STRAIN GAGE PROGRAM - MATILIJA DAM
1965 - 1975

Strain gages to monitor the movements of Matilija Dam were first installed in the right and left abutments during the latter part of February 1965 by Carlson Instruments of Campbell, California. Four strain gages were installed in the left abutment (1L, 2L, 2aL and 3L) and four in the right abutment (1R, 2R, 2aR and 3R).

Strain gage meter calibrations and lead resistances were computed by Carlson Instruments and the necessary data needed to monitor the dam movements were listed on eight abutment yield measurement data sheets and presented to the Ventura County Flood Control District.

On March 8, 1965, instructions for operation of the instruments and computation of the data were given to Flood Control personnel and the first readings were made. The initial abutment yield measurement data sheets and data of the first readings are shown in Exhibit A (8 sheets).

On April 10, 1967, Carlson Instruments visited Matilija Dam and made a check of lead resistances of the eight strain gages. The readings are tabulated in Exhibit B.

STRAIN GAGE CLEANING AND REPLACEMENT
September 28, 1972

On July 6, 1972, the technician in charge of reading the strain gages discovered an open circuit to Strain Gage 1L. A decision was made to have Carlson Instruments visit the dam and advise the Flood Control District as to the condition of the meters and leads to all strain gages.

Dr. Carlson advised us to remove and visually inspect all strain gage meters for broken seals, bellows damage, etc.

On August 2, 1972, after reading the meters, all were removed and inspected. Five were found to be defective. They were 1L, 2aL, 3L

2aR and 3R. The meters were sent to Carlson Instruments where they were reconditioned and returned to the Flood Control District along with new calibration data (Exhibit C).

On September 28, 1972, the installation of the five new meters and the cleaning of the remaining three was completed and the lead resistances were checked (Exhibit D).

The calibration values for the "abutment yield data" sheets of the five reconditioned meters had to be changed at this time. Data for the changes were supplied by Carlson Instruments (Exhibit C) and computations made by the Flood Control Field Hydrology staff. (See "Report - Removal and Replacement of Meters", dated September 1972.)

The only calibration necessary on the three meters that were cleaned was the "resistance ratio at initial reading", which was disturbed due to removal from its mounting. This calibration was performed by merely adjusting the meter in its mounting until the "resistance ratio in percent" was somewhere close to its reading prior to the cleaning operation.

Because of the length of time between the removal and installation of the meters, it became apparent that continued movement of the dam during the interval, plus new positioning of the meters on their mounting frames would necessitate an adjustment of the "resistance ratio at initial reading" in order that abutment yield measurements made after September 28 would correlate with past readings when they were plotted. (See memorandum dated 3/30/73 from S. G. Marsh to J. B. Quinn.)

After the "adjusted resistance ratio" was computed, new "abutment yield measurement data" sheets were typed and put into use (Exhibit E).

STRAIN GAGE LEAD MODIFICATION AND CALIBRATION
March 6, 1975

On December 10, 1973, because of continued deterioration of the concrete of the upper portion of Matilija Dam, it became necessary to discontinue monitoring the right abutment strain gages due to unsafe access conditions.

In February 1975, a contract was awarded to J. D. Hadley, Inc., a general engineering contractor with Zeger's Electric Company as subcontractor to install new leads to the right abutment strain gages and

extend them across the canyon to the valve house on the left abutment. On February 21, 1975, the original leads to the right abutment strain gages were severed according to plan. The new, extended leads were installed by the subcontractor and on February 26, 1975, the connections of these leads to the meters and their testing for resistance was completed by the Flood Control Hydrology staff (Exhibit F).

Due to the increased resistance caused by extending the leads, it became necessary to change the values of three of the calibrations on abutment yield data sheets 1R, 2R, 2aR and 3R. To compute these values, it was necessary to have certain data relating to the characteristics of the strain gages. As two of the strain gages on the right abutment (1R and 2R) are the original gages installed by Carlson Instruments of Campbell, California, the necessary data was not available in our files. Telephone calls to Carlson Instruments and Dr. Roy Carlson, personally, revealed that this necessary information was no longer in their files.

Carlson Instruments suggested that we remove the two strain gages 1R and 2R and send them to their laboratory for recalibration and examination. However, by use of an equation sent to us some years ago by Carlson Instruments, the Hydrology staff, using certain data taken from early abutment yield data sheets, was able to derive the missing data. The equation is as follows, as originally furnished by Carlson Instruments to derive the necessary calibrations to compute the movements of the dam.

$$C' = C + \frac{.89\,yC}{R}$$

where

C' = Calibration constant, corrected for leads.

C = Calibration constant of the meter.

y = Resistance of a pair of leads.

R = Meter resistance at 0^{o} F.

The missing data from the original meters 1R and 2R is as follows:

C = Calibration constant of the meter.

R = Meter resistance at 0^{o} F.

Data researched by the Hydrology staff from early abutment yield data sheets and a copy of the original resistance of a pair of leads, which were in our files, is as follows:

C' = Calibration constant corrected for leads.

y = Resistance of a pair of leads.

