Appendix 2B – JMM Reports: 1985 Evaluation and 1975-1977 Progress Reports

CITY OF
NEWPORT BEACH

BIG CANYON RESERVOIR

GROUND WATER
EVALUATION

JANUARY 1985

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

BIG CANYON RESERVOIR
GROUND WATER EVALUATION

INTRODUCTION

The ground water study for the Big Canyon Reservoir was begun on October 23, 1984, with authorization to proceed by the City of Newport Beach. This letter report presents the results of our analysis of data collected on ground water conditions surrounding the reservoir, over the previous four years. In addition, several alternatives are presented for dewatering the east side of the reservoir, in order to improve its structural stability during rapid drawdown operations.

SCOPE OF WORK

Work accomplished for this study included the following tasks:

"1) Review reports and analyses on historic behavior of the reservoir levels, ground water levels and drain discharges.

2) Collect all available data and measurements made at the reservoir since 1981, to include hydraulic levels, precipitation, drain discharge and water quality analyses.

3) Plot, analyze and compare all pertinent factors on hydraulic behavior of ground water related information.

4) Prepare evaluation, summary, conclusions and recommendations in brief letter report format on the behavior as analyzed above.

5) Prepare a list of proposed alternative courses of action, if appropriate, for review and analysis by the City."

BACKGROUND

The reservoir was constructed upon a base of fractured siltstone bedrock. Fill material was subsequently emplaced to provide a foundation for installation of a puddled clay base and form for the reservoir. Asphalt surfacing allows the clay to remain moist and prevent desiccation. In 1969, portions of the reservoir's east wall slumped inward after the reservoir was drained. This appears to have been caused by excess weight and water pressure in the soils surrounding the reservoir. Subsequent corrective alternatives were developed and implemented in order to relieve water level build-up along the east wall. The east wall drain now provides some relief in this regard, but is not completely effective as the reservoir storage declines.

PREVIOUS STUDIES

Based upon Montgomery's previous studies and analysis of the reservoir, a number of general conclusions were reached. These are summarized in the following paragraphs.

Ground water in the vicinity of the reservoir occurs primarily as a result of leakage from the reservoir. Ground water recharge as a result of rainfall is of minor significance during most years. In addition, irrigation on the Pacific View Memorial Park property does not appear to result in any significant recharge to the ground water surrounding the reservoir during normal operations at the cemetary. Background for this conclusion is presented in Appendix A.

Ground water movement is generally toward the northwest. However, reservoir leakage causes ground water to flow around the reservoir with the highest ground water levels found on the southeastern side of the reservoir. The resultant ground water flow is toward the north along the east side, and toward the west along the south side of the reservoir. Once beyond the reservoir's direct influence, ground water flow moves toward the northwest, in similar fashion to the historic surface and ground water flow paths.

Ground water fluctuations are of greatest magnitude along the east wall of the reservoir due to reservoir leakage, and also due to opening and closing of the east wall drain. Additionally, the south and west sides of the reservoir have significant ground water level fluctuations. This suggests that additional leakage may be occurring from other locations (walls or floor) in the southern part of the reservoir.

Analysis of gradients and aquifer transmissivities have indicated that about 3,400 gallons of water per day is moving away from the reservoir east wall. Review of drain discharge records suggests that repair of cracks in the reservoir lines may, in the past, have reduced east wall drain discharges by as much as 30 percent. When functioning properly, the east wall drain is believed to be effective in slowly capturing leakage.

Ground waters most similar to reservoir water from a standpoint of chemical character have occurred in east wall drain discharges, and in wells along the southern and eastern sides of the reservoir. Accordingly, these waters appear to have originated in the reservoir, and to have traveled relatively short distances in the aquifer zones.

PREVIOUS RECOMMENDATIONS

In the past, Montgomery has prepared the following general recommendations.

1) The monitoring program of measuring water levels in 11 piezometers surrounding the reservoir, and monitoring of flows in the Main Reservoir Underdrain, East Wall Drain and the Bren Drain should be continued. In addition, this program should be expanded to include water level measurements at new piezometers H-50 through H-56 (Broadmoor Tract) and discharge measurements of the Broadmoor Drain.

2) Careful monitoring and analysis of East Wall Drain discharge fluctuations may provide the City with a means to qualitatively assess the need for liner repairs along the east wall. Daily, or at least weekly, measurements should be taken and compared with reservoir stage fluctuations.

3) A regular maintenance program of inspection and liner repair should be continued at approximately two-year intervals, when the reservoir is drained for cleaning. Special attention should be given to the south and central portions of the east wall and to areas on the reservoir floor where shallow ponding and "spongy" conditions have been found.

4) It is recommended that the East Wall Drain be monitored carefully as an indication of increased reservoir leakage. If subsequent liner leak repair efforts fail to reduce or stabilize increased leakage, a system of dewatering wells should be designed and installed to control the water levels of the aquifers at selected sites around the reservoir.

CURRENT DATA REVIEW

Several sources of hydrologic data recorded during the previous four years were obtained for evaluation of ground water behavior in the vicinity of the reservoir. Daily rainfall data are recorded by the reservoir staff and the Orange County Environmental Management Agency staff from the Corona del Mar Station #169, located near the south reservoir entrance. Monthly piezometer water level measurements and daily reservoir stage measurements are recorded by the reservoir staff. Monthly drain discharge measurements are recorded by the Utilities Department staff. Historical hydrologic data, together with the current information, provide a base upon which the behavior of ground water in the vicinity of the reservoir can be evaluated.

The data collected between 1981 and the present was compiled and prepared in graphical form, similar to the presentation in previous reports. That is, the horizontal scale represents the days, months and years when the data were collected. The vertical scale shows several sets of data which provide an overview of all pertinent activity. Because the time frame includes four years of information instead of portions of one year, the figures appear to achieve some analytical improvement over the data presented in previous reports.

EVALUATION OF CURRENT DATA

Ground Water Levels

Ground water in the vicinity of the reservoir occurs primarily as a result of reservoir leakage. Ground water recharge resulting from the percolation of rainfall appears to be of minor significance.

Ground water level fluctuations generally coincide with the overall reservoir stage fluctuations. The most significant ground water fluctuations occur during years when the reservoir is emptied for regular maintenance and repair. During these periods, the reservoir stage fluctuates about 35 feet, from 300 feet elevation, normal maximum storage, to about 265 feet elevation. Maximum ground water levels are noted to fluctuate as much as 11 feet along portions of the east wall. Ground water levels along other portions of the reservoir fluctuate on the order of 1 to 6 feet. Normal operation of the reservoir, between years when the reservoir is emptied, apparently varies about 15 to 20 feet; i.e., 300 to 285 feet elevation. East wall ground water levels then show a maximum fluctuation of about 7 feet. Ground water levels in other portions of the reservoir fluctuate on the order of 0.5 to 3.5 feet, during non-drain periods.

Relative to amplitude, ground water levels along the east and south walls fluctuate less than the actual reservoir stage. When the reservoir is emptied, several of the piezometers in the southeastern portion of the reservoir show ground water levels as much as 19 feet above the bottom of the reservoir. They continue to show a slow decline thereafter. Indications are that it could take several months for the ground water to drain to a stable level under the existing conditions. During normal operating conditions, the ground water levels are rarely higher than the reservoir stage. One instance when this is known to have occurred was in 1983, when above-normal rainfall occurred, and also concurrent flooding of the Pacific View Memorial Park cementary property which was caused by a broken irrigation line. Reservoir staff detected the resulting high ground water levels along the East Wall, and subsequently discussed the problem with the cemetary staff. Apparently, the cementary's water supply pressure regulator was inoperative. This allowed higher pressure into their PVC irrigation system and broken lines. The several irrigation line leaks, together with the heavy rainfall produced the high ground water levels. Subsequent repairs to the irrigation system and diminished rainfall allowed ground water levels to decline to more normal conditions.

Ground Water Movement

Ground water movement is generally toward the northwest. However, reservoir leakage continues to cause ground water to flow around the reservoir. The resultant ground water flow is toward the north along the east side, and toward the west along the south side of the reservoir. Once beyond the reservoir's direct influence, ground water flow moves toward the northwest in a similar fashion to the natural, historic surface and ground water flow paths.

Reservoir Drains

The City's records indicate that only three of the four local drains were operative over the past four years. These are the Bren Tract, East Wall and the West Drains. The reservoir staff have indicated that the Seaview Drain has not been used because of chronic maintenance problems associated with the drain pump. During the past year, it is understood that two neighborhood complaints were noted of highly saline rising ground water.

The three drains have been used on a fairly constant basis over the past four years. The most consistent flows are found to be associated with the East Wall Drain, averaging 2 to 5 gallons per minute. The Bren Tract Drain flows a similar quantity of water but is slightly more variable. The West Drain has the most inconsistent record. It has flows which vary from almost zero when the reservoir is empty, to about 10 gallons per minute. The West Drain also responds the most rapidly to fluctuations of the reservoir stage, decreasing and increasing as the stage is lowered and raised, respectively. Although the records are not completely clear, there are occasionally times when the drains are inoperative. Subsequent operation usually results in initial drain flow which is above normal, and then becomes more "normal" within about two months.

Water Quality

Water samples were collected by Montgomery on November 21, 1984, from 8 of the 11 existing piezometers and the three drains for measurements of electrical conductivity. Electrical conductivity (EC) is a rapid means to indicate the approximate quantity of total dissolved solids (TDS) in a water sample. The following Table lists the EC measurements recorded for the samples obtained, and also for samples collected during previous studies at the same sites.

Electrical Conductivity Measurements

Piezometer	Date Sampled	EC (umhos/cm)
SL-1	12/14/73	1,590
	8/8/75	1,690
	11/21/84	4,000
SL-2	12/13/73	22,080
	11/21/84	8,200
H-35	8/8/75	4,180
	11/21/84	4,400
H-37	10/22/74	12,300
	11/21/84	4,600
H-38	NA	NA
	11/21/84	1,620
H-39	10/31/74	6,260
	8/8/75	7,060
	11/21/84	4,200
I-40	8/8/75	2,640
	11/21/84	4,000
I-41	8/7/75	3,010
	11/21/84	4,800
Drain		
Bren Tract	8/8/75	14,030
	11/21/84	7,200
East Wall	8/8/75	1,195
	11/21/84	1,140
West Drain	3/15/74	2,100
	11/21/84	1,900

Comparison of recent field EC results with historical EC measurements indicates that the amount of dissolved salts in the ground water surrounding the reservoir has changed, but not uniformly. For example, along the east side , the EC has increased by about 50 percent. Along the southwest and north side, the EC has decreased by about 60 percent. The EC of waters received by the East Wall and West drains are presently 5 to 10 percent less than shown by previous measurements. Of all three drains, the Bren Tract drain shows the best quality improvement; an EC decrease of about 50 percent since it was last measured.

In general, the overall quality of ground water near the reservoir has improved significantly except along the East Wall. It is possible that because this area is not sufficiently drained, salts have tended to build up in the ground water. The average EC of ground water along the East Wall is about 4,200 umhos/cm, based upon samples obtained by Montgomery. This contrasts with the East Wall drain EC of 1,140 umhos/cm. This suggests that the East Wall drain is tapping recent reservoir leakage, but little surrounding ground water at this time.

If a dewatering system is developed for the South and East Walls to control ground water levels, the extracted water could, from a mineral quality standpoint, be discharged directly into the reservoir. The reservoir currently releases about 34 acre-feet per day of water with an EC between 500 and 1,100 umhos/cm. Dewatering of the East Wall sediments would produce approximately 1 acre-foot per day of water with an EC of about 4,200 umhos/cm. Assuming continuous reservoir operation, discharge of the ground water to the reservoir would increase the reservoir discharge by approximately 100 umhos/cm.

Relative to total mineralization, the worst case scenario would occur as the reservoir was drawn down. If ground water at 4,200 umhos was discharged into the reservoir with the supply at 1,000 umhos, discharge could continue until about 160 acre-feet of water remained in the reservoir. At that point, the mixed supply would total about 1,570 umhos (1,000 mg/l, total dissolved solids). As the reservoir stage declined to storage values of less than 160 acre-feet, the ground water would need to be discharged to the storm drains. However, ground waters would in all probability have been dewatered by the time the reservoir was drained to the 150 acre-foot level.

Alternatives for Ground Water Control

Some threat to the reservoir's structural stability occurs when the reservoir stage is significantly below the ground water level in soils surrounding the reservoir. This would be particularly true if the reservoir stage were lowered rapidly. In order to control and maintain the structural stability of the reservoir walls from exterior pressures, and to control the existing reservoir leakage to the surrounding soils, a number of alternatives were evaluated. These include:

- "No Action"
- Drainage Trench
- Extraction Wells

"No Action" Alternative

The so-called "No Action" alternative considers that additional construction activities would not occur to relieve the hydrostatic pressure in the surrounding soils. Inherent in this alternative would be the repair and maintenance of the existing East Wall drain system, and continued observation and monitoring of both piezometers and the reservoir walls and floor. Specifically, these "no action" activities would include:

1) Periodic measurement and sampling of selected observation wells and drains.

2) Repair of East Wall drain system, including cracks and leaks in East Wall, manifold into the reservoir and drain piping system within the reservoir.

3) Inspection of the reservoir wall and floor approximately every two years and repair all observed cracks, holes and spongy areas.

Drainage Trench Alternative

The most critical areas where high ground water levels may induce structure instability during rapid drawdown, occur along the east and south sides of the reservoir. The saturated soils along the sides and beneath these portions of the reservoir are composed of sandy terrace deposits, sandy fill material and fractured silstone bedrock. This soil is assumed to have an average ground water level elevation of 286 feet. Dewatering the soils to an elevation of 265 feet, the lowest reservoir stage, would require the extraction of approximately 2,500,000 gallons (7.7 acre-feet) of ground water.

A drainage trench excavated along the reservoir roadway could be designed and constructed to dewater the soils and improve the structural stability of the reservoir during rapid drawdown. The trench would be approximately 1,000 feet long and about 40 feet deep along the east side of the reservoir. The preliminary design of the drainage trench would be guided by the following general criteria:

- o Excavate a 40-foot deep trench for approximately 1,000 feet with a 2 percent grade to the north;
- o Install a 10-inch diameter perforated PVC pipe along the trench invert;
- o Install and connect a clearwell (24-inch diameter maximum strength concrete pipe) at the northern end of the trench to a depth of about 50 feet;
- o Backfill the trench with a sand and gravel filter mixture to within 10 feet of ground surface.

The trench would contain more porous materials than the soils which currently surround the reservoir, and would thus increase the volume of water needed to be removed to about 2,600,000 gallons to effectively dewater the east side of the reservoir. Upon completion of the drainage trench installation, the clearwell can be used to extract water from the trench pipeline. The pump installed in the clearwell should extract an average of 260 gpm.

Total cost for construction of the trench drainage system is estimated to be approximately $400,000. This cost estimate includes trench and clearwell construction, and the clearwell equipment (i.e., pump, meters, cables, valves, control box and a 8x6x8 foot vault).

Extraction Well Alternative

Assuming the physical conditions described in the first paragraph under Drainage Trench, a series of extraction wells could be designed and constructed to withdraw the desired volume of ground water to dewater the soil. Preliminary estimates indicate that these wells should be spaced between 130 to 200 feet apart, in a line along the reservoir roadway. The exact number of wells needed will depend upon the extraction capacity of the wells and the anticipated duration of time to complete soil dewatering. For example, if each well continually extracts an average of 26 gallons per minute (gpm), 10 wells would be needed to dewater the soils within one week (7 wells if each at 37 gpm, or 12 wells if each at 22 gpm).

The preliminary design of extraction wells should be guided by the following general criteria:

- o Drill 16-inch diameter borehole to a depth of 60 feet;
- o Install 45 feet of blank and 15 feet of perforated 8-inch diameter PVC casing;
- o Install gravel pack and surface sanitary seal;
- o Develop the well and gravel pack;
- o Install 4-inch diameter submersible pump;
- o Equip well for removal of extracted ground water, install vaults and manifold piping.

The estimated cost per well is $18,000. This estimate includes $6,000 for well construction and $12,000 for well equipment (i.e., pump, cables, valves, control box, meters). If it is considered that 8 extraction wells would be needed to dewater the soils, the capital cost for this alternative would be $144,000.

<u>In summary</u>, should the City of Newport Beach elect to approach the problem of ground water behind the East Wall of Big Canyon Reservoir from a direct structural standpoint, either a drainage trench or extraction wells could be constructed. Approximate capital costs for these facilities would range from $144,000 for the wells to about $400,000 for the drainage trench. These are considered to be order of magnitude estimates for the two alternatives. It appears that ground water pumped from such systems could be discharged directly into the water supply for a major portion of the time during the emptying of the reservoir. The value of these ground waters (7.7 acre-feet @ $\pm$ $200/acre-feet) pumped back into the reservoir would help offset power and maintenance costs.

APPENDIX A

SUPPLY FROM ADJACENT WATERSHEDS

SUPPLY FROM ADJACENT WATERSHEDS

A brief analysis was made of rainfall, irrigation, evapo-transpiration and consumptive use on a 22.5 acre portion of the Pacific View Memorial Park adjacent to the reservoir. Precipitation information was summarized from data at the Corona del Mar Station (No. 169) at the south end of the reservoir. Water application information for the cemetery, available on a two-month basis, was divided equally, and added to monthly rainfall to estimate the total monthly water supply. This resulted in a "rounding out" of the water application over time.

A specially constructed floating evaporation pan is maintained and measured on the reservoir surfce by the City staff. A U.S. Geological-Type floating pan has been shown to have a relationship to actual lake surfaces of about 0.8.[a] However, studies at the reservoir indicate that actual evaporation from the water surface approximates a factor of 1.0 to the special floating pan. This calculated value for reservoir water surface evaporation is considered to approximate the maximum evapotranspiration potential (ETP). Evapotranspiration potential is defined as that water loss which would occur if at no time there is a water deficiency in the soil for use by vegetation. ETP values for 1974 and 1975 are plotted and appear as the upper curve on Figure 1.

