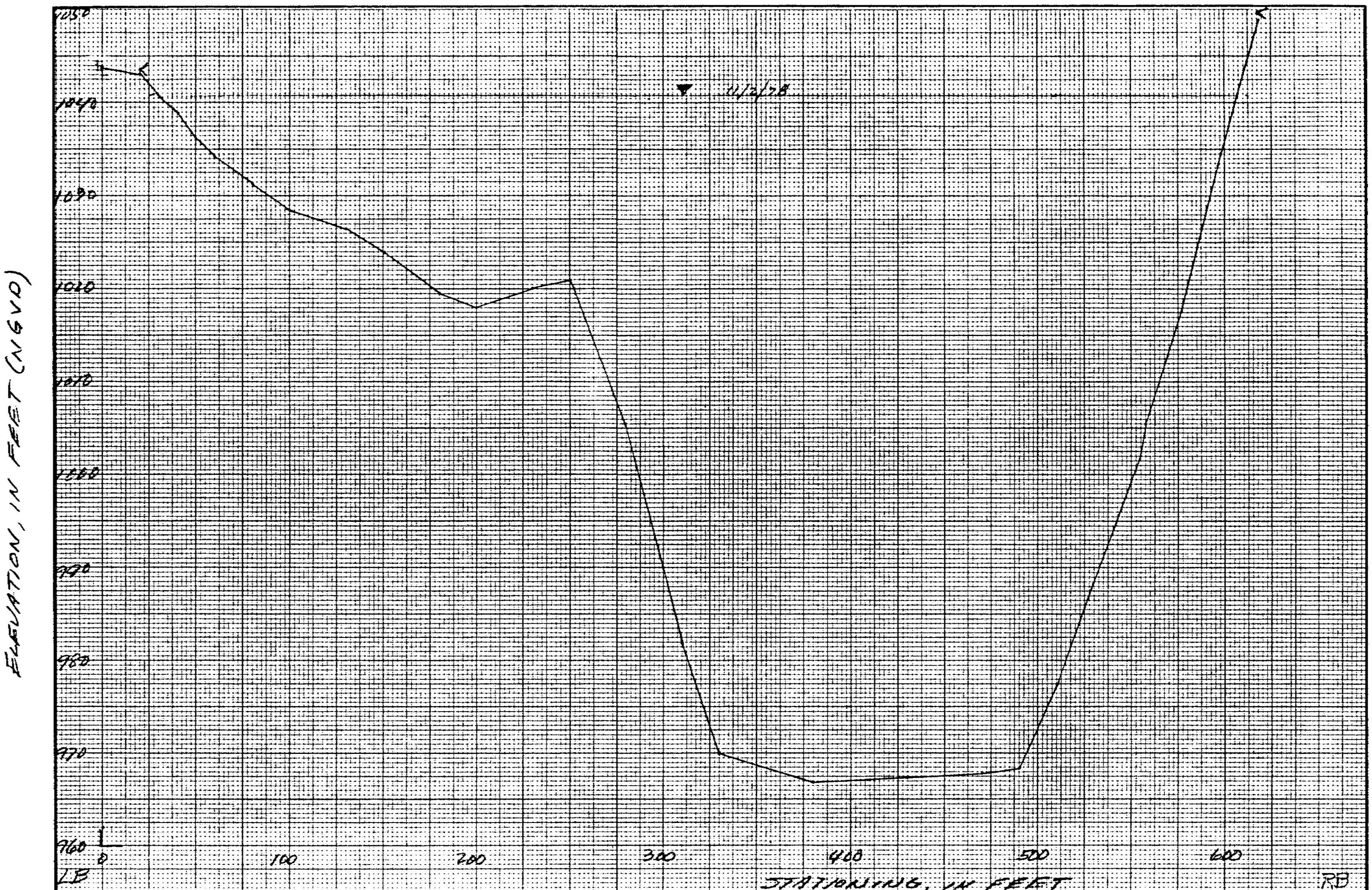

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(March 1949)
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GEOLOGICAL SURVEY
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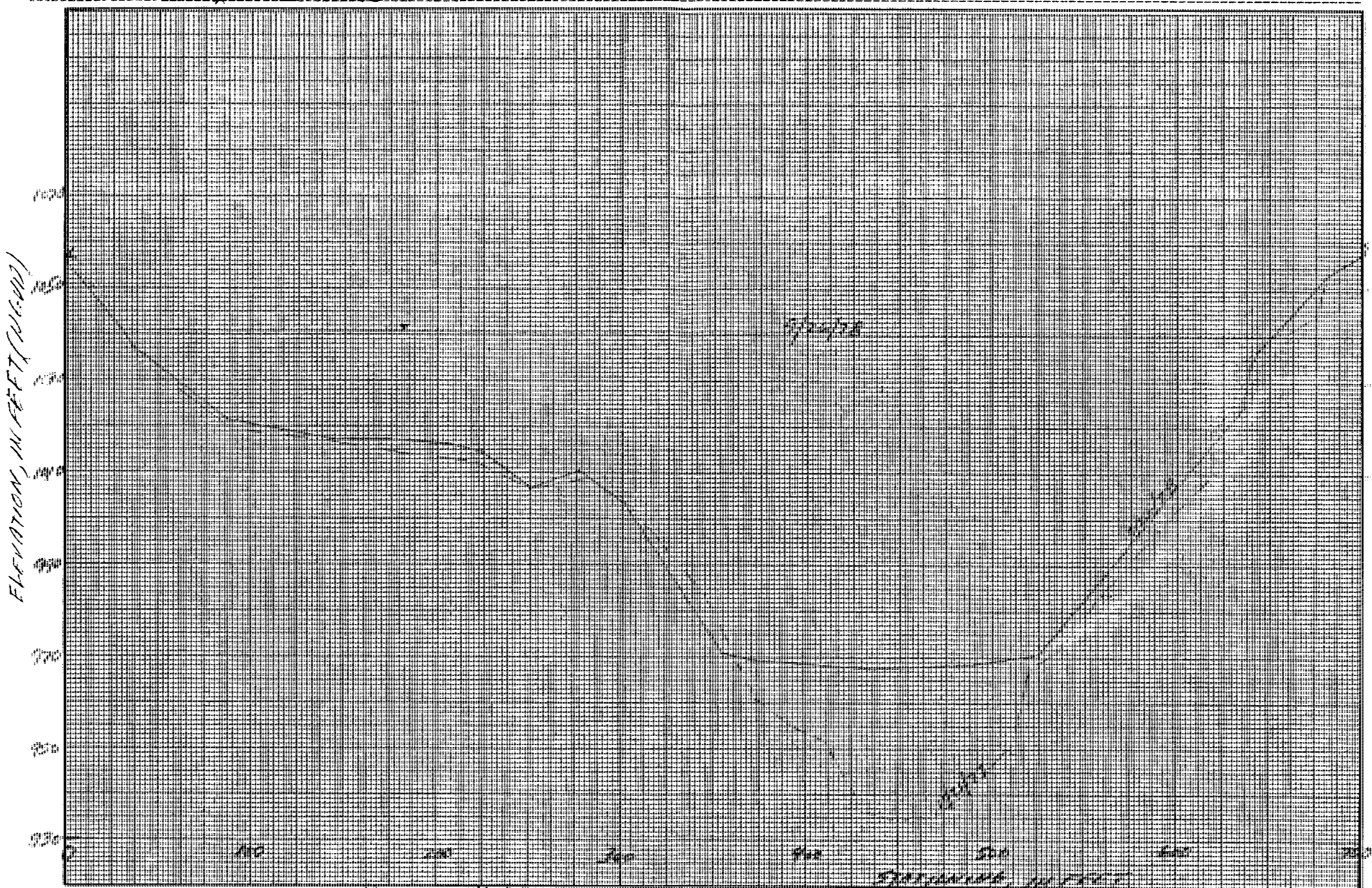

