STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES
1069 State Office Building
Portland Oregon - 97201

OPEN FILE REPORT
July 1, 1971

GEOLOGIC EVALUATION

OF THE

ALKALI LAKE DISPOSAL SITE

BY

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GEOLOGIC EVALUATION OF THE ALKALI LAKE DISPOSAL SITE

The State Department of Geology and Mineral Industries began studies on a proposed chemical disposal site at Alkali Lake in June 1969. The work was carried out in cooperation with the Oregon State University Department of Environmental Science, which is conducting research under a federal grant. The Lake County Planning Commission, Governor's Advisory Committee on Synthetic Chemicals in the Environment and several other state agencies are interested because of the storage of toxic chemical residues at the lake by Chem Wastes, Inc. The state is also involved to the extent that legislature agreed to accept responsibility for storage of the chemicals at Alkali Lake.

The object of this investigation was to determine if geologic conditions at Alkali Lake were suitable for disposal of toxic chemicals. Geologic structure, relationships of rock formations, chemistry of playa sediments and associated brine pool, surface drainage, underground aquifers and soil permeability, all are relevant to the proposed disposal project. A secondary objective of this study was to estimate reserves of sodium carbonate in the brine pool and playa crust to see if mining would be feasible with low cost backhaul from the disposal operation.

The first phase of geological investigations was to sample foundation material in the vicinity of experimental test plots where various applications of chemicals were to be observed. Apparent permeability was checked and depth to the water table measured. Analyses were made of the brine beneath the test plots. The auger drilling in the summer of 1969 showed that test plots should be located at the south end of the lake where permeability of sediments was low and the water saline. More drilling was done in 1970 for determining the limits of the brine pool as well as sampling the lake beds to a depth of 50 feet. A total of 16 auger holes were drilled in the summer of 1969 and 1970 (see figure 1). Lake sediments above the water table were analyzed for salt content by the State Department of Geology and Mineral Industries. Reconnaissance geologic mapping was done to verify published data and a study made of aerial photographs of the lake to locate faults and evaluate geomorphic features. Prevailing wind direction could be learned by examining the dune structures on the aerial photographs.

Results of this study indicate the lake playa and bordering area to be useable for disposal purposes as far as geological features are concerned. The possibility of chemical liquids or residues reaching useable water supplies by surface drainage or underground seepage appears remote. Low cost backhaul should make the deposits at Alkali Lake economic; however, the mining would be on a small scale because of limited reserves of sodium carbonate. No major problems are evident in connection with disposal of wastes at Alkali Lake.

History and prior investigations

Mining claims were first filed on Alkali Lake in the latter part of the 1800's by a Portland firm which was interested in the boron prospects (later tests showed little boron at Alkali Lake). Prior to World War I the Pearson Engineering Corp., London, England, took an option on the claims along with options at Searles Lake, California, because these dry lakes appeared to them as good mining prospects for soda ash. The outbreak of war terminated this project. Some sodium carbonate was mined from Alkali Lake in the 1920's and sold in Portland as washing soda (Stott, 1952). Eyde Nitrogen Company, Norway, became interested in the property in the 1920's for manufacturing sodium nitrate. Although the process appeared to be commercial, nothing came of the Eyde inquiry.

M.F. Gouge of the Ottawa Department of Mines, Canada, visited Alkali Lake in 1924 to study the potholes and determine how they formed. O.F. Stafford, a mining consultant, was hired by the Oregon Department of Geology and Mineral Industries in 1939 to explore the commercial possibilities of dry lakes in eastern Oregon. The importance of sodium salts for many chemical processes led to a study of the evaporite deposits at Alkali Lake, Summer Lake, and Lake Abert by Allison and Mason in 1947. Later, in 1952, Bonneville Power Administration funded a study by W. J. Stott, Professor of Chemistry at Portland University, to explore for evaporite layers at depths below the playa surface. This study also included other dry lakes in eastern Oregon. Chem Wastes, Inc., Portland, purchased the Alkali Lake patent in 1967 for the purpose of storing and treating chemical wastes. The company also planned to re-examine the commercial value of salts in the playa sediments and in solution in the brine pool and thus take advantage of the low cost backhaul of evaporite to Portland.

Geologic mapping has been done in northern Lake County by the U.S. Geological Survey and the Department of Geology and Mineral Industries. N.L. Mundorff did geologic mapping at Alkali Lake in 1947 for a thesis project at Oregon State College. Some mapping was done during the present project to supplement the earlier work.

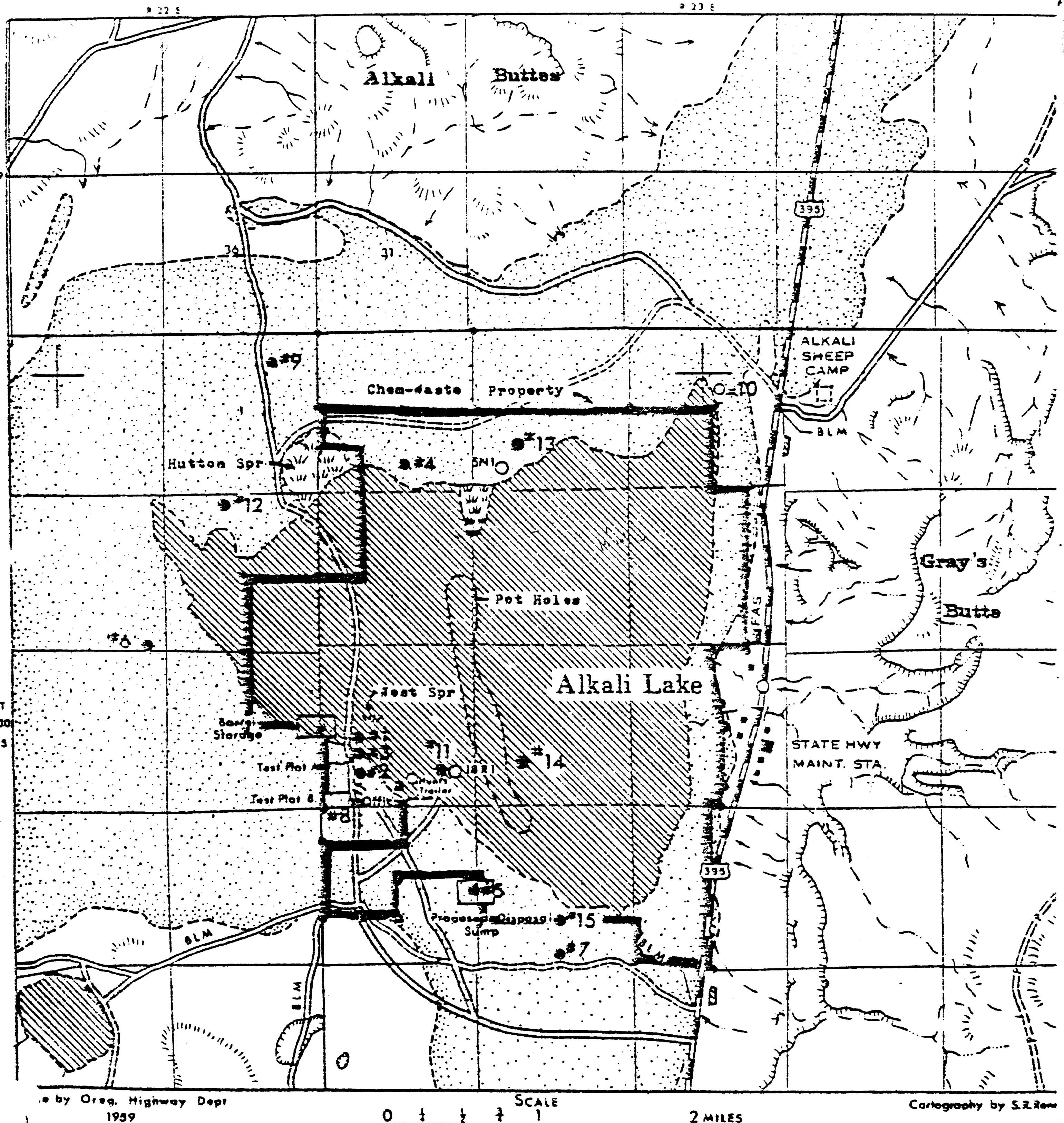
Geography and physiography

Alkali Lake is located in northeastern Lake County about 60 miles north of the city of Lakeview and 15 miles north of Lake Abert in Lake County. The dry lake is approximately 8 miles long by 5 or 6 miles wide. It is separated from North Alkali Lake by small volcanic cones named Alkali Buttes and the highlands between Alkali Lake and Lake Abert are also eruptive volcanic features. The northern extension of Abert Rim borders the east side of Alkali Lake rising 1200 feet above the valley floor. Highway 395 traverses the valley along the base of the Abert fault scarp in a north-south direction roughly parallel to the scarp. Elevation at the lake is 4244 feet. Mean annual temperature is 50°F, rainfall 10 to 16 inches, and evaporation approximately 55 inches per year.

Settlement around Alkali Lake consists of a highway maintenance station, service station, restaurant, and one or two ranches; the remainder of the property is Federal Range Land. In contrast to the desert appearance of the area, fresh water is available 50 to 200 feet below the ground surface. Vegetation is typical of the Oregon High Desert, consisting of sage, greasewood, rabbit brush, and range grasses. The alkali flat is barren of growth except for green patches around springs which flow year around.

Alkali Lake lies within a broad lowland forty miles wide stretching from Summer Lake on the west to Lake Abert and Alkali Lake on the east. This broad depression is bounded by the Winter Ridge fault scarp at Summer Lake and the Abert fault scarp on the east side.

ALKALI LAKE AND VICINITY



STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Figure 1

Several levels of ancient lake terraces are evident on the slopes of buttes and high areas testifying to the existence of a large fresh-water lake during the ice age at a time when the climate was more humid than the present. Drainage in the broad lowland is controlled by cross faults, one set trending northwest and the other northeast. Structural features in the vicinity of Alkali Lake can be seen on aerial photographs.

A north-south lineation in the west half of the playa appears to be a surface drainage course and not a fault trace. Just west of this linear groove is a high area where springs seep out at the surface, and the accompanying growth has prevented erosion of sediments by wind.

The arrangement of sand dunes around the perimeter of the playa shows that winds prevail from the southwest and northeast. This probably has been the case for several hundred years. The dunes at the north end of the playa show the work of varying wind currents as well as the prevailing winds. The varied direction of winds here are caused by Alkali Buttes. Auger drilling disclosed that there is 20 to 30 feet of aeolian deposits at the north and south ends of the lake (see descriptions of auger borings in appendix). Erosional remnants of lake beds are evident along the west sides of the lake and to some extent on the east shore. Mundorff (1947) concluded from his studies that the lake basin is a deflation basin from which 20 or 30 feet of sediment has been stripped by the wind.

Stratigraphy

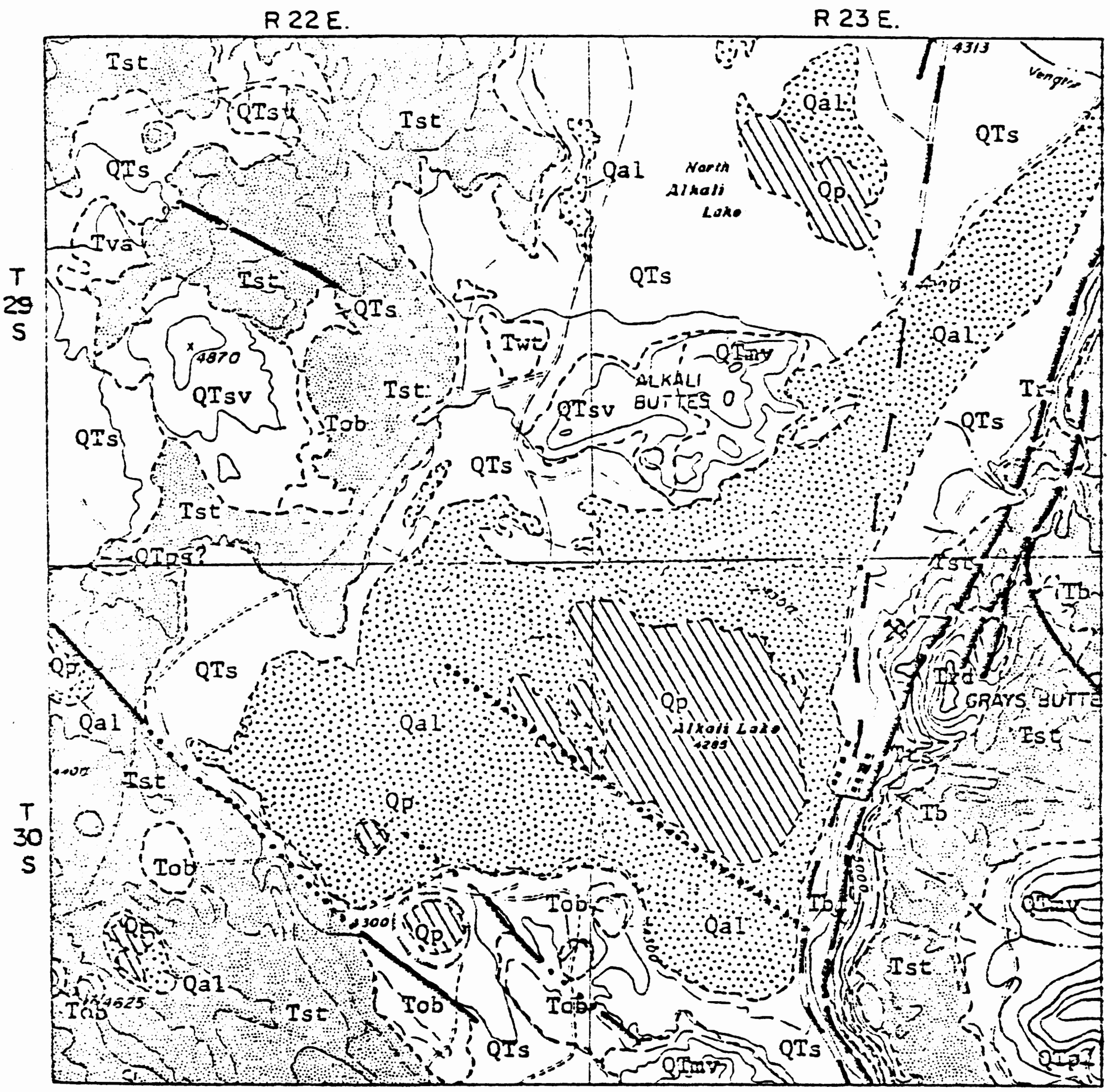
The oldest rocks in the vicinity of Alkali Lake are tuffaceous sediments and tuffs exposed along the Abert scarp south of Gray's Butte. This rock unit (Tts,on geologic map , Fig. 2) is approximately 1300 feet thick (Walker and Repenning, 1965). Several hundred feet of Miocene-Pliocene andesite and basalt flows overlie the oldest rocks . Younger lavas and lacustrine beds of Pliocene age approximately 300 to 400 feet thick rest on the andesite and basalt flows. Pliocene-Pleistocene pyroclastics, basalt and interbedded lake sediments overlie the Pliocene rocks. This upper unit is 150 to 300 feet thick where exposed west and east of the lake playa (Walker, 1963). Cinder cones and volcanic vents were also formed during Pliocene-Pleistocene time. Alluvium, lake sediments, wind deposits, and capping flows of basalt represent deposition during Pleistocene and Holocene time. Allison (1945) found that pumice and ash falls were deposited with the youngest sediments in northern Lake County. Test wells 18 R-1 and 5 N-1 encountered Pliocene volcanics at 170' and 130 feet respectively after drilling through Holocene-Pleistocene and Pleistocene-Pliocene sediments. No prominent unconformities have been recognized in northern Lake County in the mapping done thus far (Walker, 1963).

Rhyolite plugs, (Gray's Butte) dikes,and domes intruded existing rocks some time between the end of Pliocene time and early Pleistocene time. These intrusions appear to occur along faults.

Geologic structure

Southeastern Oregon from Crater Lake to the Idaho border lies within the Basin and Range geomorphic province and between these two locations there are several large north-south trending tectonic depressions bounded by high scarps of uplifted intervening fault blocks (Fuller and Waters, 1929). Alkali Lake and Lake Abert are situated on the east margin

GEOLOGY OF ALKALI LAKE AND VICINITY



Scale 1:125,000

9 MILES

CONTOUR INTERVAL 200 FEET

WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

1970 MAGNETIC DECLINATION

Figure 2.

EXPLANATION

MAP UNITS

HOLOCENE	Qp	Playa deposits Clay, silt, sand, and some evaporites.
HOLO-PLEISTOCENE	Qal	Alluvium Unconsolidated fluviatile gravel, sand, and silt. Large areas of windblown sand designated by stipple pattern.
PLEISTO-PLIOCENE	QTs	Sedimentary deposits Lacustrine, fluviatile, and aeolian sedimentary rocks.
PLIOCENE	Tba Tob Tst	Tba, basaltic and andesitic flows, interbedded sandstone, siltstone, and tuff. Tob, vesicular basalt flows, gray and reddish-gray. Tst, semi-consolidated lacustrine tuffaceous sandstone and siltstone, ash and ashy diatomite, tuff, lapilli tuff, and tuff breccia.
PLIO-MIOCENE	Tb	Basalt Basalt flows, generally dipping 5 to 10 degrees. Many major topographic rims capped by these flows.
MIOCENE	Tts	Tuffaceous sedimentary rocks Mostly fine-grained, poorly to moderately well-bedded tuffaceous sedimentary rocks and some ashy tuffs representing flood plain or shallow lake deposits.

VOLCANIC ROCKS - STRATIGRAPHIC RELATIONS UNCERTAIN

Trd	Intrusive rhyolite and dacite Plugs, dikes, small endogenous domes.
QTp QTps	Pyroclastic rocks of basaltic cinder cones QTp, subareal deposits of unconsolidated, reddish, fine to coarse scoriaceous basaltic ejecta. Age, Miocene(?), Pliocene, and Pleistocene or Recent. QTps, subaqueous deposits of partly consolidated yellowish-brown palagonitized basaltic ejecta.
QTsv	Rocks of silicic vents Dikes, plugs, and complex exogenous domes, including related flows and flow breccias, of dacitic to rhyolitic composition. Age, Pliocene and Pleistocene (?).
QTmv	Rocks of mafic vents Basaltic and andesitic agglomerate, breccia, scoria, cinders, flows, and intrusive masses forming constructional volcanic landforms. Age, Pliocene, Pleistocene, and Recent (?).
Tva	Andesite flows

Figure 3.

of one of these large depressions; Summer Lake, Silver Lake, and Chewaucan Marsh are on the west side. This broad basin is a composite graben consisting of numerous small fault block units resulting from criss-crossing faults. The upthrown fault blocks dip to the east and west away from the main graben basin. Also, smaller fault blocks within the graben, tilt away from the center suggesting that the gross structure is a broad faulted anticline with the crest down-dropped. The greatest displacements occur at the margins of the graben and decrease toward the center (Donath, 1958).

The main fault system, which developed in Pliocene time, divides the region into large blocks separated by N 35° W and N 20° E trending fractures. The northwest-trending faults die out northward, becoming hinge-type faults. Displacement along the northeast-trending Abert fault also decreases to the north. Later faulting on a grand scale superimposed north-south trending fractures over the earlier main fault pattern and produced the characteristic Basin and Range structure. The "Range Faults"(Larson, 1965) are believed to have been initiated in early Pleistocene time (Peterson and McIntyre, 1969). Subordinate faulting adds to the complexity of the structure. The structural evolution of the region relates to tensional stresses and adjustments to igneous activity in the crustal rocks (Ikeagwauni, 1965).

Seismic profiles by Donath (1958) disclose that faults buried under quaternary sediments in the Summer Lake area conform to surface trends and that dips of the faults are nearly vertical.

