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NWC TP 7019
Supplement

A WATER GEOCHEMISTRY STUDY OF INDIAN WELLS VALLEY, INYO AND KERN COUNTIES, CALIFORNIA
Supplement. Isotope Geochemistry and Appendix H

by
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SEPTEMBER 1990

NAVAL WEAPONS CENTER
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FOREWORD

This report documents a water geochemistry study performed to determine possible sources of leakage of geothermal waters into the Indian Wells Valley. The study reported on here was partially funded by a grant from the Eastern Kern County Resource Conservation District. This document is being published as a technical report by the Geothermal Program Office to make the information part of the permanent record of the Department of Defense. Any reference to company or product names does not constitute endorsement by the U.S. Navy.

This supplement is in addition to the original two volumes published in September 1989. Volume 1 contains the main body of the report and Appendix A; Volume 2 contains Appendixes B through G.

This supplement was reviewed for technical accuracy by Carl F. Austin, NWC; James Moore, California Energy Co.; and Robert O. Fournier, Unites States Geological Survey.

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13. ABSTRACT *(Maximum 200 words)*

(U) Hydrogen and oxygen isotope data on waters of Indian Wells Valley, the Sierra, Rose Valley, and Coso thermal and nonthermal waters were studied.

(U) The isotope ratios of Sierran waters are a function of latitude with both ratios becoming depleted in the heavier isotopes from south to north. Assuming that groundwater recharge is from the Sierra, recharge areas for the various groundwater types can be designated.

(U) Hydrogen and oxygen isotopes do not uniquely define the recharge area for the Coso geothermal system but strongly suggest Sierran recharge with perhaps some local recharge. Sierran recharge is best supported by structural features and stream flow characteristics in the Sierra. Coso geothermal brines may have a component of waters from several different past pluvial periods, but the volume and midfield recharge rate of the system suggest continuous recharge.

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CONTENTS

INTRODUCTION

This supplement to NWC TP 7019 documents what is known about the isotope geochemistry of groundwaters in Indian Wells and Rose Valleys, the local Sierran groundwaters and surface waters, and thermal and nonthermal waters of the Coso Range, based on studies by the NWC Geothermal Program Office on the groundwater hydrology of these areas. Results of chemical studies are given in Volumes 1 and 2 of this report. General data on the geography and geology of the study area are given in Volume 1.

Isotope geochemistry is another tool that may provide additional knowledge of sources and flow paths of groundwater and their changes with time. Definitions and theory are given in the following section.

ISOTOPES

In a gross sense, atoms of an element are made up of three particles—protons, electrons, and neutrons. The electrical charge of protons is positive, and that of electrons is negative. Neutrons have no electrical charge. The number of protons determines what element an atom is and gives it its atomic number. In a neutral or nonionized atom the number of electrons equals the number of protons. The most common form of the element carbon is given an arbitrary weight of 12.00. It consists of six protons, six electrons, and six neutrons. Protons and neutrons each have a weight of one. Electrons are essentially weightless. Within limits, the number of neutrons in an atom of an element may vary. Thus, there are carbon atoms with weights of 10, 11, 12, 13, and 14. These varying weights of carbon are called isotopes of carbon.

Water is composed of two elements, hydrogen (H) and oxygen (O) combined as H_2O. There are hydrogen atoms with a weight of one (normally just called hydrogen), two (commonly called deuterium (D)), and three (commonly called tritium (T)). Tritium is radioactive. Hydrogen one and deuterium are stable. All hydrogen isotopes occur naturally. Oxygen has isotopes with weights of 15, 16, 17, 18, and 19. Oxygen 16, 17, and 18 are stable and occur naturally. Hydrogen, deuterium, and oxygen 16 and 18 are the isotopes used in this study. The isotope ratios were determined by the U.S. Geological Survey; by the Geology and Geophysics Department, University of Utah for the Eastern Kern County Resource Conservation District (EKCRCD); and by the Stable Isotope Laboratory, Southern Methodist University, for the California Energy Company.

PREVIOUS STUDIES

The first significant study of isotope geochemistry of the area was done by the U.S. Geological Survey partially supported with Navy funds. Fournier and Thompson (1980) published the study as an open-file report. Fournier and Thompson sampled thermal and nonthermal waters from the Coso Range, Dirty Socks Hot Spring, and springs, wells, and surface waters from Rose Valley, and from Big Pine Meadow north to Wild Rose Ranch (formerly the Sam Lewis Ranch) in the Sierra. Waters were also sampled from selected wells at NWC. Fournier and Thompson concluded that the recharge of the Coso Geothermal Field is derived from the portion of the Sierra Nevada generally to the west of the Coso Range.

The EKCRCD supported the geochemical and isotope studies of waters of Indian Wells Valley conducted by the Department of Geology and Geophysics, University of Utah. With EKCRCD permission, the results of the geochemical studies were included with the results of Navy studies in Volumes 1 and 2 of this technical report. The results of the isotope studies were presented to the EKCRCD by Bowman (1988) in an unpublished report.* Bowman reported on surface waters and well and spring waters from the Sierra from Nine Mile Canyon to Freeman Canyon and from various wells in the Indian Wells Valley. One well was sampled in Searles Valley. Bowman concluded that without seasonal sampling of precipitation at selected sites in the Sierra and Indian Wells Valley, and without better knowledge of the depths from which various wells were producing, it was not possible to identify specific areas of recharge for individual wells in Indian Wells Valley. However, he noted that a geothermal component is present in the Red Hill-Little Lake-Lumber Mill-Brown Road waters (warm springs occur in Little Lake).

As part of their continuing studies of the Coso Geothermal Field, California Energy Company, the operator of the field, has had isotope determinations made on 23 water samples from 16 wells. The California Energy Company has given the Navy permission to utilize its data in this study.

Williams and McKibbin (1990), using the data of the California Energy Company and new data, have written a voluminous paper in which they interpret all chemical and isotopic data available on the Coso Geothermal Field. They preferred to conclude that the recharge of the Coso Geothermal system could be rainfall and snowfall in the Coso and Argus Ranges. They also noted that the pattern "could indicate recharge from any nearby region of similar overall elevation." Thus, their data were not absolutely definitive as to the area of recharge for the Coso Geothermal Field. They also concluded that the oxygen isotope ratios indicated "a high degree of water-rock interaction at high temperatures and moderate water/rock ratios." They postulate leakage of geothermal fluids into Coso Wash in the vicinity of the resort area (see page 34 Volume 1). Sulfur isotopes are concordant with those of the granitic Sierran host rocks and indicate little if any sedimentary contribution. They noted that "oxidized and reduced sulfur are far from equilibrium at reservoir conditions. This implies very recent mixing and/or disequilibrium production near to or within the reservoir." They also conclude that carbon isotope ratios are concordant with gases of igneous or clastic sedimentary rocks but that there is no significant contribution of organic or marine carbonate carbon. They noted that there are two areas with steam caps; and from chemical data, concluded that there are regional differences in the source rocks and that convective mixing is slower than the processes creating the differences.

Buchanan (1989) proposed a theory, based on isotopic evidence, that recharge of geothermal systems in Utah and Nevada comes from "Paleo-fluid (Pleistocene - 8000 to 12000 years before present) recharge"; this theory is difficult to reconcile with the pattern of pluvial events that have affected this region.

The purpose of this supplement to NWC TP 7019 is to review available data and to determine what we have learned from isotopic data to date that may be of local significance.

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* Bowman, J. R. 1988. *Stable Isotope Analysis of Ground Waters of Indian Wells Valley and Vicinity - Preliminary Results.* Unpublished Report to EKCRD. 7 p.

DISCUSSION

Fournier and Thompson (1980) give a good but simple discussion of isotopic fractionation in waters.

The concentrations of the stable isotopes of oxygen and hydrogen in water are generally expressed in terms of $\delta^{18}O$ and δD, where

$$\delta^{18}O = \frac{(^{18}O/^{16}O)\text{ sample} - (^{18}O/^{16}O)\text{ standard}}{(^{18}O/^{16}O)\text{ standard}} \times 1000 \qquad (1)$$

and

$$\delta D = \frac{(D/H)\text{ sample} - (D/H)\text{ standard}}{(D/H)\text{ standard}} \times 1000 \qquad (2)$$

and the standard is usually mean ocean water (SMOW). Craig (1961) found that on a plot of δD vs $\delta^{18}O$, meteoric waters from throughout the world lie close to a straight line given by the equation,

$$\delta D = 8\delta^{18}O + 10 \qquad (3)$$

This straight-line relationship comes about because ocean water is the source of most of the water vapor that precipitates over landmasses.* When ocean water evaporates, the lighter isotopes of oxygen and hydrogen are preferentially partitioned into the vapor phase. Because the reservoir of ocean water is very large compared to the amount of water vapor in the atmosphere at any given moment, and because most rain water eventually returns to the ocean, the isotopic composition of the ocean remains relatively constant. Over long periods of time, however, there are small but significant changes in the isotopic composition of ocean water as the amount of water tied up in polar ice caps changes. When and where the water vapor condenses and precipitates, the heavier isotopes in the vapor partition preferentially into liquid droplets (rain) and ice (snow). This leaves the remaining vapor relatively depleted in D and ^{18}O so that the last rain that falls from a given initial quantity of vapor will be isotopically lighter than the first rain that falls from that vapor. The partitioning or fractionation of light and heavy isotopes between vapor and liquid is also temperature dependent: the lower the temperature of the reaction, the greater the fractionation. The processes that control the concentrations of stable isotopes in precipitation are presented by Dansgaard (1953, 1964), Ehhalt and others (1963), Friedman and others (1964), Craig and Gordon (1965), and Stewart and Friedman (1975). The net result of these processes is that rain water falling from a given storm becomes isotopically lighter as the storm moves inland, and rain (or snow) that forms at colder temperatures (high elevations and latitudes closer to the poles) is lighter than rain that forms at higher temperatures. Although the isotopic composition of rain that falls in a given region will be different for each storm, the average over a

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* This assumption could easily founder, however, on the problems of "lake effects" given major stands of water in the San Joaquin Valley, either fresh or saline, and major stands of water in the basins east of the Sierra during the past 14 identified pluvial events (Whelan footnote).

long period of time remains relatively constant. The isotopic composition of ground water reflects that average.

Smith and others (1979) measured the deuterium concentrations in rain and snow at 26 stations in California and Nevada during the exceptionally wet 1968-69 season.* They showed that the winter precipitation upon the Sierra Nevada was isotopically slightly lighter than the summer and fall precipitation on the nearby Mojave Desert. Most of the Sierra ground water recharge comes from winter storms moving generally from west to east.** These winter storms drop most of their moisture before reaching the Coso Range. In contrast, most of the Coso Range recharge is from large, but infrequent tropical storms that come from the south. On the basis of these data, we expected the isotopic composition of the normal, non-thermal ground water in the vicinity of the Coso geothermal field to be different from the isotopic composition of nearby Sierran waters. The purpose of the present study was to determine if variations in isotopic composition of ground waters in the region around Coso indicate whether the recharge for the Coso geothermal system comes from precipitation on the Sierra Nevada or from local precipitation at Coso.

More detailed explanations are given by Faure (1986, Chapter 2), O'Neil; Cole and Ohmoto; Gregory and Criss; and Sheppard (all 1986).

Fournier and Thompson (1980) sampled waters of the Sierra, Rose Valley, and thermal and nonthermal waters of the Coso Range in addition to some miscellaneous waters. At that time there were only two sites at which Coso reservoir waters could be sampled: well Coso No. 1 in the resort area (samples CF-79-1 and CF-79-2) and Coso Geothermal Exploration Hole No. 1 (CGEH No. 1) (samples CC-77-4 and CF-78-1).

Both the waters of the Sierra and the nonthermal waters of the Coso Range have isotope ratios, which on a plot of isotope ratios, plot close to the meteoric line (Figure 1). The waters from each locality occupy distinct fields on the plot with no overlap. The Coso waters have less negative δD values and generally less negative $\delta^{18}O$ values than do the Sierran waters.

Oxygen is much more abundant than is hydrogen in rock-forming minerals. Therefore, when meteoric waters react with hot rocks, oxygen exchange dominates; and on a standard isotope ratio plot the shift is away from the meteoric line, essentially horizontally, with $\delta^{18}O$ values becoming less negative. The magnitude of this horizontal shift increases with temperature, but depends also on the $\delta^{18}O$ value of the rocks and residence time of water in a given reservoir (Faure 1986, pp. 450-51). The CGEH No. 1 waters are horizontally displaced toward less negative $\delta^{18}O$ values from the area containing the Sierran waters. The deep Coso No. 1 water lies horizontally away from the Coso nonthermal waters, which could indicate all or some local recharge. However, all four points (the two CGEH No. 1 samples and the Coso No. 1 deep and shallow waters) lie on a line with a positive slope of about 50 degrees. This could be an evaporative effect line (see Figure 1). Fournier and Thompson (1980) feel that the shallow Coso No. 1 sample

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* This was a westerly storm series (Whelan footnote).

** This assumption requires much more analysis, as the position of the Pacific High determines the temperature of storms and their direction. Thus, some winters, especially very wet ones, present a totally different weather pattern that would affect isotope ratios (Whelan footnote).

