

INVESTIGATION OF GROUNDWATER QUALITY AND ITS EFFECT ON SUBURBAN DEVELOPMENT IN WASHOE VALLEY, NEVADA

by

A. Thomas Armstrong

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Project Report No. 48

Water Resources Center
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The work upon which this report is based was supported in part by the United States Department of the Interior, Office of Water Research and Technology as authorized under the Water Resources Research Act of 1964 (P.L. 88-379) and in part by the Washoe County Health Department and the State of Nevada Bureau of Laboratories and Research.

FOREWORD

This Project Report presents results of an investigation of ground-water quality problems in Washoe Valley located between Reno and Carson City, Nevada. This investigation was initiated to determine the areal extent of three chemical constituents found in the ground-water supply; namely flouride, nitrate and iron and their effect on suburban development.

The study was funded in part by the Washoe County Health Department and in part by U.S. Department of the Interior, Office of Water Research and Technology under Project No (A-065-NEV). Chemical analyses were provided by the Nevada Bureau of Laboratories and Research.

Gilbert F. Cochran
Acting Executive Director

ABSTRACT

In response to water quality problems in the New Washoe City-Washoe Farms portion of the Washoe Valley, Nevada, an area of more than 200 households, a water quality study was initiated in November 1974 by the Water Resources Center. During the course of the study, 257 water samples were collected for chemical analysis from domestic wells and streams flowing into the valley. In addition, approximately 260 well analyses were available from other sources. Also, the rates of flow were measured, on a monthly basis, of inflowing streams for a period of one year.

The study has yielded knowledge not previously available. This information is, however, subject to revision and refinement as more wells are sampled by other interested parties. The major points are:

1. Surface inflow may be eliminated as the direct source of contamination in the groundwater of the New Washoe City-Washoe Farms area.
2. A more accurate estimate of the volume of surface inflow to the valley than was previously possible has been made.
3. The areal occurrences of fluoride, nitrate and iron, which constitute the major water quality problems is described as well as numerous other constituents of interest and areas of deleterious levels delineated.