Folding of crustal rocks in Lake County is believed to have taken place both concurrently and following Pliocene faulting. Deformation appears to have occurred after most eruptive centers had been formed. The entire area was folded into low broad anticlines and synclines with northwest or northeast axial trends (Peterson and McIntyre, 1969).

Correlation of deep wells

Two deep test wells were drilled at Alkali Lake by Portland University in 1952. (see figure 2). The well at the south end of the playa in sec. 18 is referred to as well 18R-1 and the well at the north end of the playa in sec. 5 is referred to as 5N-1. Drilling was halted in the test wells when it seemed apparent that no more saline waters would be encountered. Sands at the top of both wells probably are Holocene aeolian deposits. Directly beneath the aeolian sediments are Pliocene-Pleistocene lake beds (Qts, Walker, 1963). Both wells probably penetrated Pliocene volcanics (Tba and Tob, Walker, 1963) which contained fresh water. Analyses of water from the wells correspond quite closely (see appendix). Based upon stratigraphic relationships described by Walker (1963) Miocene volcanics should be found below the lake playa at a depth of 400 or 500 feet. Older lake beds should underlie the volcanics and may possibly contain brackish or saline water. Saline water was found at 1200 feet in a well on the ZX Ranch south of Summer Lake and when the well was plugged back to 400 feet it produced fresh water (Stott, 1952).

Correlation of auger holes

A total of 15 auger holes were drilled around the periphery of Alkali Lake by the Oregon Department of Geology and Mineral Industries in the summer of 1969 and 1970 to obtain data on the brine pool and to define stratigraphy of lake beds to a depth of 50 feet. Generally speaking, the holes on the outer margin of the playa encountered a covering of aeolian deposits to depths of 10 to 30 feet and beneath these sediments, lake beds were found. (See figure 5). There were

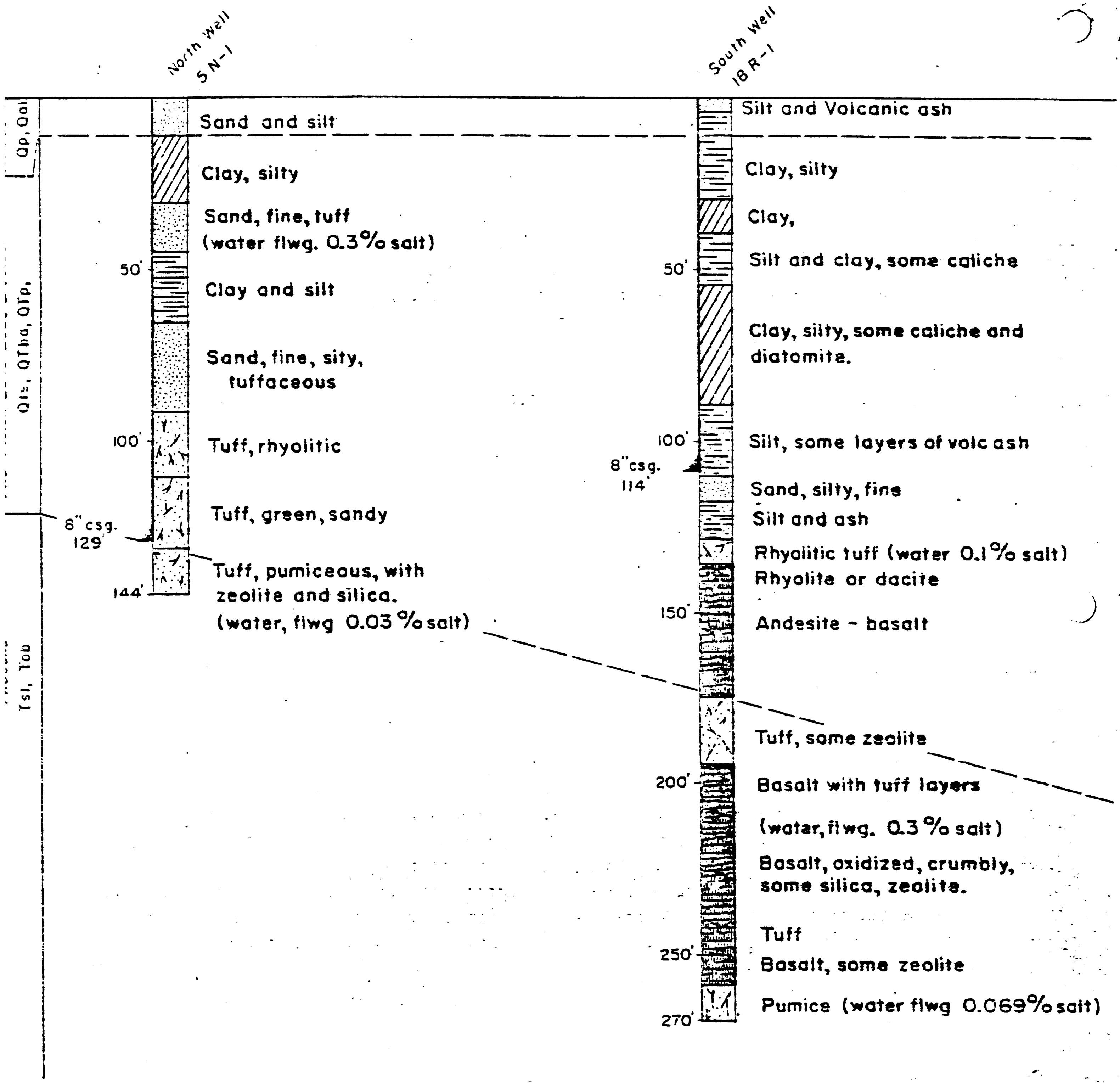


Figure 4 Correlation of wells 5N-1 and 18R-1

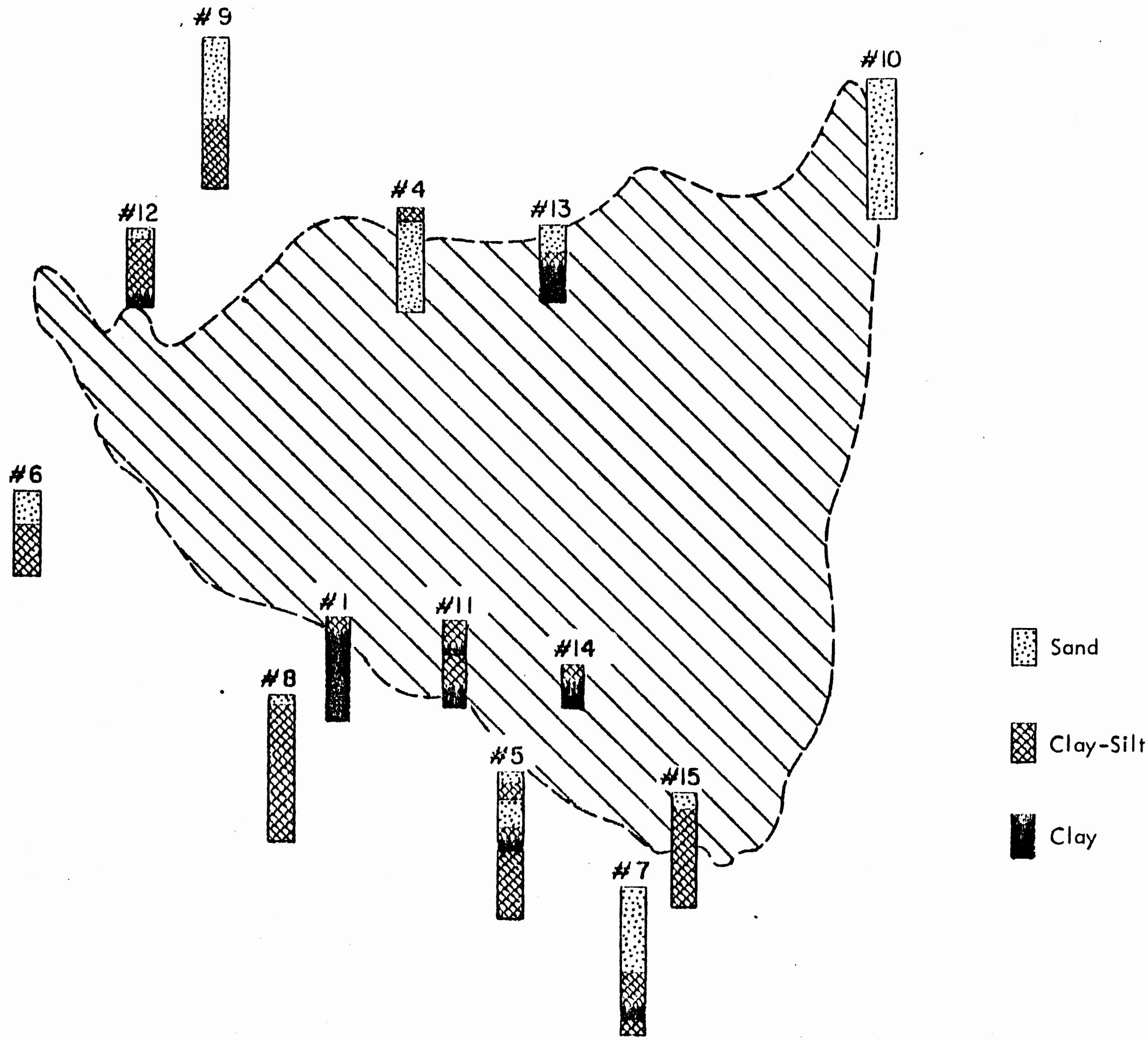


Figure 5 Alkali Lake auger holes

some fine silty sands in the lake beds but silts and clays predominated. Scattered diatoms were noted in auger samples but no diatomite layers were found. Thin beds of peat were drilled in the lower portion of a few holes and thin hard layers of siliceous material were common. Silicified ash beds caused holes No. 10 and 14 to be abandoned prematurely. Most of the samples of lake sediments were intermixed with volcanic debris. Dunes contain a post-lacustrine pumice mixed with aeolian sediments derived from lake beds (Allison, 1945).

Water characteristics

Analysis of water from springs, water wells, and auger holes (see appendix) were made to assist with geologic interpretation and to determine limits of the shallow brine pool. Three main features can be seen from these analyses: 1) the brine pool is situated adjacent to a northwest-trending fault barrier at the south end of the playa (see isogram in appendix); 2) the spring water and deep fresh water aquifers show a common source; and 3) water supply to the basin from the surface and from below is relatively fresh. Evidently the playa salts and brine pool result from evaporation of these relatively fresh waters (a conclusion suggested by Allison and Mason, 1947). Presence of arsenic in the deep water and concentration of arsenic in the brine pool confirmthis conclusion. The arsenic may in some way be related to mineralization along the barrier fault at the south end of the lake. Metals found in the water sample from auger hole No. 6 could also be associated with this postulated fault. It has been suggested, however, that these metallic constituents could have come from corrosion of shells and cartridge brackets left on the Air Corps firing range. Hole No. 6 is situated on the approach to the old target area.

Analyses made by Portland University in 1952 (see appendix) show a marked decrease in salinity in formation water below a depth of 40 feet in well 18R-1. Water sampled in well 5N-1 was fairly fresh even at the top. Evidently only the top 20 or 30 feet of water contained in the lake sediments is saline; below this depth the salinity decreases.

Soda ash reserves

Several estimates of evaporite reserves have been made in past investigations of Alkali Lake. Most investigators agreed that sodium carbonate was the chief prospect for mining and that Alkali Lake seemed to hold the largest deposit of this salt of any of the dry lakes in eastern Oregon (Stott, 1952). Sodium carbonate is a relatively rare occurrence in nature, being formed from certain spring and alkali lake brines. Most sodium carbonate used today is made artificially by the ammonia-soda process (Solvay Process) for use in organic and inorganic chemicals. Sodium carbonate has been mined at Alkali Lake and sold for washing soda. One problem not mentioned in prior studies is the presence of arsenic in the evaporite and the brine. Can it be easily separated from the sodium carbonate?

The principal salts at Alkali Lake are: sodium carbonate, sodium chloride, and sodium sulfate. There are also smaller amounts of potassium sulfate, phosphate, boron, arsenic, silica, iodine, and fluoride intermixed with the soda. The greatest concentration of salts at Alkali Lake occurs in the pot hole area (see figure 1). Allison and Mason (1947) sampled the potholes to a depth of 4 feet to check salt content of the evaporite lenses and underlying lake beds. They found the lenses to be 3 or 4 feet thick in the center of the "potholes" tapering to a few inches at the perimeter. The "potholes" range from 2 feet to 30 feet in diameter. The top portion of

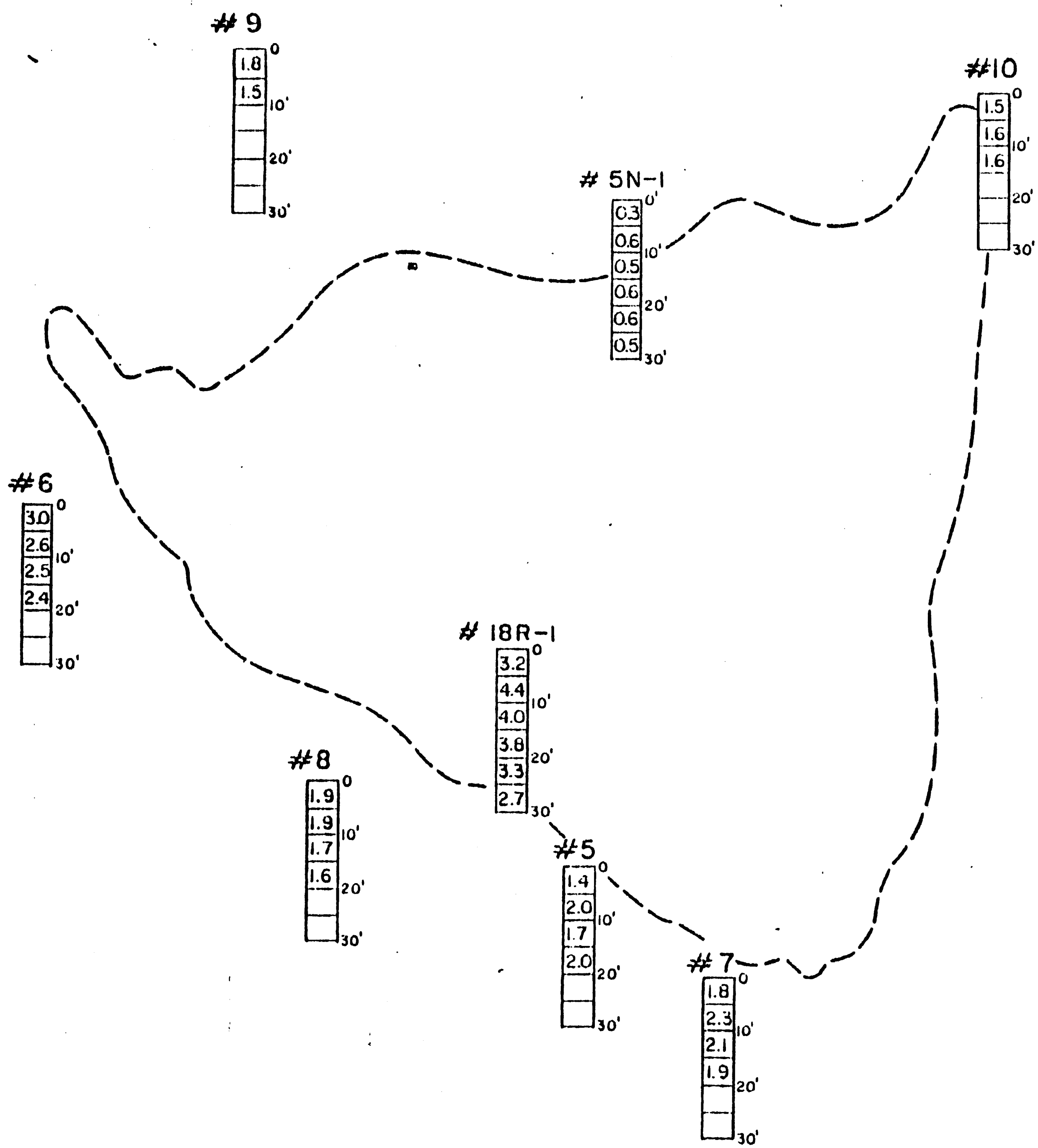


Figure 6. Percentage of salts in the playa sediments

the lens analyzed 40% sodium carbonate decreasing to 18% at 42 inches. Tests on well 18R-1 show that sodium carbonate diminishes to 1% at a depth of 20 feet; it is reasonable to expect a similar decline beneath the potholes.

The surface crust on the playa yielded 7% sodium carbonate (see figure 4) in tests made by Allison and Mason (1947). Replacement of evaporite was checked at one pothole during the 1947 project. After one year a 13-inch layer of new crystals formed in a pothole that had been cleaned of evaporite. The potholes are thought to originate from seepage of fresh water from the deep aquifer upward to the playa. Evaporation and concentration of salts occurs near the surface of the potholes and crystals form when saturation is reached. Surface crusts at Summer Lake yielded 5 tons of salt per acre (Allison and Mason, 1947), 3.5 tons of which are sodium carbonate.

Sodium carbonate concentrated enough to extract commercially at Alkali Lake is limited to the upper 20 or 30 feet of the brine pool. Limits of the producible brine are assumed to fall above the 20,000 mc mho line (see figure 7). Studies of auger samples indicate that the lake beds have low permeability and porosity but no laboratory tests were made in this investigation. Effective porosity is assumed to be 10% and concentration of sodium carbonate approximately 8% in the brine. Total recoverable reserves of sodium carbonate at Alkali Lake appear to be:

Brine Pool	200,000 tons
Potholes	100,000 tons
Surface Crust	10,000 tons
Total	310,000 tons

Inasmuch as the average annual evaporation rate in Lake County is 55 inches (Waring, 1908), some replacement of sodium carbonate can be expected annually. However, mining operations depending on solar evaporation in the playas of southeastern California have failed even though the water source contained a much larger dissolved content than source waters at Alkali Lake (Stott, 1952).

