IN THE SUPREME COURT OF THE STATE OF NEVADA

JASON KING, P.E., Nevada State Engineer, DIVISION OF WATER RESOURCES, DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES, Appellant, vs. HAPPY CREEK, INC., Respondent.	Case No. 74266

JOINT APPENDIX

<u>Volume VIII of XVII</u>
(Pages JT APP 339-381)

Docket 74266 Document 2018-08887

DATE	DOCUMENT DESCRIPTION	VOLUME	PAGE NOS.
06/12/17	Request for Submission and Oral Argument	XVI	937-934
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08/14/17	Transcript of Oral Argument	XVI-XVII	1043-1172

RESPECTFULLY SUBMITTED this 6th day of March, 2018.

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CERTIFICATE OF SERVICE

I certify that I am an employee of the Office of the Attorney General and that on this 6th day of March, 2018, I served a copy of the foregoing JOINT APPENDIX (Volumes I-XVII, Pages JT APP 1-1183), by electronic service to:

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Sampling frequencies for monitoring wells will depend on: (1) The frequency of application of contaminants at the source, (2) the dynamics of the ground-water flow system, (3) the purpose of the monitoring, and (4) knowledge based on initial data. Initial sampling schedules for point-source monitoring should assume that quality will vary periodically; sampling frequencies should be close enough to document the shortest anticipated variations. Monitoring results should be examined promptly and repeatedly and the sampling schedule revised as needed.

An interesting discussion of the spacing of monitoring wells and sampling frequencies has been presented by Pettyjohn (1976). Figures 8 and 9 indicate the perils of interpreting data based on insufficient sampling points and frequencies. Figure 8 shows the differing sets of data for chloride concentrations obtained from three adjacent wells. Well A was open to the aquifer at 9 feet, well B was open at 23 feet, and well C was open to the entire vertical section. The complexity of the resultant water-quality hydrographs indicates the perils of basing conclusions on annual samples from single wells. At this particular monitoring site, single samples taken at infrequent or annual intervals would have resulted in markedly differing observations of chloride concentration depending upon the month of sampling and the sampled depth. Figure 9 shows how misleading interpretations may be when based on data from too few observation wells. Two groups of observation wells (A and B) and hypothetical target plumes of chloride contamination are illustrated in the cross section. Plan views (a) and (b) show the lines of equal chloride concentration resulting from data for observation-well groups A and B, respectively; plan view (c) shows lines derived from data for both sets of wells; and (d) shows lines that would result from full delineation of the plumes. Pettyjohn aptly summarized these problems:

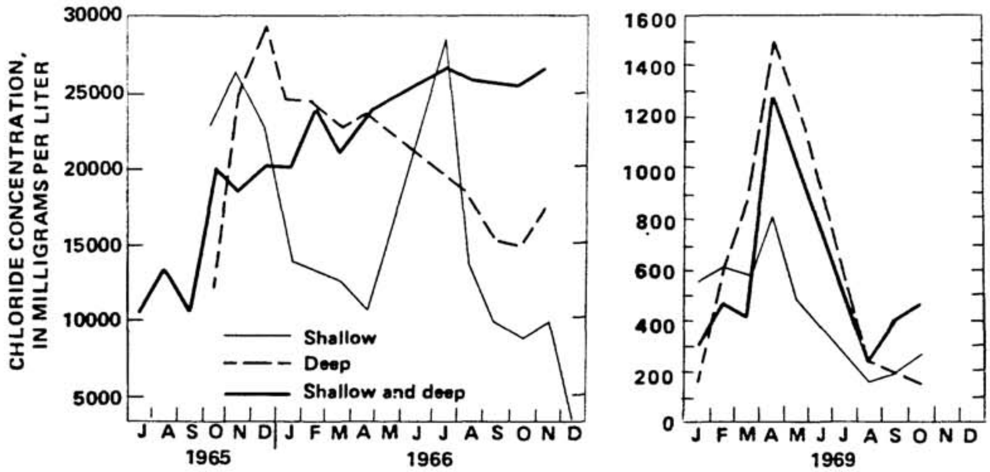

FIGURE 8.--Varying chloride concentration in water from three closely spaced observation wells with different producing intervals (modified from Pettyjohn, 1976).

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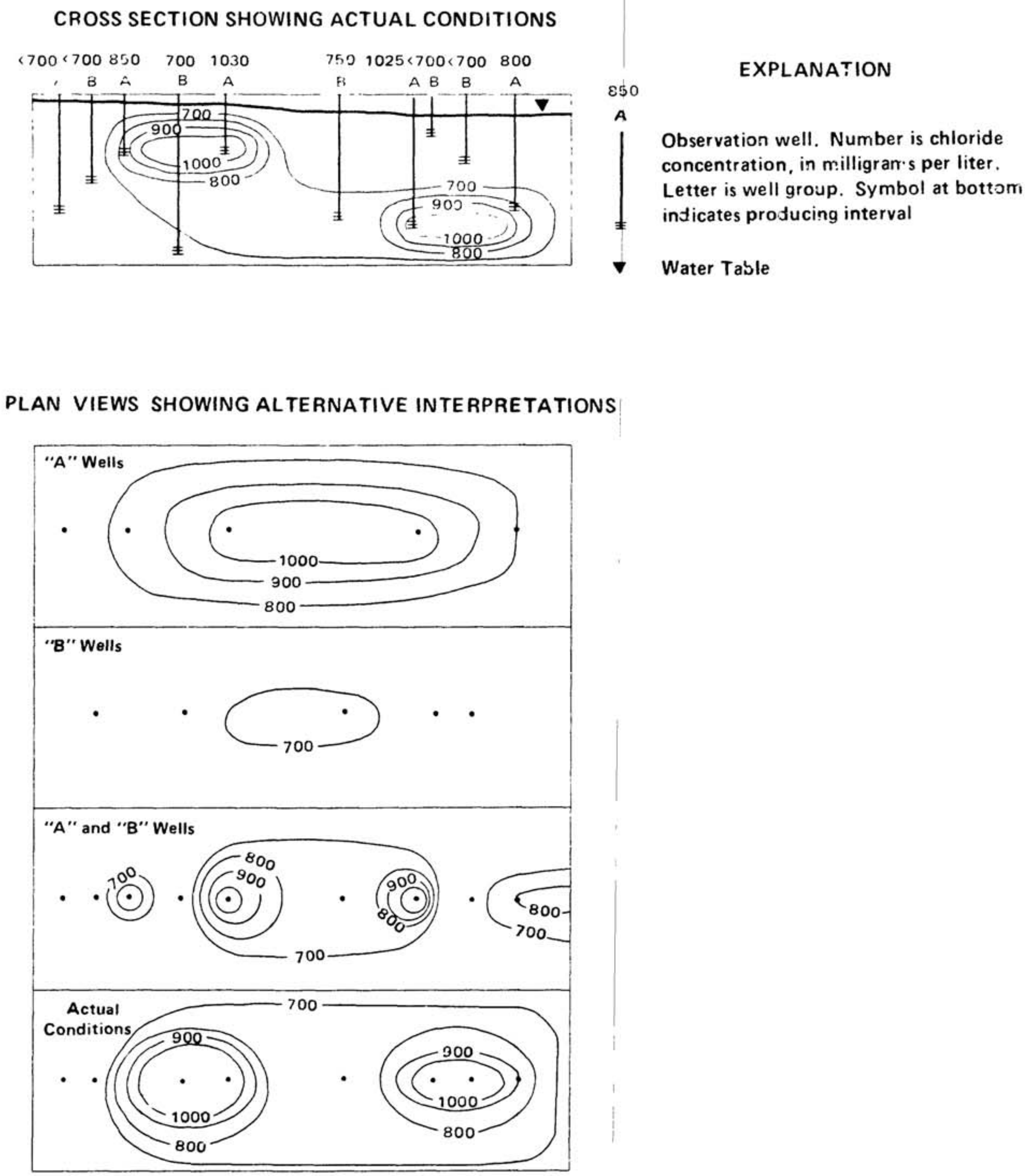

Differing chloride distribution on the basis of data from different groups of observation wells.

FIGURE 9.--Differing interpretations of contamination in a hypothetical aquifer (modified from Pettyjohn, 1976, figure 9).

"Existing data indicate that in many situations, cyclic fluctuations of ground-water quality can occur and in fact may be common. These fluctuations are greatly influenced by the characteristics of the wastes, recharge events, and aquifer stratigraphy. Cyclic events can best be monitored by using a series of closely-spaced wells, each of which is screened opposite a small part of the aquifer and withdraws water from only that limited section. Moreover, samples should be collected from these wells at closely-spaced, regular intervals until the hydrologic nature of the site is recognized. Furthermore, we must not blithely pass over or ignore quality data that appear to be anomalous for they may tell us far more than the expected analysis."

Sample Collection and Analysis Techniques

The residence time of ground water in an aquifer may be long enough for the water to be in equilibrium with its chemical environment (Hem, 1970, p. 74); however, a drastic change in chemical environment is common when water is rapidly withdrawn from the aquifer by means of a pumping well. The changes in pressure and temperature between the native aquifer and atmospheric conditions at land surface may produce abrupt, significant changes in equilibria in the sample.

Eh (oxidation potential), pH, abundance of dissolved gasses (loss of CO_2, gain of O_2), and carbonate-mineral equilibria commonly change in the first few minutes as the water adjusts to atmospheric conditions. Precipitation of calcium carbonate may accompany loss of CO_2 and changing pH, resulting in lower concentrations of calcium, bicarbonate, and carbonate (and thus alkalinity and total hardness) in the sample as compared to water in the aquifer. Changes in Eh as water is brought from reducing conditions commonly found in aquifers to oxidizing environments in the atmosphere may result in precipitation of iron and manganese. Other trace metals may be lost through direct precipitation, by adsorption onto the walls of sample containers, or by sorption by the iron and manganese precipitates (phosphorus is particularly susceptible). Oxidation reactions may also affect observed concentrations of sulfur and nitrogen species. Microbiological changes during the period between sample collection and analysis may either decrease or increase measured concentrations of nutrients, and may result in the breakdown of more complex organics.

Procedures to minimize the differences between the measured quality of water samples and the true quality of the in-situ ground water fall in three categories: Collection techniques, field analyses, and sample-preparation and -preservation techniques. Sample-collection techniques should be designed to minimize the effects of environmental changes between the aquifer and the sample container. Field analyses reduce the time during which water-quality changes might occur. Sample-preparation techniques attempt to insure maximum analytical recovery in the laboratory of the constituents of interest, and sample-preservation techniques attempt to minimize changes during the period between collection and analysis. An excellent discussion of techniques for sampling and field analysis of ground water has been given by Wood (1976).

Sampling techniques.—Sampling techniques for ground water, whether from wells or springs, should be selected to obtain the most representative sample possible from the target aquifer. New wells or infrequently used wells should be thoroughly developed before sampling to: (1) Insure good hydraulic connection with the aquifer, (2) remove any sediment or loose encrustations or corrosion products from the well bore, screen, or perforations, and, for new wells, (3) remove any extraneous material introduced by drilling.

Water levels should be measured prior to development and during recovery to determine if the well is open, partially open, or plugged extensively by encrustation or sediments. If part of the screen or one of the screens in a well is not open or has reduced flow compared to another sampling period, the composite water from the well may be different in quality.

Wells should be pumped long enough prior to sampling to insure that standing water has been removed from the well bore and has been replaced by formation water. The pumping methods employed should be those that will result in the least change in sample environment for the specific target constituents. If existing production pumps are used, they should be in good working order and not pumping air due to excessive drawdown or cavitation effects. Methods for sampling wells without production pumps will depend upon depth to water, well construction, the constituents to be measured, and available equipment. Use of a portable electric submersible pump has been described by McMillion and Keeley (1968). Shallow, small-diameter wells may be sampled with a peristaltic pump (Ball and others, 1976). Deeper small-diameter wells may be pumped using gas lift (Smith, 1976) or gas pressure (Sommerfeldt and Campbell, 1975). If pumps are unavailable, a variety of devices may be employed for obtaining samples by bailing, ranging from simple homemade equipment to commercial units designed to sample discrete depths (Wood, 1976, p. 2). However, most bailers are incapable of obtaining samples uncontaminated by oxygen; exceptions are those which have positive-closure valves. For small-diameter wells, the sample volume obtained by bailers may make the process of flushing the well prior to sampling tedious and time consuming.

The sampling of springflow requires special precautions to obtain representative ground water. Well points may be driven into unconsolidated deposits in or adjacent to small springs and samples thus collected from the resulting flow. Springs discharging from consolidated rocks may be sampled by inserting a pipe into the orifice or by using a small submersible pump. Contamination by oxygen is highly probable in whatever method is used to sample springflow; if analyses are to be made for easily oxidized constituents such as iron and manganese, dissolved-oxygen concentrations may be determined in advance of sampling by inserting a probe from a dissolved-oxygen meter into the sampling stream. The sampling intake may then be located so as to minimize the concentration of dissolved oxygen.

Sampling the unsaturated zone is generally difficult. Porous-cup samplers may be placed in bore holes and samples obtained by a combination of vacuum and pressure application through a series of check valves (Wood, 1973). Useful data also may be obtained from analyses of extracts from core samples taken during test drilling in the unsaturated zone.

Field analyses.--Recent developments in instrumentation and equipment make it possible to measure some water-quality characteristics on site with precision and reproducibility equal to that traditionally obtained in the laboratory. On-site measurement is the only way to obtain truly representative values for unstable parameters such as pH, Eh, dissolved oxygen, bicarbonate and carbonate, nutrients such as ammonia, or microbiological determinations. Techniques for field analyses suitable for application to ground-water quality investigations have been discussed in detail by Wood (1976) and Ball and others (1976).

A summary of available techniques for field analyses of ground waters is presented in table 7. Analytical precisions vary with the particular instruments or techniques used and the training and diligence of the operator.

Field determinations of pH and titrations of alkalinity (bicarbonate and carbonate) are mandatory if these parameters are of particular concern to the investigation. Field filtration and incubation of bacteriological samples is highly advisable unless chilled samples can be transported to a laboratory and processed within 6 hours of collection (American Public Health Association and others, 1976, p. 907). Although commercially available water-quality field kits do not generally provide results comparable to the accuracy of laboratory analyses, such kits, if properly selected and calibrated against known standards, provide a quick method of screening water in the field for the presence of significant concentrations of constituents of interest. In this manner, a large number of samples may be screened at relatively low cost to reduce the ultimate analytical load at the laboratory. A procedure for evaluating the accuracy of test kits and its application to analyses for iron concentrations has been discussed by Duncan and others (1976).

Sample preparation and preservation.--Required sample preparation and preservation techniques will differ with the sophistication of the monitoring effort, the requirements of the receiving laboratory, and the parameters to be analyzed. Most samples collected in the course of ground-water monitoring should be filtered to remove particulate matter which may be present even though the water appears clear. Filtration must be accomplished before samples come in contact with the atmosphere, however, or easily oxidized constituents such as iron amd manganese will precipitate and be removed by the

TABLE 7.--*Available techniques for field analyses of ground water*

Parameter	Techniques	Readily obtainable precision	References
Temperature	Thermometer or meter	0.5 to 0.1°C 0.5 to 0.01°C	Wood, 1973; Stevens and others, 1975
pH	Meter	Equal to laboratory	Wood, 1976
Eh	Meter	Equal to laboratory	Wood, 1976
Specific conductance	Meter	Equal to laboratory	Wood, 1976
Dissolved oxygen	Titration or meter	Equal to laboratory	Wood, 1976
Alkalinity, carbonate, bicarbonate	Electrometric titration	Equal to laboratory	Wood, 1976
Ammonia, bromide, cadmium, calcium, chloride, copper, cyanide, fluoride, iodide, lead, nitrate, potassium, silver, sulfide, sodium, divalent cations	Meter, ion-selective electrodes	Variable with parameter, concentration, and interferences	Durst, 1969; Sekerka and Lechner, 1973; Presser and Barnes, 1974
Total coliforms, fecal coliforms, fecal streptococci	Membrane filtration	Equivalent to laboratory	Slack and others, 1973
Alkalinity, ammonia, bromine, calcium, chlorine, chromium, color, copper, cyanide, MBAS, fluoride, hardness, iodine, iron, manganese, nitrate, nitrite, phosphate, sulfate, sulfide, and others	Field kits (titration, colorimetry)	Highly variable with parameter selected and kit used; kits should be evaluated for precision and accuracy and periodically calibrated against known standards	Duncan and others, 1976

filter, resulting in laboratory concentrations for those that are lower than actual concentrations in the unoxygenated ground water. Filtration should be performed under a positive pressure maintained by the pumping device or an inert gas; vacuum filtration exposes the sample to the atmosphere and removes carbon dioxide and other gases from the filtered sample that may result in significant changes in pH, bicarbonate, and carbonate.

Samples taken for determination of constituents in the dissolved phase are by convention filtered through a membrane filter of 0.45-micrometer pore size (Skougstad and others, 1979; U.S. Environmental Protection Agency, 1976d). Filtration through such a filter also removes bacteria, thus reducing microbiological changes in the resultant samples. Colloidal material of small particle size may pass through a 0.45-micrometer filter and greatly affect measured concentrations of metals (Kennedy and others, 1974); filters of a smaller pore size (0.10 micrometer or less) may be needed for special investigations. Most commonly used filtration devices and membrane filters are constructed of plastics and are non-contaminating for routine inorganic analyses. Analyses for organic parameters such as dissolved organic carbon require use of a metalic apparatus and filters (Malcolm and Leenheer, 1973).

Sample-preservation techniques are designed to minimize chemical, physical, or biological changes in the samples during transit to the laboratory; at best, however, these techniques will only retard the inevitable changes. Preservation techniques generally attempt to stabilize samples by (1) retarding of biological action, (2) retarding hydrolysis, and (3) reducing the volatility of constituents. Specific techniques depend upon the constituents in question; analysis for a large suite of water-quality characteristics requires preparation of a number of subsamples, each with individual methods of preservation. Preservation techniques recommended as of 1977 by the U.S. Geological Survey and the U.S. Environmental Protection Agency for parameters commonly included in ground-water monitoring are summarized in table 8. These methods are periodically revised as research continues on the sample-preservation problem.

Monitoring Results

The initial product of a state-wide monitoring program will be a large volume of diverse types of data. Raw data residing in files, whether the files are plain manila or impressive bound computer printouts, do little to protect the ground-water resource. A primary function of the monitoring agency will be to review, interpret, analyze, and disseminate the results of monitoring.

Monitoring results should be reviewed promptly to provide the necessary feedback to maintain an efficient network. Preliminary results in the form of summary tables or graphs, or both, should be made available to State, Federal, and local management and regulatory agencies interested in water resources. Results should be summarized at least annually for release to the general public, and more often if of particular local significance. The U.S. Environmental Protection Agency (EPA) requires that ground-water monitoring data be made available to that agency within 90 days of collection (40 CFR 35, Subpart B); monitoring-site inventories and summary reports are required annually.

TABLE 8.—*Recommended methods for preserving samples for water-quality analyses*

[Methods compiled from available USGS and EPA publications; may vary with receiving laboratory and are subject to change with improving methodologies. Preservative effects: $CuSO_4$, bacteriocide; HNO_3, dissolves metals; $HgCl_2$, bacteriocide; H_2SO_4, bacteriocide; H_3PO_4, forms salts with organic bases; NaOH, forms salts with volatiles; cooling or freezing, retards biologic activity]

Parameters	Filtration recommended	Preservative	Maximum holding time	Remarks
Inorganic				
Cations:	X	HNO_3 to pH <2[1]	6 months	—
Calcium, magnesium, sodium, potassium, iron, manganese, arsenic, other metals				
Anions:				
Bicarbonate, carbonate		—	—	Field analyses preferred
Sulfate, chloride, fluoride	[2]X	None required	—	—
Nutrients:	X	Cool to <4°C, add 40 mg $HgCl_2$ per liter	7 days	Ammonia, organic N, NO_2-N are unstable
Nitrogen and phosphorus species				
Dissolved solids	X	None required	—	—
Organic				
BOD	—	Cool to <4°C	6 hours	—
COD	—	H_2SO_4 to pH <2	7 days	—
Carbon, organic	X	Cool to <4°C	7 days	—
Cyanide	—	NaOH to pH 12, cool to <4°C	24 hours	—
MBAS (detergents)	—	Cool to <4°C	—	—
Oil and grease	—	H_2SO_4 to pH <3, cool to <4°C	24 hours	—
Pesticides:	—	Cool to <4°C	—	—
Organochlorines, organophosphates, Chlorophenoxy acids				
Phenolics	—	1.0 gm $CuSO_4$ per liter, H_3PO_4 to pH <4	24 hours	—

[1] HNO_3 used to preserve trace constituents must be of very high purity.

[2] Do not filter, or use only inert gases or non-contaminating pumps to provide pressure for filtration.

The preferred format for reporting raw data to EPA is in a format compatible with the STORET data system. The potential variety and number of data parameters to be generated by a long-term statewide monitoring network necessitates an automated data-handling system for efficient operation. An ideal system would do more than store and retrieve numbers; its capabilities should include:

1. Satisfaction of EPA reporting requirements.
2. Generation of tables of publication quality to speed data dissemination.
3. Generation of graphical output for data reduction and analysis.
4. Statistical reduction and analyses of raw data.
5. The ability to manipulate other ground-water data such as water levels, aquifer characteristics, well construction, and geologic logs as well as water quality.

These needs are discussed in more detail in a later section of this report.

A REVIEW OF MONITORING FOR GROUND-WATER QUALITY IN NEVADA AS OF 1978

Data on ground-water quality have been collected in Nevada in a variety of programs ranging from the random submission of samples by private individuals for analysis of domestic water supplies to a specialized statewide network for the systematic monitoring of radionuclides in ground water. These efforts have generally had one of three principal objectives: (1) To describe the ambient quality of ground water areally or regionally; (2) to monitor the quality of ground water at points of withdrawal in relation to intended uses; or (3) to monitor the effects of point or nonpoint sources of pollution on the quality of ground water. Most published data fall in the first category and were collected in the course of areal studies on the general hydrology or ground-water resources of one or more hydrographic basins. As an initial step in organizing data on ground-water quality in Nevada on a statewide basis, published reports (through 1978) containing data on ground-water quality are indexed by hydrographic area in table 9.

Agencies involved in the collection and analysis of data on the quality of ground water in Nevada as of about 1977 include: The Nevada Consumer Health Protection Services (CHPS); Clark County District Health Department; Washoe County District Health Department; Nevada Division of Environmental Protection (DEP); the Nevada State Engineer; Desert Research Institute, University of Nevada System (DRI); Cooperative Extension Service, College of Agriculture, University of Nevada at Reno; U.S. Bureau of Land Management (BLM); U.S. Bureau of Reclamation (USBR); U.S. Geological Survey (USGS); and the Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency (EPA). Locations of sites sampled by these agencies are shown on plate 1 and are discussed below.

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*

Hydrographic areas		Reference number in Bibliography
Number	Name	
1--NORTHWEST REGION		
1	Pueblo V.	--
2	Continental Lake V.	80, 81, 125
3	Gridley Lake V.	--
4	Virgin V.	--
5	Sage Hen V.	--
6	Guano V.	--
7	Swan Lake V.	--
8	Massacre Lake V.	122
9	Long V. (Washoe Co.)	122
10	Macy Flat	--
11	Coleman V.	--
12	Mosquito V.	--
13	Warner V.	--
14	Surprise V.	--
15	Boulder V.	--
16	Duck Lake V.	123
2--BLACK ROCK DESERT REGION		
17	Pilgrim Flat	--
18	Painters Flat	--
19	Dry V. (Washoe Co.)	--
20	Sano V.	--
21	Smoke Creek Desert	51
22	San Emidio Desert	51
23	Granite Basin	--
24	Hualapai Flat	55, 80, 81, 121
25	High Rock Lake V.	--
26	Mud Meadow	80, 81
27	Summit Lake V.	--
28	Black Rock Desert	80, 81, 87, 91, 124
29	Pine Forest V.	80, 81, 119
30A	Kings River V., Rio King Subarea	79, 146
30B	Kings River V., Sod House Subarea	79, 146
31	Desert V.	120
32	Silver State V.	--
33A	Quinn River V., Orovada Subarea	63, 87, 129, 135
33B	Quinn River V., McDermitt Subarea	63, 87, 129, 135

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		
Number	Name	Reference number in Bibliography
3--SNAKE RIVER BASIN		
34	Little Owyhee River Area	--
35	South Fork Owyhee River Area	--
36	Independence V.	27, 80, 81
37	Owyhee River Area	80, 81
38	Bruneau River Area	--
39	Jarbidge River Area	--
40	Salmon Falls Creek Area	80, 81, 87
41	Goose Creek Area	80, 81
4--HUMBOLDT RIVER BASIN		
42	Marys River Area	80, 81, 87
43	Starr Valley Area	87
44	North Fork Area	80, 81, 87
45	Lamoille V.	87
46	South Fork Area	87
47	Huntington V.	87, 109
48	Dixie Creek, Tenmile Creek Area	87
49	Elko Segment	80, 81, 87
50	Susie Creek Area	87
51	Maggie Creek Area	80, 81, 87
52	Marys Creek Area	87
53	Pine V.	23, 80, 81, 87
54	Crescent V.	80, 81, 87, 144, 145
55	Carico Lake V.	43, 87, 137
56	Upper Reese River V.	38, 53, 87, 98, 118, 137
57	Antelope V. (Lander Co.)	17, 53, 87, 137
58	Middle Reese River V.	17, 53, 87, 137
59	Lower Reese River V.	53, 87, 137
60	Whirlwind V.	80, 81, 87
61	Boulder Flat	87, 137
62	Rock Creek V.	87
63	Willow Creek V.	87
64	Clovers Area	80, 81, 87
65	Pumpernickel V.	80, 81, 87
66	Kelly Creek Area	87
67	Little Humboldt V.	80, 81, 87
68	Hardscrabble Area	87
69	Paradise V.	60, 73, 80, 81, 87

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas Number	Name	Reference number in Bibliography
4--HUMBOLDT RIVER BASIN--Continued		
70	Winnemucca Segment	9, 10, 12, 15, 80, 81, 87
71	Grass V. (Pershing-Humboldt Co.)	11, 80, 81, 91, 100
72	Imlay Area	25
73	Lovelock V.	42, 99
73A	Oreana Subarea	99
74	White Plains	--
5--WEST CENTRAL REGION		
75	Brady's Hot Spring Area	91
76	Fernley Area	--
77	Fireball V.	--
78	Granite Spring V.	56
79	Kumiva V.	--
6--TRUCKEE RIVER BASIN		
80	Winnemucca Lake V.	145
81	Pyramid Lake V.	80, 81, 87
82	Dodge Flat	--
83	Tracy Segment	--
84	Warm Springs Area	111
85	Spanish Springs V.	--
86	Sun V.	--
87	Truckee Meadows	8, 14, 16, 45, 87, 126, 131, 133, 141
88	Pleasant V. (Washoe Co.)	45, 80, 81
89	Washoe V.	45, 87, 102
90	Lake Tahoe Basin	45
91	Truckee Canyon Segment	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		
Number	Name	Reference number in Bibliography
7--WESTERN REGION		
92A	Lemmon V., Western Part	58, 111
92B	Lemmon V., Eastern Part	58, 111
93	Antelope V. (Washoe Co.)	--
94	Bedell Flat	--
95	Dry V. (Washoe Co.)	87
96	Newcomb Lake V.	--
97	Honey Lake V.	--
98	Skedaddle Creek V.	--
99	Red Rock V.	--
100	Cold Spring V.	--
8--CARSON RIVER BASIN		
101	Carson Desert	50, 80, 81, 87, 89, 91, 127, 128, 131
101A	Packard V.	50
102	Churchill V.	50, 61, 131
103	Dayton V.	50, 131
104	Eagle V. (Carson City)	45, 50, 87, 131, 143
105	Carson V.	45, 50, 80, 81, 87, 131
9--WALKER RIVER BASIN		
106	Antelope V. (Douglas Co.)	49, 90
107	Smith V.	71, 80, 81, 87
108	Mason V.	64, 80, 81, 87
109	East Walker Area	49
110A	Walker Lake V., Schurz Subarea	44, 87
110B	Walker Lake V., Lake Subarea	44, 87
110C	Walker Lake V., Whiskey Flat-Hawthorne Subarea	39, 44, 87

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
10--CENTRAL REGION		
111A	Alkali V., Northern Part	--
111B	Alkali V., Southern Part	--
112	Mono V.	--
113	Huntoon V.	--
114	Teels Marsh V.	--
115	Abode V.	--
116	Queen V.	--
117	Fish Lake V.	21, 87, 113
118	Columbus Salt Marsh V.	132
119	Rhodes Salt Marsh V.	--
120	Garfield Flat	--
121A	Soda Springs, Eastern Part	80, 81, 132
121B	Soda Springs, Western Part	132
122	Gabbs V.	28, 87
123	Rawhide Flats	--
124	Fairview V.	13, 89
125	Stingaree V.	--
126	Cowkick V.	--
127	Eastgate V. Area	--
128	Dixie V.	13, 80, 81, 87, 89
129	Buena Vista V.	72, 80, 81, 87
130	Pleasant V. (Pershing Co.)	--
131	Buffalo V.	80, 81, 91
132	Jersey V.	80, 81
133	Edwards Creek V.	40
134	Smith Creek V.	41, 80, 81, 87
135	Ione V.	41, 87
136	Monte Cristo V.	--
137A	Big Smoky, Tonopah Flat	46, 53, 86, 87, 98, 115
137B	Big Smoky, Northern Part	46, 53, 80, 81, 86, 87, 98, 115, 118
138	Grass V. (Lander-Eureka Co.)	43, 46, 80, 81, 98
139	Kobeh V.	46, 98, 108, 118
140A	Monitor V., Northern Part	18, 46, 80, 81, 87, 98, 108, 118
140B	Monitor V., Southern Part	18, 46, 87, 98, 108, 118
141	Ralston V.	29, 46, 53, 87, 96, 98 118
142	Alkali Spring V.	53, 86
143	Clayton V.	53, 86, 87, 103

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
10--CENTRAL REGION--Continued		
144	Lida V.	--
145	Stonewall Flat	103
146	Sarcobatus Flat	77, 87
147	Gold Flat	3, 106, 118
148	Cactus Flat	106, 118
149	Stone Cabin V.	29, 46, 98, 118
150	Little Fish Lake V.	18, 46, 67, 98, 110, 118
151	Antelope V. (Eureka-Nye Co.)	46, 80, 81, 98, 108, 118
152	Stevens Basin	--
153	Diamond V.	26, 54, 87, 98, 118
154	Newark V.	22, 98
155A	Little Smoky V., Northern Part	18, 46, 98, 110, 118
155B	Little Smoky V., Central Part	18, 46, 98, 110
155C	Little Smoky V., Southern Part	18, 46, 98, 118
156	Hot Creek V.	18, 46, 67, 80, 81, 87, 98, 110, 118
157	Kawich V.	3, 106
158A	Emigrant V., Groom Lake V.	6, 106, 116, 117, 142
158B	Emigrant V., Papoose Lake V.	106, 116, 117, 142
159	Yucca Flat	6, 106, 116, 117, 142
160	Frenchman Flat	6, 106, 116, 117, 142
161	Indian Springs V.	5, 6, 53, 84, 85, 87, 88, 97, 106, 116, 117
162	Pahrump V.	53, 76, 87, 88, 97, 138, 142
163	Mesquite V.	47, 87, 138
164A	Ivanpah V., Northern Part	47, 53, 138
164B	Ivanpah V., Southern Part	47, 53, 138
165	Jean Lake V.	--
166	Hidden V. (South)	--
167	Eldorado V.	112
168	Three Lakes V. (Northern)	106
169A	Tikapoo V., Northern Part	106
169B	Tikapoo V., Southern Part	106
170	Penoyer V.	134
171	Coal V.	32
172	Garden V.	32
173A	Railroad V., Southern Part	46, 53, 87, 98, 118, 134
173B	Railroad V., Northern Part	46, 53, 87, 98, 118, 134
174	Jakes V.	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas Number	Name	Reference number in Bibliography
10--CENTRAL REGION--Continued		
175	Long V. (White Pine Co.)	24
176	Ruby V.	80, 81
177	Clover V. (Elko Co.)	--
178A	Butte V., Northern Part	48, 87
178B	Butte V., Southern Part	48, 87
179	Steptoe V.	7, 36, 53, 87
180	Cave V.	30
181	Dry Lake V.	31, 87
182	Delamar V.	31
183	Lake V.	107
184	Spring V. (White Pine Co.)	87, 114
185	Tippett V.	--
186A	Antelope V., Southern (White Pine-Elko Co.)	87
186B	Antelope V., Northern (White Pine-Elko Co.)	87
187	Goshute V.	37, 87
188	Independence V. (Elko Co.)	--
11--GREAT SALT LAKE BASIN		
189A	Thousand Springs V., Herrill Siding-Brush Creek Area	87, 104
189B	Thousand Springs V., Toano-Rock Springs Area	87, 104
189C	Thousand Springs V., Rocky Butte Area	87, 104
189D	Thousand Springs V., Montello-Crittenden Creek Area	--
190	Grouse Creek V.	--
191	Pilot Creek V.	57
192	Great Salt Lake Desert	87
193	Deep Creek V.	--
194	Pleasant V. (White Pine Co.)	--
195	Snake V.	62
196	Hamlin V.	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas Number	Name	Reference number in Bibliography
12--ESCALANTE DESERT		
197	Escalante Desert	--
13--COLORADO RIVER BASIN		
198	Dry V. (Lincoln Co.)	1
199	Rose V.	1
200	Eagle V. (Lincoln Co.)	1
201	Spring V. (Lincoln Co.)	1
202	Patterson V.	1
203	Panaca V.	95
204	Clover V. (Lincoln Co.)	1, 53
205	Lower Meadow V. Wash	1, 53, 87, 101
206	Kane Springs V.	1, 34, 35
207	White River V.	1, 35, 53, 82, 87
208	Pahroc V.	1, 33, 35
209	Pahranagat V.	1, 33, 35, 53, 87
210	Coyote Spring V.	1, 34, 35
211	Three Lakes V., Southern Part	--
212	Las Vegas V.	2, 4, 5, 19, 20, 53, 65, 66, 68, 70, 74, 75, 83, 84, 85, 87, 92, 93, 94, 97, 106, 139, 140, 142
213	Colorado River V.	5, 70
214	Piute V.	87, 112
215	Black Mountains Area	1, 5, 105
216	Garnet V.	1
217	Hidden V. (North)	1
218	California Wash	1
219	Muddy River Springs Area	1, 34, 53, 87
220	Lower Moapa V.	1, 53, 105
221	Tule Desert	1
222	Virgin River V.	1, 52, 53, 87
223	Gold Butte Area	105
224	Greasewood Basin	--

TABLE 9.--*Partial index of publications containing data on ground-water quality in Nevada*--Continued

Hydrographic areas		Reference number in Bibliography
Number	Name	
14--DEATH VALLEY BASIN		
225	Mercury V.	6, 53, 88, 106, 142
226	Rock V.	88, 106, 116, 117
227A	Forty Mile Canyon, Jackass Flats	6, 88, 106, 116, 117, 142
227B	Forty Mile Canyon, Buckboard Mesa	3, 6, 88, 106, 116, 117, 142
228	Oasis V.	3, 6, 77, 78, 88, 97, 142
229	Crater Flat	88, 106
230	Amargosa Desert	53, 69, 87, 88, 97, 116, 117, 130, 136, 142
231	Grapevine Canyon	97
232	Oriental Wash	--

State Agencies

Nevada Consumer Health Protection Services

Ground-water monitoring activities of the CHPS include (1) transmission of water samples from private domestic wells to the Nevada Bureau of Laboratories and Research in Reno for analysis, (2) monitoring of public water supplies, and (3) investigations of ground-water quality in relation to the approval of facilities for water supply and wastewater disposal for subdivisions and developments.