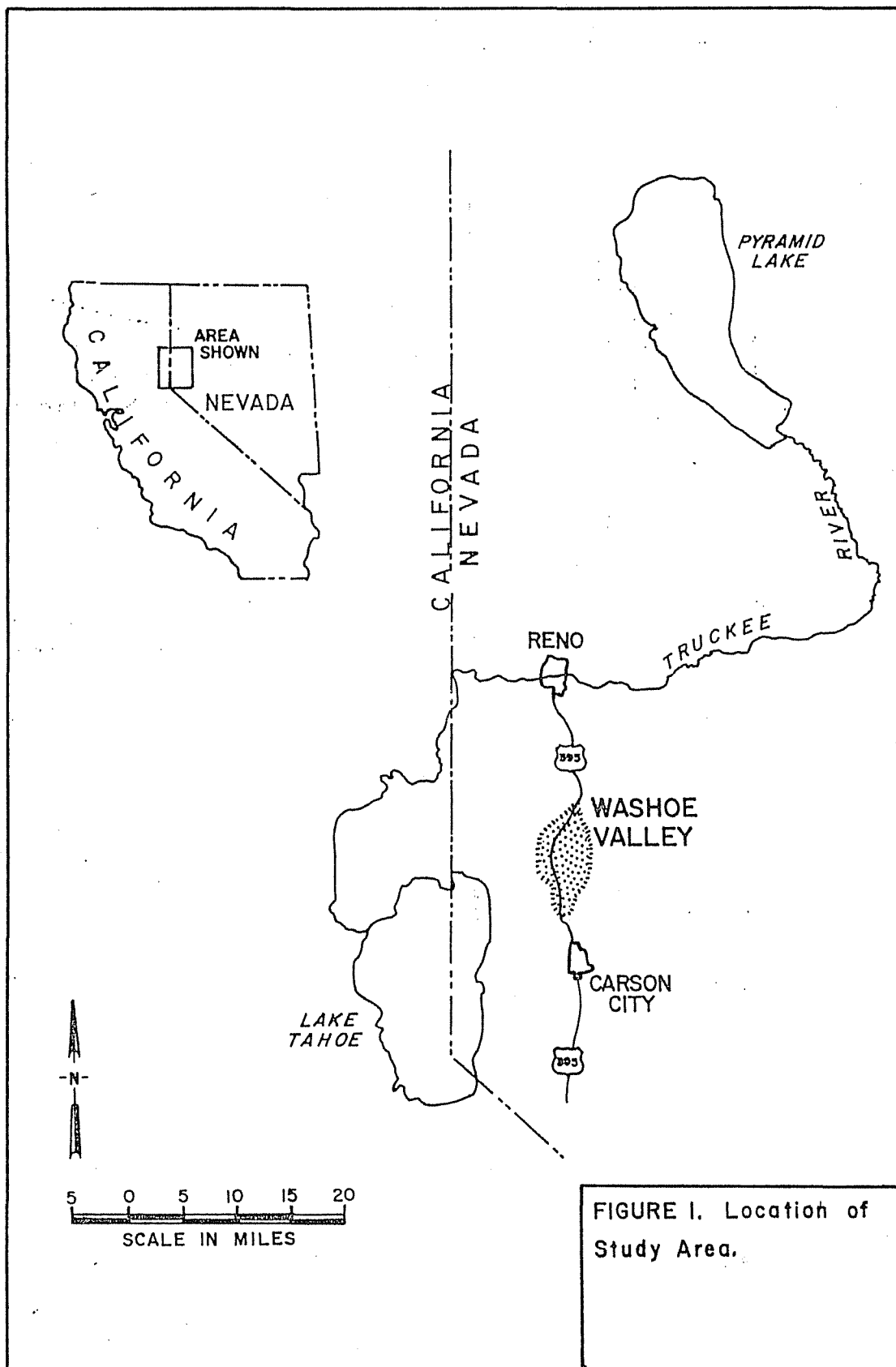
HYDROLOGIC AND GEOLOGIC SETTING

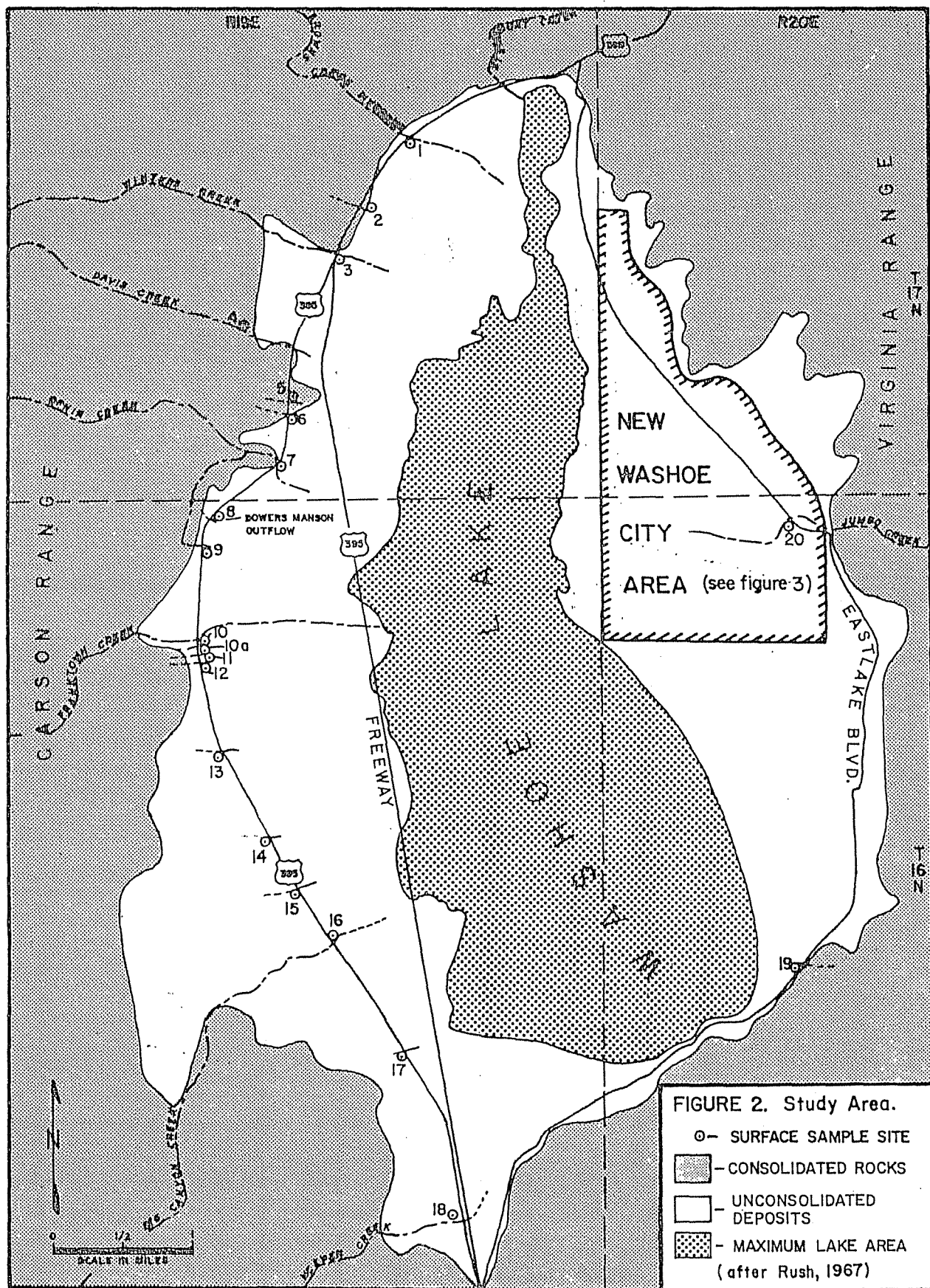
Washoe Valley, shown in Figure 1, lies along the eastern front of the Carson Range between Reno and Carson City, Nevada. The basin has an area of approximately 84 square miles and nearly 25 percent of the valley floor is occupied by Washoe and Little Washoe Lakes. It is bounded on the west by the tree covered Carson Range and on the east by the Virginia Range. Elevations vary from 9000 feet along the mountain crest to 5000 feet at Steamboat Creek.