Summary and conclusions

All the geologic evidence suggests that Alkali Lake is a closed drainage basin. Surface water appears to drain from all directions to the lake flat. Geologic structure indicates that regional drainage is south to southeast in the Summer Lake-Lake Abert graben. Artesian flows in wells 18R-1 and 5N-1 establish that the deep fresh-water aquifer is separated from shallower water zones by confining layers of sedimentary rock. The occurrence of several large fresh-water springs and artesian wells in the vicinity of the lake playa show that ground water is moving into the basin; thus, liquids placed on the ground surface are not likely to escape the lake basin. Permeability of lake beds is generally low as seen from the auger samples; therefore, movement of fluids through them should be slowed considerably. Where wind-deposited sand occurs around

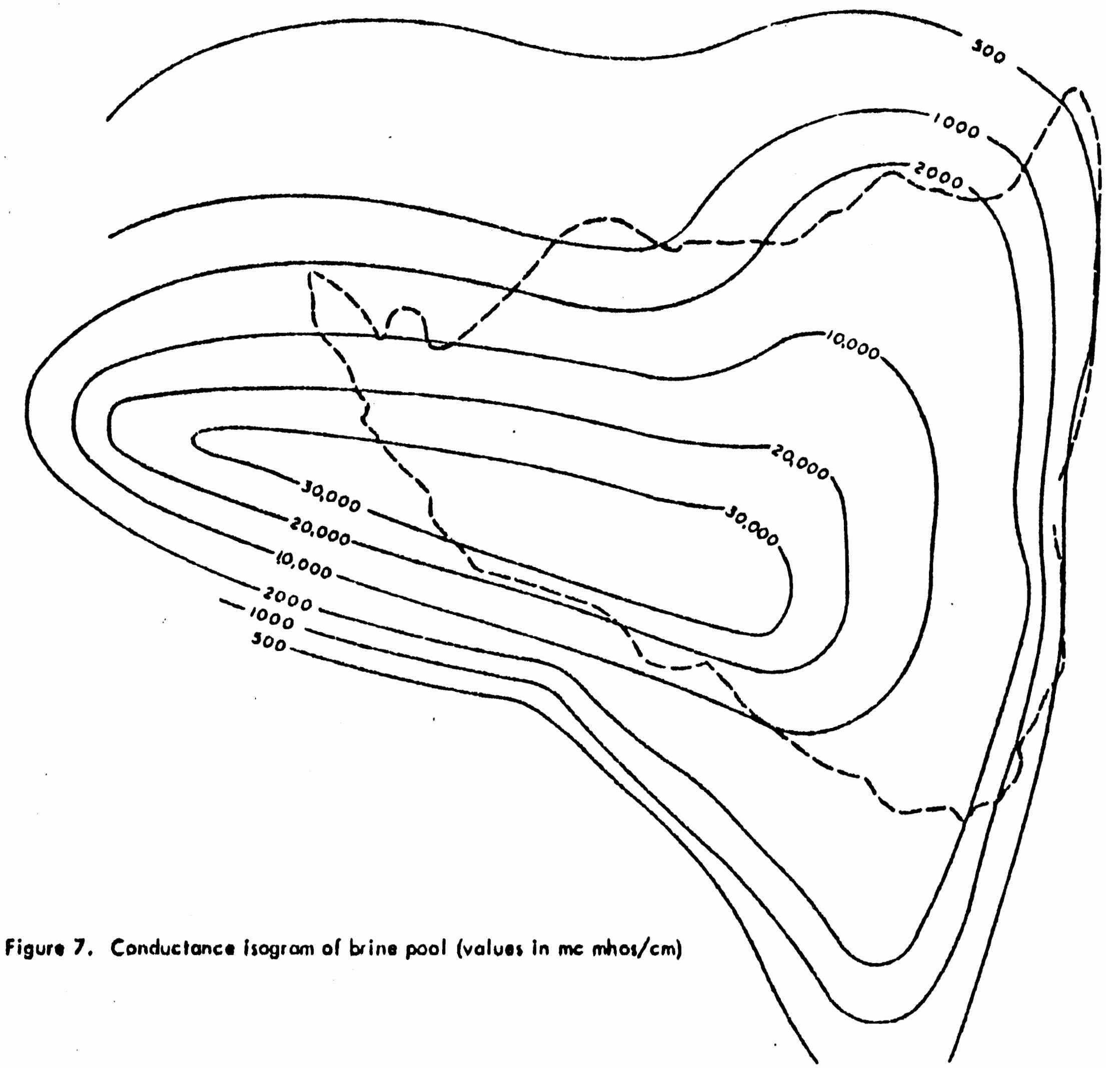


Figure 7. Conductance isogram of brine pool (values in mc mhos/cm)

the playa margins, seepage of surface-applied liquid would be rapid until lake beds were encountered. Some of the lake bed silt layers transmit fluid fairly well as seen in the 15-foot hole near the Chem Waste office. This hole can be pumped at approximately 6 gpm of alkali water without going dry, but the underlying clayey layers would retard vertical movement of fluids. Lateral seepage would be toward the brine pool.

Geology of the Alkali Lake playa has been covered in prior projects so the present investigation offers only a few additions to geologic interpretations, mainly to describe the lake sediments to a depth of 50 feet and establish limits of the brine pool. Previous mapping is used here to relate geology to proposed disposal operations. A fault along the south lake margin is indicated by the salinity isogram as well as a lineament on the aerial photograph of the playa. Springs occur in the west half of the playa but no surface expression of structure can be identified; perhaps some north-south trending structure influences upward seepage.

The possibility of economic mining of sodium carbonate depends upon low cost transportation to markets. Reserves of this salt are relatively small and would support only a small venture. Source of the brine appears to be in the deep fresh-water zone which evaporates after reaching the surface; thus, renewal of salt supply will be quite slow. The brine is confined to the upper 30 feet of the lake beds and below that depth salinity decreases rapidly. The presence of arsenic in the evaporites may interfere with processing the soda ash.

Use of the lake playa for disposal of chemical wastes has merit as there is little danger of polluting usable water supplies. The location is remote and land-use potential low. Methods of disposing of toxic chemical wastes being tested at Alkali Lake by Oregon State University Department of Environmental Science include degradation by soil bacteria, degradation by photosynthesis, surface spreading dilution in conjunction with bacterial degradation, and range brush control. Some other methods which reportedly hold promise for use at Alkali Lake are dehydration, high temperature incineration, and chemical neutralization utilizing alkaline salts contained in the brine pool. Chem Waste, Inc. also may utilize the property for storage of chemical residues for recycling to secondary uses.

Wind erosion will be a problem if the lake site is used for disposal of solid waste residues. Sand dunes around the perimeter of the playa testify to the erosive force of the wind. Prevailing wind direction is from the southwest and northeast but cross currents also occur because of topographic obstacles. A diversity of dune alignments is evident at the north end of the playa on aerial photographs. Relative to the wind, odors from spread wastes will be noticeable for some distance unless methods can be devised to screen them. Another detrimental character of the site is the alkaline soil which will likely retard bacterial activity. Results of test plot studies will undoubtedly determine to what extent this is true.

The State Department of Environmental Quality is the licensing agency for disposal facilities and may place restrictions on the proposed operations or require certain monitoring stations. The State Engineer may, in conjunction with the Department of Environmental Quality, request test drilling and monitoring wells. Recommendations for additional work by the Oregon Department of Geology and Mineral Industries include a cored hole to 50 feet to better define the lake beds and measurements for permeability or percolation tests on fluid seepage in the lake beds. Seismic profiles may be helpful in the interpretation of subsurface geology but they are not essential, especially if another deep test hole is drilled.

BIBLIOGRAPHY

Allison, I. S., 1945, Pumice Beds at Summer Lake: Geol. Soc. Ameria Bull., v. 56, p. 791-794.

Allison, I. S. and Mason, R. S., 1947, Sodium Salts of Lake County, Oregon: Oregon Dept. Geology and Mineral Industries, Short Paper 17.

Dole, H. M., 1941, Petrography of Quaternary Lake Sediments of Northern Lake County: Master's thesis Oregon State College.

Donath, F. A., 1958, Basin-Range Structure of South-Central Oregon: doctoral diss. Stanford University.

Fuller, R. E. and Waters, A. C., 1929, The Nature and Origin of the Horst and Graben Structure of Southern Oregon: Jour. Geology, v. 37, p. 204-238.

Ikeagwauni, F. D., 1965, Photo Geology of the Picture Rock Pass Area, Lake County: Master's thesis, University of Oregon.

Larson, E. E., 1965, The Structure, Stratigraphy and Paleomagnetics of the Plush Area, Southeastern Lake County: doctoral diss. University of Colorado.

Mundorff, N. L., 1947, Geology of Alkali Lake Basin: Master's thesis, Oregon State College.

Peterson, N. V. and McIntyre, J. R., 1969, Geology and Mineral Resources of Eastern Klamath and Western Lake County: Oregon Dept. Geology and Mineral Industries, Bull. 66.

Stafford, O. F., 1939, Preliminary Report on Oregon Saline Lakes: Oregon Dept. Geology and Mineral Industries Short Paper 1.

Stott, W. J., 1952, Investigation of Saline Deposits in Southern Oregon: Bonneville Power Admin. Study Contract No. 1 6 p - 7748 to University of Portland.

Trauger, F. D., 1950, Basic Groundwater Data in Lake County: U.S. Geol. Survey Open-file Report.

Van Winkle, W., 1914, Quality of Surface Water of Oregon: U.S. Geol. Survey Water-Supply Paper 363.

Walker, G. W., 1963, Geology of the Eastern Half of the Klamath Falls (AMS) Quadrangle; U.S. Geol. Survey Map MF-260.

Walker, G. W. and Repenning, C. A., 1965, Geol. Map of the Adel Quadrangle: U.S. Geol. Survey Map I-446.

Walker, G. W., et al., 1967, Geology of the East Half of the Crescent Quadrangle: U.S. Geol. Survey Map I-493.

Waring, G. A., 1908, Geol. and Water Resources of a Portion of South-Central Oregon: U.S. Geol. Survey Water-Supply Paper 220.

PAGE	19 -	WEST SPRINGS -	TOTAL SOLIDS
"	20	HUTTON "	182
			311
	23	AUGER HOLE IN BRINE POOL	4847

State of Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE MEMO

To: Vern Newton, Geology Dept.

Date: 1/14/71

From: Alan W. Hose

Subject: Alkali Lake Arsenic

Results of sample collected on 12/20/70 by Dr. William Kondo of Chem Wastes Inc., taken from a fresh water spring on the west side of Alkali Lake are 0.018 mg/l arsenic.

bf

Public Health Service

Recommended Max.	0.01 mg/l	Arsenic
Max. Allowable	0.05 mg/l	Arsenic

State of Oregon

DEPARTMENT OF ENVIRONMENTAL QUALITY

INTEROFFICE MEMO

To: J.C. Newton, Geology Department

Date: 9/24/70

From: Alan W. Hose

Subject: Alkali Lake

Results of analysis for Alkali Lake are as follows:

	pH	Conductance	Arsenic (mg/l)
Auger hole # 12	8.9	1220	7.2
Pot hole - Playa	10.0	94000	127
Auger hole # 13	9.6	2500	3.2
Auger hole # 11	9.7	19000	2.2
Auger hole # 15	9.6	3000	3.2

Alan Hose

OREGON STATE BOARD OF HEALTH

Mineral Content of Water

CARD No.	1 2 (1)
SYSTEM No.	X (2-)
SAMPLE I.D. No.	(7-)
1 Raw, 2 Treated, 3 Blend, 4 Abandoned	(10)

Name of Water Supply: Alkali Lake(Hunt Trailor)

County: Lake

Source:

Sampling Point:

Bottle No.:

Collected By: VCN — Date: 7 X 31 X 69 (11-16)

Analysis By: A.W. Hose — Date: 8 X 21 X 69

(MONTH, Day, YEAR)

Laboratory Number: 1495

NOTE: Double vertical line below shows location of decimal point.

*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75	mg/l, or as shown	Cols.
Color, units (15)*	5 0	17-18
Turbidity, JTU (5)*	1	19-22
Solids, Total (500)*	1 5 4 0	23-26
Solids, Volatile	4 8 4	27-30
Carbon Dioxide	-	31-33
pH	9 ‖ 1	34-36
Alkalinity, Total as $CaCO_3$		37-39
Hardness as $CaCO_3$	6 3	40-43
Calcium	1 5	44-47
Magnesium	6	48-51
Total Iron (0.3)*	0 0 6	52-54
Manganese (0.05)*	0 0 1	55-57
Arsenic (0.01)* (0.05)**	0 9 0	58-61
Alkalinity, Total as $CaCO_3$	6 3 0 0	62-68
Boron	5 4	69-75

Card No. 2, Card Columns 17-75	mg/l, or as shown	Cols.
Conductance (mc mho/cm)	13 6 0 0	17-20
Chlorides (250)*		21-24
Sodium		25-28
Potassium		29-31
Fluoride	1 0 ‖ 1	32-
Phosphates (Soluble Ortho)	2 1 ‖ 8	35-
Sulfates (250)*	1 2 5 0	38-41
Silicon	3 7	42-44
Aluminum	0 ‖ 0 2	45-
Nitrogen, Ammonia	0 ‖ 0 2	48-
Nitrogen, Nitrite	< ‖ 0 1	51-
Nitrogen, Nitrate (45)*	0 ‖ 0 6	54-
Chlorides	1 4 5 0	50-
Sodium	4 6 0 0	64-
Potassium	3 2 5	70-

REMARKS

OREGON STATE BOARD OF HEALTH

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Mineral Content of Water

CARD No.	1 2 (1)
SYSTEM No.	X (2-6)
SAMPLE I.D. No.	(7-9)
1 RAW, 2 TREATED, 3 BLEND, 4 ABANDONED	(10)

Name of Water Supply: Alkali Lake

County: Lake

Source: Spring on West side

Sampling Point: West Side of Alkali Lake

Bottle No.

Collected By: V. Newton — Date: 9 X 25 X 69 (11-16)

Analysis By: A.W. Hose — Date: 10 X 10 X 69

(MONTH, DAY, YEAR)

Laboratory Number: 1540

NOTE: Double vertical line below shows location of decimal point.

*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75	mg/l, or as shown	
Color, units (15)*	0	17-18
Turbidity, JTU (5)*	0	19-22
Solids, Total (500)*	182	23-26
Solids, Volatile	45	27-30
Carbon Dioxide	2.4	31-33
pH	8.1	34-36
Alkalinity, Total as $CaCO_3$	146	37-39
Hardness as $CaCO_3$	15.2	40-43
Calcium	4.1	44-47
Magnesium	1.2	48-51
Total Iron (0.3)*	0.08	52-54
Manganese (0.05)*	0.11	55-57
Arsenic (0.01)* (0.05)**	0.267	58-61
Boron	< 0.5	62-68
		69-75

Card No. 2, Card Columns 17-75	mg/l, or as shown	
Conductance (mc mho/cm)	710	17-20
Chlorides (250)*	30.9	21-24
Sodium	90	25-28
Potassium	20	29-31
Fluoride	0.44	32-34
Phosphates (Soluble Ortho)	0.15	35-37
Sulfates (250)*	80	38-41
Silicon	47	42-44
Aluminum	0.01	45-47
Nitrogen, Ammonia	0.08	48-50
Nitrogen, Nitrite	< 0.1	51-53
Nitrogen, Nitrate (45)*	0.5	54-57
		58-63
		64-69
		70-75

REMARKS

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Mineral Content of Water

CARD No.	1 2 (1)
SYSTEM No.	X (2-6)
SAMPLE I.D. No.	(7-9)
1 RAW, 2 TREATED, 3 BLEND, 4 ABANDONED	(10)

Name of Water Supply: Alkali Lake

County: Lake

Source: Hutton Spring

Sampling Point: Surface of Spring

Bottle No. ______

Collected By: V. Newton — Date: 0 X 25 X 69 (11-16)

Analysis By: A. W. Hose — Date: 10 X 10 X 69

(MONTH, DAY, YEAR)

Laboratory Number: 1536

NOTE: Double vertical line below shows location of decimal point.
*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75

mg/l, or as shown

Color, units (15)*	0	17-18
Turbidity, JTU (5)*	3	19-22
Solids, Total (500)*	311	23-26
Solids, Volatile	78	27-30
Carbon Dioxide	1	31-33
pH	8.4	34-36
Alkalinity, Total as $CaCO_3$	127	37-39
Hardness as $CaCO_3$	43.4	40-43
Calcium	8.0	44-47
Magnesium	5.7	48-51
Total Iron (0.3)*	0.03	52-54
Manganese (0.05)*	0.01	55-57
Arsenic (0.01)* (0.05)**	<0.005	58-61
Boron	<0.5	62-68
		69-75

Card No. 2, Card Columns 17-75

mg/l, or as shown

Conductance (mc mho/cm)	370	17-20
Chlorides (250)*	29.2	21-24
Sodium	60	25-28
Potassium	12	29-31
Fluoride	0.37	32-34
Phosphates (Soluble Ortho)	0.13	35-37
Sulfates (250)*	24	38-41
Silicon	40	42-44
Aluminum	<0.1	45-47
Nitrogen, Ammonia	<0.1	48-50
Nitrogen, Nitrite	<0.1	51-53
Nitrogen, Nitrate (45)*	0.95	54-57
		58-63
		64-69
		70-75

REMARKS

OREGON STATE BOARD OF HEALTH

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Mineral Content of Water

CARD No. 1 2 | 1

Name of Water Supply	Alkali Lake	SYSTEM No. X 2-6
County	Lake	SAMPLE I.D. No. 7-9
Source	Well 5N-1	1 Raw, 2 Treated, 3 Blend, 4 Abandoned 10
Sampling Point	Well Head	Bottle No.
Collected By	V. Newton	Date 9 X 25 X 69 11-16
Analysis By	A.W. Hose	Date 10 X 10 X 69
Laboratory Number	1538	(MONTH, DAY, YEAR)

NOTE: Double vertical line below shows location of decimal point.
*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75 (mg/l, or as shown)

Color, units (15)*	0	17-18
Turbidity, JTU (5)*	2	19-22
Solids, Total (500)*	293	23-26
Solids, Volatile	52	27-30
Carbon Dioxide	0.6	31-33
pH	8.6	34-36
Alkalinity, Total as $CaCO_3$	122	37-39
Hardness as $CaCO_3$	49.2	40-43
Calcium	7.5	44-47
Magnesium	7.4	48-51
Total Iron (0.3)*	0.04	52-54
Manganese (0.05)*	0.01	55-57
Arsenic (0.01)* (0.05)**	0.036	58-61
Boron	<0.5	62-68
		69-75

Card No. 2, Card Columns 17-75 (mg/l, or as shown)

Conductance (mc mho/cm)	382	17-20
Chlorides (250)*	29.6	21-24
Sodium	55	25-28
Potassium	15	29-31
Fluoride	0.38	32-34
Phosphates (Soluble Ortho)	0.18	35-37
Sulfates (250)*	25	38-41
Silicon	45	42-44
Aluminum	<0.1	45-47
Nitrogen, Ammonia	<0.1	48-50
Nitrogen, Nitrite	<0.1	51-53
Nitrogen, Nitrate (45)*	1.2	54-57
		58-63
		64-69
		70-75

REMARKS

Mineral Content of Water

CARD No.	1 2 (1)
SYSTEM No.	X (2-6)
SAMPLE I.D. No.	(7-9)
1 RAW, 2 TREATED, 3 BLEND, 4 ABANDONED	(10)

Name of Water Supply: Alkali Lake

County: Lake

Source: Well 18R-1

Sampling Point: Well head

Bottle No. ____

Collected By: V. Newton — Date: 9 X 25 X 69 (11-16)

Analysis By: A.W. Hose — Date: 10 X 10 X 69

(MONTH, DAY, YEAR)

Laboratory Number: 1535

NOTE: Double vertical line below shows location of decimal point.