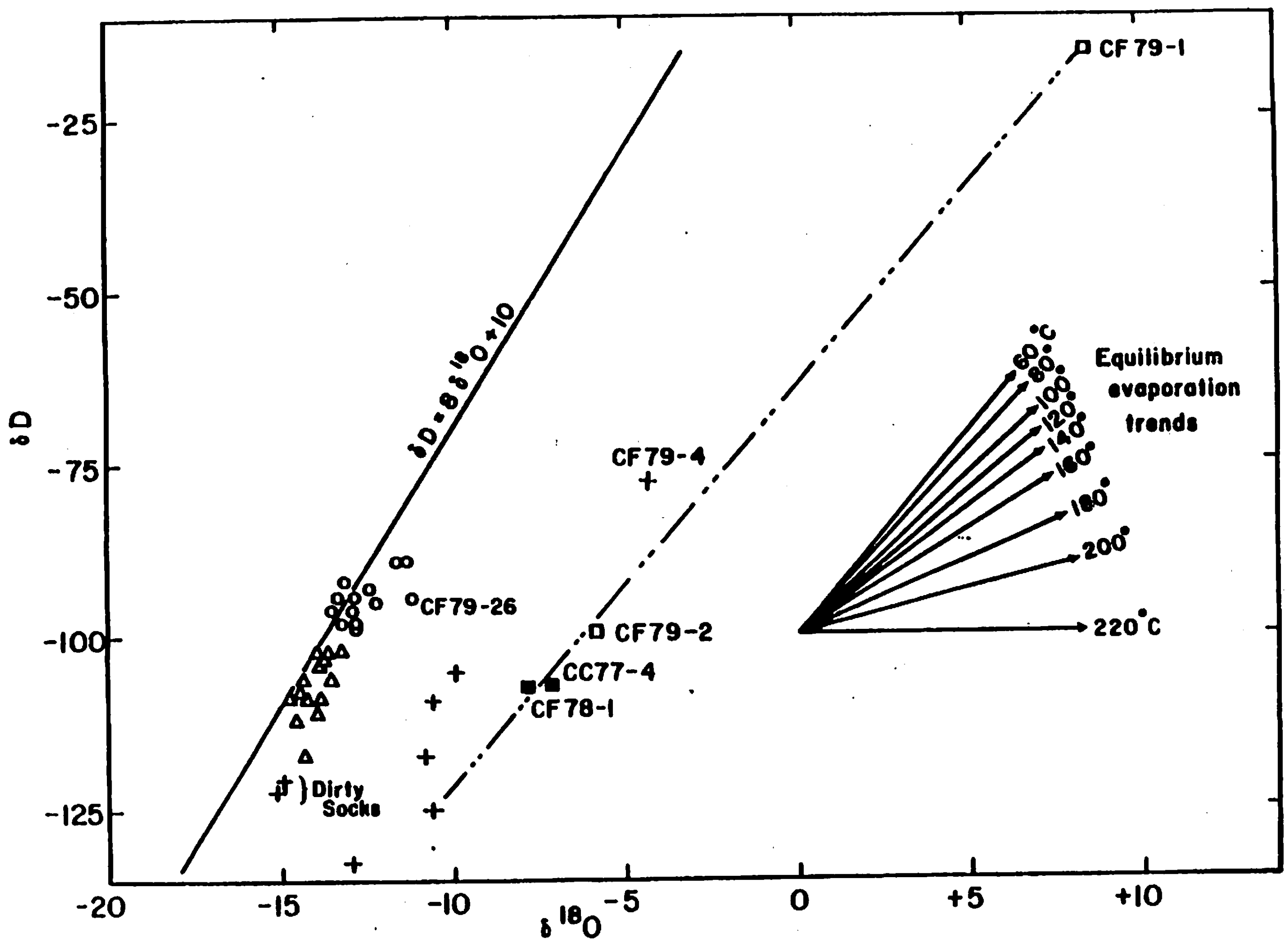
represents the deep Coso No. 1 water affected by evaporation. The chemistry of Coso No. 1 deep and the CGEH No. 1 samples strongly suggest that they are the same water. Thus, Fournier and Thompson concluded:

> The δD value of CGEH No. 1 water supports the view that recharge for the hydrothermal system comes from the Sierra Nevada to the west and that little or no component of the recharge comes from the Coso Range. However, the data do not rule out the possibility that recharge is a mixture of isotopically light Sierra water from the north with some isotopically heavy locally derived Coso Range water. The isotopic data do show that recharge for the CGEH No. 1 thermal water could not be from locally derived ground water, nor could it be from Owens Lake which is isotopically very heavy because of extensive evaporation (Friedman and others, 1976).

In 1986 Rob Baskin and David Turner, both University of Utah graduate students, sampled springs, wells, and surface waters for chemical and isotope analyses, respectively. Unfortunately, while collecting samples independently, their sampling numbering system became confused. Table 1 shows how their numbering systems correlate. The sample numbers of Baskin are used on the chemical analyses published in Volume 2 of this technical report (Appendix E). The University of Utah study was supported by the EKCRCD. The chemical studies were incorporated into Volume 1 of this technical report. The results of the isotope study were furnished to the EKCRCD in an unpublished report by Dr. John R. Bowman, Professor of Geology, University of Utah. Table 1 gives the results of his analyses.

Baskin and Turner sampled alpine waters from the crest and eastern flank of the Sierra from Kennedy Meadows south to Walker Well in Freeman Canyon. The overlap of the sampling sites of Baskin and Turner and Fournier and Thompson allowed a comparison of the results of the two laboratories. On samples run by both laboratories, the results were nearly identical. For isotopic studies, some Navy wells were sampled for which chemical analyses of the water were not previously published in this series. These analyses are given in Appendix H.

The University of Utah isotopic analyses of alpine waters also fell along the meteoric line on the standard isotope ratio plot but expanded the Sierran field considerably (Figure 2). The Sierran field using Bowman's data now covers most of the Sierran field of Fournier and Thompson (1980), and the field containing the nonthermal waters of the Coso Range (Figure 2). Thus, the isotopes of hydrogen and oxygen do not uniquely define the recharge area of the Coso geothermal system (Figure 3).



Circles represent non-thermal waters from the Coso Range, triangles represent non-thermal waters from the Sierra Nevada Mountains and Rose Valley. Solid squares represent waters from the CGEH No. 1 well; open squares represent waters from the Coso No. 1 well, crosses represent other thermal waters and steam condensates. (Modified from Fournier and Thompson, 1980.)

FIGURE 1. δD - δ^{18}O Relations for Thermal and Non-Thermal Waters From the Coso Region.

Whelan plotted δD and $\delta^{18}O$ of the alpine samples against the distance south of Coso Junction (Figures 4 and 5). Values of δD generally become less negative as one goes south from Coso Junction. Values of $\delta^{18}O$ behave in a similar manner. This systematic variation is probably the result of a combination of a latitude effect and an altitude effect. The average elevation of the Sierra increases to the north from Walker Pass. This increase in elevation will decrease the mean air temperature, which tends to make the $\delta^{18}O$ of the precipitation (mainly snowfall) more negative. A good discussion of the latitude and temperature effects is given on pages 434 and 435 of Faure (1986). In both cases it was possible to fit a linear least squares (best fitting) line to the data with good fits. The formulas for these lines are

$$\delta D = -107.8 + 0.81m$$

$$r^2 = 0.72$$

$$\delta^{18}O = -14.32 + 0.10m,$$
$$r^2 = 0.66,$$

where

m = miles south of Coso Junction and

r^2 = regression coefficient (0.00 = no correlation; 1.00 = perfect correlation)

The fact that there is some scatter is not surprising. Samples were collected from various types of sources—springs, wells, and streams—and at different elevations relative to the ridge line. Because of this fact, regression coefficients of 0.66 and 0.72 are considered quite good. These regression coefficients would give correlation coefficients of +0.81 and +0.85, respectively (a -1.00 correlation coefficient represents perfect correlation with the line having a negative slope; a +1.00, perfect correlation with a positive slope; and 0.00, no correlation). If one makes the assumption that the recharge areas for the various groundwater types are the Sierra—based on surface geology, regional hydrologic gradient, and flow models—then possible areas in the Sierra can be assigned as recharge areas for the various water types based on isotopic composition.

TABLE 1. Hydrogen and Oxygen Isotopic Compositions of Waters,
Indian Wells Valley and Vicinity.
(Modified from Bowman, 1988)

Sample No.		δD	$\delta^{18}O$	Location
(Turner)	(Baskin)			
1.	IWV 1	-109	-14.4	Kennedy Meadows well
1b.		-103	-14.0	Kennedy Meadows surface
2.	IWV 18	-101	-13.4	Chimney Peak Forest Service Fire Station well
3.	IWV 2	-105	-13.6	Genesis Minerals well from holding tank
4.	IWV 3	-93	-12.8	C. F. Austin well
5b.	IWV 4	-90	-11.0	Hi-Peak Tungsten Mine water
6.	IWV 5	-94	-13.1	Beckman Spring
7.	IWV 6	-104	-13.4	Leroy Marquardt well
8.	IWV 7	-91	-11.8	John German well
9.	IWV 8	-99	-12.9	Desert Construction well
10.		-89	-12.3	Ben Widtfeldt well
11.	IWV 9	-93	-11.2	Louisiana Pacific Lumber Mill well
12.	IWV 10	-83	-10.8	Sand Canyon stream
13.	IWV 11	-89	-12.5	Walker well, South Valley
14.	IWV 14	-96	-13.1	Gene Edwards well
15.	IWV 12	-97	-12.4	Little Lake Spring, upper
16.		-113	-15.6	L. A. aqueduct
17.		-94	-10.8	Little Lake surface, middle
18.		-95	-11.1	Little Lake surface, lower
19.	IWV 13	-105	-14.2	Little Lake Ranch well
20.	IWV 15	-92	-12.0	Brown Rd. turn well
21.	IWV 16	-92	-12.2	Conrad Neal well
22.		-102	-14.0	Cerro Coso Comm. College holding tank
23.		-104	-13.8	Community well, S. Ridgecrest
24.		-95	-13.5	Griffin well, S. Ridgecrest
25.		-102	-13.8	Charles Smith well, S. Ridgecrest
26.	IWV 17	-84	-12.0	Indian Wells Canyon stream
27.	IWV 21	-89	-12.2	Nine Mile Canyon stream at Chimney Peak Meadows
28.		-94	-13.2	Nine Mile Canyon stream
29.		-88	-12.4	Pearsonville well
30.		-98	-11.5	Brady's Restaurant well
31.		-96	-13.4	Navy well #18B
32.		-97	-13.4	Navy well #29
33.		-92	-12.7	Navy well #15
34.		-99	-13.6	Navy well #27
35.		-95	-12.5	Navy well #B4
36.		-89	-12.5	Navy well #C
37.		-105	-14.5	Well at Ridgecrest Blvd. and Jack's Ranch Rd.
38.		-88	-11.4	Well in Searles Valley

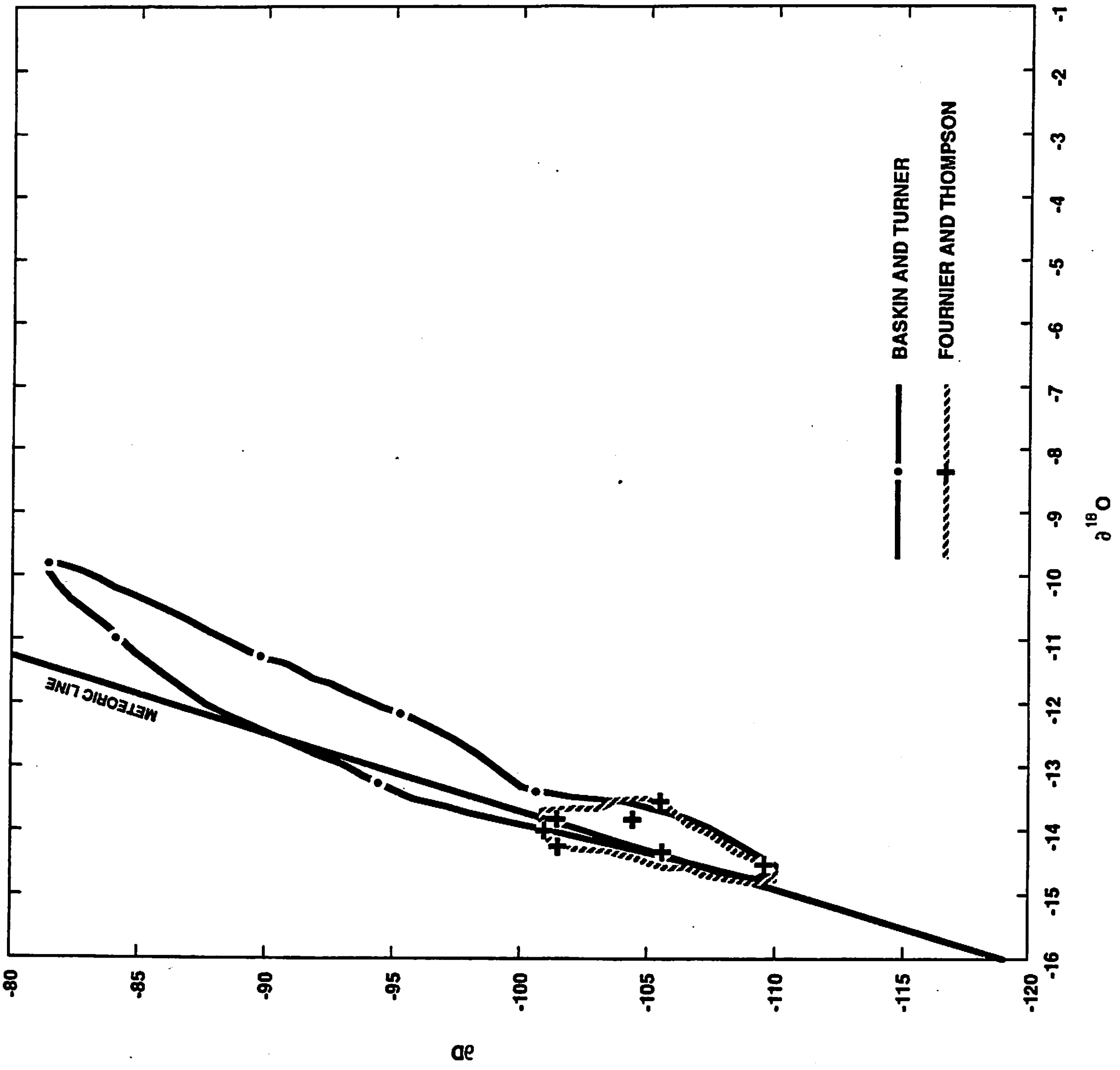


FIGURE 2. δD Versus $\delta^{18}O$ Ratios, Sierran Waters.

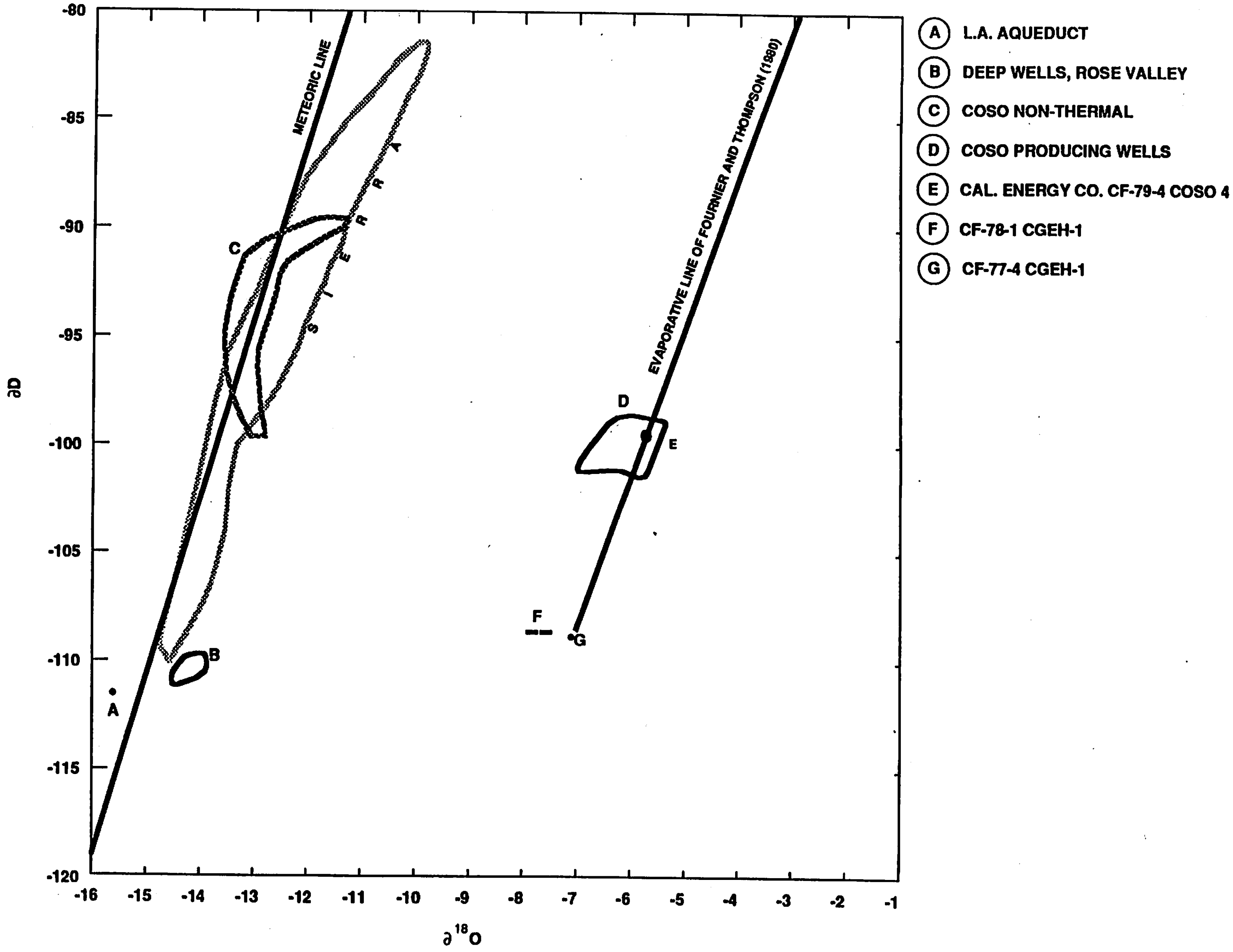


FIGURE 3. δD Vs $\delta^{18}O$ For Various Water Types.