The valley is a structural depression along the western margin of the Great Basin section of the Basin and Range physiographic province (Feneman, 1931). The valley floor is broad and flat abruptly joining the Carson Range on the west. On the east side of the valley the valley floor is separated from the Virginia Range by a poorly developed alluvial apron.

The climate of Washoe Valley is characterized by relatively cold winters with considerable amounts of snow principally accumulated at the higher elevations of the Carson Range. The summers are mild and dry with warm days and cool nights. Precipitation ranges from over 30 inches annually at higher elevations to less than 12 inches on the valley floor (Rush, 1967). Runoff from the Carson and Virginia Ranges is carried by several principal creeks (Figure 2) extending from the mountains across the valley floor to Washoe and Little Washoe Lakes. When the lakes reach high stage water drains northward from the valley through Steamboat Creek and eventually discharges into the Truckee River.

Ground water in the valley is developed from the valley fill reservoir which is about 8 miles long and 3 to 5 miles wide (Rush, 1967). The fill is recharged principally by the streams draining the Carson Range to the west and to some extent by the subsurface flow from the Virginia Range.





Water used in the valley is restricted to irrigation of hay and pasture to the west of Washoe Lake through stream diversion and to domestic use throughout the valley with the highest concentration in New Washoe City (Figure 2) in the northeast portion of the basin.

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INTRODUCTION

Over the past ten years Washoe Valley, Nevada, (Figure 1) has undergone rapid change in land use from either undeveloped land and irrigated pasture to rural suburban use. This change in use has been brought by the increased demand for housing in and near the rapidly growing metropolitan areas of Reno and Carson City to the north and south of Washoe Valley. The development pressures have been extremely great in the northeast portion of the valley in the New Washoe City-Washoe Farms area (Figure 2). This area of the valley has a more limited water supply, both ground and surface, than the western portion of the valley which is also experiencing development, but at a somewhat slower rate. As more wells have been drilled in the New Washoe City area it has become evident that deleterious levels of fluoride, iron and nitrate exist in parts of the groundwater basin.

The problem, in fact, is of such extreme nature it has caused delays in the issuance of building and development permits and reluctance on the part of lending institutions to become financially involved with property within the affected area. While the iron-manganese problem is mainly esthetic and economic in nature, the high fluoride and nitrate concentrations do in fact present distinct health problems. In order to accurately define the water quality problem in detail and offer practical solutions, the Water Resources Center began this study of the affected area (Figure 1 and 2) in response to the request of the Washoe District Health Department.