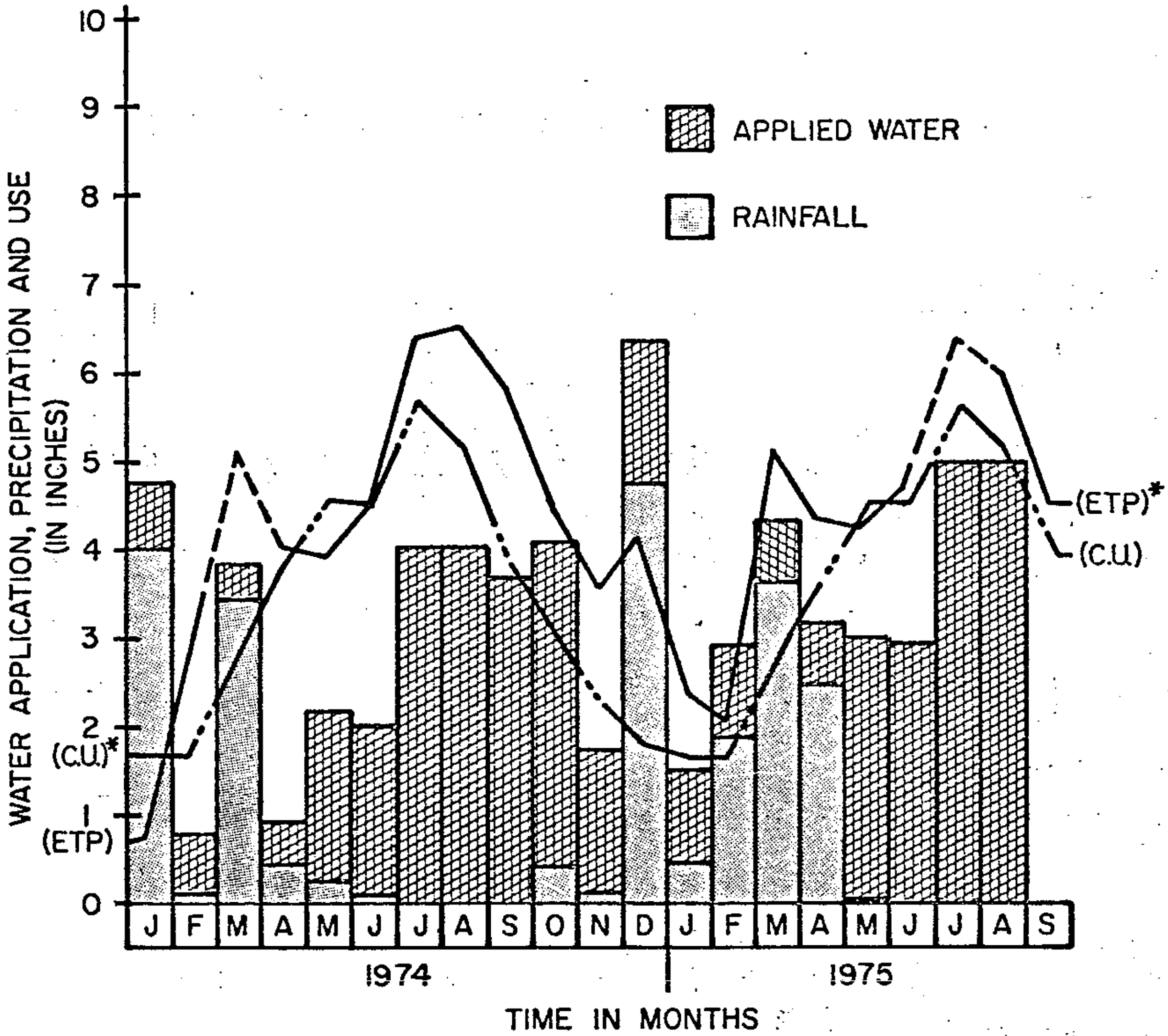
Values for actual measured consumptive use for turf, grasses and pasture over a 9-year period were obtained from the University of California - Agricultural Extension Service in Riverside, and from the Extension Services Field Station in Irvine. Estimates of probable actual Orange County Coastal evapotranspiration were also obtained from specialists at the University of California at Irvine, and from the California Department of Water Resources in Los Angeles. The average of the values is 40.68 inches per year. The average was broken into monthly totals based upon a ratio of monthly consumptive use at the Irvine station. These values are plotted as the lower curve labeled C.U. on Figure 1.

A comparison of these data indicates that total consumptive use exceeded water supply. For example, during 1974 the total deficiency in supply was 2.37 inches or approximately 53 acre-feet of water over the cemetery area. This trend continued into 1975 with a cumulative deficiency of 1.4 inches by the end of August.

It should be noted that data for several individual months exhibit significant surplus. During those months runoff probably occurred. In 1974, two storms in January, one in March and two in December contributed more than 1 inch in 24 hours, and probably resulted in potentially measurable quantities of surface runoff. Small quantities of this runoff may have percolated in the drainage ditch around the east side of the reservoir. Some of the excess supply also replenished soil moisture deficiencies, which had developed during months of insufficient supply. However, the principal thrust of the data presented in Figure 1 is that during 1974 and a major part of 1975, significant quantities of water were not available for percolation and ground water recharge from the Pacific View Memorial Park area.

---

[a]Evaporation relationships are presented in "Evaporation from Water Surfaces", California Department of Water Resources, Bulletin 73, 1959.



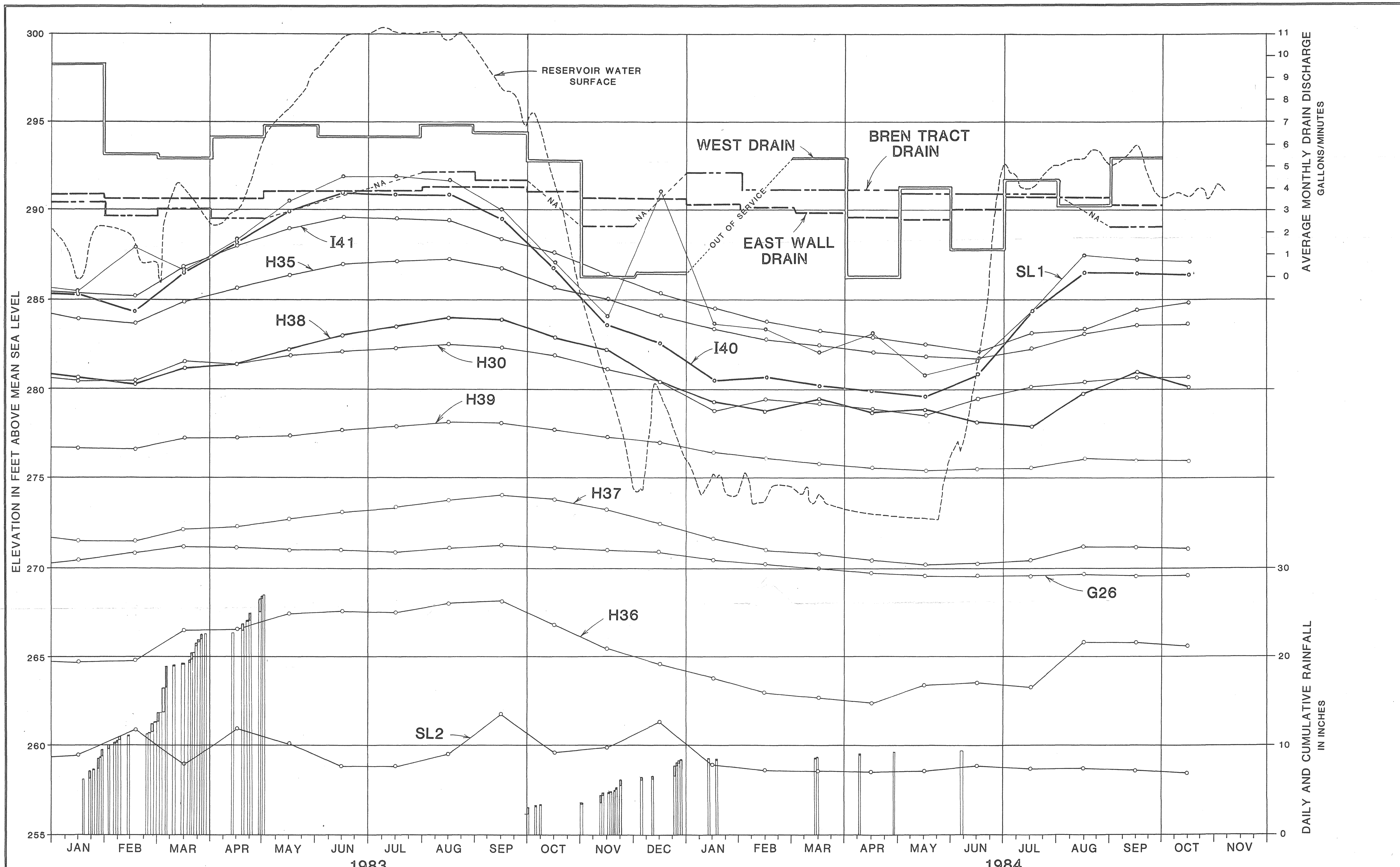
SURPLUS OR DEFICIENCY OF SUPPLY
FOR RUNOFF AND PERCOLATION (IN ACRE FEET)

J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
+ 3.14	- 0.86	+ 1.08	- 2.95	- 2.36	- 2.51	- 1.60	- 1.06	- 0.23	+ 1.02	- 0.61	+ 4.57	- 0.15	+ 1.30	+ 1.60	- 0.35	- 1.48	- 1.52	- 0.67	- 0.13

(ETP) Evapotranspiration Potential (From Floating Pan Evaporation)
(C.U.) Consumptive Use of Grasses (From Irvine Test Plot Data Modified For Coastal Climate)

WATER SUPPLY AND CONSUMPTIVE USE
PACIFIC VIEW MEMORIAL PARK

FIGURE 1



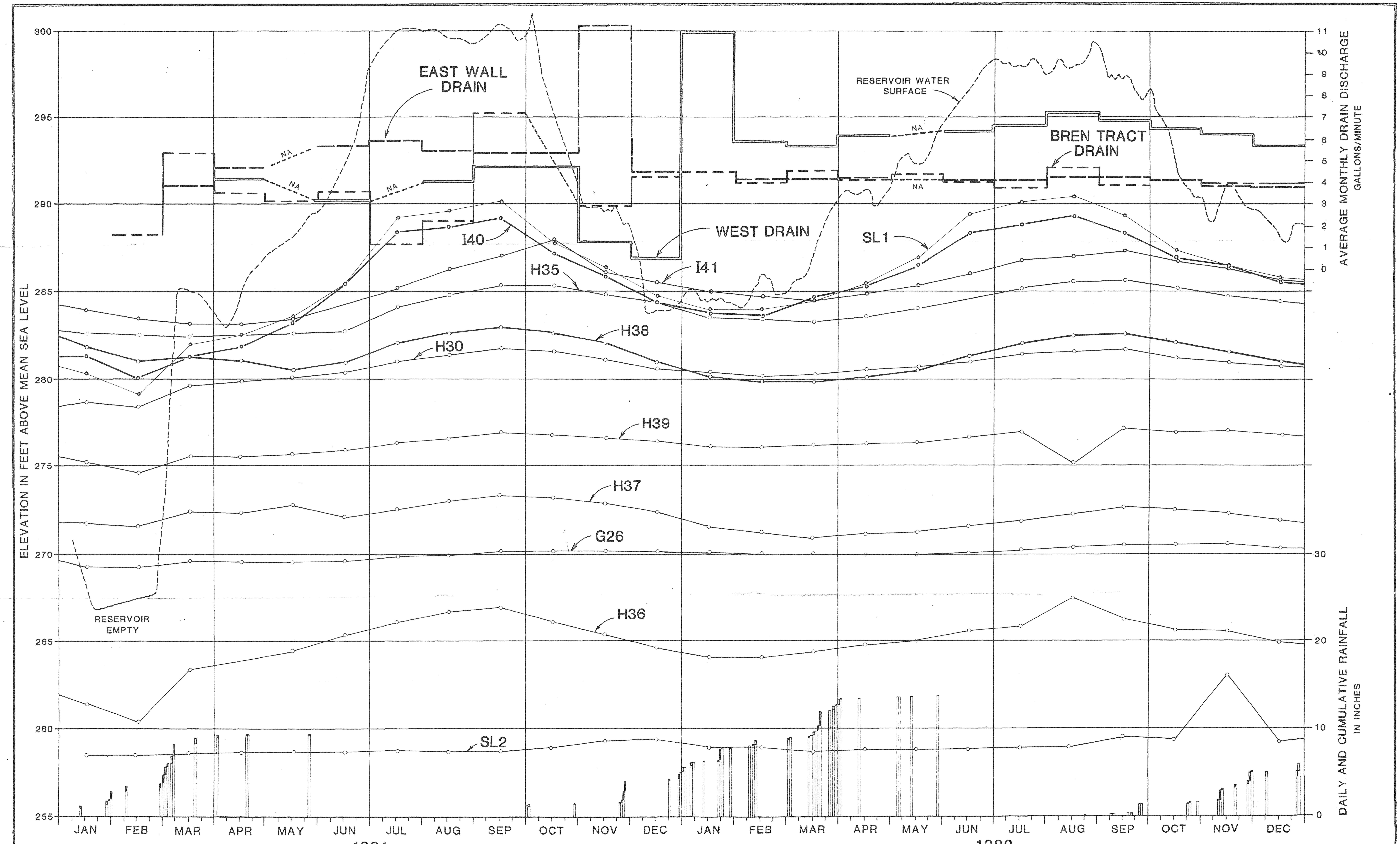
NA - NOT AVAILABLE

REV	DATE	BY	DESCRIPTION	SCALE:	DESIGNED KELLY E. ROWE DRAWN DEBORAH CLARK CHECKED KARL H. WIEBE	SUBMITTED PROJECT ENGINEER R.C.E. NO. DATE RECOMMENDED JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. R.C.E. NO. DATE	APPROVED DATE APPROVED DATE	BIG CANYON RESERVOIR GROUND WATER EVALUATION	SHEET 2 OF 2 SHEETS

CC 8-80

FILE

JOB NO.



NA - NOT AVAILABLE

REV	DATE	BY	DESCRIPTION

SCALE:

DESIGNED KELLY E. ROWE
DRAWN DEBORAH CLARK
CHECKED KARL H. WIEBE

SUBMITTED
PROJECT ENGINEER R.C.E. NO. DATE
RECOMMENDED
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. R.C.E. NO. DATE

APPROVED DATE
APPROVED DATE

BIG CANYON RESERVOIR
GROUND WATER EVALUATION

SHEET 1 OF 2 SHEETS

JOB NO. FILE CC 8 80

10

CITY OF NEWPORT BEACH

BIG CANYON RESERVOIR
GROUND WATER STUDY

PROGRESS REPORT NO. 1

JANUARY 1975

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

PASADENA • IRVINE • LA JOLLA • RANCHO • UPLAND • WALNUT CREEK
BOISE • FORT LAUDERDALE • LAS VEGAS • WASHINGTON

CITY OF NEWPORT BEACH

BIG CANYON RESERVOIR
GROUND WATER STUDY

PROGRESS REPORT NO. 1

JANUARY 1975

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.
17802 Sky Park Circle, Suite 201, Irvine, California 92707 / (714) 979-8733

DuWayne R. Lidke
Vice President and Manager

January 7, 1975

City of Newport Beach
3300 Newport Blvd.
Newport Beach, California 92660

Attention: Mr. Steve Bucknam

Gentlemen:

Transmitted herewith are ten copies of Progress Report No. 1, Big Canyon Reservoir Ground Water Study, in accordance with the terms of your Professional Services Agreement dated September, 1974. The purpose of this study is "to collect sufficient geologic, hydrologic and water quality data to define the quantity and direction of ground water flow in the vicinity of Big Canyon Reservoir.

Work on the investigation was begun in early October, 1974. This first work progress report describes activities which have been completed, and contains a brief review of initial data including an analysis of the direction of ground flows and the nature and permeability of aquifer units.

We are available to discuss this preliminary report at your convenience. If you have any questions please contact us.

Very truly yours,

Karl H. Wiebe
Senior Hydrogeologist

DuWayne R. Lidke

DuWayne Lidke
Vice President

BIG CANYON RESERVOIR
GROUND WATER STUDY

PROGRESS REPORT NO. 1

INTRODUCTION

On October 4, 1974, James M. Montgomery, Consulting Engineers, Inc. was authorized by the City of Newport Beach to proceed with a program of ground water study and monitoring in the Big Canyon Reservoir area. The work to be undertaken was described in a Professional Services Agreement dated September 1974. The purpose of study was "to collect sufficient geologic, hydrologic and water quality data to define the quantity and direction of ground water flow in the vicinity of Big Canyon Reservoir". It was agreed that progress reports would be submitted to outline accomplishments and initial analysis at the end of each three (3) month period. This first progress report includes a list of study activities which have been completed, a brief analysis of initial data, a descriptive plate and three hydrogeologic profiles, and three appendices containing pertinent basic data.

CONDUCT OF THE STUDY

Work on the study was initiated in early October, 1974. Significant items of work which have been completed are outlined in the following paragraphs.

A. On October 8, 1974, the firm of Converse, Davis and Associates was asked to proceed with a program of exploratory drilling, testing and piezometer construction at eleven sites on and around the reservoir property.

B. Exploratory drilling, logging, and soil and water sampling were initiated on October 22, 1974. While the original exploration program included work at 11 sites, it was expanded to 13 sites as drilling proceeded. Hole depth ranged from 33 to 49 feet (24-inch diameter); at each site drive samples were obtained at five-foot intervals. Water samples were bailed wherever possible after the zone of saturation was encountered.

C. Water injection tests were conducted at four test sites to determine transmissivity of the siltstone section and approximate permeability of the individual fracture zones. Laboratory tests (constant head) for permeability were run on eight samples, and mineral analyses were run on 10 ground water samples.

D. Two-inch diameter PVC piezometer pipes were installed, gravel packed and sealed in test holes at 10 sites.* Three of these piezometers are located outside of the reservoir fence on Pacific View Memorial Park property. An elevation survey of all piezometers was subsequently conducted by the City of Newport Beach. (Piezometer design shown in Appendix A.)

E. In order to depict and analyze hydrologic, geologic and water quality data, a large map at a scale of 1 inch equals 80 feet was assembled from a variety of sources. This new map forms the base for Plate 1.

F. In order to measure and monitor ground water intercepted by the Harbor View Hills (Bren) subdrain on Newport Hills Drive East, a general design for discharge measurement system was prepared and transmitted to the City of Newport Beach on November 5, 1974 in preliminary form.

G. On November 21, 1974, a comprehensive program of piezometer measurement was initiated at 30 sites. Measurements are being made at 2-week intervals (Appendix B).

PRELIMINARY DATA EVALUATION

A. Lithologic Units.

The materials penetrated in the "H" series boreholes include surface soils, compacted fill, alluvium or slope wash, landslide debris, terrace deposits and the siltstone bedrock. Compacted fills comprise black to brown sandy silt, silt and silty clay. Alluvium includes silty and clayey sand and silty clay with gravel and cobbles, while local slide debris is composed of brown and black silty clay with fractured siltstone and shale fragments.

The lithologic units of major importance from a ground water standpoint include the Quaternary age terrace deposits and the Tertiary age Monterey Formation which forms the siltstone bedrock. The terrace deposits were laid down directly on the beveled and eroded siltstones during late Pleistocene time. The materials are red-brown to gray and comprise

---

*It should be noted that test holes and piezometers have been installed during a number of prior investigations. Although numbered sequentially, a letter designation was used for each stage of study. The present study piezometers are designated the "H-series".

fine silty and clayey sands and sandy or silty clays. The underlying Miocene age Monterey siltstone includes thin interbeds of silty claystone, silty sandstone and hard, cemented sandstone. These marine deposits are moderately to highly weathered, especially near the terrace-siltstone contact. Locally, the siltstone is intensely fractured and contorted. Where fracture zones are open, the siltstones can conduct and transmit significant quantities of ground water.

B. Permeability and Transmissivity.

During exploratory drilling at the 13 test sites, drive samples were obtained for examination and for possible later permeability analysis. Constant head laboratory permeability tests were subsequently run by Converse, Davis and Associates on four samples of fine sand comprising the terrace deposits, and four samples of clayey siltstone and siltstone comprising the Miocene bedrock. These tests yielded average values of 1.34×10^{-3} cm/sec (28.4 gpd/ft^2) for the uncemented terrace deposits, and 2.7×10^{-8} cm/sec (5.7×10^{-4} gpd/ft^2) for the Miocene bedrock. Tests were run for 180 hours in the siltstones and for 44 to 71 hours in the unconsolidated sands. Permeability values are shown on Table 1.