To obtain the missing R of the equation, the original resistance of a pair of leads was subtracted from the meter resistance at 0^{o} F corrected for leads, which is given in the early abutment yield data sheets from our files. This left only one unknown in the equation which was C. To solve for C, the equation was stated as follows:

$$RC' = RC + .89\,yC$$

$$RC' = C(R + .89\,y)$$

$$C = \frac{RC'}{R + .89\,y}$$

With all the missing elements of the equation for Meters 1R and 2R now at our disposal, the staff proceeded to obtain the necessary calibrations for the extended leads as shown in Table 1, Exhibit G.

Using the meter calibration data for strain gages 2aR and 3R (Exhibit E), the derived meter calibration data for strain gages 1R and 2R (Exhibit G) plus the adopted values of the lead resistances (Exhibit F) in the original Carlson Instruments' equation, the new calibrations for the right abutment strain gages were computed.

As only five days had elapsed between the severing of the right abutment strain gages leads and the completion of installation of the lengthened leads, it was decided to adjust the new resistance ratio at initial reading in order that the abutment yield measurements made on February 21 at 8 A.M. would correlate exactly with measurements made on February 26 at 8 A.M. (See "Equation - Computation of Adjusted Resistance Ratio", dated March 6, 1975.)

New abutment yield measurement data sheets were typed for meters 1R, 2R, 2aR and 3R. It was not necessary to type new abutment yield measurement data sheets for the left abutment strain gages, as no changes were made there (Exhibit H).

The indicated movement from initial position in inches prior to severing the original leads and after lengthening the leads is tabulated in Exhibit H for clarification purposes only.

STRAIN GAGE DH-1L REPLACEMENT

AUGUST 4, 1976

In July, 1976, Meter J-12 located in Drill Hole 1L was recognized as being inoperative. From observations made during the past year, it became obvious that approximately from January 5, 1976, through July 12, 1976, readings made at DH-1L were in error.

On July 23, 1976, Meter J-12 was removed from its foundation at DH-1L and found damaged. Upon examination of data concerning the range limits of this meter, it was found that about the first part of January, 1976, the closed limit had been reached. It is assumed that from January, 1976 through July 23 the compression at this location continued and eventually damaged the meter.

A new meter was installed on July 26, 1976, and its Initial Resistance Ratio set to read 102.60 percent on the Carlson Test Set. A resistance check was made on the leads from the monitoring station to the new meter and found to be in good condition (Exhibit J). A new "Abutment Yield Data Sheet" was initiated and the Initial Resistance Ratio recorded (Exhibit K). The "Calibration Constant Corrected for Leads" was computed by use of an equation shown in Exhibit L. Other data on the Data Sheet was supplied with the new meter received from Carlson Instruments. (Exhibit M).

In order to provide some estimate of the movement between the Left Abutment and the Dam during the inoperative period, a graph was drawn on rectangular coordinate graph paper through two plotted points representing the readings of the deformation in inches for August 1, 1974, and August 1, 1975. A straight line was extended on the graph to August 1, 1976 and the deformation in inches read off. (Exhibit N).

In order to correlate plots of previous deformation readings and plots of future readings, an adjustment of the "Initial Resistance Ratio" was calculated (Exhibit P) and entered on the new Abutment Yield Data Sheet. An asterisk precedes this entry.

Mr. Gordon L. Dukleth, Division Engineer, for the California Division of Safety of Dams was informed by letter dated August 6, 1976, of the foregoing proceedings(Exhibit Q).

George A. Gonsman

George A. Gonsman
Supervisor, Field Hydrology

ABUTMENT YIELD MEASUREMENT DATA

Project: MATILIJA DAM

Drill-hole No. DH-1L
Meter No. M-8
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001194 inches per 0.01 % ratio change
Resistance ratio at initial reading 99.96 per cent
Resistance ratio, meter closed: 97.3 per cent
Resistance ratio, meter open: 102.2 per cent
Meter resistance at 0°F, corrected for leads 51.18 ohms
Change in temperature per ohm change in resistance 10.84 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
				FIRST READING MARCH 8, 1965							
3-8-65	2:50 PM			62°				100.02	+0.06	+0.0072	

SUPERSEDED
9/28/72

EXHIBIT "A"

ABUTMENT YIELD MEASUREMENT DATA

Project: *MATILIJA DAM*

Drill-hole No. DH-2L
Meter No. M-3
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001073 inches per 0.01 % ratio change
Resistance ratio at initial reading 101.16 per cent
Resistance ratio, meter closed: 98.6 per cent
Resistance ratio, meter open: 104.2 per cent
Meter resistance at 0°F, corrected for leads 49.67 ohms
Change in temperature per ohm change in resistance 10.95 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
				FIRST READING MARCH 8, 1965							
3-8-65	2:50 PM			62°				101.21	+0.05	+0.0054	

SUPERSEDED
9/28/72

EXHIBIT "A"

ABUTMENT YIELD MEASUREMENT DATA

Project: *MATILIJA DAM*

Drill-hole No. DH-2aL
Meter No. M-7
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001032 inches per 0.01 % ratio change
Resistance ratio at initial reading 101.04 per cent
Resistance ratio, meter closed: 98.4 per cent
Resistance ratio, meter open: 104.2 per cent
Meter resistance at 0°F, corrected for leads 49.84 ohms
Change in temperature per ohm change in resistance 10.91 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
				FIRST READING MARCH 8, 1965							
3-8-65	2:50 PM			62°				101.00	-0.04	-0.0041	