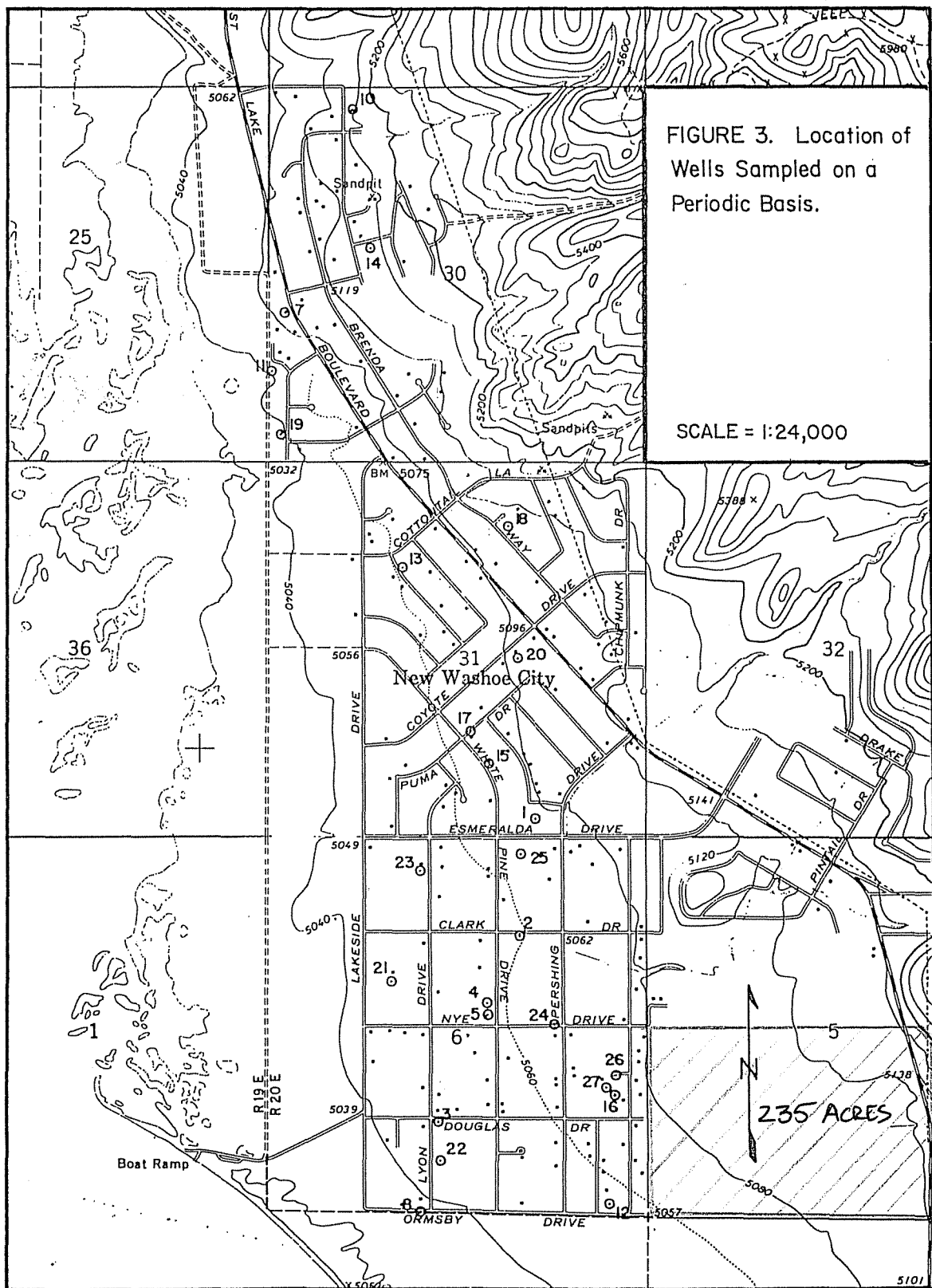
METHODOLOGY

The study was set up with two specific objectives: 1) delineate areas in the New Washoe City-Washoe Farms area with water quality problems and 2) attempt to define the cause or causes of these problems and if possible offer alternative solutions.

In order to fulfill these objectives field studies were initiated looking at both the ground and surface components of the hydrologic budget in the area of interest. A network of 27 wells was established in the New Washoe City-Washoe Farms area; each of these wells were sampled on a quarterly basis (Figure 3) and analyzed chemically (Appendices: A, B). As a result of the sampling, combined with pre-existing chemical data from the area (Figure 4), isoconcentration maps were constructed which illustrate the areal distribution of various elements or species. Those of particular interest are isoconcentration maps for fluoride, nitrate, and iron as shown in figures 5,6,7 and 8.