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Cross Section - Double

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WATER RESOURCES DIVISION

File

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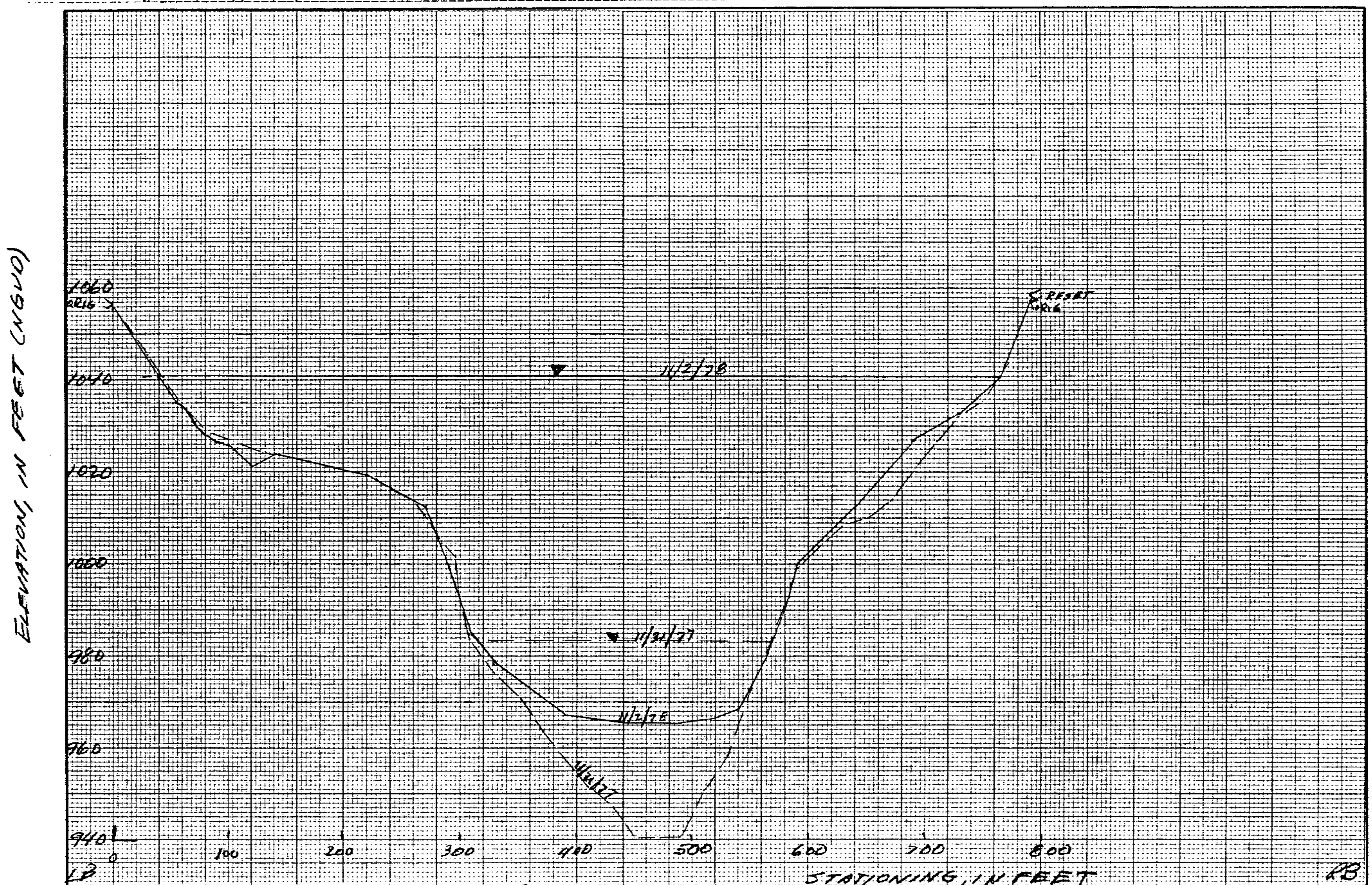

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WATER RESOURCES DIVISION

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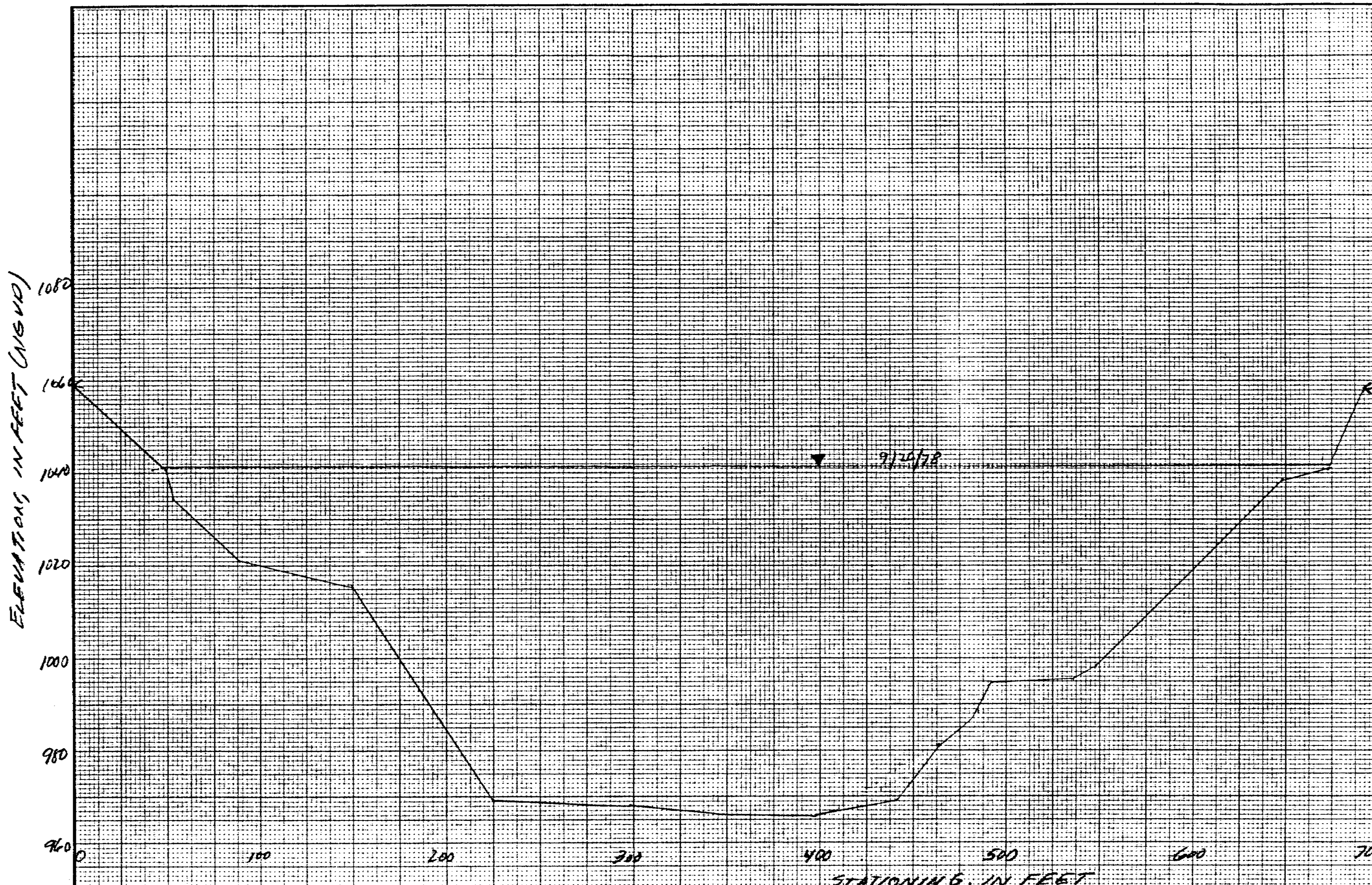

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GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File