No State requirement exists in Nevada for the submission of water samples from private domestic wells for chemical or bacteriological analyses; however, many homeowners do submit such samples after drilling a new well, renovating an old well, or upon purchase of property with a private well. In addition, analyses of private water supplies are generally made during property sales involving Veterans Administration (VA) or Federal Housing Administration (FHA) loans. Since 1930, an estimated 13,000 samples have been submitted to the State laboratory for domestic supply analyses; as of 1977, samples are being submitted at the rate of about 200 per month.

Parameters included in a routine domestic supply analysis by the Bureau of Laboratories and Research are those listed on the preprinted transmittal and reporting forms shown in figure 10. Chemical and bacteriological data laboratory procedures follow those recommended in "Standard Methods" (American Public Health Association and others, 1976). Samples are generally taken in the field by the homeowner or other individual concerned with the quality of the well water; sampling techniques thus are highly variable, with the point of sampling often being determined by convenience.

IN TRIPLICATE
(PLEASE PRINT)

BUREAU OF LABORATORIES AND RESEARCH
NEVADA DIVISION OF HEALTH
790 Sutro Street
Reno, Nevada 89502

7530

WATER CHEMISTRY:

WELL WATER: Pump should be delivering clear water before sampling.

Date sampled .... Date submitted ....

Owner ....

Report to:

Name ....

Address ....

City .... State ....

County ....

Township ....

Range .... Section ....

Area ....

WATER SOURCE:

Well .... Spring .... Surface ....

Hot .... Cold .... Depth .... Ft.

Casing diameter .... in depth .... Ft.

Now in use .... Yes ☐ No ☐

ROUTINE DOMESTIC ANALYSIS PLEASE CHECK BOX		FOR PARTIAL ANALYSIS CIRCLE CONSTITUENT DESIRED		FOR CONSTITUENTS NOT LISTED BELOW PRINT IN CONSTITUENT DESIRED IN SPACE BELOW			
Constituent P.P.M.	Constituent P.P.M.	Constituent P.P.M.		Constituent	P.P.M.	Constituent	P.P.M.
T.D.S.	Chloride	Iron					
Hardness	Nitrate	Manganese					
Calcium	Alkalinity	Color					
Magnesium	Bicarbonate	Turbidity					
Sodium	Carbonate	pH					
Potassium	Fluoride						
Sulfate	Arsenic						

Remarks ....

Chemical analysis

BUREAU OF LABORATORIES AND RESEARCH
NEVADA DIVISION OF HEALTH
790 Sutro Street, Reno, Nevada 89502
625 Shadow Lane, Las Vegas, Nevada 89106

DO NOT USE

SAMPLED BY ________ DATE ________ HOUR ________

LOCATION ________ COUNTY ________

SAMPLE IS:

DRINKING ________, RAW SURFACE ________, SEWAGE ________, OTHER ________

MEMBRANE FILTER METHOD USED

NAME ________

ADDRESS ________

WATER BACTERIOLOGY

THIS SPACE FOR LAB USE ONLY RESULTS:

COLIFORMS ________/100 ML.; FECAL COLI ________/100 ML.

OTHER ________

NOTE: IF ABOVE COLIFORMS IS O, THE SAMPLE IS CONSIDERED AS MEETING USPHS BACTERIOLOGICAL STANDARDS FOR DRINKING WATER.

OTHERWISE

CALL YOUR AREA SANITARIAN AT ________ FOR INTERPRETATION.

7325

Bacteriological analysis

FIGURE 10.--Examples of transmittal and analytical-reporting forms used by the Nevada Bureau of Laboratories and Research for water-quality samples.

Samples are not treated or preserved in any manner prior to shipment (usually by mail) to the laboratory; thus, the reported values for pH and unstable constituents such as iron, manganese, bicarbonate, carbonate, calcium, and magnesium may reflect equilibrium conditions in the bottle on the laboratory bench rather than being representative of the chemical environment in the native ground water. Given the uncertain collection procedures, and unknown storage and transit times, the results of bacteriological analyses of domestic wells are particularly suspect.

The utility of these analyses for defining ground-water quality is further impaired by site-location data that may be inaccurate or absent. Space is provided on the sample-transmittal forms to indicate the site location by township, range, and section and to provide data on well diameter and depth; however, these data may be unknown to the collector of the sample, and thus are often either missing from the submitted forms or supplied in the form of approximations or guesses.

If interpretations are made with full recognition of the limitations described above, the large number of historical analyses and relatively broad areal coverage within the inhabited parts of the State result in a potentially valuable data base for determining the background quality of Nevada ground water. The utility of these data could be enhanced by modifying the sample transmittal forms to include more specific descriptions of the sampling point and site location. For example, check-off boxes could be added to indicate whether the sample was from the well head, a line preceding or following the storage tank, filter, or softener. Options for site location should include the street address of the site, if available, and the subdivision name and lot number. Space should be provided for owner's comments and a location sketch to refine the site description. An example format is shown in figure 11.

Public water supplies in Clark and Washoe Counties are monitored under the authority of the respective local Distric Health Departments; the CHPS has responsibility for the remainder of the State. Responsibility for sample collection and transmittal is left to the operator of the water supply. Sampling frequencies for chemical analyses have been approximately annual in theory, but intermittent in practice; bacteriological analyses have been requested quarterly for non-community supplies and bimonthly to daily (dependent upon population served) for community supplies.

An estimated 350 community public supplies and 600 to 700 non-community public supplies are served by ground water in Nevada. Approximate locations of the community supply well or springs are shown on plate 1. These sites have potential for monitoring long-term changes in water quality in areas of relatively intense pumping. Evaluation of the historical records in the files of the CHPS and local health departments is beset by the same difficulties as for the domestic-water analyses; unstandardized sample-handling techniques, lack of specific site documentation, and degradation and alteration of unstable constituents during sampling and transportation. Nevada Water Supply regulations as of 1977 require monitoring of all public ground-water supplies at approximately 3-year intervals (table 2).

To be completed by party collecting sample: Samples will not be analysed without adequate location

Date sampled ____________ Date submitted ________

Owner ____

____

Report to:

Name ________________________________

Address ________________________________

City ______________ State ________

Sample collected by: ______________________

|_| Owner |_| Tenant |_| Driller ______________

Reason for sample collection:

____

____

SITE LOCATION--Please identify the location as accurately as possible:

Street address ________________________________

Nearest town ________________________________

Location sketch: Owner's well no. _____

County ________________________________

Township ________________________________

Range ____________ Section ____________

Area ________________________________

____

WATER SOURCE:

Surface ____________ Spring ____________

Hot ____________ Cold ____________

Now in use _________ Yes _ No _ _________

Sewage ____________ Other ____________

WELLS:

Date drilled ____________

Depth _______ ft, Casing diameter _____ in

Perforated zone(s) _____ ft to ________ ft

_____ ft to ________ ft

_____ ft to ________ ft

Sampled at:

|_| faucet in house |_| outside faucet

|_| storage tank |_| well head

Equipment between site and sampling point:

|_| storage tank |_| iron filter

|_| water softener |_| ________________

For office use only: Location checked by _____ Date _____ Office check |_| Field check |_| Revised |_|

Remarks:

For laboratory use only: | Lab log no. and date received

Sample condition upon receipt ______________________

ROUTINE DOMESTIC ANALYSIS PLEASE CHECK BOX		FOR PARTIAL ANALYSIS CIRCLE CONSTITUENT DESIRED			FOR CONSTITUENTS NOT LISTED BELOW PRINT IN CONSTITUENT DESIRED IN SPACE BELOW			
Constituent P.P.M.	Constituent P.P.M.	Constituent P.P.M.			Constituent	P.P.M.	Constituent	P.P.M.
T.D.S.	Chloride	Iron						
Hardness	Nitrate	Manganese						
Calcium	Alkalinity	Color						
Magnesium	Bicarbonate	Turbidity						
Sodium	Carbonate	p.H.						
Potassium	Fluoride							
Sulfate	Arsenic							

Summary of results:

|_| The above water meets all current drinking-water standards.

|_| Concentrations of the following exceed recommended limits for drinking waters:

____

FIGURE 11.--Examples of sample—transmittal form with more descriptive information.

The designated sampling point is at a tap supplying treated water representative of water in the distribution system. The analyses of these samples, however, are likely to provide little utility to an effective ground-water monitoring program because:

1. The quality of finished waters in a distribution system may not be representative of water in the source aquifers.
2. No documentation is provided of quality changes in water from individual wells supplying a system with multiple sources.
3. A 3-year sampling frequency is inadequate to define seasonal or periodic variations in water quality.
4. Monitoring of public supplies can only document the occurrence of contamination; effective monitoring to forecast or provide warning of contamination requires sampling at points between the sources of contamination and the supply wells.

Data on the quality of ground water are also collected by CHPS staff in the course of site studies for approval of water-supply or sewage-disposal systems. Parameters analyzed are generally the same as for routine domestic analyses, and the same qualifications as to the use of the data generally exist. Results of chemical analyses are kept in the CHPS files in Carson City.

Clark County District Health Department

The District Health Department in Las Vegas has been delegated responsibility to monitor the quality of public water supplies in Clark County. Public community water supplies are scheduled for annual chemical analysis and monthly to quarterly bacteriological analyses. Historical data indicate that chemical analyses were made intermittently more commonly than annually. Chemical analyses include the parameters for routine domestic analysis previously described and are made in the Bureau of Laboratories and Research in Reno. Bacteriological analyses are made by the District Health Department in Las Vegas. In addition to the regularly scheduled analyses of public supplies, an attempt has been made to sample, once, the water of each private domestic well in the county for a routine chemical analysis. During 1975-77, such samples were collected at the time of residential sales involving VA or FHA loans. Analytical results are kept in files at Las Vegas. The historical domestic analyses provide a potential data base for documentation of areal water chemistry in the developed areas of the valley. Continuing periodic analyses of public supplies will document temporal changes in quality in the highly stressed zones of the deeper aquifer system. The interpretation of these data is likely to be subject to the same limitations as for the other analyses performed by the State laboratory.

Washoe County District Health Department

The activities of the Washoe County District Health Department within its jurisdiction parallel those of the Clark County District. Samples for bacteriological analyses have been collected monthly on public supplies; sampling for chemical analyses has been intermittent in the past and will become annual under adjustment to provisions of the Safe Drinking Water Act. Samples have been collected from private domestic wells in response to individual requests or in conjunction with VA or FHA loans. Analyses for both chemical and bacteriological parameters are made by the Bureau of Laboratories and Research in Reno. Analytical results are filed in the county offices in Reno and the CHPS offices in Carson City.

Nevada Division of Environmental Protection

The Nevada DEP is not engaged in the direct collection of data on ground-water quality as of 1977. Some analyses of ground water are generated by point-source pollution monitoring required by individual Pollution Discharge Elimination Permits. Responsibility for sample collection and analysis is left to the permittee, with collection frequencies and parameters to be analyzed following individual permit requirements. Results are in the files of the DEP in Carson City.

Nevada State Engineer

The office of the Nevada State Engineer, in the course of operating a network of observation wells for water-level measurements, has collected field measurements of specific conductance in areas of intensive irrigation pumping. This effort spanned the years 1967 to 1973, with annual sampling in some areas and one-time sampling in others. Data are filed in the office of the Nevada State Engineer, Carson City. Hydrographic areas covered and the amount of available data are summarized below:

Hydrographic area		Number of wells	Period of record	Remarks
24	Hualapai Flat	22	1968-69	Generally one-time
31	Desert Valley	19	1968-75	Intermittent
57	Antelope Valley	16	1967-69	Generally one-time
58	Middle Reese River valley	26	1967	One-time
128	Dixie Valley	13	1968-70	Generally one-time

Desert Research Institute

The Water Resources Research Center of the DRI has collected considerable data on ground-water quality in conjunction with various hydrologic research projects throughout the State. These data have been published in various reports (included in table 9) and a large amount of data are stored in computer data bases maintained by DRI in Las Vegas. Analytical support for DRI water projects is provided by DRI laboratories in Reno and Boulder City and by the Nevada Bureau of Laboratories and Research in Reno. The parameters analyzed and the sample collection, preparation, and preservation techniques used differ from project to project. The Center is not engaged in any long-term monitoring of ground-water quality in Nevada as of 1977.

Cooperative Extension Service

The Cooperative Extension Service, College of Agriculture, University of Nevada, Reno, monitors ground water for pesticide residues at four pesticide disposal sites in Churchill, Humboldt, Lander, and Pershing Counties (pl. 1). These sites are operated for the disposal of contaminated containers and excess stocks of pesticides used in agricultural operations by licensed pesticide applicators. Samples are collected from the soil and representative vegetation immediately surrounding each site and are analyzed for chlorinated hydrocarbon and organophosphate insecticides and herbicides to monitor possible movement of pesticides from the sites; water samples are collected from the nearest existing well or spring. Samples are taken each spring and fall to bracket the active season of pesticide use. Analyses are made in the laboratories of the College of Agriculture at the University of Nevada, Reno.

The approximate location of the four disposal sites and the ground-water sampling points used for monitoring each one are shown on plate 1 and in figures 12-15. Available information on the monitoring points is summarized in table 10. Ground-water monitoring points were chosen on the basis of accessibility of existing wells and springs more than by position in the hydrologic system. As a result, few of the sampling points appear to be effectively placed with respect to potential ground-water movement from the disposal sites.

Quinn River valley site (Humboldt County).--The disposal site is on an alluvial fan at the west side of the valley (fig. 12). Ground-water samples are collected at a windmill well about 2-1/2 miles southeast of the site and at a springfed stock-watering facility about 1-3/4 miles south of the site. Neither site is on a probable path of ground-water flow from the disposal site.

TABLE 10.—*Ground-water monitoring at pesticide disposal sites*

[Site use: S, stock]

Site type	Local site number	Owner	Site use	Land-surface altitude (feet)	Total depth (feet)[1]	Casing diameter (inches)	Representative depth to water: Feet	Representative depth to water: Date	Remarks
Quinn River Valley (Orovada Subarea) Disposal Site, Humboldt County; location 33A N43 E36 18DDD									
Well	33A N43 E36 27CAAA1	McErguiaga	S	4155	—	—	3	2-64	Not effective site: too distant and off probable flow path from disposal area.
Spring	33A N43 E36 29C	—	—	—	—	—	—	—	Location uncertain: not effective site; upgradient from disposal area.
Middle Reese River Valley Disposal Site, Lander County, location 58 N25 E42 18DB									
Well	58 N25 E42 20AAD1	Powers	S	4907	110	6	87	2-63	Not effective site: off probable flow path from disposal area.
Lovelock Valley Disposal Site, Pershing County, location 73 N27 E31 30B									
Well	73 N27 E31 29BDDC1	Powers	S	3960	—	—	—	—	Not effective site: too distant and off probable flow path from disposal area.
Well	73 N27 E31 30ADDC1	—	—	3980	—	—	—	—	Not effective site: off probable flow path from disposal area.
Carson Desert Disposal Site, Churchill County, location 101 N20 E28 24CB									
Well	101 N20 E28 24BC1	—	—	3960	10	32	28	12-76	Dug well made from 2 oil drums. Appears to be downgradient and flow path from disposal site.

[1] No information available regarding perforated or screened intervals.

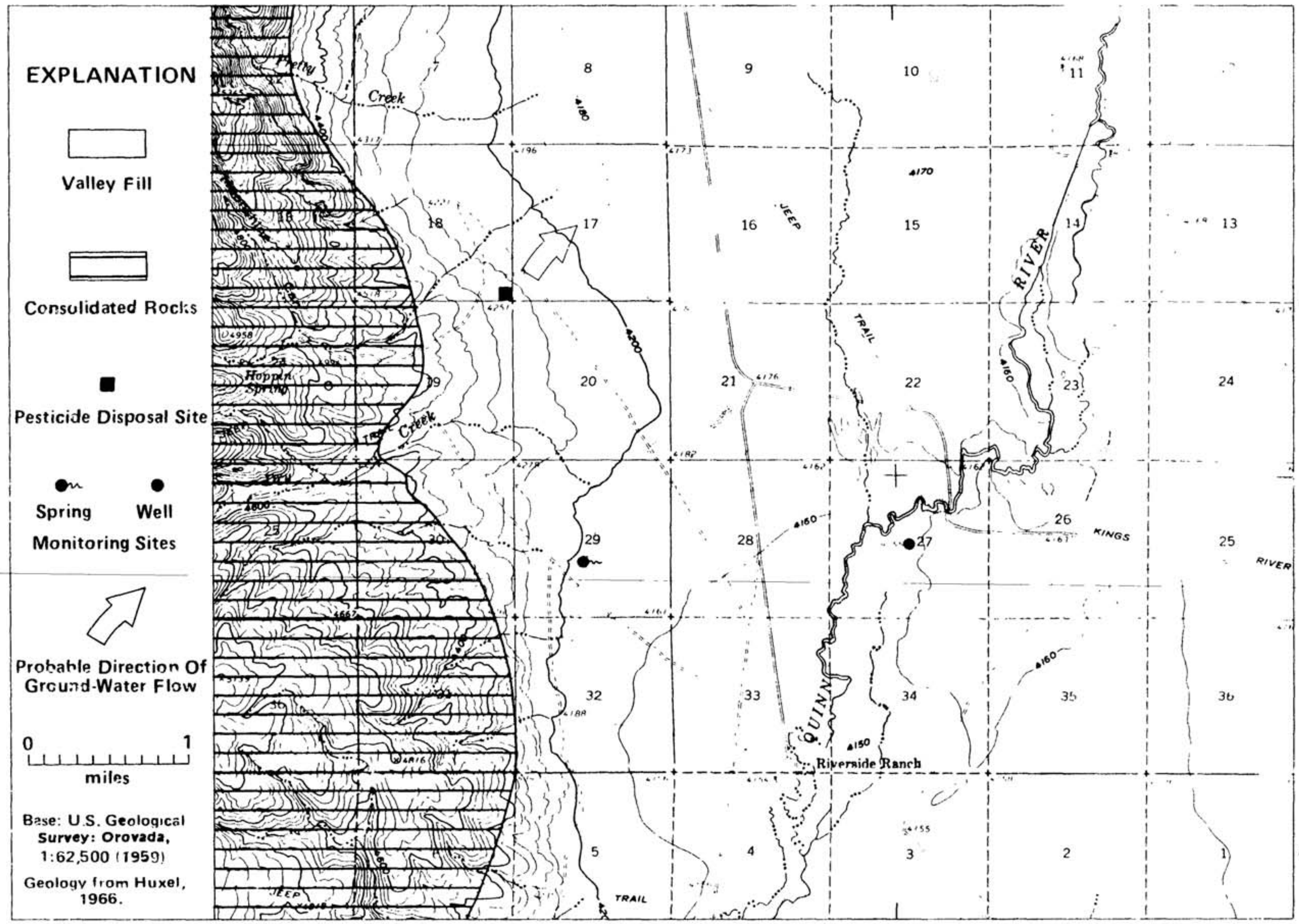

FIGURE 12.--Pesticide-disposal and monitoring sites, Quinn River Valley (Orovada subarea).

Middle Reese River valley site (Lander County).--The disposal site is on alluvium at the point of ground-water underflow from Antelope Valley to the Middle Reese River Valley (fig. 13). Crosthwaite (1963, p. 15) estimated that the hydraulic gradient from Antelope Valley to Middle Reese River Valley is approximately 30 feet per mile and that the volume of underflow between valleys is about 6,000 acre-feet per year. Depths to ground water at the site probably range from 70 to 90 feet. Ground-water samples are collected at a well about 1.5 miles southeast of the disposal site, off the probable path of ground-water flow from the site.

Lovelock valley site (Pershing County).--The Lovelock Valley disposal site lies on alluvium on the southwest flank of a bedrock outcrop about 3.5 mi west of Lovelock (fig. 14). Probable paths of shallow ground-water flow from the site are downslope to the south, then curving southwest to a possible discharge along the east half of section 31. Sample points are two wells east of the site; neither is along a probable flow path.

Carson Desert site (Churchill County).--The disposal site is on a series of lakebed deposits in the Carson Desert about 7.5 mi north of Fallon (fig. 15). Depth to water at the site is about 28 ft; the shallow ground-water system flows to the northeast with a gradient of about 1.7 feet per mile (Olmsted and others, 1975, p. 105). Near-surface upward vertical gradients may exist because the area discharges ground water by open-water and bare-soil evaporation. Ground water is monitored at a shallow dug well about 0.5 mile east of the disposal pit, which is off probable flow paths from the disposal area.

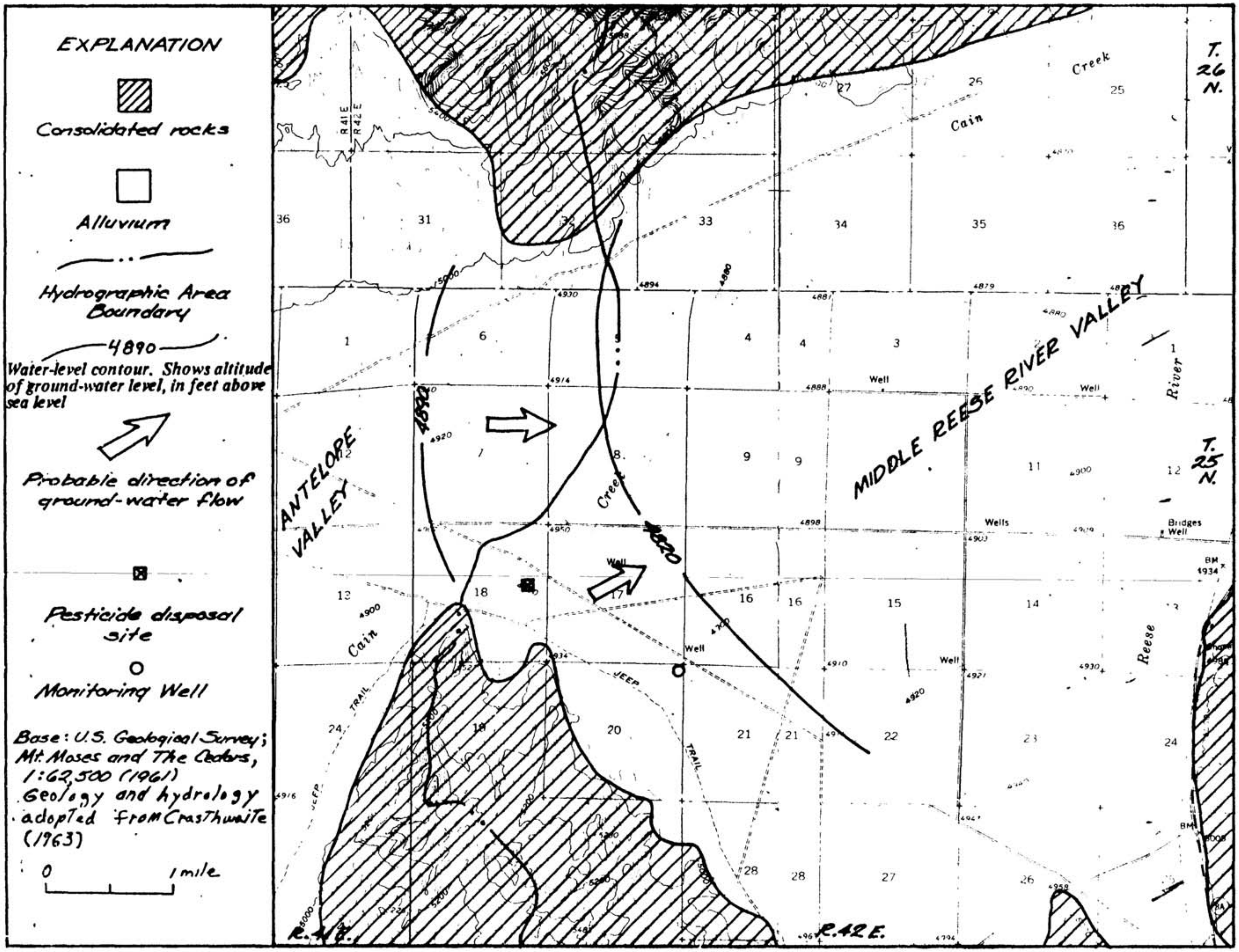

FIGURE 13.--Pesticide-disposal and monitoring sites, Middle Reese River Valley.

80

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SROA154

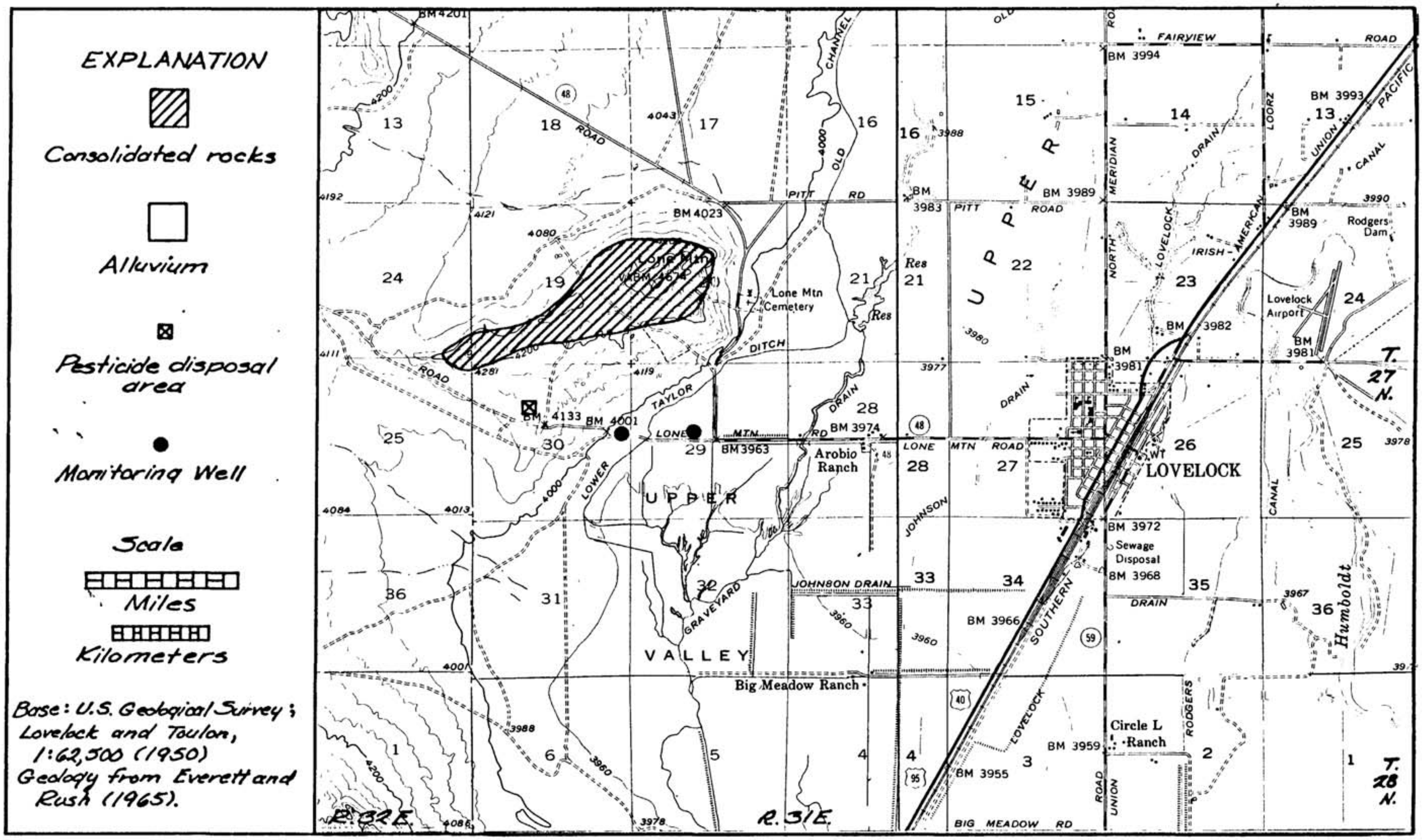

FIGURE 14.--Pesticide-disposal and monitoring sites, Lovelock Valley.

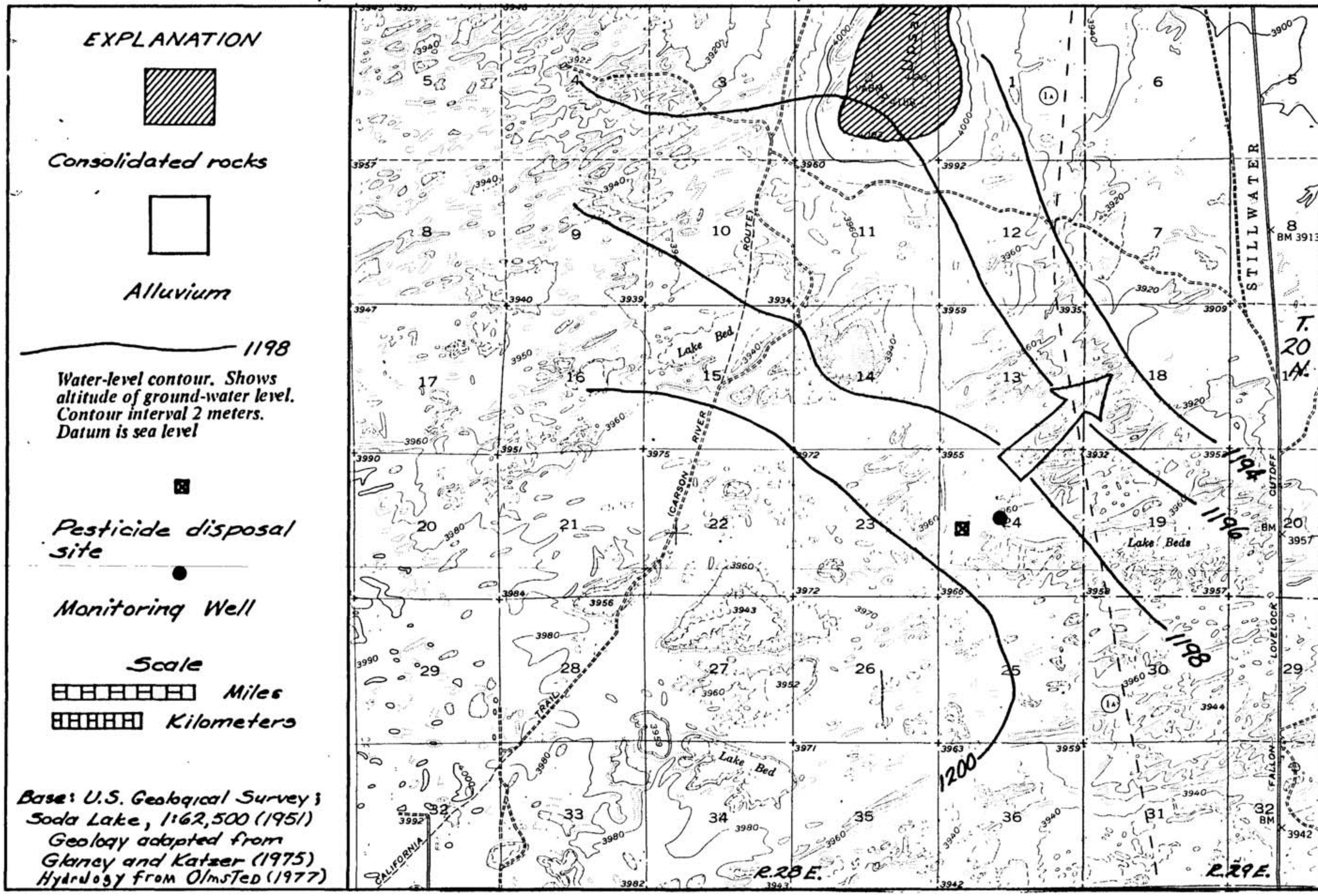

FIGURE 15.--Pesticide-disposal and monitoring sites, Carson Desert.