SUPERSEDED
9/28/72

EXHIBIT "A"

ABUTMENT YIELD MEASUREMENT DATA

Project: MATILIJA DAM

Drill-hole No. DH-3L
Meter No. M-2
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001117 inches per 0.01 % ratio change
Resistance ratio at initial reading 101.09 per cent
Resistance ratio, meter closed: 98.1 per cent
Resistance ratio, meter open: 103.6 per cent
Meter resistance at 0°F, corrected for leads 51.69 ohms
Change in temperature per ohm change in resistance 10.95 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
			FIRST	READING MARCH 8, 1965							
3-8-65	2:50 PM			62°				101.12	+0.03	+0.0034	

SUPERSEDED
9/28/72

EXHIBIT "A"

ABUTMENT YIELD MEASUREMENT DATA

Project: *MATILIJA DAM*

Drill-hole No. DH-1R
Meter No. M-6
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001159 inches per 0.01 % ratio change
Resistance ratio at initial reading 100.76 per cent
Resistance ratio, meter closed: 98.0 per cent
Resistance ratio, meter open: 103.6 per cent
Meter resistance at 0°F, corrected for leads 49.76 ohms
Change in temperature per ohm change in resistance 10.88 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
			FIRST	READING MARCH	8, 1965						
3-8-65	3:05 PM			62°				100.77	+0.01	+0.0012	

SUPERSEDED
9/28/72

EXHIBIT "A"

ABUTMENT YIELD MEASUREMENT DATA

Project: MATILIJA DAM

Drill-hole No. DH-2R
Meter No. M-1
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001147 inches per 0.01 % ratio change
Resistance ratio at initial reading 100.82 per cent
Resistance ratio, meter closed: 97.9 per cent
Resistance ratio, meter open: 103.0 per cent
Meter resistance at 0°F, corrected for leads 50.07 ohms
Change in temperature per ohm change in resistance 10.95 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
			FIRST	READING MARCH 8, 1965							
3-8-65	3:05 PM			62°				100.83	+0.01	+0.0011	

SUPERSEDED
9/28/72

EXHIBIT "A"

ABUTMENT YIELD MEASUREMENT DATA

Project: MATILIJA DAM

Drill-hole No. DH-2aR
Meter No. M-5
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001194 inches per 0.01 % ratio change
Resistance ratio at initial reading 100.84 per cent
Resistance ratio, meter closed: 98.4 per cent
Resistance ratio, meter open: 103.8 per cent
Meter resistance at 0°F, corrected for leads 49.99 ohms
Change in temperature per ohm change in resistance 10.93 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
			FIRST	READING	MARCH	8, 1965					
3-8-65	3:05 PM			62°				100.86	+0.02	+0.0024	

SUPERSEDED
9/28/72

EXHIBIT "A"

ABUTMENT YIELD MEASUREMENT DATA

Project: MATILIJA DAM

Drill-hole No. DH-3R
Meter No. M-4
Sheet No. _____

Calibrations:

Calibration constant, corrected for leads .001088 inches per 0.01 % ratio change
Resistance ratio at initial reading 101.79 per cent
Resistance ratio, meter closed: 98.9 per cent
Resistance ratio, meter open: 104.5 per cent
Meter resistance at 0°F, corrected for leads 50.57 ohms
Change in temperature per ohm change in resistance 10.93 °F

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
			FIRST READING MARCH 8, 1965								
3-8-65	3:05 PM			62°				101.80	+0.01	+0.0011	

SUPERSEDED
9/28/72

EXHIBIT "A"

TABLE OF READINGS

TAKEN ON APRIL 10, 1967

All Readings in ohms.

Meter No.	Black & White	White & Green	Black & Green	Lead Resistance	Adopted Value
1L	56.30	28.745	28.745	1.19	1.17
	56.39	28.77	28.77	1.15	
2L	55.96	28.52	28.14	0.70	0.70
	55.97	28.52	28.15	0.70	
2aL	55.71	28.33	28.04	0.66	0.67
	55.72	28.35	28.05	0.68	
3L	56.82	29.99	29.52	2.69	2.70
	56.85	30.01	29.55	2.71	
1R	54.63	27.62	27.43	0.42	0.42
	54.67	27.62	27.47	0.42	
2R	54.69	28.04	27.74	1.09	1.08
	54.68	27.95	27.79	1.06	
2aR	55.20	28.18	27.92	0.90	0.89
	55.19	28.16	27.90	0.87	
3R	55.42	28.67	28.21	1.46	1.46
	55.44	28.69	28.21	1.46	

EXHIBIT "B"

CARLSON INSTRUMENTS

MODEL NO. JO .5

DATE 8-28-72

CUSTOMER Ventura County Public Works Dept.