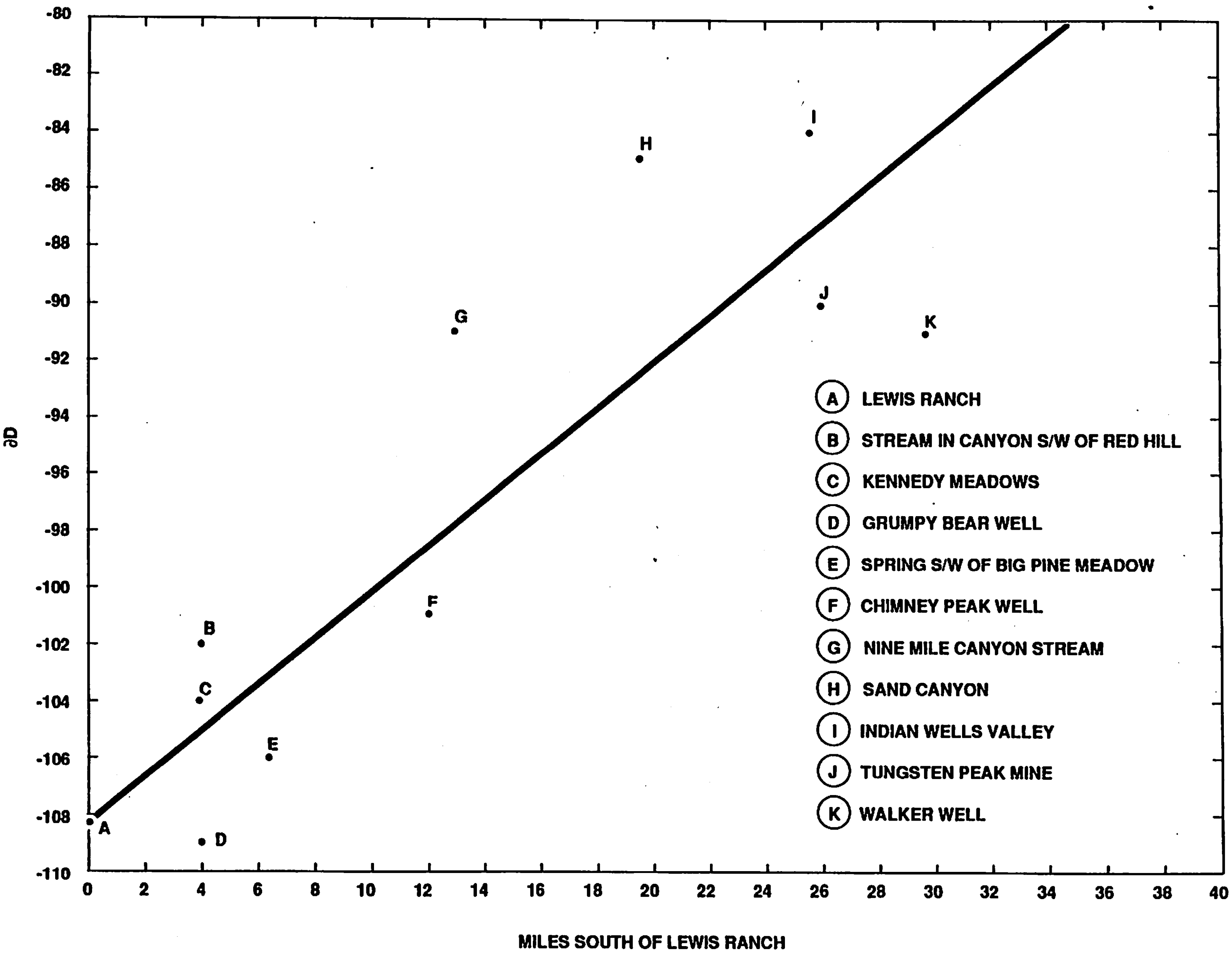


FIGURE 4. δD Relationship to Distance South of Lewis Ranch (Alpine Waters).

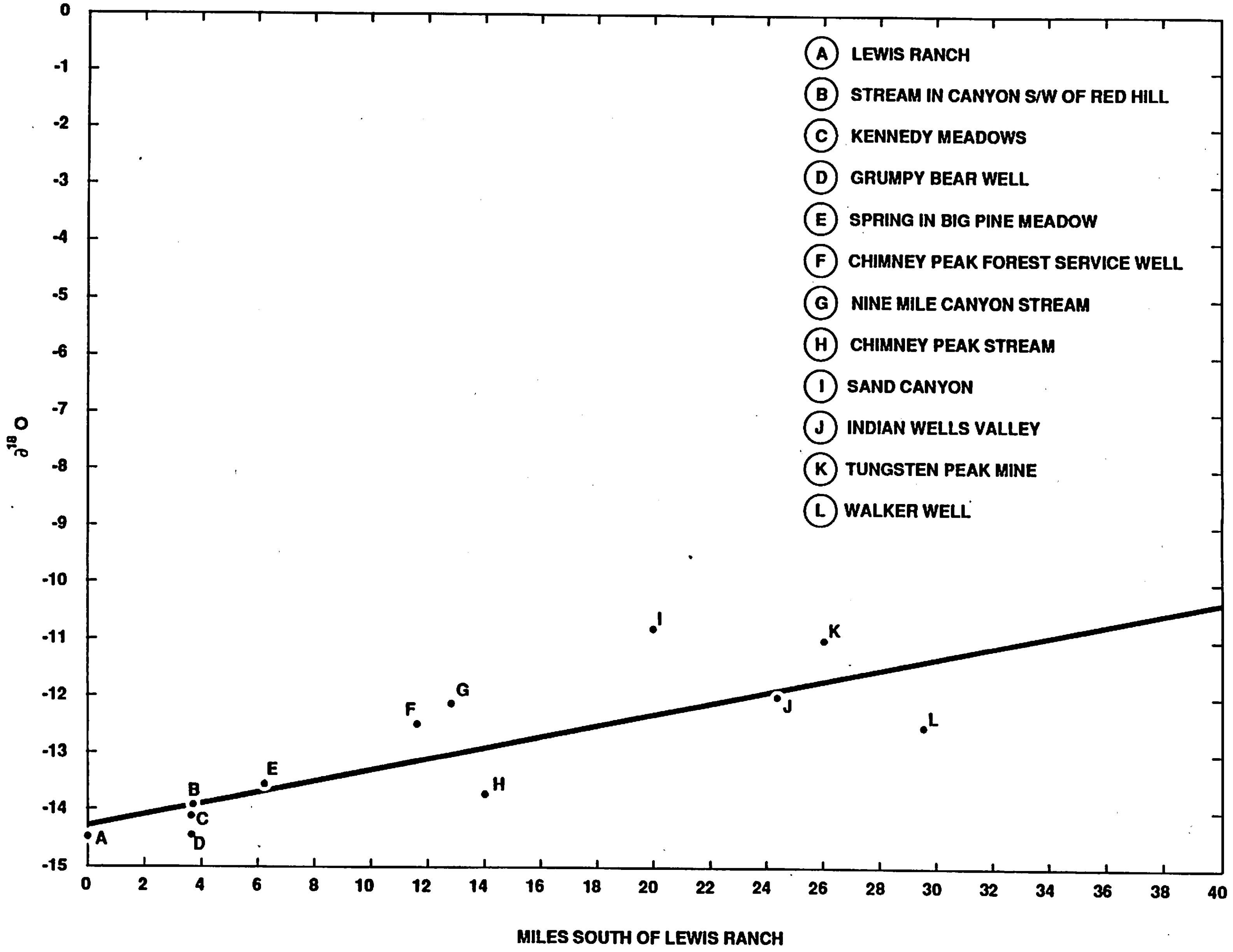


FIGURE 5. $\delta^{18}O$ Relationship to Distance South of Lewis Ranch (Alpine Waters).

The recharge area for the Rose Valley groundwaters is shown in Figure 6.* The Rose Valley recharge area would be the western side of the Sierra from about a mile south of Little Lake to about 5 miles north of Coso Junction. This corresponds almost exactly to the geographic limits of the valley and matches the listric fault-slump pattern geometry of the Sierran surface.

From Red Hill in southern Rose Valley, through the springs and wells at Little Lake to the well at Linnie Siding (the site where the lumber mill used to be) to where Brown Road turns from north-south to east-west, the groundwaters are complex but give characteristic modified Stiff Diagrams. Sodium is the dominant cation where carbonate-bicarbonate and chloride are the most significant anions (see pages 32 and 33 of Volume 1). These waters represent a mixture of alpine waters and a small amount of Coso Geothermal brines. The Red Hill to Brown Road recharge would come from the Sierra due west of Red Hill south to the Sierra due west of where Brown Road intersects U.S. Highway 395 (Figure 7).

The results for the sulfate waters from two wells and the Tungsten Peak Mine are not as definitive (Figure 8). Deuterium data give a rather limited recharge area between Short Canyon and halfway between Noname and Sand Canyons, while oxygen isotopes would indicate the recharge area to be from Nine Mile Canyon to south of Freeman Canyon. The source of the sulfate is thought to be oxidation of sulfides from the high sulfide calc-silicate hornfels in the Morris Peak-Chimney Peak area, the large pyritic breccia-pipe in upper Sand Canyon, and the skarn of the Tungsten Peak Mine. In this case, the deuterium results are thought to best represent the probable recharge area. The oxygen isotope ratios may be more affected during the oxidation of sulfides than are the hydrogen isotope ratios, although the latter may be affected some by the formation of hydroxyl during the oxidizing processes. Chemical data on the waters of the Tungsten Peak Mine and IWV well 3 are given on pages 30, 31, 36, and 37 of Volume 1 of this technical report; and on pages 10 through 13 of Volume 2. The other well producing sulfate waters is about 3-1/2 miles east-northeast of IWV well 3.

Figure 9 shows possible Sierran recharge areas for the Navy Wells that were sampled for isotope analysis and the well locations. Other data are given in Table 2.

Again the areas of recharge as determined by the isotope ratios of the two elements vary, but do have a large area of overlap. The deuterium data, which give a recharge area from Five Mile Canyon to Indian Wells Canyon, seems reasonable. The oxygen isotope ratios, which give a recharge area from Five Mile Canyon to just south of Little Lake, may show the influence of Red Hill-Brown Road waters mixing with Sierran waters.

The south Ridgecrest waters do not have isotope compositions that give reasonable Sierran recharge areas, perhaps because of recharge from the El Paso Mountains confusing the issue, or because of geothermal and connate fluids flowing from the Sierra (a source south of Walker Pass or upward-dwelling local thermal zones).

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* Although Figures 6 through 10 show only the eastern edge of the Sierra, recharge could occur completely across the Sierra, and probably much of the recharge comes from west of the crest where the amount of precipitation is greater.

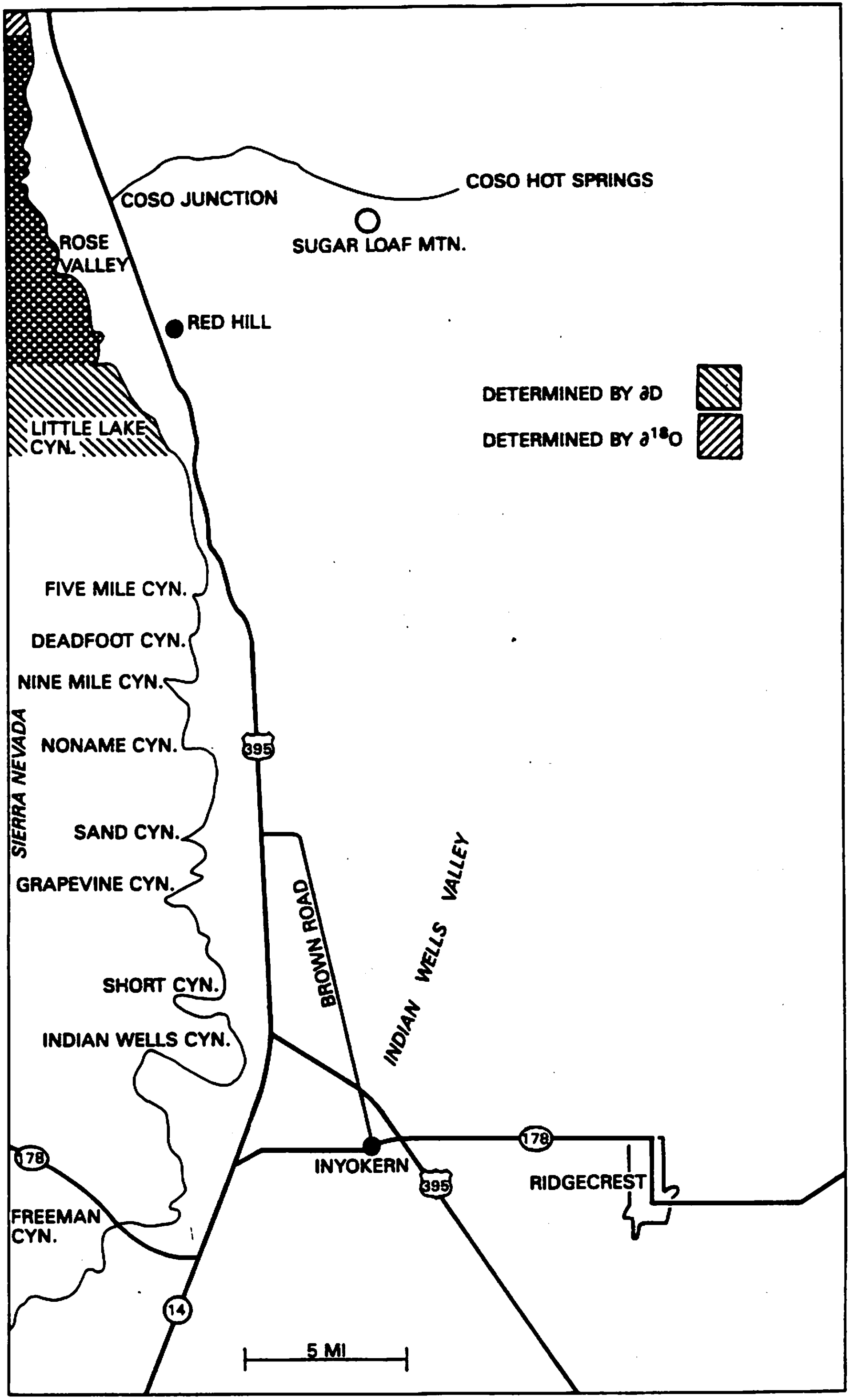

FIGURE 6. Recharge Areas, Rose Valley Groundwaters.