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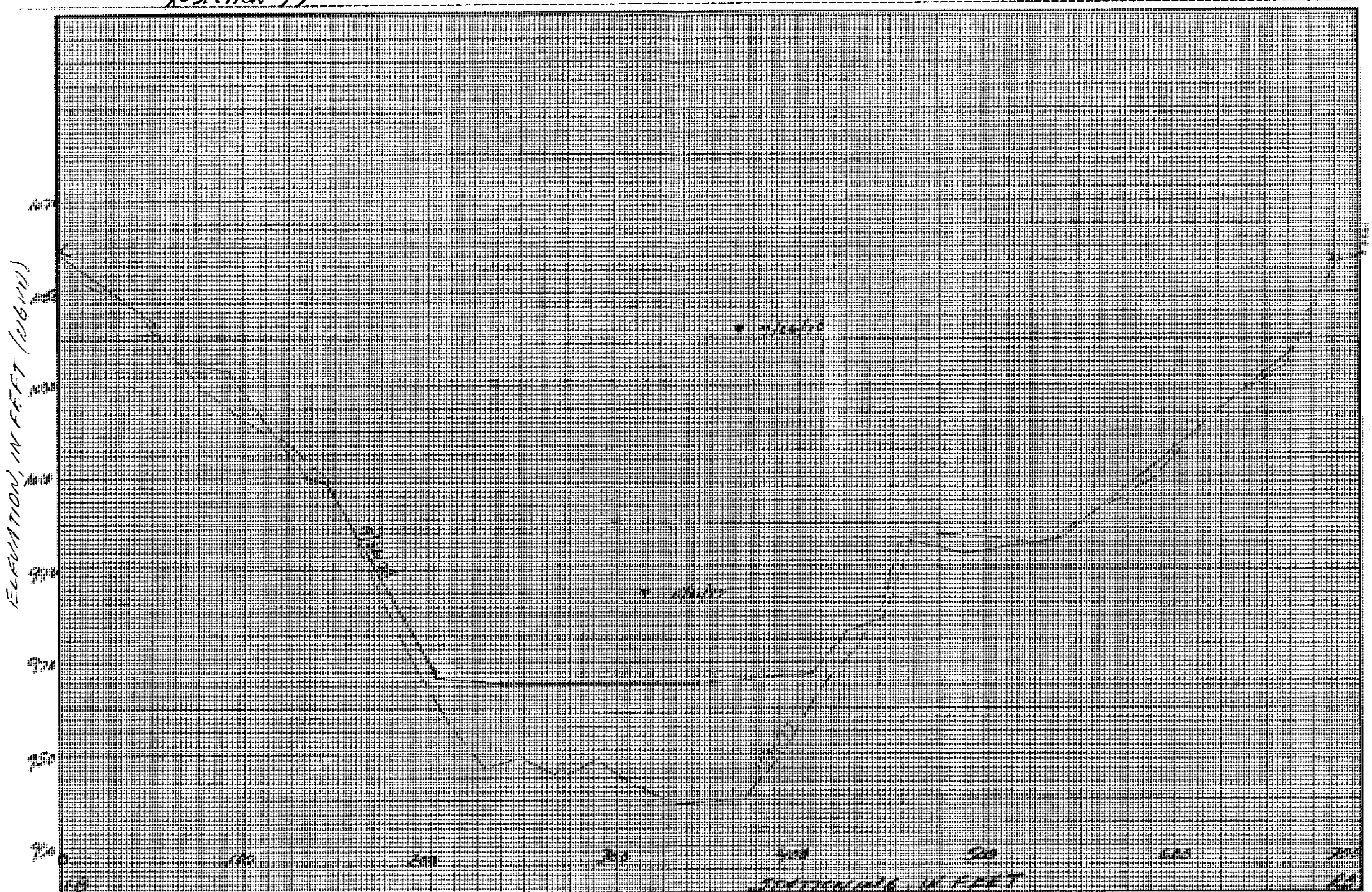

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(March 1949)
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GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File

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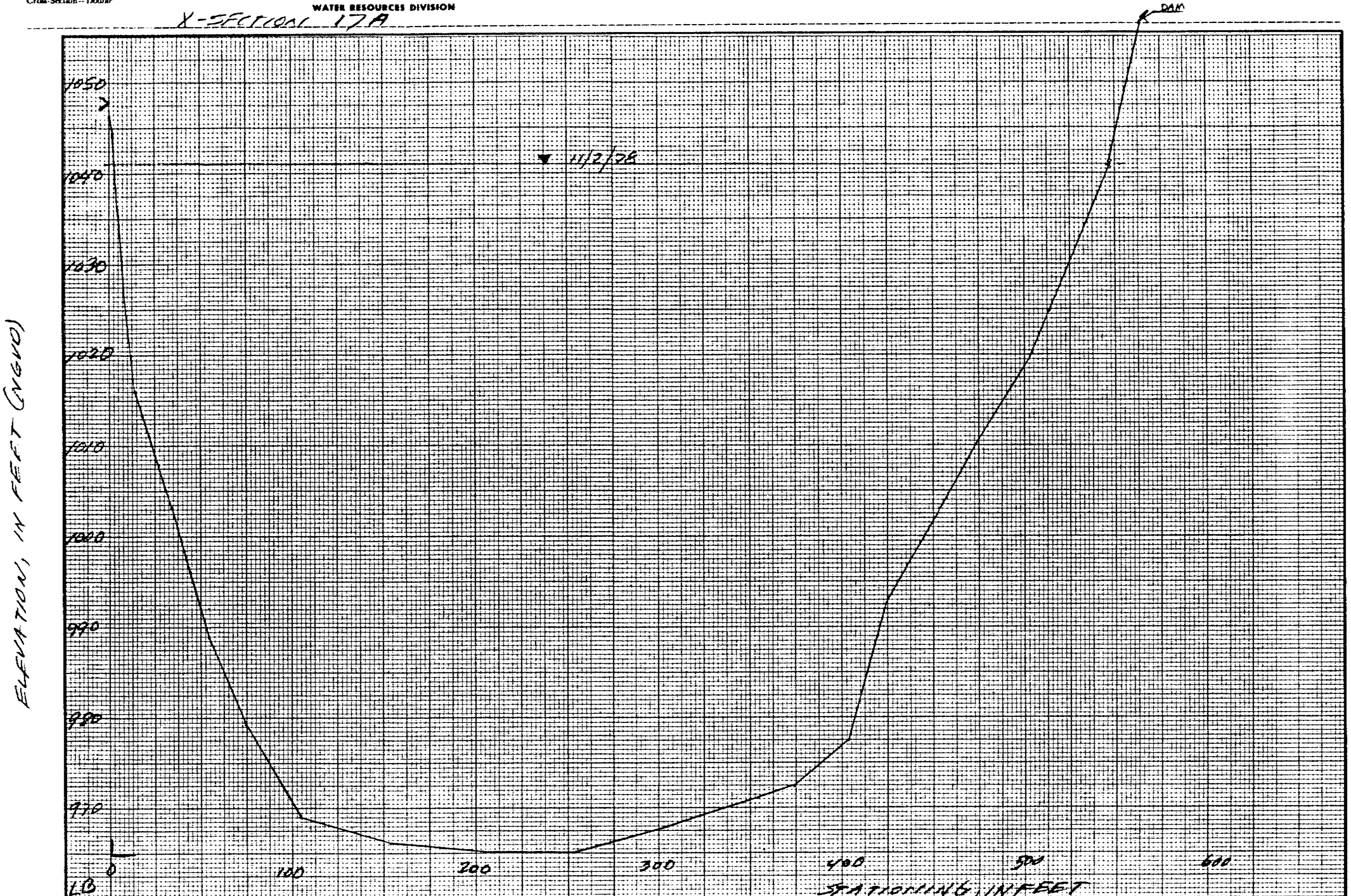

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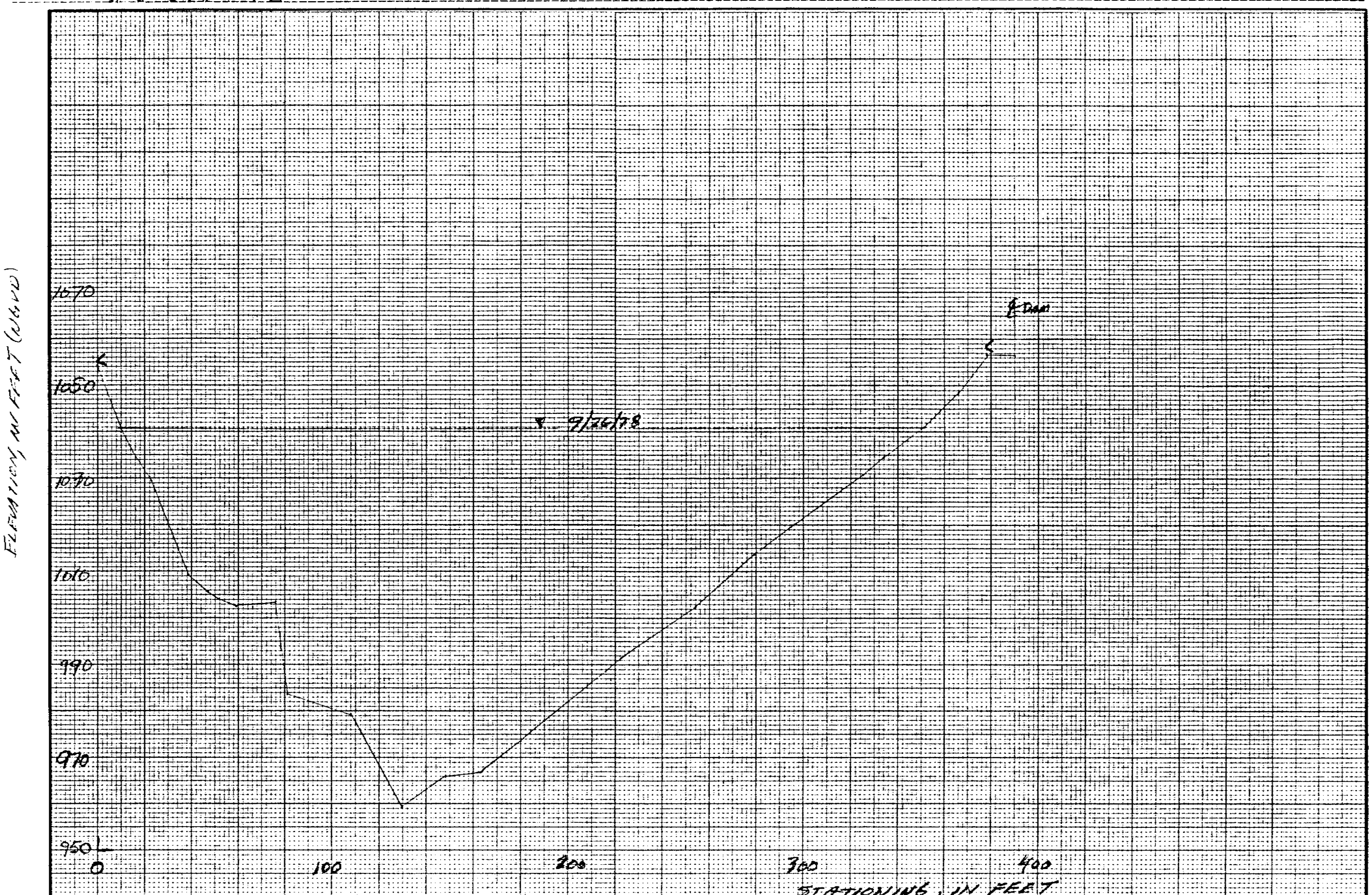
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File LOS PADRES RES