The probability of significant contamination of ground water beneath or adjacent to the four pesticide disposal sites is quite low. Many organic pesticides are only slightly soluble in water, and most soils have a high absorption capacity for commonly used pesticides; thus, the concentration of pesticides in percolating waters is likely to be greatly attenuated in moving through the unsaturated zone. The expected rates of transport of organic pesticides in the saturated zone are likely to be low; for example, one study involving the injection of DDT into a sand aquifer failed to detect any breakthrough of DDT in an observation well 33 feet from the injection well (Scalf and others, 1968). Points at which ground water is being monitored as of 1977 are too far-removed from the actual disposal grounds to permit the detection of any potential pesticide movement, and the sample points are not on probable flow paths from the disposal sites. Effective monitoring of these sites would require the drilling of observation wells to provide an early warning of pesticide movement. Provisions should be made to collect samples both in the unsaturated zone and at the top of the first saturated zone underlying each site. In addition to the present analyses for organic pesticides, samples should also be analyzed for other possible contaminants such as arsenicals and mercury compounds that might be associated with agricultural use of pesticides. A properly designed monitoring program for each site would be expensive, and perhaps would not be warranted by the low risk of contamination.

Federal Agencies

U.S. Bureau of Land Management

As of 1977, BLM had no ongoing program for monitoring ground water on the public lands in Nevada. Environmental assessments of BLM Planning Units as of 1977 are being made as part of a review of land-management practices; these assessments include a one-time sampling of well and spring water on the public lands. Samples are collected by BLM personnel and are analysed under contract by a private laboratory. Analyses include the following:

- alkalinity (carbonate/ bicarbonate)
- arsenic*
- calcium
- chloride
- copper*
- dissolved solids
- fecal coliform
- fecal streptococcus
- iron*
- manganese
- nitrate/nitrite
- pH
- phosphate, ortho
- potassium
- sodium
- sulfate
- total coliform
- turbidity
- zinc*

Asterisks indicate analyses included only if site is associated with mine drainage.

Data will be published in a summary report on each Planning Unit. These data will form a valuable addition to the available water-quality data base for sparsely populated areas of the State. The utility of the data is enhanced by the uniformity of sampling and analytical procedures.

U.S. Bureau of Reclamation

The Lower Colorado Regional Office of the U.S. Bureau of Reclamation is supervising monitoring of surface and wastewater at the Mohave Generating Station in the Colorado River Valley, Clark County. The facility is on a dissected alluvial fan on the west side of the Colorado River about 2 miles south of Davis Dam. Alluvium at the site consists of nearly horizontal interbedded deposits of gravel, sand, and clay. The pre-operational ground-water level was about 210 feet below land surface (August 1970). The station consists of two 755-megawatt steam-generating units using coal fuel delivered in a water slurry via a 275-mile pipeline from Black Mesa, Ariz. Process water is disposed of in five evaporation ponds; fly ash is disposed of in a small isolated drainage network blocked at the lower end by a retention dam. Excess coal slurry is stored in two circular ponds adjacent to the plant. All ponds are lined either with soil cement or asphalt.

Four sources of potential ground-water contamination exist at the site: (1) Leakage from evaporation ponds, (2) leakage from the coal-slurry storage ponds, (3) percolation of leachate from the ash-disposal area, and (4) accidental spills from operational problems. Two networks of monitoring wells are operated at the site (fig. 16): (1) An on-site network of 30 wells sampled monthly by the plant operator, Southern California Edison, and (2) an off-site network of five wells sampled quarterly by the U.S. Geological Survey (table 11).

On-site wells 3 and 12 monitor background quality upgradient from the plant; the remainder of the on-site wells monitor the hydrologic system downgradient from various potential sources of contamination. The following hydrologic and water-quality data are obtained for on-site wells:

Monthly		Annually
water level*	nitrate	aluminum
calcium*	fluoride	arsenic
magnesium*	boron	chromium
sodium*	pH*	copper
potassium*	specific conductance*	iron
carbonate*		lead
bicarbonate*	dissolved solids	manganese
sulfate*		tin
chloride*		zinc

Off-site wells monitor background quality of public and private domestic supplies at the periphery of the facility. Quarterly measurements are made of water levels and samples are analyzed for the items indicated by asterisk in the tabulation above, as well as silica and nitrate plus nitrite. Analytical results are on file at the Bureau of Reclamation office in Boulder City.

IN THE SUPREME COURT OF THE STATE OF NEVADA

JASON KING, P.E., Nevada State Engineer, DIVISION OF WATER RESOURCES, DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES, Appellant, vs. HAPPY CREEK, INC., Respondent.	Case No. 74266

JOINT APPENDIX

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(Pages JT APP 296-338)

Docket 74266 Document 2018-08887

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08/07/17	Hearing Statement (State Engineer's)	XVI	941-970
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RESPECTFULLY SUBMITTED this 6th day of March, 2018.

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CERTIFICATE OF SERVICE

I certify that I am an employee of the Office of the Attorney General and that on this 6th day of March, 2018, I served a copy of the foregoing JOINT APPENDIX (Volumes I-XVII, Pages JT APP 1-1183), by electronic service to:

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GROUND-WATER QUALITY IN NEVADA--A PROPOSED MONITORING PROGRAM

By Jon O. Nowlin

ABSTRACT

A program was designed for the systematic monitoring of ground-water quality in Nevada. Basic hydrologic and water-quality principles are discussed in the formulation of a rational approach to developing a statewide monitoring program. A review of ground-water monitoring efforts in Nevada through 1977 indicates that few requirements for an effective statewide program are being met. A suggested program has been developed that consists of five major elements: (1) A Background-Quality Network to assess the existing water quality in Nevada aquifers, (2) a Contamination Source Inventory of known or potential threats to ground-water quality, (3) Surveillance Networks to monitor ground-water quality in selected hydrographic areas, (4) Intensive Surveys of individual instances of known or potential ground-water contamination, and (5) Ground-Water Data File to manage data generated by the other monitoring elements. Two indices have been developed to help assign rational priorities for monitoring ground water in the 255 hydrographic areas of Nevada: (1) A Hydrographic-Area Priority Index for surveillance monitoring, and (2) A Development-Potential Index for background monitoring of areas with little or no current development.

Requirements for efficient management of data from ground-water monitoring are discussed and the three major systems containing Nevada ground-water data are reviewed. More than 11,000 chemical analyses of ground water have been acquired from existing systems and incorporated into a prototype data base.

INTRODUCTION

Purpose and Scope of the Study

Water in Nevada is regarded as a more valuable resource than the precious metals for which the State is noted (Scott and others, 1971). Ground water is an important part of the State's water resources. Water-use estimates for Nevada in 1969 (Smales and Harrill, 1971) showed that 84 percent of rural domestic withdrawals, 63 percent of public-supply withdrawals, and 59 percent of industrial and institutional withdrawals were supplied by ground water. Of some 60 major public-supply systems inventoried for the 1969 study, 78 percent were supplied solely by ground water, 15 percent by both ground water and streams, and 7 percent by surface-water sources. Sources of supply for major water uses in 1969 are illustrated in figure 1.

Federal and State water-quality-monitoring efforts historically have been concentrated on protecting surface-water resources. The cultural need for easy, quick, and economic means of disposing of wastes was often served by relatively accessible surface water which was expected to either dilute the waste to acceptable concentrations or, at the least, flush it downstream. The rising environmental awareness of the American public has focused on the visible surface water, resulting in a plethora of laws and regulations inhibiting or prohibiting the traditional methods of waste disposal and promoting on-land or underground disposal of wastes. The attendant increased risk of ground-water contamination has been legislatively recognized in Public Law 92-500 (the Water Pollution Control Act Amendments of 1972) which include mandates for the States to develop monitoring programs for ground-water quality and by the Safe Drinking Water Act of 1974 (Public Law 93-523), which specifies monitoring requirements for public water supplies and underground injection systems.

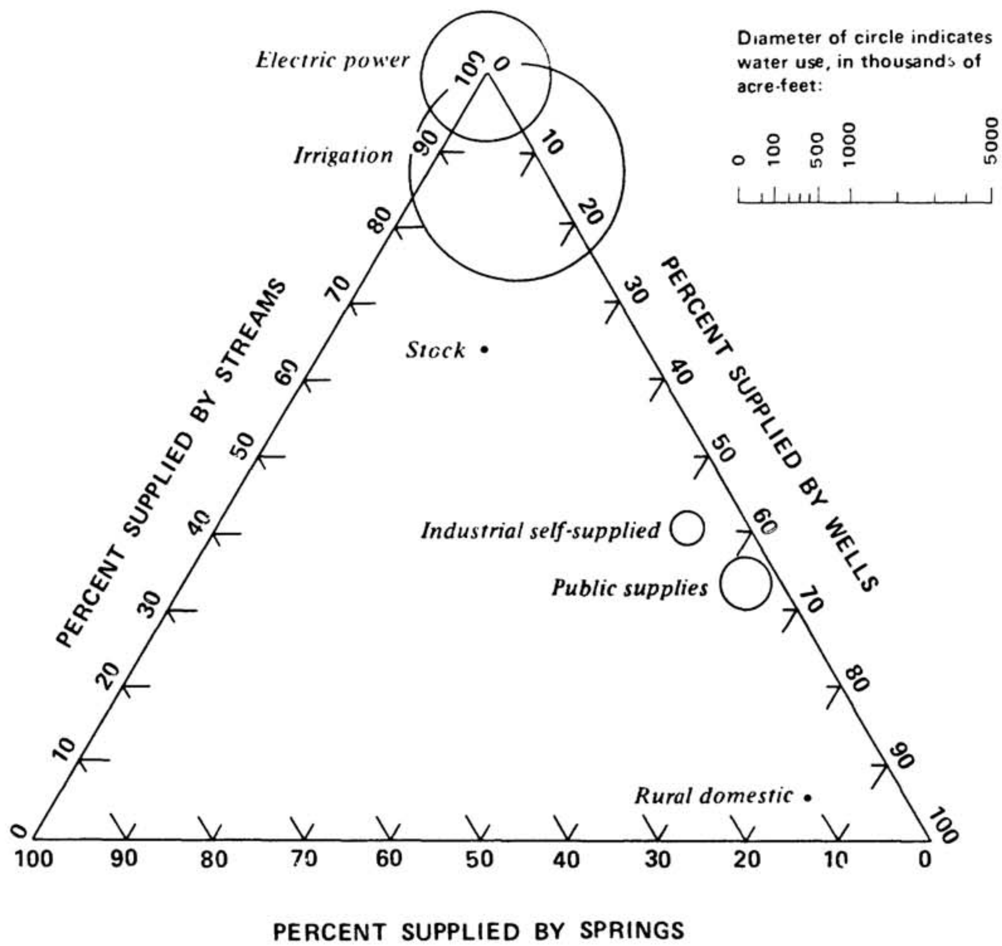

FIGURE 1.--Sources of supply for major water uses as of 1969 (based on data from Smales and Harrill, 1971).

In response to requirements of Public Law 92-500, the Division of Environmental Protection (DEP) of the Nevada Department of Conservation and Natural Resources was designated as the agency to establish and maintain a program to monitor ground-water quality in Nevada. The U.S. Geological Survey (USGS) was asked to assist in the design of such a program to meet the objectives of Public Law 92-500, which include (1) determination of existing ground-water quality, (2) providing early detection of ground-water contamination, and (3) inventorying sources of ground-water contamination.

This report contains suggestions for establishing such a program for Nevada. Specific program elements are described along with suggested methods for selection of: Monitoring sites, constituents and properties to be determined, sampling frequencies, sample-collection techniques, and data-processing and analysis procedures. Recognizing that the ultimate constraints on any monitoring system are economic, the report presents rational schemes for setting implementation priorities for program elements. Selection of specific sampling sites has not been attempted on a statewide basis; such details must follow more thorough hydrologic evaluation of selected target areas.

This report was completed in 1978, but other commitments precluded its publication at that time. The material herein has not been updated since the 1978 draft. Thus, the discussion of specific legal mandates existing monitoring programs in Nevada and available systems for managing ground-water data along with the bibliography on ground-water quality in Nevada deal with the period prior to about 1977. In contrast, the general discussions regarding suggested methods for establishing a monitoring program in Nevada remain pertinent in the 1980's.

Hydrographic and Climatic Setting

Nevada lies almost entirely within the Great Basin, that part of the Basin and Range Province which drains into topographically closed basins rather than to the sea. Of the State's total area of 110,540 square miles only 16 percent drains to the sea--5,230 square miles within the Snake River Basin in the northeastern part of the State and 12,376 square miles within the Colorado River Basin in the southeastern part (Scott and others, 1971). The topography of the State is characterized by isolated north-trending mountain ranges with intervening sediment-filled valleys or basins. The valleys are commonly flat floored and elongated parallel to the mountain trends; in many valleys an ephemeral lake or playa forms the terminus of the drainage system. Sedimentary deposits in the valleys are generally thick, with local thicknesses in some valleys estimated to exceed 8,000 ft (Glancy and Katzer, 1975). The typical hydrologic system for a valley consists of recharge by precipitation near the bordering mountain ranges, seasonal and ephemeral surface-water runoff to the terminal playa lake, ground-water storage in the alluvial valley, and discharge by evaporation and transpiration.

Nevada's unique topographic setting has resulted in the valley commonly being the basic unit of social, economic, and water development. Rush (1968) divided the State into 14 hydrographic regions and approximately 250 individual hydrographic areas (individual valleys or valley segments) based on topographic or hydrologic boundaries (table 1, fig. 2). These areas are commonly used by State and Federal agencies in Nevada for indexing or compiling hydrologic data, and they will be thus used in this report.

Table 1.--*Hydrographic regions and areas in Nevada*

1-NORTHWEST REGION
1. Pueblo V.
2. Continental Lake V.
3. Gridley Lake V.
4. Virgin V.
5. Sage Hen V.
6. Guano V.
7. Swan Lake V.
8. Massacre Lake V.
9. Long V.
10. Macy Flat
11. Coleman V.
12. Mosquito V.
13. Warner V.
14. Surprise V.
15. Boulder V.
16. Duck Lake V.

2-BLACK ROCK DESERT REGION
17. Pilgrim Flat
18. Painters Flat
19. Dry V.
20. Sano V.
21. Smoke Creek Desert
22. San Emidio Desert
23. Granite Basin
24. Hualapai Flat
25. High Rock Lake V.
26. Mud Meadow
27. Summit Lake V.
28. Black Rock Desert
29. Pine Forest V.
30. Kings River V.
    (A) Rio King Subarea
    (B) Sod House Subarea
31. Desert V.
32. Silver State V.
33. Quinn River V.
    (A) Orovada Subarea
    (B) McDermitt Subarea

3-SNAKE RIVER BASIN
34. Little Owyhee River Area
35. South Fork Owyhee River Area
36. Independence V.
37. Owyhee River Area
38. Bruneau River Area
39. Jarbidge River Area
40. Salmon Falls Creek Area
41. Goose Creek Area

4-HUMBOLDT RIVER BASIN
42. Marys River Basin
43. Starr V. Area
44. North Fork Area
45. Lamoille V.
46. South Fork Area
47. Huntington V.
48. Dixie Creek--Tenmile Creek Area
49. Elko Segment
50. Susie Creek Area
51. Maggie Creek Area
52. Marys Creek Area
53. Pine V.
54. Crescent V.
55. Carico Lake V.
56. Upper Reese River V.
57. Antelope V.
58. Middle Reese River V.
59. Lower Reese River V.
60. Whirlwind V.
61. Boulder Flat
62. Rock Creek V.
63. Willow Creek V.
64. Clovers Area
65. Pumpernickel V.
66. Kelly Creek Area
67. Little Humboldt V.
68. Hardscrabble Area
69. Paradise V.
70. Winnemucca Segment
71. Grass V.
72. Imlay Area
73. Lovelock V.
    (A) Oreana Subarea
74. White Plains

5-WEST CENTRAL REGION
75. Bradys Hot Springs Area
76. Fernley Area
77. Fireball V.
78. Granite Springs V.
79. Kumiva V.

6-TRUCKEE RIVER BASIN
80. Winnemucca Lake V.
81. Pyramid Lake V.
82. Dodge Flat
83. Tracy Segment
84. Warm Springs V.
85. Spanish Springs V.
86. Sun V.
87. Truckee Meadows
88. Pleasant V.
89. Washoe V.
90. Lake Tahoe Basin
91. Truckee Canyon Segment

7-WESTERN REGION
92. Lemmon V.
    (A) Silver Lake Subarea
    (B) Lemmon Subarea
93. Antelope V.
94. Bedell Flat
95. Dry V.
96. Newcomb Lake V.
97. Honey Lake V.
98. Skedaddle Creek V.
99. Red Rock V.
100. Cold Spring V.

8-CARSON RIVER BASIN
101. Carson Desert
    (A) Packard Desert
102. Churchill V.
103. Dayton V.
104. Eagle V.
105. Carson Valley

9-WALKER RIVER BASIN
106. Antelope V.
107. Smith V.
108. Mason V.
109. East Walker Area
110. Walker Lake V.
    (A) Schurz Subarea
    (B) Lake Subarea
    (C) Whisky Flat--Hawthorne Subarea

10-CENTRAL REGION
111. Alkali V. (Mineral)
    (A) Northern Part
    (B) Southern Part
112. Mono V.
113. Huntoon V.
114. Teels Marsh V.
115. Adobe V.
116. Queen V.
117. Fish Lake V.
118. Columbus Salt Marsh V.
119. Rhodes Salt Marsh V.
120. Garfield Flat
121. Soda Spring V.
    (A) Eastern Part
    (B) Western Part
122. Gabbs V.
123. Rawhide Flats
124. Fairview V.
125. Stingaree V.
126. Cowkick V.
127. Eastgate V. Area
128. Dixie V.
129. Buena Vista V.
130. Pleasant V.
131. Buffalo V.
132. Jersey V.
133. Edwards Creek V.
134. Smith Creek V.
135. Ione V.
136. Monte Cristo V.
137. Big Smoky V.
    (A) Tonopah Flat
    (B) Northern Part
138. Grass V.
139. Kobeh V.
140. Monitor V.
    (A) Northern Part
    (B) Southern Part
141. Ralston V.
142. Alkali Spring V. (Esmeralda)
143. Clayton V.
144. Lida V.
145. Stonewall Flat
146. Sarcobatus Flat
147. Gold Flat
148. Cactus Flat
149. Stone Cabin V.
150. Little Fish Lake V.
151. Antelope V. (Eureka & Nye)
152. Stevens Basin
153. Diamond V.
154. Newark V.
155. Little Smoky V.
    (A) Northern Part
    (B) Central Park
    (C) Southern Part
156. Hot Creek V.
157. Kawich V.
158. Emigrant V.
    (A) Groom Lake V.
    (B) Papoose Lake V.
159. Yucca Flat
160. Frenchman Flat
161. Indian Springs V.
162. Pahrump V.
163. Mesquite V. (Sandy V.)
164. Ivanpah V.
    (A) Northern Part
    (B) Southern Part
165. Jean Lake V.
166. Hidden V. (South)
167. Eldorado V.
168. Three Lakes V. (Northern Part)
169. Tikapoo V. (Tickaboo V.)
    (A) Northern Part
    (B) Southern Part
170. Penoyer V. (Sand Spring V.)
171. Coal V.
172. Garden V.
173. Railroad V.
    (A) Southern Part
    (B) Northern Part
174. Jakes V.
175. Long V.
176. Ruby V.
177. Clover V.
178. Butte V.
    (A) Northern Part (Round V.)
    (B) Southern Part
179. Steptoe V.
180. Cave V.
181. Dry Lake V.
182. Delamar V.
183. Lake V.
184. Spring V.
185. Tippett V.
186. Antelope V. (White Pine & Elko)
    (A) Southern Part
    (B) Northern Part
187. Goshute V.
188. Independence V. (Pequop V.)

11-GREAT SALT LAKE BASIN
189. Thousand Springs V.
    (A) Herrell Siding--Brush Creek Area
    (B) Toano--Rock Spring Area
    (C) Rocky Butte Area
    (D) Montello--Crittenden Creek Area (Montello V.)
190. Grouse Creek V.
191. Pilot Creek V.
192. Great Salt Lake Desert
193. Deep Creek V.
194. Pleasant V.
195. Snake V.
196. Hamlin V.

12-ESCALANTE DESERT
197. Escalante Desert

13-COLORADO RIVER BASIN
198. Dry V.
199. Rose V.
200. Eagle V.
201. Spring V.
202. Patterson V.
203. Panaca V.
204. Clover V.
205. Lower Meadow Valley Wash
206. Kane Springs V.
207. White River V.
208. Pahroc V.
209. Pahranagat V.
210. Coyote Spring V.
211. Three Lakes V. (Southern Part)*
212. Las Vegas V.
213. Colorado River V.
214. Piute V.
215. Black Mountains Area
216. Garnet V. (Dry Lake V.)
217. Hidden V. (North)*
218. California Wash
219. Muddy River Springs Area (Upper Moapa V.)
220. Lower Moapa V.
221. Tule Desert
222. Virgin River V.
223. Gold Butte Area
224. Greasewood Basin

14-DEATH VALLEY BASIN
225. Mercury V.
226. Rock V.
227. Fortymile Canyon
    (A) Jackass Flats
    (B) Buckboard Mesa
228. Oasis V.
229. Crater Flat
230. Amargosa Desert
231. Grapevine Canyon
232. Oriental Wash

* Noncontributing part of the Colorado River Basin

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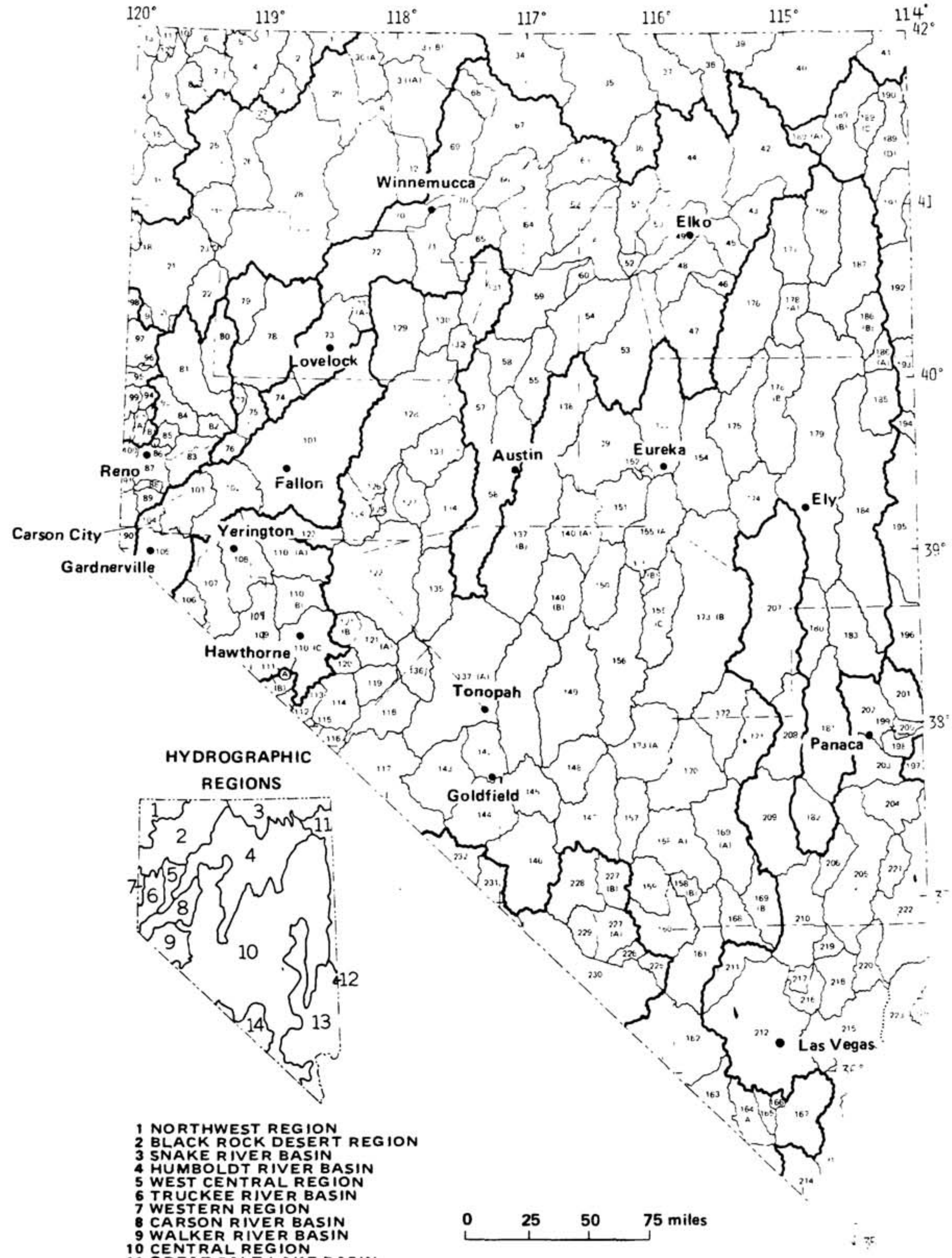

FIGURE 2.--Hydrographic regions and areas.

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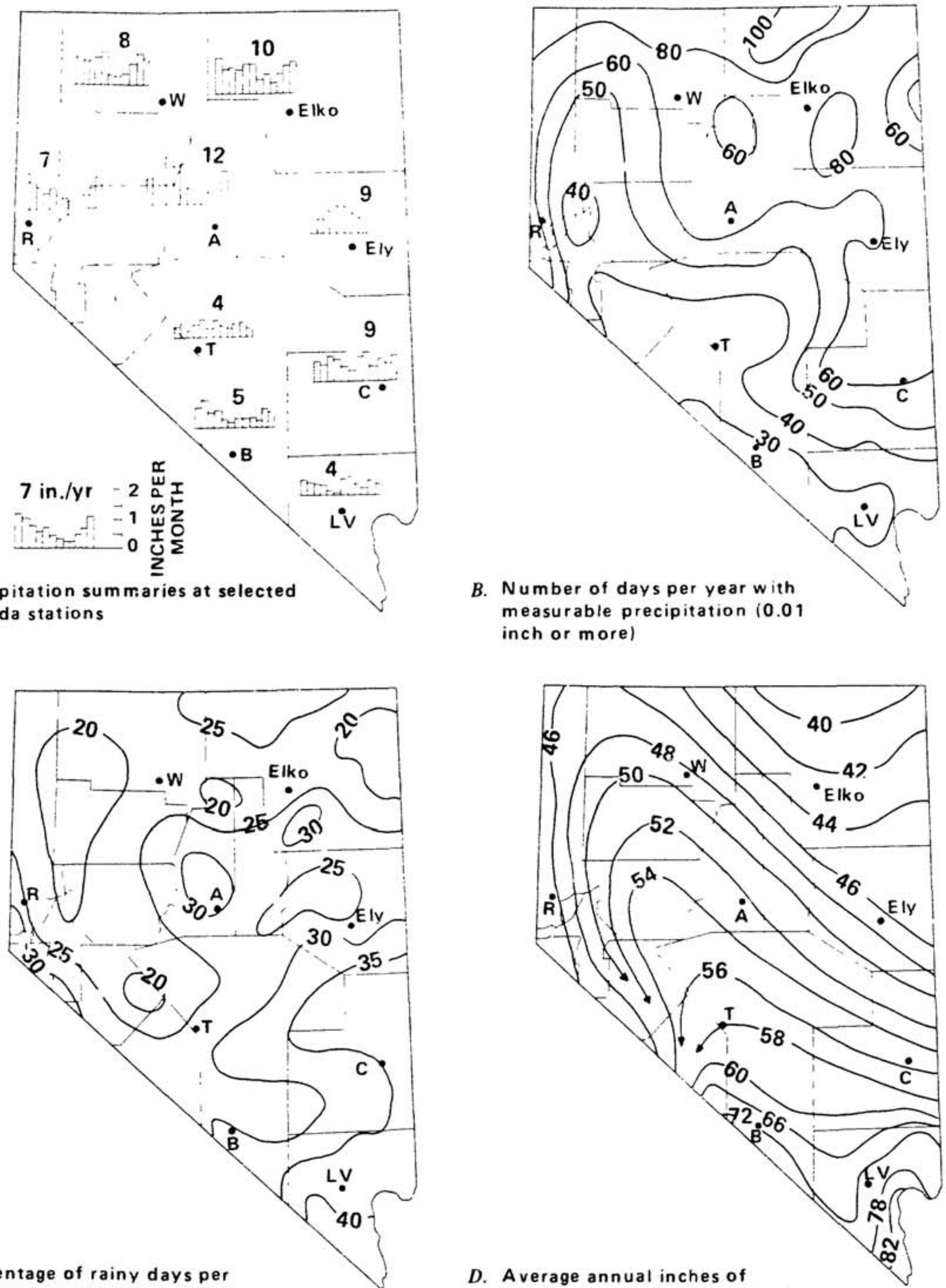
SROA81

Nevada's climate is the driest of the 50 States, with precipitation ranging from less than 4 inches per year in the drier southern valleys to more than 30 inches per year in the higher mountain ranges (Houghton and others, 1975). Precipitation events are infrequent and short-lived, but their distribution is relatively uniform over the year and they may be intense during short periods (fig. 3A-C). The low humidity and abundant sunshine result in evaporation rates in the State ranging from more than 80 inches in the southeastern part to about 40 inches in the northeastern corner (fig. 3D). Low precipitation coupled with high evapotranspiration results in high soil-moisture deficits on the floors of many of the lower valleys (fig. 4), a factor placing severe limitations on the amount of local ground-water recharge.



A. Precipitation summaries at selected Nevada stations

B. Number of days per year with measurable precipitation (0.01 inch or more)

C. Percentage of rainy days per year with moderate to heavy precipitation (0.25 inch or more)

D. Average annual inches of evaporation from lake surfaces in Nevada

FIGURE 3.--Climatic data (from Houghton and others, 1975). Towns are indicated as follows: A, Austin; B, Beatty; C, Caliente; LV, Las Vegas; R, Reno; T, Tonopah; and W, Winnemucca.