TABLE 1

SUMMARY OF PERMEABILITY VALUES
(CONSTANT HEAD LABORATORY TESTS)

Test Site	Depth Interval (in feet)	Material	Permeability cm/sec	Permeability gpd/ft^2
29	30.8-21.6	Fine Sand	6.2×10^{-4}	13.1
31	9.0-9.8	Silty Sand	1.0×10^{-3}	21.2
32	24.0-24.8	Siltstone	4.0×10^{-8}	0.00085
34	24.0-24.8	Silty Sand	2.4×10^{-3}	50.9
36	34.0-34.8	Clayey Siltstone	8.0×10^{-9}	0.00017
37	19.0-19.8	Fine Sand (sl. cemented)	1.8×10^{-5}	0.382
38	39.0 x 39.8	Siltstone	2.0×10^{-8}	0.00042
39	24.0-24.8	Siltstone	4.0×10^{-8}	0.00085

In order to obtain an understanding of permeability value ranges in the fractured portions of the siltstone bedrock, field tests were run in four boreholes. Measured volumes of water were injected for both constant head measurements, and also to partially fill the hole for subsequent falling head tests. Water level changes were measured on Stevens Type F recorders. Resultant data were analyzed for transmissivity and permeability by recovery and slug test methods of C. V. Theis, C. E. Jacob and H. E. Skibitzke.* Constant head data were also analyzed by well specific capacity methods.** Transmissivity values represent the quantity of water moving through a strip one foot wide, by the thickness of the aquifer; permeability coefficient is found by dividing transmissivity by aquifer thickness. Within the sand and silty sand terrace deposits, aquifer thickness is represented by the saturated thickness. However, in the siltstones, only the zones of open fractures represent the aquifers. These bedrock fracture zones are delineated on the lithologs - Appendix A, and also on Table 2.

TABLE 2

SUMMARY OF TRANSMISSIVITY AND PERMEABILITY VALUES***
(CONSTANT AND FALLING HEAD FIELD TESTS)

Test Site	Estimated Thickness of Fracture Zone (ft)	Transmissivity Values (gpd/ft) Range	Average	Permeability Values gpd/ft^2	cm/sec
H-28	3-6	-	406	68-135	3.2×10^{-3} 6.4×10^{-3}
H-32	± 6	72-421	242	40	1.9×10^{-3}
H-36	± 6.5	197-566	371	57	2.7×10^{-3}
H-37	± 4	83-401	206	52	2.5×10^{-3}

*J. G. Ferris and Others, 1962, "Theory of Aquifer Tests", USGS Water Supply Paper 1536-E.

**J. F. Logan, 1964, "Estimating Transmissibility from Routine Production Tests of Water Wells", Ground Water Journal, National Water Well Association 2:35.

***Basic data for these tests are included in Appendix C. All calculations are included in JMM-Irvine files.

C. Ground Water Conditions.

Levels of saturation and general direction of ground water movement in terrace and bedrock materials are shown on Figures 1, 2 and 3, Hydrogeologic Sections A, B and C. To the east of the reservoir, levels of saturation have built up in the terrace sand. Waters move to the northwest and southwest from the sands, around the reservoir down into the zones of fractured siltstone. On the west side of the reservoir, saturated flow occurs principally in the fractured siltstone and ground water is generally under moderate artesian pressure (1 to 11 feet on the reservoir property).

The general contours of ground water elevation shown on Plate 1 were prepared from water level measurements made on December 5, 1974. Contours show ground water to be moving north and northwesterly around the northern end of the reservoir as mentioned earlier, and westerly to northwesterly around the south end. Gradients range from about 0.3 foot per 100 to 11 feet per 100 feet. Data suggests that gross permeability (terrace sands and fractured siltstone) is highest along the east and northeast sides of the reservoir and lowest at the northern tip of the reservoir property near piezometer B-7. The marked steepening of gradients between G-26 and B-7 appears to be a result of significant permeability reductions in the fractured portions of the siltstone. Permeable horizons in the siltstone have generally been described as zones of intense fracturing. However, in logs of drill holes B-4 and B-7, seepage was also noted (GEOLABS) to be occurring along the bedding planes which dip northwest in the general direction of ground water movement.

Based upon December, 1974 levels of saturation, general magnitude values for the quantity of subsurface flow were determined at three locations. Subsurface flow between H-30 and H-29 beneath the reservoir property was about 900 gallons per day (gpd), total, in the terrace sands and fractured siltstone. From the reservoir fence to the Pelican Hills Fault Zone, northwestward across a line through H-27, subsurface flow totaled about 2,000 gpd in the sand and siltstone. Along the southwest corner of the reservoir near H-37, about 1,600 gpd of ground water was calculated to be flowing beneath the reservoir property.

Relative to water level fluctuations, periodic measurement of all significant piezometers was initiated in mid-November, 1974. These data are shown in Appendix B. Of the 24 piezometers measured, all declined in level through the period to December 24, 1974, except those at B-2 and B-7. Maximum declines occurred south and east of the reservoir and averaged about 1.3 feet. Minimum decline occurred north of the reservoir (B-8, B-10, G-24, G-26) and averaged about 0.2 feet. During the same period, the reservoir water surface fluctuated from elevation 286.4 feet (Nov. 25), to 289.2 feet (Dec. 5), and back to 286.4 feet on Dec. 24, 1974. Rainfall (daily) measured at the reservoir in November and December was as follows:

Nov. 1 - 0.10 in.	Dec. 4 - 0.76 in.
Nov. 22 - 0.01 in.	Dec. 28 - 0.68 in.
Dec. 3 - 2.00 in.	Dec. 29 - 1.32 in.

D. Ground Water Quality.

During exploratory drilling, 10 water samples were obtained for complete mineral analyses. These data will be included and evaluated in Progress Report No. 2, Spring, 1975.

GENERAL COMMENTS

The following general comments are based upon the preliminary review presented in the foregoing sections;

A. Ground water was encountered in all of the 13 exploratory holes drilled around the reservoir. Based upon elevation and fluctuation, this surface of saturation appears to be continuous, and is not isolated solely to the north or east sides of the reservoir, or to individual fracture zones.

B. Overall fluctuations in ground water surface elevation between Nov. 21 and Dec. 24 in the study area exhibit little relationship to rainfall during the same period, or to fluctuation in reservoir water surface elevation. Individual interrelationships will be clarified when longer term measurements are available for analysis, later in the 12-month study.

C. Permeability in the fractured portions of the siltstone bedrock is somewhat higher than in the terrace sands. While those zones of open fractures in the siltstone are relatively thin, ground waters they carry are locally under artesian head.

CITY OF NEWPORT BEACH - PUBLIC WORKS DEPARTMENT

MEMO

TO: Utilities Division - Attn: John MacDonald   Date: January 27, 1975

FROM: Engineering Division - Steve Bucknam

SUBJECT: Big Canyon Reservoir Ground Water Study

John: Attached is a copy of James M. Montgomery's 1ST Quarterly Progress Report Re: Subject Study. A map is inserted (Plate 1) which shows locations of all piezometers. Ground surface elevations at each piezo are shown in a Table in Appendix "B"

If you have any questions please give me a call on X274. Info is Confidential.

Copies To: B-241

Steve Bucknam

Signed

PUT IT IN WRITING . . . . . . WRITTEN MESSAGES SAVE TIME AND AVOID ERRORS

APPENDIX A

BORING LOGS
AND
PIEZOMETER DETAILS

SUMMARY — BORING NO. 27 (Piezometer installed)

DATE DRILLED: Nov. 7, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET		SAMPLES	SYMBOL					DRIVE ENERGY FT. KIPS/FT.
0	FILL		CL	dry	very stiff	dark gray	SILTY CLAY sandy	
	SLOPEWASH	1	SM		loose medium dense	gray brown	SILTY SAND	4
5		2	CL	moist	stiff very stiff	brown	SANDY CLAY	11
			SC		very dense		CLAYEY SAND	
10		3	SM			light brown	SILTY SAND gravelly slightly cemented + freq. cobbles	22
			CL		very stiff & very dense	black gray	SILTY CLAY sandy slightly cemented	
15		4	SC			dark gray & brown	+ alternating merging silty sand pockets	14
20		5	CL		very stiff	red brown	SANDY CLAY slightly cemented	13

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 2

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ NO. A-74-628-A

SUMMARY — BORING NO. 27 (continued)

DATE DRILLED: Nov. 7, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL					DRIVE ENERGY FT. KIPS/FT.	
20–25 (SLOPEWASH TERRACE DEPOSITS)	6	CL & SM	moist	very stiff & very dense	red brown	SANDY CLAY + alternating merging streaks to 3" silty sand with traces of clay	11	
25					light brown			
		SM	wet	dense		SILTY SAND		Ground water encountered at 27 feet. Collected sample and drove casing to continue
30	7	SP/SM				SAND fine saturated interval	7	PERFORATED PIPE
35 (BEDROCK)	8	ML & CL	very moist	soft & medium hard streaks	brown & gray streaked	SILTSTONE & SILTY CLAYSTONE very weathered & intensely fractured + calcium cement streaks	33	
40	9	DIPS 35°SW				very thinly bedded streaks	17	

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 3

CONVERSE, DAVIS AND ASSOCIATES — Consulting Engineers and Geologists — PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 28 (Piezometer installed)

DATE DRILLED: Nov. 7, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET	SAMPLES	SYMBOL					DRIVE ENERGY FT. KIPS/FT.
0 — FILL		CL/CH	dry & slightly moist	v. stiff	black & gray brown	CLAY adobe with frequent fine ¼" bits shale	
				firm			
	1						6
			moist	stiff			
					black gray	CLAY adobe	
5 — Talus or slide Debris		CL			brown	SILTY CLAY gravelly with shale fragments	
	2						8
						with hard cemented rock fragments	
10	3						9
Terrace Deposit		SM		dense		SILTY SAND	
15		SP/SM	slightly moist	very dense	light brown	SAND fine	
	4						10
		SW				gravelly	
20	5						14

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 4

CONVERSE, DAVIS AND ASSOCIATES — *Consulting Engineers and Geologists* — PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 28 (continued)

DATE DRILLED: Nov. 7, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL	Moisture	Consistency	Color	Description	DRIVE ENERGY FT. KIPS/FT.	Remarks
20		SW	slightly moist	very dense	light brown	SAND fine to coarse gravelly		
BEDROCK	6 (DIPS 15°NE)	ML	moist to very moist streaks	soft to medium hard	gray & brown streaked	very to moderately weathered streaks interbedded SILTSTONE very thinly bedded SILTY CLAYSTONE intensely fractured + occasional very fine 1" streaks very fine SILTY SANDSTONE & frequent streaks very fine SANDY SILTSTONE	5	
25		CL & SM		medium hard				
				& hard streaks				
30	7 (DIPS 15°N)						31	
35	8 (DIPS 15°N)		& wet streaks				37	← Slight seepage into hole
40	9 (DIPS 25° NO DIRECTION)						19	PERFORATED PIPE

No significant ground water encountered

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 5

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 29 (Piezometer installed)

DATE DRILLED: Oct. 24, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET	SAMPLES	SYMBOL					DRIVE ENERGY FT. KIPS/FT.
0 (F I L L)		CL SM	dry	stiff & dense	dark gray brown	SANDY CLAY & SILTY SAND mixed	
	1	CL ML & occ. CL/CH	moist	stiff to very stiff	brown & light brown gray & dark gray & occ. black gray	SILTY CLAY SILT SANDY SILT mixed + occ. mixed clay; with fractured shale & cemented siltstone	4
5	2						6
10	3						6
		& SM		& dense		+ mixed silty sand	
15	4						4
			very moist				
20	5						4

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO. 6

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 29 (continued)

DATE DRILLED: Oct. 24, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET		SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.	
20	FILL		CL ML SM	very moist	stiff very stiff & dense	brown & lt. brn. gray & dr. gray	SILTY CLAY, SILT, SANDY SILT, & SILTY SAND mixed	+ shale frags. & cemented siltstone		
	Terrace Deposits	6	CL	moist	very stiff	red brown	SILTY CLAY		9	
25		7	SC			brown	SANDY CLAY			
							CLAYEY SAND		13	
30			SM	very moist	very dense	dark brown	SILTY SAND	with frequent fine bits of charcoal stained streaks		First H2O. Water level rose to 30' in 5 minutes
				wet		gray brown				
		8	SP/SM				SAND fine	saturated interval	14	
			SM				SILTY SAND			
35	BEDROCK	9	ML		soft	gray & brown & light brown	SILTSTONE CLAYEY-SILTSTONE & SANDY SILTSTONE very fine	very weathered & int. fract.		PERFORATED PIPE
			ML/CL	moist to very moist streaks	medium hard to hard streaks			mod. weathered to very weathered very thinly bedded & very fractured	14	
40		10	& SM					& occasional silty sandstone lenses	16	

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 7

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 29 (continued)

DATE DRILLED: Oct. 24, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
40 BEDROCK			moist & very moist	medium hard to hard streaks	gray & brown & light brown	SILTSTONE CLAYEY-SILTSTONE SANDY-SILTSTONE very fine & SILTY-SANDSTONE	moderately to very weathered streaks, very thinly bedded & very frac. + occasional fine 1" cemented streaks below 40'-9"	
45	11							31
	12							47
50								
55								
60								

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 8

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 30 (Piezometer installed)

DATE DRILLED: Oct. 29, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET		SAMPLES	SYMBOL					DRIVE ENERGY FT. KIPS/FT.
0	FILL		ML	dry	very soft	gray brown	SANDY SILT + fractured shale	
			CL		stiff	black	SILTY CLAY	
	?Soil?		CL/CH	moist			CLAY - ADOBE	
		1					cracked- ½" voids + fractured shale	4
						dark gray		
5		2						2.8
			CL		very stiff	brown	SILTY CLAY	
10	Slopwash or Terrace Dep	3					+ fractured shale & siltstone	13
15		4				light brown	GRAVELLY CLAY + fractured shale & siltstone	14
							SILTY CLAY	
20		5	SP/SM		v. dense	lt. gray	SAND fine	13

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 9

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ NO A-74-628-

SUMMARY — BORING NO. 30 (continued)

DATE DRILLED: Oct. 29, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET		SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.	
20	Terrace Deposits			moist	very dense	light gray brown	SAND fine			
								with occ. gravel		
			SP/SM							
25		6							16	PERFORATED PIPE
				very moist				saturated interval		
				wet						Water
	BEDROCK	7	DIPS 15°S	very moist	medium hard & hard streaks	gray & brown & light brown	interbedded SILTSTONE & SILTY CLAYSTONE	moderately to slightly weathered, intensely fractured, very thinly bedded with alternating cemented streaks & layers	30	
30			ML/CL							
			& SM					+ occasional streaks silty sandstone		
35		8	DIPS 7°SSE						49	
40										

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 10

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-

SUMMARY — BORING NO. 31

DATE DRILLED: Oct. 24, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

Unit	Depth in Feet	Samples	Symbol				Description	Drive Energy Ft. Kips/Ft.
FILL	0		CL	dry	v. soft stiff	black gray	SILTY CLAY	
FILL		1	ML			dark gray	SANDY SILT slightly porous	3
FILL	5	2	CL CL/CH	moist	very stiff	brown & brown & black & gray	SILT SILTY CLAY CLAY mixed	8
Terrace Dep	10	3	SM & SC		very dense	brown & gray	SILTY SAND + occasional fine streaks clayey sand	8
Terrace Dep			SP/SM			light brown	SAND fine	
BEDROCK	15	4	ML ML/CL SM		stiff & hard	gray & brown & light brown	mixed SILTSTONE, CLAYEY SILTSTONE, very fine SANDY SILTSTONE very fine SILTY SANDSTONE — very weathered; + occasional hord cemented streaks	8
BEDROCK	20	5	ML ML/CL SP/SM		medium hard to hard	gray & light brown	SILTSTONE CLAYEY SILTSTONE SANDSTONE	13

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 11

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 31 (continued)

DATE DRILLED: Oct. 24, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

BEDROCK

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.	
20		ML CL	moist / wet	medium hard to hard	gray & brown	interbedded SILTSTONE to SHALE & SILTY CLAYSTONE	moderate to slightly weathered, very thinly bedded, very fractured		seepage
					& light gray		+ diatoms with siltstone		
25	6							16	stronger water flow
				& very hard streaks	& gray brown		+ hard cemented streaks		
30	7							30	
35	8						saturated interval	33	
40	9							42	

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 12

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ. NO. A-74-628-

SUMMARY — BORING NO. 32 (Piezometer installed)

DATE DRILLED: Nov. 1, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

Depth in feet	Geology	Samples	Symbol	Moisture	Consistency	Color	Description	Drive Energy Ft. Kips/Ft.
0	Soil		CL/CH	dry	v. soft	black	CLAY - ADOBE	
					firm		cracked fine ½" voids	
		1		moist	stiff		with pea gr. ½" frac. shale	28
	Slopewash		CL			brown	SANDY CLAY + pea gravel	
			SM		dense	light brown	SILTY SAND sandy + gravel & cobbles	
			CL		stiff	brown	SILTY CLAY	
5		2			very stiff	red brown	CLAY	11
							SILTY CLAY + pea gravel	
						yellow brown		
	Terrace Deposit		SM & SC		very dense	light brown	SILTY SAND	
10		3						16
						& gray brown	+ alt. stks. clayey sand & occ. pea gr.	
	?Slide Debris						large boulder 12 to 24" +	
			ML CL			gray brown	slide debris SILT & SILTY CLAY mixed; fractured shale & siltstone	
15		4						9
	BEDROCK				soft		SILTSTONE & SILTY CLAYSTONE & very fine SANDY SILTSTONE mixed v. weathered, v. fract. indistinct bedding	
20		5						11

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 13

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 32 (continued)

DATE DRILLED: Nov. 1, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.	
20			moist	soft to medium hard streaked & occ. hard streaks	brown & gray streaked	interbedded SILTSTONE, SILTY CLAYSTONE very fine SANDY SILTSTONE with occasional cemented fine streaks	very to slight weathed thinly bedded intensely fractured		
25	6 (DIPS 30° SW)							11	
		ML & CL		medium hard to hard streaks			moderately to slightly weathered with frequent hard cemented streaks		
30	7 (DIPS 33° W)							32	
35	8 (DIPS 33° W)			& very hard streaks				47	H2O sample; water at 35'-3" after 20 minutes
			very moist				sat'd interval		1st water in hole
40	9		wet				+ alt. hard cem. silty sandstone streaks	47	

BEDROCK

PERFORATED PIPE (26 - 41')

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 14

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ. NO A-74-628-/

SUMMARY — BORING NO. 32 (continued)

DATE DRILLED: Nov. 1, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
40 BEDROCK	10	ML CL SM	wet	medium hard to hard & very hard	brown & gray & light brown	interbedded SILTSTONE, SILTY CLAYSTONE, very fine SANDY SILTSTONE & SILTY SANDSTONE	very thinly bedded, intensely fractured, moderately to slightly weathered	saturated interval
45								
50								
55								
60								

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 15

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 33

DATE DRILLED: Oct. 28, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET		SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
0	Soil		CL/CH	dry	very soft	black	CLAY - ADOBE	disturbed	
					stiff			cracked fine ½" voids	
		1						with much fine ¼" calcarious fragments	6
				slightly moist					
5	Slopewash		CL	moist	very stiff				
		2						fragments of shale	11
						dark gray			
10		3						sandy	9
						gray brown			
							SILTY CLAY		
15		4						+ shale fragments	11
								sandy	
						dark brown			
						brown			
20		5							11

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 16

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

APPROVED FOR PUBLICATION 11/27/74

SUMMARY — BORING NO. 33 (continued)

DATE DRILLED: Oct. 28, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

Unit	DEPTH IN FEET	SAMPLES	SYMBOL	Moisture	Consistency	Color	Description	Remarks	DRIVE ENERGY FT. KIPS/FT.	Notes
Slopewash	20		CL	moist	very stiff	brown	SILTY CLAY sandy	+ freq. bits & very fine lenses		
			CL/CH			dark brown & brown	CLAY			H20 sample
			CL SC				SILTY CLAY CLAYEY SAND	sandy		Water at 24' after 16 hours
				v. moist	very dense					
Terrace Deposit	25	6	SM	wet		light brown	SILTY SAND	saturated interval	13	First water
	30		SP/SM				SAND fine			
BEDROCK		7	ML & CL	moist	medium hard to hard streaks	brown & light brown & gray streaked	interbedded SILTSTONE, SILTY CLAYSTONE	moderately to slightly weathered, very thinly bedded, intensely fractured with cemented layers & streaks	21	
	35	8	DIPS 35°SSE						19	
								+ frequent streaks very fine sandy siltstone		
	40	9							31	