X-SECTION 18



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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resource Division
855 Oak Grove Avenue
Menlo Park, California 94025

Copy

November 23, 1979

Mr. Bruce Buel, Manager
Monterey Peninsula
Water Management District
P.O. Box 85
Monterey, California 93940

Dear Bruce:

Enclosed are some data obtained on Los Padres Reservoir this last summer; I apologize for not getting this information to you sooner.

You can see from the plots that Range 13 had very little change from 1978. Range 12 experienced some deposition, but the cross sectional area of the accretion in the cross section is not large. An additional section was run about 60 feet downstream from Range 12. The only comparative information provided by this section is as shown on the plot of the Thalweg profile (lowest point of each section). This section is at the edge of the depositional fan in the upper part of the reservoir and indicates little advancement of significant deposition down the reservoir.

As I noted to you during our phone conversation, we will be contacting the Forest Service in the next few months to attempt to secure funding for a complete re-survey of the crosssections after the coming winter. We will keep you aware of any developments in that regard.

Very truly yours,

Charles W Boning

Charles W. Boning, Chief
Menlo Park Subdistrict, WRD

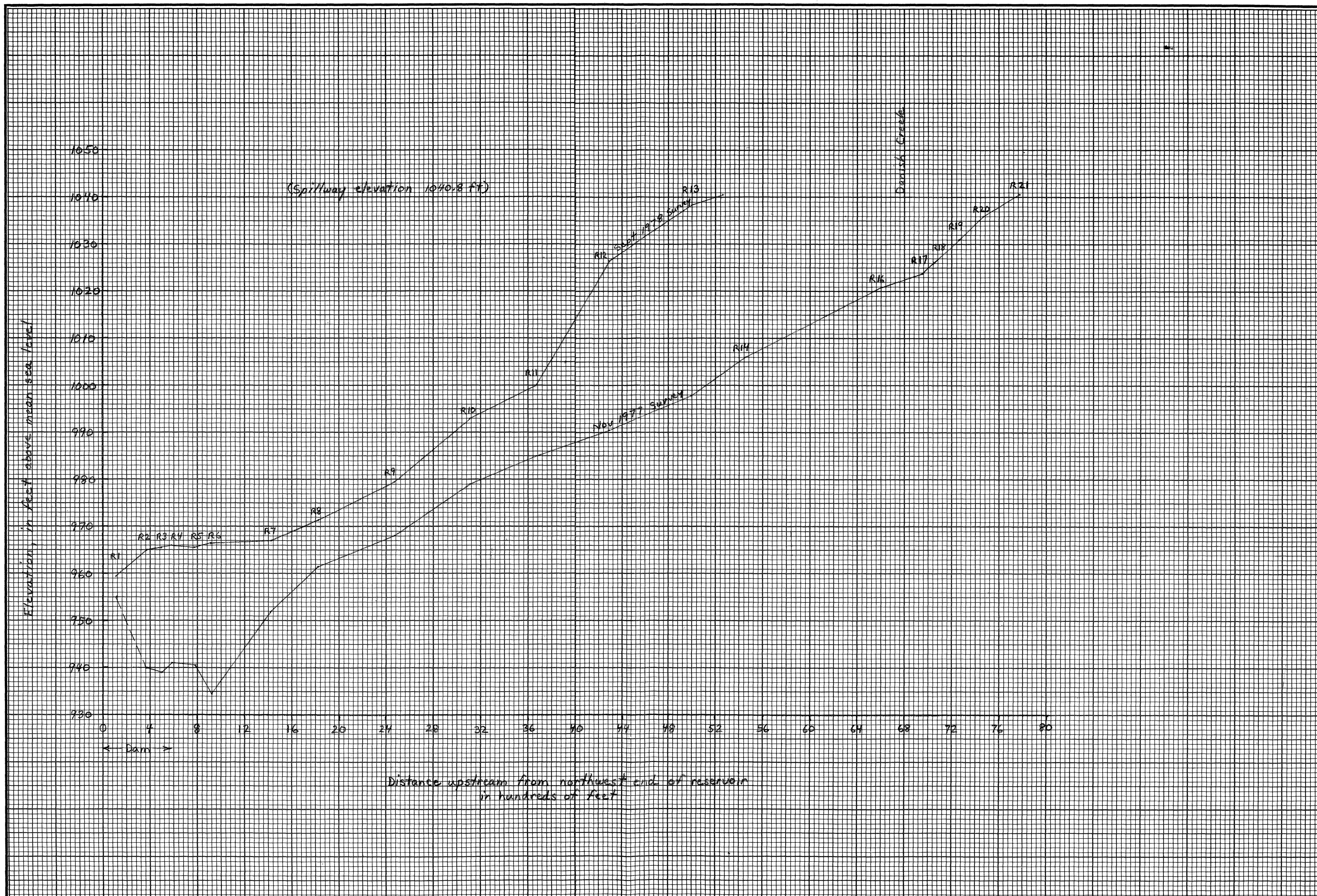
Enclosure

9-213-F
(March 1949)
Cross-Section—Double

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File

THALWEG PROFILES OF LOS PADRES RESERVOIR



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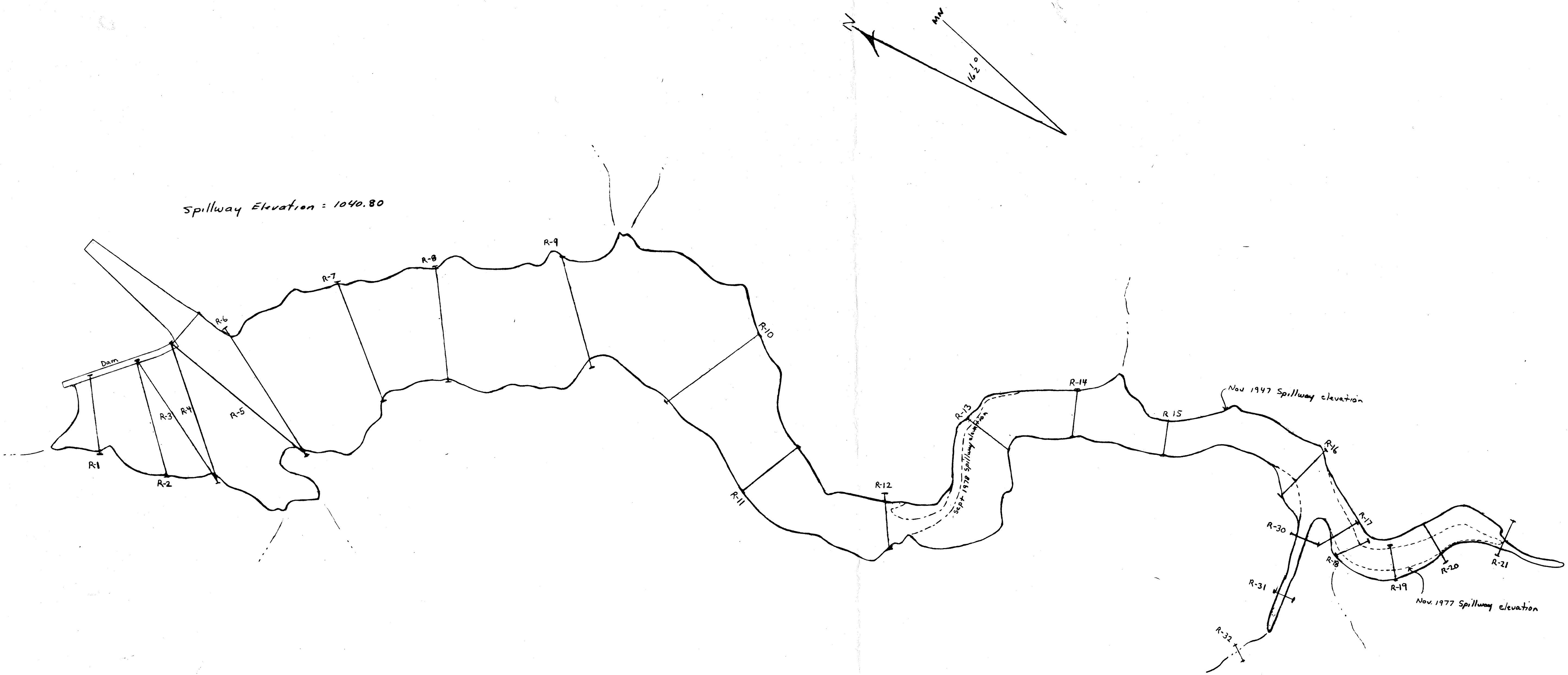


LOS PADRES RESERVOIR
1" = 300'

0 100 200 300 600 900

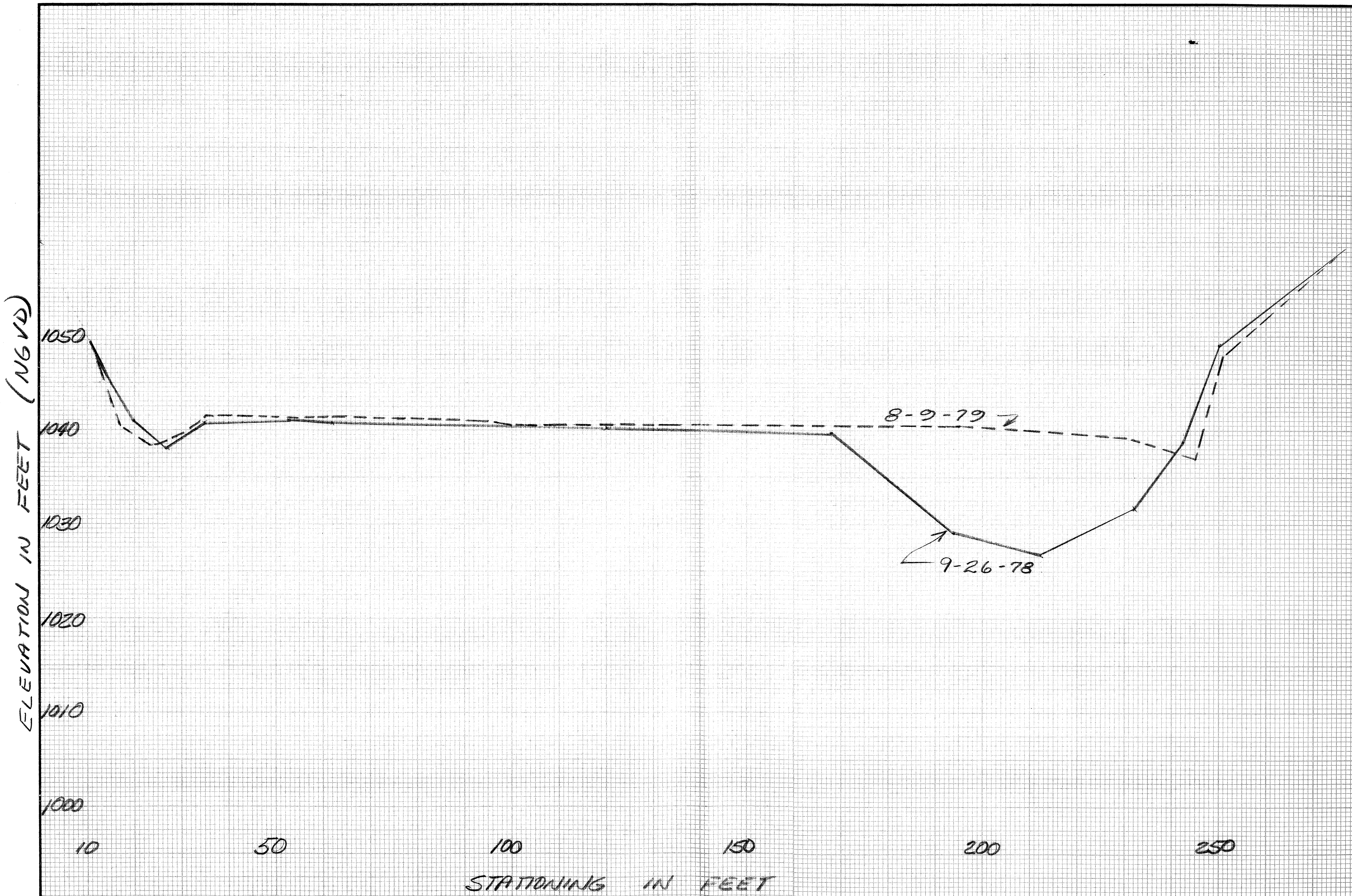
Ref, 11/23/79 letter from Boning (USGS) to Buel (MPWMD)

9-213-F
(March 1949)
Cross-Section—Double

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File____________

RANGE 12 - LOS PADRES RESERVOIR



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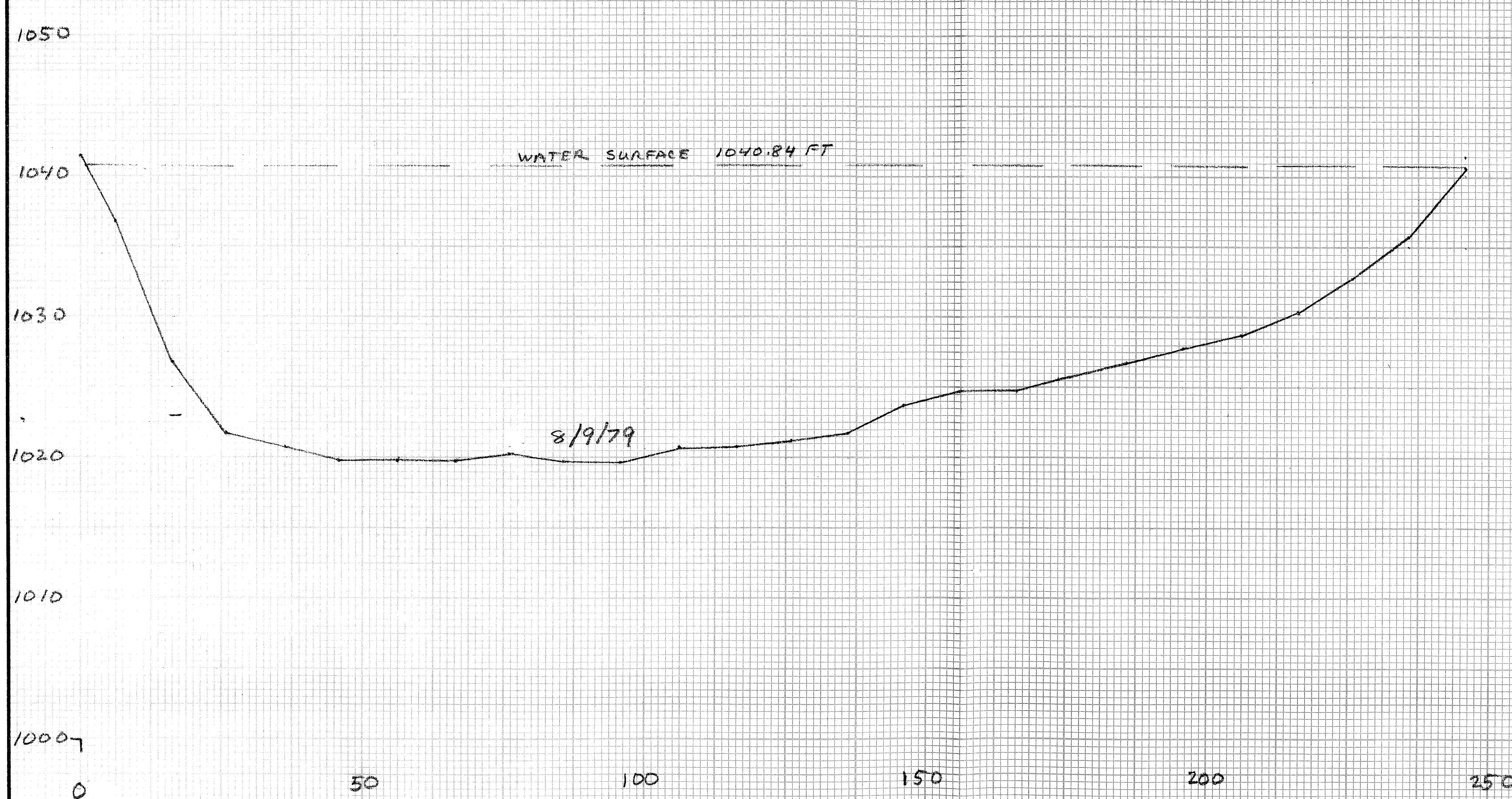
9-213-F
(March 1949)
Cross-Section—Double