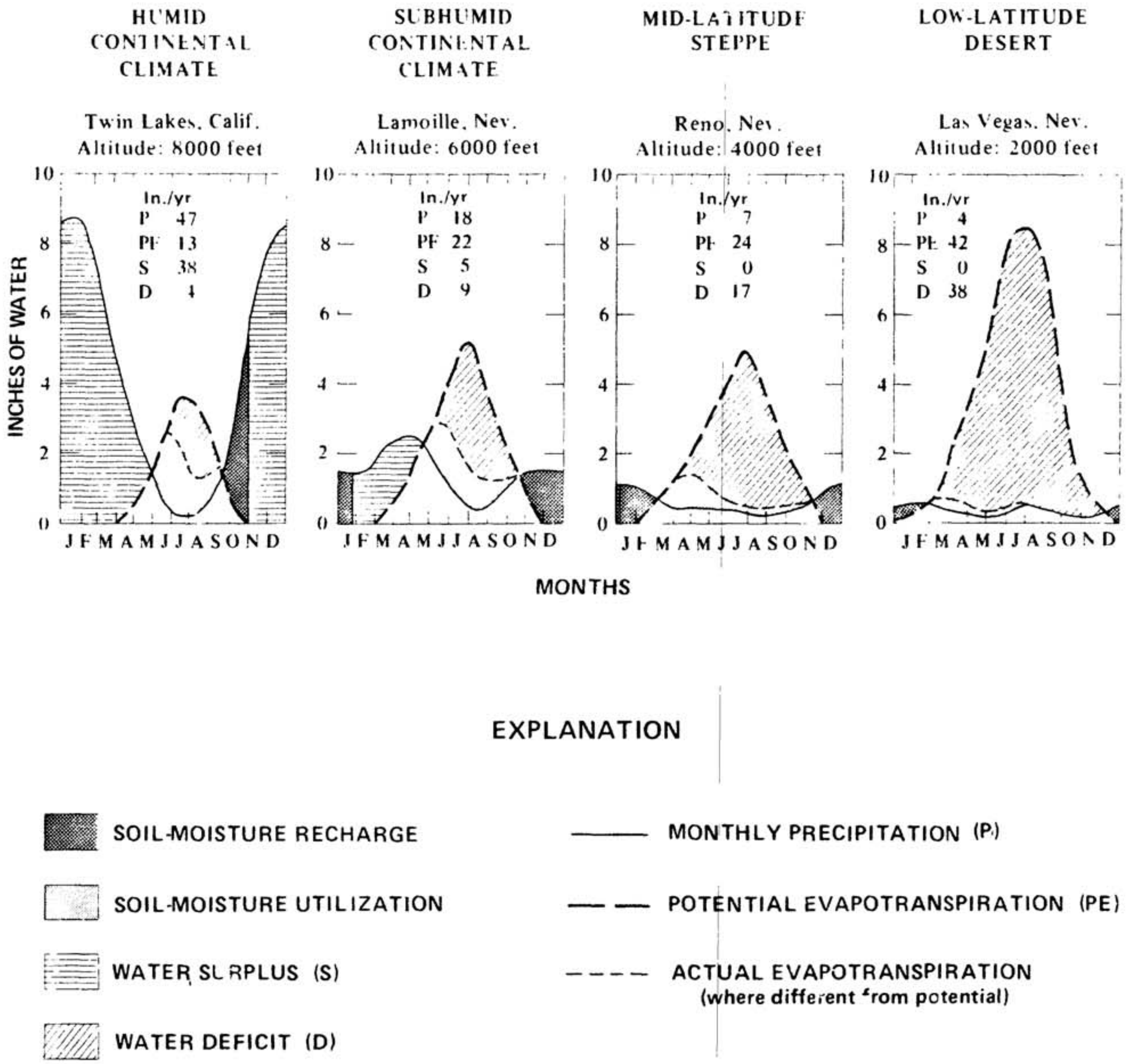


FIGURE 4.--Seasonal water and soil-moisture balance for four climatic zones in and adjacent to Nevada (from Houghton and others, 1975).

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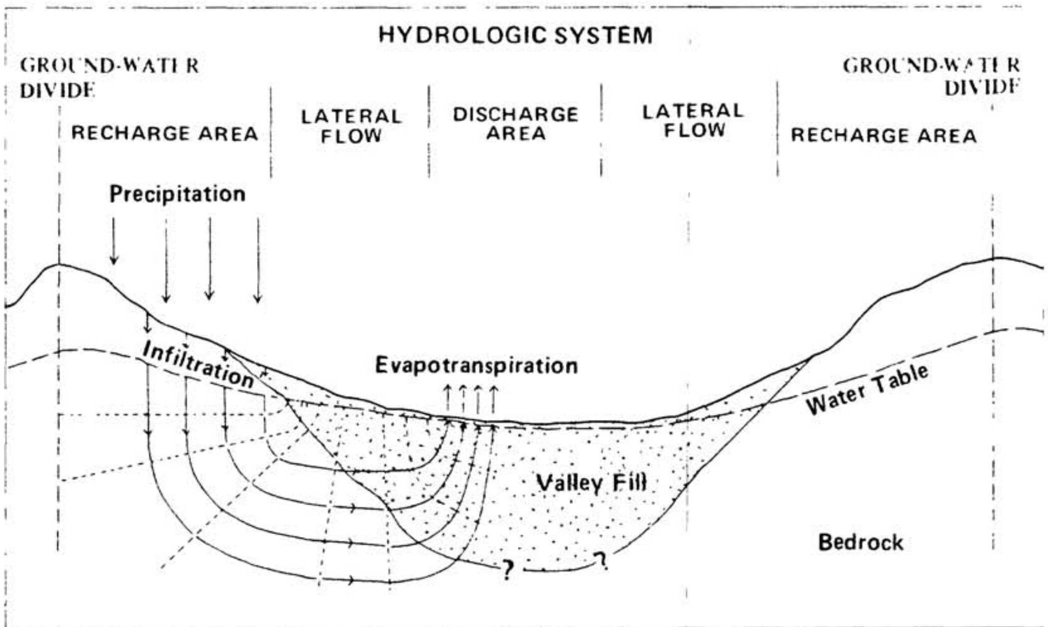
Concepts of Ground-Water Quality

The occurrence and movement of ground water is governed primarily by the nature of geologic units through which it moves. The quality of ground water at any given point in a ground-water flow system is a function of (1) the quality of the original recharge water (surface and subsurface, either natural or cultural), (2) the mineralogy of the materials through which it moves, and (3) the duration of contact with those materials.

Hydrologic Framework

A conceptual model of ground-water movement in a hypothetical desert basin is reproduced in figure 5. Under natural conditions the greatest source of recharge is from precipitation in the bordering mountain ranges. In Nevada, such precipitation may be several times greater than on the valley floors. Some water is stored and transmitted through fractures and faults in the mountain mass to discharge as base flow to mountain streams or as underflow to the adjacent valley fill. Direct precipitation and surficial runoff from the mountain front recharge the higher alluvial fans. The higher altitudes of the mountain and alluvial-fan recharge areas provide the hydraulic potential to move the ground water downgradient to the discharge areas. Natural recharge in the lower parts of the basins is minor to nonexistent, as precipitation commonly is insufficient to satisfy the soil-moisture deficiency in the unsaturated zone. Natural discharge occurs from the valley floor, primarily through soil moisture evaporation and transpiration losses from vegetation. In open-basin valleys with sufficient recharge, ground water may be discharged as base flow in perennial streams leaving the valley. In closed-basin valleys, surface-water flow may be ephemeral, ending at a playa, or perennial, into a terminal lake.



GEOCHEMICAL SYSTEM

RECHARGE AREA	LATERAL FLOW	DISCHARGE AREA
SHALLOW AQUIFERS: Generally good quality	SHALLOW AQUIFERS: Quality generally degrades going downgradient	SHALLOW AQUIFERS: Quality poor to saline; may improve with depth
DEEP AQUIFERS: Generally good quality; locally may be mineralized	DEEP AQUIFERS: Generally good quality; locally may be mineralized	DEEP AQUIFERS: Generally fair to good quality; locally may be mineralized

FIGURE 5.--Idealized ground-water flow system for an intermontane arid basin (modified from Domenico and others, 1964).

Deeper patterns of ground-water circulation may exist in areas underlain by geologic materials of sufficient permeability; there may be net inflow or outflow of ground water between individual basins in such a regional ground-water system. Such systems have been described for carbonate-rock terranes in southern and southeastern Nevada (Eakin, 1966; Mifflin, 1968; Blankennagel and Weir, 1973; Winograd and Thordarson, 1975).

Natural Determinants of Ground-Water Quality

The processes controlling the quality of natural waters have been discussed in detail by Hem (1970). Precipitation in the mountain recharge areas is dilute. From the time precipitation enters the pore spaces of the soil profile, the water is exposed to a variety of chemical reactions that affect its quality. Infiltrating recharge water dissolves various substances from the surrounding rock materials as it percolates towards the water table. Rates of ground-water movement in the saturated zone are typically in the range of 5 feet/yr to 5 feet/day (Todd, 1959). Residence times in aquifers are, in many places, sufficient for the water to be in chemical equilibrium with the surrounding rock materials. The quality of a natural water moving downgradient from recharge in the mountains to discharge at the valley floor thus reflects the cumulative effects of its present and prior geologic environments, with concentrations of dissolved solids increasing with distance and time from the recharge area. Near-surface materials in many of the valley floors of closed basins are alternating layers of fine-grained lakebed deposits--clay, silt, and evaporite minerals with high salt contents. Salts are concentrated in the near-surface zones of discharge areas by the evapotranspiration "still." Much shallow ground water in the discharge zones of desert valleys is highly mineralized, with concentrations of salts (notably sodium chloride and sodium sulfate) exceeding recommended limits for most beneficial uses.

Cultural Determinants

Man's influence on ground-water quality may be significant at virtually any point in the flow system from recharge to discharge. The quality of precipitation may be degraded downwind from urban or industrial areas with atmospheric pollution. The resulting precipitation may have lower pH and greater concentrations of sulfate, metals, and organic compounds than noncontaminated precipitation. The quality of infiltrating water in recharge zones may be degraded by disposal of both liquid and solid wastes, excessive application of agricultural chemicals, and mineral-extraction activities. Water in transit at depth in the flow system may be degraded by (1) waste injection, (2) surficial contamination moving down improperly sealed or abandoned well casings, or (3) migration of more mineralized water, either through natural flow barriers breached by wells or mine shafts, or induced by local overpumping. Mineralization of near-surface ground water in discharge areas by the concentration effects of natural evapotranspiration may be increased in magnitude or areal extent by intensive agriculture.

Man's activities also affect ground-water quality by changing the dynamics of the natural flow system. Hydraulic potentials in natural discharge areas increase with depth, favoring the extraction of deeper ground water that commonly has better quality than water near the surface. Intensive development may result in the lowering of heads of deep aquifers to the point where gradients are reversed and the poor quality water in upper water-table aquifers is induced to recharge and degrade the deeper ground water. The degradation may be exacerbated by pollution of the shallow water by domestic, municipal, agricultural, or industrial wastes.

Criteria and Standards for Ground Water

The terms criteria and standards are often confused. Water-quality criteria are recommendations, based on available scientific data, for maximum concentrations of constituents in water applied to specific beneficial uses. Water-quality standards are those criteria selected by regulatory authorities to be the maximum concentrations allowable by law.

Existing water-quality standards in Nevada stress the protection of surface water for various beneficial uses, with little specific provision for ground water. Nevada Water Pollution Control Regulations peripherally include ground water under the general class of "All waters of the State," to which narrative rather than numerical standards are applied (Nevada Bureau of Environmental Health, 1975). Nevada Water Supply Regulations apply numerical standards to ground water used as sources of supply to public water-distribution systems (Nevada Division of Health, 1977) and are summarized in table 2. These standards are based on National Primary and Secondary standards promulgated by the U.S. Environmental Protection Agency (EPA, 1976c; 1977) and apply to finished water taken from the purveyor's distribution system rather than to raw water as withdrawn from the source aquifer.

Water-quality criteria are functions of the intended water use. Comprehensive criteria for water quality have been published in a number of references, the more recent of which are the reports by the National Academy of Science and Engineering (1974) and the U.S. Environmental Protection Agency (1976b). Criteria that apply to uses likely to be supplied by ground water are summarized in table 3; included are recommended concentrations for

TABLE 2.—*Nevada drinking-water standards as applied to ground-water sources (Nevada Division of Health, 1977)*

Public water supplies: Those supplies in service for 60 or more days per year that (a) have 15 or more connections or (b) serve an average of 25 or more persons per day.
Community supplies: Those public supplies operating on a year-round basis.
Point sampled: Tap that delivers water representative of the supply system.

Constituent or property	Milligrams per liter, except as indicated: Maximum concentration or value	Milligrams per liter, except as indicated: Recommended concentration or range[1]	Monitoring requirements for public supplies served by ground-water sources: Non-community supplies	Monitoring requirements for public supplies served by ground-water sources: Community supplies
Inorganic and physical			Initial analyses by June 1979; subsequent sampling at 3-year intervals, or more frequently where warranted	
Arsenic	0.05	—	—	X
Barium	1	—	—	X
Cadmium	.01	—	—	X
Chloride	400	250	X	X
Chromium	.05	—	—	X
Color (units)	—	15	X	X
Copper	—	1	X	X
Dissolved solids	1,000	500	X	X
Fluoride	[2]1.4-2.4	—	—	X
Foaming agents (MBAS)	—	.5	X	X
Iron	.6	.3	X	X
Lead	.05	—	—	X
Magnesium	150	125	X	X
Manganese	.1	.05	X	X
Mercury	.002	—	—	X
Nitrate (as N)	10	—	X	X
Odor (threshold number)	—	3	X	X
pH (units)	—	6.5-8.5	X	X
Selenium	.01	—	—	X
Silver	.05	—	—	X
Sulfate	500	250	X	X
Zinc	—	5	X	X
Organic pesticides			Analyses only for systems selected by State (based on likelihood of contamination)	
Endrin	0.0002			
Lindane	.004			
Methoxychlor	.1			
Silvex	.01			
Toxaphene	.005			
2,4-D	.1			
Microbiology			Initial sampling by June 1978. Sampled once during each calendar quarter during which system is operating, or at frequency determined by State	Required number of samples per month based on population served
Coliform group, membrane-filtration method[3]				
Mean of all samples/month	1 colony/100 mL			
Single sample	<20/month or 4 colonies/100 mL			
5 percent of all samples	<20/month			
Chlorine residual			May be substituted for not more than 75 percent of required microbiological samples. Minimum sampling frequency is daily, at rate at least 4 times that required for microbiological samples	
Free chlorine	0.2			
Radioactivity				Initial analyses by June 1980
Alpha, gross	15 pCi/L			Average or annual composite of 4 quarterly samples[4]
Radium, combined 226 and 228	5 pCi/L			(5)

[1] Recommended values should not be exceeded where suitable alternate supplies are, or can be made, available.

[2] Fluoride limits are based on annual average of maximum daily air temperatures: <12.0°C (53.7°F), 2.4 mg/L; 12.1 to 14.6°C (53.8 to 58.3°F), 2.2 mg/L; 14.7 to 17.6°C (58.4 to 63.8°F), 2.0 mg/L; 17.7 to 21.4°C (63.9 to 70.6°F), 1.8 mg/L; 21.5 to 26.2°C (70.7 to 79.2°F), 1.6 mg/L; 26.3 to 32.5°C (79.3 to 90.5°F), 1.4 mg/L.

[3] Standards for determination by Multiple Fermentation Tube Method exist but are not included in this table.

[4] More frequent monitoring at State discretion in the vicinity of suspected sources. Systems having multiple sources with differing radioactivity concentrations shall monitor the individual point sources.

[5] In localities where Ra-228 may be present, monitoring is recommended when gross-alpha activity exceeds 2 pCi/L; otherwise, when gross alpha exceeds 5 pCi/L.

water to be used for domestic supplies, stock watering, irrigation, and fish and wildlife propagation. The latter category is included for the potential use of ground water as a supplementary source of water for hatchery operations or for commercial fish farms. Criteria are not included for industrial uses, as specific requirements vary greatly from industry to industry. Where the references cited in table 3 presented different values for the same criterion, the value tabulated is that recommended by the most recent of the references.

TABLE 3.—*Water-quality criteria for beneficial uses of ground water*

Principal references: 1, Nevada Division of Health, 1977; 2, U.S. Public Health Service, 1962; 3, U.S. Environmental Protection Agency, 1976c,d; 4, National Academies of Sciences and Engineering, 1974; 5, McKee and Wolf, 1963. Multiple criteria for the same parameter are listed in the same order as their references.

Parameters	Units	Drinking water	Industrial	Agricultural: Livestock	Agricultural: Irrigation: Continuous use, all soils	Agricultural: Irrigation: 20-yr use, fine soils, pH 6.0-8.5	Fresh-water aquatic life	Principal references	Remarks ["(a)" indicates remark for specific item in main body of table]
Principal inorganic chemical constituents	mg/L								
Silica (SiO_2)		—	1-100	—	10	50	—	5	
Calcium (Ca)		—	10-500	—	—	—	—	5	
Magnesium (Mg)		125; 150	5-30	500-5,000	—	—	—	1, 5	
Sodium (Na)		10-200	50	2,000	crop-specific	—	—	5	
Potassium (K)		1,000-2,000	—	—	—	—	200-2,000	5	
Iron (Fe)		0.3; 0.6	0.1	—	5.0	20	1.0	1, 3, 4, 5	
Manganese (Mn)		0.05; 0.1	0.05	10	0.2	10	1.0	1, 4, 5	
Bicarbonate (HCO_3)		—	—	—	—	—	30-130	4	
Sulfate (SO_4)		250; 500	20-250	500	200	—	—	1, 5	
Chloride (Cl)		250; 400	50	1,500	100	—	1,500	1, 5	
Fluoride (F)		1.4-2.4	1.0	2.0	1.0	15	1.5	1, 4, 5	
Nitrate (NO_3), as N		10	—	100	—	—	90 (a)	1, 3	(a) Warm-water species
Nitrite (NO_2), as N		1.0	—	10	—	—	51/0.06 (a)	3	(a) Warm-water species/salmonids
Ammonia (NH_3), as N		0.5	—	—	—	—	0.02 (a)	2, 3	(a) Or 0.05 X 96 hr. LC50
Phosphorus (P), as P		—	—	—	—	—	—	3	Concentrations in excess of 0.25 mg/L, as P, may stimulate eutrophication in receiving waters
Phosphate (PO_4), as P		—	—	—	—	—	—	3	
Orthophosphate ($O-PO_4$), as P		—	—	—	—	—	—	3	
Other common chemical or physical parameters									
Alkalinity, as $CaCO_3$	mg/L	—	—	—	—	—	>20	3	
Chlorine residual	ug/L	200	—	—	—	—	2.0-10	3	
Color	Pt-Co units	15	—	—	—	—	—	1	
Gases, total pressure (CO_2+N_2+O_2)	percent of atmospheric	—	—	—	—	—	110	3	
Hydrogen sulfide (H_2S)	ug/L	50	—	—	—	—	2	3	
Odor	threshold number	3	—	—	—	—	—	1 ,	
Oxygen, dissolved	mg/L	—	—	—	—	—	5.0	3	
pH	units	6.5-8.5	—	4.5-9.0	—	—	6.5-90	1, 3	
Residual sodium carbonate (RSC)	mg/L	—	—	—	1.25-25	—	—	5	
Solids, dissolved	mg/L	500; 1,000	2,500	3,000	700	—	2,000	1, 5	
Solids, suspended	mg/L	—	—	—	—	—	25-400	3	
Turbidity	JTU	5	—	—	—	—	—	1	

TABLE 3.--*Water-quality criteria for beneficial uses of ground water*—Continued

Parameters	Units	Drinking water	Industrial	Agricultural: Livestock	Agricultural: Irrigation: Continuous use, all soils	Agricultural: Irrigation: 20-yr use, fine soils, pH 6.0-8.5	Fresh-water aquatic life	Principal references	Remarks
Trace metals and other minor inorganics	ug/L								
Aluminum (Al)		—	—	5,000	5,000	20,000	—	4	
Arsenic (As)		50	—	200	100	2,000	1,000	1, 3, 5	
Barium (Ba)		1,000	—	—	—	—	5,000	1, 5	
Beryllium (Be)		—	—	—	100	500	11/1,100 (a)	3	(a) Soft/hard water
Boron (B)		—	—	5,000	750	2,000 (a)	—	3	(a) 500 for sensitive crops
Cadmium (Cd)		10	—	50	10	50	0.4-12	1, 3, 4	
Chromium (Cr)		50	—	1,000	100	1,000	100	1, 3, 4	
Cobalt (Co)		—	—	1,000	50	5,000	—	4	
Copper (Cu)		1,000	—	—	200	5,000	0.1 (a)	1, 3, 4	(a) Or 0.1 X 96 hr. LCD50
Lead (Pb)		50	—	100	5,000	10,000	30 (a)	1, 3, 4	(a) Or 0.01 X 96 hr. LCD50
lithium (Li)		—	—	—	2,500 (a)	2,500 (a)	—	4, 5	(a) 75 for citrus crops
Mercury (Hg)		2	—	10	—	—	0.05	1, 3	
Molybdenum (Mo)		—	—	1	10 (a)	50 (a)	—	4	(a) 0.50 for acid soils
Nickel (Ni)		—	—	—	200	2,000	(a)	4	(a) 0.01 X 96 hr. LCD50
Selenium (Se)		10	—	10	20	20	(a)	1, 3, 4	(a) 0.01 96 hr. LCD50
Silver (Ag)		50	—	—	—	—	(a)	1	(a) 0.01 X 96 hr. LCD50
Uranyl (UO_2)		5,000	—	—	—	—	—	2	
Vanadium (V)		—	—	100	100	10,000	—	2, 4	
Zinc (Zn)		5,000	25,000	25,000	2,000	10,000	(a)	3	(a) 0.01 X 96 hr. LCD50
Organic chemicals Miscellaneous									
Cyanide (Cn)	ug/L	0.1; 0.2	—	—	—	—	5.0 (a)	3, 4	(a) Or 0.05 X 96 hr. LCD50
Detergents (LAS, MBAS)	mg/L	.5	—	—	—	—	.2 (a)	1, 4	(a) Or 0.05 X 96 hr. LCD50
Oil and grease	mg/L	—	—	—	—	—	(a)	4	(a) Or 0.05 X 96 hr. LCD50
Phenolics	ug/L	1.0	—	1 x 10^6	50,000	—	1.0	3, 5	
Plasticizers, phthalate, esters	ug/L	—	—	—	—	—	3	3	
Polychlorinated biphenols (PCB's)	ug/L	(a)	—	—	—	—	.001	3	(a) Minimum exposure

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TABLE 3.--*Water-quality criteria for beneficial uses of ground water*--Continued

Parameters	Units	Drinking water	Industrial	Livestock	Agricultural — Irrigation: Continuous use, all soils	Agricultural — Irrigation: 20-yr use, fine soils, pH 6.0-8.5	Fresh-water aquatic life	Principal references	Remarks
Pesticides									
Organochlorine pesticides	ug/L								
Aldrin		1	—	—	—	—	0.003	3, 4	
Chlordane		3	—	—	—	—	.01	3, 4	
DDT		50	—	—	—	—	.001	3, 4	
DDE		—	—	—	—	—	.006	4	
Dieldrin		1	—	—	—	—	.003	3, 4	
Endosulfan		—	—	—	—	—	.003	3	
Endrin		.2	—	—	—	—	.004	1, 3	
Heptachlor		.1	—	—	—	—	.001	3, 4	
Heptachlor Epoxide		.1	—	—	—	—	—	4	
Lindane		4.0	—	—	—	—	.01	1, 3	
Methoxychlor		100	—	—	—	—	.03	1, 3	
Mirex		—	—	—	—	—	.001	3	
Toxaphene		5	—	—	—	—	.005	1, 3	
Organophosphate insecticides	ug/L								
Azinphosmethyl		—	—	—	—	—	0.001	4	
Ciodrin		—	—	—	—	—	.1	4	
Coumaphos		—	—	—	—	—	.001	4	
Demeton		—	—	—	—	—	.1	3	
Diazinon		—	—	—	—	—	.009	4	
Dichlorvos		—	—	—	—	—	.001	4	
Dioxathion		—	—	—	—	—	.09	4	
Disulfonton		—	—	—	—	—	.05	4	
Dursban		—	—	—	—	—	.001	4	
Ethion		—	—	—	—	—	.02	4	
EPN		—	—	—	—	—	.06	4	
Fenthion		—	—	—	—	—	.006	4	
Guthion		—	—	—	—	—	.01	3	
Malathion		—	—	—	—	—	.1	3	
Mevinphos		—	—	—	—	—	.002	4	
Naled		—	—	—	—	—	.004	4	
Oxydemeton methyl		—	—	—	—	—	.4	4	
Parathion		—	—	—	—	—	.04	3	
Phosphamidon		—	—	—	—	—	.03	4	
TEPP		—	—	—	—	—	.4	4	
Trichlorophon		—	—	—	—	—	.002	4	
Carbamate insecticides	ug/L								
Carbaryl		—	—	—	—	—	.02	4	
Zectran		—	—	—	—	—	.1	4	

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TABLE 3.--*Water-quality criteria for beneficial uses of ground water*--Continued

Parameters	Units	Drinking water	Industrial	Agricultural: Livestock	Agricultural: Irrigation: Continuous use, all soils	Agricultural: Irrigation: 20-yr use, fine soils, pH 6.0-8.5	Fresh-water aquatic life	Principal references	Remarks
Herbicides, fungacides, defoliants	ug/L								
Aminotriazole		--	--	--	--	--	300	4	
Dalapon		--	--	--	--	--	110	4	
Dicamba		--	--	--	--	--	200	4	
Dichlobenil		--	--	--	--	--	37	4	
Dichlone		--	--	--	--	--	.2	4	
Dignat		--	--	--	--	--	.5	4	
Diuron		--	--	--	--	--	1.6	4	
2, 4-D (BEE)		100	--	--	--	--	4.0	1, 4	
2, 4-5T		2	--	--	--	--	--	4	
Fenae (sodium salt)		--	--	--	--	--	45	4	
Silvex (2,4-5TP; BEE)		10	--	--	--	--	2.5	4	
Silvex (7,4-5TP; PGBE)		10	--	--	--	--	2.0	4	
Simazine		--	--	--	--	--	10.0	4	
Botanicals	ug/L								
Allethrin		--	--	--	--	--	.02	4	
Pyrethrum		--	--	--	--	--	.01	4	
Rotenone		--	--	--	--	--	10.0	4	
Bacteriological	Colonies/100 mL								
Coliform Group:									
Mean in month		1	--	--	--	--	--	1	
Single sample (<20 samples)		4	--	--	--	--	--	1	
5 percent of samples (>20 samples)		4	--	--	--	--	--	1	
Fecal coliforms		--	--	--	1,000	--	--	4	
Radiological	pCi/L								
Gross alpha		15	--	15	15	--	--	1, 4	See table 2
Gross beta		(a)	--	(a)	--	--	--	1, 4	(a) Annual total or
Radium-226		(a)	--	(a)	--	--	--	1, 4	single-organ dose <4
Strontium-90		(a)	--	(a)	--	--	--	1, 4	millirem/yr

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RATIONALES FOR MONITORING GROUND-WATER QUALITY

Purposes For Monitoring

The process of monitoring has been defined as "a scientifically designed surveillance system of continuing measurements and observations, including evaluation procedures" (Todd and others, 1976). Water-quality monitoring has three basic purposes: (1) Water-use protection--monitoring to provide warning of undesirable or hazardous changes in quality to protect one or more specific water uses; (2) pollution control--monitoring to provide data that support pollution-control functions; and (3) research--monitoring to acquire data that define environmental systems and processes affecting water quality. A comprehensive water-quality monitoring program addresses, in varying degrees, all three information needs, providing data on the existing quality of the water resource, the effects of pollution on that resource, and a scientific basis for understanding the processes, both natural and cultural, that affect the quality of that resource. Specific areas of emphasis differ among different monitoring programs, depending upon administrative and legal mandates for monitoring, the uses and values of the target resource, and economic constraints on the monitoring agency.

The fundamental purpose of monitoring the quality of ground water is to provide data necessary for the protection of both present and future beneficial uses of the water. The need of such protection for a given aquifer is dependent upon the nature and magnitude of existing and potential threats to the quality of the ground water, the magnitude and value of current and potential uses of the water, the sensitivity of those uses to changes in water quality, and the availability of alternative sources of water. To actually protect ground water, however, a monitoring program must be part of an overall management and control effort. Monitoring without appropriate action provides only documentation, not protection.

Legal Mandates

Provisions for ground-water monitoring are made under two major pieces of Federal legislation: Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972, and Public Law 93-523, the Safe Drinking Water Act of 1974.

Public Law 92-500

Under provisions of the Federal Water Pollution Control Act Amendments of 1972, each State is mandated to establish and operate systems to monitor the quality of water in the State. Section 106 of the act ties eligibility for grants supporting pollution-control programs to the requirement that the State include in its programs:

> "*** the establishment and operation of appropriate devices, methods, systems, and procedures necessary to monitor, and to compile and analyze data on... the quality of navigable waters and to the extent practicable, ground waters including biological monitoring; and provision for annually updating such data***"

Regulations implementing the provisions of Public Law 92-500 are contained in Combined Federal Regulations (CFR), 1974, and include the following as primary objectives for a State water-quality monitoring program:

1. Determine compliance with permit terms or conditions,
2. Develop and maintain an understanding of the quality (and causes and effects of such quality) of the waters in the State for the purpose of supporting State water pollution control activities,
3. Report on such quality and its causes and effects, and
4. Assess the effectiveness of the State's pollution abatement program.

Ground-water monitoring is included as one of six monitoring activities specified for inclusion in a State water-monitoring program:

"The water monitoring program of the state shall include the following monitoring activities:

1. Intensive monitoring surveys;
2. Fixed station monitoring of representative points;
3. Compliance monitoring***;
4. Ground-water monitoring;
5. Quality assurance activities relating to sampling, sample transport, and laboratory analysis and support; and
6. Data processing, reporting, and interpretation***"

Public Law 92-500 consistently delegates authority for pollution-abatement programs, including that for monitoring, to the States. Appendix A, Section 40 CFR (Combined Federal Regulations), provides broad outlines for a water-quality monitoring "strategy" rather than issuing regulations defining technical details of monitoring.

Cooperation between Federal, State, local, and private agencies involved in water resources, geology, and public health is assumed and encouraged insofar as such activities "***meet, to the satisfaction of the Regional [EPA] Administrator, the laboratory support and quality assurance requirements set forth in this Appendix [A, 40 CFR], and where sampling frequency, parameter coverage, station locations, and data availability meet pollution abatement program requirements***."

Public Law 93-523

The Safe Drinking Water Act of 1974 has several provisions dealing with protecting ground-water resources for drinking-water supply. The most direct provisions were those promulgated in the National Interim Primary Drinking Water Standards, which specify monitoring requirements for public water supplies served by ground-water sources (U.S. Environmental Protection Agency, 1976c). Those requirements are listed below (also see table 2):

Parameters	Sampling frequency
Coliform bacteria	Quarterly for systems serving 1,000 people or less, frequencies for greater populations a function of the population.
Inorganic chemicals	Every 3 years
Organic chemicals	As specified by the State
Radiochemical	Every 4 years

Other provisions of the Act spell out authority for regulation that will require ground-water monitoring for support. Section 1424 (e) provides for the designation for protection of "an aquifer which is the sole or principal drinking water source for the area, and which, if contaminated, would create a significant hazard to public health." If such determination is made, no Federal funds are allowable for any development that could contaminate the aquifer through a recharge zone.

Further authority has been extended by the Act for control of underground-waste implacement, protecting aquifers containing water with less than 10,000 mg/L of dissolved solids that are used, or have the potential for use, as sources of drinking water.

Objectives of a State Program

General water-monitoring requirements at the State level are outlined in a recommended-practice document published by the U.S. Environmental Protection Agency (1975):

1. The ultimate goal of monitoring is to fulfill the data and information needs of the State pollution control program.
2. Monitoring is part of the overall State program, not an end in itself--only justifiable work is to be done.
3. Monitoring is used to collect, evaluate, and present data and other information in a rational and methodical manner.
4. The annual monitoring work load is commensurate with the money and manpower resources available.

The document outlines four overall objectives for monitoring ground water:

1. To obtain data for the purpose of determining existing baseline conditions in ground-water quality and quantity.
2. To provide data for the early detection of ground-water pollution or contamination, particularly in areas of ground-water use.
3. To identify existing and potential ground-water pollution sources and to maintain surveillance of those sources in terms of their impact on ground-water quality.
4. To provide a data base upon which management and policy decisions can be made concerning the surface and subsurface disposal of wastes and the management of ground-water resources.

Data Requirements

Meeting the objectives of ground-water monitoring on a statewide basis will require the collection and evaluation of a large amount of diverse data. Specific needs will differ with the particular hydrologic system being analyzed, but the general categories may include data on:

1. Water use--to evaluate the relative importance of the resource to be protected.
2. Waste-disposal practices--to evaluate potential sources of degraded recharge water.
3. Geologic characteristics--to define natural controls on water occurrence, movement, and quality.
4. Hydrologic characteristics--to quantify the amount of water and the dynamics of its movement.
5. Climatic factors--to determine the amount and distribution of natural recharge.
6. Water quality—to describe the natural, or background, quality of recharge water, the quality of the ground water itself, and the changes in quality with movement in the hydrologic system.

Definition of the Resource to be Protected

The ultimate goal of any monitoring system is to provide information to support decisions or actions required to protect a resource from degradation that would affect current or future uses. The first step in a systematic approach to ground-water monitoring is to characterize the target aquifers by defining their areal and vertical extent, sources of recharge, points of discharge, and the nature of their boundaries. The amount of available data will differ with the intensity of development of the area being studied. Similarly, the need for data will differ with the size and complexity of the hydrologic system, the magnitude of real or potential contamination sources, and the distribution and intensity of water withdrawals. Fortunately, those areas with the most pressing needs for monitoring are usually areas of intensive ground-water use. Thus, existing water-supply wells generally will be of sufficient density to allow at least a preliminary characterization of the hydrologic system. Exceptions will involve background and point-source monitoring in lightly developed basins. In such cases preliminary estimates of the hydrologic characteristics will have to be made from a sparse number of data points, supplemented by any available geologic and physiographic information.