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 17

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ. NO. A-74-628-

SUMMARY — BORING NO. 34 (Piezometer installed)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET		SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
0	FILL		CL	dry	stiff	dk. brn.	SILTY CLAY		
			SM		dense	dk. gr.	SILTY SAND		
		1	CL	moist	stiff	brown & black, gray	SILTY CLAY		3
5		2	& SM					mixed silty sand	3
	? SLOPEWASH ?		SP/SM		dense to very dense	light brown & brown	SAND, fine & SILTY SAND		
10		3	& SM & SC					+ clayey sand	11
			CL		very stiff	red brown	SILTY CLAY sandy		
15		4							8
20		5	& ML			& brown		+ streaks to 3" sandy silt with some clay	9

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 18

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 34 (continued)

DATE DRILLED. Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	UNIT	SAMPLES	SYMBOL	MOISTURE	CONSISTENCY	COLOR	DESCRIPTION		DRIVE ENERGY FT. KIPS/FT.
20	TERRACE DEPOSIT		CL & ML	moist	stiff	brown	SILTY CLAY + frequent merging streaks SANDY SILT with trace clay		
			SM	wet	dense		SILTY SAND	saturated interval; H₂O after 1 min.	
25		6							3.3
			SP/SM				SAND fine		
	BEDROCK		ML & CL	wet & alt. moist streaks	soft & hard	brown & light brown & gray	interbedded SILTSTONE & SILTY CLAYSTONE & very fine SANDY SILTSTONE	very thinly bedded, moderately fractured with alt. very weathered to hard cemented streaks & layers	
30		7			medium hard to alt. hard streaks				23
35		8			medium hard				24
40		9							17

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 19

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-

SUMMARY — BORING NO. 35 (Piezometer installed)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET	SAMPLES	SYMBOL					DRIVE ENERGY FT. KIPS/FT.
0 FILL		ML/CL	dry	v.soft	gr. brn.	SILT & SILTY CLAY mixed	
SLOPEWASH	1	CL/CH	slightly moist	firm	black gray	CLAY - ADOBE very cracked & fine	3
		CL	moist		dk. gray brown	SILTY CLAY	
		SM		dense	gray brown	SILTY SAND	
5	2	CL		very stiff	brown	SILTY CLAY	
						SANDY CLAY	13
		& SM & SC		& very dense	& light brown	+ alternating streaks & layers silty sand & clayey sand	
	3						3
10		CL		very stiff	dark brown	CLAY	
					brown	SANDY CLAY	
	4	SM				SILTY SAND varying streaks	18
15		CL			dark brown & gray brown	SILTY CLAY	
20	5						3

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 20

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 35 (continued)

DATE DRILLED: Oct. 25, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET		SAMPLES	SYMBOL						DRIVE ENERGY FT KIPS/FT.	
20–23	TERRACE DEPOSIT		CL & SM	moist & very moist	very stiff	gray brown & brown	SILTY CLAY	+ alt stks. silty sa		
23–29	TERRACE DEPOSIT	6	SP & SM	& wet	very dense	light brown & light gray brown	SAND fine		3	First H_2O encountered; sat'd. int.
29–40	BEDROCK	7, 8, 9 (DIPS 15°S)	ML CL & SM	very moist; moist	soft; medium hard & hard streaks	gray & brown & light brown & yellow	interbedded SILTSTONE, SILTY CLAYSTONE, & very fine SANDY SILTSTONE + occasional cemented streaks	very to slightly weathered streaks, very thinly bedded, very fractured; + frequent very fine streaks silty sandstone	22, 23, 17	PERFORATED PIPE (approx. 24.5–35)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 21

CONVERSE, DAVIS AND ASSOCIATES — *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 36 (Piezometer installed)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

Unit	Samples	Symbol	Moisture	Consistency	Color	Description	Drive Energy FT KIPS/FT.
fill		SM	dry	dense	black	SILTY SAND	
SOIL		CL		very stiff	groy	CLAY	
SOIL	1	CL		dense	gray brown	SILTY SAND	8
SOIL		SC		very dense	dark brown	CLAYEY SAND	
TERRACE DEPOSITS	2	SM	moist		light brown	SILTY SAND	14
TERRACE DEPOSITS		SM				with trace of clay	
TERRACE DEPOSITS	3	SM					16
BEDROCK	4	ML & ML/CL		soft to medium hard & hard	gray & brown streaked	interbedded SILTSTONE & CLAYEY SILTSTONE with alternating hard cemented streaks; very to moderately weathered, intensely fractured	13
BEDROCK		R		very hard	gray brown	SILICEOUS cemented rock very fractured	
BEDROCK		ML ML/CL		soft	gray & gr/brown	SILTSTONE & CLAYEY SILTSTONE interbedded	

Depth in feet: 0, 5, 10, 15, 20

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 22

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-

SUMMARY — BORING NO. 36 (continued)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.	
20 (BEDROCK)	5	ML & ML/CL	moist	soft	gray & brown	interbedded SILTSTONE & CLAYEY SILTSTONE & SANDY SILTSTONE	very weathered & very fract. contorted very thin bed	11	
				medium hard & occ. hard streaks			very weathered moderately fractured very thinly bedded		
25	6		& very moist				+ frequent fine 1" streaks slightly weathered & hard	11	PERFORATED PIPE
30	7		& occ. wet streaks					15	H2O sample; H2O rose to 30' by the end of drilling
		& SM			& light brown		+ occasional fine streaks silty sandstone		First H2O
35	8						saturated interval	12	
40	9		moist					29	

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO. 23

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 36 (continued)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
40 (BEDROCK)		ML	moist to wet streaks	medium to occ. hard streaks	gray & brown	interbedded SILTSTONE CLAYEY SILTSTONE & SANDY SILTSTONE	very to slightly fractured stks. very to slightly weathered, + hard cemented streaks, very thinly bedded	
					black		non-fractured	
45	10							27
50								
55								
60								

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 24

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 37 (Piezometer installed)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET		SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
0	SOIL	1	CL	dry	very stiff	dark brown	CLAY		9
			SM & SP/SM	slightly moist	very dense	brown	SILTY SAND with some clay		
	TERRACE DEPOSIT			moist		light brown & gray streaked	SILTY SAND	alternating merging streaks with occasional fine 1" streaks with some clay	
5		2							11
		3						& + alternating merging streaks sand, fine	14
10									
			SP/SM			light brown	SAND fine		
15		4							18
		5				light gray brown			18
20									

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 25

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO A-74-628-A

SUMMARY — BORING NO. 37 (continued)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

Unit	DEPTH IN FEET	SAMPLES	SYMBOL	Moisture	Consistency	Color	Description	Remarks	DRIVE ENERGY FT. KIPS/FT.
TERRACE DEPOSIT	20		SP/SM	moist	very dense	light brown & light gray brown	SAND fine		
BEDROCK	25	6	ML/CL		soft	gray & brown streaked	CLAYEY SILTSTONE	very weathered very fractured	8
			SM			light brown & gray streaked	SILTY SANDSTONE		
	30	7	& ML		& medium hard	& brown streaked		+ interbedded very fine 3" streaks siltstone, clayey	29
	35	8	ML & SM		medium hard to hard streaks	gray & dark gray gray & brown	interbedded SILTSTONE & CLAYEY SILTSTONE with occ. very fine 1" streaks SILTY SANDSTONE with frequent fine 1" cemented streaks	very fine 1" streaks moderately weathered, moderately fractured, very thinly bedded	14
	40	9	& CL	& moist				streaks silty claystone	26

saturated interval

H_2O seepage

H_2O level after four hours

PERFORATED PIPE

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 26

CONVERSE, DAVIS AND ASSOCIATES — *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 37 (continued)

DATE DRILLED: Oct. 22, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.	
40–45 BEDROCK	10		moist to very moist	medium hard to hard streaked	gray & dark gray & brown streaked	interbedded SILTSTONE & SILTY CLAYSTONE with occasional to frequent cemented streaks	slightly weathered, moderately fractured, very thinly bedded	19	H_2O sample
50									
55									
60									

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 27

CONVERSE, DAVIS AND ASSOCIATES — *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

SUMMARY — BORING NO. 38 (Piezometer installed)

DATE DRILLED: Oct. 30, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
0–15 (FILL)		CL & SM	dry	soft	dark gray & brown & black gray	SILTY CLAYS & SANDY SILT mixed, varying	with pea gr. fractured + shale & occ. fragments to 6"	
	1		moist	stiff				6
5	2							8
				& dense			+ mixed silty sand	
10	3							8
15	4							6
TERRACE DEPOSITS		SM	very moist to moist streaks	dense	brown & dark brown streaks	SILTY SAND		
		SP/SM	moist	very dense	light brown	SAND very fine		
20	5							18

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 28

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ NO A-74-628-A

SUMMARY — BORING NO. 38 (continued)

DATE DRILLED: Oct. 30, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.
20 TERRACE DEPOSITS		SP/SM	moist / very moist	very dense	light brown	SAND very fine		
	6	& SM ML CL	wet	dense & stiff	& brown & gray		+ merging fine streaks silty sand & silt, & silty clay + occasional fine shale fragments	4
25								
BEDROCK			very moist & moist streaks	soft	gray & brown	interbedded SILTSTONE & SILTY CLAYSTONE	very weathered, intensely fractured, bedding indistinct (sat'd. int.) ← H_2O seepage; ±▼ w.l. not stabilized	
30	7							13
		ML CL		& medium hard streaks			+ occasional bedding streaks, very to moderately weathered	
35	8							12
							+ occasional streaks sandy siltstone	
40	9 (DIPS 14°N)							6

PERFORATED PIPE (20 to 35 ft)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 29

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists* PROJ. NO. A-74-628-A

SUMMARY — BORING NO.39 (Piezometer installed)

DATE DRILLED: Oct. 30, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

ELEVATION:

Geologic unit	DEPTH IN FEET	SAMPLES	SYMBOL				Description		DRIVE ENERGY FT. KIPS/FT.	Remarks
SLOPEWASH	0	1	CL	dry	stiff	brown	SILTY CLAY sandy		4	
		2	SC & SM & ML	moist	dense & stiff	& gray	CLAYEY SAND & SILTY SAND with trace clay	+ alternating fine 3" streaks sandy silt with some clay	3	
	5									
		3	CL & CL/CH		very stiff	dark brown	SILTY CLAY	+ alternating streaks clay	11	
	10		CL			brown				
		4	SM & ML/CL	very moist			SILTY SAND & CLAYEY SILT sandy, alternating merging streaks		9	H2 0 sample; H_2O rose to 15' within 15 minutes
	15									First H_2O
TERRACE DEPOSIT			SM	wet	very dense	gray	SILTY SAND	saturated interval		
		5	SP/SM			gray brown	SAND fine		9	
	20									

(continued)

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO 30

CONVERSE, DAVIS AND ASSOCIATES — *Consulting Engineers and Geologists*

PROJ. NO A-74-628-

SUMMARY — BORING NO. 39 (continued)

DATE DRILLED: Oct. 30, 1974

THIS SUMMARY APPLIES ONLY AT THE LOCATION OF THIS BORING AND AT THE TIME OF DRILLING. SUBSURFACE CONDITIONS MAY DIFFER AT OTHER LOCATIONS AND MAY CHANGE AT THIS LOCATION WITH THE PASSAGE OF TIME. THE DATA PRESENTED IS A SIMPLIFICATION OF ACTUAL CONDITIONS ENCOUNTERED.

DEPTH IN FEET	SAMPLES	SYMBOL						DRIVE ENERGY FT. KIPS/FT.	
20 (TERR. DEP.)		SP/SM	wet	very dense	light brown	SAND very fine		saturated interval	PERFORATED PIPE
(BEDROCK)			very moist	soft	gray & brown streaks	interbedded SILTSTONE, SILTY CLAYSTONE & very fine SANDY SILTSTONE	very weathered		
25	6 (DIPS 12°S)	ML & CL	moist	& medium hard & hard streaks			very to moderately weathered, intensely fractured, thinly bedded with hard cemented streaks below 25.5'	8	
30	7 (DIPS 11°W)							24	
	8							26	
35									
40									

BIG CANYON RESERVOIR STUDY
for City of Newport
in cooperation with James M. Montgomery, Consulting Engineers, Inc.

DRAWING NO. 31

CONVERSE, DAVIS AND ASSOCIATES *Consulting Engineers and Geologists*

PROJ. NO. A-74-628-A

APPROVED FOR PUBLICATION, 11/27/74 BY [signature]

FORM NO D3-73

APPENDIX B

MEASUREMENTS
OF
GROUND WATER SURFACE

APPENDIX B

MEASUREMENTS OF GROUND WATER SURFACE
BIG CANYON RESERVOIR AREA

(All Measurements in Feet)

Piezometer Number	Ref. Point Elevation (Mean Sea Level Datum)	Approximate Distance - Ref. Point to Ground Surface	Distance - Ref. Point to Ground Water Surface 11/21/74	12/5/74	12/24/74
B-1	271.99	-.67	-	-	11.50
B-2	271.43	-.57	10.66	10.59	10.65
B-3	269.97	-1.0	9.42	9.54	9.54
B-4	269.29	-.92	14.81	Submerged	15.21
B-5	274.60	-.75	-	-	14.50
B-6	273.13	-.83	-	-	22.75
B-7	268.90	-.63	18.45	18.66	18.32
B-8	292.14	.92	20.71	20.79	20.84
B-10	277.55	.67	10.79	10.90	10.97
B-23	272.98	-.23	15.71	15.83	16.18
C-11	-	-	-	-	-
C-12	256.17	-	-	-	-
C-15	-	-	-	-	-
C-16	255.14	-	-	5.80	6.41
G-22	307.45	-.42	39.21	39.44	39.65
G-24	278.37	-.25	7.10	7.22	7.31
G-25	287.71	-.25	10.87	11.09	11.28
G-26	277.42	-.08	7.71	7.76	7.94
H-27	304.92	.63	27.46	27.69	27.88
H-28	314.30	.83	31.69	32.29	32.93
H-29	309.59	2.42	31.41	31.79	32.02
H-30	311.10	2.63	29.93	30.48	30.90

APPENDIX B (Cont.)

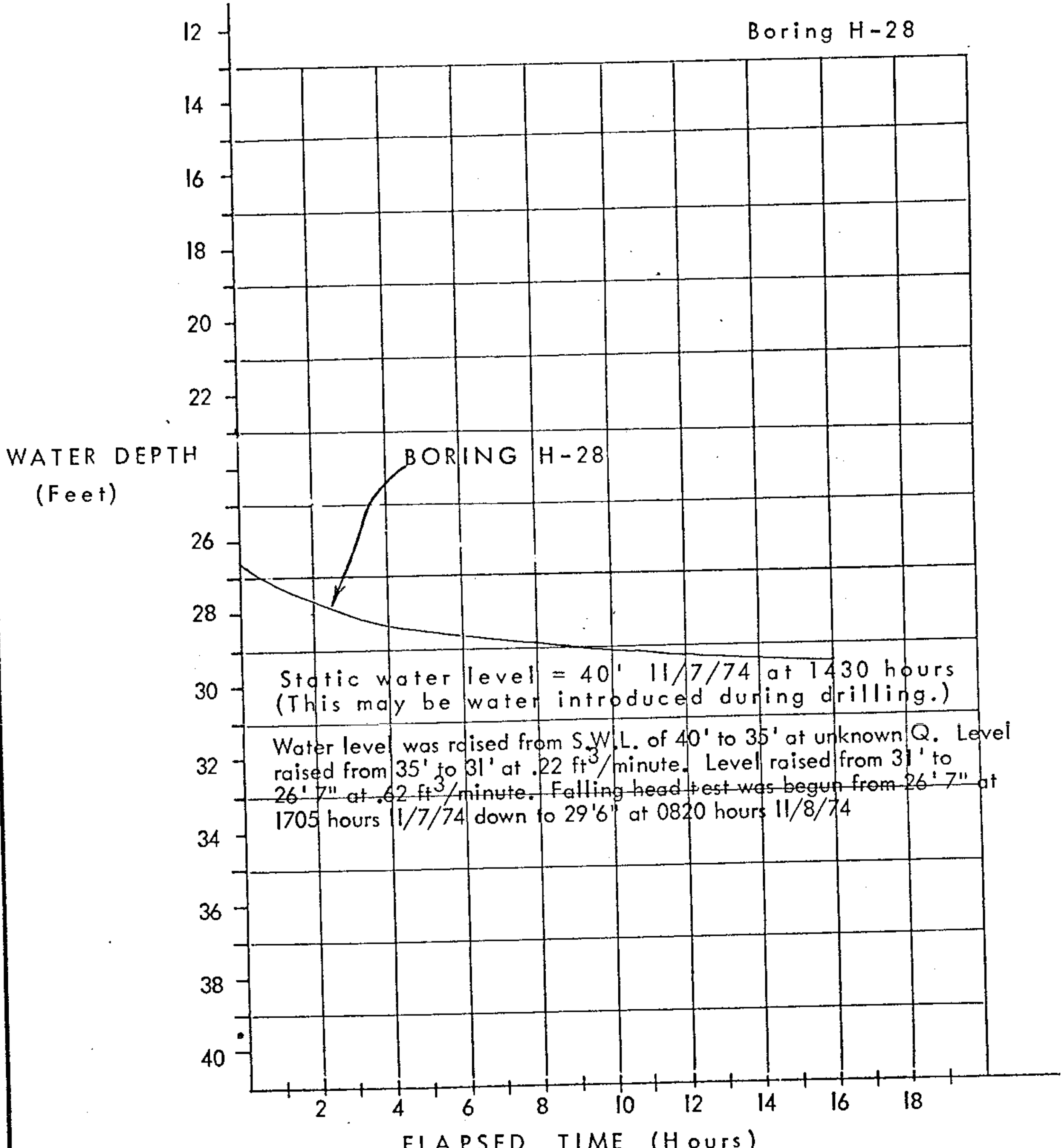
MEASUREMENTS OF GROUND WATER SURFACE
BIG CANYON RESERVOIR AREA

Piezometer Number	Ref. Point Elevation (Mean Sea Level Datum)	Approximate Distance - Ref. Point to Ground Surface	Distance - Ref. Point to Ground Water Surface 11/21/74	12/5/74	12/24/74
H-32	319.57	-.56	34.83	35.39	35.92
H-35	312.66	2.07	28.54	29.08	29.44
H-36	289.29	2.5	24.54	25.19	25.80
H-37	301.08	2.42	29.80	30.17	30.53
H-38	309.78	2.33	27.92	28.58	29.14
H-39	293.94	2.42	16.29	16.60	16.91
SL-1	309.07	1.06	22.96	24.54	25.35
SL-2	308.77	1.37	49.80	49.66	50.04
I-40	309.81				
I-41	318.95				

APPENDIX C

BASIC DATA
FIELD PERMEABILITY TESTS
(FALLING HEAD)