*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75

	mg/l, or as shown	
Color, units (15)*	0	17-18
Turbidity, JTU (5)*	0	19-22
Solids, Total (500)*	4 9 7	23-26
Solids, Volatile	6 6	27-30
Carbon Dioxide	-	31-33
pH	9 ‖ 9	34-36
Alkalinity, Total as $CaCO_3$	2 7 3	37-39
Hardness as $CaCO_3$	0 5	40-43
Calcium	0 ‖ 2	44-47
Magnesium	< 0 ‖ 1	48-51
Total Iron (0.3)*	0 ‖ 0 3	52-54
Manganese (0.05)*	0 ‖ 0 4	55-57
Arsenic (0.01)* (0.05)**	0 ‖ [illegible] 4 5	58-61
Boron	< 0 ‖ 5	62-68
		69-75

Card No. 2, Card Columns 17-75

	mg/l, or as shown	
Conductance (mc mho/cm)	6 4 0	17-20
Chlorides (250)*	3 5 ‖ 6	21-24
Sodium	1 4 0	25-28
Potassium	1 5	29-31
Fluoride	0 ‖ 6 2	32-34
Phosphates (Soluble Ortho)	0 ‖ 4 6	35-37
Sulfates (250)*	3 2	38-41
Silicon	6 2	42-44
Aluminum	< ‖ 0 1	45-47
Nitrogen, Ammonia	< ‖ 0 1	48-50
Nitrogen, Nitrite	< ‖ 0 1	51-53
Nitrogen, Nitrate (45)*	< ‖ 0 5	54-57
		58-63
		64-69
		70-75

REMARKS ____

OREGON STATE BOARD OF HEALTH
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Mineral Content of Water

CARD No.	1 2
SYSTEM No.	X
SAMPLE I.D. No.	
1 RAW, 2 TREATED, 3 BLEND, 4 ABANDONED	

Name of Water Supply: Alkali Lake (Test Plot #1)
County: Lake
Source:
Sampling Point: Auger Hole #3
Bottle No.
Collected By: VCN — Date: 7 X 30 X 69 (11-16)
Analysis By: A.W. Hose — Date: 8 X 21 X 69
(MONTH, DAY, YEAR)
Laboratory Number: 1496

NOTE: Double vertical line below shows location of decimal point.
*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75	mg/l, or as shown	Columns	Card No. 2, Card Columns 17-75	mg/l, or as shown	Columns
Color, units (15)*	5 0	17-18	Conductance (mc mho/cm)	38 0 0 0	17-20
Turbidity, JTU (5)*		19-22	Chlorides (250)*		21-24
Solids, Total (500)*	74 8 4 7	23-26	Sodium		25-28
Solids, Volatile	25 0 8 5	27-30	Potassium		29-31
Carbon Dioxide	-	31-33	Fluoride	12 7 5	32-
pH	1 0	34-36	Phosphates (Soluble Ortho)	82	35-
Alkalinity, Total as $CaCO_3$		37-39	Sulfates (250)*	30 0 0	38-4
Hardness as $CaCO_3$	6 6	40-43	Silicon	0 1	42-44
Calcium	1 6	44-47	Aluminum	0 0 4	45-
Magnesium	0 4	48-51	Nitrogen, Ammonia	0 1 1	48-
Total Iron (0.3)*	0 3 0	52-54	Nitrogen, Nitrite	4 0 1	51-
Manganese (0.05)*	0 0 2	55-57	Nitrogen, Nitrate (45)*	0 2 2	54-
Arsenic (0.01)* (0.05)**	16 0	58-61	Chloride	3 0 5 0	58-
Alkalinity, Total as $CaCO_3$	25 0 0 0	62-68	Sodium	12 5 0 0	64-
Boron	1 0 0	69-75	Potassium	8 1 3	70-

REMARKS

OREGON STATE BOARD OF HEALTH

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Mineral Content of Water

CARD No. 1 2 1

SYSTEM No. [ ] X [ ] 2-

SAMPLE I.D. No. [ ] 7-9

1 RAW, 2 TREATED, 3 BLEND, 4 ABANDONED [ ] 10

Name of Water Supply: Alkali Lake

County: Lake

Source: Auger hole #4

Sampling Point: Surface of Hole

Bottle No.

Collected By: V. Newton — Date: 9 X 25 X 69 — 11-16

Analysis By: A.W. Hose — Date: 10 X 10 X 69

(MONTH, DAY, YEAR)

Laboratory Number: 1537

NOTE: Double vertical line below shows location of decimal point.

*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75

mg/l, or as shown

Color, units (15)*	5	17-18
Turbidity, JTU (5)*	160	19-22
Solids, Total (500)*	2113	23-26
Solids, Volatile	278	27-30
Carbon Dioxide	-	31-33
pH	9.9	34-36
Alkalinity, Total as $CaCO_3$	395	37-39
Hardness as $CaCO_3$	3.1	40-43
Calcium	0.4	44-47
Magnesium	0.5	48-51
Total Iron (0.3)*	0.17	52-54
Manganese (0.05)*	0.09	55-57
Arsenic (0.01)* (0.05)**	0.145	58-61
Boron	<0.5	62-68
		69-75

Card No. 2, Card Columns 17-75

mg/l, or as shown

Conductance (mc mho/cm)	780	17-20
Chlorides (250)*	268	21-24
Sodium	175	25-28
Potassium	41	29-31
Fluoride	1.95	32-34
Phosphates (Soluble Ortho)	0.64	35-37
Sulfates (250)*	27	38-41
Silicon		42-44
Aluminum	<0.1	45-47
Nitrogen, Ammonia	0.2	48-50
Nitrogen, Nitrite	<0.1	51-53
Nitrogen, Nitrate (45)*	0.14	54-57
Silicon	126	58-63
		64-67

REMARKS

Mineral Content of Water

CARD No. | 1 | 2 | 1

Name of Water Supply: Alkali Lake - Auger Drilling — SYSTEM No. ☐☐ X ☐☐☐ 2-

County: Lake — SAMPLE I.D. No. ☐☐☐ 7-

Source: hole #5 — 1 RAW, 2 TREATED, 3 BLEND, 4 ABANDONED ☐ 10

Sampling Point: Water Level 22' — Bottle No. 5

Collected By: Dept. of Geol & Min Ind. — Date 0 6 X 1 3 X 7 0 11-16

Analysis By: AWH — Date 0 7 X 0 6 X 7 0

(MONTH, DAY, YEAR)

Laboratory Number: 1698

NOTE: Double vertical line below shows location of decimal point.

*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75 (mg/l, or as shown)			Card No. 2, Card Columns 17-75 (mg/l, or as shown)		
Color, units (15)*		17-18	Conductance (mc mho/cm)	510	17-20
Turbidity, JTU (5)*		19-22	Chlorides (250)*	378	21-24
Solids, Total (500)*		23-26	Sodium	1190	25-28
Solids, Volatile		27-30	Potassium	150	29-31
Carbon Dioxide		31-33	Fluoride	3.7	32
pH	8.9	34-36	Phosphates (Soluble Ortho)	0.61	35
Alkalinity, Total as $CaCO_3$	246	37-39	Sulfates (250)*	1030	38-4
Hardness as $CaCO_3$	304	40-43	Silicon	6	42-4
Calcium	64	44-47	Aluminum	<0.1	45
Magnesium	35	48-51	Nitrogen, Ammonia	0.6	48
Total Iron (0.3)*	<0.02	52-54	Nitrogen, Nitrite	0.1	51
Manganese (0.05)*	0.02	55-57	Nitrogen, Nitrate (45)*	<0.80	54
Arsenic (0.01)* (0.05)**	34	58-61	Cu	<0.05	56
B	4.0	62-68	Ni	<0.5	6
Cr	<0.1	69-75	Pb	<0.5	7

Ag <0.02

Hg <2

REMARKS

OREGON STATE BOARD OF HEALTH
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Mineral Content of Water

CARD No.	1 2
SYSTEM No.	X — 2-6
SAMPLE I.D. No.	7-9
1 Raw, 2 Treated, 3 Blend, 4 Abandoned	10

Name of Water Supply: Alkali Lake Auger Drilling

County: Lake

Source: Hole #6

Sampling Point: Water Level 16'

Bottle No. 6

Collected By: Dept. of Geo & Min Ind — Date: 06 X 13 X 70 (11-16)

Analysis By: AWH — Date: 07 X 06 X 70

(Month, Day, Year)

Laboratory Number: 1699

NOTE: Double vertical line below shows location of decimal point.

*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75	mg/l, or as shown	Cols.	Card No. 2, Card Columns 17-75	mg/l, or as shown	Cols.
Color, units (15)*		17-18	Conductance (mc mho/cm)	33000	17-20
Turbidity, JTU (5)*		19-22	Chlorides (250)*	3510	21-24
Solids, Total (500)*		23-26	Sodium	9600	25-2-
Solids, Volatile		27-30	Potassium	1000	29-31
Carbon Dioxide		31-33	Fluoride	6 0	32-
pH	9 0	34-36	Phosphates (Soluble Ortho)	110	35-
Alkalinity, Total as $CaCO_3$	16500	37-39	Sulfates (250)*	7700	38-41
Hardness as $CaCO_3$	4 1 1	40-43	Silicon	6	42-44
Calcium	2 8	44-47	Aluminum	<0 1	45-
Magnesium	8 3	48-51	Nitrogen, Ammonia	<0 1	48-
Total Iron (0.3)*	0 1 4	52-54	Nitrogen, Nitrite	<0 1	51-
Manganese (0.05)*	0 0 5	55-57	Nitrogen, Nitrate (45)*	0 3 0	54-
Arsenic (0.01)* (0.05)**	2 5 2	58-61	Cu	0 4 8	58-
B	1 1 8	62-68	Ni	0 8	64-
Cr	<0 1	69-75	Pb	<0 5	

Ag 0.04
Hg 8

REMARKS

OREGON STATE BOARD OF HEALTH

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Mineral Content of Water

CARD No. 1 2

Name of Water Supply Alkali Lake - Auger Drilling SYSTEM No. __ __ X __ __ __

County Lake SAMPLE I.D. No.

Source Hole #7 1 Raw, 2 Treated, 3 Blend, 4 Abandoned

Sampling Point Water Level 20' Bottle No. 7

Collected By Dept of Geo & Min Ind. Date 06 X 13 X 70 11-16

Analysis By AWH Date 07 X 06 X 70

(MONTH, DAY, YEAR)

Laboratory Number 1700

NOTE: Double vertical line below shows location of decimal point.

*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75 (mg/l, or as shown)	Value	Columns	Card No. 2, Card Columns 17-75 (mg/l, or as shown)	Value	Columns
Color, units (15)*		17-18	Conductance (mc mho/cm)	3 - 0 0	17-20
Turbidity, JTU (5)*		19-22	Chlorides (250)*	2 0 0	21-2
Solids, Total (500)*		23-26	Sodium	3 3 9	25-2
Solids, Volatile		27-30	Potassium	9 0	29-3
Carbon Dioxide		31-33	Fluoride	0 9 3	
pH	8 9	34-36	Phosphates (Soluble Ortho)	0 2 4	
Alkalinity, Total as $CaCO_3$	3 8 3	37-39	Sulfates (250)*	4 7 1	38-
Hardness as $CaCO_3$	2 4 0	40-43	Silicon	7	42-
Calcium	4 0	44-47	Aluminum —	<0 1	
Magnesium	3 4	48-51	Nitrogen, Ammonia	<0 1	
Total Iron (0.3)*	0 6 3	52-54	Nitrogen, Nitrite	<0 1	
Manganese (0.05)*	0 0 2	55-57	Nitrogen, Nitrate (45)*	0 4 5	
Arsenic (0.01)* (0.05)**	0 3 4	58-61	Cu	<0 0 5	
B	2 4	62-68	Ni	<0 5	
Cr	<0 1	69-75	Pb	<0	

Ag<0.02

Hg<2

REMARKS

OREGON STATE BOARD OF HEALTH
28
Mineral Content of Water

CARD No.	1 2
SYSTEM No.	X
SAMPLE I.D. No.	
1 RAW, 2 TREATED, 3 BLEND, 4 ABANDONED	

Name of Water Supply: Alkali Lake - Auger Drilling

County: Lake

Source: Hole #8

Sampling Point: Water Level 15'

Bottle No. ____

Collected By: Dept. of Geo. Min Inds. Date: 06 X 13 X 70 (11-16)

Analysis By: AWH Date: 07 X 06 X 70

(MONTH, DAY, YEAR)

Laboratory Number: 1701

NOTE: Double vertical line below shows location of decimal point.
*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75	mg/l, or as shown	Cols.	Card No. 2, Card Columns 17-75	mg/l, or as shown	Cols.
Color, units (15)*		17-18	Conductance (mc mho/cm)	700	17-20
Turbidity, JTU (5)*		19-22	Chlorides (250)*	41	21-24
Solids, Total (500)*		23-26	Sodium	83	25-28
Solids, Volatile		27-30	Potassium	23	29-31
Carbon Dioxide		31-33	Fluoride	0.51	32
pH	8.9	34-36	Phosphates (Soluble Ortho)	0.3	35
Alkalinity, Total as $CaCO_3$	324	37-39	Sulfates (250)*	140	38-4
Hardness as $CaCO_3$	247	40-43	Silicon	4	42-4
Calcium	48	44-47	Aluminum	<0.1	45
Magnesium	31	48-51	Nitrogen, Ammonia	0.4	48
Total Iron (0.3)*	0.02	52-54	Nitrogen, Nitrite	0.6	51
Manganese (0.05)*	0.04	55-57	Nitrogen, Nitrate (45)*	<0.40	54
Arsenic (0.01)* (0.05)**	0.18	58-61	Cu	<0.05	5
B	1.0	62-68	Ni	<0.5	6
Cr	<0.1	69-75	Pb	<0.5	7

Ag <0.02
Hg <2

OREGON STATE BOARD OF HEALTH

Mineral Content of Water

CARD No.	1 2
SYSTEM No.	X
SAMPLE I.D. No.	
1 Raw, 2 Treated, 3 Blend, 4 Abandoned	

Name of Water Supply: Alkali Lake; Auger Drilling

County: Lake

Source: Hole #9

Sampling Point: Water Level 7½'

Bottle No. ______

Collected By: Dept. of Geo and Min Ind. Date: 06 X 13 X 70 (11-16)

Analysis By: AWH Date: 07 X 06 X 70

(MONTH, DAY, YEAR)

Laboratory Number: 1702

NOTE: Double vertical line below shows location of decimal point.
*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75	mg/l, or as shown	Cols.
Color, units (15)*		17-18
Turbidity, JTU (5)*		19-22
Solids, Total (500)*		23-26
Solids, Volatile		27-30
Carbon Dioxide		31-33
pH	8.9	34-36
Alkalinity, Total as $CaCO_3$	250	37-39
Hardness as $CaCO_3$	45.1	40-43
Calcium	4.4	44-47
Magnesium	8.3	48-51
Total Iron (0.3)*	1.8	52-54
Manganese (0.05)*	0.55	55-57
Arsenic (0.01)* (0.05)**	1.0	58-61
B	0.6	62-68
Cr	<0.1	69-75

Ag <0.02
Hg < 2

Card No. 2, Card Columns 17-75	mg/l, or as shown	Cols.
Conductance (mc mho/cm)	830	17-20
Chlorides (250)*	52	21-24
Sodium	130	25-28
Potassium	38	29-31
Fluoride	1.07	32
Phosphates (Soluble Ortho)	1.2	35
Sulfates (250)*	260	38-41
Silicon	5	42-44
Aluminum	0.1	45
Nitrogen, Ammonia	3.1	48
Nitrogen, Nitrite	0.4	51
Nitrogen, Nitrate (45)*	0.75	54
Cu	0.30	58
Pb	<0.5	64
Mn	<0.5	70

REMARKS

OREGON STATE BOARD OF HEALTH
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Mineral Content of Water

CARD No. 1 2 1

Name of Water Supply	Alkali Lake-Auger Drilling #10
County	Lake
Source	Hole #10
Sampling Point	Water Level 9'
Collected By	Dept. of Geo. & Min Ind.
Analysis By	AWH
Laboratory Number	1703

SYSTEM No. ☐ X ☐ 2-
SAMPLE I.D. No. ☐ 7-9
1 Raw, 2 Treated, 3 Blend, 4 Abandoned ☐ 10

Bottle No. #10

Date 06 X 13 X 70 11-16
Date 07 X 06 X 70
(MONTH, Day, YEAR)

NOTE: Double vertical line below shows location of decimal point.
*PHS Recommended max. **PHS Max. Allowable

Card No. 1, Card Columns 17-75	mg/l, or as shown	Columns
Color, units (15)*		17-18
Turbidity, JTU (5)*		19-22
Solids, Total (500)*		23-26
Solids, Volatile		27-30
Carbon Dioxide		31-33
pH	8.6	34-36
Alkalinity, Total as $CaCO_3$	692	37-39
Hardness as $CaCO_3$	145.1	40-43
Calcium	23.2	44-47
Magnesium	21.2	48-51
Total Iron (0.3)*	0.02	52-54
Manganese (0.05)*	0.05	55-57
Arsenic (0.01)* (0.05)**	0.14	58-61
B	7.0	62-68
Cr	<0.1	69-75

Card No. 2, Card Columns 17-75	mg/l, or as shown	Columns
Conductance (mc mho/cm)	310	17-20
Chlorides (250)*	437	21-24
Sodium	640	25-28
Potassium	100	29-31
Fluoride	0.74	32-34
Phosphates (Soluble Ortho)	0.3	35-37
Sulfates (250)*	310	38-41
Silicon	3	42-44
Aluminum	<0.1	45-47
Nitrogen, Ammonia	4.2	48-50
Nitrogen, Nitrite	<0.1	51-53
Nitrogen, Nitrate (45)*	<0.40	54-57
Cu	<0.05	58-63
Ni	<0.5	64-69
Pb	<0.5	70-75

Ag < 0.02
Hg < 2

REMARKS

STATE DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

1069 STATE OFFICE BUILDING
PORTLAND 1, OREGON

Sample submitted by V.C. Newton

Sample received on July 29, 1970

Analysis requested Sodium and Potassium

Analysis by:

Wm Kahn, Chemist

Lab. No.	Sample Marked	Results of Analysis		Remarks
P35166	#5(1')	Na - 10000,	K - 7750	E$\frac{1}{4}$ cor Sec 19, T 3CS, R 2E
P35167	#5(2')	Na - 3750,	K - 4000	" " " "
P35168	#5(3')	Na - 3750,	K - 4000	" " " "
35169	#5(4')	Na - 8000,	K - 5000	" " " "
P35170	#5(5')	Na - 14250,	K - 8750	" " " "
P35171	#5(6')	Na - 13750,	K - 8500	" " " "
P35172	#5(7')	Na - 15000,	K - 8500	" " " "
P35173	#5(10')	Na - 6750,	K - 5000	" " " "
P35174	#5(11')	Na - 16750,	K - 8500	" " " "
P35175	#5(13')	Na - 3500,	K - 2500	" " " "
P35176	#5(14')	Na - 12500,	K - 7250	" " " "
P35177	#5(15')	Na - 13750,	K - 8500	" " " "
P35178	#5(17')	Na - 12500,	K - 10000	" " " "
P35179	#5(20')	Na - 7750,	K - 6250	" " " "

STATE DEPARTMENT OF GEOLOGY
AND MINERAL INDUSTRIES
1069 STATE OFFICE BUILDING
PORTLAND 1, OREGON

mple submitted by V.C. Newton Jr

mple received on June 29, 1970

alysis requested Leachable Sodium and Potassium

Analysis by:

Wm Kahn, Chemist

Lab. No.	Sample Marked	Results of Analysis				Remarks
P35061	#6(0-3)	Na	14000	K	18500	SE¼SE¼ Sec 11, 30S, 22E Lake Co
P35062	#6(3-6)	-	14000	-	12500	" " " "
P35063	#6(6-9)	-	15000	-	11500	" " " "
P35[illegible]	#6(9-12)	-	13000	-	12500	" " " "
P35065	#6(12-15)	-	11500	-	13000	" " " "
P35066	#6(15-18)	-	12500	-	11000	" " " "
P35067	#7(0-3)	-	10500	-	8500	S¼ Cor Sec 20, 30S, 23E Lake Co
P35068	#7(3-6)	-	10000	-	7500	" " " "
P35069	#7(6-9)	-	17000	-	9950	" " " "
P35070	#7(9-12)	-	15500	-	9000	" " " "
P35071	#7(12-15)	-	9950	-	8000	" " " "
P35072	#7(15-18)	-	10500	-	8500	" " " "
P35073	#7(18-21)	-	8500	-	10000	" " " "
P35074	#8(0-3)	-	7000	-	9950	SW Cor Sec 18, 30S, 23E Lake Co
P35075	#8(3-6)	-	12000	-	9950	" " " "
P35076	#8(6-9)	-	9000	-	8000	" " " "
P35077	#8(9-12)	-	9000	-	8500	" " " "
P35078	#8(12-15)	-	8000	-	8500	" " " "
P35079	#8(15-18)	-	7000	-	9000	" " " "
P35080	#9(0-3)	-	11000	-	8000	NW¼NE¼ Sec 1, 30S, 22E Lake Co
P35081	#9(3-6)	-	8000	-	9950	" " " "
P35082	#9(6-9)	-	4000	-	8500	" " " "
P35083	#10(0-3)	-	7000	-	5500	SW¼NE¼ Sec 4, 30S, 23E Lake Co
P35084	#10(3-6)	-	9500	-	7000	" " " "
P3[illegible]5	#10(6-9)	-	7500	-	7000	" " " "
P35086	#10(9-12)	-	7000	-	8500	" " " "

OREGON STATE
BOARD OF HEALTH

STATE OFFICE BUILDING • P.O. BOX 231 • PORTLAND, OREGON • 97207

4 June 1970

Mr. Vernon C. Newton, Jr.
Petroleum Engineer
State of Oregon
Department of Geology and
Mineral Industries
1069 State Office Building
Portland, Oregon

Dear Mr. Newton:

Below please find the results of the soil pH determinations performed by this laboratory.