Determining Background Water Quality

Once an aquifer system has been preliminarily defined, the existing, or "background," quality of its native, uncontaminated water must be determined. In highly stressed areas, historical data may be of sufficient density and reliability to determine variations in water quality at various points in the system. In undeveloped areas, natural spring flow and seepage may be sampled, if available; if not, preliminary estimates of water quality may have to be inferred from available knowledge of the geology and physiography of the area.

Inventory of Monitoring Targets

With the exception of samplings to determine background quality, monitoring implies the existence of known, suspected, or potential sources of contamination. For point-source monitoring, the source whose presence instigated the monitoring effort is known. In contrast, areal monitoring requires an inventory of potential sources of contamination. The search for potential sources should be guided by the preliminary definition of the hydrologic system. An evaluation of the possible effect of a potential contamination source on ground-water quality may be based on its physical position in the hydrologic system, the nature of the contaminants, and the estimated quality of the native ground water.

Classification of contamination sources.--Sources of ground-water contamination have been categorized by mode of occurrence as (1) point, (2) line, and (3) diffuse (Schmidt, 1975). Point sources are those covering a limited, definable area which is approximately one-dimensional at the scale of interest. Examples include solid- or liquid-waste disposal in pits, ponds, lagoons, and wells; chemical stockpiles; and leaking well casings. Line sources are those predominantly linear at the scale of interest. Examples include waste disposal in ditches or streambeds, leaking pipelines, and road-salt runoff from highways. Diffuse (non-point) sources are those with a significant areal extent at the scale of interest, including agricultural return flow, general urbanization, and induced recharge from poor-quality aquifers. Obviously, the classification of any particular source depends on the scale of the investigation. Septic-tank effluent could, for example, be considered as a line source if one were attempting to model the movement of leachate from a leach line in the unsaturated zone, as a point source in terms of defining the development of a contaminated plume at the water table, or as part of a diffuse source in terms of the impact of suburban sprawl on the quality of a large hydrologic system.

Contamination sources have also been classified by cultural origin: Municipal, agricultural, industrial, oil field wastes, mining wastes, and miscellaneous (Todd and others, 1976). Candidates for these classes are listed along with their modes of occurrence in table 4. Ground water may also be contaminated by natural sources such as deep brines, buried organic deposits, saline geothermal waters, and deposits of soluble salts.

An inventory of monitoring targets must include the determination of the expected types of contaminants from each source. Major classes of potential contaminants are listed in table 5. Todd and others (1976) have reviewed the contaminants that can be expected for the sources listed in the table. Case histories of various types of contamination are becoming numerous in ground-water literature and have been annotated by Meyer (1973), Summers and Spiegel (1974), and Tinlin (1976) among others.

Establishing the Hydrologic Framework

Once the potential sources of contamination have been identified, their impact on the ground-water resource must be assessed. The preliminary conceptual model of the hydrologic system must be refined to predict the fate of the contaminants in the subsurface environment. Gathering data to define fully the hydrologic controls on contaminant movement may be prohibitively expensive; economic constraints may require that assessments of many contamination problems be based on less-than-optimum hydrologic data.

Table 4.--*Major sources and causes of ground-water contamination by waste disposal (from Todd and others, 1976)*

SOURCE	CATEGORY			COMMON METHOD OF DISPOSAL						
	Point	Line	Diffuse	Percolation Pond	Surface Spreading and Irrigation	Seepage Pits and Trenches	Dry Stream Beds	Landfills	Disposal Wells	Injection Wells
Municipal										
Sewer Leakage	X	X		NOT APPLICABLE						
Sewage Effluent	X	X	X	X	X		X		X	
Sewage Sludge	X		X		X	X		X		
Urban Runoff	X	X	X	X	X		X		X	
Solid Wastes	X				X			X		
Lawn Fertilizers			X		X					
Agricultural										
Evapotranspiration and Leaching (Return Flow)			X		X					
Fertilizers			X		X					
Soil Amendments			X		X					
Pesticides and Herbicides			X		X					
Animal Wastes (Feedlots and Dairies)	X		X	X	X	X		X		
Stockpiles	X			NOT APPLICABLE						
Industrial										
Cooling Water	X		X	X					X	
Process Waters	X			X					X	X
Storm Runoff	X		X	X	X		X		X	
Boiler Blowdown	X			X					X	
Stockpiles	X			NOT APPLICABLE						
Water Treatment Plant Effluent	X			X				X	X	
Hydrocarbons	X			X					X	X
Tanks and Pipeline Leaks	X	X		NOT APPLICABLE						
Oilfield Wastes										
Brines	X	X	X	X	X	X	X			X
Hydrocarbons	X			X					X	X
Mining Wastes	X	X	X	X			X	X	X	X
Miscellaneous										
Polluted Precipitation and Surface Water		X	X	NOT APPLICABLE						
Septic Tanks and Cesspools			X		X	X		X		
Highway Deicing		X		NOT APPLICABLE						
Seawater Intrusion			X	NOT APPLICABLE						

TABLE 5.--*Classification of potential ground-water contaminants (adapted from Todd and others, 1976)*

A.--By type of constituent

Physical	Organic Chemical
Temperature	Carbon
Density	Chlorophylls
Odor	Extractable organic matter
Turbidity	Methylene blue active substances
Inorganic Chemical	Nitrogen
Major constituents	Chemical oxygen demand
Other constituents	Phenolic material
Trace elements	Pesticides (insecticides and herbicides)
Gases	Hydrocarbons
Bacteriological	Radiological
Coliform group	Gross alpha activity
Fecal streptococci	Gross beta activity
Pathogenic micro-organisms	Strontium
Enteric viruses	Radium
	Tritium

TABLE 5.--*Classification of potential ground-water contaminants--Continued*

B.--By source

Source	Type of contaminant and potential importance					
	Physical	Inorganic chemical	Trace elements	Organic chemical	Bacterio-logical	Radio-logical
Municipal						
Sewer leakage	Minor	Primary	Secondary	Primary	Primary	Minor
Sewage effluent	Minor	Primary	Secondary	Primary	Primary	Minor
Sewage sludge	Minor	Primary	Primary	Primary	Primary	Minor
Urban runoff	Minor	Secondary	Variable	Primary	Minor	Minor
Solid wastes	Minor	Primary	Primary	Primary	Secondary	Minor
Lawn fertilizers	Minor	Primary	Minor	Minor	Minor	Minor
Agricultural						
Evapotranspiration and leaching	Minor	Primary	Minor	Minor	Minor	Minor
Fertilizers	Minor	Primary	Secondary	Secondary	Minor	Minor
Soil amendments	Minor	Primary	Minor	Minor	Minor	Minor
Pesticides	Minor	Minor	Minor	Primary	Minor	Minor
Animal wastes (feed-lots and dairies)	Minor	Primary	Minor	Secondary	Primary	Minor
Stockpiles	Minor	Primary	Minor	Variable	Variable	Minor
Industrial						
Cooling water	Primary	Minor	Primary	Minor	Minor	Minor
Process waters	Variable	Primary	Primary	Variable	Minor	Variable
Storm runoff	Minor	Secondary	Variable	Primary	Minor	Minor
Boiler blowdown	Primary	Secondary	Primary	Minor	Minor	Minor
Stockpiles	Minor	Primary	Variable	Variable	Minor	Variable
Water-treatment plant effluent	Minor	Primary	Secondary	Minor	Minor	Minor
Hydrocarbons	Secondary	Secondary	Secondary	Primary	Minor	Minor
Tank and pipeline leakage	Variable	Variable	Variable	Variable	Minor	Variable
Oilfield Wastes						
Brines	Primary	Primary	Primary	Minor	Minor	Minor
Hydrocarbons	Secondary	Secondary	Secondary	Primary	Minor	Minor
Mining Wastes	Minor	Primary	Primary	Variable	Minor	Variable
Miscellaneous						
Polluted precipitation and surface water	Variable	Variable	Variable	Variable	Variable	Variable
Septic tanks and cesspools	Minor	Primary	Minor	Secondary	Primary	Minor
Highway deicing	Minor	Primary	Minor	Secondary	Minor	Minor
Seawater intrusion	Primary	Primary	Primary	Minor	Minor	Minor
Natural Sources						
Evapotranspiration	Minor	Primary	Secondary	Minor	None	Minor
Evaporite deposits	Minor	Primary	Primary	None	None	Minor
Hydrothermal activity	Primary	Primary	Variable	None	None	Variable

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Many factors affect the infiltration of contaminants into the subsurface and their transport into an aquifer (fig. 6). Documentation of contaminant movement may require collection of hydrologic data for the soil horizons, the unsaturated zone, and the saturated zone.

Soil permeabilities determine the infiltration rate of wastes through the soil horizons. Effective permeabilities are influenced by the types of soil, the soil moisture and temperature, and the viscosity and chemical properties of the contaminants. Reactions tending to reduce, or attennate, the strength of a contaminant in the soil zone include filtration, sorption, ion exchange, buffering, precipitation, volatilization, spontaneous decay, dilution dispersion, and biologic uptake. Factors that may increase the strength of contaminants include solution of soil minerals, evapotranspiration, desorption of previously adsorbed materials, and ion exchange between the waste and the soil minerals. The degree to which any of these factors is effective is a function of the type and amount of contaminant, the rate of movement through the soil zone, the mineral and organic composition of the soil, and the soil depth. Theoretical quantification of these factors is difficult; laboratory determinations of infiltration rates and contaminant transport may be made using properly collected soil samples and aliquots of the particular contaminant in question. Field determinations of infiltration rates may be made using infiltrometers; porous-cup samplers may be employed to obtain soil-water samples for analysis.

Rates of flow in the unsaturated zone may vary greatly. The specific retention capacity of the materials in the unsaturated zone must be satisfied before a significant downward flux occurs; in areas where evapotranspiration losses exceed available recharge, this may never happen. In areas of large evapotranspiration losses and shallow water tables, the net vertical flux may

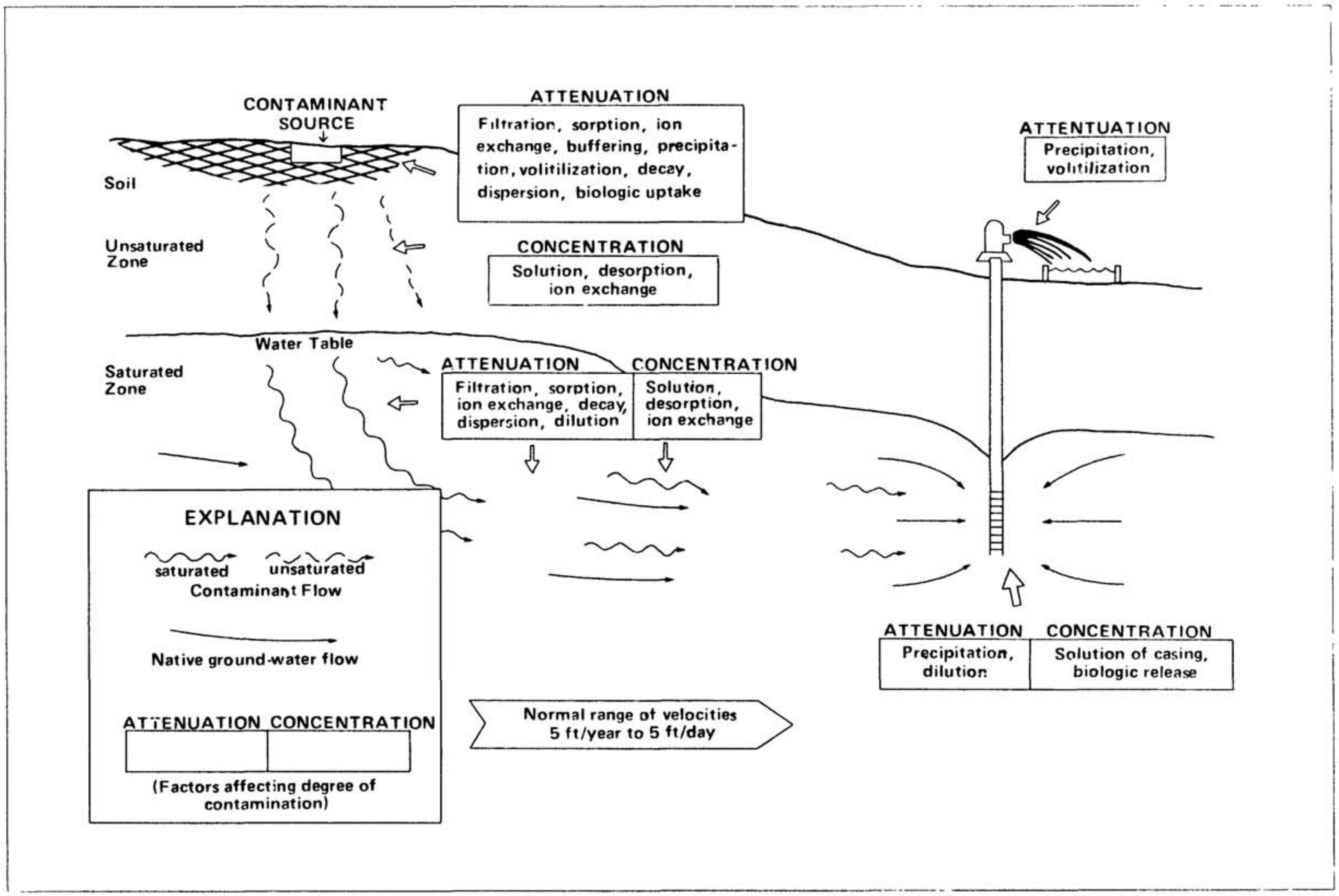

FIGURE 6.--Hydrologic factors affecting transport and concentration of contaminants in an idealized ground-water flow system.

be upward, precluding contamination of the aquifer except in the immediate vicinity of the waste application. Reactions that attenuate contaminants in the unsaturated zone are similar in type to those in the overlying soil profile, except that biologic activity usually decreases greatly with depth.

Definition of the ground-water flow system in the saturated zone is usually achieved by determining hydrologic gradients on the basis of water-level measurements, and determining aquifer permeabilities from drilling cuttings and core samples, by aquifer tests, or by making estimates from drillers' logs. Attenuation of contaminants in the saturated zone is a function of the physical and chemical characteristics of the aquifer (or aquifers), the rate and direction of water movement, and the chemistry of both the contaminant and the native water.

Uniform mixing of the contaminant and native water generally does not occur, instead, the contaminated water tends to form a plume, with concentrations decreasing away from the source. A variety of reactions may occur within the plume, including solution of aquifer minerals, ion exchange, and sorption or desorption. Physical or chemical fractionation of complex contaminants may develop, resulting in multiple fronts or waves of differing water quality within the plume. Episodes of contaminated recharge are often intermittent rather than continuous, resulting in a series of contamination plumes within the aquifer. The position of the plumes and the concentrations of contaminants within them may vary markedly with time.

Chemical and physical reactions affecting ground-water flow and contaminant transport may also occur in the vicinity of discharging wells. Converging ground water at well perforations results in higher velocities, which may increase solution of the aquifer materials and of metallic components of the well. The higher velocities near the well result in decreased pressure, which may change the chemical equilibrium of the water, causing precipitation of dissolved constituents. Biologic processes also are known to occur in the vicinity of the well.

The final set of reactions affecting the quality of the withdrawn ground water occurs during the pumping process. Aeration in the well bore and at the point of discharge may induce precipitation of dissolved materials. Contaminant losses also may result from escape of dissolved gasses or by volatilization.

The simplistic illustration in figure 6 is based on assumption of a homogeneous, isotropic aquifer contiguous with the unsaturated zone. Real-world hydrology seldom presents such a convenient simplicity. A composite of some of the potential hydrologic complications is shown in figure 7. Homogeneity and isotropy seldom exist in valley-fill sedimentary deposits such as those forming many of the aquifers in Nevada. The depositional history of most alluvial aquifers results in greater horizontal than vertical permeability in both the saturated and unsaturated zones. The structural fabric of bedrock aquifers may be highly linear; flow of fluids in bedrock aquifers commonly is controlled by fracture zones, faults, joints, solution cavities in carbonate rocks, and interbeds between volcanic flows. The net effect of hydrologic complexities may be either to attenuate contaminants or to offer a more direct flow path from their source to a point of water use.

The amount of geologic and hydrologic detail needed for effective monitoring is partly a function of the scale of the investigation. For areal studies involving diffuse sources, a generalized large-scale definition of the ground-water flow system may suffice. Detailed investigation of point or line sources requires more exact definition of the hydrology.

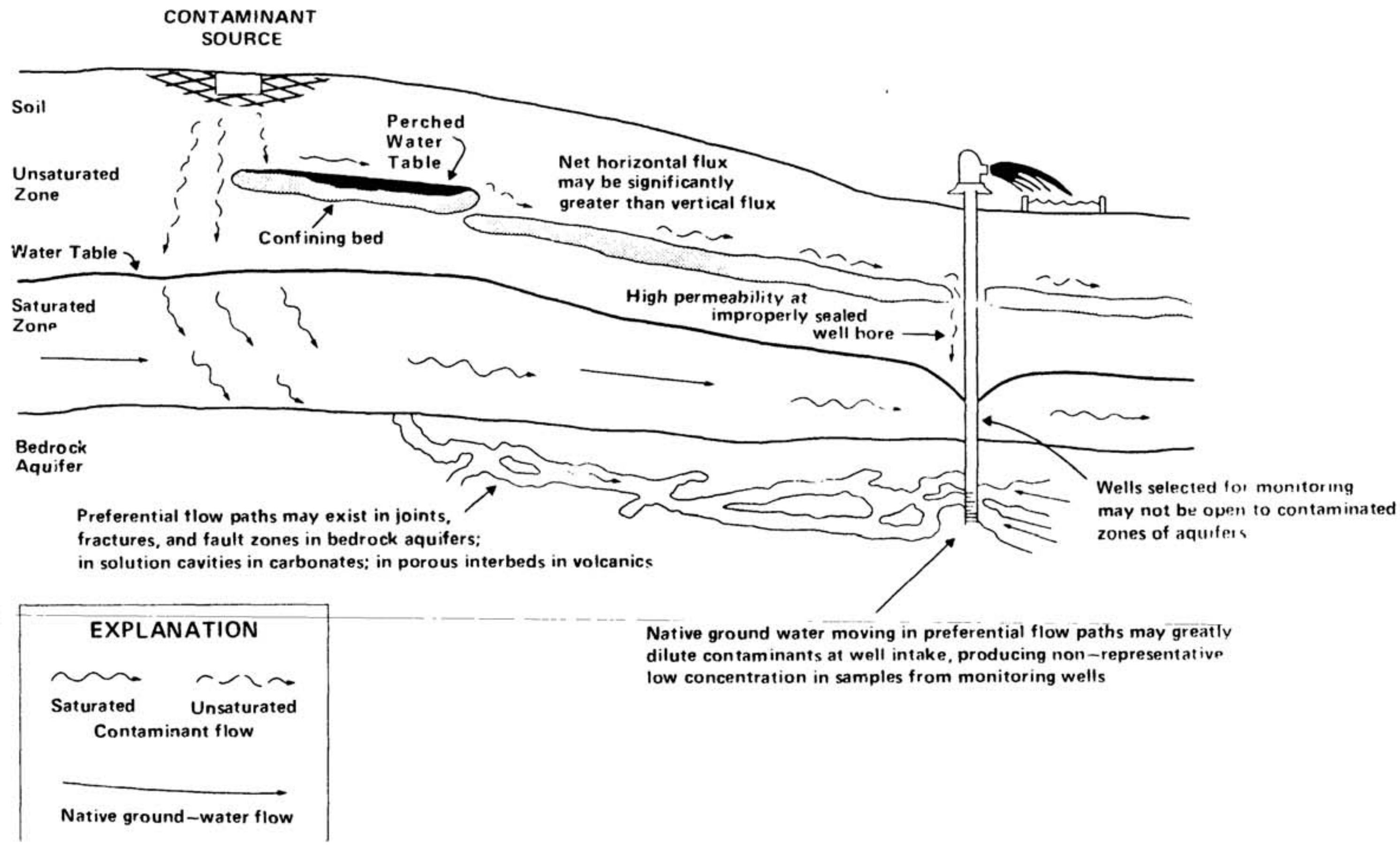

FIGURE 7.--Examples of some hydrologic complexities in "real-world" flow systems.

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Siting and Construction of Observation Wells

Observation wells are required to: Provide water-level data that indicate directions of ground-water movement; document the subsurface lithology; determine aquifer hydraulics; and obtain samples for analysis. The proper siting of observation wells is a crucial, difficult, expensive, and underfunded phase of most monitoring studies. The search for good observation wells begins with the initial evaluation of the aquifer. Once a preliminary conceptual model of the flow system has been made and contamination sites have been inventoried and assessed, observation wells are needed to refine the knowledge of the hydrologic system and determine the presence and movement of contaminants.

Except in background surveys or large-scale areal studies, existing production wells seldom serve as good wells for monitoring water quality. At best, production wells document only the arrival of contamination at the point of use, a condition which a well-designed monitoring program is intended to forecast in advance rather than document after the fact. Production wells are designed for high sustained yields under substantial drawdowns; thus, they are generally finished in deeper parts of aquifers, often with multiple perforated zones. Monitoring for early detection of contamination requires controlled vertical and horizontal sampling at the upper-level portions of aquifers--zones least likely to have existing production wells.

Most monitoring efforts will require the drilling of one or more observation wells. Optimum placement of these wells requires a thorough preliminary evaluation of site hydrology. Monitoring needs may dictate sampling of multiple zones in the vertical section. With proper well design, a nested set of casings may be installed with individual openings to the aquifer sections of interest. Provisions should be made to sample drill cuttings and log the penetrated materials during drilling. Core samples for laboratory determination of aquifer characteristics may be required. If the observation well is near a source of contamination, provisions should be made for obtaining samples from the unsaturated zone for analysis of pore-water extracts. For some monitoring targets, extra precautions are required to prevent aquifer contamination during drilling, particularly if the well is being drilled through materials known or suspected to be contaminated. Well design should also consider the need for obtaining water-quality samples; well-construction materials should be noncontaminating for the range of constituents or properties being monitored. Monitoring for organic contaminants will require use of metals for all components in contact with the water; conversely, non-metallic components will be required if trace metals are of interest.

Sampling Parameters and Frequencies

The parameters to be included in analyses of ground-water samples will vary with the function of the monitoring program and the nature of known or suspected sources of contamination. Source-monitoring programs will emphasize analyses for key indicator parameters that (1) most accurately trace the movement of the contaminant in the subsurface and (2) have the greatest potential for adversely affecting existing or future uses of the ground water. These two functions may be complimentary or exclusive in different monitoring situations. For example, a program to monitor septic-tank effluents on a regional scale may be able to use the nitrate ion as a parameter to satisfy both requirements; mapping variations in nitrate concentrations may help define the areal extent of the contamination, and nitrate also is one of the products of septic-tank effluents that may seriously affect domestic use of ground water. An example of conflicting functions of indicator parameters is the monitoring of contaminants from a percolation pond for the disposal of industrial wastes. In this case, a conservative parameter such as chloride may serve as an indicator of contaminant movement, despite the fact that the increases in chloride concentrations may not be great enough to impact local ground-water uses adversely. Conversely, toxic trace metals such as cadmium or mercury may be the waste constituents with the greatest potential for adverse impact on water uses, yet these constituents may be greatly attenuated within the subsurface environment and thus not serve as accurate tracers of waste migration. In such a situation, the water analyses would have to include both the best indicators and the more toxic constituents to serve the monitoring needs.

Table 5 lists general categories of contaminants that may be expected for various sources of ground-water contamination. Representative water-quality parameters are listed for each of those general categories in table 6. Most monitoring programs will not need an extensive suite of parameters for routine analyses; however, the preliminary assessment of contamination sources should include comprehensive analyses of waste samples to characterize the potential contaminants adequately. An evaluation of those results along with the results of background sampling will allow an intelligent selection of characteristics for routine monitoring.

Monitoring for background quality and monitoring to document quality changes in production wells not threatened by specific known sources of contamination require emphasis on parameters that affect particular beneficial uses of ground water. The water-quality characteristics and constituents listed in table 6 outline a broad menu for consideration in monitoring background quality. Selection of individual parameters for an initial survey of background water quality would be based on an analysis of existing

TABLE 6.--*Ground-water quality parameters to be considered for monitoring programs (adapted from Todd and others, 1976)*

Parameter	Units
Chemical - Organic	
Biochemical oxygen demand (BOD)	mg/L
Carbon chloroform extract (CCE)	ug/L
Chemical oxygen demand (COD)	mg/L
Chlorinated phenoxy acid herbicides	ug/L
Detergents (surfactants)	mg/L
Oil and grease	mg/L
Organic carbon (C)	mg/L
Organophosphorus pesticides	ug/L
Phenols	mg/L
Tannins and ligins	mg/L
Chemical - Inorganic	
Acidity	mg/L
Alkalinity	mg/L
Ammonia (NH_4)	mg/L
Bicarbonate (HCO_3)	mg/L
Calcium (Ca)	mg/L
Carbonate (CO_3)	mg/L
Chloride (Cl)	mg/L
Fluoride (F)	mg/L
Hardness	mg/L
Hydroxide (OH)	mg/L
Magnesium (Mg)	mg/L
Nitrate (NO_3 N)	mg/L
Nitrite (NO_2 N)	mg/L
Nitrogen (N N)	mg/L
Oxygen (O_2)	mg/L
pH	units
Phosphorus	mg/L
Phosphate (PO_4 P)	mg/L
Potassium (K)	mg/L
Silica (SiO_2)	mg/L
Sodium (Na)	mg/L
Solids, dissolved	mg/L
Solids, suspended	mg/L
Sulfate (SO_4)	mg/L
Sulfide (S)	mg/L
Sulfite (SO_3)	mg/L
Chemical - Trace Elements	
Aluminum (Al)	ug/L
Antimony (Sb)	ug/L
Arsenic (As)	ug/L
Barium (Ba)	ug/L
Beryllium (Be)	ug/L
Chemical - Trace Elements--continued	
Bromide (Br)	ug/L
Cadmium (Cd)	ug/L
Chromium (Cr)	ug/L
Cobalt (Co)	ug/L
Copper (Cu)	ug/L
Cyanide (CN)	ug/L
Iron (Fe)	ug/L
Lead (Pb)	ug/L
Lithium (Li)	ug/L
Manganese (Mn)	ug/L
Mercury (Hg)	ug/L
Molybdenum (Mo)	ug/L
Nickel (Ni)	ug/L
Selenium (Se)	ug/L
Silver (Ag)	ug/L
Strontium (Sr)	ug/L
Tin (Sn)	ug/L
Titanium (Ti)	ug/L
Vanadium (V)	ug/L
Zinc (Zn)	ug/L
Biological	
Coliform bacteria	colonies/100 mL
Fecal coliform bacteria	colonies/100 mL
Fecal streptococci bacteria	colonies/100 mL
Physical	
Color	units
Conductance, specific	umhos/cm at 25°C
Odor	threshold odor
Temperature	°C
Turbidity	units
Radiological	
Barium-140 (^{140}Ba)	pc/L
Cerium-141 and 144 (^{141}Cs, ^{144}Ce)	pc/L
Cesium-134 and 137 (^{134}Cs, ^{137}Cs)	pc/L
Gamma spectrometry	pc/L
Gross alpha	pc/L
Gross gamma	nc/L
Iodine-131 (^{131}I)	pc/L
Neptunium-239 (^{239}Np)	pc/L
Radium (Ra)	pc/L
Thorium (Th)	ug/L
Tritium (^3H)	pc/L
Uranium (U)	ug/L

historical water-quality data, knowledge of the local hydrogeologic environment, and information on the types and intensities of existing water uses and their specific water-quality requirements (see table 3). Results of the initial sampling would then be used to select a rational and economic suite of analyses for a routine sampling program.

Minimum monitoring requirements for public water supplies in Nevada are set by law and are listed in table 2. Rational monitoring of ground water used for public supplies may require the inclusion of either fewer or more parameters than those specified by law. For example, in aquifers with well-defined natural controls on ground-water quality and low probabilities of contamination from cultural sources, historical water-quality data may be adequate to define statistical relationships between inorganic parameters such as concentrations of dissolved solids, chloride, and sulfate and an index parameter such as specific electrical conductance. Once such a relationship has been defined, routine monitoring of conductance alone would provide estimates of concentrations of the major inorganic constituents at a very low cost. More comprehensive analyses would be made at legally specified intervals to check that the relationships used remain valid with time. In other situations, local hydrologic or cultural environments may require that effective monitoring include either more or different parameters than those specified in water-quality standards.

IN THE SUPREME COURT OF THE STATE OF NEVADA

JASON KING, P.E., Nevada State Engineer, DIVISION OF WATER RESOURCES, DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES, Appellant, vs. HAPPY CREEK, INC., Respondent.	Case No. 74266

JOINT APPENDIX

<u>Volume VI of XVII</u>
(Pages JT APP 250-295)

Docket 74266 Document 2018-08887

DATE	DOCUMENT DESCRIPTION	VOLUME	PAGE NOS.
06/12/17	Request for Submission and Oral Argument	XVI	937-934
12/19/16	Stipulation and Order Regarding Briefing Schedule	I	27-29
03/02/17	Stipulation and Order to Extend Briefing Schedule	II	175-177
12/28/16	Summary of Record on Appeal and Documents SE ROA 1-137	I	30-174
03/16/17	Supplemental Record on Appeal and Documents SROA 1-670	III-XVI	213-891
08/14/17	Transcript of Oral Argument	XVI-XVII	1043-1172

RESPECTFULLY SUBMITTED this 6th day of March, 2018.

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CERTIFICATE OF SERVICE

I certify that I am an employee of the Office of the Attorney General and that on this 6th day of March, 2018, I served a copy of the foregoing JOINT APPENDIX (Volumes I-XVII, Pages JT APP 1-1183), by electronic service to:

Paul G. Taggart, Esq.
TAGGART & TAGGART, LTD.
108 North Minnesota Street
Carson City, Nevada 89703

/s/ Dorene A. Wright

This appraisal of the ground-water resources of Pine Forest Valley is based on a limited amount of data. A more detailed appraisal of the ground-water resources can be obtained by a program of continued periodic inventories of pumpage correlated with water-level measurements and chemical analyses of water from wells at selected sites in the valley. Such a program would supply the necessary information for the development and management of the water resources of Pine Forest Valley.

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Table 1. - - Yield, drawdown, and specific capacity of wells in Pine Forest Valley, Humboldt County, Nev.

Well number and location	Yield (gpm)	Drawdown (feet)	Specific capacity (gpm per foot of drawdown) 1/
45/31-19A1	10	20	0.5
43/32-20A1	1,100	95	12
43/32-20C1	3,100	97	32
43/32-29B1	3,600	97	37
43/32-30A2	1,600	40	40
42/30-23C1	25	6	4.2
42/31-11B1	2,400	48	50
41/32-2A1	2,250	32	70

1/ Computed from yield and drawdown data contained in drillers' reports to the State Engineer of Nevada.

Table 2.--Record of wells and springs in Pine Forest Valley, Humboldt County, Nev.
Use of water: D, domestic; I, irrigation; S., stock.
Water level: M, measured; R, reported.
Altitude: Determined from altimeter readings, rounded to nearest 5 feet.