The chemical data collected from wells sampled during the course of the project was punched on computer cards, making the data easily accessible and ready for application of statistical and chemical analysis programs. One such program which was applied to the data was the WATEQF program. This is a program designed to compute from data gathered in the field such chemical parameters as molality, equivalence per million (EPM), %EPM error, ionic strength, log PCO₂, activity, mole ratios of various ions and saturation levels of various minerals. This information greatly facilitates analysis of the chemical data with the ultimate goal of describing the physical and chemical reasons for the observed variations in groundwater quality in mind.

Thirteen streams which flow into Washoe Valley were also sampled on a monthly basis for water chemistry. The results of the chemical analyses indicate the streams individually, or as a group, are not directly responsible



PARK VIEW LOCATION

120
ACRES

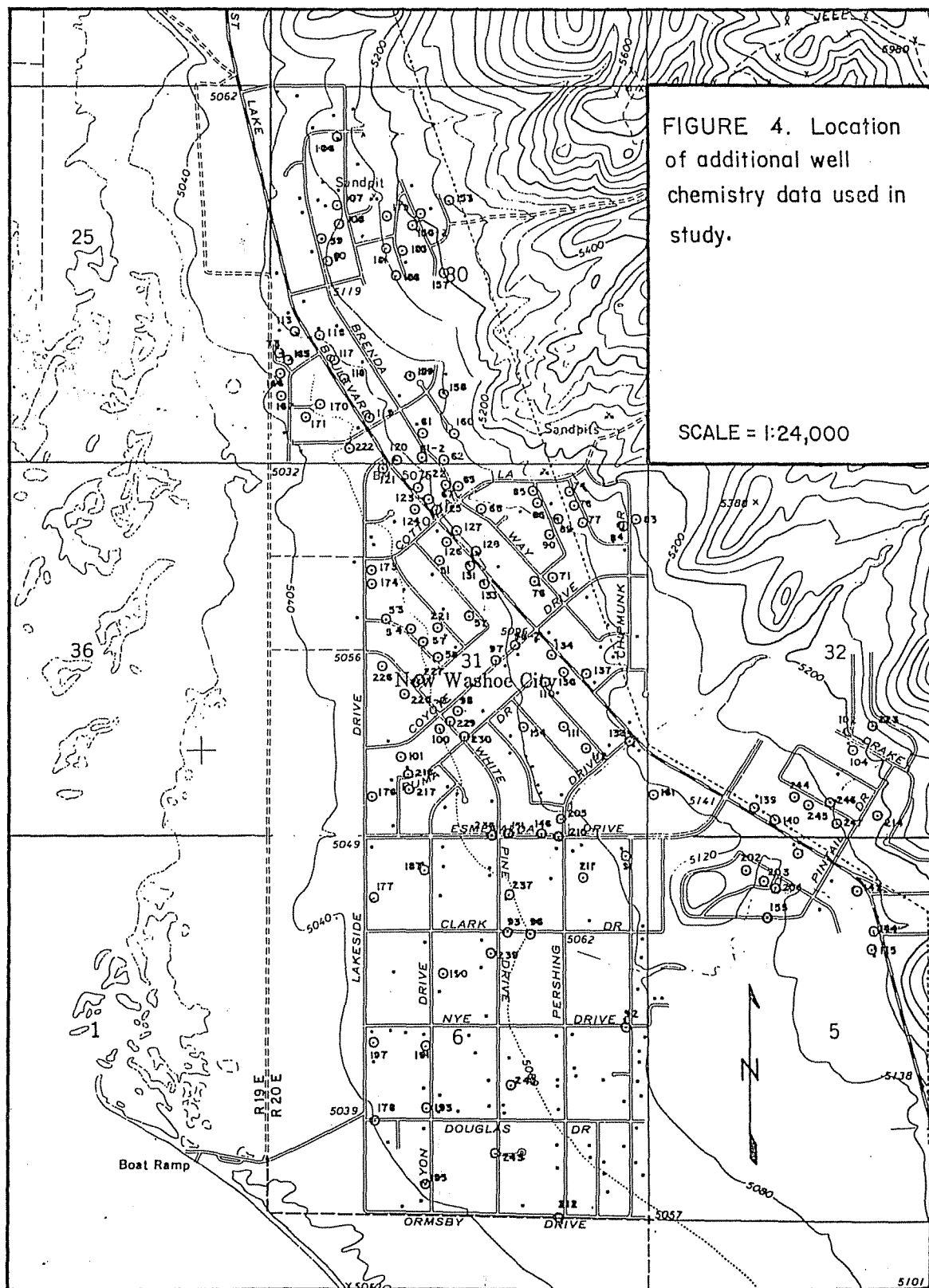


FIGURE 4. Location of additional well chemistry data used in study.