SALES ORDER NO. 0062

METER CALIBRATION DATA

Meter Location	Meter No.	Resistance at 0° F.	Degrees per Ohm	Calibration Constant	Resistance Ratios		
					Open	Closed	As Shipped
1L	J-12	53.85	9.61	.00063	103.7	95.8	97.3
2aL	J-13	54.17	9.56	.00062	104.0	96.0	97.2
3L	J-14	53.89	9.61	.00065	102.9	95.2	96.6
2aR	J-15	53.73	9.65	.00063	104.0	96.1	97.6
3R	J-16	53.66	9.66	.00063	104.6	96.7	98.2

EXHIBIT "C"

TABLE OF READINGS

TAKEN ON SEPT. 28, 1972

TIME: Left abut. 1200 PST. Right abut. 1300 PST.

AIR TEMPERATURE: Left abut. 78° F. Right abut. 73° F.

RESERVOIR ELEV.: 1046.59 ft.

ELEV. OF SILT, UPSTREAM FACE OF DAM (AV): 1036 ft.

All readings in ohms.

METER NO.	BLACK & WHITE	WHITE & GREEN	BLACK & GREEN	LEAD RESISTANCE	ADOPTED VALUE
1L	63.81	32.51	32.51	1.21	1.20
	63.85	32.53	32.52	1.20	
2L	56.86	28.80	28.76	.70	.70
	56.87	28.81	28.76	.70	
2aL	63.01	31.84	31.84	.67	.67
	63.02	31.84	31.84	.66	
3L	63.95	33.42	33.39	2.86	2.86
	63.96	33.42	33.39	2.85	
1R	56.04	28.23	28.19	.38	.38
	56.04	28.23	28.19	.38	
2R	56.18	28.62	28.55	.99	.98
	56.18	28.61	28.55	.98	
2aR	61.50	31.27	31.13	.90	.90
	61.50	31.28	31.13	.91	
3R	62.29	31.92	31.89	1.52	1.52
	62.29	31.92	31.89	1.52	

EXHIBIT "D"

REPORT

REMOVAL AND REPLACEMENT OF METERS

September 1972

In September 1972, Strain Gage Meters 1L, 2aL, 3L, 2aR and 3R were removed and replaced with new meters. The calibration constants on the Abutment Yield Data sheets for these meters were changed at this time from data supplied by Carlson Instruments, Campbell, California (EXHIBIT "C") and computations and tests made by the Ventura County Flood Control Field Hydrology staff.

The calibrations computed by the Hydrology staff are as follows:

Calibration constant, corrected for leads
Meter resistance at 0° F, corrected for leads

The equation used in these computations is as follows:

$$C' = C + \frac{yC\ .89}{R}$$

where

C' = New calibration constant, corrected for leads
C = Calibration of meter
y = Resistance of a pair of leads
R = Meter resistance at 0° F

Example of Meter 1L

$$C' = \frac{1.20 \times .00063 \times .89}{53.85} = .00001249 + .00063 = .00064249$$

$C' = .000642$ (See EXHIBIT E)

To obtain the Meter resistance at 0° F corrected for leads, the Resistance at 0° F for the meters (EXHIBIT C) was added to the Adopted value of the lead resistance to each meter. (EXHIBIT D)

The only calibration necessary on the three meters that were cleaned only was the Resistance ratio at initial reading which was disturbed due to removal from it's mounting. This calibration was performed by merely adjusting the meter in it's mounting until the resistance ratio was someplace close to it's reading prior to the cleaning operation.

The Adjusted resistance ratio after 9-28-72 which is preceeded by an asterisk, was determined by Mr. Gordon Marsh of the Ventura County Public Works Roads Section, in order to make the new Abutment Yield measurements correlate with past readings when they are plotted. (See memorandum dated March 30, 1973 from S. G. Marsh to J. B. Quinn)

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

New meter installed 9-28-72.

Drill-hole No DH-1L
Meter No. J-12
Sheet No.

Calibrations:

Calibration constant, corrected for leads .000642 inches per 0.01% ratio change
Resistance ratio at initial reading 100.06 per cent *
Resistance ratio, meter closed: 95.8 per cent
Resistance ratio, meter open: 103.7 per cent
Meter resistance at 0°F, corrected for leads 55.05 ohms
Change in temperature per ohm change in resistance 9.61 °F

*Adjusted resistance ratio after 9-28-72 (103.409)

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							
						EXHIBIT "E"					

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Original meter-cleaned & reinstalled 9-28-72.

Drill-hole No DH-2L

Meter No. M-3

Sheet No.

Calibrations:

Calibration constant, corrected for leads .001073 inches per 0.01% ratio change

Resistance ratio at initial reading 100.20 per cent *

Resistance ratio, meter closed: 98.6 per cent

Resistance ratio, meter open: 104.2 per cent

Meter resistance at 0°F, corrected for leads 49.67 ohms

Change in temperature per ohm change in resistance 10.95 °F

*Adjusted resistance ratio after 9-28-72 (100.06).

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							

EXHIBIT "E"

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Drill-hole No DH-2aL

Meter No. J-13

Sheet No.

New meter installed 9-28-72.

Calibrations:

Calibration constant, corrected for leads .000627 inches per 0.01% ratio change

Resistance ratio at initial reading 100.04 per cent *

Resistance ratio, meter closed: 96.0 per cent

Resistance ratio, meter open: 104.0 per cent

Meter resistance at 0°F, corrected for leads 54.84 ohms

Change in temperature per ohm change in resistance 9.56 °F

*Adjusted resistance ratio after 9-28-72 (99.88).