Well or spring number and location (See Fig. 2.)	Owner	Date drilled	Diameter (inches)	Depth (feet)	Depth of main aquifers (feet)	Measuring point: Altitude (feet)	Measuring point: Above land surface (feet)	Measuring point	Water level: Below measuring point (feet)	Water level: M or R	Water level: Date	Use	Remarks
46/30-13A1	Quinn River Crossing Ranch	9-55	8	194	191-194	--	1.5	Top of casing	113.9	M	10- 1-60	S	Chemical analysis
45/30-13D1	Big Creek Ranch	5-51	8	80	25-38	--	--	--	18	R	5- 51	D	
45/31-17B1	--	--	--	161	--	--	0	Top of soil drum	130.9	M	9-20-60	S	Chemical analysis
45/31-19A1	Nevada Highway Department	2-56	6	230	193-227	--	--	--	195	R	2-18-56	D	
45/31-28A1	--	--	6	123	--	--	.5	Top of casing	90.7	M	10- 5-60	S	Chemical analysis
44/30-24C1	Big Creek Ranch	--	--	40	--	--	0	Hole in pump base	20.5	M	10- 5-60	D	
44/31-4A1	--	--	--	--	--	--	--	--	--	--	--	S	Thermal Springs; flow about 50 gpm. Chemical analysis
44/31-5A1	--	--	--	--	--	--	--	--	--	--	--	S	Thermal spring; flow about 5 gpm. Chemical analysis
44/31-35B1	U.S. Bureau of Land Management	--	--	--	--	4,195	.5	Top of oil drum	81	M	10- 4-60	S	Chemical analysis
43/30-25D1	--	--	--	--	--	--	--	--	--	--	--	S	Thermal spring; flow about 40 gpm. Chemical analysis
43/31-19B1	Harold Woodward	1931	--	25	--	4,100	2	Concrete pump base	10.2	M	10- 8-60	S	Chemical analysis
43/31-21B1	U.S. Bureau of Land Management	--	8	33	--	4,090	.5	Top of casing	14.1	M	10- 8-60	S	Chemical analysis
43/32-20A1	Quinn River Crossing Ranch	3-51	14	925	348-925	--	--	--	--	--	--	I	
43/32-20C1	Quinn River Crossing Ranch	--	16	706	300-706	--	--	--	--	--	--	I	
43/32-21C1	Quinn River Crossing Ranch	10-57	6	75	61-75	4,120	1	Top of casing	32.1	M	9-30-60	S	
43/32-29B1	Quinn River Crossing Ranch	5-60	16	700	110-190	--	--	--	13	R	5-20-60	I	
43/32-30A1	Quinn River Crossing Ranch	3-51	8	60	15-20	--	--	--	15	R	3- -51	--	
43/32-30A2	Quinn River Crossing Ranch	3-51	16	395	60-120	--	--	--	--	--	--	I	
42/30-12A1	--	--	--	--	--	--	--	--	--	--	--	--	Thermal springs; flow 1-2 gpm. Chemical analysis
42/30-23C1	U.S. Bureau of Land Management	10-58	6	128	117-125	4,055	1	Top of casing	32.9	M	9-30-60	S	Chemical analysis
42/31-11B1	Quinn River Crossing Ranch	8-55	17	352	55-120	4,055	3	Top of casing	+4.6	R	8-30-55	I	Flows about 170 gpm Chemical analysis
42/32-11D1	--	8-49	8	--	--	--	1	Top of casing	25.7	M	6- 2-61	--	Not used
42/32-19D1	--	--	--	--	--	--	--	--	--	--	--	S	Thermal springs; flow about 5 gpm. Chemical analysis
42/32-27C1	--	--	--	--	--	--	--	--	--	--	--	S	Chemical analysis
42/32-36C1	Happy Creek Ranch	--	--	65	--	--	--	--	--	--	--	D	Chemical analysis
41/30-1B1	U.S. Bureau of Land Management	--	6	57	--	4,055	1	Top of casing	57.1	M	9-30-60	S	
41/31-3B1	U.S. Bureau of Land Management	--	6	--	--	4,040	1	Top of casing	17.7	M	9-30-60	S	
41/31-5B1	U.S. Bureau of Land Management	--	6	78	--	4,030	1	Top of casing	20.3	M	10-8-60	S	Chemical analysis
41/32-2A1	Happy Creek Ranch	8-54	16	202	142-202	4,130	0	Pump base	38	M	9-30-60	I	Water level measured by airline
41/33-4B1	--	--	6	--	--	4,100	0	Top of casing	2.6	M	11- 7-60	S	Not used

Table 3.--Chemical analyses of ground water in Pine Forest Valley, Humboldt County, Nev.

[Analyses by U.S. Geological Survey unless otherwise stated. Constituents in parts per million. For information on classification for irrigation, see Fig. 3 and p. 14.]

Well or spring number	Date collected	Temperature (°F)	Specific conductance (micromhos at 25°C)	Dissolved solids (ppm) residue at 180°C	Sodium adsorption ratio (SAR)	Residual sodium carbonate (RSC)-(epm)	Classification for irrigation	Silica (Si)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Carbonate (CO_3)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Hardness as $CaCO_3$	Hardness non-carbonate	pH
46/30-13A1	10- 1-60	55	[a] 209																			
45/31-17B1	9-20-60	57	[a] 339																			
45/31-28A1	10- 5-60	59	338	239	1.3	0.10	C2S1	39	28	7.5	30	5.8	0	128	26	26	0.2	3.5	0.08	100	0	7.7
44/31-4A1	10- 7-60	136	401	324	14	1.99	C2S2	84	2.4	.5	91	2.0	39	52	64	14	7.9	.1	.26	8	0	9.3
44/31-5A1	10- 7-60	163	398	344	14	2.16	C2S2	84	3.2	.0	90	2.3	41	58	46	12	8.0	.2	.21	8	0	9.3
44/31-35B1	10- 4-60	61	354	262	2.1	.57	C2S1	54	26	4.4	45	3.8	0	136	40	21	2.0	.7	.16	83	0	7.6
43/30-25D1	10- 8-60	158	636	470	22	3.94	C2S4	83	3.2	.0	146	3.7	16	218	76	6.0	8.9	.3	.41	8	0	8.7
43/31-19B1	10- 8-60	55	367	272	1.6	.51	C2S1	57	33	6.3	39	3.6	0	164	44	15	.2	.1	.10	109	0	7.7
43/31-21B1	10- 8-60	53	315	241	1.5	.54	C2S1	55	26	5.8	33	3.0	0	140	31	17	1.0	.3	.06	88	0	7.6
42/30-12A1	10- 8-60	104	883	660	24	5.82	C3S4	125	3.2	1.5	210	6.2	7	358	67	54	14	1.2	2.9	14	0	8.3
42/30-23C1	11- 9-60	--	845	--	7.7	2.66	C3S2	--	21	5.7	153	11	0	255	--	66	--	--	--	76	0	8.1
42/31-11B1	10- 8-60	75	259	244	2.0	.63	C2S1	65	18	2.4	34	4.8	0	104	25	15	.6	.8	.11	54	0	7.7
42/32-19D1	10- 7-60	70	1,900	1,290	20	13.54	C3S4	51	30	6.3	455	9.9	0	948	204	69	9.8	.4	1.3	100	0	8.1
42/32-27C1	10- 7-60	55	648	436	2.0	0	C2S1	57	41	17	76	7.1	0	204	91	56	.4	1.7	.19	171	4	7.6
42/32-36C1	9-30-60	51	[a] 172																			
41/31-5B1	10- 8-60	56	345	250	2.4	1.16	C2S1	49	20	4.6	47	8.2	0	156	22	23	.4	.9	.13	70	0	7.6

[a] Field test.

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SROA33

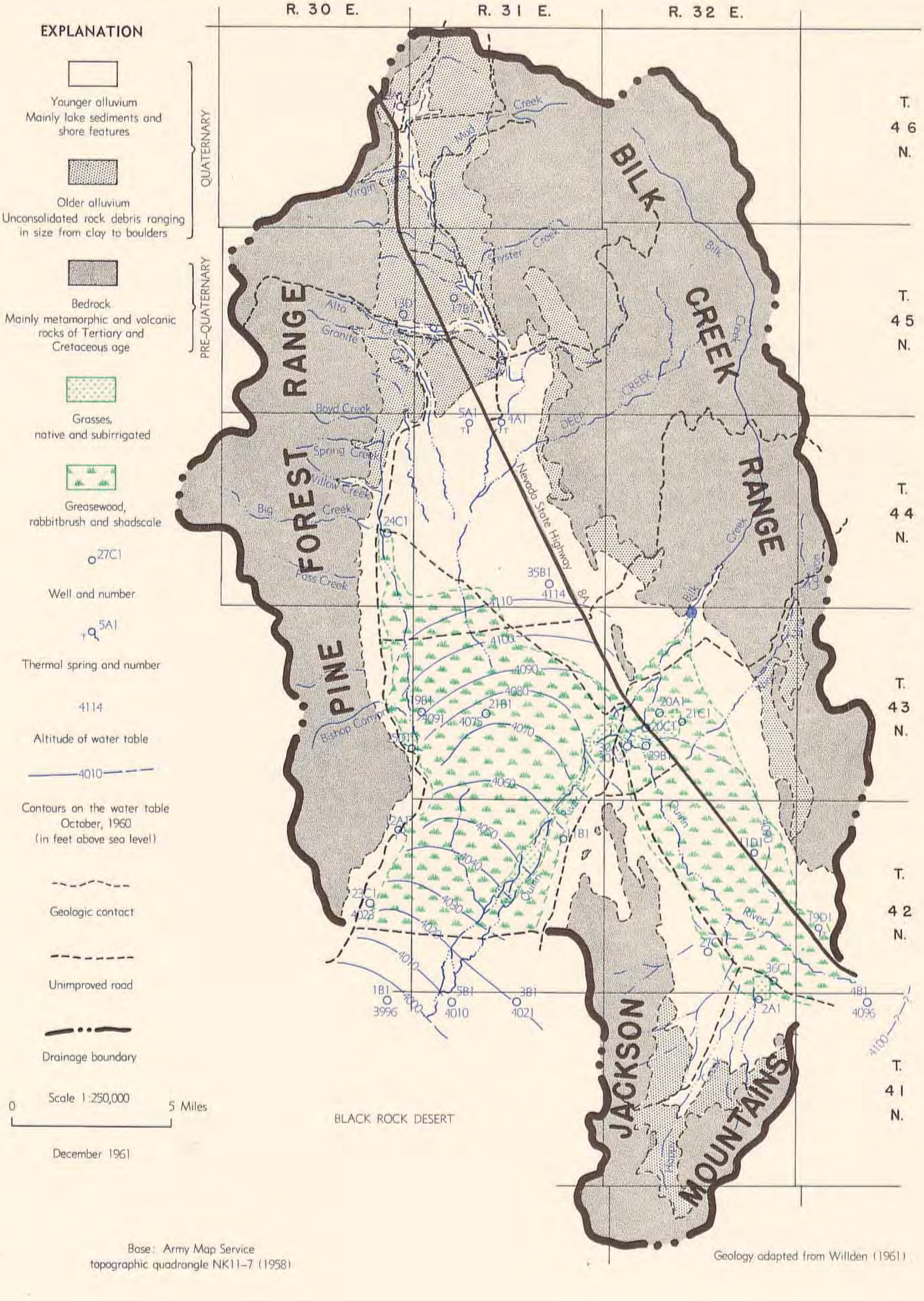

PLATE 1. GENERALIZED GEOLOGIC AND HYDROLOGIC MAP OF PINE FOREST VALLEY, HUMBOLDT COUNTY, NEVADA

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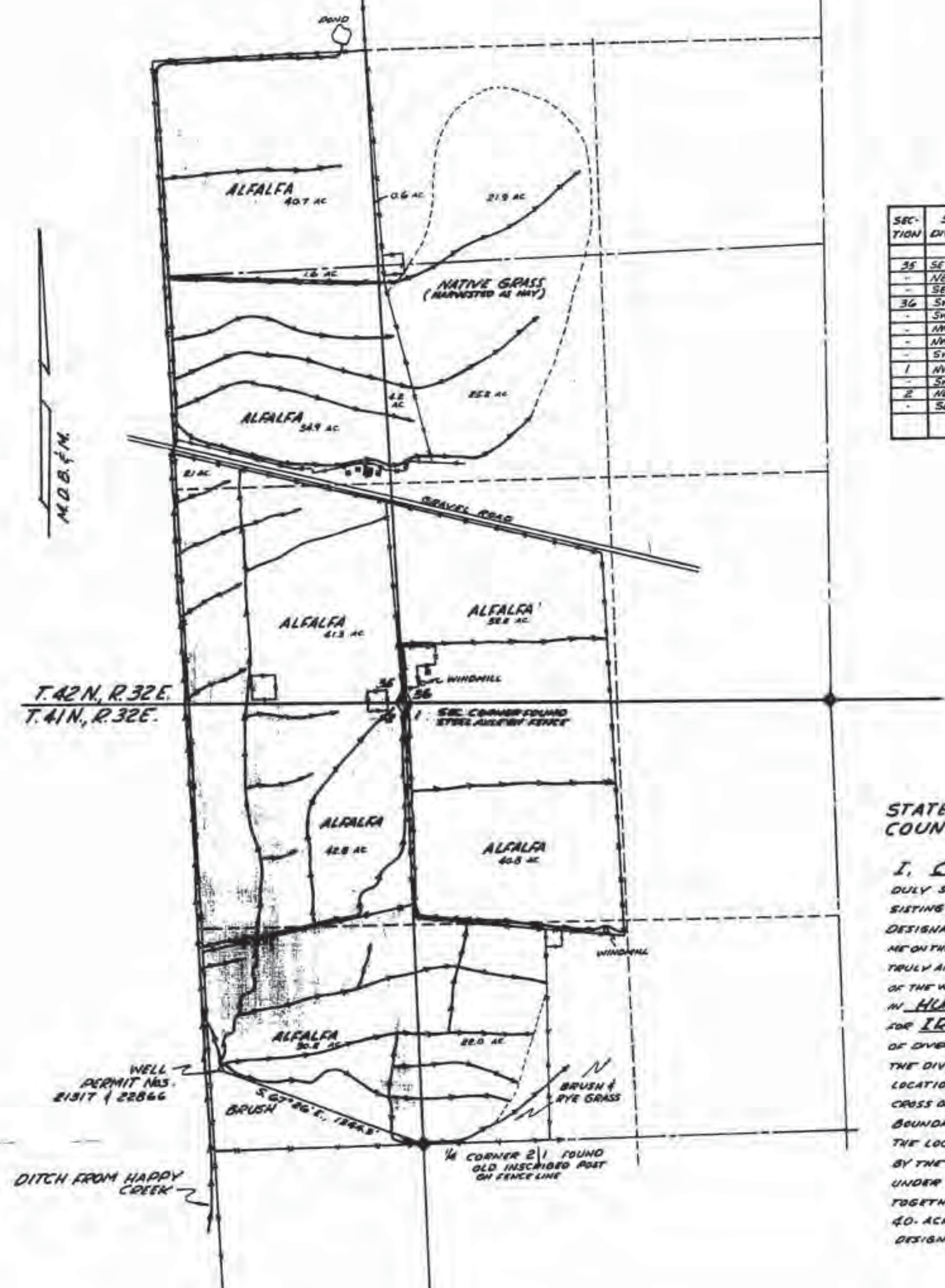
MAP TO ACCOMPANY
PROOF OF BENEFICIAL USE
UNDER PERMIT Nos. 21317 & 22866
IN THE NAME OF JULE DELONG
FROM UNDERGROUND
FOR IRRIGATION

SCALE: 1" = 400'

22866 21317

FILED
DEC 26 1967
STATE ENGINEER'S OFFICE



CULTURAL TABULATION

SECTION	SUB-DIVISION	TOWN-SHIP	RANGE	CULTIVATED ACREAGE	DESCRIPTION OF CULTURE
35	SE¼ NE¼	42 N.	32 E.	40.7	ALFALFA
"	NE¼ SE¼	"	"	38.6	"
"	SE¼ SE¼	"	"	41.3	"
36	SW¼ NW¼	"	"	0.6	"
"	SW¼ NW¼	"	"	21.9	NATIVE GRASS
"	NW¼ SW¼	"	"	25.2	" "
"	NW¼ SW¼	"	"	4.2	ALFALFA
"	SW¼ SW¼	"	"	32.2	"
1	NW¼ NW¼	41 N.	32 E.	40.8	"
"	SW¼ NW¼	"	"	22.0	"
2	NE¼ NE¼	"	"	42.8	"
"	SE¼ NE¼	"	"	30.8	"
				Σ = 340.5 AC	

22866 CERTIFICATE No. 6626 ISSUED 4-25-68

21317 CERTIFICATE No. 6110 ISSUED 7-17-61

STATE OF NEVADA
COUNTY OF HUMBOLDT } S.S.

I, CHARLES C. ARMUTH, JR., BEING FIRST DULY SWORN, DEPOSE AND SAY, THAT THIS MAP CONSISTING OF ONE SHEET HAS BEEN CORRECTLY DRAWN TO THE DESIGNATED SCALE FROM FIELD NOTES OF A SURVEY MADE BY ME ON THE 4TH AND 5TH DAYS OF DECEMBER, 1967; THAT IT TRULY AND CORRECTLY REPRESENTS THE LOCATION AND EXTENT OF THE WORKS USED TO DIVERT WATER FROM UNDERGROUND IN HUMBOLDT COUNTY, BY JULE DELONG FOR IRRIGATION PURPOSES. THAT PURPOSED POINT OF DIVERSION, THE APPROXIMATE LOCATION AND SIZE OF THE DIVERTING CHANNEL, ALL RESERVOIRS OR BASINS, THE LOCATION AND NAMES OF ALL OTHER WORKS WHICH WILL CROSS OR CONNECT WITH THE PROPOSED WORKS, AND THE BOUNDARY OF ALL LANDS, SHOWING BY 40-ACRE SUBDIVISIONS THE LOCATION AND EXTENT OF LANDS OWNED OR CONTROLLED BY THE APPLICANT UPON WHICH WATER APPLIED FOR UNDER APPLICATION NOS. 21317 AND 22866 IS USED TOGETHER WITH THE AREA AND KIND OF CULTURE IN EACH 40-ACRE SUBDIVISION ARE FULLY AND CORRECTLY DESIGNATED THEREON.

Chas. C. Armuth Jr.
STATE WATER RIGHT SURVEYOR

SUBSCRIBED AND SWORN TO BEFORE ME THIS 21st DAY OF DECEMBER, 1967.

Marguerite E. Mowry
NOTARY PUBLIC IN AND FOR HUMBOLDT COUNTY, NEV.

MARGUERITE E. MOWRY
Notary Public — State of Nevada
Humboldt County
My Commission Expires May 16, 1970

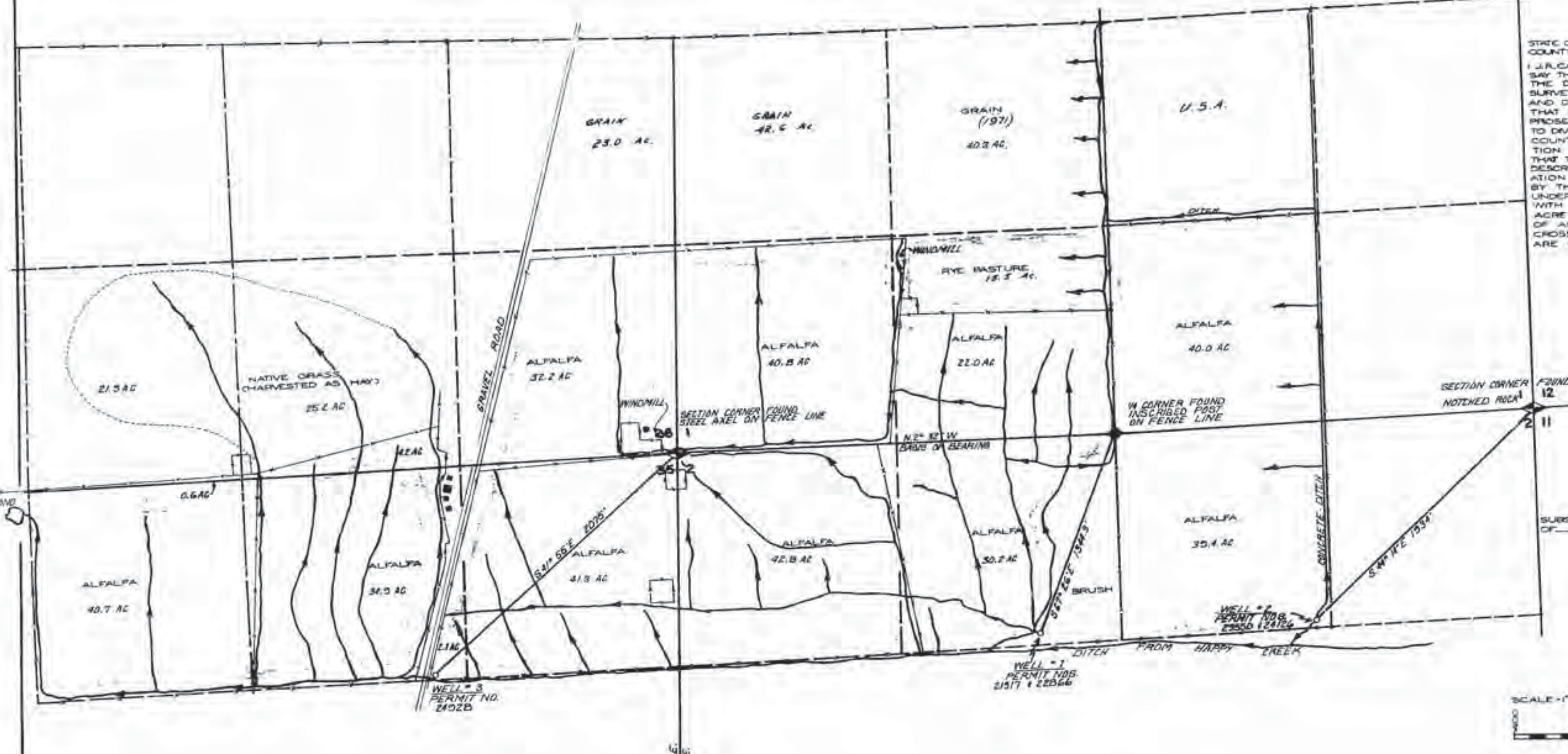
JT APP 256

CULTURAL TABULATION FOR WELL NO. 24126

SEC.	SUBDIVISION	TOWN-SHIP	RANGE	CULTURAL ACREAGE	DESCRIPTION OF CULTURE
35	SE¼ NE¼	42N	32E	40.7	Alfalfa
1	NW¼ NW¼	41 N	"	40.8	"
1	SW¼ NW¼	"	"	22.0	"
1	" "	"	"	15.5	Pasture
	Total			119.0	

CULTURAL TABULATION FOR WELL NO. 23550

SEC.	SUBDIVISION	TOWN-SHIP	RANGE	CULTURAL ACREAGE	DESCRIPTION OF CULTURE
2	NE¼ SE¼	41 N	32E	39.4	Alfalfa
2	NE¼ NE¼	"	"	42.8	"
2	SE¼ NE¼	"	"	30.2	"
1	NW¼ NW¼	"	"	40.8	"
1	SW¼ NW¼	"	"	22.0	"
1	" "	"	"	15.5	Pasture
1	NW¼ SW¼	"	"	40.0	Alfalfa
	Total			230.7	



STATE OF NEVADA }
COUNTY OF HUMBOLDT } SS

I J.R. CALDWELL, BEING FIRST DULY SWORN, DEPOSE AND SAY THAT THIS MAP HAS BEEN CORRECTLY DRAWN TO THE DESIGNATED SCALE FROM FIELD NOTES OF A SURVEY MADE BY ME (OR UNDER MY SUPERVISON AND AND DIRECTION) ON THE 24th DAY OF February 1972, THAT IT TRULY AND CORRECTLY REPRESENTS THE PROPOSED LOCATION AND EXTENT OF THE WORKS USED TO DIVERT WATER FROM Underground IN HUMBOLDT COUNTY, BY JULE & ELIZABETH DELONG FOR IRRIGATION PURPOSES UNDER APPLICATION NO. 23550 & 24126 THAT THE POINT OF DIVERSION, THE LOCATION AND DESCRIPTION OF ALL MEASURING DEVICES, THE LOCATION AND EXTENT OF LANDS OWNED OR CONTROLED BY THE APPLICANT UPON WHICH WATER APPLIED FOR UNDER APPLICATION NO. 23550 & 24126 IS USED, TOGETHER WITH THE AREA AND KIND OF CULTURE IN EACH 40 ACRE SUBDIVISION AND THE LOCATION AND NAMES OF ALL OTHER WORKS OR STREAMS WHICH ARE CROSSED BY OR CONNECTED WITH SAID WORKS ARE FULLY AND CORRECTLY DESIGNATED THEREON.

J.R. Caldwell
STATE WATER RIGHT SURVEYOR

J. R. CALDWELL

SUBSCRIBED AND SWORN TO BEFORE ME THIS 3 DAY OF March 1972.

Gladys Paul
Humboldt County Recorder

24126 CERTIFICATE No. 7950 ISSUED 10-2-72
23550 CERTIFICATE No. 7981 ISSUED 1-9-73

FILED
MAR 6 1972
STATE ENGINEER'S OFFICE

MAP
TO ACCOMPANY
PROOF OF BENEFICIAL USE

UNDER APPLICATION NO. 23550 & 24126
BY JULE & ELIZABETH DELONG
FROM UNDERGROUND FOR IRRIGATION
IN HUMBOLDT COUNTY, NEVADA

24126 File under 23550

JT APP 257

Section	Subdivision	Township	Range	Acres	Culture
APPLICATION 24927					
35	NE1/4 SE1/4	42N	32E	37.0	Alfalfa
	SE1/4 SE1/4			41.3	"
36	NW1/4 SW1/4			21.4	" Meadow Hay
	SW1/4 SW1/4			31.8	" "
1	NE1/4 NW1/4	41N	32E	70.9	Alfalfa
	SE1/4 NW1/4			40.3	"
Total				219.8	
APPLICATION 24928					
35	NE1/4 SE1/4	42	32E	34.9	Alfalfa
	SE1/4 NE1/4			40.7	"
36	NW1/4 SW1/4			29.4	" Meadow Hay
	SW1/4 NW1/4			21.9	"
	SE1/4 NW1/4			37.8	Barley
	NE1/4 SW1/4			35.9	"
	SE1/4 SW1/4			20.3	Brush & Pasture
	SW1/4 SW1/4			7.5	Alfalfa & Pasture
Total				228.4	

STATE OF NEVADA
COUNTY OF HUMBOLDT] SS

I, J. R. Caldwell, being first duly sworn, depose and say that this map, consisting of ____ sheets, has been correctly drawn to the designated scale from field notes of a survey made by me (or under my supervision and direction), on the 15th Day of May 1974, that it truly and correctly represents the proposed location and extent of the works used to divert water from Underground in Humboldt County, by Jule & Elizabeth DeLong for irrigation

That the proposed point of diversion, the location and size of the diverting channel, all reservoirs and basins, location and description of all measuring devices, and the boundary of all lands showing by 40 acre subdivision the areas to be irrigated

and the location and names of all other works or streams which are crossed by or connected with said works are duly and correctly designated thereon.

State Water Right Surveyor No. 376

J. R. CALDWELL

Subscribed and sworn to before me this 28th day of May 197_

Humboldt County Recorder

24927 CERTIFICATE NO. 8375 ISSUED 11-11-74

24928 CERTIFICATE NO. 8376 ISSUED 11-11-74

24927 corrected CERTIFICATE NO. 8375 ISSUED 11-19-74

24928 Corrected CERTIFICATE NO. 8376 ISSUED 11-19-74

FILED
MAY 29 1974
STATE ENGINEER'S OFFICE

J. R. Caldwell		
Winnemucca, Nevada		
Job No.	By	Date
Survey		
Calculations		
Drawing		
Checked		
Corrections	J.R.C.	

MAP TO ACCOMPANY

PROOF OF BENEFICIAL USE

FOR IRRIGATION

BY JULE & ELIZABETH DELONG

FROM UNDERGROUND

IN HUMBOLDT COUNTY, NEVADA

24928 24927

IN THE OFFICE OF THE STATE ENGINEER

OF THE STATE OF NEVADA

ORDER

DESIGNATING AND DESCRIBING

THE PINE FOREST VALLEY GROUND WATER BASIN

HUMBOLDT COUNTY, NEVADA

The State Engineer finds that conditions warrant the Designation of the Pine Forest Valley Ground Water Basin, Humboldt County, Nevada and by this Order designates the following described area of land as a ground water basin coming under the provisions of Chapter 534 NRS (Conservation and Distribution of Underground Waters).

T.40N.,R.31E.

Those portions of Sections 1, 12 and 13 lying within the Pine Forest Valley Drainage Basin.

T.40N.,R.32E.

Sections 3, 4, 5, 7, 8 and 9 and those portions of Section 2, 6, 10, 11, 14, 15, 16, 17 and 18 lying within the Pine Forest Valley Drainage Basin.

T.41N.,R.31E.

Those portions of Sections 1 and 12 lying within the Pine Forest Valley Drainage Basin.

T.41N.,R.32E.

Sections 1 through 6, 8 through 17, 20 through 24, 26 through 29, 32 through 34 and those portions of Sections 7, 18, 19, 25, 30, 31, 35 and 36 lying within the Pine Forest Valley Drainage Basin.

T.41N.,R.33E.

All or those portions of Sections 5, 6, 7, 18, 19 and 30 unsurveyed lying within the Pine Forest Valley Drainage Basin.

T.42N.,R.30E.

Sections 1 through 3, 11 through 14, 23 and 24 and those portions of Sections 4, 9, 15, 16, 21, 22, 25, 26, 27 and 28 lying within the Pine Forest Valley Drainage Basin.

ORDER
PINE FOREST VALLEY GROUND WATER BASIN

T.42N.,R.31E.

Sections 1 through 24 and those portions of Sections 25, 26, 27, 28, 29, 30 and 36 lying within the Pine Forest Valley Drainage Basin.

T.42N.,R.32E.

All

T.42N.,R.33E.

All or those portions of Sections 3, 4, 5, 6, 7, 8, 9, 16, 17, 18, 20 and 21 unsurveyed lying within the Pine Forest Valley Drainage Basin, Sections 19, 30 and 31 and those portions of Sections 28, 32 and 33 lying within the Pine Forest Valley Drainage Basin.

T.43N.,R.29E.

All that unsurveyed portion of the Township lying within the Pine Forest Valley Drainage Basin.

T.43N.,R.30E.

Sections 1 through 4, 9 through 16, 22 through 27, 34 through 36 and those portions of Sections 5, 6, 8, 17, 21, 28 and 33 lying within the Pine Forest Valley Drainage Basin.

T.43N.,R.31E.

All

T.43N.,R.32E.

All

T.43N.,R.33E.

All that unsurveyed portion of the Township lying within the Pine Forest Valley Drainage Basin.

T.44N.,R.29E.

All that unsurveyed portion of the Township lying within the Pine Forest Valley Drainage Basin.

T.44N.,R.30E.

Sections 1 through 5, 7 through 29, 32 through 36 and those portions of Sections 6, 30 and 31 lying within the Pine Forest Valley Drainage Basin.

T.44N.,R.31E.

All

T.44N.,R.32E.

All

ORDER PINE FOREST VALLEY GROUND WATER BASIN

T.44N.,R.33E.

That portion of Section 6 and the remaining portion of the unsurveyed Township lying within the Pine Forest Valley Drainage Basin.

T.45N.,R.29E.

All that unsurveyed portion of the Township lying within the Pine Forest Valley Drainage Basin.

T.45N.,R.30E.

Sections 1 through 5, 8 through 17, 20 through 29, 32 through 36 and those portions of Sections 6, 7, 18, 19, 30 and 31 lying within the Pine Forest Valley Drainage Basin.

T.45N.,R.31E.

All

T.45N.,R.32E.

Sections 3 through 10, 14 through 22, 26 through 36 and those portions of Sections 2, 11, 12, 13, 23, 24 and 25 lying within the Pine Forest Valley Drainage Basin.

T.45N.,R.33E.

Those portions of Sections 30 and 31 lying within the Pine Forest Valley Drainage Basin.

T.46N.,R.30E.

Sections 12, 13, 24, 25, 35 and 36 and those portions of Sections 1, 11, 14, 23, 26, 27, 32, 33 and 34 lying within the Pine Forest Valley Drainage Basin.

T.46N.,R.31E.

Sections 6 through 10, 14 through 36 and those portions of Sections 3, 4 and 5 lying within the Pine Forest Valley Drainage Basin.

T.46N.,R.32E.

Sections 17, 19 through 21, 28 through 33 and those portions of Sections 7, 8, 9, 15, 16, 18, 22, 26, and 35 lying within the Pine Forest Valley Drainage Basin.

T.47N.,R.30E.

That portion of Section 36 lying within the Pine Forest Valley Drainage Basin.

T.47N.,R.31E.

Those portions of Sections 30, 31 and 32 lying within the Pine Forest Valley Drainage Basin.

Roland D. Westergard
State Engineer

Dated at Carson City, Nevada

this 1st day of May

1978.

Jan. 23—From printer. To committee.
Apr. 9—From committee: Amend, and do pass as amended.
Apr. 10—Read second time. Amended. To printer.
Apr. 13—From printer. To engrossment. Engrossed. First reprint.
Apr. 14—Read third time. Passed, as amended. Title approved, as amended. To Senate.
Apr. 15—In Senate. Read first time. Referred to Committee on Commerce and Labor. To committee.
Jun. 1—From committee: Amend, and do pass as amended. Read second time. Amended. To printer.
Jun. 2—From printer. To re-engrossment. Re-engrossed. Second reprint. Read third time. Passed, as amended. Title approved, as amended. To Assembly. In Assembly. Senate amendment concurred in. To enrollment.
Jun. 3—Returned from enrollment. Action of passage rescinded. Read third time. Amended. To printer. From printer. To re-engrossment. Re-engrossed. Third reprint. Placed on General File. Read third time. Passed, as amended. Title approved. To Senate. In Senate. Action of passage rescinded. Read third time. Passed. Title approved. To Assembly. In Assembly. To enrollment.
Jun. 9—Enrolled and delivered to Governor.
Jun. 14—Approved by the Governor. Chapter 738.
Sections 18 and 24 of this act effective at 12:01 a.m. July 1, 1981. Remainder of this act effective July 1, 1981.