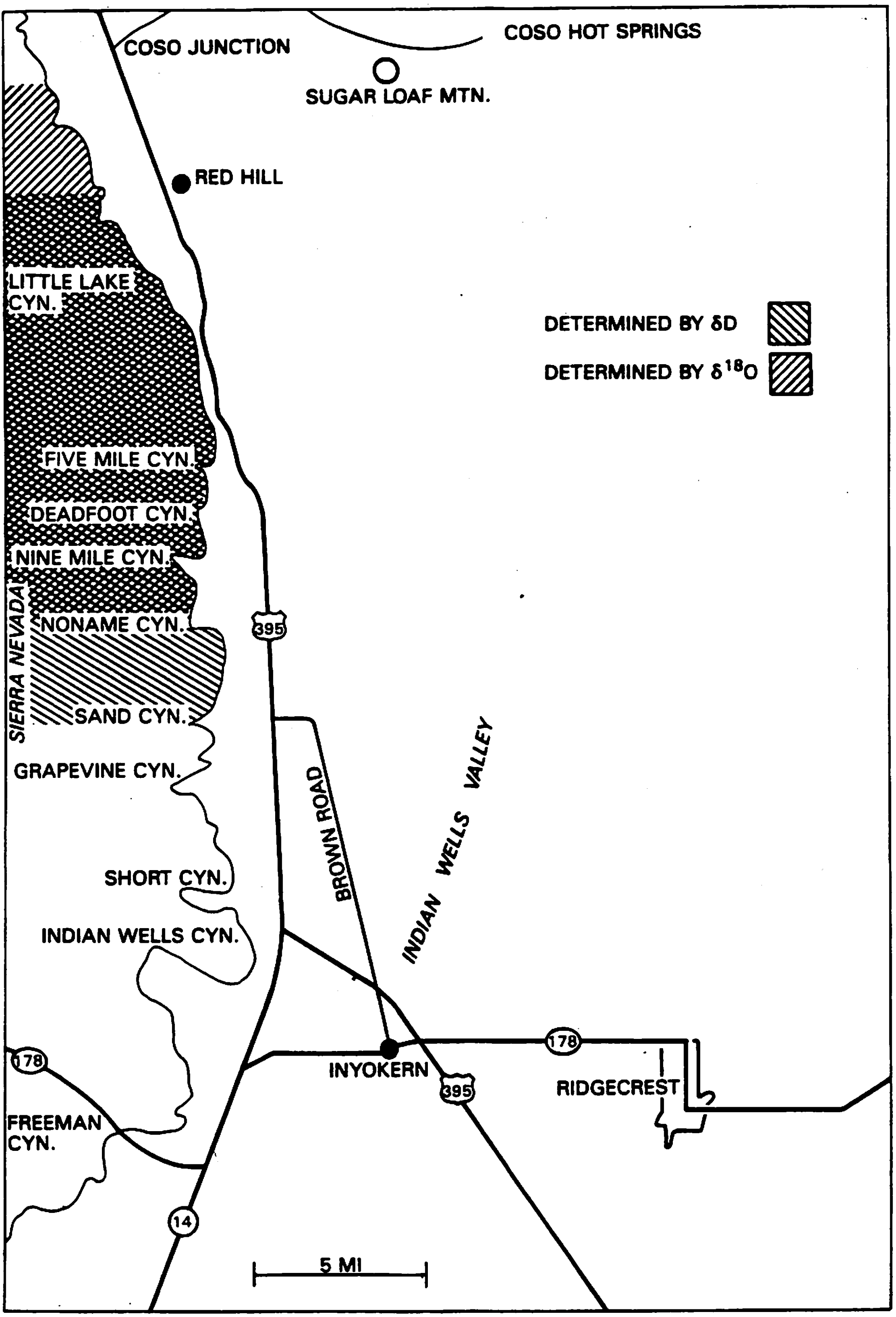

FIGURE 7. Recharge Area, Red Hill to Brown Road Groundwaters.

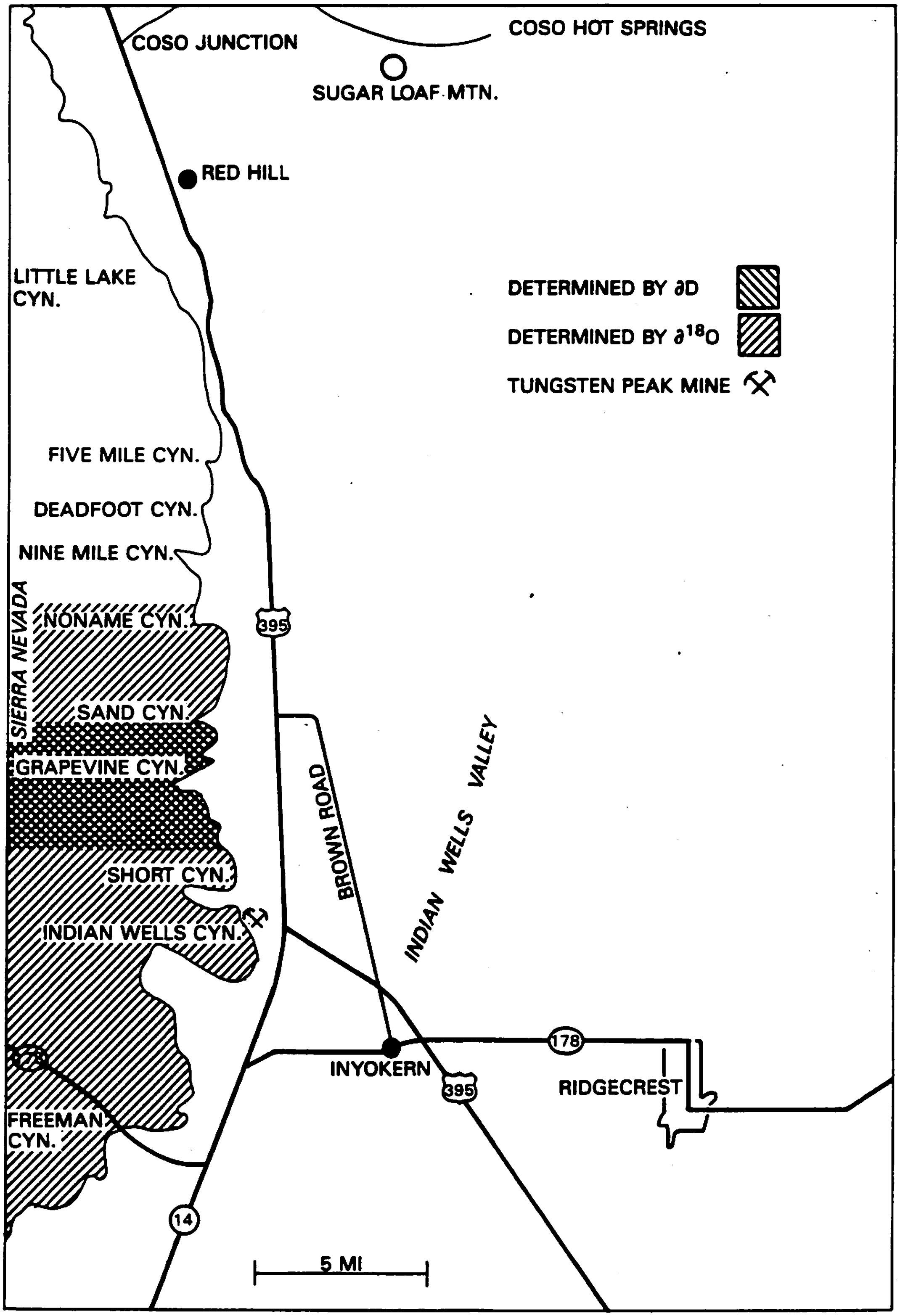

FIGURE 8. Recharge Areas, Sulfate-Bearing Groundwaters.

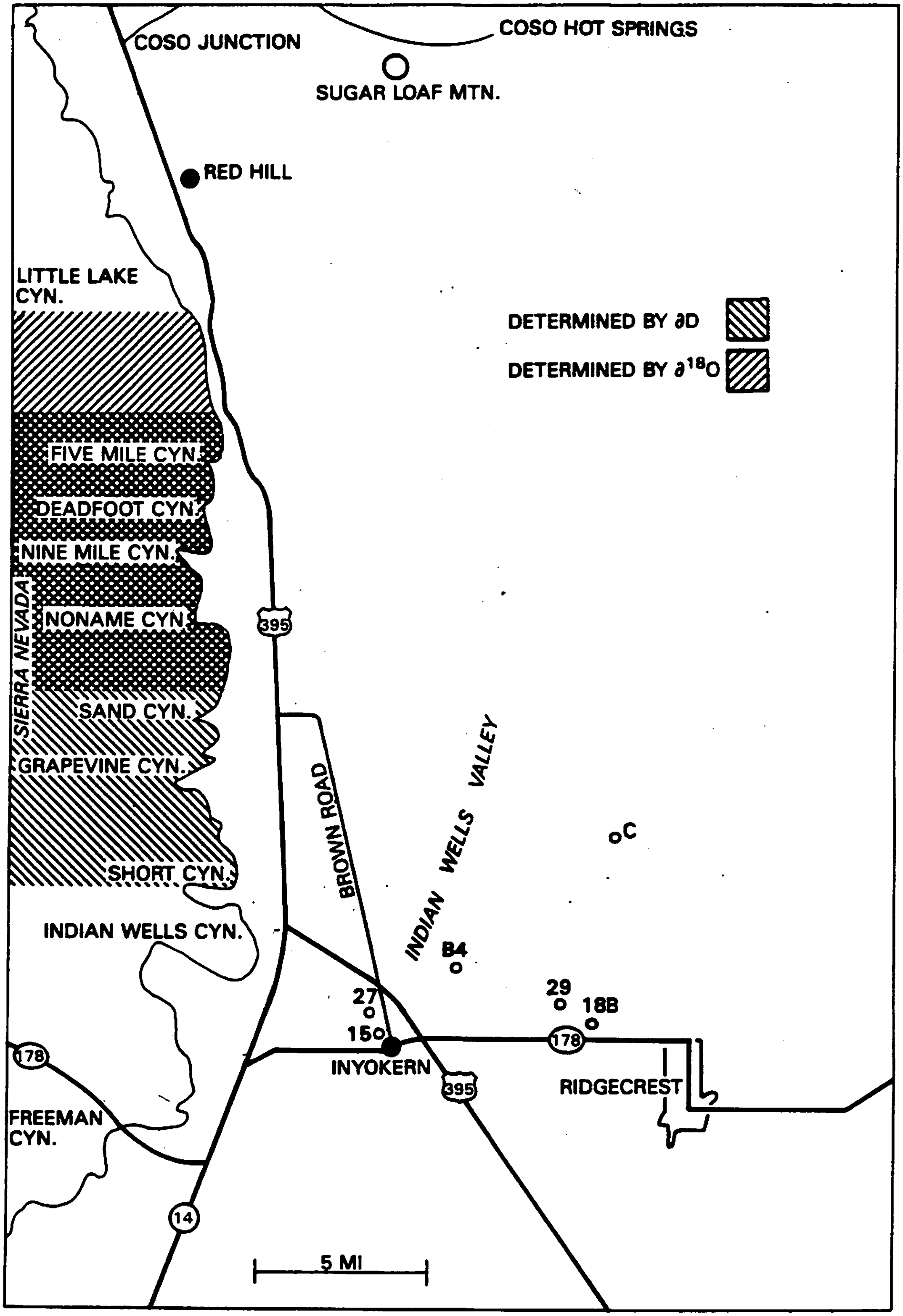

FIGURE 9. Recharge Area, Navy Wells.

TABLE 2. Data on Navy Wells for Which Stable Isotope Analyses of Waters Are Available.

All wells were rotary drilled.

Well No.	Date drilled	Diameter, in.	Depth, ft	Perforation depth, ft
15	1944	16	446	360-390 405-420
18B	1965	16	800	250-350 490-580 640-780
27	1960	16	803	270-540 550-625 700-791
29	---	16	800	220-405 450-620 730-800
B4 (23)	---	16	800	100-200
C (22)	---	10	200	65-145

Only the deuterium data are applicable to the Coso thermal waters, because thermal waters exhibit a large $\delta^{18}O$ shift. The deuterium data indicate a possible Sierran recharge area from just south of Coso Junction to Nine Mile Canyon (Figure 10). The Coso geothermal system is bounded by a set of arcuate fractures (Austin and Durbin, 1985, page 37), the western portion of which extends well into the Sierra. This fracture system could indeed be the plumbing for recharge of the geothermal system from the Sierra. The arcuate fracture system is bounded on the south by the Wilson Canyon fault zone. The deuterium data would indicate that if this is so, the southern portion of the arcuate fracture system would be taking more recharge than would the northern. This would be in agreement with the interpretation of convective flow from southwest to northeast as postulated by Moore and others (1989) based on chemical and fluid inclusion data. C. F. Austin has noted that during the drought of the 1960s the South Fork of the Kern River at the latitude of Little Lake disappeared into the bedrock (C. F. Austin, personal communication, 10 April 1989). Flow resumed to the south. This would appear to represent a major infiltration into the westerly extension of the Wilson Canyon fault zone. The Wilson Canyon fault is named for the two Wilson Canyons in the Argus Range. That fault zone, however, goes northwest across Coso Basin, the lavas at the south end of the Coso Range, and into the Sierra where it is the south boundary of the arcuate shear zone (see Austin and Durbin, 1985, pages 54 and 56), and displaces the Sierra Nevada front by 7800 feet.