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
						EXHIBIT "E"					

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

New meter installed 9-28-72.

Drill-hole No DH-3L
Meter No. J-14
Sheet No. ______

Calibrations:

Calibration constant, corrected for leads .000681 inches per 0.01% ratio change
Resistance ratio at initial reading 100.14 per cent *
Resistance ratio, meter closed: 95.2 per cent
Resistance ratio, meter open: 102.9 per cent
Meter resistance at 0°F, corrected for leads 56.75 ohms
Change in temperature per ohm change in resistance 9.61 °F
*Adjusted resistance ratio after 9-28-72 (98.231).

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							

EXHIBIT "E"

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Original meter-cleaned &
reinstalled 9-28-72.

Drill-hole No DH-1R
Meter No. M-6
Sheet No.

Calibrations:

Calibration constant, corrected for leads .001158 inches per 0.01% ratio change
Resistance ratio at initial reading 100.17 per cent *
Resistance ratio, meter closed: 98.0 per cent
Resistance ratio, meter open: 103.6 per cent
Meter resistance at 0°F, corrected for leads 49.76 ohms
Change in temperature per ohm change in resistance 10.88 °F
*Adjusted resistance ratio after 9-28-72 (100.861).

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							

SUPERSEDED

Feb. 26th 1975

EXHIBIT "E"

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Drill-hole No DH-2R

Meter No. M-1

Sheet No. _____

Original meter-cleaned & reinstalled 9-28-72.

Calibrations:

Calibration constant, corrected for leads .001145 inches per 0.01% ratio change

Resistance ratio at initial reading 100.21 per cent *

Resistance ratio, meter closed: 97.9 per cent

Resistance ratio, meter open: 103.0 per cent

Meter resistance at 0°F, corrected for leads 50.07 ohms

Change in temperature per ohm change in resistance 10.95 °F

*Adjusted resistance ratio after 9-28-72 (100.079).

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.

SUPERSEDED

Feb. 26th 1975

EXHIBIT "E"

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

New meter installed 9-28-72.

Drill-hole No DH-2aR
Meter No. J-15
Sheet No.

Calibrations:

Calibration constant, corrected for leads .000639 inches per 0.01% ratio change
Resistance ratio at initial reading 100.52 per cent *
Resistance ratio, meter closed: 96.1 per cent
Resistance ratio, meter open: 104.0 per cent
Meter resistance at 0°F, corrected for leads 54.63 ohms
Change in temperature per ohm change in resistance 9.65 °F
*Adjusted resistance ratio after 9-28-72 (100.082).

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							

SUPERSEDED

Feb 26th 1975

EXHIBIT "E"

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Drill-hole No DH-3R

Meter No. J-16

Sheet No. _____

New meter installed 9-28-72.

Calibrations:

Calibration constant, corrected for leads .000646 inches per 0.01% ratio change

Resistance ratio at initial reading 100.13 per cent *

Resistance ratio, meter closed: 96.7 per cent

Resistance ratio, meter open: 104.6 per cent

Meter resistance at 0°F, corrected for leads 55.18 ohms

Change in temperature per ohm change in resistance 9.66 °F

*Adjusted resistance ratio after 9-28-72 (100.13).

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.

SUPERSEDED

Feb 26th 1975

EXHIBIT "E"

TABLE OF READINGS

DATE OF READINGS: Feb. 25, 1975

TIME OF READINGS: Right Abutment 1100 PST

All readings in ohms

METER READING	BLACK & WHITE	WHITE & GREEN	BLACK & GREEN	LEAD RESISTANCE	ADOPTED VALUE
1R	57.76 57.77	30.56 30.56	30.40 30.41	3.20 3.20	3.20
2R	57.97 57.98	30.87 30.87	30.88 30.88	3.78 3.77	3.77
2aR	63.30 63.32	33.57 33.57	33.46 33.47	3.73 3.72	3.73
3R	64.16 64.16	34.45 34.45	34.34 34.34	4.63 4.63	4.63

EXHIBIT "F"

TABLE 1

DERIVED CALIBRATION CONSTANTS FOR STRAIN GAGES 1R AND 2R

MARCH 5, 1975

Meter Location	Meter Number	Resistance @ 0° F.	Degrees Per Ohm	Calibration Constant	Resistance Ratios	
					Open	Closed
1 R	M-6	49.34	10.88	.001150	103.6	98.0
2 R	M-1	48.99	10.95	.001125	103.0	97.9

Equation:

$$C = \frac{R\,C'}{R + .89\,y}$$

where

C = Calibration constant of the meter.

R = Meter resistance at 0° F.

C'= Calibration constant, corrected for leads.

y = Resistance of a pair of leads.

Computed by
William C. Minger

Checked by
George A. Gonsman

EXHIBIT "C"

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

New Meter installed 9-28-72

Drill-hole No DH - 1L

Meter No. J - 12

Sheet No.