The soil samples were received on 19 May 1970 and the determinations completed on 25 May 1970.

Lab. No.	Depth in Feet	pH Determination
48-317	1	10.61
48-318	2	10.79
48-319	3	11.03
48-320	4	11.25
48-321	5	11.08
48-322	6	11.27
48-323	7	11.18
48-324	10	11.42
48-325	11	10.89
48-326	13	11.06
48-327	14	10.51
48-328	15	10.59
48-329	17	10.28
48-330	20	10.59
48-331	24	10.09
48-332	25	10.19

Sincerely,

Olav Merilo

Olav Merilo
Chief Chemist
Occupational Health Section

OM/dp

WATER WELL LOG

OWNER Favel-Utley Real Estate COUNTY Lake WELL No-USGS 5N-1

LOCATION SW$\frac{1}{4}$ SW$\frac{1}{4}$ Sec 5 T30S R 23E ALTITUDE 4220' Topo

DATE DRILLED 1952 DRILLER Stooksberry-Robinson

STATIC LEVEL Flowing DATE July 1952

CASING RECORD 8-inch set at 129'

Depth	Thickness	Description of Material
		YOUNG ALLUVIUM:
10	10	Sand and silt with some coarse grains.
30	20	Brown silty clay with some caliche.
40	10	Sand, fine grained, siliceous.
65	25	Clay and silt, gray.
70	5	Sand, fine grained, with clay and silt.
85	15	Silt with fine sand.
		TERTIARY VOLCANIC & SEDIMENTARY ROCK:
90	5	Tuff, fine sandy, gray silty with some drilled up Rhyolite.
110	20	Tuff, rhyolitic, gray.
130	20	Tuff, sandy, green, with rounded siliceous grains.and opaline material.
135	5	Tuff, sandy, red with zeolitic and opaline material.
144	9	Tuff, as above with pumiceous material, water bearing.

WATER WELL LOG

OWNER Favel-Utley Real Estate COUNTY Lake WELL No-USGS 18R-1

LOCATION SE¼SE¼ Sec 18 T30S R 23E ALTITUDE 4220' Topo

DATE DRILLED 1952 DRILLER Stooksberry-Robinson

STATIC LEVEL Flowing DATE August 1952

CASING RECORD 8-inch set at 114' with 6-inch hole to total depth.

Depth	Thickness	Description of Material
		YOUNG ALLUVIUM:
110	110	Silt and clay with sand, caliche streaks, lava rock pebbles, siliceous sinter and fine volcanic ash, gray and brown.
118	8	Sand silty, gray, fine to medium grained.
130	12	Silt, ashy, gray.
		TERTIARY VOLCANIC & SEDIMENTARY ROCK:
143	13	Rhyolite and rhyolitic tuff.
175	32	Andesite (?), lava rock.
195	20	Tuff, sandy textured, brown.
205	10	Basalt.
212	7	Tuffa, with some thin basalt rock included and much hyaline silica.
260	48	Basalt, crumbly, red and gray, with tuff (244-246).
270	10	Pumice, andesitic(?), granular, gray, water bearing.

ALKALI LAKE WELLS - LOGS

Bonneville Power Adm conducted a study of the saline deposits of Alkali Lake in 1952. The project was under the supervision of the University of Portland. Two holes were drilled on the Favel-Utley land at Alkali Lake; one 270' deep at the south end of the playa, and one 145' deep at the north end of the playa. The southern well flowed at a rate of 30 gallons per minute and the northern well flowed at a rate of 150 gallons per minute. Some of the samples from the south end well were studied by the Dept of Geology and Mineral Ind and were found to be:

Sample No	Depth	Description
43	145 - 175'	Andesite.
-	175 - 195'	Samples too soupy to wash.
53	195 - 205'	Vesicular basalt.
58	205 - 210'	Glass shards.
60	210 - 219'	Olivine basalt.
66	219 - 230'	Basalt.
73	230 - 245'	Basalt, brownish red, altered.

R.S. Mason file, August 9, 1952

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 1 DATE July 29, 1969

LOCATION Vicinity of Test Plot #1

ELEVATION WATER LEVEL $5\frac{1}{2}$' below surface

DRILLER C. Hickman DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Alkali Silt, whitish tan, friable, calcareous* with many very fine angular fragments of black mineral or rock (Volcanic Debris).
3 - 6'	Silty Clay, medium grayish green, sticky with abundant small angular fragments of black mineral or rock (Volcanic Debris), calcareous.*
6 - 9'	As above described.
9 - 12'	Plastic Clay, medium - dark greenish brown with scattered small angular fragments of black mineral or rock (Volcanic Debris), calcareous.*
12 - 21'	As above described, with thin layers of hard pan at 13 - 16' and 18 - 20'.
21 - 36'	Plastic Clay, dark grayish brown with scattered small angular black fragments of mineral or rock (Volcanic Debris), slightly calcareous.*

* Effervescence in dilute hydrochloric acid is described as being calcareous however, many of the carbonates effervesce in acid including the evaporite minerals trona and natron.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 2 DATE July 31, 1969

LOCATION In the vicinity of Test Plot #1

ELEVATION WATER LEVEL

DRILLER C. Hickman DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Alkali Silt, grayish tan, very fine, clayey with many very small angular fragments of black mineral or rock (Volcanic Debris), effervesces in dilute HCL.
3 - 6'	Alkali Silt, brownish gray, as above.
6 - 9'	Silt, whitish gray, fine, friable, with scattered small angular fragments of black mineral or rock (Volcanic Debris), effervesces in dilute HCL.
9 - 12'	Silty Clay, medium gray, with scattered very small angular fragments of black mineral or rock (Volcanic Debris), strongly effervescent in dilute HCL.
12 - 15'	As above described.
15 - 18'	Silty Clay, medium greenish gray, as above, with thin hard streaks of evaporite.
18 - 21'	Clay, medium greenish gray with scattered very fine angular fragments of black mineral or rock (Volcanic Debris), effervesces in dilute HCL.
21 - 24'	Heavy Clay, medium - dark greenish gray with scattered fine fragments of black mineral or rock (Volcanic Debris), effervesces in dilute HCL.
24 - 27'	Clayey Silt, medium gray, very fine, firm, with small angular fragments above described, effervesces in dilute HCL. Thin hard layer at 25'.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 2 DATE ______

LOCATION ______

ELEVATION ______ WATER LEVEL ______

DRILLER ______ DESCRIPTIONS BY ______

Sample Depth	Description of Material
27 - 30'	No recovery.
30 - 33'	Heavy Clay, dark grayish brown, effervesces in dilute HCL.
33 - 36'	Heavy Clay, dark brown, organic (?), slightly effervescent in dilute HCL.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 3 DATE July 31, 1969

LOCATION In the Vicinity of Test Site #1

ELEVATION ______ WATER LEVEL 20' from the ground surface

DRILLER C. Hickman DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 36'	The original 4" hand auger hole was deepened to 36' on 7-31-69. A hard pan was encountered at 20' and continued to approximately 21½'. The lower portion of the hole consisted of a heavy, plastic, greenish gray Clay.

(See Water Analysis by State Health Lab)

& Mineral Industries
(Original log lost, supplement made 1-14-70)

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 4 DATE August 1, 1969

LOCATION SW$\frac{1}{4}$ SE$\frac{1}{4}$ Sec 6, T 30 S, R 22E Lake County

ELEVATION ________ WATER LEVEL At Surface - Flowed day after it was drilled.

DRILLER C. Hickman DESCRIPTIONS BY V.C. Newton

Sample Depth	Description of Material
0 - 3'	Sand and Silt; tan color, fine grained, consists of volcanic debris.
3 - 36'	Fine Silty Sand; medium gray, loose, quicksand. Water was encountered at 6 feet. Sand consists of volcanic debris.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 5 DATE July 23, 1970

LOCATION Proposed disposal Area; E½ cor Sec 19, T 30S, R 23E

ELEVATION ______ WATER LEVEL 22 feet

DRILLER D. Baggs DESCRIPTIONS BY V.C. Newton

Sample Depth	Description of Material
1'	Clayey Silt; whitish gray with occasional volc fragments. Strong effervescence in dil. HCl.
2'	Tuffaceous Sand; light gray, fine grain, consists of angular feldspar and subangular grains of basalt and volcanic glass. Moderate efferv. in HCl.
3'	As Above except only slightly efferv. in HCl.
4 - 6'	Clayey Silt; whitish gray with scattered pieces of volcanic material. Strong efferv in dil HCl.
7'	As Above except moderately effev in dil HCl.
10'	Tuffaceous Sand; tan color, fine-medium grain, consisting of feldspar and fragments of basalt and volcanic glass.
11'	Clay, whitish gray, plastic, occasional pieces of volcanic material. Fair efferv in dil HCl.
13'	Tuffaceous Sand; light gray, silty, med. grain, loose, with scattered pieces of basalt and volcanic glass. No effervescence in dil HCl.
14'	Clay; greenish gray, plastic, with occasional pieces of volcanic material. Slight efferv in dil HCl.
15'	Tuffaceous Sand; whitish gray, fine, silty, with scattered pieces of basalt and volcanic glass. Moderate - strong efferv in dil HCl.
17'	Clay; light gray, plastic. Fair efferv in dil HCl.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 5 DATE July 23, 1970

LOCATION ______

ELEVATION ______ WATER LEVEL ______

DRILLER ______ DESCRIPTIONS BY ______

Sample Depth	Description of Material
20'	Tuffaceous Sand; light gray, fine, composed of feldspar, basalt and glass fragments.
24'	Clay; light gray, plastic with occasional pieces of volcanic material. Slight efferv in dil HCl.
25 - 27'	As Above.
27 - 30'	Clayey Silt; light gray, semi-plastic, with fine pieces of feldspar and basalt scattered throughout. Moderately efferv in dil HCl.
30 - 33'	Tuffaceous Sandy Silt; light gray, consisting of feldspar and volcanic debris.
33 - 36'	Clayey Silt; light greenish gray, with scattered fragments of feldspar and basalt. Moderately efferv in dil HCl.
36 - 39'	As Above.
39 - 42'	No Recovery.
42 - 45'	Clayey Sand; light gray with scattered fragments of feldspar and basalt. Moderately efferv in HCl.
45 - 48'	Tuffaceous Silty Sand; medium gray, fine, consisting of feldspar and basalt. Fair efferv in dil HCl.
48 - 51'	Clayey Silt; med gray with fine fragments of basalt. Strong efferv in dil HCl.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 6 DATE August 21, 1970

LOCATION SE¼ SE¼ Sec 11, T 30S, R 22E Lake County

ELEVATION ______ WATER LEVEL 16'

DRILLER Don Baggs DESCRIPTIONS BY V.C. Newton

Sample Depth	Description of Material
0-3'	Silty Clay; whitish gray, semi-plastic. Moderate effervesence in dil. HCl.
3 - 6'	Fine Sandy Silt; whitish gray, contains fine subangular grains of feldspar and basalt. Moderate effervescence in dil. HCl.
6 - 9'	As Above.
9 - 12'	As Above.
12 - 15'	Silty Clay; light tan color, semi-plastic, contains fine subangular fragments of feldspar and basalt. Fair effervescence in dil. HCl.
15 - 18'	As Above.
18 - 21'	As Above; moderate effervescence in dil. HCl. Sample appears to contain a fair percentage of evaporite.
21 - 24'	Silty Clay; light greenish gray, plastic. Fair effervescence in dil. HCl.
24 - 27'	Clay; cream color, plastic, contains scattered fine fragments of subangular basalt. Fair effervescence in dil. HCl.
27 - 30'	Silty Clay; dark greenish gray, plastic, contains fine subangular pieces of basalt. Moderate to strong effervescence in dil. HCl. Appears to contain a fair percentage of evaporite.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 7 DATE August 21, 1970

LOCATION South ¼ Cor Sec 20, T 30S, R 23E Lake County

ELEVATION ______ WATER LEVEL 20'

DRILLER Don Baggs DESCRIPTIONS BY V.C. Newton

Sample Depth	Description of Material
0 - 3'	Fine Silty Sand; light tan color, composed of feldspar, basalt and volcanic glass. Fair effervescence in dil. HCl.
3 - 6'	As Above; appears to contain a fair percentage of evaporite. Moderate effervescence in dil. HCl.
6 - 9'	No Recovery.
9 - 12'	Fine Sandy Silt; light tan color, contains fragments as above. Moderate effervescence in dil HCl.
12 - 15'	Fine Silty Sand; light tan color, feldspathic with fine fragments of subangular basalt. Moderate effervescence in dil. HCl.
15 - 18'	Fine Sandy Silt; light tan color, contains fine to medium size fragments of feldspar and basalt. Fair effervescence in dil. HCl.
18 - 21'	As Above; moderate effervescence in dil. HCl.
21 - 24'	No Recovery.
24 - 27'	No Recovery.
27 - 30'	No Recovery.
30 - 33'	Clayey Sand; light gray, fine feldspathic, contains scattered pieces of basalt. Strong effervescence in dil. HCl.

Oregon Department of Geology
& Mineral Industries

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 7 DATE August 21, 1970

LOCATION

ELEVATION WATER LEVEL

DRILLER DESCRIPTIONS BY

Sample Depth	Description of Material
33 - 36'	Clayey Silt; medium greenish gray, contains scattered fragments of basalt and feldspar. Appears to contain a fair percentage of evaporite. Strong effervescence in dil. HCl.
36 - 39'	Clayey Sand; dark greenish gray, fine to medium grain, composed of feldspar and basalt, some fine fragments of cinnabar. Strong effervescence in dil HCl.
39 - 42'	Silty Sand; dark greenish gray, fine to medium, feldspathic and contains fragments of basalt, occasional fine piece of cinnabar. Strong effervescence in dil HCl.
42 - 45'	Clay; greenish gray, soft, contains grains of feldspar and basalt. Moderate effervescence in dil. HCl.
45 - 48'	Silty Clay; greenish gray, contains sparsely scattered fine fragments of basalt. Moderate effervescence in dil. HCl.
48 - 51'	Silty Clay; greenish gray, contains some fine grains of feldspar and basalt. Appears to contain a fair percentage of evaporite. Strong effervescence in dil. HCl.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 8 DATE August 21, 1970

LOCATION SW Corner of Sec 18, T 30S, R 23E Lake County

ELEVATION ______ WATER LEVEL 15'

DRILLER Don Baggs DESCRIPTIONS BY V.C. Newton

Sample Depth	Description of Material
0 - 3'	Fine Sand; whitish gray, feldspatic with fine subangular pieces of basalt. Moderate effervescence in dil. HCl.
3 - 6'	Clayey Silt; whitish gray, contains scattered fine fragments of basalt. Moderate to strong effervescence in dil. HCl.
6 - 9'	Fine Sandy Silt; whitish gray, contains fine fragments of basalt. Moderate to strong effervescence in dil HCl.
9 - 12'	Clayey Silt; cream color, contains a few scattered pieces of feldspar and basalt. Clayey material in Alkali Lake sediments results from devitrification of volcanic glass and alteration of feldspar. Moderate effervescence in dil. HCl.
12 - 15'	As Above; moderate to strong effervescence in dil. HCl.
15 - 18'	As Above; Fair effervescence in dil HCl.
18 - 21'	As Above.
21 - 24'	Silty Clay; light gray, plastic, contains scattered fine grains of basalt. No effervescence in dil HCl.
24 - 27'	Silty Clay; light tan, contains scattered fine grains of feldspar and basalt. Strong effervescence in dil. HCl.

Oregon Department of Geology
& Mineral Industries

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 8 DATE August 21, 1970

LOCATION

ELEVATION WATER LEVEL

DRILLER DESCRIPTIONS BY

Sample Depth	Description of Material
27 - 30'	No Recovery.
30 - 33'	Clayey Silt; medium gray, contains fine fragments of basalt. Moderate to strong effervescence in dil. HCl.
33 - 36'	No Recovery.
36 - 39'	No Recovery.
39 - 42'	No Recovery.
42 - 45'	Clayey Silt; whitish gray, plastic, contains fine pieces of basalt. Moderate effervescence in dil. HCl.
45 - 48'	No Recovery.
48 - 51'	Clayey Sand; dark green, fine, loose, feldspathic, contains fine pieces of basalt. Moderate effervescence in dil. HCl.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 9 DATE August 21, 1970

LOCATION NW¼ NE¼ Sec 1, T 29S, R 22E Lake County

ELEVATION ______ WATER LEVEL 7½'

DRILLER Don Baggs DESCRIPTIONS BY V.C. Newton

Sample Depth	Description of Material
0 - 3'	Fine Sandy Silt; cream color, contains fine fragments of basalt and feldspar. Moderate to strong effervescence in dil. HCl.
3 - 6'	As Above.
6 - 9'	As Above.
9 - 12'	Silty Sand; light gray, fine feldspathic, contains fine subangular fragments of basalt. Moderate effervescence in dil. HCl.
12 - 15'	Silty Sand; grayish green, medium to fine grain, feldspathic and contains small fragments of basalt and some crystals of evaporite. Strong effervescence in dil. HCl.
15 - 18'	As Above.
18 - 21'	As Above.
21 - 24'	As Above.
24 - 27'	As Above.
27 - 30'	Clayey Silt; grayish green, semi-plastic, contains scattered small pieces of basalt and fine grains of feldspar. Sample appears to contain a fair percentage of evaporite. Strong effervescence in dil. HCl.
30 -33'	As Above.
33 - 36'	As Above.
36 - 39'	As Above.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 9

DATE August 21, 1970

LOCATION

ELEVATION

WATER LEVEL

DRILLER

DESCRIPTIONS BY

Sample Depth	Description of Material
39 - 42'	Sandy Silt; greenish brown, semi-plastic, fine, contains altered grains of feldspar. Sample appears to contain a fair percentage of evaporite. Strong effervescence in dil. HCl.
42 - 45'	Silty Clay; greenish brown, plastic, contains fine subangular pieces of basalt. Moderate effervescence in dil. HCl.
45 - 48'	Clayey Silt; brownish gray, plastic, contains fine pieces of basalt and feldspar. Moderate to strong effervescence in dil. HCl.
48 - 51'	Silty Clay; greenish gray, moderate effervescence in dil. HCl.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 10 DATE August 21, 1970

LOCATION SW$\frac{1}{4}$ NE$\frac{1}{4}$ Sec 4, T 29S, R 23E Lake County

ELEVATION ________ WATER LEVEL 9'

DRILLER Don Baggs DESCRIPTIONS BY V.C. Newton

Sample Depth	Description of Material
0 - 3'	Fine Sand; light gray, loose, consists of subangular fragments of basalt, feldspar and volcanic glass. Moderate effervescence in dil. HCl.
3 - 6'	Fine Silty Sand; light tan, composed as above, few pieces of reddish zeolite. Moderate to strong effervescence in dil. HCl.
6 - 9'	As Above.
9 - 12'	As Above.
12 - 15'	Fine Sand; light gray, feldspathic with scattered small subangular fragments of basalt. Strong effervescence in dil. HCl.
15 - 18'	No Recovery.
18 - 21'	Fine Sand; as above.
21 - 24'	As Above.
24 - 27'	As Above.
27 - 30'	As Above.
30 - 33'	No Recovery.
33 - 36'	No Recovery.
36 - 39'	No Recovery.
39 - 42'	Fine Sand; as above.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 10 DATE August 21, 1970

LOCATION

ELEVATION WATER LEVEL

DRILLER DESCRIPTIONS BY

Sample Depth	Description of Material
42 - 45'	No Recovery.
45 - 48'	Fine Sand; as above, light gray color. Color change may be due to less basaltic material.
48'	Hit hard layer - gravel?. Could not drill any deeper with auger.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 11 DATE January 21, 1971

LOCATION SW¼ Sec 18, T30S, R 22E

ELEVATION ________ WATER LEVEL 18' initially, 7' after 24 hours

DRILLER D. Baggs DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 6'	Clay Silt; tan color, tuffaceous, contains angular fragments of volcanic glass and basalt. Slight effervescence in dilute HCl.
6 - 9'	Silty Clay; light green, tuffaceous, contains volcanic debris as above. Slightly effervescent.
9 - 12'	Clay; light brownish green, very finely tuffaceous. No effervesence.
12 - 15'	Clay-Silt; whitish gray, tuffaceous, contains fine angular fragments of basalt and white ash. Slight effervescence.
15 - 18'	No sample recovered.
18 - 21'	Clay Silt; gray, tuffaceous, contains volcanic debris as above. Strong effervescence.
21 - 24'	Clay Silt; as above. Fair effervescence.
24 - 27'	Clay; brownish green, plastic, tuffaceous, contains volcanic debris as above.
27 - 30'	Clay; brownish green as above. Strong effervescence.

Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 12　　DATE January 21, 1971

LOCATION NW$\frac{1}{4}$ Sec 12, T 30S, R 22E

ELEVATION ________　　WATER LEVEL 12'

DRILLER D. Baggs　　DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Silty Sand; buff color, tuffaceous, contains very fine fragments of feldspar, quartz, and basalt. Strong effervescence in dilute HCl.
3 - 6'	Clay Silt; light gray, plastic, tuffaceous, contains volcanic debris as above. Fair effervescence.
6 - 9'	Clay Silt; light gray, tuffaceous, contains fine fragments of volcanic debris above. Fair effervescence.
9 - 12'	Silty Clay; light gray, tuffaceous, contains above volcanic debris. Strong effervescence.
12 - 15'	Clay Silt; light gray, tuffaceous, contains very fine fragments of basalt. Fair effervescence.
15 - 18'	No recovery of sample (water saturated zone).
18 - 21'	Ditto.
21 - 24'	Ditto.
24 - 27'	Ditto.
27 - 30'	Clay; light greenish gray, plastic, tuffaceous, contains volcanic debris as before. Strong effervescence.

Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 13 DATE January 21, 1971

LOCATION SW¼ Sec 5, T 30S, R 23E

ELEVATION ________ WATER LEVEL 7'

DRILLER D. Baggs DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Silty Sand; light gray, very fine, contains volcanic debris.
3 - 6'	As above.
6 - 9'	As above.
9 - 12'	Silt; dark greenish gray.
12 - 24'	Clay; brownish green, plastic, tuffaceous, contains very fine fragments of volcanic debris. Fair effervescence.
24 - 27'	No recovery of sample.

Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES
(Hand Auger)

HOLE NO. 14 DATE January 22, 1971

LOCATION SW¼ Sec 19, T 30S, R 23E

ELEVATION ______ WATER LEVEL Not encountered.

DRILLER D Baggs DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Clay Silt; light gray.
3 - 6'	As above.
6 - 13'	Clay; grayish green to greenish brown, some peat in lower section.
13 - 14'	Vitric Tuff; grayish white, very hard. Sediments were moist just above the tuff but no water sample could be obtained.
	Drilling with the hand auger stopped at the tuff as it was too hard to penetrate.

Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 15 DATE Janaury 22, 1971

LOCATION SE¼ Sec 20, T 30S, R 23E

ELEVATION WATER LEVEL 18'

DRILLER D. Baggs DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Silty Sand; light grayish tan, tuffaceous, contains feldspar, quartz and basalt fragments. Fair to strong effarvescence in dilute HCl.
3 - 6'	Silty Sand; as above, some volcanic glass also.
6 - 9'	Silt; light gray, tuffaceous. Fair to strong effervescence in dilute HCl.
9 - 12'	Clay Silt; light gray, tuffaceous, contains very fine particles of volcanic debris. Fair effervescence.
12 - 15'	Silt; medium gray, tuffaceous, containing feldspar, quartz and basalt fragments. Fair to strong effervescence.
15 - 18'	Silty Sand; light brown, very fine, contains grains of feldspar, quartz, basalt and white ash. Fair to strong effervescence.
18 - 21'	Silt; light gray, clayey. Fair to strong effervescence.
21 - 24'	Silt; light gray, clayey, tuffaceous, as above.
24 - 27'	Silt; as above.
27 - 30'	No sample recovered.
30 - 33'	No sample recovered.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 15 DATE January 22, 1971

LOCATION

ELEVATION WATER LEVEL

DRILLER DESCRIPTIONS BY

Sample Depth	Description of Material
33 - 36'	No recovery of sample.
36 - 39'	No recovery of sample.
39 - 42'	No recovery of sample.
42 - 45'	Clay Silt; light gray, tuffaceous. Fair effervescence.

Effervescence in dilute HCl used to indicate amount of evaporite in samples.

Department of Geology and
Mineral Industries
August 8, 1972

SUPPLEMENT TO ALKALI LAKE REPORT

This supplement has been prepared for the purpose of incorporating data developed after publishing of the initial report in 1971. Several more auger holes have been drilled and chemical tests made of fluids and soil samples. Twelve auger holes were cased with 3" plastic pipe to be used as monitor holes for water-table measurements and changes in chemical composition of the brine pool. The geologic map was enlarged and then hand colored. Several of the charts and figures of the original report have been modified to include recent information.

The following comments on analyses, geology, and hydrology, together with recommendations should be useful if additional investigations are undertaken relative to disposal of chemical wastes at Alkali Lake.

Analyses - Chemical analyses were run on samples from the four new auger holes drilled on the playa. Tests were made to determine amount of sodium and potassium in the top 40' of sediments. Results of infiltration tests made by OSU are attached. They show the infiltration rate of water into typical soil from Alkali Lake near the Metallurgical Test Site to be .03" per hour under an initial head of 6 inches. Descriptions of soils in northern Lake County by the U. S. Soil Conservation Service are also included. The permeability of typical soils in the area are described as "slow" by the USCS studies. Electrical conductivities were run on 14 test holes this past year to establish a basis for comparisons with future tests.

Geology - The geology of the northern Lake County was discussed in the original report and not a great deal more can be said except to mention the prominent lake terraces which describe at least three main periods of moist climate when the lake level was static long enough for waves to cut benches on the steep slopes around Alkali Lake. No offsetting was noted in the terraces so it is unlikely that much fault displacement has occurred in the past 20,000 years.

Auger holes Nos. 10, 14, and 20 bottomed in a hard silicious layer originally described as volcanic ash or tuff. After reviewing the sample descriptions of deep wells 5N-1 and 18R-1 it appears likely that the hard layers were lenses of lime-cemented fine gravel. No ash or tuff should have been reached until a depth of 90' or more.

Hydrology - The regional drainage appears to be south to southeast but more studies are needed to substantiate this. Another deep test hole should be drilled near the playa and water pressures measured. If faulting does not prevent migration of groundwater from the Alkali Lake Basin, the underground waters would likely move very slowly to Lake Abert Basin. (Tests, 1901, show Abert Lake water contains 67,000 ppm dissolved solids, however, deep aquifers are probably fresh in the Abert Basin) Hydrologic studies should be made of the springs and deep wells in the vicinity of Alkali Lake to determine groundwater movement.

Recommendations - The studies conducted at Alkali Lake have yielded the information sought except perhaps for hydrologic data. Additional measurements of water levels in monitor holes and springs should be made and a deep test hole drilled prior to granting permission to dispose of chemical wastes at the present site.

Chemical wastes should be placed so they will not migrate to the shallow water under the playa. If such a condition existed, the disposal would not be under control. Rainfall in northern Lake County is reported to be approximately 12 inches per year and evaporation 40 inches per year so there is a deficit of moisture in the soil. Tests by OSU disclosed that it took 6 inches or more of flooding to drive moisture below 18 inches in the soil. Therefore, disposal of fluid wastes on the margins of Alkali Playa and at an elevation of 10 or more feet above the highest water level should prove safe. Disposal locations south and east of Alkali Lake above elevation 4,300 feet and in sediments of the QTs rock unit would give an added measure of safety. These locations are outside of the property now held by Mr. Hunt. It may be appropriate to consider the playa in trade for lands underlain by the QTs rock unit bordering Alkali Lake Basin.

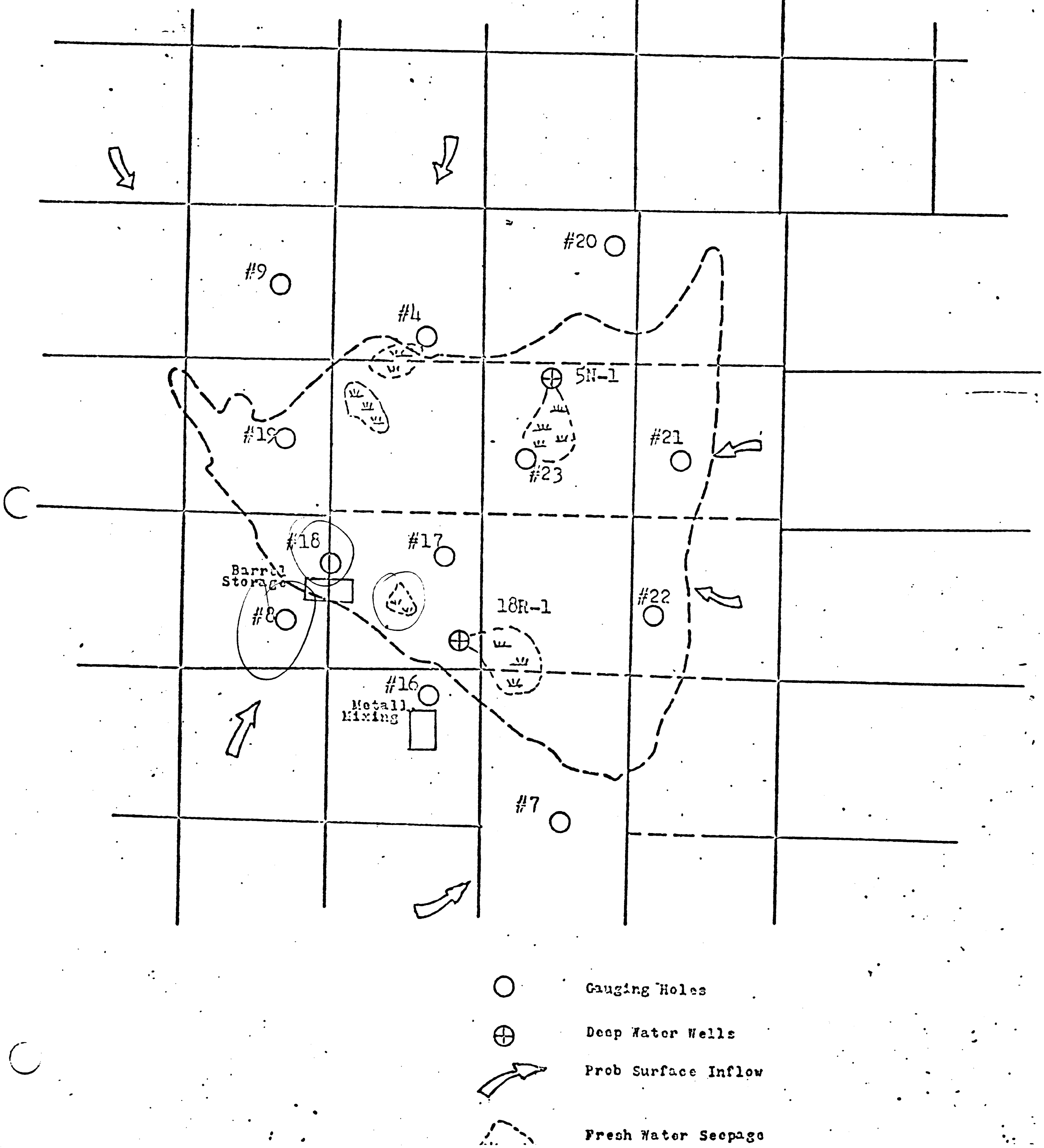
One last consideration in preparation of the area for disposal operations and the monitoring system is the establishment of elevations. No topographic mapping of any detail has been done in the vicinity of Alkali Lake and this sort of control is essential to development of the site. All springs, wells and facilities should be accurately located.

<u>Additional Reference:</u>

Trouger, F.D., 1950, Basic Ground-water Data in Lake County: U.S. Geological Survey Open File Report.

Dept Geol & Min Industr
July 5, 1972 Revised

ALKALI LAKE PLAYA
WATER LEVEL AND SALINITY GAUGING
STATIONS



Dept of Geology & Min. Ind
May 4, 1972

ALKALI LAKE FAULT SYSTEM

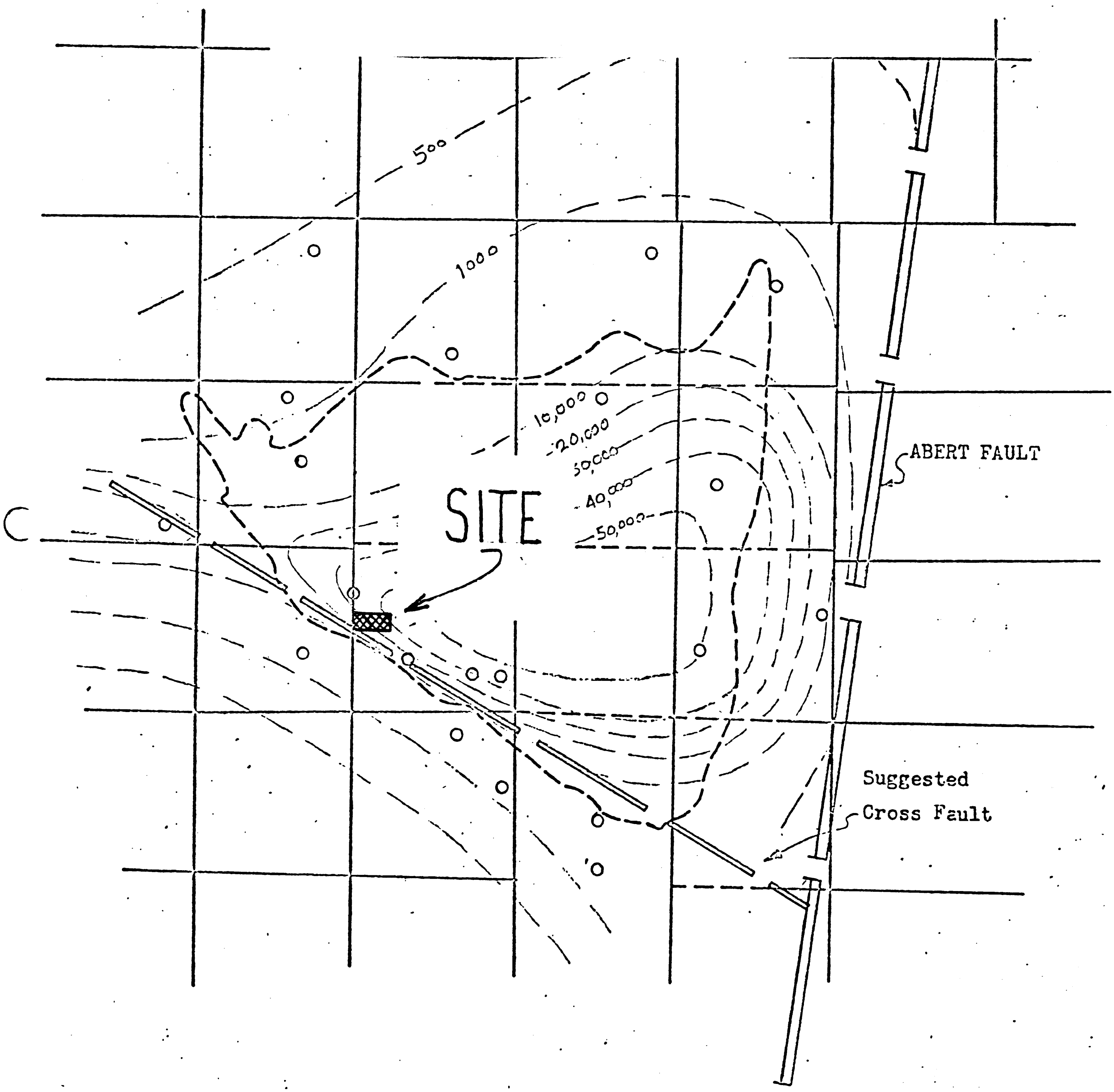
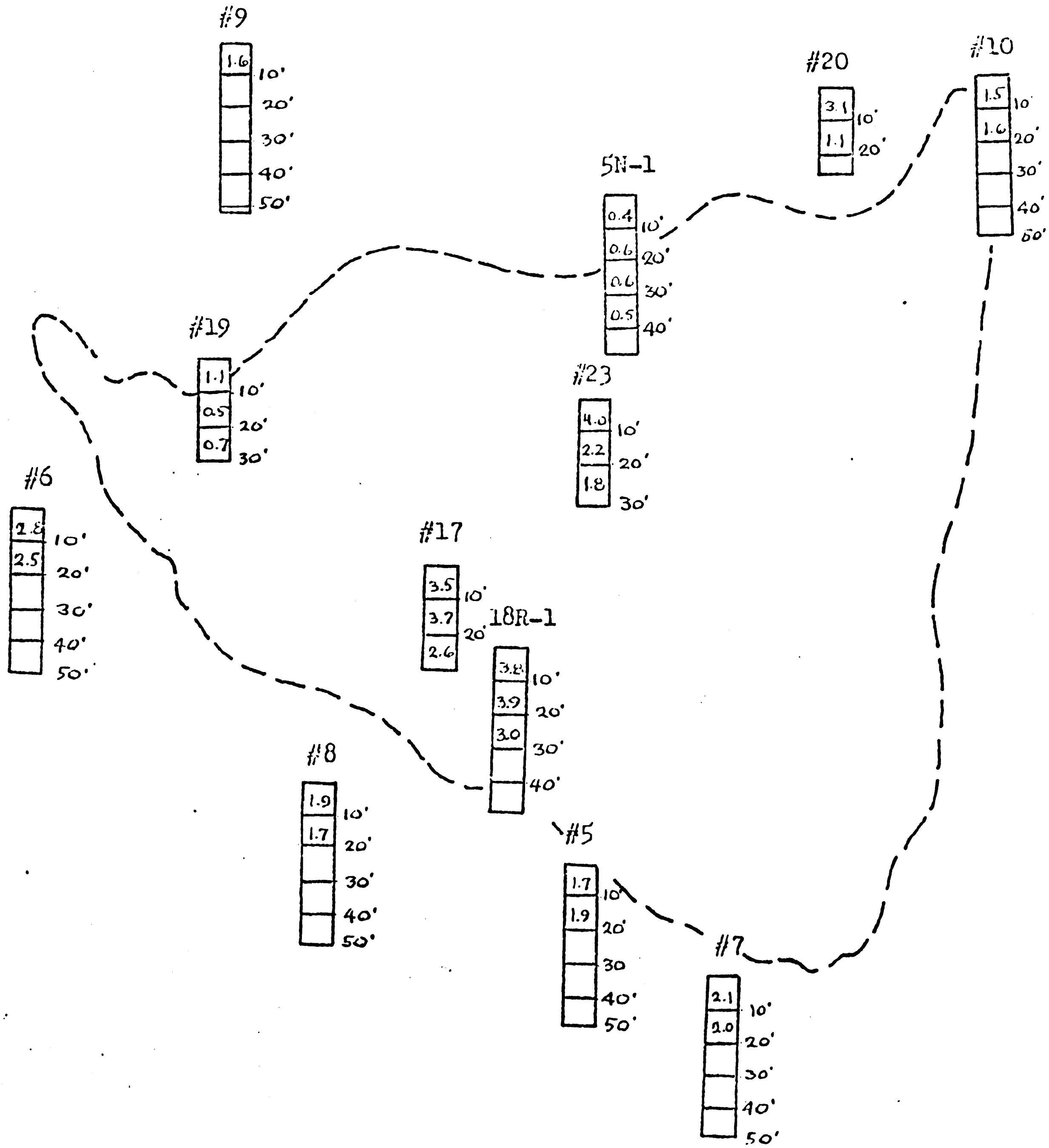