A. B. 26—Bremner, Robinson, Marvel, Dini, Hayes, Price, Barengo, May, Glover, Vergiels, Coulter and Kovacs, Jan. 22.

Summary—Provides for optional program of additional contributions under the public employees' retirement system. (BDR 23-400) Fiscal Note: Effect on Local Government: No. Effect on the State or on Industrial Insurance: Yes.
Jan. 22—Read first time. Referred to Committee on Ways and Means. To printer.
Jan. 23—From printer. To committee.
Apr. 7—From committee: Amend, and do pass as amended.
Apr. 8—Read second time. Amended. To printer.
Apr. 9—From printer. To engrossment. Engrossed. First reprint. Placed on General File for Monday, April 13, 1981.
Apr. 13—Read third time. Passed, as amended. Title approved. To Senate.
Apr. 14—In Senate. Read first time. Referred to Committee on Finance. To committee.
Apr. 21—From committee: Do pass.
Apr. 22—Read second time.
Apr. 23—Taken from General File. Placed on General File for next legislative day.
Apr. 24—Read third time. Passed. Title approved. To Assembly.
Apr. 27—In Assembly. To enrollment
Apr. 28—Enrolled and delivered to Governor.
May 1—Approved by the Governor. Chapter 157.
Effective July 1, 1981.

A. B. 27—Dini, Jeffrey and Schofield, Jan. 23.

Summary—Makes administrative changes regarding appropriation of water. (BDR 48-153) Fiscal Note: Effect on Local Government: No. Effect on the State or on Industrial Insurance: No.
Jan. 23—Read first time. Referred to Committee on Economic Development and Natural Resources. To printer.
Jan. 26—From printer. To committee.
Feb. 13—From committee: Do pass.
Feb. 16—Read second time. To engrossment. Engrossed.
Feb. 17—Read third time. Passed. Title approved. To Senate.
Feb. 18—In Senate. Read first time. Referred to Committee on Natural Resources. To committee.

1981 A.B. 27

Mar. 12—From committee: Do pass.
Mar. 13—Read second time.
Mar. 16—Read third time. Passed. Title approved. To Assembly.
Mar. 17—In Assembly. To enrollment.
Mar. 18—Enrolled and delivered to Governor. Approved by the Governor. Chapter 45.
Effective July 1, 1981.

A. B. 28—Dini, Jeffrey and Schofield, Jan. 23.

Summary—Changes various provisions relating to appropriation of underground water. (BDR 48-155) Fiscal Note: Effect on Local Government: No. Effect on the State or on Industrial Insurance: No.
Jan. 23—Read first time. Referred to Committee on Economic Development and Natural Resources. To printer.
Jan. 26—From printer. To committee.
Mar. 4—From committee: Amend, and do pass as amended.
Mar. 5—Read second time. Amended. To printer.
Mar. 6—From printer. To engrossment. Engrossed. First reprint.
Mar. 9—Taken from General File. Placed on General File for next legislative day.
Mar. 10—Read third time. Passed, as amended. Title approved. To Senate.
Mar. 11—In Senate. Read first time. Referred to Committee on Natural Resources. To committee.
Apr. 7—From committee: Amend, and do pass as amended.
Apr. 8—Read second time. Amended. To printer.
Apr. 9—From printer. To re-engrossment. Re-engrossed. Second reprint.
Apr. 10—Taken from General File. Placed on General File for next legislative day.
Apr. 13—Read third time. Taken from General File. Placed on Secretary's desk.
Apr. 14—Taken from Secretary's desk. Placed on General File. Read third time. Passed, as amended. Title approved. To Assembly.
Apr. 15—In Assembly. Senate amendment not concurred in. To Senate.
Apr. 16—In Senate.
Apr. 21—Senate amendment not receded from. Conference requested. First Committee on Conference appointed by Senate. To Assembly.
Apr. 22—In Assembly. First Committee on Conference appointed by Assembly. To committee.
May 1—From committee: Concur in Senate amendment and further amend. First Conference report adopted by Assembly.
May 4—First Conference report adopted by Senate. To printer.
May 5—From printer. To re-engrossment. Re-engrossed. Third reprint. To enrollment.
May 6—Enrolled and delivered to Governor. Approved by the Governor. Chapter 186.
Section 3 of this act effective at 12:01 a.m. July 1, 1981. Remainder of this act effective July 1, 1981.

A. B. 29—Dini, Jeffrey and Schofield, Jan. 23.

Summary—Provides for review by state agencies of water quantity and sewage disposal in planned unit developments. (BDR 22-152) Fiscal Note: Effect on Local Government: No. Effect on the State or on Industrial Insurance: No.
Jan. 23—Read first time. Referred to Committee on Government Affairs. To printer.
Jan. 26—From printer. To committee.
Feb. 19—From committee: Amend, and do pass as amended.
Feb. 23—Read second time. Amended. To printer.
Feb. 24—From printer. To engrossment. Engrossed. First reprint.

WATER, IRRIGATION DISTRICTS AND GEOTHERMAL RESOURCES

A.B. 16 (chapter 736)
Revises certain fees collected by the state engineer. Revises certain provisions of law relating to the time within which appropriated water must be put to a beneficial use, clarifies the date after which a period of nonuse of water causes the forfeiture of rights, requires well drillers to furnish copies of certain records to the state engineer, and requires access to water by wildlife in certain circumstances. Requires persons with domestic wells in designated basins drilled on or after July 1, 1981, to plug such wells within one year after community water supplied by a public entity becomes available if the hook-up fee is less than $200.

A.B. 27 (chapter 45)
Relates to the appropriation of water. Abolishes the requirement of proof of commencement of work and provides for an administrative appeal on cancellation of water permits.

A.B. 28 (chapter 186)
Clarifies a provision regarding publication of an application to appropriate certain water, allows the rejection of an application without publication under certain circumstances and authorizes the state engineer to plug wells drilled by unlicensed persons.

A.B. 163 (chapter 5)
Amends the water district act for the Las Vegas Valley by increasing certain interest rates.

A.B. 176 (chapter 270)
Reduces the number of acres needed to qualify an elector to vote in elections of irrigation districts and provides a weighted system of voting based on acreage owned by electors within districts.

A.B. 428 (chapter 474)
Establishes priorities among certain applicants to appropriate water for irrigation purposes, giving highest priority to an owner of land for irrigation on that land. Applicants for public lands under the Carey Act or Desert Land Entry Act receive the lowest priority unless such public land is adjacent to private land under the ownership of the applicant.

1981 Summary of Legislation

ASSEMBLY BILL NO. 27—ASSEMBLYMEN DINI, JEFFREY AND SCHOFIELD

JANUARY 23, 1981

Referred to Committee on Economic Development and Natural Resources

SUMMARY—Makes administrative changes regarding appropriation of water. (BDR 48-153)

FISCAL NOTE: Effect on Local Government: No. Effect on the State or on Industrial Insurance: No.

EXPLANATION—Matter in *italics* is new; matter in brackets [ ] is material to be omitted.

AN ACT relating to the appropriation of water; abolishing the requirement of proof of commencement of work; providing for an administrative appeal on cancellation of water permits; and providing other matters properly relating thereto.

The People of the State of Nevada, represented in Senate and Assembly, do enact as follows:

SECTION 1. NRS 533.380 is hereby amended to read as follows:

533.380 1. In his endorsement of approval upon any application, the state engineer shall:

(a) [Set a time prior to which actual construction work shall begin, which shall not be more than 1 year from the date of such approval, and order that the work shall be prosecuted diligently and uninterruptedly to completion unless temporarily interrupted by the elements.

(b)] Set a time prior to which the construction of the work must be completed, which [shall] *must* be within 5 years of the date of such approval.

[(c)] *(b)* Set a time prior to which the complete application of water to a beneficial use must be made, which [time shall] *must* not exceed 10 years from the date of the approval.

2. The state engineer may limit the applicant to a less amount of water than that applied for, to a less period of time for the completion of work, and a less period of time for the perfecting of the application than named in the application.

3. The state engineer [shall have authority,] *may,* for good cause shown, [to] extend the time [within which construction work shall begin,] within which construction work shall be completed, or water applied to a beneficial use under any permit therefor issued by the state engineer; but an application for [such] *the* extension must in all

cases be made within 30 days following notice by registered or certified mail that proof of [such] *the* work is due as provided for in NRS 533.390 and 533.410.

SEC. 2. NRS 533.390 is hereby amended to read as follows:

533.390 1. Any person holding a permit from the state engineer shall, on or before [30 days after] the date set for the [commencement of work as endorsed thereon, and at other times required by the state engineer, file with the state engineer a statement setting forth the time when, the place where, and the amount of such work as may have been performed by him thereunder in connection with such appropriation; and the person holding a permit shall also, within 30 days after the date set for the] completion of [such] *the* work, file in detail a description of the work as actually constructed. [, which statement shall] *This statement must* be verified by the affidavit of the applicant, his agent or his attorney.

2. Should any person holding a permit from the state engineer fail [, prior to the date set for such filing in his permit,] to file with the state engineer [proof of commencement of work, or should he fail to file, within 30 days of the date set prior to which proof of completion of the work must be made,] the proof of completion of work, as provided in this chapter, the state engineer shall [, in either case,] advise the holder of the permit, by registered or certified mail, that [the same] *it* is held for cancellation, and should the holder, within 30 days after the mailing of such advice, fail to file the required affidavit [with] , the state engineer [,] *shall cancel* the permit. [shall be canceled and no further proceedings shall be had thereunder.] For good cause shown, upon application made prior to the expiration of the 30-day period, the state engineer may, in his discretion, grant an extension of time in which to file the instruments.

SEC. 3. NRS 533.395 is hereby amended to read as follows:

533.395 *1.* If, in the judgment of the state engineer, the holder of any permit to appropriate the public water is not proceeding in good faith and with reasonable diligence to perfect the appropriation, the state engineer may require at any time the submission of such proof and evidence as may be necessary to show a compliance with the law. [The state engineer shall, after duly considering the matter, if,] *If, in* his judgment, the holder of a permit is not proceeding in good faith and with reasonable diligence to perfect the appropriation, *the state engineer shall* cancel the permit, and advise the holder of [the permit of the] *its* cancellation.

2. If any permit is canceled under the provisions of NRS 533.390, 533.395 or 533.410, the holder of the permit may within 60 days of the cancellation of the permit file a written petition with the state engineer requesting a review of the cancellation by the state engineer at a public hearing. The state engineer may, after receiving and considering evidence, affirm, modify or rescind the cancellation.

3. If the decision of the state engineer modifies or rescinds the cancellation of a permit, the effective date of the appropriation under the permit is vacated and replaced by the date of the filing of the written petition with the state engineer.

4. The cancellation of a permit may not be reviewed or be the subject of any judicial proceedings unless a written petition for review has been filed and the cancellation has been affirmed, modified or rescinded pursuant to subsection 2.

SEC. 4. NRS 533.410 is hereby amended to read as follows:

533.410 Should [any] *the* holder of a permit from the state engineer fail, prior to the date set for [such] filing in his permit, to file with the state engineer proof of application of water to beneficial use, and the accompanying map, if [such] *a* map is required, the state engineer shall advise the holder of the permit, by registered or certified mail, that the [same] *permit* is held for cancellation. Should the holder, within 30 days after the mailing of [such advice,] *this notice,* fail to file the required affidavit and map, if [such] *a* map is required, [or either of them, with the state engineer,] the *state engineer shall cancel the* permit. [shall be canceled and no further proceedings shall be had thereunder.] For good cause shown, upon application made prior to the expiration of such 30-day period, the state engineer may, in his discretion, grant an extension of time in which to file the instruments.

SEC. 5. NRS 533.435 is hereby amended to read as follows:

533.435 1. The following fees shall be collected by the state engineer:

For examining and filing an application for permit to appropriate water	$35.00
The $35 fee shall include the cost of publication, which publication fee is $25.	
For examining and filing an application for permit to change the point of diversion, manner of use, or place of use	40.00
The $40 fee shall include the cost of permit should the same issue thereunder, and the cost of publication of such application, which publication fee is $25.	
For issuing and recording permit to appropriate water for irrigation purposes, for each acre to be irrigated, up to and including 100 acres, per acre	.10
For each acre in excess of 100 acres up to and including 1,000 acres	.05
For each acre in excess of 1,000 acres	.03
For issuing and recording permit for power purposes, for each theoretical horsepower to be developed	.05
For issuing final certificate under permit for power purposes, for each theoretical horsepower to be developed up to and including 100 horsepower	.25
For each horsepower in excess of 100 horsepower up to and including 1,000 horsepower	.20
For each horsepower in excess of 1,000 horsepower	.15
For issuing and recording permit to store water	25.00

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SROA44

For issuing final certificate under permit to store water, for each acre-foot of water stored up to and including 1,000 acre-feet	$0.05
For each acre-foot in excess of 1,000 acre-feet	.03
For issuing and recording permit to appropriate water for any other purpose, for each second-foot of water applied for or fraction thereof	10.00
For filing secondary permit under reservoir permit	5.00
For approving and recording permit under reservoir permit	5.00
[For filing proof of commencement of work	1.00]
For filing proof of completion of work	1.00
For filing proof of beneficial use	1.00
For filing any protest	10.00
For filing any application for extension of time within which to file proofs	5.00
For filing any assignment or water right deed, for each water right assigned	1.00
For filing any other instrument	1.00
For making copy of any document recorded or filed in his office, for the first 100 words	1.00
For each additional 100 words or fraction thereof	.20
Where the amount exceeds $5, then only the actual cost in excess of that amount shall be charged.	
For certifying to copies of documents, records or maps, for each certificate	1.00
For blueprint copy of any drawing or map, per square foot	.15
The minimum charge for a blueprint copy, per print	1.00

2. When fees are not specified in subsection 1 for such other work as may be required of his office, the state engineer shall collect the actual cost of the work.

3. The minimum fee for issuing and recording any permit is $10.

4. Except as otherwise provided in this subsection, all fees collected by the state engineer under the provisions of this section [shall] *must* be deposited in the state treasury for credit to the general fund. All fees received for blueprint copies of any drawing or map [shall] *must* be kept by him and used only to pay costs of printing and maintenance of printing equipment. Any publication fees received which are not used by him for publication expenses [shall] *must* be returned to the persons who paid the fees. If, after exercising due diligence, the state engineer is unable to make the refunds, he shall deposit the fees in the state treasury for credit to the general fund. The state engineer may maintain, with the approval of the state board of examiners, a checking account in any bank qualified to handle state [moneys for the purpose of carrying] *money to carry* out the provisions of this subsection. The bank account shall be

secured by a depository bond satisfactory to the state board of examiners to the extent the account is not insured by the Federal Deposit Insurance Corporation.

(30)

JT APP 266

3

SROA45

MEMBERS PRESENT: Chairman Jeffrey
Vice Chairman Redelsperger
Assemblyman Dini
Assemblyman Polish
Assemblyman Rhoads
Assemblyman Schofield
Assemblyman DuBois
Assemblyman Kovacs

MEMBERS ABSENT: Assemblyman Mello (excused)

GUESTS PRESENT: Diane Campbell, Nevada Miners & Prospectors
Roland Westergard, State of Nevada Department of Conservation
Fred Welden, Senior Research Analyst LCB
Mr. Bill Newman, State Engineer
Mr. Ross deLipkow, Attorney
Mr. George Peek, Nevada Association of Realt
Mr. Tom Young, NEAT
Mr. Jim Hadden, Concepts, Inc.

The meeting was called to order by Chairman Jeffrey at 3:06 P.M.

A.B. 16 Provides for extensions of time for use of appropriated water and for registration of certain wells.

Mr. Fred Welden, of the Research Division of the Legislative Counsel, stated that he was on the staff of the subcommittee that did the study on water problems in the state. The subcommittee met seven times throughout the state. There were two points that were made as finding of the study: one being Nevada water laws have been developed over a number of years and that the concepts are basically sound, the second finding was that State Engineers office, which is a division of Water Resources does not have enough financing or staff to adequately do th job that is expected of them.

At this time Mr. Welden began going through AB 16 section by section. There are two sections that raise the fees that are charged by the State Engineers office.

Section One raised the fee for the proofs of appropriation from $10.00 to $100.00. This deals with the vested water rights. A person can claim that they have been using water over many years, that they first started using the water prior to 1905 and they have continued up to the present time, that is a claim of a vested waterright. These go through the courts to adjudication for proof. The price to file and say you have one of these vested water rights has been $10.00, the suggestion is to go to $100.00.

Section Two deals with the municipal and quasi municipal applications for water. The operative portions are Sub-Section C, on page 2, lines whereas, a normal year usually yields only about 100 protests.

Assemblyman Dini wondered how much revenue would be raised by these increased fees. Mr. Newman stated that he has based figures on 2500 applications per year and that would be 2100 to appropriate and 400 applications to change. One-third of the new applications would be for stock water water at $100.00 per fee. Mr. Newman stated he had calculated about $700,000.00 that these fees would generate based on the 2500 applications submitted in a year. Last year's fees only came to about $68,000.00 to contribute to the state general fund. The budget for this department is $1,200,000.00.

A.B. 27 — Makes administrative changes regarding appropriation of water.

Mr. Bill Newman, State Engineers Office, testified in regards to AB 27 which deletes the requirement for commencement of work.

Chairman Jeffrey asked if this would be a conflict and Mr. Newman stated that it would because AB27 still has a commencement of work in it and they have another bill in the works that deletes the commencement of work. On line 29, page 5, he stated that the State Engineer's concern regarding this language would be establishing a minimum flow on a stream for wildlife.

Assemblyman Rhoads recommended amending this section as he is also concerned about establishing a minimum flow. Assemblyman Dini stated that the intent was not to establish any minimum flow. Mr. Welden stated that the intent was, originally, to speak to springs and seeps but it would speak to streams as well. The subcommittee did not want to get into mandating minimum flows. For instance, if a rancher wants to pipe a spring he could go ahead but leave some access to water as basically non-consumptive water for wildlife.

The committee members felt the language, as it now stands, in this bill, would leave the bill open for challenge. Chairman Jeffrey asked that Mr. Welden while working on amending this bill also work on the language regarding this matter so as to not be establishing a minimum flow.

Mr. Newman, returning to the fee portion of this bill stated that payment of these fees may be a problem area. For example, if the new fees went into effect on July 1, and someone had filed an application to appropriate on June 30 and then his permit fees were due after the 1st day of July, would he then pay the old fee schedule or would he pay the new fee schedule. The State Engineers office has a judicial direction that they have to act on the fees at the time the petition was filed.

Mr. Welden felt this was a legal question and should be given interpertation by Mr. Frank Daykin.

The forfieture clause was the next section to be reviewed by Mr. Newman. He felt that there would be no problem with this particular clause other than if the forfieture occurred at the time of the request for the extension of time. For instance if someone stated that they wanted a year's extension before the forfieture was declared they would have to determine if the five year limit had already run out. This would probably require a hearing thus increasing the number of hearings now heard by the State Engineers office.

Section Seven Mr. Newman felt this section needed no changes. Mr. Redelsperger wondered if this would be the first step in registering domestic wells. Mr. Newman replied that this was indeed the intention of the committee.

Mr. Newman stated that their budget, in reference to Section Eleven reflects 6 additional employees instead of 12. He felt that after reassessing some of the office priorities that the addition of 6 to the staff would be sufficient instead of 12. This staff addition would be four engineers, one would be an engineering technicologist and one would be a clerical person.

Mr. Ross deLipkow, an attorney specializing in water laws, was next to testify on AB 16 he felt that the fee of $100.00 for filing a rpoof of appropriation of water is excessively high. Sometimes as many as 60 or 70 proofs of appropriation of water would be a definite hardship on many of the ranchers that would be directly effected by this increase. By not being able to pay this fee it might render a person helpless to protect his rights. Mr. deLipkow suggested a compromise fee of $25.00. He stated that he was totally in favor of the language on Page 2, beginning on line 6 to the bottom of the page. The filing fee of $150.00 on page 3 he felt was excessive. He felt the two large items, the filing fee and the permit fee should be reduced substantially. On Section 5, page 5 he also felt that this would be a reservation on stream flow. He stated that he would assist in the rewriting of this section if requested, in order to cover the intent. He felt Section 6 is a very complex issue and needs more study.

Mr. deLipkow generally supports passage of this bill with reconsideration of the fees mentioned herein.

Next to testify on AB 16 in behalf of the Nevada Miners and Prospectors was Diane Campbell. She stated that she felt that the fees in this bill were excessive, otherwise she supported passage of this bill.

Tom Young, Executive Manager of the Nevada Environmental Action Trust, requested that on page 5 of AB 16, line 5 additional language be added to that paragraph as follows: on line 31 after the comma to read"...if there is justification for this as an existing beneficial use." He felt this would protect the private individual and his investment.

Mr. Jim Hadden, Carson City Public Works Department stated in regards to AB 16 they were in agreement with this bill, except for the permit portion of the bill. This includes the $200.00 per second foot or each portion of a second foot that is applied for and felt this amount is excessive.

Mr. George Peek, representing the Nevada Association of Realtors, and himself, as a developer and a purveyor of water, testified on AB 16 and stated that he has some experience in quasi-municipal water rights. He stated that he appreciated that at this time there is a recognition for an extended period of time for beneficial use for quasi-municipal purposes. This is expecially important now in this economically tight time. His blanket statement concerning the fees in this bill are that they are excessive. He feels that the State Engineers office is indeed in need of additional staffing.

There being no further testimony on AB 16 the public hearing was closed.

Chairman Jeffrey then called a brief recess before hearing the public testimony on AB 27.

Mr. William J. Newman, State Engineer was the first to testify on AB 27. He stated that the changes on AB 27 come in Section 3 on the cancellation clause. He stated that they were not opposed to it as it was written it just provided the appropriator with another level of review prior to being cancelled. He stated it was an attempt by his office to cut down on the number of appeals that his office has to handle. For instance, if the 30 day notice that someone with water rights is due to be cancelled , goes out and it is misplaced or it is not received in time and the instrument is filed a day late, or two days late they are mandated to cancel it and it is not subject to review except by appeal in court but in this bill it provides for additional reasons for reviewing it.

The only other change he mentioned was the removal of the provision for filing of proof of commencement of work and fees.

Mr. DeLipkow stated that he was totally in favor of AB 27 in particular 2, on the bottom of page 2, he stated that losing water rights because the mails were late would carry tremendous consequences to the individual. He felt that this would give the individual a second chance to take care of a simple oversight.

George Peek, Nevada Association of Realtors state that he was in suppor of this bill also and he concurred with Mr. Newman's remarks.

There being no further testimony on AB 27 the public hearing was closed.

Chairman Jeffrey then called for testimony on AB 28.

Mr. Newman of the State Engineers office was the first to testify. The purpose of AB 28 was to eliminate more paper and possible save the public money. It allows the State Engineers office to reject or cancel an application in a valley or basin that has already similar applications denied. For instance in the Las Vegas Valley where irrigation applications have bee denied since 1941 this bill would permit the State Engineers offic to deny applications before it goes to publication. It would relieve the person of having to have the publication fee and having to have a supporting map prepared. It would also relieve the State Engineers of alot of office work, from the time the application is filed clear down to the time of publication.

Mr. Newman's suggestion is that on Page 2, line 42 that which is in brackets be left as presently in the statute. He stated that his office used that narrative quite often in their rulings to appropriate water which specifically does not contemplate the application of water to a beneficial use.

Mr. Newman stated that his language was very important because there are applications that are made for water for a different use than what the stated intention is. It is his feeling that the public should have their due process in being able to protest if they wish to do so.

Assemblyman Dini then wondered about the rational for the language regarding plugging wells.

Mr. Newman stated that his office had had problems with wells being drilled by unlicensed drillers and they have attempted to get these wells plugged because it is the responsibility of the State Engineers office to protect the resource and when they are not drilled by licensed well drillers they are not properly sealed and are a potential for contamination of the resource. There were some wells in the Las Vegas Valley that had been drilled by unlicensed drillers. The State Engineers office ordered these wells plugged and sealed, the orders were appealed in court and the drillers were given a misdemeanor fine of about $25.00 and thus had a drill for the sum of the fine, plus the cost of labor and the State Engineers office had no further recourse.

Mr. Ross deLipkow approves entirely fo this bill and with the suggestions of Mr. Newman.

Mr. deLipkow also felt the language contained in the brackets starting on line 39 on page 2 should be set forth. He feels that it is necessary in order to keep consistency for the State Engineers Office. For ecample, he can deny an application only on three grounds: (1) There is no unappropriated water; (2) It would conflict wich existing rights; or (3) It would be detrimental to the public interest or a combination of all three.

He agrees with Mr. Newman on the well drilling aspects.

Mr. George Peek wondered if all wells drilled had to be drilled by a licensed well driller. He felt that perhaps it was an invasion of an individuals right to drill his own well as per state specifications

Assemblyman Redelsperger asked for the language in the statute regardi this matter.

Mr. Newman stated that N.R.S. 534.160, Section reads "No person shall drill a well for water in this state without having first obtained a well drillers license as provided for in NRS 534.140 to 534.170, inclusive." This is interperted as meaning on private land or otherwise, this is to protect the resource from contamination.

There being no further testimony on AB 28 the public hearing was closed.

BDR 43-197 Makes certain changes in the Nevada boat act. Chairman Jeffrey asked for a committee introduction on this bill. Mr. Dini moved and Mr. Redelsperger seconded the motion for committee introduction. The Motion carried unanimously. Mr. Mello was absent from voting.

Chairman Jeffrey called for volunteers to be on the sub-committee for the amendments for Mr. Newman's office. Mr. Dini, Mr. Kovacs, and Mr. Rhoads were appointed.

Assemblyman Dini moved for a DO PASS on AB 27, Assemblyman Schofield seconded the motion. The motion carried unanimously with Mr. Mello absent from voting.

Assemblyman Kovacs moved for an AMEND as agreed and DO PASS on AB 28, the motion was seconded by Assemblyman Schofield. The motion carried unanimously with Mr. Mello absent from voting.

There being no further business the meeting adjourned at 5:20 P.M.

Respectfully submitted,

Judy E. Sappenfield

Judy E. Sappenfield, Secretary

Assemblyman Hayes moved that the bill be referred to the Committee on Economic Development and Natural Resources.
Motion carried.

Senate Bill No. 182.
Assemblyman Vergiels moved that the bill be referred to the Committee on Judiciary.
Motion carried.

SECOND READING AND AMENDMENT

Senate Bill No. 106.
Bill read second time and ordered to third reading.

Senate Bill No. 108.
Bill read second time and ordered to third reading.

Senate Bill No. 109.
Bill read second time and ordered to third reading.

GENERAL FILE AND THIRD READING

Assembly Bill No. 27.
Bill read third time.
Remarks by Assemblyman Jeffrey.
Roll call on Assembly Bill No. 27:

YEAS—39.
NAYS—Stewart.

Assembly Bill No. 27 having received a constitutional majority, Mr. Speaker declared it passed.
Bill ordered transmitted to the Senate.

Assembly Bill No. 83.
Bill read third time.
Remarks by Assemblyman Sader.
Roll call on Assembly Bill No. 83:

YEAS—40.
NAYS—None.

Assembly Bill No. 83 having received a constitutional majority, Mr. Speaker declared declared it passed, as amended.
Bill ordered transmitted to the Senate.

Assembly Bill No. 102.
Bill read third time.
Remarks by Assemblymen Schofield, Robinson and Dini.
Roll call on Assembly Bill No. 102:

YEAS—40.
NAYS—None.

Assembly Bill No. 102 having received a constitutional majority, Mr. Speaker declared it passed, as amended.
Bill ordered transmitted to the Senate.

Senate Bill No. 42.
Bill read third time.
The following amendment was proposed by Assemblyman Westall:

MINUTES OF THE
MEETING OF THE SENATE COMMITTEE
ON NATURAL RESOURCES

SIXTY-FIRST SESSION
NEVADA STATE LEGISLATURE
March 9, 1981

The Senate Committee on Natural Resources was called to order by Chairman Norman D. Glaser at 1:30 P. M., Monday, March 9, 1981, in Room 323 of the Legislative Building, Carson City, Nevada. Exhibit A is the Meeting Agenda. Exhibit B is the Attendance Roster.

COMMITTEE MEMBERS PRESENT:

Senator Norman D. Glaser, Chairman
Senator Wilbur Faiss, Vice Chairman
Senator James H. Bilbray
Senator Lawrence E. Jacobsen
Senator Joe Neal

COMMITTEE MEMBER ABSENT:

Senator Floyd R. Lamb

STAFF MEMBERS PRESENT:

Robert E. Erickson, Senior Research Analyst
Carolyn L. Freeland, Committee Secretary

Vice Chairman Faiss presided at the opening of the meeting. He briefly outlined the matters to be heard.

ASSEMBLY BILL NO. 27--Makes administrative changes regarding appropriation of water.

Mr. William Newman, State Engineer, made comments on this bill, enumerating each page and line change and voicing support for them. Senator Bilbray asked Mr. Newman if this bill was requested by his department, and Mr. Newman replied part of it is, and the remainder is a joint effort by the sub-committee on water problems in his department.

There ensued a discussion involving commencement of work.

Senator Neal said the bill abolishes the requirement of proof of commencement of work, and asked if, in effect, this does not extend the required time of the permit. Mr. Newman replied the proof of completion of work is the key factor. He said the bill would save a great deal of bookkeeping in his office. Mr. Newman pointed out a permit must be applied for prior to start of construction, as in a designated basin, a permit is necessary before a well is drilled or any water is diverted for use.

Senator Bilbray asked what the purpose is of asking for this bill. Mr. Newman answered there are a lot of abuses and it was difficult to establish if works of diversion had actually been started. The really key issue is to establish the works of diversion are completed.

Senator Neal said he recalled in the last Session the same chapter came up for consideration in which some of the language included is that which is now being deleted. Mr. Newman did not remember if they had asked for completion of work to be deleted. He said a filing of completion of work could not be done if the actual diversion is not completed.

Mr. Roland Westergard, Director of the Department of Conservation and Natural Resources, supports this legislation. It would save time and paperwork. He said the second significant amendment to the bill would allow an appeal to the State Engineer rather than to the courts, affording not only the state to protect the water resources but also to provide an administrative review short of litigation.

Senator Neal and Mr. Westergard engaged in a discussion regarding completion time.

Mrs. Diane Campbell, Nevada Miners and Prospectors Association, supports this bill, especially page 2, line 41.

The Chairman called for any further questions or testimony. The hearing on Assembly Bill No. 27 was concluded.

SENATE BILL NO. 241--Provides for temporary water permits for construction purposes, grants additional powers to political subdivisions and municipal corporations.

Mr. Newman said he opposes line 9 on page 1. He would like to use the word "may" instead of the word "shall," and stated there is

MINUTES OF THE
MEETING OF THE SENATE COMMITTEE
ON NATURAL RESOURCES

SIXTY-FIRST SESSION
NEVADA STATE LEGISLATURE
March 11, 1981

The Senate Committee on Natural Resources was called to order by Chairman Norman D. Glaser, at 1:35 p.m. on Wednesday, March 11, 1981, in Room 323 of the Legislative Building, Carson City, Nevada. Exhibit A is the Meeting Agenda. Exhibit B is the Attendance Roster.

COMMITTEE MEMBERS PRESENT:

Senator Norman D. Glaser, Chairman
Senator Wilbur Faiss, Vice Chairman
Senator James H. Bilbray
Senator Joe Neal
Senator Lawrence E. Jacobsen

COMMITTEE MEMBERS ABSENT:

Senator Floyd R. Lamb (Excused)

GUEST LEGISLATORS PRESENT:

Assemblyman James W. Schofield
Assemblyman Louis W. Bergevin

STAFF MEMBERS PRESENT:

Robert E. Erickson, Senior Research Analyst
Azalea Reynolds, Committee Secretary

Senator Glaser stated there were three bills to be heard: ASSEMBLY CONCURRENT RESOLUTION NO. 19, which relates to the State Engineer imposing certain conditions upon permits for appropriation of water for uses related to MX Missile System; ASSEMBLY JOINT RESOLUTION NO. 20, which requests Congress to recognize necessity of applying for water rights pursuant to state law for MX Missile project; and ASSEMBLY BILL NO. 9, which provides for use of real property as security by livestock dealer in lieu of surety bond.

Senator Neal moved Senate Bill No. 153 be approved as amended and as detailed above (Exhibit D).

Senator Faiss seconded the motion.

The motion carried unanimously. (Senator Lamb was absent for the vote).

ASSEMBLY BILL NO. 27

Chairman Glaser asked if there were any amendments required on this bill.

Bob Erickson said that testimony had been heard at the previous meeting and there appeared to be no problems.

Senator Faiss moved Do Pass Assembly Bill No. 27 (Exhibit E).

Senator Bilbray seconded the motion.

The motion carried unanimously. (Senator Lamb was absent for the vote).

ASSEMBLY JOINT RESOLUTION NO. 7

Chairman Glaser enquired if this bill was ready for final action by the Committee, saying he had two problems with it.

Senator Bilbray said he had some questions on this also, and would prefer to have it tabled.

It was the consensus of the Committee to hold this Resolution for the time being.

This concluded the items on the Agenda.

Chairman Glaser said Senator Wagner had given him some bill draft resolutions which she would like to have intoduced covering the following:

BDR 45-546 -Requires daily visits to traps which trap animals alive;

Senate Bill No. 293 having received a constitutional majority, Mr. President declared it passed.

Bill ordered transmitted to the Assembly.

Assembly Bill No. 13.

Bill read third time.

Remarks by Senators Don Ashworth and Glaser.