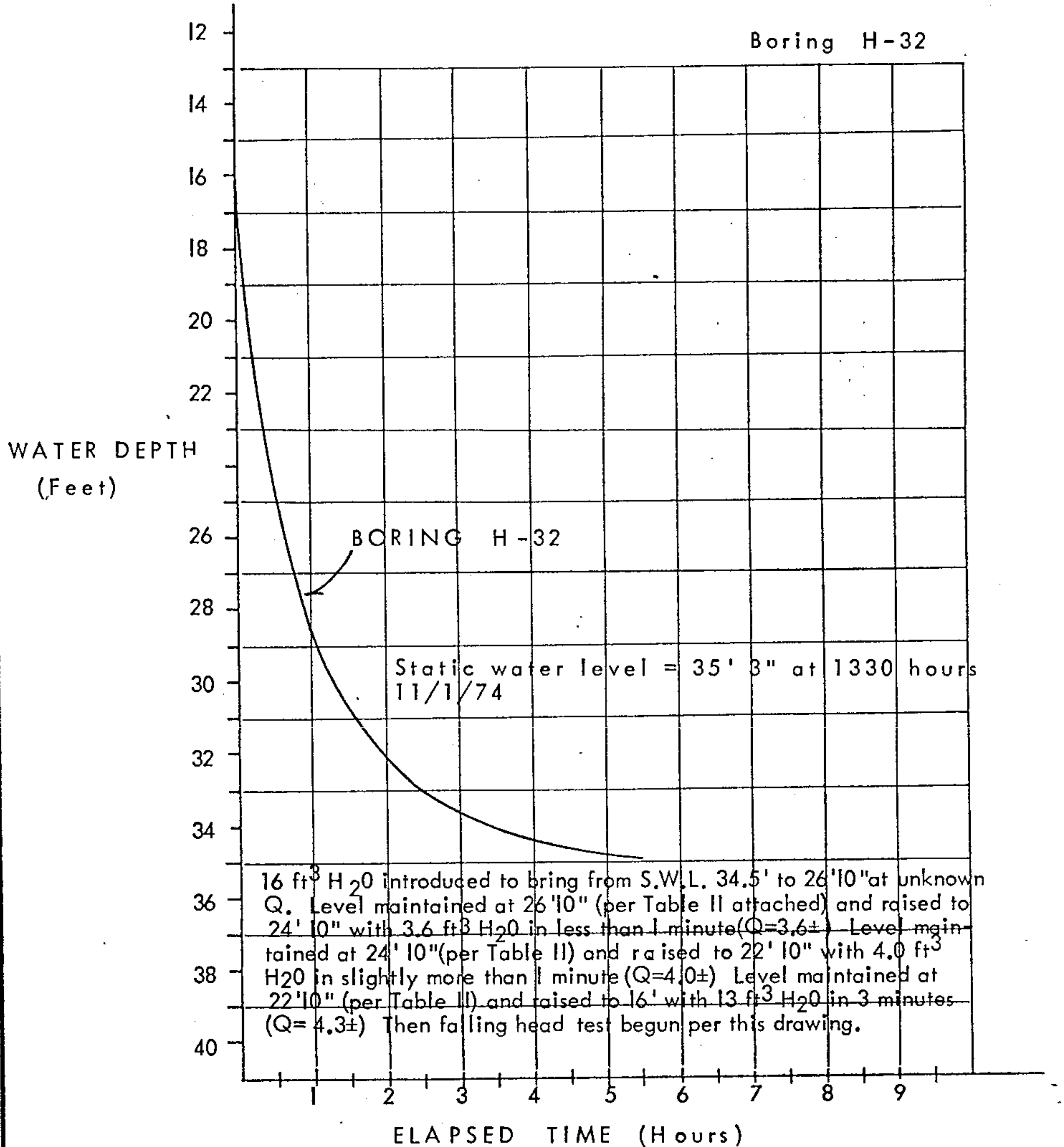
FALLING HEAD PERMEABILITY TESTS
(Slug tests)



Field permeability tests were run using off-site water introduced into the boring to bring water levels to desired depth. Decay in elevation was measured with a Stevens Recorder.

BIG CANYON GROUND WATER STUDY FOR JAMES M. MONTGOMERY, CONSULTING ENGINEERS	Drawing 32a
CONVERSE, DAVIS AND ASSOCIATES • ANAHEIM, CALIF.	PROJ. NO. A-74-628-AE

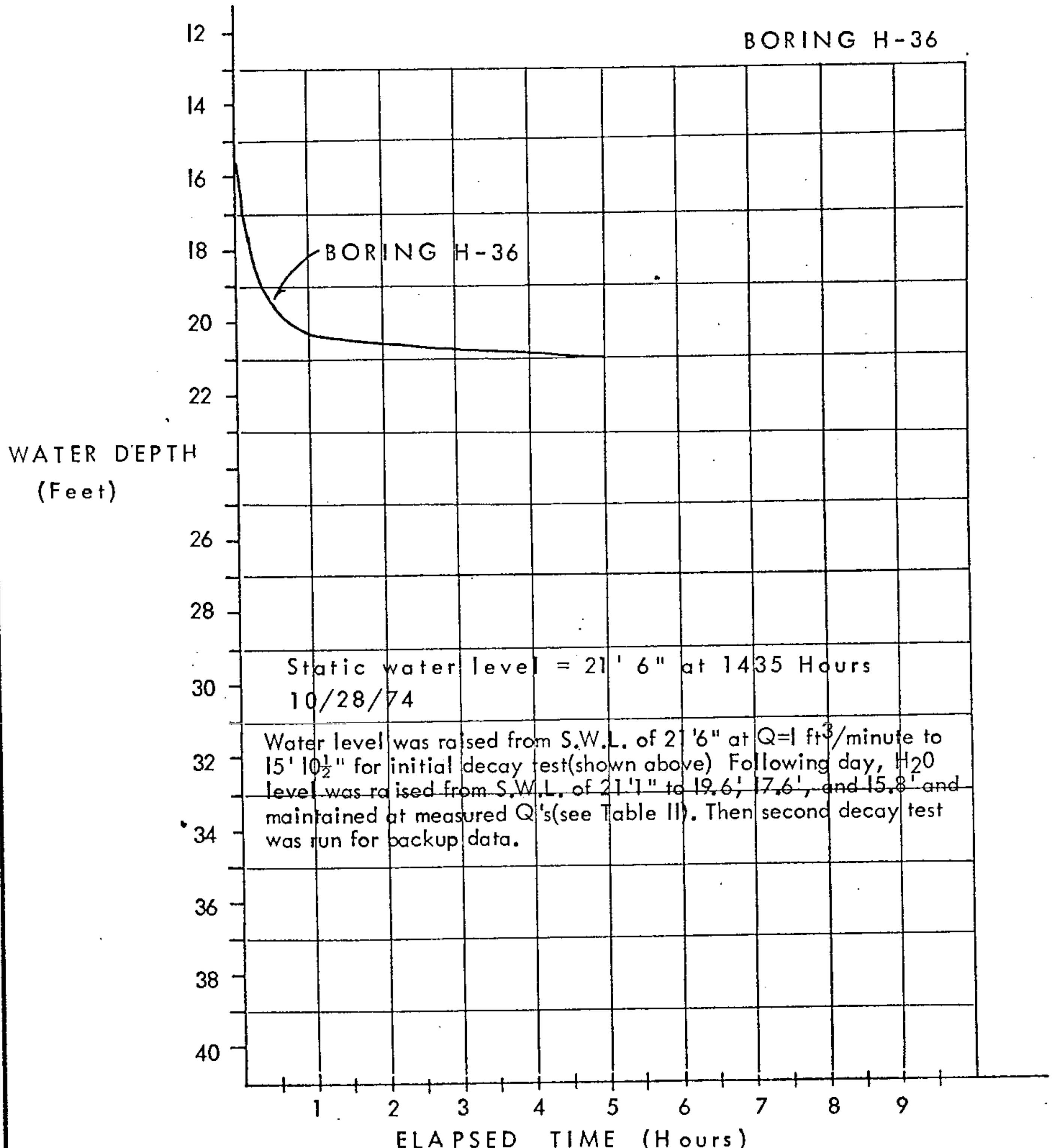
FALLING HEAD PERMEABILITY TESTS
(Slug tests)



Field permeability tests were run using off-site water introduced into the boring to bring water levels to desired depth. Decay in elevation was measured with a Stevens Recorder.

BIG CANYON GROUND WATER STUDY FOR JAMES M. MONTGOMERY, CONSULTING ENGINEERS	Drawing 33a
CONVERSE, DAVIS AND ASSOCIATES • ANAHEIM, CALIF.	PROJ. NO. A-74-628-AE

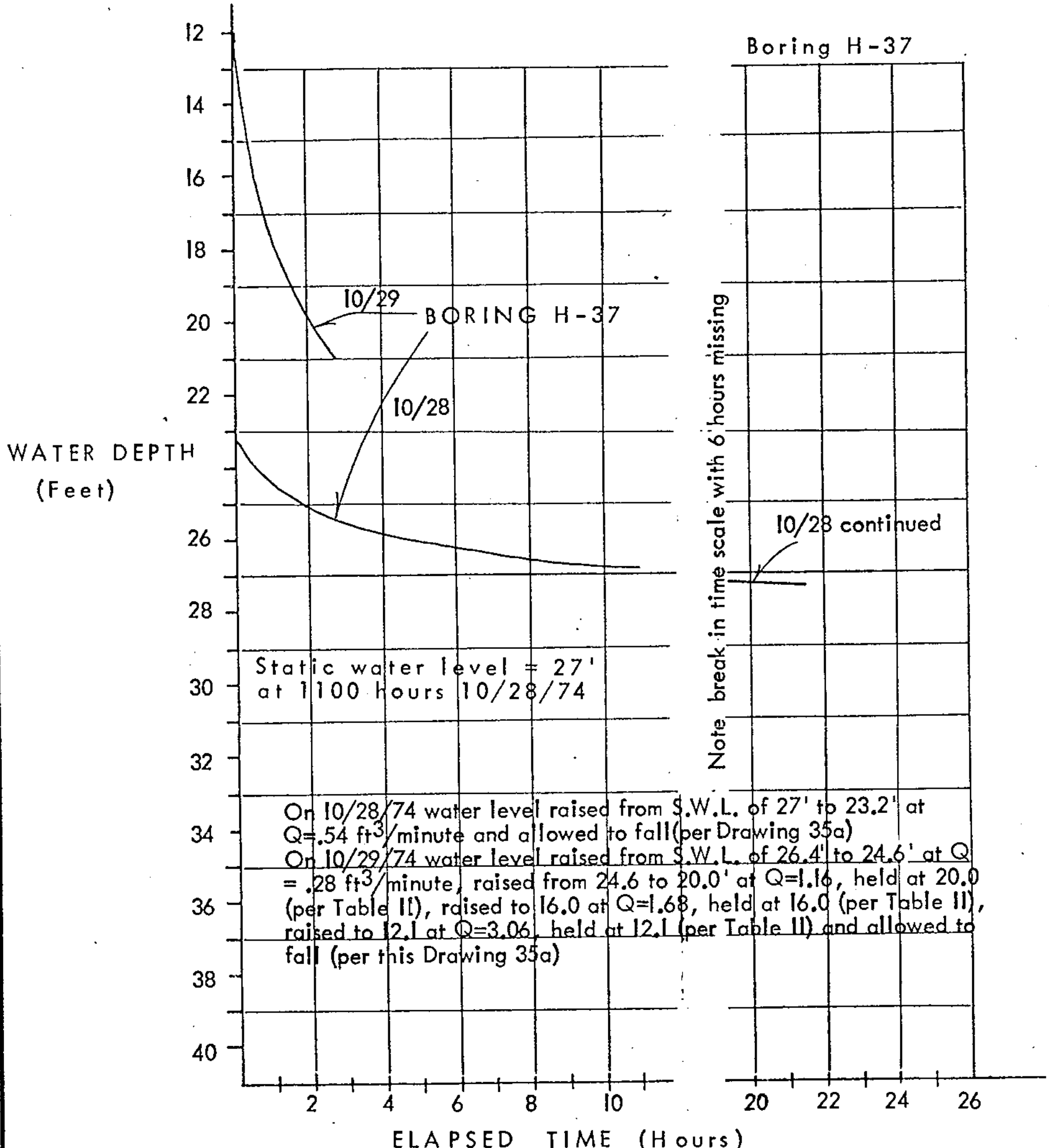
FALLING HEAD PERMEABILITY TESTS
(Slug tests)



Field permeability tests were run using off-site water introduced into the boring to bring water levels to desired depth. Decay in elevation was measured with a Stevens Recorder.

BIG CANYON GROUND WATER STUDY FOR JAMES M. MONTGOMERY, CONSULTING ENGINEERS	Drawing 34a
CONVERSE, DAVIS AND ASSOCIATES • ANAHEIM, CALIF.	PROJ. NO. A-74-628-AE

FALLING HEAD PERMEABILITY TESTS
(Slug tests)



Field permeability tests were run using off-site water introduced into the boring to bring water levels to desired depth. Decay in elevation was measured with a Stevens Recorder.

BIG CANYON GROUND WATER STUDY FOR JAMES M. MONTGOMERY, CONSULTING ENGINEERS	Drawin 35a
CONVERSE, DAVIS AND ASSOCIATES • ANAHEIM, CALIF.	PROJ. NO. A-74-628-AE

SECTION A-A'
HORIZ. SCALE: 1" = 80'

EXPLANATION

- CLAY AND/OR SILT
- SANDY CLAY AND/OR SILT
- SAND
- SILTY AND/OR CLAYEY SAND
- GRAVEL
- ROCK FRAGMENTS
- SILTSTONE (LOCALLY SANDY, CLAYEY, ETC.) SHOWING APPROXIMATE APPARENT DIP
- PRINCIPAL FRACTURE ZONE
- DEPTH OF FIRST SEEPAGE ENCOUNTERED DURING DRILLING
- GROUND-WATER SURFACE (DEC. 1974)
- GEOLOGIC CONTACT

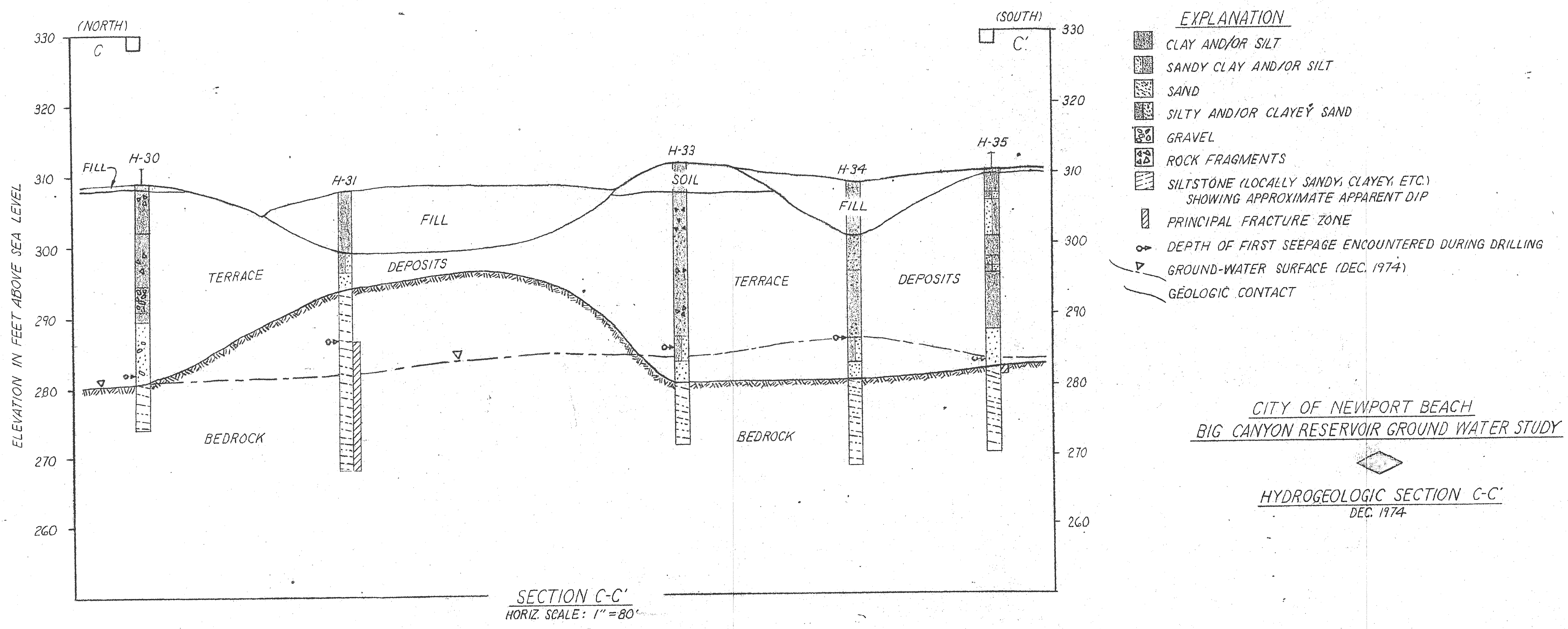
CITY OF NEWPORT BEACH
BIG CANYON RESERVOIR GROUND WATER STUDY

HYDROGEOLOGIC SECTION A-A'
DEC., 1974

FIGURE 1


(WEST)
B
(EAST)
B'
ELEVATION IN FEET ABOVE SEA LEVEL
320
310
300
290
280
270
260
250
240
230
C-1Q
B-4
B-10
G-26
G-24
G-25
H-39
H-29
H-30
FILL
SOIL
TERRACE
DEPOSITS
BEDROCK
SLIDE
DEBREE
SECTION B-B'
HORIZ. SCALE: 1"=80'
EXPLANATION
CLAY AND/OR SILT
SANDY CLAY AND/OR SILT
SAND
SILTY AND/OR CLAYEY SAND
GRAVEL
ROCK FRAGMENTS
SILTSTONE (LOCALLY SANDY, CLAYEY, ETC) SHOWING APPROXIMATE APPARENT DIP
PRINCIPAL FRACTURE ZONE
DEPTH OF FIRST SEEPAGE ENCOUNTERED DURING DRILLING
GROUND-WATER SURFACE (DEC. 1974)
GEOLOGIC CONTACT
CITY OF NEWPORT BEACH
BIG CANYON RESERVOIR GROUND WATER STUDY
HYDROGEOLOGIC SECTION B-B'
DEC. 1974

FIGURE 2



CITY OF NEWPORT BEACH
BIG CANYON RESERVOIR GROUND WATER STUDY

HYDROGEOLOGIC SECTION C-C'
DEC. 1974

FIGURE 3

CITY OF NEWPORT BEACH

BIG CANYON RESERVOIR
GROUND WATER STUDY

PROGRESS REPORT NO. 2

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.
17802 Sky Park Circle, Suite 201, Irvine, California 92707 / (714) 979-8733

DuWayne R. Lidke
Vice President and Manager

May 13, 1975

City of Newport Beach
3300 Newport Boulevard
Newport Beach, California 92660

Attention: Mr. Steve Bucknam

Gentlemen:

Transmitted herewith are ten copies of Progress Report No. 2, Big Canyon Ground Water Study, in accordance with the terms of your Professional Services Agreement dated September, 1974. The purpose of the investigation as stated is "to collect sufficient geologic, hydrologic and water quality data to define the quantity and direction of ground water flow in the vicinity of Big Canyon Reservoir."

This is the second in a series of brief progress reports. It describes activities which have been undertaken since January 1975 and presents basic data on ground water levels and water quality. We are available to discuss this investigation and data contained herein, at your convenience. If you have any questions, please contact us.

Very truly yours,

Karl H. Wiebe
Senior Hydrogeologist

DuWayne R. Lidke
Vice President

BIG CANYON RESERVOIR
GROUND WATER STUDY

PROGRESS REPORT NO. 2

INTRODUCTION

On October 4, 1974, James M. Montgomery, Consulting Engineers, Inc. was authorized by the City of Newport Beach to proceed with a program of ground water study and monitoring in the Big Canyon Reservoir area. The work to be undertaken was described in a Professional Services Agreement dated September, 1974. The purpose of investigation was "to collect sufficient geologic, hydrologic and water quality data to define the quantity and direction of ground water flow in the vicinity of Big Canyon Reservoir." It was agreed that progress reports would be submitted to outline accomplishments at the end of each three (3) month period. This letter report describes monitoring activities completed in the past quarter, and presents basic data and information on water level fluctuations, rainfall, discharge from drains and ground water mineral quality analyses.

CONDUCT OF THE STUDY

Work on the investigation in the past three months has included the following items:

A. Water level measurement and monitoring at 27 piezometer sites around the reservoir, measurement of discharge on the main reservoir underdrain, the east wall drain and the Bren Tract (Harbor View Hills) drain, and collection of both measured and recorded rainfall data. Measurements are at two-week intervals.