SCALE = 1:24,000

for the high levels of fluoride, nitrate or iron-manganese in the ground-water (Appendix C). The fluoride levels in the inflowing streams range from 0.03 parts per million (ppm) to 1.94 ppm, however, when weighted according to volume of flow, the average is about .12 ppm. The iron-manganese levels range from 0 ppm to 1.56 ppm, but when weighted according to flow are approximately .20 ppm. The highest iron-manganese levels in the surface streams were consistently found in the southwestern portion of the valley and could account directly for high levels of these constituents in that area. The possibility, however, that these elements, especially iron and manganese are becoming more concentrated with time due to the relatively large amount of evaporation and evapotranspiration compared to surface and subsurface outflow, has not been eliminated. According to Rush (1967), there were 23,000 acre-feet of runoff into the valley in 1965, and 5,100 acre-feet of precipitation. During the same period, evaporation and evapotranspiration eliminated 22,500 acre-feet while the surface outflow was only 1,000 acre-feet from the system. Nitrate levels ranged from .01 ppm to 1.8 ppm in the surface streams and when weighted accordingly to flow are about .3 ppm. The flow measurements of these streams plus measurements on ten smaller streams also provide an improved data base to determine the total amount of water entering the valley as surface water.

DISCUSSION AND RESULTS

FLUORIDE IN GROUNDWATER

Fluoride concentrations exceeding 1.0 ppm are found in many places in the United States and are obtained from a variety of geologic terrains. Its concentration in natural waters has been extensively studied in connection with study of tooth structure and decay since the element fluorine is utilized by higher life forms in the structure of bones and teeth. The U.S. Public Health Service (1962) states:

When fluoride is naturally present in drinking water the concentration should not average more than the appropriate upper limit... Presence of fluoride in average concentrations greater than two times the optimum values ... shall constitute grounds for rejection of supply.

The USPHS recommended limits are as follows:

Annual average of maximum daily air temperatures (°F) ¹	Recommended control limits (ppm)		
	Lower	Optimum	Upper
50. 0-53. 7	0.9	1.2	1.7
53. 8-58. 3	.8	1.1	1.5
58. 4-63. 8	.8	1.0	1.3
63. 9-70. 6	.7	.9	1.2
70. 7-79. 2	.7	.8	1.0
79. 3-90. 5	.6	.7	.8