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File LOS PADRES RESERVOIR

X- SECTION 60 FT D.S. OF R-12



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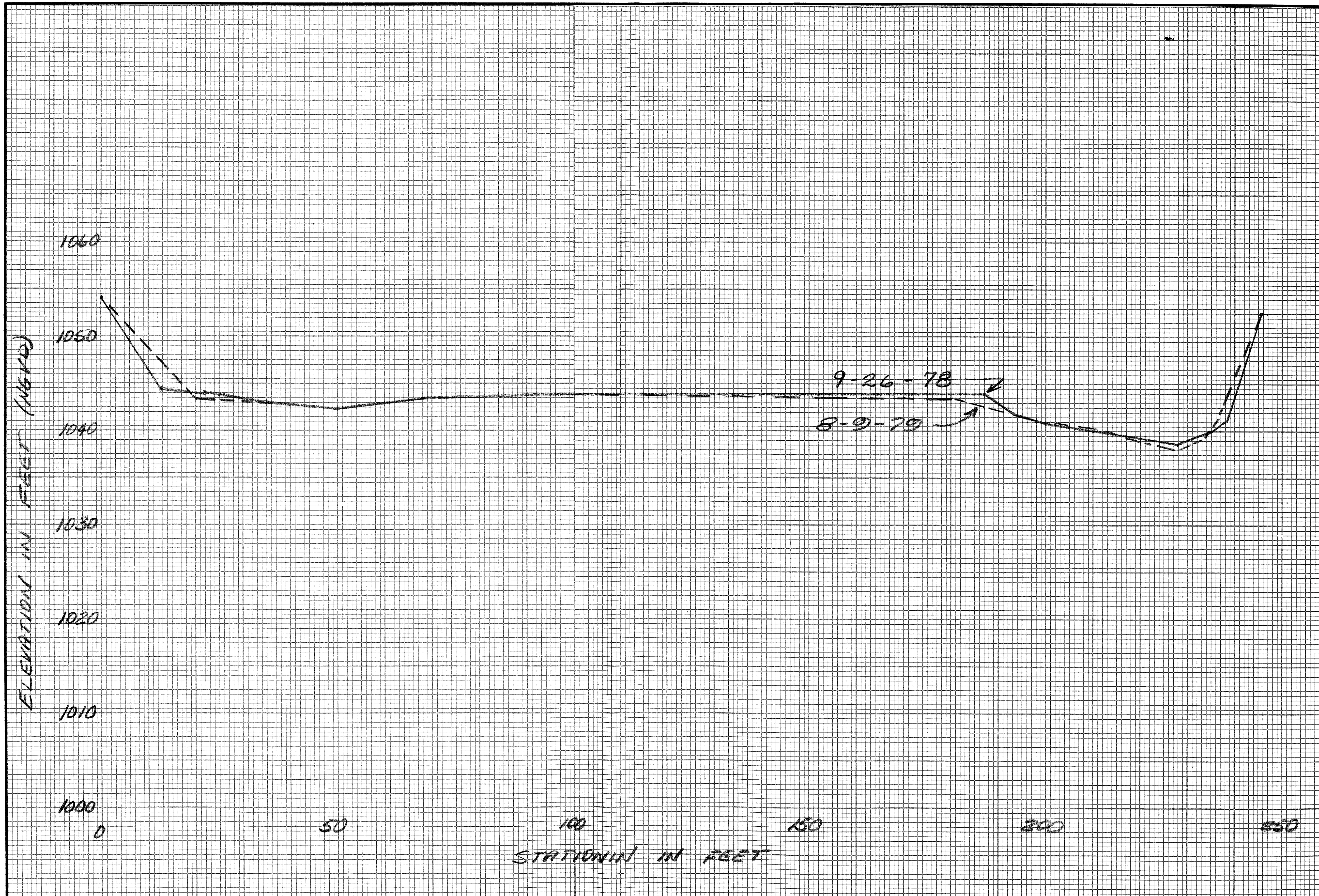
9-213-F
(March 1949)
Cross-Section—Double

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File____________

RANGE 13 - LOS PADRES RESERVOIR



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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Water Resources Division
855 Oak Grove Avenue
Menlo Park, California 94025

April 16, 1979

Mr. William R. Gianelli, Chairman
Monterey Peninsula Water Management
District
P.O. Box 85
Monterey, California 93940

Dear Mr. Gianelli:

As requested by members of your staff at our afternoon meeting on April 9, I am sending additional illustrative material that summarizes our study in Los Padres Reservoir. Included is a summary table of our computations that shows the volume of the reservoir at spillway level in 1947, 1977, and 1978, and the loss in capacity during the periods 1947-1977 and 1977-1978. To illustrate the capacity reductions more clearly, cylindrical portrayals of the volume of the reservoir in 1947, 1977, and 1978 are shown. The shaded portion of the cylinders depict the depositions of sediment in the reservoir. The capacity curves show the reservoir volumes in 1947 and 1948. This illustration is similar to that transmitted previously, but contain additional explanatory remarks identifying reservoir capacity at spillway elevation and loss in capacity over the periods 1947-1977 and 1977-1978.

Additional illustrations show how the rate of volume reduction in 1977-78 differed from the average rate of reduction over the 1947-1977 period. One illustration shows the average reduction in volume each year, the other illustration shows the percentage reduction by years since reservoir construction.

As discussed during your board meeting we will send you a summary list of accomplishments of work-schedule items of the Carmel-model study. This list to be sent shortly after May, will summarize work completed through that date. I am contemplating requesting that the project leader prepare summaries of this type, identifying completed work and the next three month's expected achievements, on a quarterly basis. This review of the project will be beneficial to our maintaining the proposed schedule as well as keeping you informed of our progress.

I am also enclosing a report entitled "Reports for California by the Geological Survey, Water Resources Division." The contents of the publication are indexed by county, and if you desire copies of any of these reports, please let us know.

Very truly yours,

Charles W. Boning

Charles W. Boning, Chief
Menlo Park Subdistrict

Enclosure

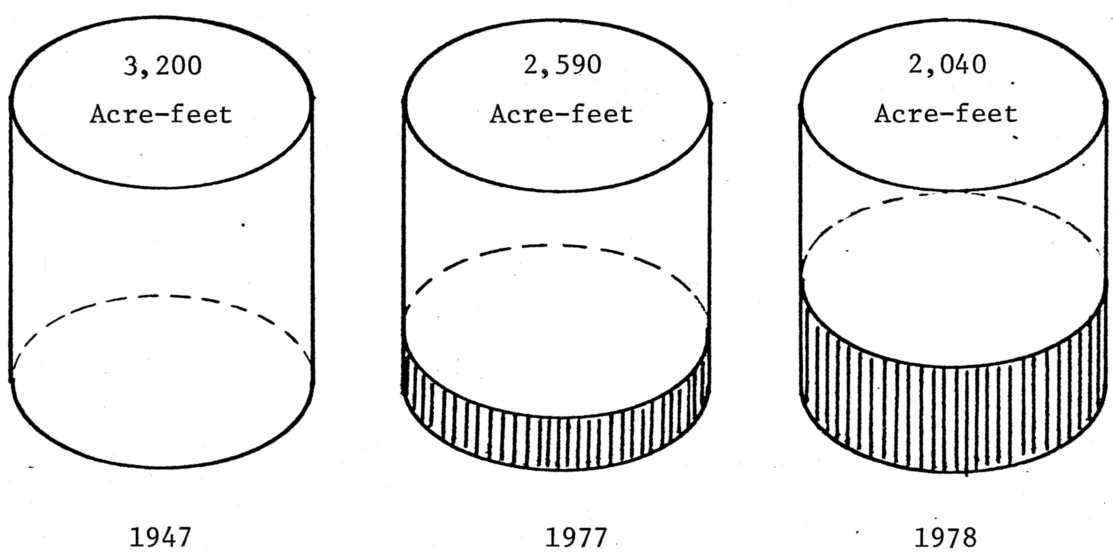
SUMMARY OF CAPACITY STUDIES ON LOS PADRES RESERVOIR

(1040.8 ft spillway elevation)