Figure 3
Revised July , 1972

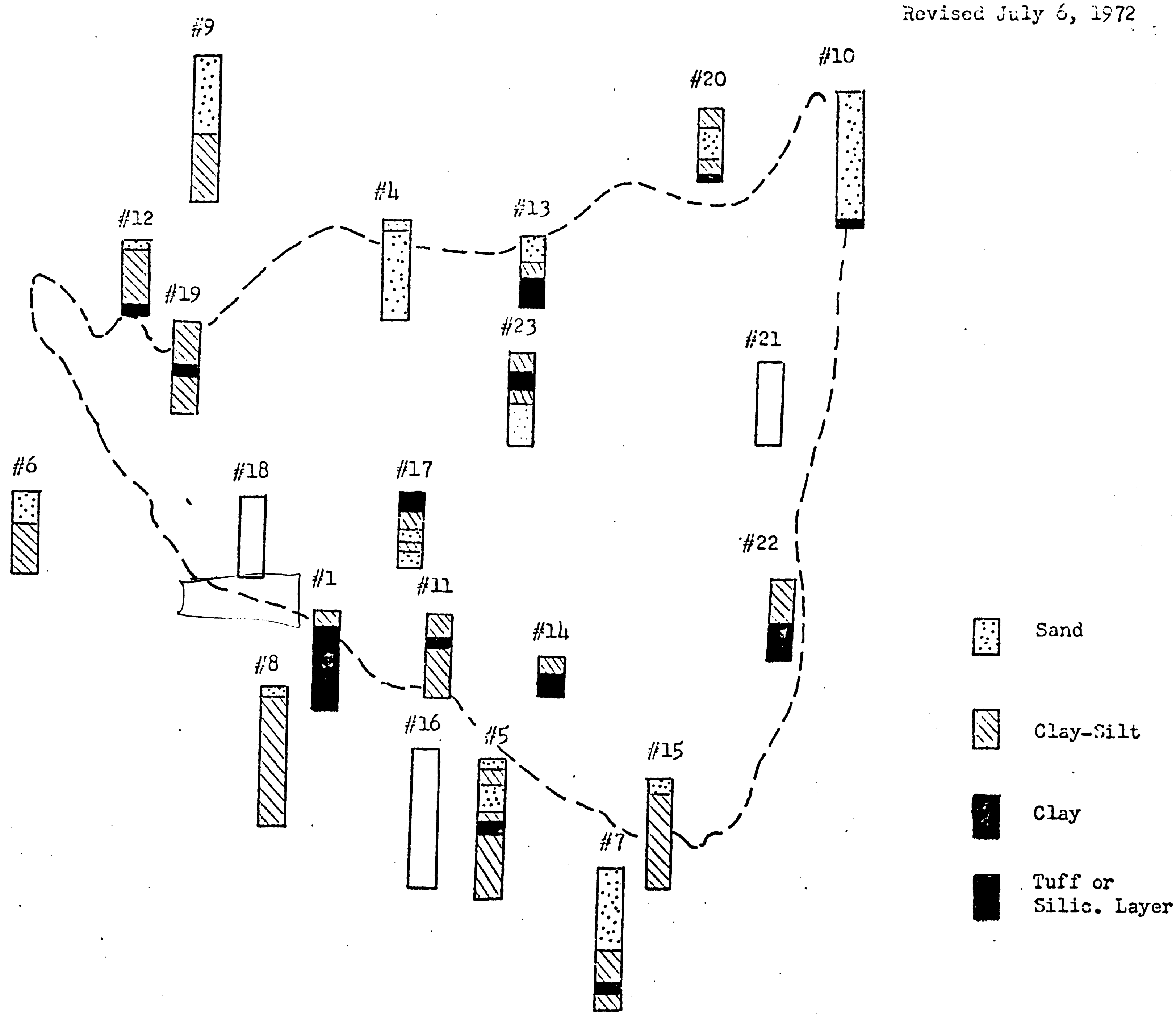
PERCENTAGE OF SOD[illegible] and POTASSIUM

in PLAYA SEDIMENTS



ALKALI LAKE . ER HOLES

Figure 2
Revised July 6, 1972



Analyses of waters in Chewaucan basin, Oreg.

1. Chewaucan River, average of 37 composite analyses by Van Winkle, reduced to [illegible]
2. [illegible] River, a feeder of Summer Lake. Analysis by Van Winkle.
3. A[illegible] Analysis by T. M. Chatard, U. S. Geol. Survey Bull. 60, p. 55, 20.
4. Abert Lake. Analysis by Stillwell and Gladding, 1901. Cited by Van Winkle.
5. Abert Lake. Analysis by E. T. Dumble, 1902. Cited by Van Winkle.
6. Abert Lake, February, 1912. Analysis by Van Winkle.
7. Summer Lake. Analysis by Stillwell and Gladding, 1901. Cited by Van Winkle.
8. Summer Lake. Analysis by Dumble, 1902. Cited by Van Winkle.
9. Summer Lake, 1912. Analysis by Van Winkle.
10. Summer Lake. Analysis by J. G. Smith, U. S. Dept. Agr. Bull. 61, p. 80, 1914.

I. Parts per million.

	1	2	3	4	5	6	7	8	9	10
O_3	21.6	50.9	8,008	15,742	15,966	6,149	13,294	10,712	5,916	1,667
O_4	4.5	8.1	744	1,281	1,411	565	1,452	1,233	694	1,062
	.5	11.0	14,118	22,359	27,483	10,711	6,280	5,550	3,033	853
O_3	.34	.2				1			3.6	Tr.
O_4										Tr.
O_7										Tr.
	7.6	4.9				Tr.			Tr.	130
g	1.9	4.4				6			.4	26
	6.8	39.0	15,406	26,570	30,032	11,470	14,520	12,105	6,567	2,171
	2.5		563	1,043	1,233	502	727	560	265	1.06
O_3						64			.45	
O_3	.3	.01				2			.25	
O_2	29.0	37.0	243	300	165	96	268	288	104	
	75.04	155.51	39,172	67,295	76,323	29,565	36,550	30,457	16,633.25	6,000

[1] Analyses 4 to 9 are stated in milligrams per kilogram.

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6	7	8	9	10
O_3	28.79	32.72	20.67	23.39	20.92	20.80	36.37	35.17	35.57	27.79
O_4	5.99	5.20	1.90	1.91	1.86	1.91	3.98	4.05	4.17	17.70
	.67	7.07	36.04	33.22	36.02	36.23	17.15	18.25	18.27	13.96
O_3	.45	.12				Tr.			.02	Tr.
O_4										Tr.
O_7										Tr
	10.13	3.15				Tr.			Tr.	2.16
g	2.53	2.83				.02			Tr.	.43
	9.06	25.07	39.33	39.48	39.32	38.80	39.75	39.74	39.48	36.19
	3.33		1.44	1.55	1.66	1.70	1.93	1.84	1.59	1.77
O_3						.22			.27	
O_3	.40	.05				Tr.			Tr.	
O_2	38.65	23.79	.62	.45	.22	.32	.73	.95	.63	
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The specific gravity was determined as follows:

No. 3 (19.5° C.)	1.03117	No. 7 (15.5° C.)	1.0319
No. 4 (15.5° C.)	1.0515	No. 8	1.0354
No. 5	1.064	No. 9 (15° C.)	1.0162
No. 6 (15° C.)	1.0255		

The analyses of Abert Lake agree very well, except regards concentration. So too do three of those of ummer Lake, but Smith's analysis is unlike the others. 'as his sample of water a surface sample taken near e point of influx of Ana River?

MINOR BASINS.

North of the Chewaucan basin there are several nall lakes for which analyses have been made. The 'ailable data are as follows:

Analyses of water from six small lakes north of Chewaucan basin, Oreg.

1. Silver Lake. Not to be confused with Silver Lake of the Harney Basin. Analysis by Van Winkle. Sample taken in 1912.
2. Fossil Lake.
3. Christmas Lake.
4. North Alkali Lake.
5. Middle Alkali Lake.
6. South Alkali Lake. Analyses 2 to 6 by J. G. Smith, U. S. Dept. Agr. Bull. 61, p. 80, 1914.

I. Parts per million.

	1	2	3	4	5	6
CO_3	180.0	3,766	1,353	20,437	22,235	5,005
SO_4	9.2	1,130	625	10,090	49,819	1,006
Cl	3.3	7,003	816	25,534	18,263	15,845
NO_3	.24	Tr.	Tr.	Tr.	Tr.	Tr.
PO_4		81	Tr.	162	409	103
B_4O_7		Tr.	Tr.	Tr.	Tr.	Tr.
Ca	42.0	245	96	105	15	30
Mg	25.0	20	63	19	45	41
Na	62.0	7,534	1,504	34,721	49,849	14,258
K		321	243	4,032	5,435	612
Fe_2O_3	.4					
SiO_2	57.0					
	379.14	20,100	4,700	95,100	146,100	36,900

II. Percentage composition of dissolved solids.

	1	2	3	4	5	6
CO_3	47.48	18.73	28.73	21.49	15.22	13.56
SO_4	2.42	5.62	13.29	10.61	34.12	2.73
Cl	.87	34.84	17.35	26.85	12.50	42.94
NO_3	.06	Tr.	Tr.	Tr.	Tr.	Tr.
PO_4		.41	Tr.	.17	.28	.28
B_4O_7		Tr.	Tr.	Tr.	Tr.	Tr.
Ca	11.08	1.22	2.04	.11	.01	.08
Mg	6.60	.10	1.35	.02	.03	.11
Na	16.35	37.48	32.00	36.51	34.12	38.64
K		1.60	5.13	4.24	3.72	1.66
Fe_2O_3	.11					
SiO_2	15.03					
	100.00	100.00	100.00	100.00	100.00	100.00

In five of these analyses the determination of silica was neglected. In waters of this type, however, the omission is not serious and may be disregarded.[61]

It is probable that at the time when desiccation began the water of Lake Lahontan was fairly uniform in composition, but such uniformity is not shown in its remainders. They differ one from another, apparently for two reasons. As the present lakes became separated, each one was affected by local conditions, which were not everywhere the same. In the first place the oceanic salts were unevenly distributed throughout the basin—that is, abundant at some points and relatively scarce at others. Secondly, the streams that fed the present lakes differed in composition, just as they do to-day. Hence some of the lakes are richer in chlorides than others, and some are more nearly

[61] For additional information concerning the geology of the lake region of south-eastern Oregon, see Russell, I. C., U. S. Geol. Survey Bull. 217, 1903, and Waring, G. A., U. S. Geol. Survey Water-Supply Paper 231, 1909.

CHEMISTRY LABORATORY
DEPT GEOLOGY & MINERAL INDUSTR
Robert Sauvie, Chemist

Hole # 17A	Sodium	Potassium
0 – 3'	21,000 ppm	5,300 ppm
3 – 6'	23,800	6,500
6 – 9'	36,200	7,000
9 – 12'	36,200	7,100
12 – 15'	25,500	5,400
15 – 18'	29,500	5,700
18 – 21'	16,000	4,600
21 – 24'	18,800	4,500
30 – 33'	15,400	4,700

CHEMISTRY LABORATORY
DEPT OF GEOLOGY & MINERAL INDUSTR
Robert Sauvie, Chemist

Hole # 19	Sodium	Potassium
0-3'	7,300 ppm	6600 ppm
3-6'	7,900	4,200
6-9'	7,400	3,300
9-12'	7,200	2,500
12-15'	3,700	1,600
15-18'	2,700	1,900
33'	5,700	3,500

CHEMISTRY LABORATORY
DEPT OF GEOLOGY & MINERAL INDUSTR
Robert Sauvie, Chemist

Hole # 20	Sodium	Potassium
0-3'	30,200 ppm	7,900 ppm
3-6'	19,900	5,800
6-9'	17,000	3,800
9-12'	15,000	3,500
12-15'	7,400	1,900
15-18'	6,700	1,500
18-21'	4,600	1,100
21-24'	6,800	2,200
25'	5,000	2,900

CHEMISTRY LABORATORY
DEPT OF GEOLOGY & MINERAL INDUSTR
Robert Sauvie, Chemist

Hole # 23B	Sodium	Potassium
0 – 3'	5,600 ppm	2,500 ppm
3 – 6'	29,100	9,400
6 – 9'	36,600	9,800
9 – 12'	26,900	8,100
12 - 15'	18,400	6,200
15 - 18'	14,300	5,800
18 - 21'	13,300	4,600
21 - 24'	16,900	6,500
27 - 30'	4,900	3,700
30 - 33'	14,200	5,600

ALKALI LAKE

Water Levels at Gauging Wells

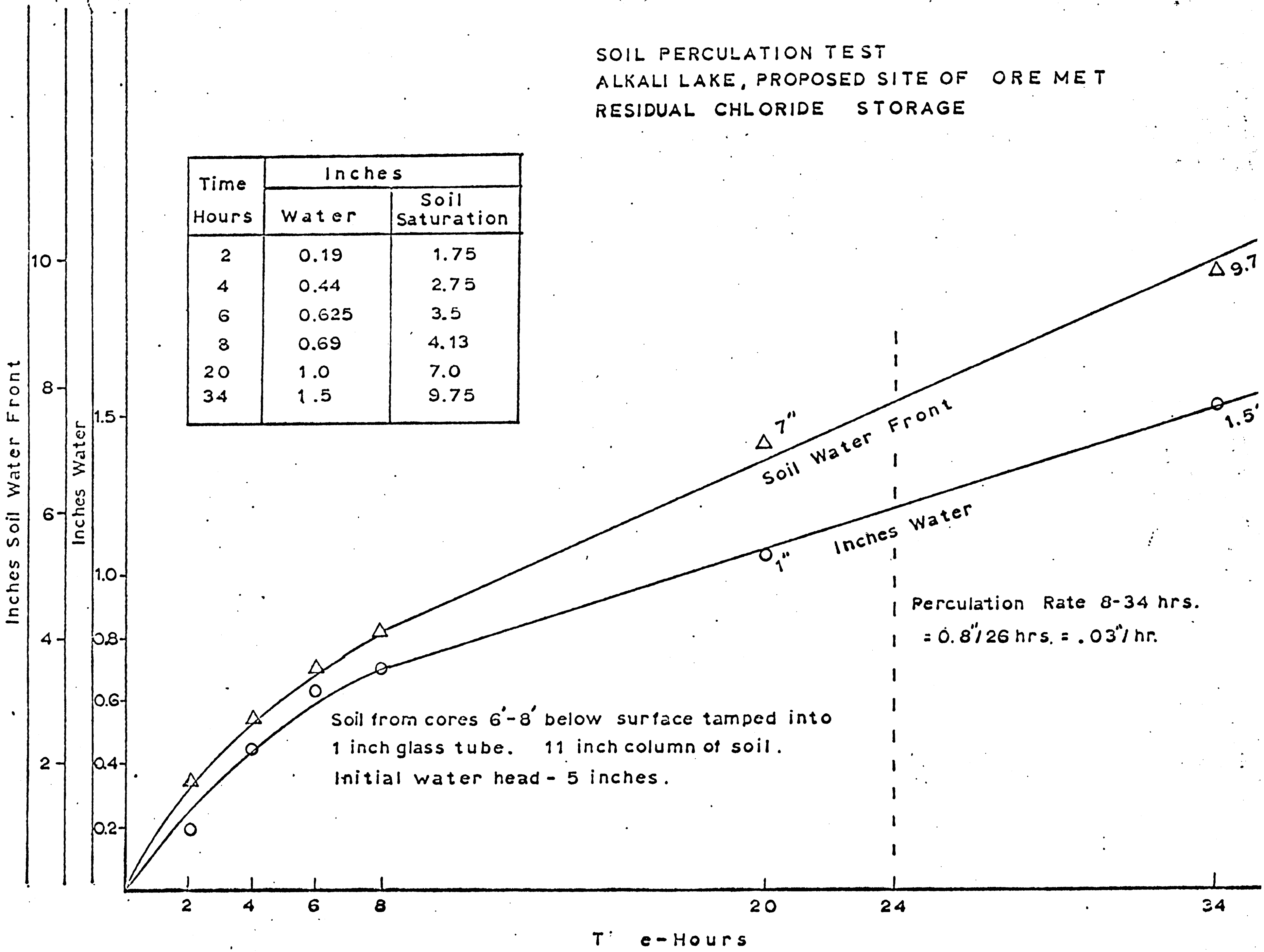
Station	Level	Date	Level	date	Level	Date	Level	Date	Level	Date
Trailer	5.9'	10-7-71	2'	3-15-72						
1	5.5'	7-29-69								
2										
3	20'	7-31-69								
4	Flwg	8-1-69	Flwg	8-21-70	Flwg	1-21-71				
5	22'	7-23-70								
6	16'	8-21-70								
7	20'	8-21-70	15.6'	3-15-72						
8	15'	8-21-70	19'	10-7-71	20'	3-15-72				
9	7.5'	8-21-70	7.9'	3-15-72						
10	9'	8-21-70								
11	7'	9-4-70								
12	12'	9-4-70								
13	7'	9-4-70								
14	14'	9-4-70								
15	18'	9-4-70								
16	15'	8-27-71	10.2'	10-7-71	9.2'	3-15-72				
17	3'	4-18-72	3.8'	10-7-71	3.0'	3-15-72				
18	5'	8-28-71	7.0'	10-7-71	5.9'	3-15-72				
19	14'	4-18-72	13.8'	3-15-72						
20	17'	4-18-72	16.5'	3-15-72						
21	3'	10-7-71	0.3	3-15-72						
22	3'	10-7-71	1.3'	3-15-72						
23	Flwg	4-18-72								

Newton and Baggs
March 15 - 16, 1972

ALKALI LAKE
Gauging Monitor Holes

Site	Depth to Water From Ground Level	Dissolved Solids, ppm	Description of Location
at bus	2'-0"	12,000 ppm	Hole drilled at trailer office
18R-1	Flwg.	400 ppm	Deep well at south end of playa
West Spring	at faucet	350 ppm	Office
#7	15'-6"	900 ppm	Road going east from the south end of the landing strip
#8	20'-0"	850 ppm	Road on south side of brush control plot
#9	7'-9"	600 ppm	On road 3/4 mi. north of Hutton Spring
#16	9'-2"	2,800 ppm	North of Ore Met pits
#17	3'-0"	50,000+ ppm (meter off scale)	On playa north of West Spring
#18	5'-9"	28,000 ppm	Approx. middle of barrel storage, north side
#19	13'-10"	800 ppm	Road west of Hutton Spring, 0.3 mi.
#20	16'-6"	2,600 ppm	Road along north edge of playa, 100' east of road
#21	0'-3"	42,000 ppm	Approx. ½ mi. north of hole #22
#22	1'-3"	50,000+ ppm (meter off scale)	Road west from highway past dump. Sand hill flagged.