Calibrations:

Calibration constant, corrected for leads .000642 inches per 0.01% ratio change

Resistance ratio at initial reading 100.06 per cent *

Resistance ratio, meter closed: 95.8 per cent

Resistance ratio, meter open: 103.7 per cent

Meter resistance at 0°F, corrected for leads 55.05 ohms

Change in temperature per ohm change in resistance 9.61 °F

* Adjusted resistance ratio after 9-28-72 (103.409)

		Temperature			Total resistance from 0°F ohms	Increase in resistance from 0°F ohms		Resistance ratio per cent	Change in ratio from initial reading per cent	Indicated movement from initial position inches	
Date	Pac Std Time	Min.	Max.	At time of Obs.	(S_2)		Temp °F	(S_1)			Lake elev.

EXHIBIT H

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Original meter-cleaned & reinstalled 9-28-72.

Drill-hole No DH-2L

Meter No. M-3

Sheet No. ______

Calibrations:

Calibration constant, corrected for leads .001073 inches per 0.01% ratio change

Resistance ratio at initial reading 100.20 per cent *

Resistance ratio, meter closed: 98.6 per cent

Resistance ratio, meter open: 104.2 per cent

Meter resistance at 0^{o}F, corrected for leads 49.67 ohms

Change in temperature per ohm change in resistance 10.95 ^{o}F

*Adjusted resistance ratio after 9-28-72 (100.06).

Date	Pac Std Time	Temperature			Total resistance from 0^{o}F ohms (S_2)	Increase in resistance from 0^{o}F ohms	Temp ^{o}F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							

EXHIBIT H

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

New meter installed 9-28-72.

Drill-hole No DH-2aL
Meter No. J-13
Sheet No. ____

Calibrations:

Calibration constant, corrected for leads .000627 inches per 0.01% ratio change
Resistance ratio at initial reading 100.04 per cent *
Resistance ratio, meter closed: 96.0 per cent
Resistance ratio, meter open: 104.0 per cent
Meter resistance at 0°F, corrected for leads 54.84 ohms
Change in temperature per ohm change in resistance 9.56 °F
*Adjusted resistance ratio after 9-28-72 (99.88).

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							
						EXHIBIT H					

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

New meter installed 9-28-72.

Drill-hole No DH-3L
Meter No. J-14
Sheet No.

Calibrations:

Calibration constant, corrected for leads .000681 inches per 0.01% ratio change
Resistance ratio at initial reading 100.14 per cent *
Resistance ratio, meter closed: 95.2 per cent
Resistance ratio, meter open: 102.9 per cent
Meter resistance at 0°F, corrected for leads 56.75 ohms
Change in temperature per ohm change in resistance 9.61 °F
*Adjusted resistance ratio after 9-28-72 (98.231).

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							

EXHIBIT H

EQUATION
COMPUTATION OF ADJUSTED RESISTANCE RATIO
March 6, 1975

The following equation was used to adjust the Resistance ratio at initial reading after the leads were lengthened so that the plots on the Right Abutment graphs would be consistent with plots made before leads were lengthened.

Equation used when "M" or movement prior to lengthening leads was positive.

$$Ra = \frac{C'R + M}{C'}$$

Equation used when "M" or movement prior to lengthening leads was negative.

$$Ra = \frac{C'R - M}{C'}$$

where

Ra = Adjusted resistance ratio.
C' = Calibration constant corrected for leads in inches per 1 % ratio change.
R = Resistance ratio at initial reading in per cent.
M = Indicated movement from initial position in inches prior to lengthening leads.

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Leads extended 2-26-75

Drill-hole No DH - 1R

Meter No. M - 6

Sheet No.

Calibrations:

Calibration constant, corrected for leads .001216 inches per 0.01% ratio change

Resistance ratio at initial reading 100.57 per cent *

Resistance ratio, meter closed: 98.0 per cent

Resistance ratio, meter open: 103.6 per cent

Meter resistance at 0°F, corrected for leads 52.19 ohms

Change in temperature per ohm change in resistance 10.88 °F

* Adjusted resistance ratio after 2-26-75 (100.723)

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
2-21-75	0800				Prior to lengthening		leads			-0.0186	
					After lengthening leads						
2-26-75	0800	—	—	49°	56.83	4.64	50°	100.57	-0.153	-0.0186	1074.25

EXHIBIT H

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Leads extended 2-26-75

Drill-hole No DH - 2R

Meter No. M - 1

Sheet No.

Calibrations:

Calibration constant, corrected for leads .001202 inches per 0.01% ratio change

Resistance ratio at initial reading 100.00 per cent *

Resistance ratio, meter closed: 97.9 per cent

Resistance ratio, meter open: 103.0 per cent

Meter resistance at 0°F, corrected for leads 52.73 ohms

Change in temperature per ohm change in resistance 10.95 °F

* Adjusted resistance ratio after 2-26-75 (99.828)

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
2-21-75	0800				Prior to lengthening leads					+0.0207	
						After lengthening leads					
2-26-75	0800	—	—	49°	57.18	4.45	49°	100.00	+0.172	+0.0207	1047.25

EXHIBIT H

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Leads extended 2-26-75

Drill-hole No DH - 2aR

Meter No. J-15

Sheet No.