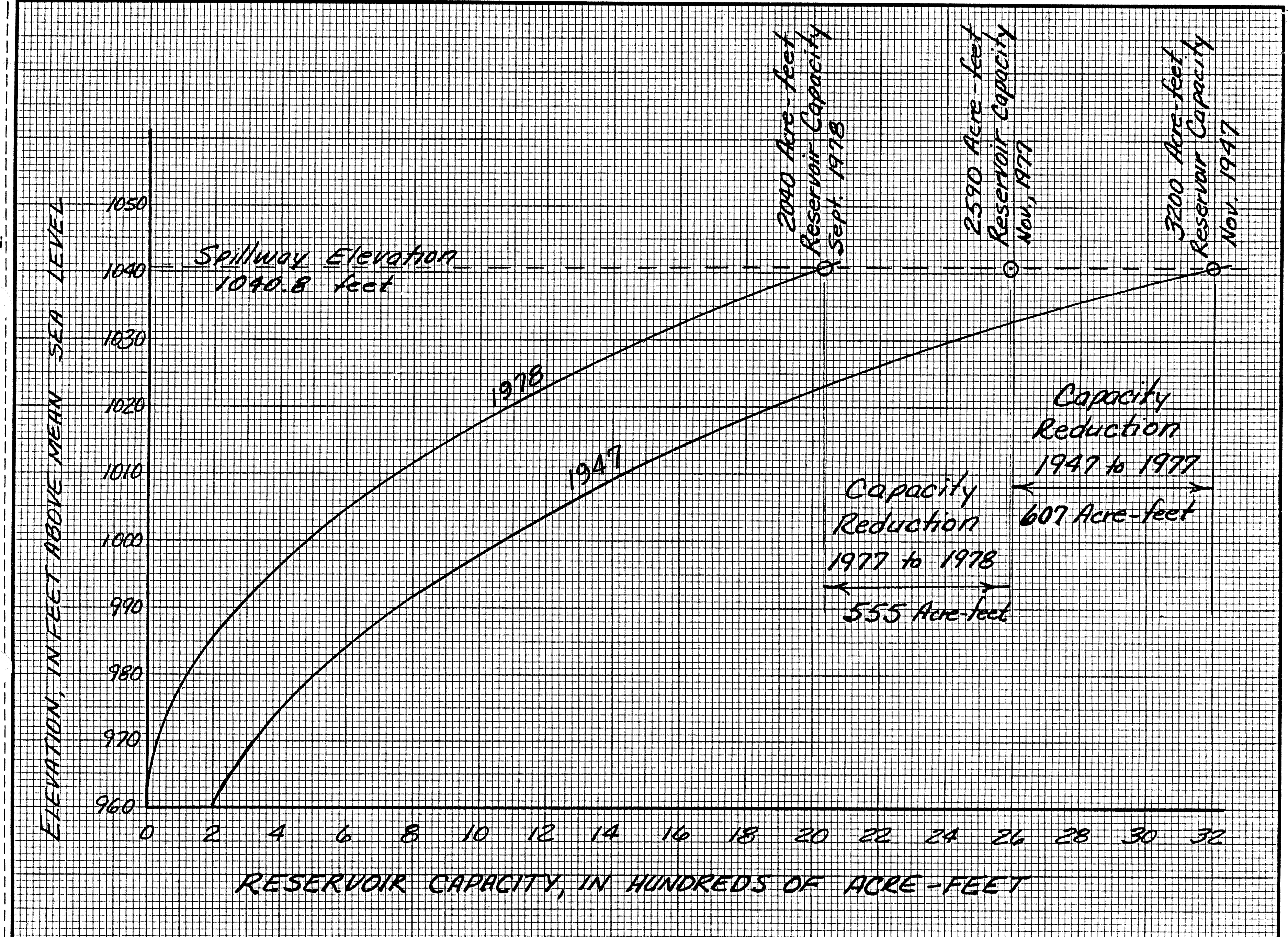
Year	Surface Area (Acres)	Total Capacity (Acre-ft)	Loss in Capacity (Acre-ft)
Nov. 1947	67[1]	3200[1]	---
Nov. 1977	67.4	2593	607
Sept. 1978	53.4	2038	555

[1] Data from 1947 capacity and area curves for Los Padres Reservoir- California Water and Telephone Company, Monterey Peninsula division

VOLUME OF LOS PADRES RESERVOIR



ELEVATION - CAPACITY CURVES FOR LOS PADRES RESERVOIR



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GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

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9-213-E (March 1949) Cross-Section

GPO : 1977 O - 229-910

9-213-E
(March 1949)
Cross-Section

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GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

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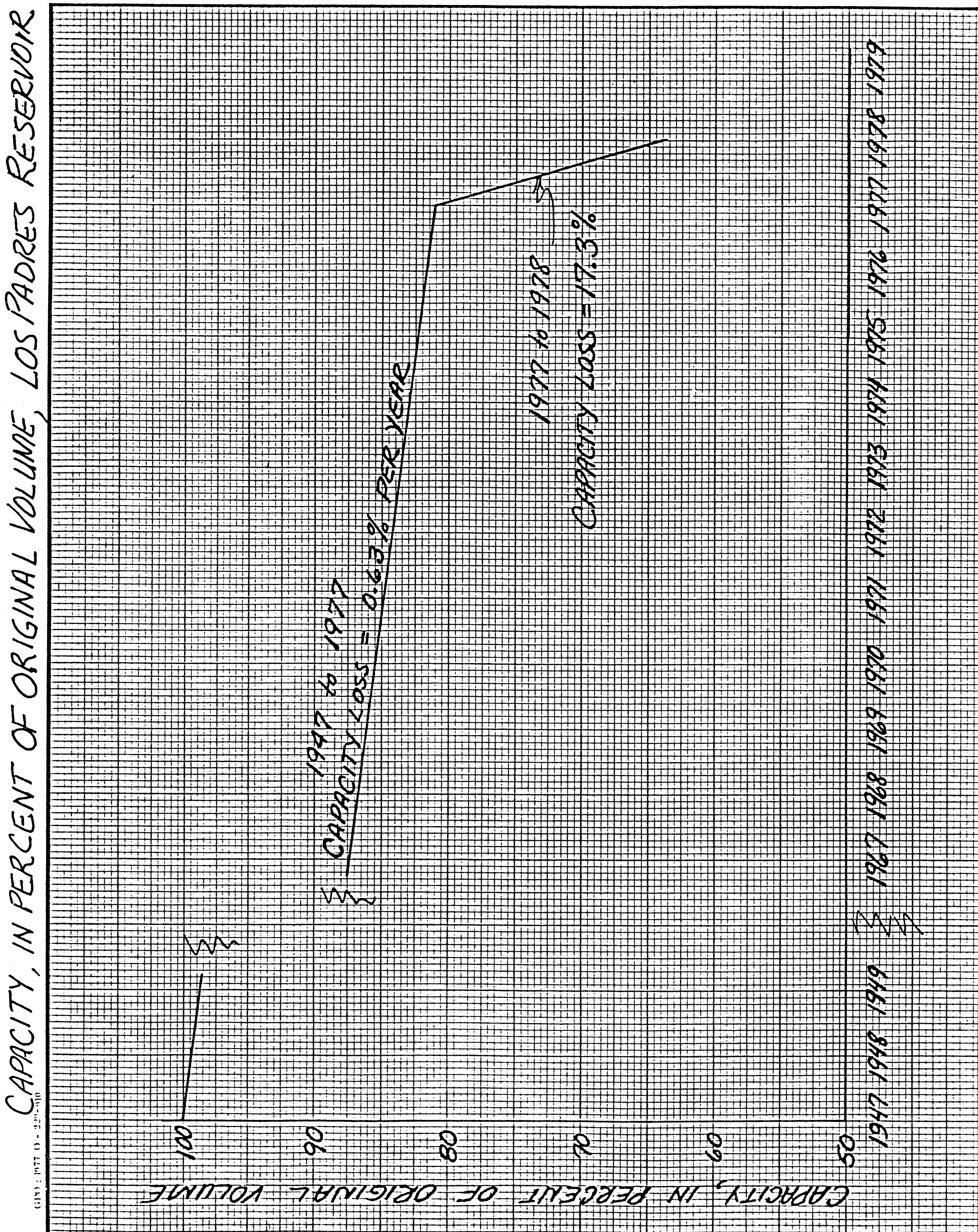