SOIL PERCULATION TEST
ALKALI LAKE, PROPOSED SITE OF ORE MET
RESIDUAL CHLORIDE STORAGE



Time Hours	Inches	
	Water	Soil Saturation
2	0.19	1.75
4	0.44	2.75
6	0.625	3.5
8	0.69	4.13
20	1.0	7.0
34	1.5	9.75

7 October 1971 Alkali Lake

Goulding & Kondo

WELL DATA

Site	Water Depth*	Dissolved Solids, PPM
at bus	5'11"	9,500
S. Artesian	Surface	400
Nr. OreMet Site #16	10'2"	2,100
#17 - Playa	3'8"	56,000
#18 - Drum storage	7'	9,000
House spring	Surface	400
#22 nr. Elmer's	3'	35,000
#21 NE	3'	40,000+?
#8 SW corner	19'	2,000

*from top of casing to water surface

Mr. D. C. Crane
District Conservationist
Lakeview, Oregon
November 1971

A L K A L I L A K E

Soils Descriptions - U. S. Soil Conservation Service

The Alkali Lake playa shares common soils characteristics with other dry lakes in Lake County. The Alkali flats form in closed basins at the base point of surface drainage. The playas are typically bounded by wind-blown sediments transported during the dry season.

Playas (400)

The miscellaneous land type, Playas, occupies round, or oval flat depressions of about 10 to 600 acres in Coleman Valley and along the east edge of Warner Valley. Parts of the playas are covered by thin sheets of water in spring which evaporate in most years by early summer.

The playas are composed of very strongly alkaline and calcareous, clayey sediments derived from basalt and volcanic tuff. Thin hummocks or coppice mounds of sandy material are scattered over the surface in places, mainly around the edges of the playa.

Vegetation is scant or nonexistent on the playa bottoms. Plants mostly are confined to the sandy mounds which are sparsely covered by greasewood, other brush plants, and bunchgrasses.

Playas occur next to and below unnamed silt loam (155A) and are commonly associated with dune land (402).

Playas are used mainly for wildlife habitat and recreation, mainly artifact collecting. Some areas are potentially valuable as sources of sodium salts and as potential sites for disposal of certain types of chemical wastes.

Capability Unit VIII W-2

(Class VIII land consists of very steep fault escarpments, marsh areas, dune land, or rock land unsuited to cultivation, forestry, or grazing. Suitability for wildlife habitat and recreation is high on most of these areas.)

Dune Land

The miscellaneous land type, Dune Land, occurs on flat basin bottoms mostly in the north end of Warner Valley. Dune land consists of sand dunes and coppice mounds about 1 to 10 feet high which commonly occupy over 60 percent of the area. The intervening soil, where present, is mainly unnamed silt loam (155A) or Playa. Relief is hummocky and ridged because of the wind blown sandy deposits.

Runoff is very slow or none and the hazard from wind erosion is very severe to adjoining soil areas. Native plants consist mainly of scattered brush plants and sprigs of grass on sandy deposits. Unnamed silt loam (155A) has a plant cover consisting chiefly of greasewood and saltgrass. Playas are mainly barren of vegetation.

Dune land is used mainly by wildlife and for recreation.

Capability Unit VIIIe

OR-SOILS-1
Rev. 8-4-69
(File Code SOILS 12)

U. S. Department of Agriculture
Soil Conservation Service

SOIL INTERPRETATIONS

State: OREGON   Date: July, 1969   Soils: 1. Lofftus silt loam. (0 to 1 percent slopes)

The Lofftus series consists of moderately well drained, silt loam, sodic soils underlain by hardpans. These soils have formed in alluvial-lacustrine sediments of mixed mineralogy, chiefly basalt and tuff, and occur on nearly level to hummocky, low terraces in basins. Slopes average 0 to 1 percent. The plant cover is chiefly greasewood, rabbitbrush and saltgrass. Elevation ranges from about 4000 to 4500 feet. Average annual precipitation is between 8 to 10 inches. Mean annual air temperature is 47 to 49°F. and the frost-free (32°F.) period is about 90 to 110 days.

The surface layer is dark grayish brown, when moist, silt loam about 2 inches thick. The subsoil is dark grayish brown, when moist, silt loam about 28 inches thick. The hardpan is weakly to strongly cemented and occurs 20 to 40 inches deep. All parts of the soil are strongly calcareous and strongly to very strongly alkaline.

Inclusions of Ozamis soils comprise an estimated 15 to 30 percent of some mapped areas of Lofftus soils.

Permeability is slow. Effective rooting depth is 20 to 40 inches. Runoff is slow and the erosion hazard is slight. The water supplying capacity is 6 to over 8 inches. Available water holding capacity is 3 to 7 inches.

ENGINEERING INTERPRETATIONS

Estimated Chemical and Physical Properties

Depth from surface of typical profile Inches	Classification				% of Material Passing Sieve				Permeability	Available Water Capacity	Soil Reaction	Shrink Swell Potential	Corrosivity
	USDA Texture	Unified	AASHO	Over 3"	#4	#10	#40	#200	Inches Per Hour	Inches per Inch of Soil	(pH)		Uncoated Steel
0-30	silt loam	ML	A-4	0	100	100	90-100	70-90	.06-.20	.19-.21	8.5-9.6	Low	High
30	hardpan												

Suitability as a source of topsoil is not suited. Suitability as a source of sand and gravel is not suited. Suitability as a source of road fill is poor. Hydrologic group is C.

INTERPRETATIONS OF ENGINEERING PROPERTIES

Use	Soil	Limitation	Major Factors Affecting Use
Highway Location	1.	moderate	24 to 48 inches deep to water table; subject to flooding; 20 to 40 inches deep to hardpan; dispersed, unstable material.
Dikes & Levees Pond Embankment	1.	severe	unstable, dispersed material; severe piping hazard; poor compaction.
Pond Reservoir Area	1.	moderate	20 to 40 inches deep to hardpan; slowly permeable; alkali material; 24 to 48 inches deep to watertable.
Agricultural Drainage	1.	severe	slowly permeable; 20 to 40 inches deep to hardpan; 24 to 48 inches deep to water table.
Terraces & Diversions	1.	---	not needed
Grassed Waterways	1.	---	not needed
Winter Grading	1.	moderate	24 to 48 inches deep to water table; wet, nonplastic material.

Continuation Sheet   Lofftus Series   July 1969
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COMMUNITY INTERPRETATIONS

Use	Soil	Limitation	Major Factors Affecting Use
Foundations for low buildings	1.	severe	24 to 48 inches deep to water table; low shear strength; subject to flooding; severe piping hazard.
Septic tank sewage disposal	1.	severe	slowly permeable; 20 to 40 inches deep to hardpan; subject to flooding; 24 to 48 inches deep to water table.
Lagoon sewage disposal	1.	---	not applicable

RECREATION INTERPRETATIONS

Use	Soil	Limitation	Major Factors Affecting Use
Playgrounds	1.	severe	24 to 48 inches deep to water table; 20 to 40 inches deep to hardpan; slowly permeable; alkali dust.
Camp Areas	1.	severe	24 to 48 inches deep to water table; slowly permeable; alkali dust.
Picnic Areas	1.	severe	24 to 48 inches deep to water table; alkali dust.
Paths & Trails	1.	severe	same

AGRICULTURE INTERPRETATIONS

Major Crops	Soil	Suitability	Optimum Yields	Major Factors Affecting Use
---	---	---	---	---
Land Capability	VIs (nonirr.)			

WOODLAND INTERPRETATIONS

Species	Soil	Site Index	Limitations					Native Species
			Seedling mortality	Erosion hazard	Windthrow hazard	Plant Competition	Equipment Limitations	
---	---	---	---	---	---	---	---	---

RANGE INTERPRETATIONS

Site Name	Soil	Key Species and %	Pot. Yields		Normal Season *	
			Total Lb/Ac	Usable Ac/AUM	Growing	Grazing
Moist Sodic Bottom	1.	sltgrs-G.wildrye grwsd			April 15 - Sept. 20	May 15 - Nov. 1

*Interpolated from Ozamis series data.

OR-SOILS-1
Rev. 8-4-69
(File Code SOILS 12)

U. S. Department of Agriculture
Soil Conservation Service

SOIL INTERPRETATIONS

State: OREGON   Date: July, 1969   Soils: 1. Icene association, (0 to 1 percent slopes).

(Icene Series)

The Icene series includes moderately well drained, very deep, loam over stratified clay loam, silt loam and loam, sodic soils. These soils occur on low basin terraces and lower edges of alluvial fans and cones on slopes of less than 1 percent. They are formed in alluvial - lacustrine sediments from basalt and tuff. The plant cover consists largely of greasewood and saltgrass. Elevation ranges from about 4400 to 4500 feet. Average annual precipitation is about 8 to 10 inches. Mean annual air temperature is 47 to 49°F. and the frost-free period (32°F.) is about 90 to 110 days.

The surface layer is dark grayish brown and very dark grayish brown, when moist, loam and silt loam about 2 inches thick. It is strongly alkaline and calcareous in places. Fine pebbles are commonly scattered over the surface. The subsoil is dark brown and dark grayish brown, when moist, clay loam and silt loam about 20 inches thick. It is strongly alkaline to very strongly alkaline and calcareous. Thin lenses and layers of grayish brown and dark grayish brown, when moist, loam, silt loam, silty clay loam, and very fine sandy loam comprise the substratum.

Inclusions of named soils are not known to occur within mapped areas of Icene soils.

Permeability is slow. Effective rooting depth is 40 to over 60 inches. Runoff is very slow and the erosion hazard is slight. The water supplying capacity is 6 to over 7 inches.

This soil is used for range by livestock and wildlife and for recreation.

ENGINEERING INTERPRETATIONS

Estimated Chemical and Physical Properties

Depth from surface of typical profile Inches	Classification				% of Material Passing Sieve				Permeability	Available Water Capacity	Soil Reaction	Shrink Swell Potential	Corrosivity
	USDA Texture	Unified	AASHO	Over 3"	#4	#10	#40	#200	Inches Per Hour	Inches per Inch of Soil	(pH)		Uncoated Steel
0-2	loam	ML	A-4	0	95-100	90-100	75-95	55-75	.06-.20	.15-.18	8.5-9.0	Low	High
2-22	clay loam & silt loam	ML	A-4	0	95-100	90-100	75-95	60-80	.06-.20	.18-.21	8.5-9.6	Low	High
22-60	loam	ML	A-4	0	95-100	90-100	75-95	55-75	.06-.20	.15-.18	8.5-9.6	Low	High

Suitability as a source of topsoil is not suited. Suitability as a source of sand and gravel is not suited. Suitability as a source of road fill is poor. Hydrologic group is C.

INTERPRETATIONS OF ENGINEERING PROPERTIES

Use	Soil	Limitation	Major Factors Affecting Use
Highway Location	1.	severe	dispersed, unstable material; subject to flooding; low shear strength.
Dikes & Levees Pond Embankment	1.	severe	dispersed materials; severe piping hazard; low shear strength; poor stability.
Pond Reservoir Area	1.	slight	alkali materials.
Agricultural Drainage	1.	slight	subject to flooding; alkali materials.
Terraces & Diversions	1.	---	not needed
Grassed Waterways	1.	---	not needed
Winter Grading	1.	slight	slightly plastic materials.

Continuation Sheet   Icene Series   July 1969
OR-SOILS-1
Rev. 8-4-69

COMMUNITY INTERPRETATIONS

Use	Soil	Limitation	Major Factors Affecting Use
Foundations for low buildings	1.	severe	low shear strength; dispersed, unstable material; flooding hazard.
Septic tank sewage disposal	1.	severe	slowly permeable; subject to flooding.
Lagoon sewage disposal	1.	moderate	subject to flooding.

RECREATION INTERPRETATIONS

Use	Soil	Limitation	Major Factors Affecting Use
Playgrounds	1.(Icene soil)	severe	slowly permeable; alkali dust.
Camp Areas	1.(Icene soil)	severe	same
Picnic Areas	1.(Icene soil)	severe	alkali dust.
Paths & Trails	1.(Icene soil)	moderate	alkali dust.

AGRICULTURE INTERPRETATIONS

Major Crops	Soil	Suitability	Optimum Yields	Major Factors Affecting Use
---	---	---	---	---
Land Capability	1 - VIs (nonirr.) (Icene series)			

WOODLAND INTERPRETATIONS

Species	Soil	Site Index	Limitations: Seedling mortality	Erosion hazard	Windthrow hazard	Plant Competition	Equipment Limitations	Native Species
---	---	---	---	---	---	---	---	---

RANGE INTERPRETATIONS

Site Name	Soil	Key Species and %	Pot. Yields Total Lb/Ac	Pot. Yields Usable Ac/AUM	Normal Season * Growing	Normal Season * Grazing
Moist Sodic Bottom	1.	g.wrye, Saltgr, Greasewd			April 1 - July 20	April 20 - Dec. 1
					*Interpolated	from Boulder Lake
					(Hayes) series	data.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 16 DATE Aug 27, 1971

LOCATION NE¼ Sec 19, T 30S, 23E Lake County

ELEVATION ________ WATER LEVEL 15 feet

DRILLER R Redfern DESCRIPTIONS BY V Newton

Sample Depth	Description of Material
0 - 51'	Hole was not logged. Plastic casing was run to a depth of 30 feet.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 17 DATE April 18, 1972

LOCATION NE¼ Sec 18, T 30S, R 23E Near Center of Playa

ELEVATION ________ WATER LEVEL 3.0' Ground

DRILLER Redfern DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Silty Clay; whitish gray, containing a few scattered fine fragments of basalt, bentonitic. Fair effervescence in dil HCl.
3 - 6'	Silty Clay; whitish gray, scattered fine pieces of basalt, quartz and feldspar. Moderately efferv-escent in dil HCl.
6 - 9'	Calyey Silt; grayish tan, very fine pieces of basalt. Moderate to strongly effervescent in dil HCl.
9 - 12'	Clayey Fine Sand; light tan, fine grains of feldspar, quartz and fragments of basalt. Moderately efferv-escent in dil HCl.
12 - 15'	Clayey Fine Sand; as above described.
15 - 18'	Clay Silt; light tan, scattered fine pieces of basalt. Fair effervescence in dil HCl.
18 - 21'	Fine Silty Sand; light tan, consisting of feldspar, quartz and fragments of basalt. Quartz is probably volcanic glass. Moderately effervescent in dil HCl.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 17 DATE April 18, 1972

LOCATION ________

ELEVATION ________ WATER LEVEL ________

DRILLER ________ DESCRIPTIONS BY ________

Sample Depth	Description of Material
21 - 24'	Clay Silt; whitish gray, few scattered fine pieces of basalt. Moderately effervescent in dil HCl.
24 - 27'	Silt; grayish green, soft.
27 - 30'	Silt; as above described.
30 - 33'	Silty Clay; light grayish green, containing very fine pieces of basalt and occasional medium size grains of feldspar and some volcanic glass. Faintly effervescent in dil HCl.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 18 DATE Aug 28, 1971

LOCATION NE¼ Sec 13, T 30S, 22E Lake County

ELEVATION ________ WATER LEVEL 5 feet

DRILLER R. Redfern DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 31'	Hole was not logged. Plastic casing was run to a depth of 30 feet.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 19 DATE April 18, 1972

LOCATION Near the center of Sec 12, T 30S, R 22E, NW side of Playa

ELEVATION ______ WATER LEVEL 14' below ground

DRILLER Baggs DESCRIPTIONS BY Newton

Sample Depth	Description of Material
0 - 3'	Clay Silt; whitish gray, containing scattered fine pieces of basalt. Moderately effervescent in dil HCl.
3 - 6'	Clay Silt; whitish gray, containing fine pieces of basalt. Moderately effervescent in dil HCl.
6 - 9'	Clay Silt; as above described.
9 - 12'	Sandy Silty Clay; whitish gray, containing very fine angular pieces of basalt and quartz (volcanic glass). Moderately effervescent in dil HCl.
12 - 15'	Fine Sandy, Silty Clay; whitish gray, containing very fine angular pieces of basalt and fragments of volcanic glass. Moderate effervescence in dil HCl.
15 - 18'	Silty Clay; whitish gray, containing scattered fine angular pieces of basalt. Moderately effervescent in dil HCl.
18 - 21'	Clay Silt; greenish gray, soft. Auger dropped through this layer.
21 - 24'	Clay Silt; as above described.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 19 DATE April 18, 1972

LOCATION

ELEVATION WATER LEVEL

DRILLER DESCRIPTIONS BY

Sample Depth	Description of Material
24 - 29'	Clay Silt; grayish green, as above.
29 - 33'	Clay; dark greenish gray, plastic. Fair effervescence in dil HCl.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 20 DATE April 18, 1972

LOCATION NE$\frac{1}{4}$ Sec 5, T 30S, R 23E NE of Playa

ELEVATION ________ WATER LEVEL 17' from ground surface

DRILLER Baggs DESCRIPTIONS BY Newton

Sample Depth	Description of Material
0 - 3'	Clay Silt; whitish gray, containing scattered fine pieces of basalt. Moderately effervescent in dil HCl.
3 - 6'	Clay Silt; as above described.
6 - 9'	Fine Silty Sand; whitish gray consisting of very fine angular pieces of basalt and volcanic glass, approximately 30% silty fines. Moderately effervescent in dil HCl.
9 - 12'	Fine Clayey Sand; cream colored, consisting of subangular fragments of feldspar, volcanic glass and basalt. Moderately strong effervescence in dil HCl..
12 - 15'	Fine Sand; whitish gray composed of subangular fragments of feldspar, volcanic glass and basalt, an ocassional piece of olivine. Fair effervescence in dil HCl.
15 - 18'	Fine Silty Sand; as above, except approximately 30% fine white matrix. Strong effervescence in dil HCl.
18 - 24'	Fine Sandy Clayey Silt; white, containing fine pieces of basalt and volcanic glass. Hard layer encountered at 23'. Strong effervescence in dil HCl.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 20 DATE April 18, 1972

LOCATION

ELEVATION WATER LEVEL

DRILLER DESCRIPTIONS BY

Sample Depth	Description of Material
24 - 25'	Fine Sandy Clayey Silt; as above described. Water at 25'. Auger stopped at 25' on hard material. Probably volcanic tuff similar to that found in Hole # 10.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 23　　DATE April 18, 1972

LOCATION $SW\frac{1}{4}$ Sec 8, T 30S, R 23E, NE of center of Playa

ELEVATION ______　　WATER LEVEL Flwg

DRILLER Redfern　　DESCRIPTIONS BY V. Newton

Sample Depth	Description of Material
0 - 3'	Clay Silt; whitish gray, scattered fine fragments of basalt, few medium size pieces of volcanic glass. Moderately effervescent in dil HCl.
3 - 6'	Silty Clay; whitish gray, soft, containing fine pieces of basalt, feldspar and volcanic glass. Moderately effervescent in dil HCl.
6 - 9'	Clayey Silt; tan, very fine pieces of basalt, feldspar and volcanic glass. Moderately effervescent in dil HCl.
9 - 12'	Very Fine Clayey Sand; light tan, very fine pieces of basalt, feldspar and quartz. Moderately effervescent in dil HCl.
12 - 15'	Clayey Fine Sand; tan, scattered very fine fragments of basalt. Moderately effervescent in dil HCl..
15 - 18'	Silty Fine Sand; tan, very fine pieces of basalt, feldspar and volcanic glass. Fair effervescence in dil HCl.
18 - 21'	Clayey Fine Sand; light tan, consists of basalt, volcanic glass and feldspar and 30% fine matrix. Moderately strong effervescence in dil HCl.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.

ALKALI LAKE

DESCRIPTIONS OF AUGER SAMPLES

HOLE NO. 23 DATE April 18, 1972

LOCATION

ELEVATION WATER LEVEL

DRILLER DESCRIPTIONS BY

Sample Depth	Description of Material
21 - 24'	Fine Sandy Silt; tan, very fine pieces of basalt, quartz and feldspar. Moderate efferv-escence in dil HCl.
24 - 27'	Silt; grayish green, soft. Auger dropped through this layer.
27 - 30'	Silt; as above described.
30 - 33'	Silty Clay; whitish gray containing fine scattered pieces of basalt, feldspar and quartz. Fair efferv-escence in dil HCl.

Note: Effervescence in dilute HCl used to indicate amount of evaporite in samples.