Roll call on Assembly Bill No. 13:

YEAS—20.

NAYS—None.

Assembly Bill No. 13 having received a constitutional majority, Mr. President declared it passed, as amended.

Bill ordered transmitted to the Assembly.

Assembly Bill No. 27.

Bill read third time.

Roll call on Assembly Bill No. 27:

YEAS—18.

NAYS—Blakemore, Neal—2.

Assembly Bill No. 27 having received a constitutional majority, Mr. President declared it passed.

Bill ordered transmitted to the Assembly.

Assembly Bill No. 45.

Bill read third time.

The following amendment was proposed by the Committee on Taxation:

Amendment No. 232.

Amend section 1, page 1, by deleting lines 3 and 4 and inserting:

"*The order to lock and seal a place of business must be delivered to the sheriff of the county in which the business is located who shall assist in*".

Amend sec. 2, page 1, line 23 by deleting "*sealed and padlocked.*" and inserting "*locked and sealed.*".

Amend sec. 3, page 2, line 5, by deleting "*served personally or by mail,*".

Amend sec. 3, page 2, line 8, by deleting "*sealed and padlocked.*" and inserting "*locked and sealed.*".

Amend sec. 5, page 2, line 22, by deleting "] 1" and inserting "1] *1.5*".

Amend sec. 6, page 2, line 28, by deleting "] 1" and inserting "1] *1.5*".

Amend sec. 7, page 2, line 39, by deleting "] 1" and inserting "1] *1.5*".

Amend sec. 8, page 2, by deleting lines 44 and 45 and inserting:

The order to lock and seal a place of business must be delivered to the sheriff of the county in which the business is located who shall assist in the".

Amend sec. 9, page 3, line 15 by deleting "*sealed and padlocked.*" and inserting "*locked and sealed.*".

Amend sec. 10, page 3, line 24, by deleting "*sealed and padlocked.*" and inserting "*locked and sealed.*".

Assembly Bill No. 27—Assemblymen Dini, Jeffrey and Schofield

CHAPTER 45

AN ACT relating to the appropriation of water; abolishing the requirement of proof of commencement of work; providing for an administrative appeal on cancellation of water permits; and providing other matters properly relating thereto.

[Approved March 18, 1981]

The People of the State of Nevada, represented in Senate and Assembly, do enact as follows:

SECTION 1. NRS 533.380 is hereby amended to read as follows:

533.380 1. In his endorsement of approval upon any application, the state engineer shall:

(a) [Set a time prior to which actual construction work shall begin, which shall not be more than 1 year from the date of such approval, and order that the work shall be prosecuted diligently and uninterruptedly to completion unless temporarily interrupted by the elements.

(b)] Set a time prior to which the construction of the work must be completed, which [shall] *must* be within 5 years of the date of such approval.

[(c)] *(b)* Set a time prior to which the complete application of water to a beneficial use must be made, which [time shall] *must* not exceed 10 years from the date of the approval.

2. The state engineer may limit the applicant to a less amount of water than that applied for, to a less period of time for the completion of work, and a less period of time for the perfecting of the application than named in the application.

3. The state engineer [shall have authority,] *may,* for good cause shown, [to] extend the time [within which construction work shall begin,] within which construction work shall be completed, or water applied to a beneficial use under any permit therefor issued by the state engineer; but an application for [such] *the* extension must in all cases be made within 30 days following notice by registered or certified mail that proof of [such] *the* work is due as provided for in NRS 533.390 and 533.410.

SEC. 2. NRS 533.390 is hereby amended to read as follows:

533.390 1. Any person holding a permit from the state engineer shall, on or before [30 days after] the date set for the [commencement of work as endorsed thereon, and at other times required by the state engineer, file with the state engineer a statement setting forth the time when, the place where, and the amount of such work as may have been performed by him thereunder in connection with such appropriation; and the person holding a permit shall also, within 30 days after the date set for the] completion of [such] *the* work, file in detail a description of the work as actually constructed. [, which statement shall] *This statement must* be verified by the affidavit of the applicant, his agent or his attorney.

2. Should any person holding a permit from the state engineer fail [, prior to the date set for such filing in his permit,] to file with the state engineer [proof of commencement of work, or should he fail to file, within 30 days of the date set prior to which proof of completion

of the work must be made,] the proof of completion of work, as provided in this chapter, the state engineer shall [, in either case,] advise the holder of the permit, by registered or certified mail, that [the same] *it* is held for cancellation, and should the holder, within 30 days after the mailing of such advice, fail to file the required affidavit [with] , the state engineer [,] *shall cancel* the permit. [shall be canceled and no further proceedings shall be had thereunder.] For good cause shown, upon application made prior to the expiration of the 30-day period, the state engineer may, in his discretion, grant an extension of time in which to file the instruments.

SEC. 3. NRS 533.395 is hereby amended to read as follows:

533.395 *1.* If, in the judgment of the state engineer, the holder of any permit to appropriate the public water is not proceeding in good faith and with reasonable diligence to perfect the appropriation, the state engineer may require at any time the submission of such proof and evidence as may be necessary to show a compliance with the law. [The state engineer shall, after duly considering the matter, if.] *If,* in his judgment, the holder of a permit is not proceeding in good faith and with reasonable diligence to perfect the appropriation, *the state engineer shall* cancel the permit, and advise the holder of [the permit of the] *its* cancellation.

2. If any permit is canceled under the provisions of NRS 533.390, 533.395 or 533.410, the holder of the permit may within 60 days of the cancellation of the permit file a written petition with the state engineer requesting a review of the cancellation by the state engineer at a public hearing. The state engineer may, after receiving and considering evidence, affirm, modify or rescind the cancellation.

3. If the decision of the state engineer modifies or rescinds the cancellation of a permit, the effective date of the appropriation under the permit is vacated and replaced by the date of the filing of the written petition with the state engineer.

4. The cancellation of a permit may not be reviewed or be the subject of any judicial proceedings unless a written petition for review has been filed and the cancellation has been affirmed, modified or rescinded pursuant to subsection 2.

SEC. 4. NRS 533.410 is hereby amended to read as follows:

533.410 Should [any] *the* holder of a permit from the state engineer fail, prior to the date set for [such] filing in his permit, to file with the state engineer proof of application of water to beneficial use, and the accompanying map, if [such] *a* map is required, the state engineer shall advise the holder of the permit, by registered or certified mail, that the [same] *permit* is held for cancellation. Should the holder, within 30 days after the mailing of [such advice,] *this notice,* fail to file the required affidavit and map, if [such] *a* map is required, [or either of them, with the state engineer,] the *state engineer shall cancel the* permit. [shall be canceled and no further proceedings shall be had thereunder.] For good cause shown, upon application made prior to the expiration of such 30-day period, the state engineer may, in his discretion, grant an extension of time in which to file the instruments.

SEC. 5. NRS 533.435 is hereby amended to read as follows:

533.435 1. The following fees shall be collected by the state engineer:

For examining and filing an application for permit to appropriate water	$35.00
The $35 fee shall include the cost of publication, which publication fee is $25.	
For examining and filing an application for permit to change the point of diversion, manner of use, or place of use	40.00
The $40 fee shall include the cost of permit should the same issue thereunder, and the cost of publication of such application, which publication fee is $25.	
For issuing and recording permit to appropriate water for irrigation purposes, for each acre to be irrigated, up to and including 100 acres, per acre	.10
For each acre in excess of 100 acres up to and including 1,000 acres	.05
For each acre in excess of 1,000 acres	.03
For issuing and recording permit for power purposes, for each theoretical horsepower to be developed	.05
For issuing final certificate under permit for power purposes, for each theoretical horsepower to be developed up to and including 100 horsepower	.25
For each horsepower in excess of 100 horsepower up to and including 1,000 horsepower	.20
For each horsepower in excess of 1,000 horsepower	.15
For issuing and recording permit to store water	25.00
For issuing final certificate under permit to store water, for each acre-foot of water stored up to and including 1,000 acre-feet	.05
For each acre-foot in excess of 1,000 acre-feet	.03
For issuing and recording permit to appropriate water for any other purpose, for each second-foot of water applied for or fraction thereof	10.00
For filing secondary permit under reservoir permit	5.00
For approving and recording permit under reservoir permit	5.00
[For filing proof of commencement of work	1.00]
For filing proof of completion of work	1.00
For filing proof of beneficial use	1.00
For filing any protest	10.00
For filing any application for extension of time within which to file proofs	5.00
For filing any assignment or water right deed, for each water right assigned	1.00
For filing any other instrument	1.00

For making copy of any document recorded or filed in his office, for the first 100 words	$1.00
For each additional 100 words or fraction thereof	.20
Where the amount exceeds $5, then only the actual cost in excess of that amount shall be charged.	
For certifying to copies of documents, records or maps, for each certificate	1.00
For blueprint copy of any drawing or map, per square foot	.15
The minimum charge for a blueprint copy, per print	1.00

2. When fees are not specified in subsection 1 for such other work as may be required of his office, the state engineer shall collect the actual cost of the work.

3. The minimum fee for issuing and recording any permit is $10.

4. Except as otherwise provided in this subsection, all fees collected by the state engineer under the provisions of this section [shall] *must* be deposited in the state treasury for credit to the general fund. All fees received for blueprint copies of any drawing or map [shall] *must* be kept by him and used only to pay costs of printing and maintenance of printing equipment. Any publication fees received which are not used by him for publication expenses [shall] *must* be returned to the persons who paid the fees. If, after exercising due diligence, the state engineer is unable to make the refunds, he shall deposit the fees in the state treasury for credit to the general fund. The state engineer may maintain, with the approval of the state board of examiners, a checking account in any bank qualified to handle state [moneys for the purpose of carrying] *money to carry* out the provisions of this subsection. The bank account shall be secured by a depository bond satisfactory to the state board of examiners to the extent the account is not insured by the Federal Deposit Insurance Corporation.

Assembly Bill No. 59—Assemblymen Glover, Marvel, Dini, Cafferata, Redelsperger, Rackley and Rhoads

CHAPTER 46

AN ACT relating to the taxation of alcohol; establishing standards for determining whether it is used as a fuel or beverage; and providing other matters properly relating thereto.

[Approved March 18, 1981]

The People of the State of Nevada, represented in Senate and Assembly, do enact as follows:

SECTION 1. Chapter 365 of NRS is hereby amended by adding thereto a new section which shall read as follows:

831

IN THE OFFICE OF THE STATE ENGINEER

OF THE STATE OF NEVADA

ORDER

NOTICE OF CURTAILMENT OF WATER
APPROPRIATION WITHIN THE DESIGNATED
PINE FOREST VALLEY GROUND WATER BASIN

The State Engineer designated the Pine Forest Valley Ground Water Basin, as provided under NRS 534.010 to 534.190, inclusive, by Order No. 711 dated May 1, 1978.

Crop and pumpage inventories maintained by the office of the State Engineer indicate that present withdrawals are exceeding the estimated recharge of the Pine Forest Valley Ground Water Basin.

The irrigation of additional land using underground water would threaten to impair the value of existing underground and surface water rights.

In accordance with NRS 534.120, subsection 2, the irrigation of additional land using underground water is not considered to be a preferred use of the limited underground water resource.

NOW THEREFORE, it is ordered that:

All applications filed after December 1, 1983, to appropriate underground water to irrigate additional land within the Designated Pine Forest Valley Ground Water Basin will be denied.

Peter G. Morros
Peter G. Morros
State Engineer

Dated at Carson City, Nevada, this
1st day of December, 1983.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

GROUND-WATER QUALITY IN NEVADA--
A PROPOSED MONITORING PROGRAM

By Jon O. Nowlin

Open-File Report 78-768

Prepared in cooperation with the
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION

Carson City, Nevada

1986

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

U.S. Geological Survey
Room 227, Federal Building
705 North Plaza Street
Carson City, NV 89701

Copies of this report may be purchased from:

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CONVERSION FACTORS AND ABBREVIATIONS

For those readers who may prefer to use metric units rather than U.S. Customary units, the conversion factors for terms in this report are listed below:

Multiply	by	To obtain
Acres	4,047	Square meters (m^2)
Acre-feet (acre-ft)	1,233	Cubic meters (m^3)
Cubic feet per second (ft^3/s)	28.32	Liters per second (L/s)
Cubic feet per second (ft^3/s)	0.02832	Cubic meters per second (m^3/s)
Feet (ft)	0.3048	Meters (m)
Gallons (gal)	3.785	Liters (L)
Gallons per minute (gal/min)	0.06309	Liters per second (L/s)
Inches (in)	25.40	Millimeters (mm)
Miles (mi)	1.609	Kilometers (km)
Square miles (mi^2)	2.590	Square kilometers (km^2)

IN THE SUPREME COURT OF THE STATE OF NEVADA

Electronically Filed
Mar 06 2018 04:12 p.m.
Elizabeth A. Brown
Clerk of Supreme Court

JASON KING, P.E., Nevada State Engineer, DIVISION OF WATER RESOURCES, DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES,

Appellant,

vs.

HAPPY CREEK, INC.,

Respondent.

Case No. 74266

JOINT APPENDIX

Volume V of XVII
(Pages JT APP 241-249)

Docket 74266 Document 2018-08887

DATE	DOCUMENT DESCRIPTION	VOLUME	PAGE NOS.
06/12/17	Request for Submission and Oral Argument	XVI	937-934
12/19/16	Stipulation and Order Regarding Briefing Schedule	I	27-29
03/02/17	Stipulation and Order to Extend Briefing Schedule	II	175-177
12/28/16	Summary of Record on Appeal and Documents SE ROA 1-137	I	30-174
03/16/17	Supplemental Record on Appeal and Documents SROA 1-670	III-XVI	213-891
08/14/17	Transcript of Oral Argument	XVI-XVII	1043-1172

RESPECTFULLY SUBMITTED this 6th day of March, 2018.

ADAM PAUL LAXALT
Attorney General

By: /s/ Justina A. Caviglia

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CERTIFICATE OF SERVICE

I certify that I am an employee of the Office of the Attorney General and that on this 6th day of March, 2018, I served a copy of the foregoing JOINT APPENDIX (Volumes I-XVII, Pages JT APP 1-1183), by electronic service to:

Paul G. Taggart, Esq.
TAGGART & TAGGART, LTD.
108 North Minnesota Street
Carson City, Nevada 89703

/s/ Dorene A. Wright

Precip-itation zone (inches)	Altitude of zone (feet)	Area of zone (acres)	Precipitation (acre-feet per year rounded)	Percent recharge	Approximate recharge (acre-feet per year rounded)
15-20	above 7,500	3,200	5,000	15	700
12-15	6,000-7,500	58,900	66,000	7	5,000
8-12	4,400-6,000	151,000	126,000	3	4,000
less than 8	below 4,400	129,200	65,000	0	0
Total (rounded)			260,000		10,000

Only a small part of the total precipitation ever reaches the ground-water reservoir in the valley. Most of it is transpired and evaporated. Part of the remainder runs off immediately and part infiltrates into the rocks of the mountain ranges and the alluvial fans from which it eventually moves directly into the valley fill or surfaces along the stream courses and at springs. Further loss by evaporation and transpiration takes place along the stream courses.

The "percent recharge" figures in the above table takes into account these losses and were determined empirically by Eakin (1951) from studies in eastern Nevada. Assuming these factors to be valid in Pine Forest Valley, the total recharge to the ground-water reservoir is on the order of 10,000 acre-feet per year.

Recharge by underflow through the gap between the Jackson Mountains and the Bilk Creek Range is estimated to be between 200 and 300 acre-feet per year.

Discharge

Ground water is discharged from the valley by evaporation, transpiration, springs, pumping, and underflow from the south end of the valley to the Black Rock Desert.

Evaporation and Transpiration

Evaporation from the ground-water reservoir occurs where the capillary fringe reaches or is near the land surface. The capillary fringe ordinarily reaches the land surface where the depth to the water table is only a few feet below the surface. In Pine Forest Valley, the areas where the water table is near enough to the surface for a significant amount of evaporation to take place are quite limited, although, no doubt, a small amount of ground water is discharged in this manner.

Transpiration, on the other hand, accounts for most of the natural discharge in the valley. Large quantities of ground water are transpired by plants, known as phreatophytes, whose roots descend to the water table or to the capillary fringe above it. Greasewood is the most common phreatophyte in the valley; others are saltgrass, ryegrass, rabbitbrush, pickleweed, willows, and associated wild rose and buckbrush. In addition, about 3,000 acres of meadow grass and alfalfa are sustained in part by flood irrigation and in part by the ground-water reservoir.

The phreatophytes are mainly in the south end of the valley, where the depth to water is less than about 30 feet, and are thickest along the channel of the Quinn River (Plate 1). A few small, isolated areas of phreatophytes also thrive at the mouths of some of the canyons.

The phreatophytes have been grouped on the basis of the dominant species and water use, into (1) greasewood, which includes rabbitbrush and some shadscale, commonly not a phreatophyte; (2) grasses, native and subirrigated; and (3) willow.

The estimated rate of use of ground water by phreatophytes used in this study is based largely on work done by White (1932, p. 28-93) in Escalante Valley, Utah, and on more recent investigations by Young and Blaney (1942, p. 41-246). The following table summarizes the estimate of discharge of ground water by phreatophytes:

Predominant phreatophyte type	Area (acres)	Depth to water (feet)	Estimated rate of use of ground water (feet per year)	Estimated discharge by evapotranspiration (acre-feet per year)
Greasewood	45,000	10-30	0.2	9,000
Grasses				
Native	1,000	5	1	1,000+
Subirrigated	3,000	5	1	[a] 3,000
Willow	[b] 200	20	5	1,000
			Total	14,000

[a] About 50 percent of irrigation water, or 3,000 acre-feet per year, is supplied by streamflow. Remainder, or estimated 1 foot per acre per year, supplied from ground water.

[b] Includes many areas, principally near mouths of canyons, too small to delineate on plate 1.

Springs

Five thermal springs, whose temperatures range from 70°F to 163°F, issue from the alluvium of the valley floor. Except for springs 44/31-4A1 and also 43/30-25D1 which flow about 50 gpm, the discharges are small, ranging from about 1 to 10 gpm. Their combined discharge is somewhat less than 200 acre-feet per year. These springs are probably associated with fault zones which provide paths along which ground water, heated at depth, and therefore less dense, can rise to the surface. Probably all of the water from the small springs is lost by evaporation and transpiration; but a small amount of the discharge of the two largest springs may be returned to the ground-water reservoir.

Springs and seeps of the gravity type are common in the surrounding mountains, particularly the Pine Forest Range. These occur in places where the water table intersects the land surface, commonly at the heads of canyons, and are the source of many of the small streams which drain the mountains. Most of the water discharged by these springs is either lost by evaporation and transpiration near the spring sites or along the stream channel; only a small part persists as streamflow, a fraction of which may return to the ground-water reservoir as seepage from streams.

Pumpage

Withdrawal of ground water by pumping for irrigation, stock, and domestic use amounted to about 3,000 acre-feet in 1960. Most of this was used to supplement water from Bilk and Happy Creeks for the irrigation of pasture and hay fields.

Underflow to the Black Rock Desert

An estimated 2 1/2 million gallons per day, or about 2,700 acre-feet of ground water per year, is discharged to Black Rock Desert. This estimate is based on the gradient of the water table, the coefficient of transmissibility[1/], and the width of the aquifer, according to the following relationship: Underflow, in gallons per day, equals the coefficient of transmissibility, in gallons per day per foot, times the gradient in feet per mile, times the width in miles. The gradient of the water table in the area of underflow to the Black Rock Desert, as shown by the contours on Plate 1, averages about 8 feet per mile. The width

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1/ The coefficient of transmissibility is defined as the number of gallons of water per day, at the prevailing temperature, that will move through a vertical strip of the aquifer 1 foot wide and having a height equal to the thickness of the aquifer under a hydraulic gradient of 100 percent. The coefficient of transmissibility also may be defined as the average field permeability of the rock material multiplied by the thickness of the aquifer, in feet.

of the aquifer, which is assumed to be bounded on the east and west by relatively impermeable bedrock, is about 6 miles. The coefficient of transmissibility, as determined by a test of well 42/31-11B1, is about 50,000 gallons per day per foot. The computed underflow therefore is: Underflow = 50,000 x 8 x 6 = about 2 1/2 million gallons per day, or about 2,700 acre-feet per year. Although this well probably taps stream deposits of the older alluvium which may not be representative of the entire width of the underflow area, the estimate of 2,700 acre-feet per year for underflow probably still is reasonable.

In addition, some ground water also discharges to the Black Rock Desert. The seasonal rise of the water table during the winter months, which is due mainly to the decreased discharge of ground water by evapotranspiration, causes ground water to discharge into the channel of the Quinn River. Ice conditions permitting, this water runs off to the Black Rock Desert. The amount of water discharged in this manner is probably negligible, on the order of 200 to 300 acre-feet per year.

Ground-Water Inventory

Under natural conditions the average annual recharge to Pine Forest Valley equals the average annual discharge from the valley. Temporary extremes of drought or flood are compensated for by changes of ground water in storage. Because pumping has not appreciably affected the equilibrium of the system, the estimated recharge should be about equal to the estimated natural discharge.

The following table shows estimates of recharge and discharge under virgin, or pre-development, conditions. The estimate for discharge by evapotranspiration does not include the losses from subirrigated fields (p. 12).

	(Acre-feet)	Text reference (page)
Estimate of average annual recharge	10,000	10
Estimate of average annual discharge by:		
Evapotranspiration	11,000	11
Underflow to Black Rock Desert	2,700	12
Discharge into the Quinn River	200	13
Springs	200	12
Total (rounded)	14,000	

Exact agreement of the estimates of average annual recharge and average annual discharge is not to be expected because of the crude methods that were used in estimating the various elements of recharge and discharge. Although the estimates of recharge and discharge differ somewhat, they are of about the same magnitude and probably are within the general range of the actual values.

Perennial Yield

The perennial yield is the maximum rate at which water can be withdrawn from a ground-water system for an indefinite period of time without permanently depleting the supply. It is ultimately limited by the amount of water available to the system through recharge.

The net amount of ground water that can be pumped perennially in Pine Forest Valley without causing a continuing decline in ground-water levels is limited to the amount of natural discharge that can be salvaged. The allowable gross pumpage may exceed the net withdrawal to the extent that some of the ground water returns to the ground-water reservoir and is suitable for reuse. The actual perennial yield of the valley can be determined only after several years of extensive development.

Ground Water in Storage

The amount of recoverable ground water in storage in the valley fill of Pine Forest Valley is many times the average annual recharge. An estimate of the magnitude of the recoverable water in storage can be obtained by computing the amount of ground water that will drain from the sediments for each foot of lowering of water level in the valley fill. A value of 10 percent is considered to be a reasonable estimate of the amount of water by volume that will drain from the sediments. The drainable unconsolidated sediments are estimated to include almost all the valley fill, which has an area of about 180,000 acres.

The recoverable ground water from storage as a result of lower water levels would thus be about 18,000 acre-feet per foot of lowering--somewhat more than the estimated average annual recharge. If water levels were lowered 100 feet, the amount of water supplied from storage would roughtly equal the total recharge for 100 years. Thus the amount of water that could be developed by pumping from storage is very large. Because it would be replenished only in part, however, the practice of pumping from storage constitutes mining and offers no hope for developing ground water on a perennial basis.

CHEMICAL QUALITY OF GROUND WATER

The chemical constituents in ground water are acquired by the solution of minerals from the materials through which the water percolates. In general, the dissolved solids content of the water is determined by the solubility of the rock or soil, the area and duration of contact, and other factors such as pressure and temperature.

Water for Irrigation

The suitability of water for irrigation may be evaluated on the basis of the salinity hazard, the sodium (alkali) hazard, and the concentration of bicarbonate,

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boron, and other ions (Wilcox, 1955, p. 7-12).

Salinity Hazard

The salinity hazard depends on the concentration of dissolved solids. It is normally measured in terms of the electrical conductivity, or specific conductance, of the water, expressed as micromhos per centimeter at 25°C. The electrical conductivity is an approximate measure of the total ionized chemical constituents of the water. Wilcox (1955, p. 7) divides water into four classes with respect to its conductivity. The dividing points between the four classes are at 250, 750, and 2,250 micromhos (see fig. 3). Water of low conductivity generally is more suitable for irrigation than water of high conductivity. Wilcox provides the following classification of irrigation water with respect to salinity hazard:

1. "Low-salinity water (C1) can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.

2. "Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.

3. "High-salinity water (C3) cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.

4. "Very high salinity water (C4) is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances."

Sodium (alkali) hazard

The sodium, or alkali, hazard is indicated by the sodium-adsorption-ratio (SAR), which may be defined by the formula

$$SAR = \frac{Na+}{\sqrt{\frac{Ca{+}{+} + Mg{+}{+}}{2}}}$$

in which concentrations are expressed in equivalents per million. If the proportion of sodium among the cations is high, the alkali hazard is high; but if calcium and magnesium predominate, the alkali hazard is low. Wilcox classifies irrigation water, with respect to sodium hazard, as follows:

1. "Low sodium water (S1) can be used for irrigation on almost all soils

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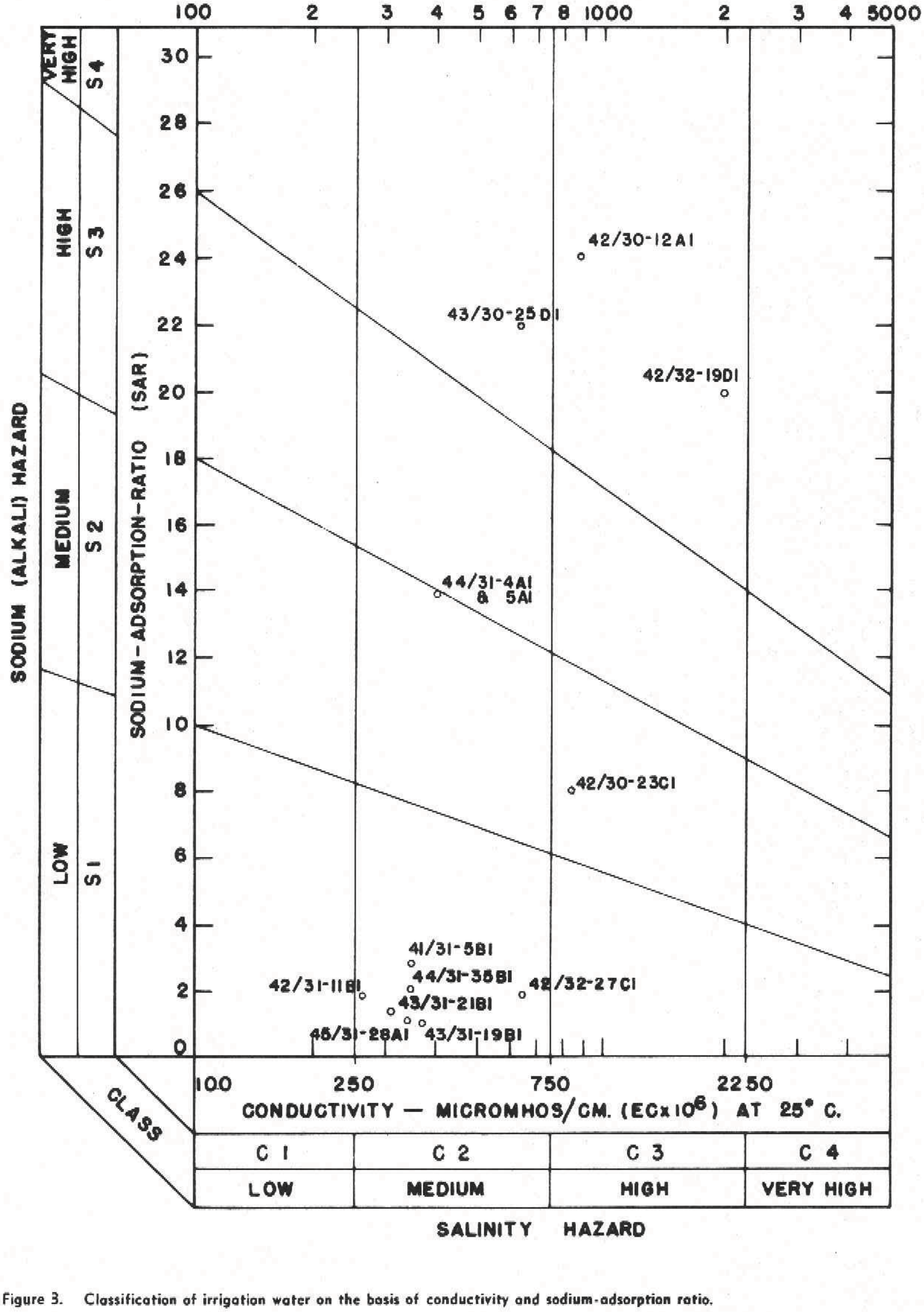

Figure 3. Classification of irrigation water on the basis of conductivity and sodium-adsorption ratio.

with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops * * * may accumulate injurious concentrations of sodium.

2. "Medium-sodium water (S2) will present an appreciable sodium hazard in fine-textured soils having high cation-exchange-capacity, expecially under low-leaching conditions, unless gypsum is present in the soil. This water may be used on coarse-textured or organic soils with good permeability.

3. "High-sodium water (S3) may produce harmful levels of exchangeable sodium in most soils and will require special soil management--good drainage, high leaching, and organic matter additions.

4. "Very high sodium water (S4) is generally unsatisfactory for irrigation purposes except under special circumstances."

Bicarbonate ion

Residual sodium carbonate (RSC), which may be defined by the formula $RSC = (CO_3{--} + HCO_3{-}) - (Ca^{++} + Mg^{++})$, in which concentrations are expressed in equivalents per million, is a measure of the hazard involved in the use of high-bicarbonate water. If residual sodium carbonate is greater than 2.5 epm (equivalents per million), the water is not suitable for irrigation. The water is marginal if the residual sodium carbonate is between 1.25 and 2.5 epm, and is probably safe if the residual sodium carbonate is less than 1.25 epm (U.S. Salinity Laboratory Staff, p. 81).

Boron

Nearly all natural water contains boron in amounts that range from a trace to several parts per million. Although boron in small amounts is essential to plant growth, it is toxic at concentrations slightly higher than the optimum. Scofield (1936, p. 286) proposed limits for boron in irrigation water, depending on the sensitivity of the crops to be irrigated. In general, boron in excess of 3 ppm (parts per million) is injurious to most crops.

Classification and Interpretation of Analyses

The results of chemical analyses of water from 11 wells and 5 thermal springs are given in table 3. The salinity and alkali hazards of all the samples that were analyzed are plotted on a diagram proposed by Wilcox for the classification of irrigation water (fig. 3). On the basis of this diagram and the residual sodium carbonate column in table 3, all the water, except that from the thermal springs and well 42/30-23A1, can be used safely for the irrigation of most crops. Water from springs 44/31-4A1, and 5A1, and well 42/30-23A1 is marginal and might be used under special conditions. Water from the other thermal springs probably will not be satisfactory for irrigating most crops.

Water from the thermal springs is somewhat more saline than the country water and is characterized by very low calcium and magnesium content. The

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two thermal springs in the northern part of the valley, 44/31-4A1 and 5A1, are dominantly sodium-sulfate water whereas the others are high in sodium-bicarbonate.

Only one small thermal spring yielded water that contained boron in excess of the limit of 2.5 ppm set by Scofield (1936, p. 286). This was spring 42/30-1D1, near the edge of the valley floor in the southwestern part of the valley, whose boron content was 3.9 ppm. The boron content of all the other water that was analyzed was not detrimental for any of the crops likely to be grown in the valley.

Water for Domestic Use

Most of the water from wells in Pine Forest Valley is within the limits prescribed for drinking water by the U. S. Public Health Service (1946). The notable exception to this is the high concentration of fluoride in well 44/31-35B1. All the thermal springs yield water having objectionable amounts of fluoride.

Temperature

The temperature of water from wells sampled in Pine Forest Valley ranged from 51° to 61° F and averaged about 58° F, with the exception of the temperature of the water from well 42/31-11B1 which was 75° F. The chemical analysis of this water shows no relation to other thermal water in the valley but is typical of the country water.

CONCLUSIONS

The most important aquifers in Pine Forest Valley are the sand and gravel deposits buried within the less permeable fine-grained sediments of the valley fill. An extensive test-drilling program would be needed to define these aquifers, particularly in the central part of the valley where the surface geology gives no indication of what may be expected at depth. Without such a program the location and extent of these aquifers will have to be determined as new wells are drilled. In addition to the occurrence of favorable water-bearing zones, success in obtaining wells that will yield large volumes of water depends, to a large extent, on proper well construction and development.

The average annual recharge to and the average annual discharge from Pine Forest Valley are each on the order of 10,000 to 15,000 acre-feet.

Recoverable ground water in storage in the valley amounts to about 18,000 acre-feet per foot of saturated sediments. Although it is desirable that some water be removed from storage to achieve optimum development of the ground-water reservoir, an economy based on depletion of stored water would necessarily be limited in time. On a long-term basis, therefore, the net pumpage draft should not exceed the perennial yield.

Chemical analyses indicate that most of the water in the valley is suitable for irrigation and domestic use.