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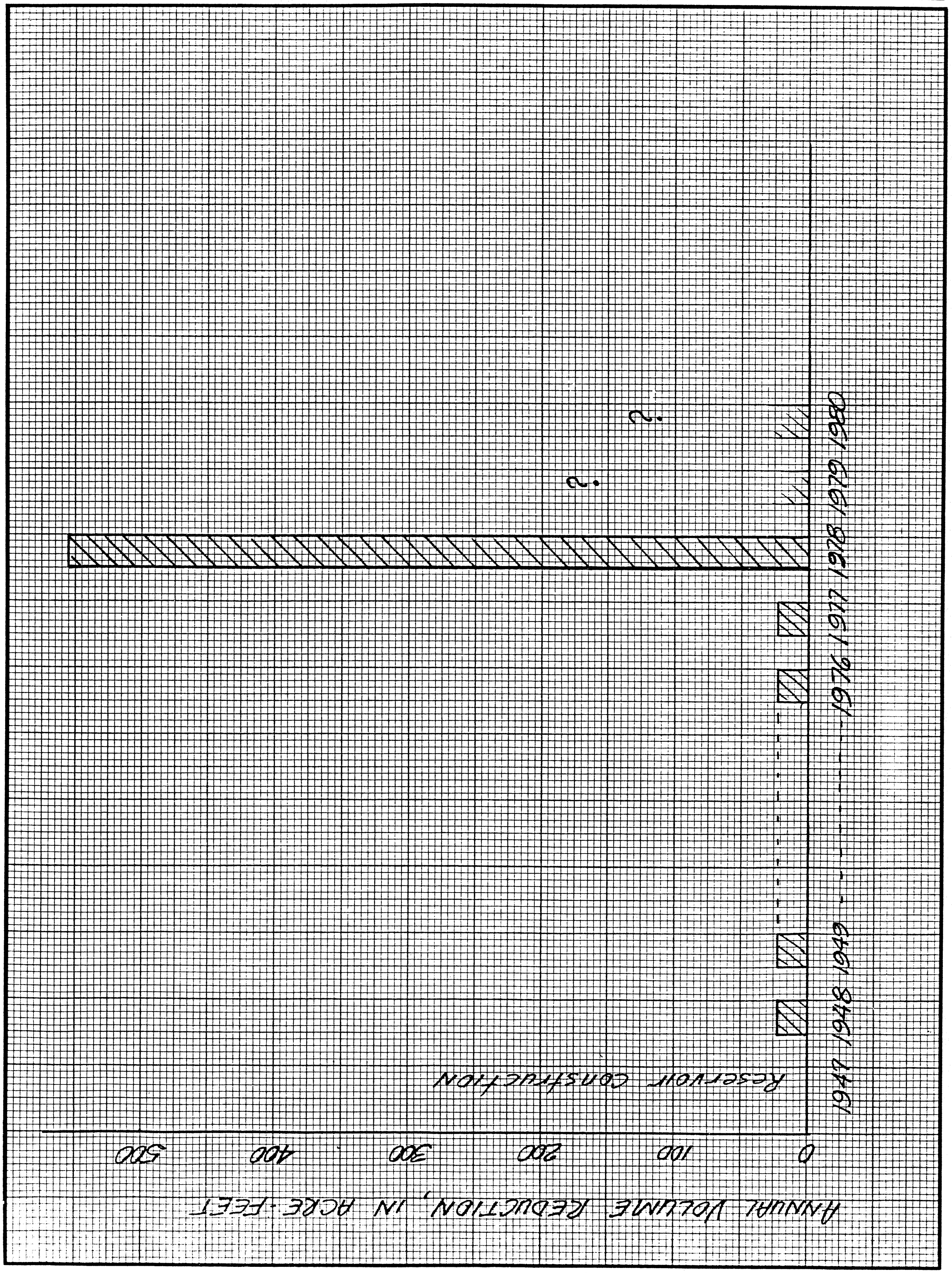
9-213-E
(March 1949)
Cross-Section

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File ....

ANNUAL VOLUME REDUCTION - LOS PADRES RESERVOIR



GPO : 1977 O - 22?-010

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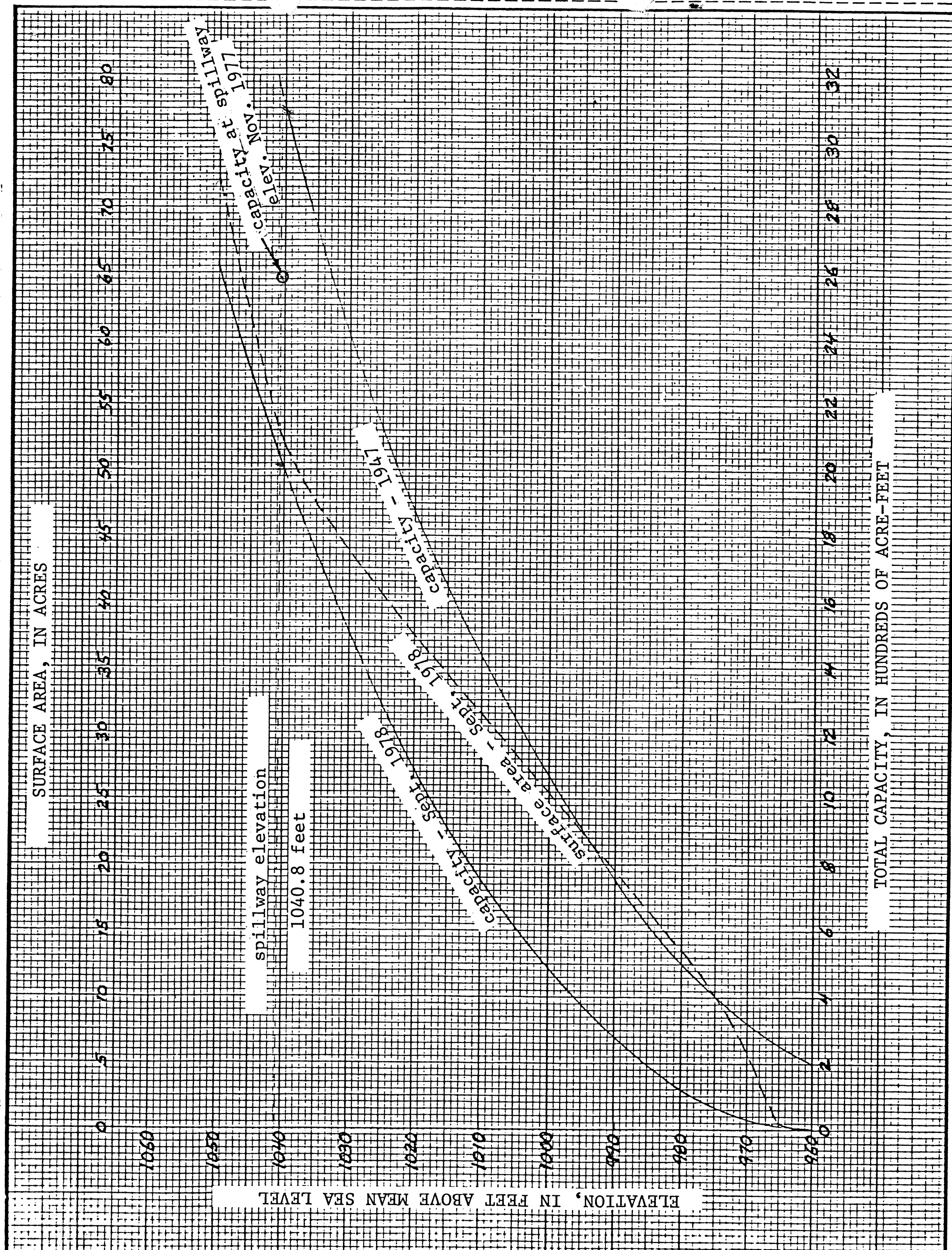
(March 1949)
Cross-Section

GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File ....



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