B. Mineral analysis of ground water samples from piezometers and the Bren Drain.

C. Review and brief data evaluation, including a graphic representation of hydrologic information collected.

HYDROLOGIC DATA

Information on precipitation for the study is obtained from Corona Del Mar Station No. 169 at the south end of the reservoir. These facilities include both a standard-type manual raingage, plus a recording gage. The recording gage is maintained by the Orange County Flood Control District, and data is collected periodically and analyzed in Santa Ana. Manual measurements are made on the standard raingage by the City staff. Daily and cumulative rainfall is shown graphically on Figures 1 and 2.

A summary of monthly precipitation is shown on Table 1.

TABLE 1

MONTHLY RAINFALL SUMMARY

Month	Rainfall (Inches)	Cumulative Rainfall (Inches)
Oct., 1974	.41	.41
Nov.	.11	.52
Dec.	4.72	5.24
Jan., 1975	.42	5.66
Feb.	1.88	7.54
Mar.	3.20	10.74

Daily fluctuations of the reservoir water surface elevation are shown on Figures 1 and 2. Beginning November 2, the water surface was lowered to about elevation 286 from about elevation 297. From November 25, 1974 to March 20, 1975, the surface elevation fluctuated from about elevation 286 to 290 feet.

Measurements of discharge at the east wall drain and the main reservoir underdrain are shown on Figures 1 and 2. The average discharges recorded from February 22 to March 20 for these drains range from 14.82-15.25 gpm, and from 3.74-5.64 gpm, respectively. Records kept at the reservoir indicate that the reservoir was drawn down approximately 10 feet at the beginning of that period. Following that lowering, the discharge in the east wall drain decreased from approximately 18.5 gpm to ± 16 gpm. The average discharge for the remainder of the period was ±15.5 gpm.

The discharge measurement system for the Bren Tract drain (Harbor View Hills) was constructed in November, 1974, but has operated only intermittantly due to periodic pump malfunction. As a result, continuous discharge measurements are not available. When the pump is activated, it discharges at about 12 gpm, between activation and shut-off levels. Average overall discharge for operational periods is shown in Table 2.

TABLE 2

AVERAGE DISCHARGE

BREN TRACT DRAIN

Dates	Duration (Min.)	Average Discharge (gpm)
3/21/75 - 4/2/75	16920	3.38
4/2/75 - 4/3/75	1412	2.98
4/3/75 - 4/3/75	33	3.68

During the early part of March, the Engineering staff of the City noted that flow in the drain had increased markedly. It was reported that during the rains of March 6 and 7, the pump operated continuously for several periods while the drain was also discharging into the overflow. This would result in a discharge considerably in excess of 12 gpm unless the pump was malfunctioning during that period.

Water level measurements were taken approximately every two weeks from November 11, 1974 to March 20, 1975, (see Figures 1 and 2). Water levels in piezometers on the reservoir and cemetary properties declined continuously (see Plate 1 in Progress Report 1 for piezometer locations). Individual net declines are shown on Table 3. The declines become progressively smaller down-gradient or westward from the reservoir east wall, ranging from 3.31 feet at piezometer SL-1 to 0.04 feet at G-25. The decline is greatest in piezometers SL-1, H-28, H-30, H-32, H-35, H-36 and H-38, all of which are located on or adjacent to, the east wall, except for H-36. Field evidence suggests the net rises of 6.38 and 1.48 feet for piezometers B-1 and B-6. This probably relects flooding and leakage into the piezometers and not a true rise in the piezometric surface.

As shown on Figures 1 and 2, ground water levels in the study area exhibited little direct effect from observed rainfall between November and March. The lack of significant rainfall effect to date may be attributed to one or both of the following factors:

TABLE 3

NET CHANGES IN PIEZOMETERS
11/21/74 THROUGH 3/20/75

RESERVOIR PROPERTY

Piezometer No.	Net Change (ft)
H-36	- .87
H-37	-1.62
H-35	-1.70
SL- 1	-3.31
H-30	-2.28
H-29	- .80
H-39	- .75
G-25	- .56
G-22	- .43
G-26	- .04
G-24	- .41
B-23	-1.06
SL- 2	- .48
H-38	-2.55

CEMETARY PROPERTY

Piezometer No.	Net Change (ft)
H-32	-1.67
H-28	-1.56
H-27	- .78
B-8	- .46
B-10	- .21

MAC ARTHUR BOULEVARD

Piezometer No.	Net Change (ft)
B-7	- .04
B-4	------*
B-3	+6.38
B-2	- .04
B-6	+1.48
B-1	+ .34

BREN TRACT

Piezometer No.	Net Change (ft)
C-12	- .60
C-16	+ .78

* No measurement, piezometer flooded, 3/20/75

(1) The lag time between rainfall and subsequent percolation to the actual ground water surface, and (2) insufficient rainfall available for deep percolation due to evapotranspiration, soil moisture deficiency, and/or moderate runoff. If significant recharge is occurring and lag time is the primary causative factor for the lack of responce in piezometers, water level rises should occur in the late spring or early summer as measurements continue.*

GROUND WATER QUALITY DATA

During the ground water studies, a total of 21 samples have been collected and analyzed for their dissolved mineral constituents. Analyses of samples collected during the recent drilling program are presented in Appendix A, and selected mineral constituents are shown in Table 4. The location of piezometers and drains are shown on Plate 1, (progress Report No. 1).

Analyses indicate that total dissolved solids (TDS) increase markedly, as ground waters flow down-gradient (Plate 1), with lowest concentrations of about 900 to 1100 mg/l at sites H-33, H-34 and SL-1. Downstream concentrations in and near the Harbor View Hills Tract, range from about 10,000 to 15,500 mg/l, TDS. As concentration increases, the chemical character of ground water changes from sodium sulfate-bicarbonate to sodium sulfate and finally to sodium chloride.

Nitrate concentrations in both reservoir water and locally applied water contain less than 2 mg/l of NO_3. Nitrate concentrations which appear in local ground waters probably originate as leachate from applied fertilizers and/or from natural animal wastes on the ground surface. Ground waters with the highest nitrate concentrations occur at piezometers G-24 and B-7, and the new Bren Tract drain, while lowest values were found in piezometers G-25, H-29, H-33, H-34 and SL-2.

A plot of the ratio (R) of electrical conductivity (EC x 10^6@ 25°C) to bicarbonate concentration (HCO_3) indicates that waters most resembling reservoir supply and applied water (R=4), occur in piezometers SL-1, H-29, H-31, H-33 and H-34 (R=6.5-8.3). Most dissimilar waters (R=50.0-89.8) were found at sites B-4, B-7, B-23 and the Bren Tract drain, with the remainder of samples exhibiting intermediate values as shown on Table 4. It should be noted that ratios greater than 4.0 reflect increased distance of travel from the source, but do not necessarily indicate the specific sources or the exact recharge areas.

* Piezometers H-32, H-28, H-27, B-8, B-10, B-2, and B-3 should be good sites to monitor possible rises due to rainfall, as they have shown steady declines with only slight fluctuations during the entire period and do not seem to show any significant reservoir effect.

TABLE 4

SELECTED MINERAL CONSTITUENTS

Sample Location	Total Dissolved Solids (mg/l)	Electrical Conductivity umhos (@25°C)	Ratio Electrical Conductivity / Bicarbonate Conc.	Nitrate Conc. (mg/l)
SL-1	(1,100)*	1,590	6.5	8.9
SL-2	(15,500)	22,080	27.6	0.22
B-1	(10,200)	14,600	44.7	0.66
B-2	(8,500)	12,100	41.3	4.87
B-4	(3,700)	5,300	50.0	7.8
B-7	(15,500)	22,100	70.2	38.5
C-16	(10,000)	14,400	21.9	4.3
G-23	(18,900)	26,940	89.8	7.3
G-24	(2,600)	3,750	13.5	20.8
G-25	(5,400)	7,730	13.4	0.22
G-26	(5,400)	7,730	18.3	3.8
H-27	2,600	4,080	12.4	6.2
H-29	1,893	2,850	7.3	0.22
H-30	4,613	6,350	20.0	22.2
H-31	2,198	3,130	9.6	7.53
H-32	2,121	3,410	11.8	3.32
H-33	904	1,330	6.8	1.77
H-34	1,106	1,660	8.3	0.22
H-36	6,169	7,210	20.4	4.87
H-37	9,203	12,300	31.5	5.54
H-39	4,068	6,260	18.9	10.6
Reservoir Underdrain	(6,600)	9,490	22.1	12.9
Bren Drain	13,430	19,200	62.9	26.6

*(TDS Value calculated from EC)

SUMMARY

A. Ground water levels in the study area exhibited little direct effect from observed rainfall between November and March. This may be a result of lag time, or of lack of deep percolation resulting from evapotranspiration, soil moisture deficiency, etc..

B. The decrease in rate of reservoir level decline after November 25, is generally mirrored by piezometers SL-1 and H-36. Fluctuations in those piezometers also relate to reservoir level changes, with a 5-10 day time lag.

C. Very minor flow increases and decreases occur in the main underdrain and the east wall drain with increase and decrease in reservoir water elevation, except at the beginning of the period when the east wall drain discharge decreased 2.5 gpm after a ± 10 foot decline in reservoir stage.

D. In the study area, the maximum ground water level declines (1.56 feet-3.31 feet) have occurred just east of the reservoir. In addition, the declines become progressively smaller down gradient or westward from the reservoir east wall. These 2 factors suggest the present effectiveness of the east wall drain. This hypothesis may be tested by closing the east wall drain, while the reservoir stage is relatively constant, and monitoring the water level changes.

E. Analyses of water samples suggest increased concentrations of dissolved minerals with increasing distance of ground water movement or travel. Observed nitrate concentrations indicate that during certain periods in the past, rain water and/or applied irrigation waters have percolated to the ground water table.

APPENDIX A

MINERAL ANALYSES

OF

GROUND WATER SAMPLES

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74232
Job No. 40.0550

lient: Newport Beach

escription and amount of sample: A74-628A Big Canyon Piezometer, H-27 Newport Beach; Opaquehigh turbidity

ate sample taken:
Date received:
ate of analysis:

Sampled by: K. Wiebe
Sample analyzed by: L. Leong
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate		
Calcium	47.6		Borate (as B)		
Magnesium	62.0		Carbonate		
Potassium	9.6		Chloride	1023	
Sodium	765		Fluoride	0.48	
			Hydroxide		
			Nitrate	6.2	
			Nitrite		
			Orthophosphate		
			Sulfate	520	
Total Cations			Total Anions		

Acidity (as $CaCO_3$)
Alkalinity
- Hydroxide
- Carbonate
- Bicarbonate 270mg/L

Arsenic (As)
Barium (Ba)
Biochemical Oxygen Demand (BOD_5)
Cadmium (Cd)
Carbon Dioxide (CO_2)
Chemical Oxygen Demand (COD)
Chlorine Demand
Chlorine Residual
Chromium, hexavalent (Cr^{VI})
Chromium, total (Cr)
Color (units) 8
Copper (Cu)
Cyanide (CN)
Dissolved oxygen (DO)
Specific conductance (EC) 4080
Hardness, total 512mg/L
I (Fe) 20ug/L

Lead (Pb)
Manganese (Mn) <50ug/L
Mercury (Hg)
Moisture in sludge
Organic nitrogen
Oil and Grease
pH (units) 7.9
Phenols
Phosphorus, total (P)
Residue
- Total solids (TS)
- Total suspended solids (TSS)
- Total dissolved solids (TDS) 2600mg/L
- Total fixed solids (TFS)
- Total volatile solids (TVS)
- Fixed dissolved solids (FDS)
- Fixed suspended solids (FSS)
- Volatile dissolved solids (VDS)
- Volatile suspended solids (VSS)
- Settleable solids ( )

Selenium (Se)
Silica (SiO_2) 40 mg/L
Silver (Ag)

Strontium (Sr)
Sulfide (S)
Sulfite (SO_3)
Surfactants
Sulfur dioxide (SO_2)
Threshold odor No.
Turbidity (J. U.) 500
Zinc (Zn)

Remarks:

Submitted by: [signature]
Raymond G. Zehnpfennig
Chief Chemist

* All values in mg/l unless otherwise noted.

MRI-1

A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74232

Job No. 40.0550

Client: Newport Beach

Description and amount of sample: A74-628A Big Canyon Piezometer, H-27
Newport Beach

Date sample taken:

Date received:

Date of analysis: 12/5/74

Sampled by:

Sample analyzed by: L. Leong

Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate		
Calcium			Borate (as B)		
Magnesium			Carbonate		
Potassium			Chloride		
Sodium			Fluoride		
			Hydroxide		
			Nitrate	6.2 as NO_3	
			Nitrite		
			Orthophosphate		
			Sulfate		
Total Cations			Total Anions		

Acidity (as $CaCO_3$) ____
Alkalinity
Hydroxide ____
Carbonate ____
Bicarbonate ____
Arsenic (As) ____
Barium (Ba) ____
Biochemical Oxygen Demand (BOD_5) ____
Cadmium (Cd) ____
Carbon Dioxide (CO_2) ____
Chemical Oxygen Demand (COD) ____
Chlorine Demand ____
Chlorine Residual ____
Chromium, hexavalent (Cr^{VI}) ____
Chromium, total (Cr) ____
Color (units) ____
Copper (Cu) ____
Cyanide (CN) ____
Dissolved oxygen (DO) ____
Specific conductance (EC) ____
Hardness, total ____
Iron (Fe) ____

Lead (Pb) ____
Manganese (Mn) ____
Mercury (Hg) ____
Moisture in sludge ____
Organic nitrogen ____
Oil and Grease ____
pH (units) ____
Phenols ____
Phosphorus, total (P) ____
Residue
Total solids (TS) ____
Total suspended solids (TSS) ____
Total dissolved solids (TDS) ____
Total fixed solids (TFS) ____
Total volatile solids (TVS) ____
Fixed dissolved solids (FDS) ____
Fixed suspended solids (FSS) ____
Volatile dissolved solids (VDS) ____
Volatile suspended solids (VSS) ____
Settleable solids ( ) ____
Selenium (Se) ____
Silica (SiO_2) ____
Silver (Ag) ____

Strontium (Sr) ____
Sulfide (S) ____
Sulfite (SO_3) ____
Surfactants ____
Sulfur dioxide (SO_2) ____
Threshold odor No. ____
Turbidity (J. U.) ____
Zinc (Zn) ____

Remarks:

Submitted by: ____
Raymond G. Zehnpfennig
Chief Chemist

* All values in mg/l unless otherwise noted.

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-221
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid.
Big Canyon Piezometer H-29

Date sample taken:
Date received: 10/24/74
Date of analysis: 10/27-11/8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z.
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	390.4	6.40
Calcium	62.0	3.10	Borate (as B)		
Magnesium	62.0	5.10	Carbonate		
Potassium	2.5	0.06	Chloride	516.7	14.58
Sodium	500.0	21.75	Fluoride	1.60	0.08
			Hydroxide		
			Nitrate	<0.22	0.00
			Nitrite		
			Orthophosphate		
			Sulfate	752.0	15.66
Total Cations	626.5	30.01	Total Anions	1461.6	36.72

Acidity (as $CaCO_3$)
Alkalinity
Hydroxide
Carbonate
Bicarbonate 320.0
Arsenic (As)
Barium (Ba)
Biochemical Oxygen Demand (BOD_5)
Cadmium (Cd)
Carbon Dioxide (CO_2)
Chemical Oxygen Demand (COD)
Chlorine Demand
Chlorine Residual
Chromium, hexavalent (Cr^{VI})
Chromium, total (Cr)
Color (units) 12
Copper (Cu)
Cyanide (CN)
Dissolved oxygen (DO)
Specific conductance (EC) 2850
Hardness, total 410.0
Iron (Fe)

Lead (Pb)
Manganese (Mn)
Mercury (Hg)
Moisture in sludge
Organic nitrogen
Oil and Grease
pH (units) 7.70
Phenols
Phosphorus, total (P)
Residue
Total solids (TS)
Total suspended solids (TSS)
Total dissolved solids (TDS) 1893
Total fixed solids (TFS)
Total volatile solids (TVS)
Fixed dissolved solids (FDS)
Fixed suspended solids (FSS)
Volatile dissolved solids (VDS)
Volatile suspended solids (VSS)
Settleable solids ( )
Selenium (Se)
Silica (SiO_2) 37.0
Silver (Ag)

Strontium (Sr)
Sulfide (S)
Sulfite (SO_3)
Surfactants
Sulfur dioxide (SO_2)
Threshold odor No.
Turbidity (J. U.)
Zinc (Zn)

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by:
Raymond G. Zehnpfennig
Chief Chemist

A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-223
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: –
Big Canyon Piezometer H-30

Date sample taken: 10/29/74
Date received: 10/31/74
Date of analysis: 11/1-8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z. &.L. Leong
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	317.2	5.2
Calcium	264.0	13.17	Borate (as B)		
Magnesium	270.0	22.21	Carbonate		
Potassium	6.7	0.17	Chloride	1936	54.61
Sodium	820	35.67	Fluoride	0.72	0.04
			Hydroxide		
			Nitrate	22.2	0.36
			Nitrite		
			Orthophosphate		
			Sulfate	880.0	18.33
Total Cations		71.22	Total Anions		78.54

Acidity (as $CaCO_3$) ____
Alkalinity
  Hydroxide ____
  Carbonate ____
  Bicarbonate 260.0
Arsenic (As) ____
Barium (Ba) ____
Biochemical Oxygen Demand (BOD_5) ____
Cadmium (Cd) ____
Carbon Dioxide (CO_2) ____
Chemical Oxygen Demand (COD) ____
Chlorine Demand ____
Chlorine Residual ____
Chromium, hexavalent (Cr^{VI}) ____
Chromium, total (Cr) ____
Color (units) 7
Copper (Cu) ____
Cyanide (CN) ____
Dissolved oxygen (DO) ____
Specific conductance (EC) 6350
Hardness, total 1770
Iron (Fe) ____

Lead (Pb) ____
Manganese (Mn) ____
Mercury (Hg) ____
Moisture in sludge ____
Organic nitrogen ____
Oil and Grease ____
pH (units) ____
Phenols ____
Phosphorus, total (P) ____
Residue
  Total solids (TS) ____
  Total suspended solids (TSS) ____
  Total dissolved solids (TDS) 4613
  Total fixed solids (TFS) ____
  Total volatile solids (TVS) ____
  Fixed dissolved solids (FDS) ____
  Fixed suspended solids (FSS) ____
  Volatile dissolved solids (VDS) ____
  Volatile suspended solids (VSS) ____
  Settleable solids ( ) ____
Selenium (Se) ____
Silica (SiO_2) 35
Silver (Ag) ____

Strontium (Sr) ____
Sulfide (S) ____
Sulfite (SO_3) ____
Surfactants ____
Sulfur dioxide (SO_2) ____
Threshold odor No. ____
Turbidity (J. U.) ____
Zinc (Zn) ____

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by:
Raymond G. Zehnpfennig
Chief Chemist

MMI-1

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-226
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid.
Big Canyon Piezometer H-32

Date sample taken: 11/1/74
Date received: 11/1/74
Date of analysis: 11/1-8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z.
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	290.3	4.76
Calcium	101.0	5.04	Borate (as B)		
Magnesium	130.7	10.75	Carbonate		
Potassium	6.4	0.16	Chloride	797.5	22.50
Sodium	520.0	22.62	Fluoride	0.95	0.05
			Hydroxide		
			Nitrate	3.32	0.05
			Nitrite		
			Orthophosphate		
			Sulfate	450.0	9.37
Total Cations		38.57	Total Anions		36.73