Calibrations:

Calibration constant, corrected for leads .000669 inches per 0.01% ratio change
Resistance ratio at initial reading 100.37 per cent*
Resistance ratio, meter closed: 96.1 per cent
Resistance ratio, meter open: 104.0 per cent
Meter resistance at 0°F, corrected for leads 57.46 ohms
Change in temperature per ohm change in resistance 9.65 °F

* Adjusted resistance ratio after 2-26-75 (99.827)

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
2-21-75	0800				Prior to lengthening leads					+0.0363	
					After lengthening leads						
2-26-75	0800	—	—	49°	63.16	5.70	55°	100.37	+0.543	+0.0363	1047.25

EXHIBIT H

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Leads extended 2-26-75

Drill-hole No DH - 3R

Meter No. J - 16

Sheet No.

Calibrations:

Calibration constant, corrected for leads .000678 inches per 0.01% ratio change

Resistance ratio at initial reading 100.38 per cent *

Resistance ratio, meter closed: 96.7 per cent

Resistance ratio, meter open: 104.6 per cent

Meter resistance at 0°F, corrected for leads 58.29 ohms

Change in temperature per ohm change in resistance 9.66 °F

* Adjusted resistance ratio after 2-26-75 (100.16)

Date	Pac Std Time	Temperature Min.	Temperature Max.	Temperature At time of Obs.	Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
2-21-75	0800				Prior to lengthening leads					+0.0149	
					After lengthening leads						
2-26-75	0800	—	—	49°	63.37	5.08	49°	100.38	+0.22	+0.0149	1074.25

EXHIBIT H

MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

JULY 23, 1976

LEAD RESISTANCE CHECK PRIOR TO NEW STRAIN GAGE METER INSTALLATION.
DH-1L

METER J-17

Following instructions supplied by Carlson Instruments, Campbell, California, the following equation was used for measuring the resistance of a pair of leads during the installation of the new strain meter J-17 in Drill Hole 1L.

EQUATION

B + C - A = resistance of a pair of leads.

Check No. 1.

Reading A = 63.30)
Reading B = 32.67) Resistance = 1.22 ohms.
Reading C = 31.85)

Check No. 2

Reading A = 63.40)
Reading B = 32.71) Resistance = 1.19 ohms.
Reading C = 31.88)

2.41 ohms.

2.41 ÷ 2 = 1.20 ohms.

Resistance of a pair of leads = 1.20 ohms.

EXHIBIT J

ABUTMENT YIELD MEASUREMENT DATA

Project MATILIJA DAM

Drill-hole No DH-1L
Meter No. J-17
Sheet No. ______

New meter installed 7/23/76

Calibrations:

Calibration constant, corrected for leads .000653 inches per 0.01% ratio change
Resistance ratio at initial reading 102.60 per cent*
Resistance ratio, meter closed: 96.3 per cent
Resistance ratio, meter open: 104.2 per cent
Meter resistance at 0°F, corrected for leads 55.70 ohms
Change in temperature per ohm change in resistance 9.51 °F

* Adjusted resistance ratio at initial reading after 7/21/76 (111.559)

Date	Pac Std Time	Temperature			Total resistance from 0°F ohms (S_2)	Increase in resistance from 0°F ohms	Temp °F	Resistance ratio per cent (S_1)	Change in ratio from initial reading per cent	Indicated movement from initial position inches	Lake elev.
		Min.	Max.	At time of Obs.							

EXHIBIT K

MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

JULY 26, 1976

OBTAINING "CALIBRATION CONSTANT CORRECTED FOR LEADS
DH-1L
METER J-17

EQUATION

$$C' = C + \frac{yC\ (0.89)}{R}$$

where
C' is the new calibration constant.
C is the original calibration constant.
y is the resistance of a pair of leads.
R is the meter resistance at 0° F

$$C' = C + \frac{1.20 \times .00064 \times 0.89}{54.50}$$

$$C' = .00064 + .00001254$$

$$C' = .000653$$

EXHIBIT L

MODEL NO. JO.5 DATE 9-12-73

CUSTOMER Ventura County SALES ORDER NO. 0262

METER NO	RESISTANCE AT 0 DEG.F	DEGREES PER OHM	CALIBRATION CONSTANT	RESISTANCE RATIOS OPEN	CLOSED	AS SHIPPED
J17	54.50	9.51	.00064	1.042	.963	.981

Exhibit M

MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

JULY 29, 1976

EXTRAPOLATION OF STRAIN GAGE READINGS JANUARY 5 TO AUGUST 1, 1976
DH-1L
METER J-12

In July, 1976, meter J-12 located in Drill Hole 1-L was recognized as being inoperative. From observations made during the past year, it became obvious that approximately from January 5, 1976 thru July 12, 1976, readings made at DH-1L were in error. In order to provide some estimate of the movement between the Left Abutment and the Dam at DH-1L, the following method was used and results plotted on the Deformation vs. Time graph:

From the current graph Deformation vs. Time, the deformation in inches for August 1, 1974 and August 1, 1975 was plotted on rectangular coordinate graph paper and was extended by a straight line to August 1, 1976. A reading of -.5850 was picked from the extended graph line and plotted on the DH-1L Deformation vs. Time graph for August 1, 1976. A dashed line was drawn from January 5, 1976 to August 1, 1976 to represent the approximate deformation at DH-1L during the period of erroneous record.