Buchanan (1989) feels that the concept of modern recharge of geothermal systems by high elevation precipitation may be in error because of the high percolation rates required—meters to tens of meters per day. He proposes a "paleo-fluid recharge" by waters 8000 to 12,000 years old, but this approach ignores the repetitive nature of pluvial/glacial events and is inconsistent with the pluvials of the Coso region as well as being inconsistent with the high hydrologic gradient of 140 feet per mile (Erskine, 1990). Buchanan used the

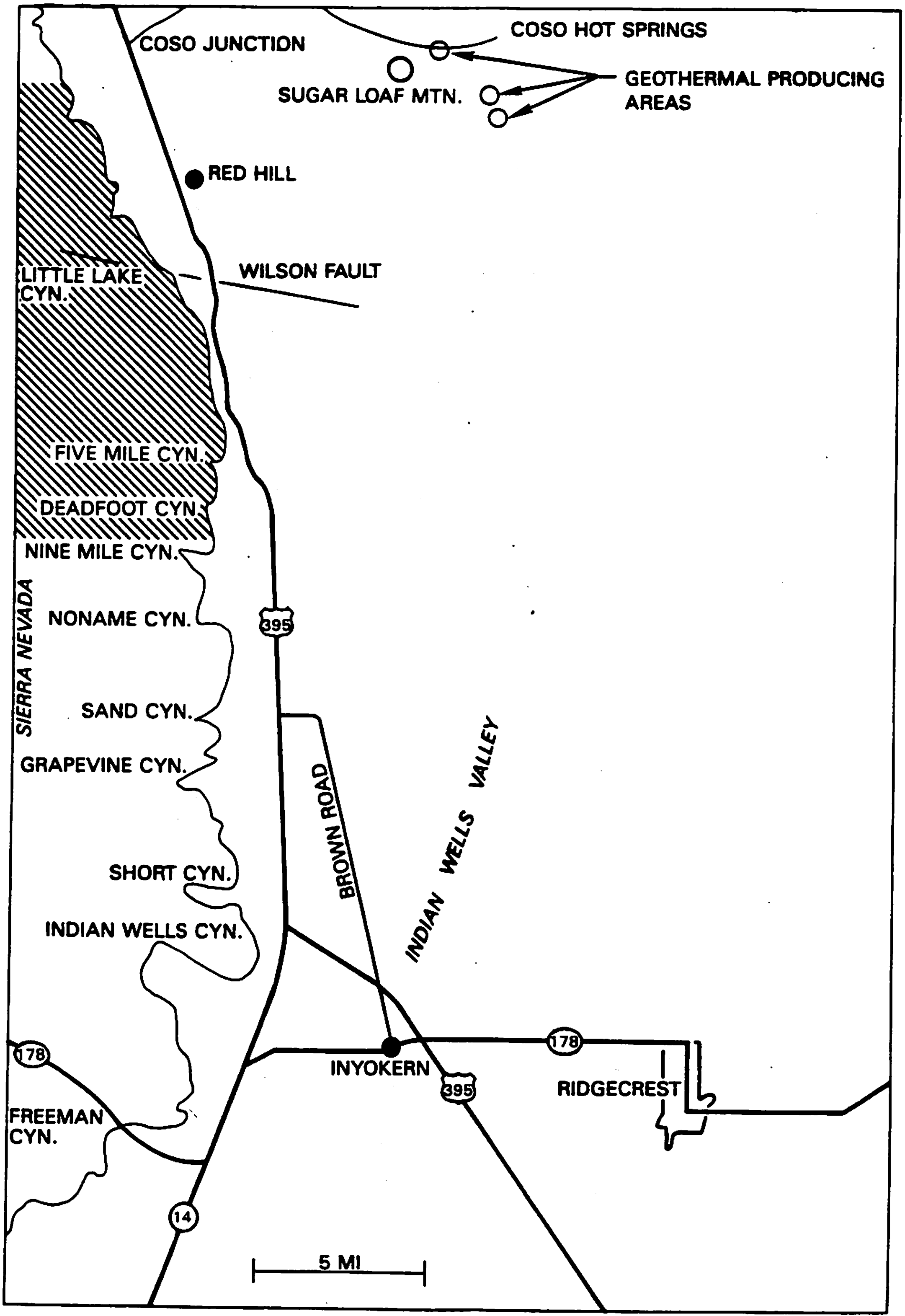

FIGURE 10. Recharge Area for Coso Geothermal Field Based on δD.

paleoclimatic data of Dansgaard and others (1969) who—using isotope data of continuous core from the Greenland ice cap—identified a transition from modern isotopically enriched low-elevation water to paleo-isotopically depleted water between 12,000 and 8000 years before present. However, the climatic shifts possible may not be fully understood or applicable to the Coso, southern Sierra region. Buchanan concludes that nine geothermal systems in Nevada and Utah have paleo-fluid recharge. He attributes the source of the water to be Pleistocene lakes. He assumes that mountain range frontal faults are the plumbing for the water into the geothermal system, based on the models of Gilbert; but the fact that Coso Geothermal Field sits in the midst of a mid-Pliocene orogenic zone and that the positioning of the Sierra may be a very young event (Eardley, 1951), may sharply alter this concept. In the past 10,000 years there have been at least four glacial periods (see Table 1, page 10, Volume 1). The present China Lake playa system has had many predecessors. Lithographic logs of a Navy well drilled near the Inyokern substation indicate at least three shorelines at various depths (see page 10 Volume 1). The Coso geothermal brines should have a complex of pluvial components. Austin and Durbin (1985) in *Coso: Example of a Complex Geothermal Reservoir* in a section entitled Effects of Pluvial Periods, state "As a result of the various pluvial periods of the past, massive flooding of the upper portions of the Coso geothermal system and the attendant periodic flushing out of the shallow chemical components should be the norm." They present convincing evidence that the site of recharge during the pluvial periods would be Rose Valley.

It should be noted, however, that even during pluvial periods, more precipitation will occur at higher elevations. Thus, even if recharge is from valley lakes, most of the water will originate from high-elevation precipitation.

SUMMARY AND CONCLUSIONS

Stable isotopes of hydrogen and oxygen do not at this time appear to uniquely identify the recharge area of the Coso Geothermal Field. Recharge could be from the Sierra or could be locally derived from the high desert ranges; and, in all probability, is a combination of the two. It should be remembered that the high plateaus and valleys of the Coso and Argus Ranges result in a large recharge system of considerable significance even today. There also could be both migrating and static bodies of waters from pluvial periods, which may move quite erratically. The writer feels that the evidence in hand shows the largest component of the recharge waters to be derived from the Sierra southwest of the Coso Geothermal Field for the following reasons: (1) Recharge from the Sierra is concordant with stable hydrogen and oxygen data. (2) Appropriate structures are present to provide the plumbing (the Wilson Canyon fault zone). (3) More precipitation will occur at higher elevations, and the Coso Geothermal Field appears to be a large-volume system.

If one assumes from structural and chemical data that recharge to Rose and Indian Wells Valleys is from the Sierra, one can then use stable isotope data to predict the recharge areas in the Sierra for the various water types.

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Appendix H

WATER ANALYSES OF NAVY WELLS
(Locations shown on Figure 9)

This appendix consists of reports of the chemical analysis of water taken from selected wells located at NWC. The water samples were taken and the analyses made intermittently between 31 July 1978 and 6 May 1987. The reports are reproduced here as is to avoid recomposition and proofreading effort and expense.

FROM Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command San Diego California 92132

DATE 12 Sep 78

TO NAVWPNSCEN CHINA LAKE

The following is a report of a complete mineral analysis of water Well Water

SOURCE OF SAMPLE Well #15

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
31 Jul 78	31 Jul 78	W. Kester/P. Ma

	ppm	epm		ppm	epm
CALCIUM (Ca)	35.2	1.76	CARBONATE (CO_3)		
MAGNESIUM (Mg)	6.8	0.56	BICARBONATE (HCO_3)	92	1.52
SODIUM (Na)	61	2.65	HYDROXIDE (OH)		
POTASSIUM (K)	2.2	0.06	SULPHATE (SO_4)	86	1.79
			CHLORIDE (Cl)	46	1.29
			NITRATE XXX N	1.2	0.09
SUM OF EQUIVALENTS		5.03	SUM OF EQUIVALENTS		4.69

	ppm			RESULTS
TOTAL HARDNESS *(as CaCo3)*	116	SILICA *(as SiO_2)*		28
CALCIUM HARDNESS *(as CaCo3)*	88	FLUORIDE *(F)*		0.8
MAGNESIUM HARDNESS *(as $CaCO_3$)*	28	BORON *(B)*		0.2
PHENOLPHTHALEIN ALKALINITY *(as $CaCO_3$)*	0	IRON *(Fe)*	Total	0.043
METHYL ORANGE ALKALINITY *(as $CaCO_3$)*	76	MANGANESE *(Mn)*	Total	< 0.002
TOTAL DISSOLVED SOLIDS	364	COPPER *(Cu)*	Total	< 0.001
SPECIFIC CONDUCTIVITY *(Micromhos @ 25°C)*	520	SYNTHETIC DETERGENTS *(APPARENT ABS)*		0.016
HYDROGEN-ION CONCENTRATION *(pH)*	7.36	PHOSPHATE *(PO_4)*	Total	<0.02

REMARKS

80727-16 (5)

COMPLETE MINERAL ANALYSIS OF W[illegible]
12ND WESTDIV 11330 16 (2 76)

FROM
Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE
13 JULY 1979

TO
Public Works Office, Naval Weapons Station, China Lake

The following is a report of a complete mineral analysis of water: Well Water

SOURCE OF SAMPLE
Well 15

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
4 May 1979	May, June 79	Staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	32	1.60	CARBONATE (CO_3)		
MAGNESIUM (Mg)	9.8	0.80	BICARBONATE (HCO_3)	98	1.60
SODIUM (Na)	60	2.61	HYDROXIDE (OH)		
POTASSIUM (K)	2.7	0.07	SULPHATE (SO_4)	110	2.29
			CHLORIDE (Cl)	55	1.55
			NITRATE ~~(NO_3)~~ N	<1	-
SUM OF EQUIVALENTS		5.08	SUM OF EQUIVALENTS		5.44

	ppm		RESULTS
TOTAL HARDNESS (as $CaCO_3$)	120	SILICA (as SiO_2)	36
CALCIUM HARDNESS (as $CaCO_3$)	80	FLUORIDE (F)	0.80
MAGNESIUM HARDNESS (as $CaCO_3$)	40	BORON (B)	0.25
PHENOLPHTHALEIN ALKALINITY (as $CaCO_3$)	0	IRON (Fe) TOTAL	0.274
METHYL ORANGE ALKALINITY (as $CaCO_3$)	80	MANGANESE (Mn) TOTAL	0.004
TOTAL DISSOLVED SOLIDS	364	COPPER (Cu) TOTAL	0.022
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	520	SYNTHETIC DETERGENTS (APPARENT ABS)	* -
HYDROGEN-ION CONCENTRATION (pH)	7.82	PHOSPHATE (PO_4) TOTAL	0.05

REMARKS

* Insufficient sample to run the test

#90505-12
3

COMPLETE MINERAL ANALYSIS OF W R
12ND WESTDIV 11330/18 (2-78)

FROM Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE 24 APRIL 1980

TO Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water: Well

SOURCE OF SAMPLE Well #15

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
29 MAR 80	29 MAR 80	staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	54	2.68	CARBONATE (CO_3)		
MAGNESIUM (Mg)	4	0.34	BICARBONATE (HCO_3)	78	1.28
SODIUM (Na)	73	3.17	HYDROXIDE (OH)		
POTASSIUM (K)	2.9	0.07	SULPHATE (SO_4)	84	1.75
			CHLORIDE (Cl)	116	3.27
			NITRATE (NO_3) N	1.2	0.09
SUM OF EQUIVALENTS		6.12	SUM OF EQUIVALENTS		6.37

	ppm		RESULTS
TOTAL HARDNESS *(as $CaCO_3$)*	151	SILICA *(as SiO_2)* TOTAL	29
CALCIUM HARDNESS *(as $CaCO_3$)*	134	FLUORIDE *(F)*	0.84
MAGNESIUM HARDNESS *(as $CaCO_3$)*	17	BORON *(B)*	0.36
PHENOLPHTHALEIN ALKALINITY *(as $CaCO_3$)*	0	IRON *(Fe)* TOTAL	0.09
METHYL ORANGE ALKALINITY *(as $CaCO_3$)*	64	MANGANESE *(Mn)* TOTAL	0.004
TOTAL DISSOLVED SOLIDS	504	COPPER *(Cu)* TOTAL	0.06
SPECIFIC CONDUCTIVITY *(Micromhos @ 25° C)*	720	SYNTHETIC DETERGENTS *(APPARENT ABS)*	0.06
HYDROGEN-ION CONCENTRATION *(pH)*	7.91	PHOSPHATE *(PO_4)* TOTAL	0.02

REMARKS

#00318-16
5

Environmental Chemistry Laboratory, Southwest Environmental Section (Code 1141), Western Division, Naval Facilities Engineering Command, 1220 Pacific Highway, San Diego California 92132

DATE SEP 2 1982

TO NWC China Lake

The following is a report of a complete mineral analysis of water Well Water

SOURCE OF SAMPLE Well 15

DATE SAMPLE COLLECTED 7/19/82

DATE SAMPLE ANALYZED 7/19 - 8/31/82

ANALYST Staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	53.6	2.68	CARBONATE (CO$_3$)		
MAGNESIUM (Mg)	6.3	.52	BICARBONATE (HCO$_3$)	78.1	1.28
SODIUM (Na)	81	3.52	HYDROXIDE (OH)		
POTASSIUM (K)	2.86	0.07	SULPHATE (SO$_4$)	86	1.79
			CHLORIDE (Cl)	120	3.38
			NITRATE (NO$_3$) -N	1.3	0.09
SUM OF EQUIVALENTS		6.79	SUM OF EQUIVALENTS		6.54

	ppm			RESULTS
TOTAL HARDNESS (as CaCO$_3$)	160	SILICA (as SiO$_2$)		30
CALCIUM HARDNESS (as CaCO$_3$)	134	FLUORIDE (F)		0.89
MAGNESIUM HARDNESS (as CaCO$_3$)	26	BORON (B)		0.32
PHENOLPHTHALEIN ALKALINITY (as CaCO$_3$)	0	IRON (Fe)	total	<0.03
METHYL ORANGE ALKALINITY (as CaCO$_3$)	64	MANGANESE (Mn)	total	<0.01
TOTAL DISSOLVED SOLIDS Gravimetric	441	COPPER (Cu)	total	<0.01
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	780	SYNTHETIC DETERGENTS (APPARENT ABS)		0.059
HYDROGEN-ION CONCENTRATION (pH)	7.74	PHOSPHATE (PO$_4$)	total	<0.05
Temperature °F	82-84	Langlier Index		-0.15
pHs	7.89	Ryzner Index		8.04

REMARKS

20716-14
2

AGRICULTURE
CHEMICAL ANALYSIS
PETROLEUM
BC LABORATORIES INC
J. J. EGLIN, REG CHEM ENGR
MAIN OFFICE: 4100 PIERCE ROAD, BAKERSFIELD, CA 93308 PHONE 327-4911

Submitted by: Naval Weapons Center
China Lake, California 93555

Date Reported: 12/27/85
Date Received: 11/20/85
Laboratory No.: 20403

Sample Description: Harvey Field Sample 15, 11/19/85, sample collected by: David Rittenhouse of B C Labs

WATER ANALYSIS

CONSTITUENTS	mg/liter	DESIRABLE LIMITATIONS
Calcium (Ca)	34.	
Magnesium (Mg)	4.7	125.
Sodium (Na)	63.	350.
Potassium (K)	2.5	-
Carbonate (CO_3)	0.	25.
Bicarbonate (HCO_3)	118.	250.
Chloride (Cl)	37.2	250 - 500 (600 short term)
Sulfate (SO_4)	90.	250 - 500 (600 short term)
Nitrate (NO_3)	6.6	45.
Fluoride (F)	0.68	1.0
Iron (Fe)	(-) 0.05	0.3
Manganese (Mn)	(-) 0.01	0.05
Arsenic (As)	(-) 0.01	0.05
Copper (Cu)	(-) 0.01	1.0
Zinc (Zn)	0.02	5.0
MBAS	(-) 0.10	0.5
Hardness as $CaCO_3$	105. (6.1 gr/gal)	200 ppm medium hard, 50-100 ppm very soft
Total Solids	335.	500 - 1000 (1500 short term)
pH	7.7	
Electrical Conductivity Micromhos/cm (K x 10^6) @ 25°C	510.	900 - 1600 (2200 short term)
Color		15
Odor	no observed odor	3.0
Turbidity	0.23	5.0 NT Units
Barium (Ba)	(-) 0.5	1.0
Cadmium (Cd)	(-) 0.005	0.010
Chromium (Cr)	(-) 0.01	0.05
Lead (Pb)	(-) 0.01	0.05
Mercury (Hg)	(-) 0.0002	0.002
Selenium (Se)	(-) 0.005	0.01
Silver (Ag)	(-) 0.01	0.05

(-) refers to "less than".