Acidity (as $CaCO_3$)
Alkalinity
Hydroxide
Carbonate
Bicarbonate 238.4
Arsenic (As)
Barium (Ba)
Biochemical Oxygen Demand (BOD_5)
Cadmium (Cd)
Carbon Dioxide (CO_2)
Chemical Oxygen Demand (COD)
Chlorine Demand
Chlorine Residual
Chromium, hexavalent (Cr^{VI})
Chromium, total (Cr)
Color (units) 7
Copper (Cu)
Cyanide (CN)
Dissolved oxygen (DO)
Specific conductance (EC) 3410
Hardness, total 790.0
Iron (Fe)

Lead (Pb)
Manganese (Mn)
Mercury (Hg)
Moisture in sludge
Organic nitrogen
Oil and Grease
pH (units) 7.80
Phenols
Phosphorus, total (P)
Residue
Total solids (TS)
Total suspended solids (TSS)
Total dissolved solids (TDS) 2121
Total fixed solids (TFS)
Total volatile solids (TVS)
Fixed dissolved solids (FDS)
Fixed suspended solids (FSS)
Volatile dissolved solids (VDS)
Volatile suspended solids (VSS)
Settleable solids ( )
Selenium (Se)
Silica (SiO_2) 35.5
Silver (Ag)

Strontium (Sr)
Sulfide (S)
Sulfite (SO_3)
Surfactants
Sulfur dioxide (SO_2)
Threshold odor No.
Turbidity (J. U.)
Zinc (Zn)

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by:
Raymond G. Zehnpfennig
Chief Chemist

MRI-1

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-222
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid.
Big Canyon Piezometer H-31

Date sample taken: 10/25/74/1108
Date received:
Date of analysis: 10/27-11/8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z.
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	327.0	5.36
Calcium	124.0	6.19	Borate (as B)		
Magnesium	117.0	9.62	Carbonate		
Potassium	7.6	0.19	Chloride	545.1	15.38
Sodium	480.0	20.88	Fluoride	0.66	0.03
			Hydroxide		
			Nitrate	7.53	0.12
			Nitrite		
			Orthophosphate		
			Sulfate	680.0	14.16
Total Cations	728.6	36.88	Total Anions	1393.5	35.05

Acidity (as $CaCO_3$)
Alkalinity
  Hydroxide
  Carbonate
  Bicarbonate 268.0
Arsenic (As)
Barium (Ba)
Biochemical Oxygen Demand (BOD_5)
Cadmium (Cd)
Carbon Dioxide (CO_2)
Chemical Oxygen Demand (COD)
Chlorine Demand
Chlorine Residual
Chromium, hexavalent (Cr^{VI})
Chromium, total (Cr)
Color (units) 12
Copper (Cu)
Cyanide (CN)
Dissolved oxygen (DO)
Specific conductance (EC) 3130
Hardness, total 605.0
(Fe)

Lead (Pb)
Manganese (Mn)
Mercury (Hg)
Moisture in sludge
Organic nitrogen
Oil and Grease
pH (units) 7.90
Phenols
Phosphorus, total (P)
Residue
  Total solids (TS)
  Total suspended solids (TSS)
  Total dissolved solids (TDS) 2198
  Total fixed solids (TFS)
  Total volatile solids (TVS)
  Fixed dissolved solids (FDS)
  Fixed suspended solids (FSS)
  Volatile dissolved solids (VDS)
  Volatile suspended solids (VSS)
  Settleable solids ( )
Selenium (Se)
Silica (SiO_2) 39.5
Silver (Ag)

Strontium (Sr)
Sulfide (S)
Sulfite (SO_3)
Surfactants
Sulfur dioxide (SO_2)
Threshold odor No.
Turbidity (J. U.)
Zinc (Zn)

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by:
Raymond G. Zehnpfennig
Chief Chemist

MRI-1

MONTGOMERY RESEARCH INC.

A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-224
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid.
Big Canyon Bore 33

Date sample taken: 10/29/74
Date received: 10/31/74
Date of analysis: 11/1-8/74

Sampled by: Karl Wiebe
Sample analyzed by:
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	195.2	3.20
Calcium	64.0	3.19	Borate (as B)		
Magnesium	48.6	4.00	Carbonate		
Potassium	2.5	0.06	Chloride	53.1	1.50
Sodium	170.0	7.40	Fluoride	0.87	0.05
			Hydroxide		
			Nitrate	1.77	0.03
			Nitrite		
			Orthophosphate		
			Sulfate	360.0	7.50
Total Cations		14.65	Total Anions		12.28

Acidity (as $CaCO_3$)
Alkalinity
Hydroxide
Carbonate
Bicarbonate 160.0
Arsenic (As)
Barium (Ba)
Biochemical Oxygen Demand (BOD_5)
Cadmium (Cd)
Carbon Dioxide (CO_2)
Chemical Oxygen Demand (COD)
Chlorine Demand
Chlorine Residual
Chromium, hexavalent (Cr^{VI})
Chromium, total (Cr)
Color (units) 7
Copper (Cu)
Cyanide (CN)
Dissolved oxygen (DO)
Specific conductance (EC) 1330
Hardness, total 350.0
(Fe)

Lead (Pb)
Manganese (Mn)
Mercury (Hg)
Moisture in sludge
Organic nitrogen
Oil and Grease
pH (units) 7.80
Phenols
Phosphorus, total (P)
Residue
Total solids (TS)
Total suspended solids (TSS)
Total dissolved solids (TDS) 904
Total fixed solids (TFS)
Total volatile solids (TVS)
Fixed dissolved solids (FDS)
Fixed suspended solids (FSS)
Volatile dissolved solids (VDS)
Volatile suspended solids (VSS)
Settleable solids ( )
Selenium (Se)
Silica (SiO_2) 32.5
Silver (Ag)

Strontium (Sr)
Sulfide (S)
Sulfite (SO_3)
Surfactants
Sulfur dioxide (SO_2)
Threshold odor No.
Turbidity (J. U.)
Zinc (Zn)

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by:
Raymond G. Zehnpfennig
Chief Chemist

MRI-1

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-217
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid
Big Canyon Piezometer H-34

Date sample taken: 10/22/1515
Date received: 10/24/74
Date of analysis: 10/27/11-8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z.
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	200.1	3.28
Calcium	64.0	3.19	Borate (as B)		
Magnesium	63.2	5.20	Carbonate		
Potassium	2.6	0.07	Chloride	287.4	8.11
Sodium	212.0	9.22	Fluoride	0.42	0.02
			Hydroxide		
			Nitrate	<0.22	0.00
			Nitrite		
			Orthophosphate		
			Sulfate	376.0	7.83
Total Cations	341.8	17.68	Total Anions	761.9	19.24

Acidity (as $CaCO_3$) ______
Alkalinity
Hydroxide ______
Carbonate ______
Bicarbonate 164.0
Arsenic (As) ______
Barium (Ba) ______
Biochemical Oxygen Demand (BOD_5) ______
Cadmium (Cd) ______
Carbon Dioxide (CO_2) ______
Chemical Oxygen Demand (COD) ______
Chlorine Demand ______
Chlorine Residual ______
Chromium, hexavalent (Cr^{VI}) ______
Chromium, total (Cr) ______
Color (units) 7.0
Copper (Cu) ______
Cyanide (CN) ______
Dissolved oxygen (DO) ______
Specific conductance (EC) 1660
Hardness, total 420.0
(Fe) ______

Lead (Pb) ______
Manganese (Mn) ______
Mercury (Hg) ______
Moisture in sludge ______
Organic nitrogen ______
Oil and Grease ______
pH (units) 7.70
Phenols ______
Phosphorus, total (P) ______
Residue
Total solids (TS) ______
Total suspended solids (TSS) ______
Total dissolved solids (TDS) 1106
Total fixed solids (TFS) ______
Total volatile solids (TVS) ______
Fixed dissolved solids (FDS) ______
Fixed suspended solids (FSS) ______
Volatile dissolved solids (VDS) ______
Volatile suspended solids (VSS) ______
Settleable solids ( ) ______
Selenium (Se) ______
Silica (SiO_2) 31.5
Silver (Ag) ______

Strontium (Sr) ______
Sulfide (S) ______
Sulfite (SO_3) ______
Surfactants
Sulfur dioxide (SO_2) ______
Threshold odor No. ______
Turbidity (J. U.) ______
Zinc (Zn) ______

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by: ______
Raymond G. Zehnpfennig
Chief Chemist

MRI-1

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-218
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid.
Big Canyon Piezometer H-36

Date sample taken: 10/22/1330
Date received: 10/24/74
Date of analysis: 10/27-11/8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z.
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	353.8	5.80
Calcium	720.0	35.93	Borate (as B)		
Magnesium	180.0	14.81	Carbonate		
Potassium	4.3	0.11	Chloride	1412	39.83
Sodium	1050	45.68	Fluoride	0.62	0.03
			Hydroxide		
			Nitrate	4.87	0.08
			Nitrite		
			Orthophosphate		
			Sulfate	2660	55.38
Total Cations	1954.3	96.53	Total Anions	4250.8	101.12

Acidity (as $CaCO_3$) ______
Alkalinity
Hydroxide ______
Carbonate ______
Bicarbonate 290
Arsenic (As) ______
Barium (Ba) ______
Biochemical Oxygen Demand (BOD_5) ______
Cadmium (Cd) ______
Carbon Dioxide (CO_2) ______
Chemical Oxygen Demand (COD) ______
Chlorine Demand ______
Chlorine Residual ______
Chromium, hexavalent (Cr^{VI}) ______
Chromium, total (Cr) ______
Color (units) 12
Copper (Cu) ______
Cyanide (CN) ______
Dissolved oxygen (DO) ______
Specific conductance (EC) 7210
Hardness, total 2540
(Fe) ______

Lead (Pb) ______
Manganese (Mn) ______
Mercury (Hg) ______
Moisture in sludge ______
Organic nitrogen ______
Oil and Grease ______
pH (units) 7.70
Phenols ______
Phosphorus, total (P) ______
Residue
Total solids (TS) ______
Total suspended solids (TSS) ______
Total dissolved solids (TDS) 6169
Total fixed solids (TFS) ______
Total volatile solids (TVS) ______
Fixed dissolved solids (FDS) ______
Fixed suspended solids (FSS) ______
Volatile dissolved solids (VDS) ______
Volatile suspended solids (VSS) ______
Settleable solids ( ) ______
Selenium (Se) ______
Silica (SiO_2) 35.5
Silver (Ag) ______

Strontium (Sr) ______
Sulfide (S) ______
Sulfite (SO_3) ______
Surfactants ______
Sulfur dioxide (SO_2) ______
Threshold odor No. ______
Turbidity (J. U.) ______
Zinc (Zn) ______

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by: ______
Raymond G. Zehnpfennig
Chief Chemist

MRI-1

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.,
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-219
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid.
Big Canyon Piezometer H-37

Date sample taken: 10/22/741345
Date received: 10/24/74
Date of analysis: 10/27-11/8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z.
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	390.4	6.40
Calcium	760.0	37.92	Borate (as B)		
Magnesium	329.5	27.10	Carbonate		
Potassium	20.0	0.51	Chloride	3804	107.31
Sodium	1760	76.56	Fluoride	0.95	0.05
			Hydroxide		
			Nitrate	5.54	0.09
			Nitrite		
			Orthophosphate		
			Sulfate	1860	38.74
Total Cations	2869.5	142.09	Total Anions	5861.8	152.59

Acidity (as $CaCO_3$) ______
Alkalinity
Hydroxide ______
Carbonate ______
Bicarbonate 320.0
Arsenic (As) ______
Barium (Ba) ______
Biochemical Oxygen Demand (BOD_5) ______
Cadmium (Cd) ______
Carbon Dioxide (CO_2) ______
Chemical Oxygen Demand (COD) ______
Chlorine Demand ______
Chlorine Residual ______
Chromium, hexavalent (Cr^{VI}) ______
Chromium, total (Cr) ______
Color (units) 71
Copper (Cu) ______
Cyanide (CN) ______
Dissolved oxygen (DO) ______
Specific conductance (EC) 12300
Hardness, total ______
Iron (Fe) ______

Lead (Pb) ______
Manganese (Mn) ______
Mercury (Hg) ______
Moisture in sludge ______
Organic nitrogen ______
Oil and Grease ______
pH (units) 7.70
Phenols ______
Phosphorus, total (P) ______
Residue
Total solids (TS) ______
Total suspended solids (TSS) ______
Total dissolved solids (TDS) 9203
Total fixed solids (TFS) ______
Total volatile solids (TVS) ______
Fixed dissolved solids (FDS) ______
Fixed suspended solids (FSS) ______
Volatile dissolved solids (VDS) ______
Volatile suspended solids (VSS) ______
Settleable solids (   ) ______
Selenium (Se) ______
Silica (SiO_2) 37.5
Silver (Ag) ______

Strontium (Sr) ______
Sulfide (S) ______
Sulfite (SO_3) ______
Surfactants ______
Sulfur dioxide (SO_2) ______
Threshold odor No. ______
Turbidity (J. U.) ______
Zinc (Zn) ______

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by: ______
Raymond G. Zehnpfennig
Chief Chemist

MRI-1

MONTGOMERY RESEARCH INC.
A Subsidiary of James M. Montgomery, Consulting Engineers, Inc.
555 East Walnut Street, Pasadena, California 91101
Telephone: (213) 796-9141 or (213) 681-4255

REPORT OF WATER ANALYSIS

Lab No. 74-227
Job No. 40.0550

Client: City of Newport Beach

Description and amount of sample: 1 gal muddy liquid.
Big Canyon Piezometer H-39

Date sample taken: 10/31/74
Date received: 11/1/74
Date of analysis: 11/1-8/74

Sampled by: Karl Wiebe
Sample analyzed by: R. Z.
Report No.:

Cations	mg/l	meq/l	Anions	mg/l	meq/l
Ammonium			Bicarbonate	331.8	5.44
Calcium	146.0	7.29	Borate (as B)		
Magnesium	246.6	20.29	Carbonate		
Potassium	3.1	0.08	Chloride	1809	51.03
Sodium	1010	43.94	Fluoride	0.94	0.05
			Hydroxide		
			Nitrate	10.6	0.17
			Nitrite		
			Orthophosphate		
			Sulfate	900.0	18.75
Total Cations	1405.7	71.60	Total Anions	2883.1	75.44

Acidity (as $CaCO_3$) ______
Alkalinity
Hydroxide ______
Carbonate ______
Bicarbonate 272.0
Arsenic (As) ______
Barium (Ba) ______
Biochemical Oxygen Demand (BOD_5) ______
Cadmium (Cd) ______
Carbon Dioxide (CO_2) ______
Chemical Oxygen Demand (COD) ______
Chlorine Demand ______
Chlorine Residual ______
Chromium, hexavalent (Cr^{VI}) ______
Chromium, total (Cr) ______
Color (units) 6
Copper (Cu) ______
Cyanide (CN) ______
Dissolved oxygen (DO) ______
Specific conductance (EC) 6260
Hardness, total 1160
[illegible] (Fe) ______

Lead (Pb) ______
Manganese (Mn) ______
Mercury (Hg) ______
Moisture in sludge ______
Organic nitrogen ______
Oil and Grease ______
pH (units) 7.30
Phenols ______
Phosphorus, total (P) ______
Residue
Total solids (TS) ______
Total suspended solids (TSS) ______
Total dissolved solids (TDS) 4068
Total fixed solids (TFS) ______
Total volatile solids (TVS) ______
Fixed dissolved solids (FDS) ______
Fixed suspended solids (FSS) ______
Volatile dissolved solids (VDS) ______
Volatile suspended solids (VSS) ______
Settleable solids ( ) ______
Selenium (Se) ______
Silica (SiO_2) 44.0
Silver (Ag) ______

Strontium (Sr) ______
Sulfide (S) ______
Sulfite (SO_3) ______
Surfactants ______
Sulfur dioxide (SO_2) ______
Threshold odor No. ______
Turbidity (J. U.) ______
Zinc (Zn) ______

Remarks:

* All values in mg/l unless otherwise noted.

Submitted by: ______
Raymond G. Zehnpfennig
Chief Chemist

MRI-1

MAY 1 4 1975

REV	DATE	BY	DESCRIPTION

SCALE: AS SHOWN

DESIGNED R.W.P.
DRAWN G.H.
CHECKED K.H.W.

SUBMITTED
PROJECT ENGINEER — R.C.E. NO. — DATE
RECOMMENDED
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. — R.C.E. NO. — DATE

JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
17802 SKY PARK CIRCLE SUITE 201, IRVINE, CALIFORNIA 92707
PASADENA · BOISE · FORT LAUDERDALE · IRVINE · LA JOLLA · LAS VEGAS · UPLAND · WALNUT CREEK

APPROVED — DATE
APPROVED — DATE

CITY OF NEWPORT BEACH
BIG CANYON RESERVOIR GROUND WATER STUDY
FLUCTUATION OF WATER LEVELS, RAINFALL & DRAIN OUTFLOW
1/25/74 – 3/20/75

FIGURE 2

JOB NO. ——— FILE ——— DP 12-74

CITY OF NEWPORT BEACH

BIG CANYON RESERVOIR
GROUND WATER STUDY

PROGRESS REPORT NO. 3

AUGUST, 1975

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

PASADENA • IRVINE • LA JOLLA • RANCHO CALIFORNIA • UPLAND • WALNUT CREEK
BOISE • FORT LAUDERDALE • LAS VEGAS • WASHINGTON

CITY OF NEWPORT BEACH

BIG CANYON RESERVOIR GROUND WATER STUDY

PROGRESS REPORT NO. 3

AUGUST 1975

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.

JAMES M. MONTGOMERY, CONSULTING ENGINEERS, INC.
17802 Sky Park Circle, Suite 201, Irvine, California 92707 / (714) 979-8733

DuWayne R. Lidke
Vice President and Manager

August 18, 1975

City of Newport Beach
3300 Newport Boulevard
Newport Beach, California 92660

Attention: Mr. Steve Bucknam

Gentlemen:

Transmitted herewith are ten copies of Progress Report No. 3, Big Canyon Ground Water Study, in accordance with the terms of your Professional Services Agreement dated September, 1974. The purpose of the investigation as stated is "to collect sufficient geologic, hydrologic and water quality data to define the quantity and direction of ground water flow in the vicinity of Big Canyon Reservoir."

This is the third in a series of brief progress reports. It describes activities which have been undertaken from April through June, 1975 and presents basic data on rainfall, ground water and reservoir levels and drain discharges. We are available to discuss this investigation and data contained herein, at your convenience. If you have any questions, please contact us.

Very truly yours,

Karl H. Wiebe
Senior Hydrogeologist

DuWayne R. Lidke
Vice President

BIG CANYON RESERVOIR GROUND WATER STUDY

PROGRESS REPORT No. 3

INTRODUCTION

The ground water study and monitoring program at Big Canyon Reservoir was begun on October 4, 1974 with authorization to proceed by the City of Newport Beach. The work undertaken is described in a Professional Services Agreement, dated September 1974. This letter report is the third of four reports to be submitted at the end of each three-month period. The basic data and information on water level fluctuations, rainfall, and drain discharges are included in the following paragraphs.

CONDUCT OF THE STUDY

Work during the last quarter (April through June, 1975) has included the following:

A. Bimonthly water level measurements at 27 piezometers in the study area (see Plate 1, Progress Report 1 for piezometer locations and study area limits), discharge measurements on the main reservoir underdrain, the east wall drain, and Bren Tract drain; collection of rainfall data from City personnel at the reservoir and at the Orange County Flood Control District.

B. Review, analysis, and graphical presentation of all hydrologic data collected.

HYDROLOGIC DATA

The monthly and cumulative rainfall totals from March 1 to June 23 for Rain Gage No. 169 at Big Canyon Reservoir are shown on Table 1. The total cumulative rainfall to date since October 1974, is 13.83 inches.