George A. Gonsman

George A. Gonsman
Supervisor, Field Hydrology

EXHIBIT N

MEMORANDUM

MATILIJA DAM

STRAIN GAGE PROGRAM

AUGUST 2, 1976

ADJUSTMENT OF INITIAL RESISTANCE RATIO READINGS AT DH-1L

Reference: Memorandum from S. G. Marsh to J. B. Quinn dated March 30, 1973

At the time of installation of Strain Meter J-17 in Drill Hole 1-L, the "Resistance ratio at initial reading" was set to read 102.60 percent with a balanced circuit on the Carlson Test Set. In order to make subsequent readings correspond to previous readings on the DH-1L Deformation vs. Time graph, the following calculations were made:

The previously plotted deformation of -.5850 for August 1, 1976 (see memo dated July 29, 1976) was devided by the Calibration Constant Corrected for Leads per 1% ratio change of .0653 (see memo dated July 26, 1976). The resulting adjustment of -.8959 was added to the initial reading of 102.60 percent for an adjusted resistance ratio at initial reading of 111.559 percent.

The first reading made on July 26, 1976 after installation of the new meter will now correspond to previous readings and the estimated projected reading plotted for August 1, 1976.

George A. Gonsman

George A. Gonsman
Supervisor, Field Hydrology

EXHIBIT P

Drill-hole No. DH 1-L

Adjustment of initial resistance ratio readings to provide completed indicated movements from the new meter readings that will plot in the same range as those from the old meter readings.

−.5850 Adjustment of the indicated movement from initial position in inches.

Calibration constant, corrected for leads .000653 inches per 0.01% ratio change or .0653 inches per 1% ratio change.

−.5850 ÷ .0653 = −8.959 Adjustment to resistance ratio at initial reading.

102.600 Resistance ratio at initial reading in percent per 7-26-76

8.959 Adjustment to resistance ratio at initial reading (Note*)

111.559 Adjusted resistance ratio at initial reading in percent.

*NOTE: If adjusted resistance ratio at initial reading is negative add; if positive subtract.

EXHIBIT P

PUBLIC WORKS AGENCY

county of ventura

Director
A. P. Stokes

Deputy Directors
D. A. Betlach
Roads & Surveyor
E. D. Shinavar
Field Operations
G. J. Nowak
Flood Control & Drainage
H. P. Nilmeier
Water & Sanitation
T. M. Morgan
Special Projects
D. B. Perry
Management Services

August 6, 1976

Mr. Gordon L. Dukleth, Division Engineer
Division of Safety of Dams
State Department of Water Resources
P. O. Box 388
Sacramento, California 95802

Subject: MATILIJA DAM - REVISED REPORT OF INSTRUMENT READINGS, FLOOD ZONE I

Dear Mr. Dukleth:

Our letter to you dated July 9, 1976, transmitted updated copies of deflections for the twelve face targets on Matilija Dam, and plots of deformation versus time for the eight straingages. Recent deflections shown for the meter in Drill Hole 1L indicate an uncharacteristic flattening of the data points which has been recently reviewed by our staff. Our review indicates the current graph for DH-1L for most of 1976 is erroneous and we have enclosed a revised copy.

Meter J-12 was installed in Drill Hole 1L in September 1972. Information from the factory indicated that the resistance ratio for that meter at the closed position was 95.8 percent. Earlier this year an apparent deviation in the data points from the historic trend was noted; however, the resistance ratio at that time was well above 96 percent and it was assumed the indicated readings were authentic. Following a continuation of that trend into July of this year Meter J-12 was examined and found to be operating in

EXHIBIT Q

800 East Main Street, Ventura, CA 93001 (805) 648-6131

a closed position. Further analysis indicated that the resistance ratio at the closed position did not consider resistance in the lead wires. After measuring resistances of the leads, we estimate the meter has been closed since mid-January of this year.

On July 23 the meter was replaced and on July 26 the replacement was reset to an initial reading of -0.585. The initial reading for the replacement meter was approximated by extending deformation measured during late July and early August from recent years to the present time. This technique assumes that deformation during this period varied linearly with time and it represents an approximation. However, we believe this alternative more appropriate than continuing the plots from an initial reading of zero.

We have adjusted the new meter to allow a greater compressive deformation; and, with the resistance of the leads now determined, we hope to monitor more closely the deformation of this meter with respect to its closed position. If you have any questions regarding this problem or our procedures used in determining the initial reading, please do not hesitate to contact us.

Very truly yours,

Gerald J. Nowak, Deputy Director
Flood Control and Drainage Department

By Gerald D. Bickel
Gerald D. Bickel
Supervising Hydrologist

Enclosure

GDB:ggh

-600
-550
-500
-450
-400
-350
-300

DEFORMATION — INCHES

Φ = -.585

Φ = -.485

Φ = -.318

Exhibit N

MATILIJA DAM
STRAIGHT LINE EXTRAPOLATION
DH = 1'-

PLOTTED BY G.G.
AUG 3, 1976

AUG 1
1974

AUG 1
1975

AUG 1
1976