Encl: (1)

By J. J. Eglin
J. J. Eglin

[illegible]LETE MINERAL ANALYSIS OF WA
[illegible] 11320 18 (2 76)

Environmental Engineering Laboratory, Western Division, Naval Facilities Engineering Command, San Diego, California 92132	DATE 13 JULY 1979

iblic Works Office, Naval Weappns Station, China Lake

following is a report of a complete mineral analysis of water: Well Water

CE OF SAMPLE
11 18B

SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
May 1979	May, June 79	Staff

	ppm	epm		ppm	epm
IUM (Ca)	13	0.64	CARBONATE (CO_3)	12	0.40
IESIUM (Mg)	3.9	0.32	BICARBONATE (HCO_3)	68	1.12
JM (Na)	56	2.43	HYDROXIDE (OH)		
SSIUM (K)	1.9	0.05	SULPHATE (SO_4)	24	0.50
			CHLORIDE (Cl)	29	0.82
			NITRATE ~~(NO_3)~~ N	<1	–
	SUM OF EQUIVALENTS	3.44	SUM OF EQUIVALENTS		2.84

	ppm		RESULTS
. HARDNESS *(as $CaCO_3$)*	48	SILICA *(as SiO_2)*	27
JM HARDNESS *(as $CaCO_3$)*	32	FLUORIDE *(F)*	0.86
SIUM HARDNESS *(as $CaCO_3$)*	16	BORON *(B)*	0.36
LPHTHALEIN ALKALINITY *(as $CaCO_3$)*	20	IRON *(Fe)* TOTAL	0.049
L ORANGE ALKALINITY *(as $CaCO_3$)*	96	MANGANESE *(Mn)* TOTAL	< 0.002
DISSOLVED SOLIDS	259	COPPER *(Cu)* TOTAL	0.022
IC CONDUCTIVITY *(Micromhos @ 25° C)*	370	SYNTHETIC DETERGENTS *(APPARENT ABS)*	0.09
GEN-ION CONCENTRATION *(pH)*	9.01	PHOSPHATE *(PO_4)* TOTAL	0.05

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4

[illegible] ER
WESTDIV 11330/18 (2-78)

Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE
24 APRIL 1980

val Weapons Center, China Lake

llowing is a report of a complete mineral analysis of water: Well

OF SAMPLE
1 #18B

AMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
MAR 80	29 MAR 80	staff

	ppm	epm		ppm	epm
M (Ca)	2	0.08	CARBONATE (CO_3)	43.2	1.44
SIUM (Mg)	0.5	0.04	BICARBONATE (HCO_3)	58.6	0.96
(Na)	83	3.61	HYDROXIDE (OH)		
UM (K)	0.54	0.01	SULPHATE (SO_4)	13	0.27
			CHLORIDE (Cl)	68	1.92
			NITRATE (NO_3) N	<1	-
SUM OF EQUIVALENTS		3.74	SUM OF EQUIVALENTS		4.59

	ppm		RESULTS
RDNESS (as $CaCO_3$)	6.3	SILICA (as SiO_2) TOTAL	26
HARDNESS (as $CaCO_3$)	4.2	FLUORIDE (F)	0.84
M HARDNESS (as $CaCO_3$)	2.1	BORON (B)	0.54
THALEIN ALKALINITY (as $CaCO_3$)	36	IRON (Fe) TOTAL	0.02
RANGE ALKALINITY (as $CaCO_3$)	120	MANGANESE (Mn) TOTAL	0.001
SOLVED SOLIDS	308	COPPER (Cu) TOTAL	<0.01
ONDUCTIVITY (Micromhos @ 25° C)	440	SYNTHETIC DETERGENTS (APPARENT ABS)	0.05
ION CONCENTRATION (pH)	9.20	PHOSPHATE (PO_4) TOTAL	0.09

8-16
6

AGRICULTURE
CHEMICAL ANALYSIS
PETROLEUM

BC LABORATORIES INC
J. J. EGLIN, REG. CHEM. ENGR

MAIN OFFICE: 4100 PIERCE ROAD, BAKERSFIELD, CA. 93308 PHONE 327-4911

Submitted by: Naval Weapons Center
China Lake, California 93555

Date Reported: 12/27/85
Date Received: 11/20/85
Laboratory No.: 20404

Sample Description: Intermediate Sample 18B 11/19/85 sample collected by: David Rittenhouse of B C Labs

WATER ANALYSIS

CONSTITUENTS	mg/liter	DESIRABLE LIMITATIONS
Calcium (Ca)	12.	
Magnesium (Mg)	2.4	125.
Sodium (Na)	59.	350.
Potassium (K)	2.5	-
Carbonate (CO_3)	9.4	25.
Bicarbonate (HCO_3)	120.	250.
Chloride (Cl)	19.8	250 - 500 (600 short term)
Sulfate (SO_4)	27.	250 - 500 (600 short term)
Nitrate (NO_3)	6.2	45.
Fluoride (F)	0.75	1.0
Iron (Fe)	(-) 0.05	0.3
Manganese (Mn)	(-) 0.01	0.05
Arsenic (As)	0.01	0.05
Copper (Cu)	(-) 0.01	1.0
Zinc (Zn)	(-) 0.01	5.0
MBAS	(-) 0.1	0.5
Hardness as $CaCO_3$	39.9 (2.3gr/gal)	200 ppm medium hard, 50-100 ppm very soft
Total Solids	215.	500 - 1000 (1500 short term)
pH	8.3	
Electrical Conductivity	340.	
Micromhos/cm (K x 10^6) @ 25°C		900 - 1600 (2200 short term)
Color	1.	15
Odor	no observed odor	3.0
Turbidity	0.24	5.0 NT Units
Barium (Ba)	(-) 0.5	1.0
Cadmium (Cd)	(-) 0.005	0.010
Chromium (Cr)	(-) 0.01	0.05
Lead (Pb)	(-) 0.01	0.05
Mercury (Hg)	(-) 0.0002	0.002
Selenium (Se)	(-) 0.005	0.01
Silver (Ag)	(-) 0.01	0.05

(-) refers to "less than".

By J. J. Eglin
J. J. Eglin

COMPLETE MINERAL ANALYSIS

12ND WESTDIV 11330 18 (2-76)

FROM
Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE 13 JULY 1979

TO

Public Works Office, Naval Weapons Station, China Lake

The following is a report of a complete mineral analysis of water. Well Water

SOURCE OF SAMPLE
Well 22

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
4 May 1979	May, June 1979	Staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	38	1.92	CARBONATE (CO$_3$)		
MAGNESIUM (Mg)	26	2.16	BICARBONATE (HCO$_3$)	312	5.12
SODIUM (Na)	160	6.95	HYDROXIDE (OH)		
POTASSIUM (K)	13.2	0.34	SULPHATE (SO$_4$)	138	2.88
			CHLORIDE (Cl)	109	3.07
			NITRATE ~~(NO$_3$)~~-N	<1	
SUM OF EQUIVALENTS		11.37	SUM OF EQUIVALENTS		11.07

	ppm		RESULTS
TOTAL HARDNESS *(as CaCo$_3$)*	204	SILICA *(as SiO$_2$)*	42
CALCIUM HARDNESS *(as CaCo$_3$)*	96	FLUORIDE *(F)*	1.0
MAGNESIUM HARDNESS *(as CaCO$_3$)*	108	BORON *(B)*	2.7
PHENOLPHTHALEIN ALKALINITY *(as CaCO$_3$)*	0	IRON *(Fe)* TOTAL	0.016
METHYL ORANGE ALKALINITY *(as CaCO$_3$)*	256	MANGANESE *(Mn)* TOTAL	0.002
TOTAL DISSOLVED SOLIDS	728	COPPER *(Cu)* TOTAL	0.016
SPECIFIC CONDUCTIVITY *(Micromhos @ 25° C)*	1040	SYNTHETIC DETERGENTS *(APPARENT ABS)*	0.04
HYDROGEN-ION CONCENTRATION *(pH)*	7.81	PHOSPHATE *(PO$_4$)* TOTAL	0.05

REMARKS

#90505-12
10

COMPLETE MINERAL ANALYSIS OF WATER
12ND WESTDIV 11330/18 (2-76)

FROM Environmental Engineering Laboratory, Western Division, Naval Facilities Engineering Command, San Diego, California 92132	DATE 24 APRIL 1980

TO
Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water: Well

SOURCE OF SAMPLE
Well #22

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
29 MAR 80	29 MAR 80	staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	44	2.18	CARBONATE (CO_3)		
MAGNESIUM (Mg)	23	1.86	BICARBONATE (HCO_3)	317	5.20
SODIUM (Na)	182	7.91	HYDROXIDE (OH)		
POTASSIUM (K)	19.1	0.36	SULPHATE (SO_4)	139	2.90
			CHLORIDE (Cl)	148	4.17
			NITRATE ~~(NO_3)~~ N	<1	-
SUM OF EQUIVALENTS		12.31	SUM OF EQUIVALENTS		12.27

	ppm		RESULTS
TOTAL HARDNESS *(as $CaCO_3$)*	202	SILICA *(as SiO_2)* TOTAL	45
CALCIUM HARDNESS *(as $CaCO_3$)*	109	FLUORIDE *(F)*	0.9
MAGNESIUM HARDNESS *(as $CaCO_3$)*	93	BORON *(B)*	2.1
PHENOLPHTHALEIN ALKALINITY *(as $CaCO_3$)*	0	IRON *(Fe)* TOTAL	0.12
METHYL ORANGE ALKALINITY *(as $CaCO_3$)*	260	MANGANESE *(Mn)* TOTAL	0.009
TOTAL DISSOLVED SOLIDS	840	COPPER *(Cu)* TOTAL	0.03
SPECIFIC CONDUCTIVITY *(Micromhos @ 25° C)*	1200	SYNTHETIC DETERGENTS *(APPARENT ABS)*	0.06
HYDROGEN-ION CONCENTRATION *(pH)*	7.89	PHOSPHATE *(PO_4)* TOTAL	0.10

REMARKS

#00318-16
9

FROM Environmental Engineering Laboratory, Southwest Environmental Section (Code 1141), Western Division, Naval Facilities Engineering Command, 1220 Pacific Highway, San Diego, California 92132	DATE 2 SEPT 1982

TO Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water: Well Water

SOURCE OF SAMPLE Well #22 (C - Range)

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
19 JUL 1982	19 JUL - 31 AUG 1982	STAFF

	ppm	epm		ppm	epm
CALCIUM (Ca)	38.8	1.94	CARBONATE (CO_3)		
MAGNESIUM (Mg)	28.5	2.34	BICARBONATE (HCO_3)	336.7	5.52
SODIUM (Na)	172	7.48	HYDROXIDE (OH)		
POTASSIUM (K)	13.5	0.35	SULPHATE (SO_4)	132	2.75
			CHLORIDE (Cl)	128	3.61
			NITRATE XXXX -N	0.5	-------
SUM OF EQUIVALENTS		12.10	SUM OF EQUIVALENTS		11.88

	ppm			RESULTS
TOTAL HARDNESS (as $CaCO_3$)	214	SILICA (as SiO_2)		39
CALCIUM HARDNESS (as $CaCO_3$)	97	FLUORIDE (F)		0.95
MAGNESIUM HARDNESS (as $CaCO_3$)	117	BORON (B)		2.8
PHENOLPHTHALEIN ALKALINITY (as $CaCO_3$)	0	IRON (Fe)	Total	0.03
METHYL ORANGE ALKALINITY (as $CaCO_3$)	276	MANGANESE (Mn)	Total	0.01
TOTAL DISSOLVED SOLIDS Gravimetric	729	COPPER (Cu)	Total	0.04
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	1250	SYNTHETIC DETERGENTS (APPARENT ABS)		0.041
HYDROGEN-ION CONCENTRATION (pH)	7.76	PHOSPHATE (PO_4)	Total	0.05
Temperture ^{O}F	76	Langlier Index		+0.36
PHS	7.40	Ryzner Index		7.04

REMARKS

TITLE 22 CHEMICAL ANALYSES

Date of Report

Lab Sample ID Number 88136

Laboratory Name FGL

Signature Lab Director MG Wong

Name of Sampler Knut J Beruldsen

Sampler Employed By Naval Weapons Center

Date/Time Sample Collected April 28, 1987 0900 hrs

Date/Time Sample Received at Lab.

Were Holding Times Observed?

System Name U.S Naval Weapons Center

System Number 15-703

Description of Sampling Point hose attached to pump discharge line

Name/Number of Sample Source Area C Tower / Well #22

Station Number

Date and Time of Sample 8 7 0 4 2 8 0 9 0 0 (Y Y M M D D T T T T)

Water Type (G/S)

User ID

Submitted to SWQIS By

MCL Reporting Units	Constituent	TT	Storet Code	Analyses Results
	Analyzing Agency (Laboratory)		28	
mg/L	Total Hardness (as CaCO3)		900	205
mg/L	Calcium (Ca)		916	40
mg/L	Magnesium (Mg)		927	25
mg/L	Sodium (Na)		929	177
mg/L	Potassium (K)		937	20
Total Cations meq/L	Value:			

MCL Reporting Units	Constituent	TT	Storet Code	Analyses Results
mg/L	Total Alkalinity (as CaCO3)		410	305
mg/L	Hydroxide (OH)		71830	0
mg/L	Carbonate (CO3)		445	0
mg/L	Bicarbonate (HCO3)		440	372
• mg/L +	Sulfate (SO4)		945	129
• mg/L +	Chloride (Cl)		940	117
45 mg/L	Nitrate (NO3)		71850	1
1.4–2.4 mg/L	Fluoride (F) Temp. Depend.		951	0.8
Total Anions meq/L	Value:			

MCL Reporting Units	Constituent	TT	Storet Code	Analyses Results
Std Units	pH (Laboratory)		403	7.8
•• umho/cm +	Specific Conductance (E.C.)		95	1240
••• mg/L +	Total Filterable Residue at 180° C (TDS)		70300	692
UNITS	Apparent Color (Unfiltered)		81	< 5
TON	Odor Threshold at 60° C		86	< 1
NTU	Lab Turbidity		82079	2.0
0.5 mg/L +	MBAS		38260	< 0.05

• 250–500–600 •• 900–1600–2200 ••• 500–1000–1500

HS 8351 (11/86)

Enclosure (1)

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U.S. Naval Weapon Center, well 22   88136

• THE FOLLOWING CONSTITUENTS ARE REPORTED IN UG/L •

Constituent	T T	Storet Code	Analyses Results
Arsenic (As)		1002	< 30
Barium (Ba)		1007	< 500
Cadmium (Cd)		1027	< 5
Chromium (Total Cr)		1034	< 30
Copper (Cu)		1042	< 100
Iron (Fe)		1045	600
Lead (Pb)		1051	< 30
Manganese (Mn)		1055	< 30
Mercury (Hg)		71900	< 1
Selenium (Se)		1147	< 5
Silver (Ag)		1077	< 30
Zinc (Zn)		1092	< 100