TABLE 1

MONTHLY RAINFALL SUMMARY

Month	Rainfall (Inches)	Cumulative Rainfall (Oct, 1974) (Inches)
March	3.75	11.29
April	2.47	13.76
May	.07	13.83
June	---	13.83

Daily fluctuations of the reservoir water surface elevation are shown on Figures 1 and 2. From March 21 to April 29, the water surface fluctuated between elevations 285.8 and 289.8. Beginning April 30, City personnel began filling the reservoir to its anticipated annual maximum at elevation 302.5 feet*. By June 23 the water surface had risen to elevation 301.1 feet.

Measurements of discharge at the east wall drain and the main reservoir underdrain are shown on Figures 1 and 2. From March 21 to April 30, the east wall drain daily discharge ranged from 14.5 to 15.7 GPM. May 1 to June 23 the discharge increased steadily from 14.8 to 16.6 GPM, except for 3 days when the discharge was somewhat eratic.

In the main reservoir underdrain between March 21 to June 23, average discharges ranged from 4.95-6.16 GPM, the flows remaining relatively constant during the quarter. The drain metering system was under repair from May 5-May 16 so no discharges were recorded.

Bren Tract drain discharged approximately 13.2 GPM during the time the pump was actually running. Average overall discharges between measurements are shown on Table 2.

---

* Actual pumping of water into the reservoir began on May 30 at elevation ± 295 feet.

TABLE 2

AVERAGE DISCHARGE

BREN DRAIN

Dates	Duration (Min.)	Average Discharge (GPM)
4/7/75-4/18/75	15975	4.03
4/18/75-5/5/75	24480	2.55
5/5/75-5/16/75	15845	2.89
5/16/75-5/30/75	20050	.83
5/30/75-6/13/75	20110	2.88
6/13/75-6/23/75	14530	2.90

The flow in the Bren drain from 4/7/75-4/18/75 is the highest recorded average discharge for any one measuring period to date. Similarly the lowest flow for any period to date, 0.83 was recorded between 5/16/75-5/30/75. This rather substantial decline in flow from April to May appears to correspond to a similar decline in rainfall, however, the flow increased from 5/30/75-6/13/75 although rainfall continued to decrease. Additional measurements at the Bren drain will be required to varify hydrologic relationships.

Water level measurements from 3/21/75 to 6/23/75 are shown on Figures 1 and 2. Table 3 shows the net water level changes in piezometers for this quarter. Net rises measured were from 0.16 to 4.52 feet in all piezometers around the perimeter of the reservoir, except for G-24, G-26 and SL-2 which declined 0.16, 0.31 and 0.17 feet respectively. Most of the rises appear to begin around mid-April. The rises generally become greater eastward of the reservoir.

The water levels in piezometers H-27, B-1 through B-10, C-12 and C-16 declined from .09 to 5.79 feet. These piezometers are located north of the reservoir in the cemetary property, along MacArthur Boulevard and in the Bren Tract. The 5.79 feet of decline in B-3 is probably due to evaporation and percolation of the surface runoff which nearly filled the piezometer during spring rains.

TABLE 3

NET WATER LEVEL CHANGES
3/21/75 THROUGH 6/23/75

RESERVOIR PROPERTY

Piezometer No.	Net Change (ft)
H - 36	+1.70
H - 37	+ .64
H - 35	+ .42
SL - 1	+4.52
H - 30	+1.61
H - 29	+ .40
H - 39	+ .36
G - 25	+ .30
G - 22	+ .16
G - 26	- .31
G - 24	- .16
B - 23	+ .35
SL - 2	- .17
H - 38	+1.09

CEMETARY PROPERTY

Piezometer No.	Net Change (ft)
H - 32	+ .94
H - 28	+1.01
H - 27	- .09
B - 8	- .36
B - 10	- .19

MAC ARTHUR BOULEVARD

Piezometer No.	Net Change (ft)
B - 7	- .35
B - 4	*-----
B - 3	-5.79
B - 2	- .30
B - 1	- .54
B - 6	- .19

BREN TRACT

Piezometer No.	Net Change (ft)
C - 12	- .61
C - 16	-2.02

* Flooded at beginning of period

TABLE 4

NET WATER LEVEL CHANGES

11/21/74 THROUGH 6/23/75

RESERVOIR PROPERTY

Piezometer No.	Net Change (ft)
H - 36	+ .83
H - 37	- .98
H - 35	-1.28
SL - 1	+1.21
H - 30	- .67
H - 29	- .40
H - 39	- .38
G - 25	- .26
G - 22	- .27
G - 26	- .35
G - 24	+ .57
B - 23	- .21
SL - 2	- .65
H - 38	-1.46

CEMETARY PROPERTY

Piezometer No.	Net Change (ft)
H - 32	- .73
H - 28	- .55
H - 27	- .87
B - 8	- .31
B - 10	- .40

MAC ARTHUR BOULEVARD

Piezometer No.	Net Change (ft)
B - 7	- .39
B - 4	- .11
B - 3	+ .59
B - 2	- .26
B - 1	- .20
B - 6	+1.29

BREN TRACT

Piezometer No.	Net Change (ft)
C - 12	-1.21
C - 16	-1.24

The net water level changes since 11/21/74 are shown on Table 4. Piezometers H-36, SL-1, G-24, B-3 and B-6 exceed the November levels by 0.83, 1.21, 0.57, 0.59 and 1.29 feet respectively. Levels in the other piezometers are from 0.11 to 1.46 feet below the November levels.

SUMMARY

A. Total cumulative rainfall to date is 13.83 inches.

B. Ground water levels in the study area appear to have exhibited little direct effect from observed rainfall for this study period.

C. Discharges measured at the east wall drain appear to be increasing with the rising reservoir stage.

D. Average main underdrain discharges ranged from 4.95-6.16 GPM.

E. Average Bren drain discharges ranged from 0.83-4.03 GPM.

F. The rising reservoir stage from mid-April through June is generally mirrored by rising water levels in piezometers around the perimeter of the reservoir. The increase in water levels range from 0.16 to 4.52 feet, and is generally most marked on the eastern side of the reservoir, but substantial rises are also recorded on the south and west sides at H-38 and H-36 respectively.

G. During the study period, systematic rises and declines in water levels have been most pronounced in piezometers nearest the reservoir, and most particularly, on the east side of the reservoir. The expanded studies outlined in our letter of May 28, 1975, will aid materially in the precise definition and analysis of those systematic changes.

MAY 1 4 1975

REV	DATE	BY	DESCRIPTION

SCALE: AS SHOWN

DESIGNED R.W.P.
DRAWN G.H.
CHECKED K.H.W.

SUBMITTED
PROJECT ENGINEER R.C.E. NO. DATE
RECOMMENDED
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. R.C.E. NO. DATE

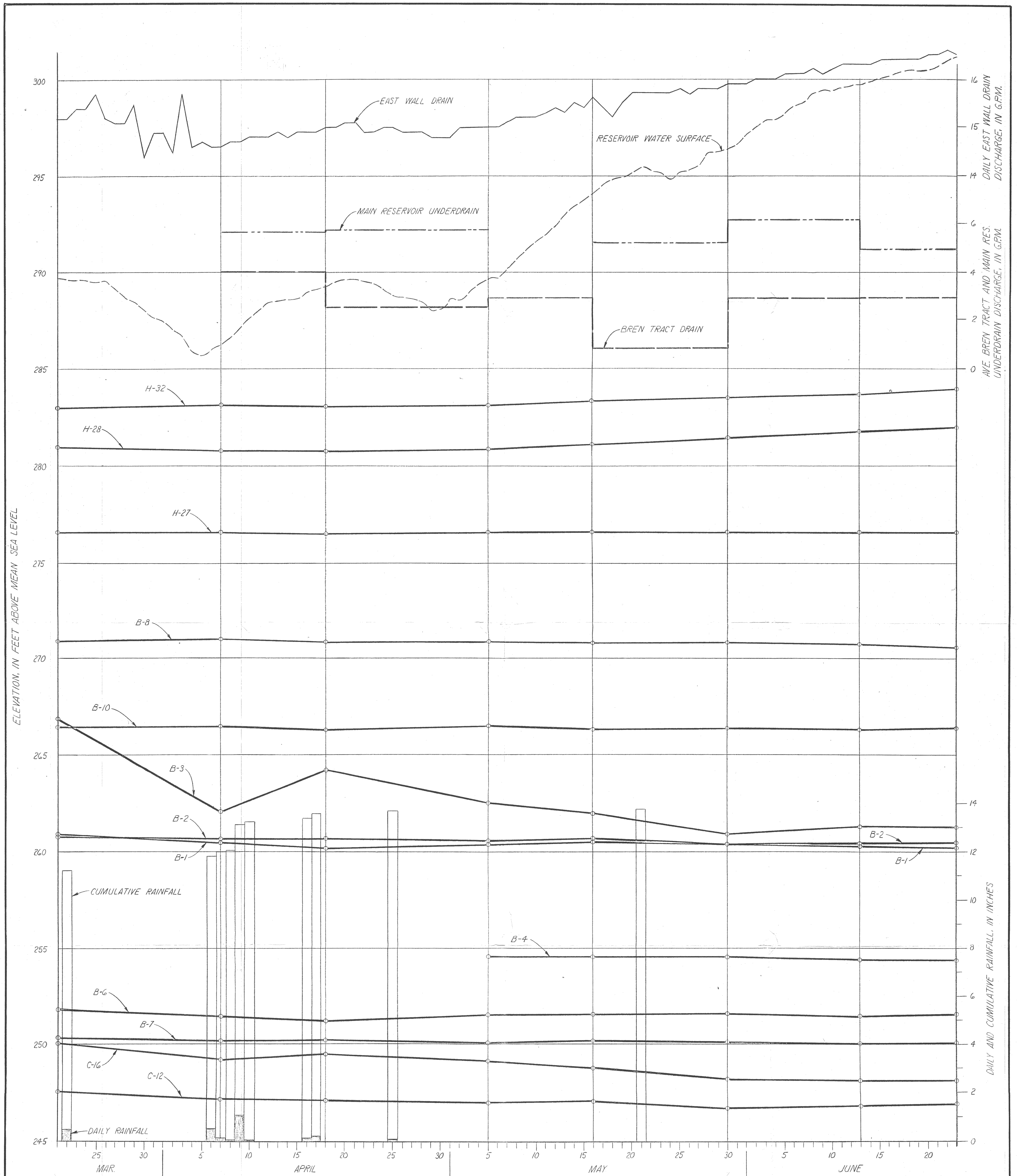
JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC.
17802 SKY PARK CIRCLE SUITE 201, IRVINE, CALIFORNIA 92707
PASADENA · BOISE · FORT LAUDERDALE · IRVINE · LA JOLLA · LAS VEGAS · UPLAND · WALNUT CREEK

APPROVED DATE
APPROVED DATE

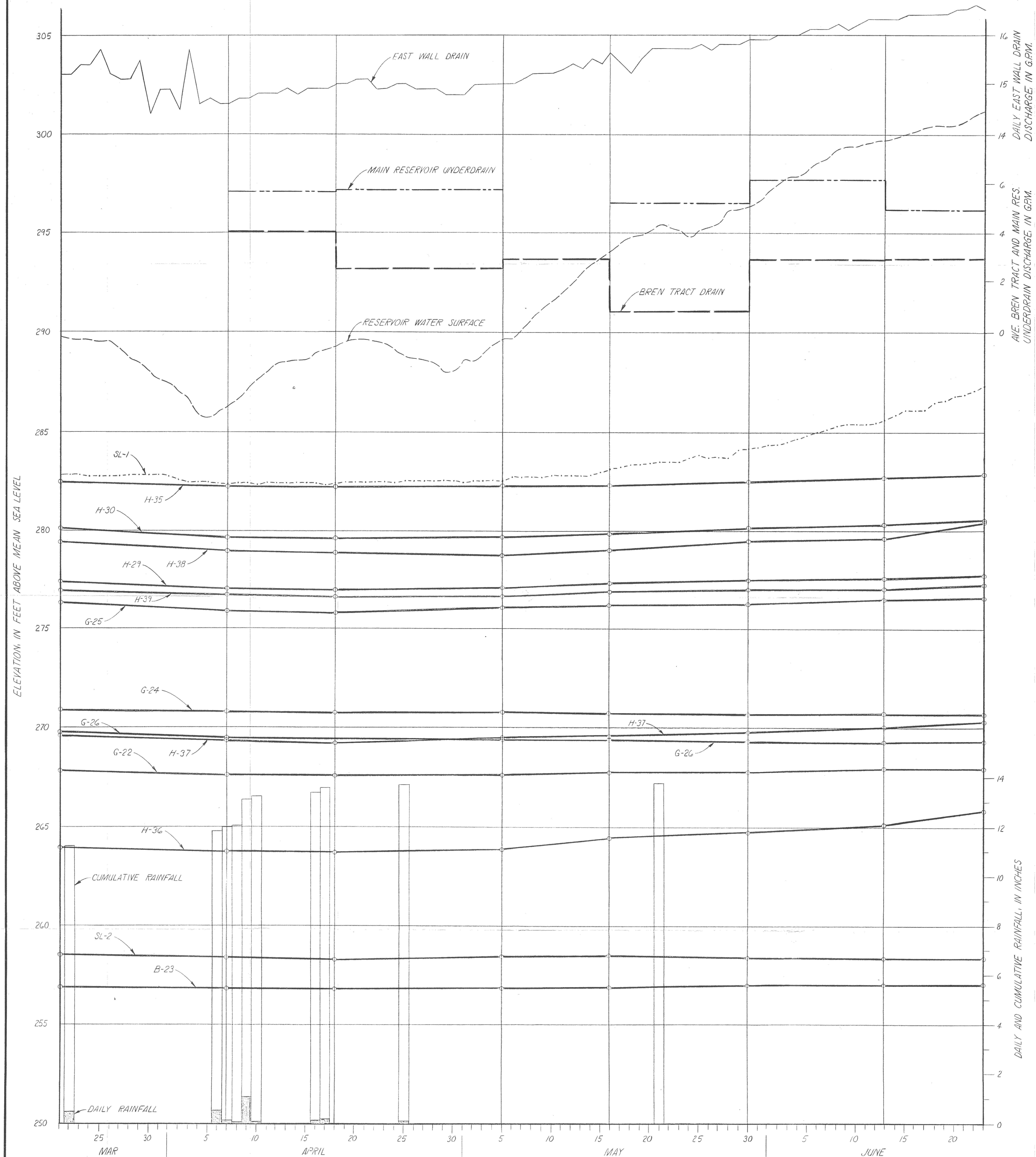
CITY OF NEWPORT BEACH
BIG CANYON RESERVOIR GROUND WATER STUDY
FLUCTUATION OF WATER LEVELS, RAINFALL & DRAIN OUTFLOW
1/25/74 – 3/20/75

FIGURE 1

JOB NO. FILE DP 12-74

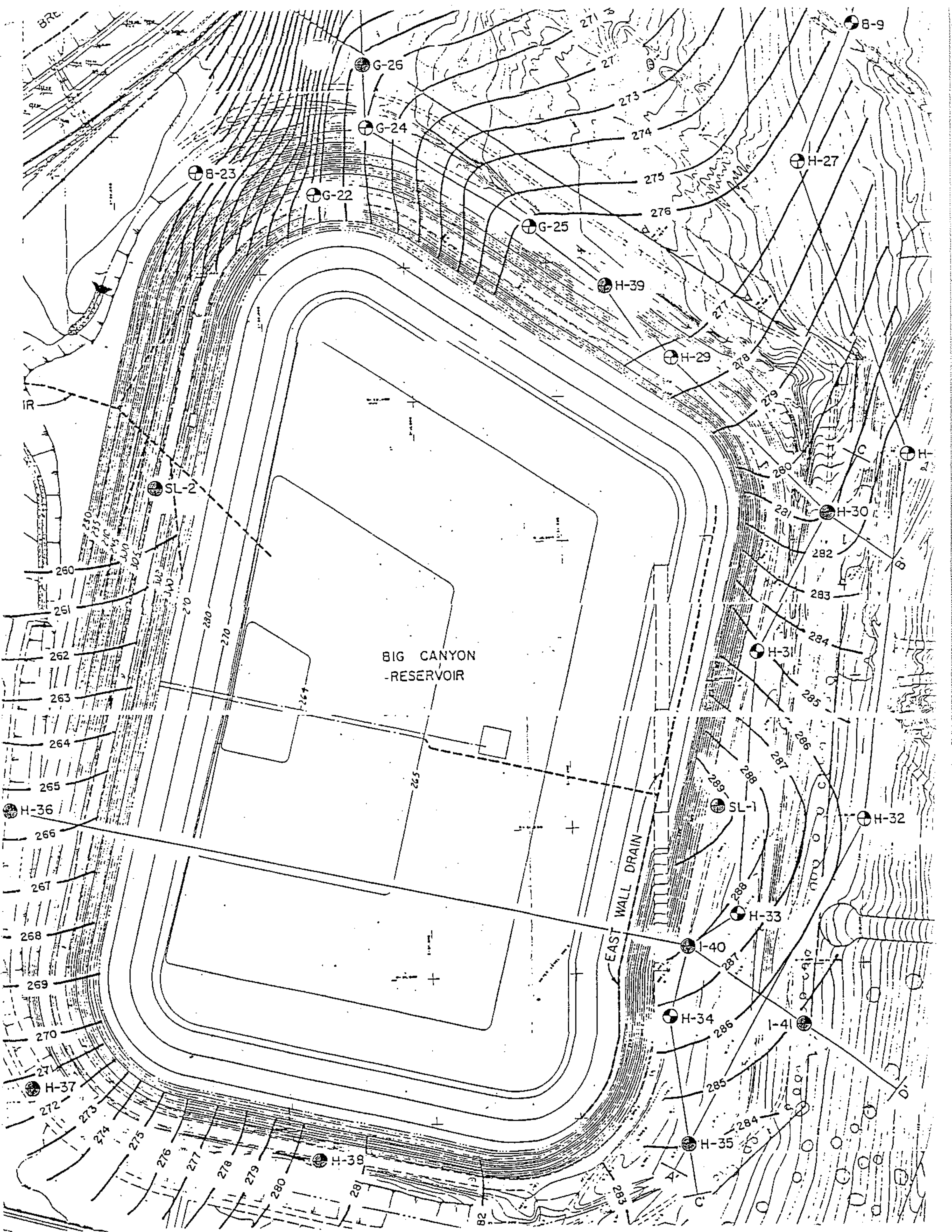


SCALE: AS SHOWN	DESIGNED DRAWN CHECKED	JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. 17802 SKY PARK CIRCLE SUITE 201, IRVINE, CALIFORNIA 92707 PASADENA · BOISE · FORT LAUDERDALE · IRVINE · LA JOLLA · LAS VEGAS · UPLAND · WALNUT CREEK	CITY OF NEWPORT BEACH BIG CANYON RESERVOIR GROUND WATER STUDY FLUCTUATION OF WATER LEVELS, RAINFALL & DRAIN OUTFLOW 3/21/75 – 6/23/75	FIGURE 1



SCALE: AS SHOWN	DESIGNED DRAWN CHECKED	JAMES M. MONTGOMERY CONSULTING ENGINEERS, INC. 17802 SKY PARK CIRCLE SUITE 201, IRVINE, CALIFORNIA 92707 PASADENA BOISE FORT LAUDERDALE IRVINE LA JOLLA LAS VEGAS UPLAND WALNUT CREEK	CITY OF NEWPORT BEACH BIG CANYON RESERVOIR GROUND WATER STUDY FLUCTUATION OF WATER LEVELS, RAINFALL & DRAIN OUTFLOW 3/21/75 – 6/23/75

FIGURE 2


BIG CANYON
RESERVOIR
EAST WALL DRAIN
G-26
G-24
B-23
G-22
G-25
H-39
H-29
H-27
B-9
H-30
H-31
SL-1
SL-2
H-32
H-33
I-40
I-41
H-34
H-35
H-36
H-37
H-38
B'
C
C'
D'
A'

Appendix 2 – URS Seismic Report