ORGANIC CHEMICALS

Endrin		39390	
Lindane		39340	
Methoxychlor		39480	
Toxaphene		39400	
2, 4–D		39730	
2, 4, 5–TP Silvex		39045	
ORGANIC Analyses Completed		73672	
			Y Y M M D D

ADDITIONAL ANALYSES

Field Turbidity		82078	
Source Temperature		10	
Langelier Index Source Temp.		71814	
Langelier Index at 60° C		71813	
Field pH		00400	
Aggressiveness Index		82383	
Silica		00955	
Phosphate		00650	
Iodide		71865	
Sodium Absorption Ratio		00931	
Asbestos		81855	
gross alpha			11 ±4.3

ces Secondary Drinking Water Standards

FROM
Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE
12 Sep 78

TO
NAVWPNSCEN CHINA LAKE

The following is a report of a complete mineral analysis of water Well Water

SOURCE OF SAMPLE
Well #23

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
31 Jul 78	31 Jul 78	W. Kester/P. Ma

	ppm	epm		ppm	epm
CALCIUM (Ca)	57.6	2.88	CARBONATE (CO_3)		
MAGNESIUM (Mg)	14.6	1.20	BICARBONATE (HCO_3)	181	2.96
SODIUM (Na)	109	4.73	HYDROXIDE (OH)		
POTASSIUM (K)	3.3	0.08	SULPHATE (SO_4) *	180	3.75
			CHLORIDE (Cl)	71	2.00
			NITRATE ~~(NO_3)~~ N	0.32	0.02
SUM OF EQUIVALENTS		8.89	SUM OF EQUIVALENTS		8.73

	ppm		RESULTS
TOTAL HARDNESS (as $CaCO_3$)	204	SILICA (as SiO_2)	28
CALCIUM HARDNESS (as $CaCO_3$)	144	FLUORIDE (F)	0.88
MAGNESIUM HARDNESS (as $CaCO_3$)	60	BORON (B)	0.2
PHENOLPHTHALEIN ALKALINITY (as $CaCO_3$)	0	IRON (Fe) Total	0.438
METHYL ORANGE ALKALINITY (as $CaCO_3$)	148	MANGANESE (Mn) Total	0.053
TOTAL DISSOLVED SOLIDS	630	COPPER (Cu) Total	0.006
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	900	SYNTHETIC DETERGENTS (APPARENT ABS)	0.022
HYDROGEN-ION CONCENTRATION (pH)	7.44	PHOSPHATE (PO_4) Total	0.17

REMARKS

* Recorded result of Sulfate (SO_4) based on the previous results; insufficient sample for further test.

80727-16 (11)

TO
Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water Well Water

SOURCE OF SAMPLE
Well #23 (B-4 Range)

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
19 JUL 1982	19 JUL - 31 AUG 1982	STAFF

	ppm	epm		ppm	epm
CALCIUM (Ca)	58.8	2.94	CARBONATE (CO_3)		
MAGNESIUM (Mg)	13.4	1.10	BICARBONATE (HCO_3)	175.7	2.88
SODIUM (Na)	114	4.96	HYDROXIDE (OH)		
POTASSIUM (K)	3.50	0.09	SULPHATE (SO_4)	174	3.62
			CHLORIDE (Cl)	108	3.04
			NITRATE XXX -N	0.5	
SUM OF EQUIVALENTS		9.09	SUM OF EQUIVALENTS		9.54

	ppm		RESULTS
TOTAL HARDNESS (as $CaCO_3$)	202	SILICA (as SiO_2)	39
CALCIUM HARDNESS (as $CaCO_3$)	147	FLUORIDE (F)	0.89
MAGNESIUM HARDNESS (as $CaCO_3$)	55	BORON (B)	0.71
PHENOLPHTHALEIN ALKALINITY (as $CaCO_3$)	0	IRON (Fe) Total	0.15
METHYL ORANGE ALKALINITY (as $CaCO_3$)	144	MANGANESE (Mn) Total	0.06
TOTAL DISSOLVED SOLIDS Gravimetric	573	COPPER (Cu) Total	<0.01
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	950	SYNTHETIC DETERGENTS (APPARENT ABS)	0.041
HYDROGEN-ION CONCENTRATION (pH)	7.44	PHOSPHATE (PO_4) Total	0.05
Temperture °F	76	Langlier Index	-0.07
PHS	7.47	Ryzner Index	7.50

REMARKS

20716-14
8

COMPLETE MINERAL ANALYSIS OF WATER
12ND WESTDIV 11330/18 (2-78)

FROM
Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE
24 APRIL 1980

TO
Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water: Well

SOURCE OF SAMPLE
Well #23

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
29 MAR 80	29 MAR 80	staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	60	3.02	CARBONATE (CO_3)		
MAGNESIUM (Mg)	11	0.92	BICARBONATE (HCO_3)	171	2.80
SODIUM (Na)	120	5.22	HYDROXIDE (OH)		
POTASSIUM (K)	3.7	0.09	SULPHATE (SO_4)	203	4.23
			CHLORIDE (Cl)	76	2.14
			NITRATE ~~(NO_3)~~ N	<1	-
SUM OF EQUIVALENTS		9.25	SUM OF EQUIVALENTS		9.17

	ppm		RESULTS
TOTAL HARDNESS (as $CaCO_3$)	197	SILICA (as SiO_2) TOTAL	35
CALCIUM HARDNESS (as $CaCO_3$)	151	FLUORIDE (F)	0.82
MAGNESIUM HARDNESS (as $CaCO_3$)	46	BORON (B)	0.71
PHENOLPHTHALEIN ALKALINITY (as $CaCO_3$)	0	IRON (Fe) TOTAL	2.30
METHYL ORANGE ALKALINITY (as $CaCO_3$)	140	MANGANESE (Mn) TOTAL	0.088
TOTAL DISSOLVED SOLIDS	665	COPPER (Cu) TOTAL	<0.01
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	950	SYNTHETIC DETERGENTS (APPARENT ABS)	0.06
HYDROGEN-ION CONCENTRATION (pH)	7.87	PHOSPHATE (PO_4) TOTAL	0.05

REMARKS

#00318-16
10

TITLE 22 CHEMICAL ANALYSES

Date of Report 5-13-87	Lab Sample ID Number 88901
Laboratory Name FGL	Signature Lab Director
Name of Sampler Knut J. Beruldsen	Sampler Employed By Naval Weapons Center

Date/Time Sample Collected 5/06/87 0900 hrs	Date/Time Sample Received at Lab.	Were Holding Times Observed?

System Name U.S Naval Weapons Center	System Number 15-703

Description of Sampling Point hose bibb

Name/Number of Sample Source B4 Range / Well # 23	Station Number

Date and Time of Sample 8 7 0 5 0 6 0 9 0 0 Y Y M M D D T T T T	Water Type G/S	User ID	Submitted to SWQIS By

MCL Reporting Units	Constituent	TT	Storet Code	Analyses Results
	Analyzing Agency (Laboratory)		28	
mg/L	Total Hardness (as CaCO3)		900	45
mg/L	Calcium (Ca)		916	13
mg/L	Magnesium (Mg)		927	3
mg/L	Sodium (Na)		929	13
mg/L	Potassium (K)		937	3
Total Cations meq/L	Value:			

mg/L	Total Alkalinity (as CaCO3)		410	70
mg/L	Hydroxide (OH)		71830	0
mg/L	Carbonate (CO3)		445	0
mg/L	Bicarbonate (HCO3)		440	85
* mg/L +	Sulfate (SO4)		945	3
* mg/L +	Chloride (Cl)		940	6
45 mg/L	Nitrate (NO3)		71850	< 1.0
1.4–2.4 mg/L	Fluoride (F) Temp. Depend.		951	0.1
Total Anions meq/L	Value:			

Std Units	pH (Laboratory)		403	7.0
** umho/cm +	Specific Conductance (E.C.)		95	170
*** mg/L +	Total Filterable Residue at 180° C (TDS)		70300	100
UNITS	Apparent Color (Unfiltered)		81	< 5
TON	Odor Threshold at 60° C		86	< 1
NTU	Lab Turbidity		82079	6.2
0.5 mg/L +	MBAS		38260	< 0.05

* 250–500–600 ** 900–1600–2200 *** 500–1000–1500

DHS 8351 (11/86)

more data on otherside

Enclosure (3)

Page 2 of 2

SYSTEM NAME AND NUMBER ______________________________

• THE FOLLOWING CONSTITUENTS ARE REPORTED IN UG/L •

MCL Reporting Units		Constituent	TT	Storet Code	Analyses Results
50	ug/L	Arsenic (As)		1002	< 30
1000	ug/L	Barium (Ba)		1007	< 500
10	ug/L	Cadmium (Cd)		1027	< 5
50	ug/L	Chromium (Total Cr)		1034	< 30
1000	ug/L+	Copper (Cu)		1042	< 100
300	ug/L+	Iron (Fe)		1045	100
50	ug/L	Lead (Pb)		1051	< 30
50	ug/L+	Manganese (Mn)		1055	< 30
2	ug/L	Mercury (Hg)		71900	< 1
10	ug/L	Selenium (Se)		1147	< 5
50	ug/L	Silver (Ag)		1077	< 30
5000	ug/L	Zinc (Zn)		1092	800

ORGANIC CHEMICALS

0.2	ug/L	Endrin		39390	
4	ug/L	Lindane		39340	
100	ug/L	Methoxychlor		39480	
5	ug/L	Toxaphene		39400	
100	ug/L	2, 4–D		39730	
10	ug/L	2, 4, 5–TP Silvex		39045	
		Date ORGANIC Analyses Completed		73672	Y Y M M D D

ADDITIONAL ANALYSES

NTU	Field Turbidity		82078	
C	Source Temperature		10	
	Langelier Index Source Temp.		71814	
	Langelier Index at 60° C		71813	
Std. Units	Field pH		00400	
	Aggressiveness Index		82383	
mg/L	Silica		00955	
mg/L	Phosphate		00650	
mg/L	Iodide		71865	
	Sodium Absorption Ratio		00931	
	Asbestos		81855	
pCi/l	gross alpha			3 ± 2.3

+ indicates Secondary Drinking Water Standards [illegible] WESTDIV [illegible]

FROM Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE 12 Sep 78

TO NAVWPNSCEN CHINA LAKE

The following is a report of a complete mineral analysis of water Well Water

SOURCE OF SAMPLE Well #27

DATE SAMPLE COLLECTED 31 Jul 78

DATE SAMPLE ANALYZED 31 Jul 78

ANALYST W. Kester/ P. Ma

	ppm	epm		ppm	epm
CALCIUM (Ca)	68.8	3.44	CARBONATE (CO$_3$)		
MAGNESIUM (Mg)	8.8	6.72	BICARBONATE (HCO$_3$)	58.6	0.96
SODIUM (Na)	56	2.43	HYDROXIDE (OH)		
POTASSIUM (K)	3.3	0.08	SULPHATE (SO$_4$)	79	1.65
			CHLORIDE (Cl)	143	4.02
			NITRATE (~~NO$_3$~~) N	0.85	0.06
SUM OF EQUIVALENTS		6.67	SUM OF EQUIVALENTS		6.69

	ppm			RESULTS
TOTAL HARDNESS (as CaCo$_3$)	208	SILICA (as SiO$_2$)		20
CALCIUM HARDNESS (as CaCo$_3$)	172	FLUORIDE (F)		0.68
MAGNESIUM HARDNESS (as CaCO$_3$)	36	BORON (B)		0.14
PHENOLPHTHALEIN ALKALINITY (as CaCO$_3$)	0	IRON (Fe)	Total	0.219
METHYL ORANGE ALKALINITY (as CaCO$_3$)	48	MANGANESE (Mn)	Total	<0.002
TOTAL DISSOLVED SOLIDS	560	COPPER (Cu)	Total	0.002
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	800	SYNTHETIC DETERGENTS (APPARENT ABS)		0.008
HYDROGEN-ION CONCENTRATION (pH)	7.47	PHOSPHATE (PO$_4$)	Total	<0.02

REMARKS

80727-16 (13)

COMPLETE MINERAL ANALY [illegible]
12ND WESTDIV 11330 18 (2 76)

FROM Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE 13 JULY 1979

TO Public Works Office, Naval Weapons Station, China Lake

The following is a report of a complete mineral analysis of water: Well Water

SOURCE OF SAMPLE Well 27

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
4 May 1979	May, June 1979	Staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	59	2.96	CARBONATE (CO_3)		
MAGNESIUM (Mg)	12	0.96	BICARBONATE (HCO_3)	63	1.04
SODIUM (Na)	65	2.83	HYDROXIDE (OH)		
POTASSIUM (K)	2.5	0.06	SULPHATE (SO_4)	84	1.75
			CHLORIDE (Cl)	122	3.44
			NITRATE ~~(NO_3)~~ N	<1	-
SUM OF EQUIVALENTS		6.71	SUM OF EQUIVALENTS		6.23

	ppm		RESULTS
TOTAL HARDNESS (as $CaCo_3$)	196	SILICA (as SiO_2)	32
CALCIUM HARDNESS (as $CaCo_3$)	148	FLUORIDE (F)	0.72
MAGNESIUM HARDNESS (as $CaCO_3$)	48	BORON (B)	0.36
PHENOLPHTHALEIN ALKALINITY (as $CaCO_3$)	0	IRON (Fe) TOTAL	0.553
METHYL ORANGE ALKALINITY (as $CaCO_3$)	52	MANGANESE (Mn) TOTAL	0.003
TOTAL DISSOLVED SOLIDS	490	COPPER (Cu) TOTAL	0.011
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	700	SYNTHETIC DETERGENTS (APPARENT ABS)	* -
HYDROGEN-ION CONCENTRATION (pH)	7.75	PHOSPHATE (PO_4) TOTAL	<0.03

REMARKS

* Insufficient sample to run the test

\# 90505-12
2.

COMPLETE MINERAL ANALYSIS OF WATER
12ND WESTDIV 11330/18 (2-78)

FROM Environmental Engineering Laboratory, Western Division, Naval Facilities Engineering Command, San Diego, California 92132.	DATE 24 APRIL 1980

TO
Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water: Well

SOURCE OF SAMPLE
Well #27

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
29 MAR 80	29 MAR 80	staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	63	3.15	CARBONATE (CO_3)		
MAGNESIUM (Mg)	7	0.60	BICARBONATE (HCO_3)	73	1.20
SODIUM (Na)	64	2.78	HYDROXIDE (OH)		
POTASSIUM (K)	2.8	0.07	SULPHATE (SO_4)	81	1.69
			CHLORIDE (Cl)	128	3.61
			NITRATE (NO_3) N	<1	-
SUM OF EQUIVALENTS		6.60	SUM OF EQUIVALENTS		6.50

	ppm		RESULTS
TOTAL HARDNESS *(as $CaCo_3$)*	185	SILICA *(as SiO_2)* TOTAL	32
CALCIUM HARDNESS *(as $CaCo_3$)*	155	FLUORIDE *(F)*	0.60
MAGNESIUM HARDNESS *(as $CaCO_3$)*	30	BORON *(B)*	0.32
PHENOLPHTHALEIN ALKALINITY *(as $CaCO_3$)*	0	IRON *(Fe)* TOTAL	0.05
METHYL ORANGE ALKALINITY *(as $CaCO_3$)*	60	MANGANESE *(Mn)* TOTAL	<0.001
TOTAL DISSOLVED SOLIDS	518	COPPER *(Cu)* TOTAL	<0.01
SPECIFIC CONDUCTIVITY *(Micromhos @ 25°C)*	740	SYNTHETIC DETERGENTS *(APPARENT ABS)*	0.03
HYDROGEN-ION CONCENTRATION *(pH)*	8.07	PHOSPHATE *(PO_4)* TOTAL	0.047

REMARKS

#00318-16
12

IND WESTDIV 11330/1E (REV. 1-80)

FROM Environmental Engineering Laboratory, Southwest Environmental Section (Code 1141), Western Division, Naval Facilities Engineering Command, 1220 Pacific Highway, San Diego, California 92132

DATE SEP 2 1982

TO NWC China Lake

The following is a report of a complete mineral analysis of water Well Water

SOURCE OF SAMPLE Well 27

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
7/27	7/27 - 8/31/82	Staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	59.2	2.86	CARBONATE (CO_3)		
MAGNESIUM (Mg)	6.1	.50	BICARBONATE (HCO_3)	73.2	1.20
SODIUM (Na)	61	2.65	HYDROXIDE (OH)		
POTASSIUM (K)	2.68	0.07	SULPHATE (SO_4)	69	1.44
			CHLORIDE (Cl)	132	3.72
			NITRATE (NO_3) -N	0.9	
SUM OF EQUIVALENTS		6.08	SUM OF EQUIVALENTS		6.36

	ppm			RESULTS
TOTAL HARDNESS *(as $CaCO_3$)*	168	SILICA *(as SiO_2)*		36
CALCIUM HARDNESS *(as $CaCO_3$)*	143	FLUORIDE *(F)*		0.89
MAGNESIUM HARDNESS *(as $CaCO_3$)*	25	BORON *(B)*		0.30
PHENOLPHTHALEIN ALKALINITY *(as $CaCO_3$)*	0	IRON *(Fe)*	total	0.09
METHYL ORANGE ALKALINITY *(as $CaCO_3$)*	60	MANGANESE *(Mn)*	total	0.02
TOTAL DISSOLVED SOLIDS Gravimetric	438	COPPER *(Cu)*	total	0.01
SPECIFIC CONDUCTIVITY *(Micromhos @ 25° C)*	720	SYNTHETIC DETERGENTS *(APPARENT ABS)*		0.040
HYDROGEN-ION CONCENTRATION *(pH)*	7.80	PHOSPHATE *(PO_4)*	total	<0.05
Temperature °F	82-84	Langlier Index		-0.08
pHs	7.88	Ryzner Index	7.96	

REMARKS

20716-14
9

TITLE 22 CHEMICAL ANALYSES

Date of Report May 1, 1987		Lab Sample ID Number 87741
Laboratory Name FGL Environmental		Signature Lab Director
Name of Sampler Knut Beruldsen		Sampler Employed By
Date/Time Sample Collected 4/1/87 0900 Hrs.	Date/Time Sample Received at Lab. 4/2/87	Were Holding Times Observed?
System Name Naval Weapons Center, China Lake		System Number 15-703
Description of Sampling Point Hose Bibb		
Name/Number of Sample Source Well #27		Station Number
Date and Time of Sample 8 7 0 4 0 1 0 9 0 0 Y Y M M D D T T T T	Water Type G/S	User ID
Submitted to SWQIS By		

MCL Reporting Units	Constituent	T T	Storet Code	Analyses Results
	Analyzing Agency (Laboratory)		28	
mg/L	Total Hardness (as CaCO3)		900	185
mg/L	Calcium (Ca)		916	60
mg/L	Magnesium (Mg)		927	9
mg/L	Sodium (Na)		929	64
mg/L	Potassium (K)		937	4
Total Cations meq/L	Value:			

MCL Reporting Units	Constituent	T T	Storet Code	Analyses Results
mg/L	Total Alkalinity (as CaCO3)		410	60
mg/L	Hydroxide (OH)		71830	0
mg/L	Carbonate (CO3)		445	0
mg/L	Bicarbonate (HCO3)		440	73
* mg/L +	Sulfate (SO4)		945	80
* mg/L +	Chloride (Cl)		940	136
45 mg/L	Nitrate (NO3)		71850	4
1.4–2.4 mg/L	Fluoride (F) Temp. Depend.		951	0.7
Total Anions meq/L	Value:			

MCL Reporting Units	Constituent	T T	Storet Code	Analyses Results
Std Units	pH (Laboratory)		403	8.1
** umho/cm +	Specific Conductance (E.C.)		95	780
*** mg/L +	Total Filterable Residue at 180° C (TDS)		70300	393
UNITS	Apparent Color (Unfiltered)		81	< 5
TON	Odor Threshold at 60° C		86	< 1
NTU	Lab Turbidity		82079	< 0.5
0.5 mg/L +	MBAS		38260	< 0.05

* 250–500–600 ** 900–1600–2200 *** 500–1000–1500

DHS 8351 (11/86)

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SYSTEM NAME AND NUMBER Naval Weapons Center, China Lake 87741

• THE FOLLOWING CONSTITUENTS ARE REPORTED IN UG/L •

MCL Reporting Units		Constituent	TT	Storet Code	Analyses Results
50	ug/L	Arsenic (As)		1002	< 30
1000	ug/L	Barium (Ba)		1007	< 500
10	ug/L	Cadmium (Cd)		1027	< 5
50	ug/L	Chromium (Total Cr)		1034	< 30
1000	ug/L+	Copper (Cu)		1042	< 100
300	ug/L+	Iron (Fe)		1045	< 100
50	ug/L	Lead (Pb)		1051	< 30
50	ug/L+	Manganese (Mn)		1055	< 30
2	ug/L	Mercury (Hg)		71900	< 1
10	ug/L	Selenium (Se)		1147	< 5
50	ug/L	Silver (Ag)		1077	< 30
5000	ug/L	Zinc (Zn)		1092	100

ORGANIC CHEMICALS

0.2	ug/L	Endrin		39390	
4	ug/L	Lindane		39340	
100	ug/L	Methoxychlor		39480	
5	ug/L	Toxaphene		39400	
100	ug/L	2, 4–D		39730	
10	ug/L	2, 4, 5–TP Silvex		39045	
		Date ORGANIC Analyses Completed		73672	
					Y Y M M D D

ADDITIONAL ANALYSES

NTU	Field Turbidity		82078	
C	Source Temperature		10	
	Langelier Index Source Temp.		71814	
	Langelier Index at 60° C		71813	
Std. Units	Field pH		00400	
	Aggressiveness Index		82383	
mg/L	Silica		00955	
mg/L	Phosphate		00650	
mg/L	Iodide		71865	
	Sodium Absorption Ratio		00931	
	Asbestos		81855	

\+ indicates Secondary Drinking Water Standards

Gross Alpha, pCi/liter less than 1 ± 1.4

COMPLETE MINERAL ANALYSIS OF WATER
12ND WESTDIV 11330 [illegible]

FROM
Environmental Engineering Laboratory, Western Division,
Naval Facilities Engineering Command, San Diego, California 92132

DATE
13 JULY 1979

TO
Public Works Office, Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water. Well Water

SOURCE OF SAMPLE
Well 29

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
4 May 1979	May, June 79	Staff

	ppm	epm		ppm	epm
CALCIUM (Ca)	22	1.12	CARBONATE (CO_3)		
MAGNESIUM (Mg)	8.8	0.72	BICARBONATE (HCO_3)	98	1.60
SODIUM (Na)	39	1.70	HYDROXIDE (OH)		
POTASSIUM (K)	2.4	0.06	SULPHATE (SO_4)	41	0.85
			CHLORIDE (Cl)	29	0.82
			NITRATE ~~NO_3~~ N	< 1	
	SUM OF EQUIVALENTS	3.60		SUM OF EQUIVALENTS	3.27

	ppm		RESULTS
TOTAL HARDNESS (as $CaCO_3$)	92	SILICA (as SiO_2)	31
CALCIUM HARDNESS (as $CaCO_3$)	56	FLUORIDE (F)	0.72
MAGNESIUM HARDNESS (as $CaCO_3$)	36	BORON (B)	0.23
PHENOLPHTHALEIN ALKALINITY (as $CaCO_3$)	0	IRON (Fe) TOTAL	0.035
METHYL ORANGE ALKALINITY (as $CaCO_3$)	80	MANGANESE (Mn) TOTAL	<0.002
TOTAL DISSOLVED SOLIDS	217	COPPER (Cu) TOTAL	0.024
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	310	SYNTHETIC DETERGENTS (APPARENT ABS)	* –
HYDROGEN-ION CONCENTRATION (pH)	8.13	PHOSPHATE (PO_4) TOTAL	<0.03

REMARKS

* Insufficient sample to run test

#90505-12

COMPLETE MINERAL ANALYSIS OF V R
12ND WESTDIV 11330/18 (2-76)

FROM Environmental Engineering Laboratory, Western Division, Naval Facilities Engineering Command, San Diego, California 92132	DATE 24 APRIL 1980

TO

Naval Weapons Center, China Lake

The following is a report of a complete mineral analysis of water: WELL

SOURCE OF SAMPLE

Well #29

DATE SAMPLE COLLECTED	DATE SAMPLE ANALYZED	ANALYST
29 MAR 80	29 MAR 80	sr-ff

	ppm	epm		ppm	epm
CALCIUM (Ca)	22	1.10	CARBONATE (CO$_3$)		
MAGNESIUM (Mg)	3	0.24	BICARBONATE (HCO$_3$)	88	1.44
SODIUM (Na)	42	1.82	HYDROXIDE (OH)		
POTASSIUM (K)	3.6	0.09	SULPHATE (SO$_4$)	38.	0.79
			CHLORIDE (Cl)	36	1.01
			NITRATE (NO$_3$) N	<1	-
SUM OF EQUIVALENTS		3.25	SUM OF EQUIVALENTS		3.24

	ppm		RESULTS
TOTAL HARDNESS (as CaCo$_3$)	67	SILICA (as SiO$_2$) TOTAL	25
CALCIUM HARDNESS (as CaCo$_3$)	55	FLUORIDE (F)	0.74
MAGNESIUM HARDNESS (as CaCO$_3$)	12	BORON (B)	0.25
PHENOLPHTHALEIN ALKALINITY (as CaCO$_3$)	0	IRON (Fe) TOTAL	0.24
METHYL ORANGE ALKALINITY (as CaCO$_3$)	72	MANGANESE (Mn) TOTAL	0.056
TOTAL DISSOLVED SOLIDS	287	COPPER (Cu) TOTAL	<0.01
SPECIFIC CONDUCTIVITY (Micromhos @ 25° C)	410	SYNTHETIC DETERGENTS (APPARENT ABS)	0.05
HYDROGEN-ION CONCENTRATION (pH)	8.20	PHOSPHATE (PO$_4$) TOTAL	0.09

REMARKS

~~#00318-16~~
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ME AND NUMBER U.S. China Lake Naval Weapon Center 88290
Well 29

• THE FOLLOWING CONSTITUENTS ARE REPORTED IN UG/L •

orting Units	Constituent	T T	Storet Code	Analyses Results
ug/L	Arsenic (As)		1002	< 30
ug/L	Barium (Ba)		1007	< 500
ug/L	Cadmium (Cd)		1027	< 5
ug/L	Chromium (Total Cr)		1034	< 30
ug/L+	Copper (Cu)		1042	< 100
ug/L+	Iron (Fe)		1045	< 100
ug/L	Lead (Pb)		1051	< 30
ug/L+	Manganese (Mn)		1055	< 30
ug/L	Mercury (Hg)		71900	< 1
ug/L	Selenium (Se)		1147	< 5
ug/L	Silver (Ag)		1077	< 30
ug/L	Zinc (Zn)		1092	< 100

ORGANIC CHEMICALS

ug/L	Endrin		39390	
ug/L	Lindane		39340	
ug/L	Methoxychlor		39480	
ug/L	Toxaphene		39400	
ug/L	2, 4–D		39730	
ug/L	2, 4, 5–TP Silvex		39045	
Date ORGANIC Analyses Completed			73672	Y Y M M D D

ADDITIONAL ANALYSES

NTU	Field Turbidity		82078	
C	Source Temperature		10	
	Langelier Index Source Temp.		71814	
	Langelier Index at 60° C		71813	
Std. Units	Field pH		00400	
	Aggressiveness Index		82383	
mg/L	Silica		00955	
mg/L	Phosphate		00650	
mg/L	Iodide		71865	
	Sodium Absorption Ratio		00931	
	Asbestos		81855	
pCi/l	gross alpha			5 ±2.0

+ Indicates Secondary Drinking Water Standards

TITLE 22 CHEMICAL ANALYSES

Date of Report: April 21, 1987
Lab Sample ID Number: 88290
Laboratory Name: FGL Environmental
Signature Lab Director:
Name of Sampler: Knut J. Beruldsen
Sampler Employed By: Naval Weapons Center
Date/Time Sample Collected: 4/21/87 0900 hrs.
Date/Time Sample Received at Lab.:
Were Holding Times Observed?
System Name: U.S Naval Weapons Center
System Number: 15-703
Description of Sampling Point: hose bib
Name/Number of Sample Source: Well # 29 (Intermediate well field)
Station Number:
Date and Time of Sample: 8 7 0 4 2 1 0 9 0 0 (Y Y M M D D T T T T)
Water Type: (G/S)
User ID:
Submitted to SWQIS By:

MCL Reporting Units	Constituent	T T	Storet Code	Analyses Results
	Analyzing Agency (Laboratory)		28	
mg/L	Total Hardness (as CaCO3)		900	55
mg/L	Calcium (Ca)		916	16
mg/L	Magnesium (Mg)		927	4
mg/L	Sodium (Na)		929	46
mg/L	Potassium (K)		937	3
Total Cations meq/L	Value:			

MCL Reporting Units	Constituent	T T	Storet Code	Analyses Results
mg/L	Total Alkalinity (as CaCO3)		410	100
mg/L	Hydroxide (OH)		71830	0
mg/L	Carbonate (CO3)		445	0
mg/L	Bicarbonate (HCO3)		440	122
* mg/L +	Sulfate (SO4)		945	28
* mg/L +	Chloride (Cl)		940	24
45 mg/L	Nitrate (NO3)		71850	3
1.4–2.4 mg/L	Fluoride (F) Temp. Depend.		951	0.7
Total Anions meq/L	Value:			

MCL Reporting Units	Constituent	T T	Storet Code	Analyses Results
Std Units	pH (Laboratory)		403	8.2
** umho/cm +	Specific Conductance (E.C.)		95	350
*** mg/L +	Total Filterable Residue at 180° C (TDS)		70300	212
UNITS	Apparent Color (Unfiltered)		81	< 5
TON	Odor Threshold at 60° C		86	< 1
NTU	Lab Turbidity		82079	< 0.5
0.5 mg/L +	MBAS		38260	< 0.05

* 250–500–600 ** 900–1600–2200 *** 500–1000–1500

DHS 8351 (11/86)

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