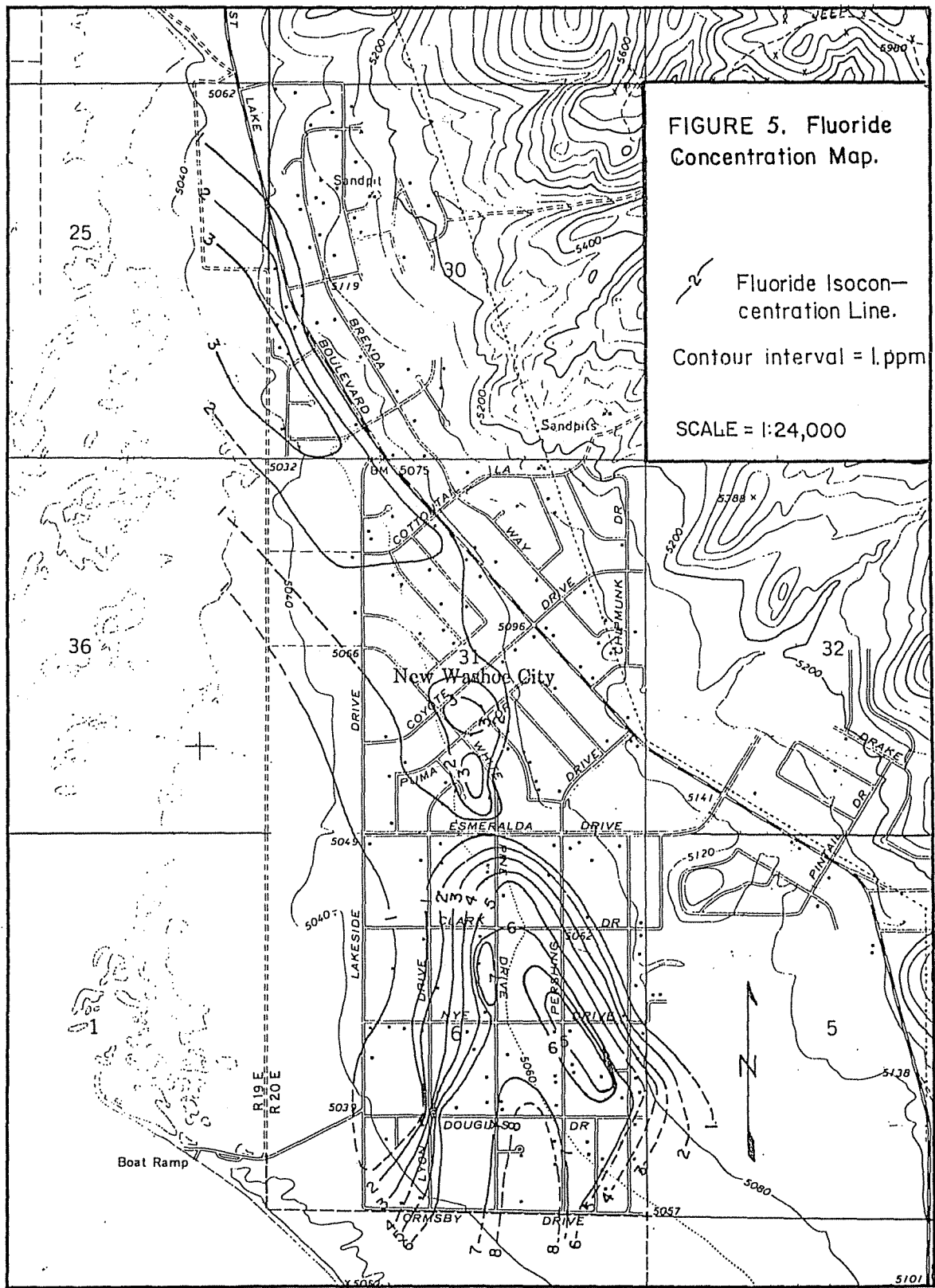
¹ Based on temperature data obtained for a minimum of 5 years.

From the above recommended limits and the fluoride concentration map (Figure 5) for the study area it can be seen that a large portion of this area has fluoride concentrations in excess of the "twice optimum value"

which could be and has been grounds for rejection. With the information gathered attempts were made to relate fluoride concentration to depth and location as described below.

The fluoride isoconcentration map (Figure 5) indicates there are three separate areas of high fluoride concentration (greater than 1.8 ppm) which lie along a north-south trending line. Along this line, in general, fluoride concentrations decrease toward the north and, in general water temperatures also decrease toward the north. However, when the correlation coefficient (r) is calculated between fluoride concentrations above 1.8 ppm and water temperatures, a value of only .284 is obtained. When the correlation coefficient is calculated between fluoride concentration and distance from the well which contains the highest levels of fluoride, a value of -.525 is obtained. Similar calculations between fluoride concentrations and well depth, holding the effects of distance from the highest fluoride concentration constant, yield values of $r = -.320$ and $r = .430$ respectively. These figures indicate that, while well depth is a factor affecting fluoride concentration, a more important factor is the distance of a well along the north-south trending line, from the highest fluoride concentration observed. This implies a source of fluoride in the southern portion of the area and a line, perhaps structural in nature, along which mixing occurs. The existence of three separate areas of high fluoride levels also tends to indicate the existence of a geologic structure which affects the fluoride concentration distribution.

As noted earlier, the coefficient of correlation between well depth and fluoride concentration was calculated to be $-.320$. This probably reflects the heterogeneous nature of the alluvial fill in the area together with local topography. It has been noted, however, in three cases of deepening pre-existing wells, that each of these wells when deepened had higher levels of fluoride than before. This same relationship has also been noticed in cases where two wells are located very close to each other but drilled to different depths. The fluoride level in the deeper of the wells is higher and this concentration increase is nearly proportional to the difference in depth of the two wells.



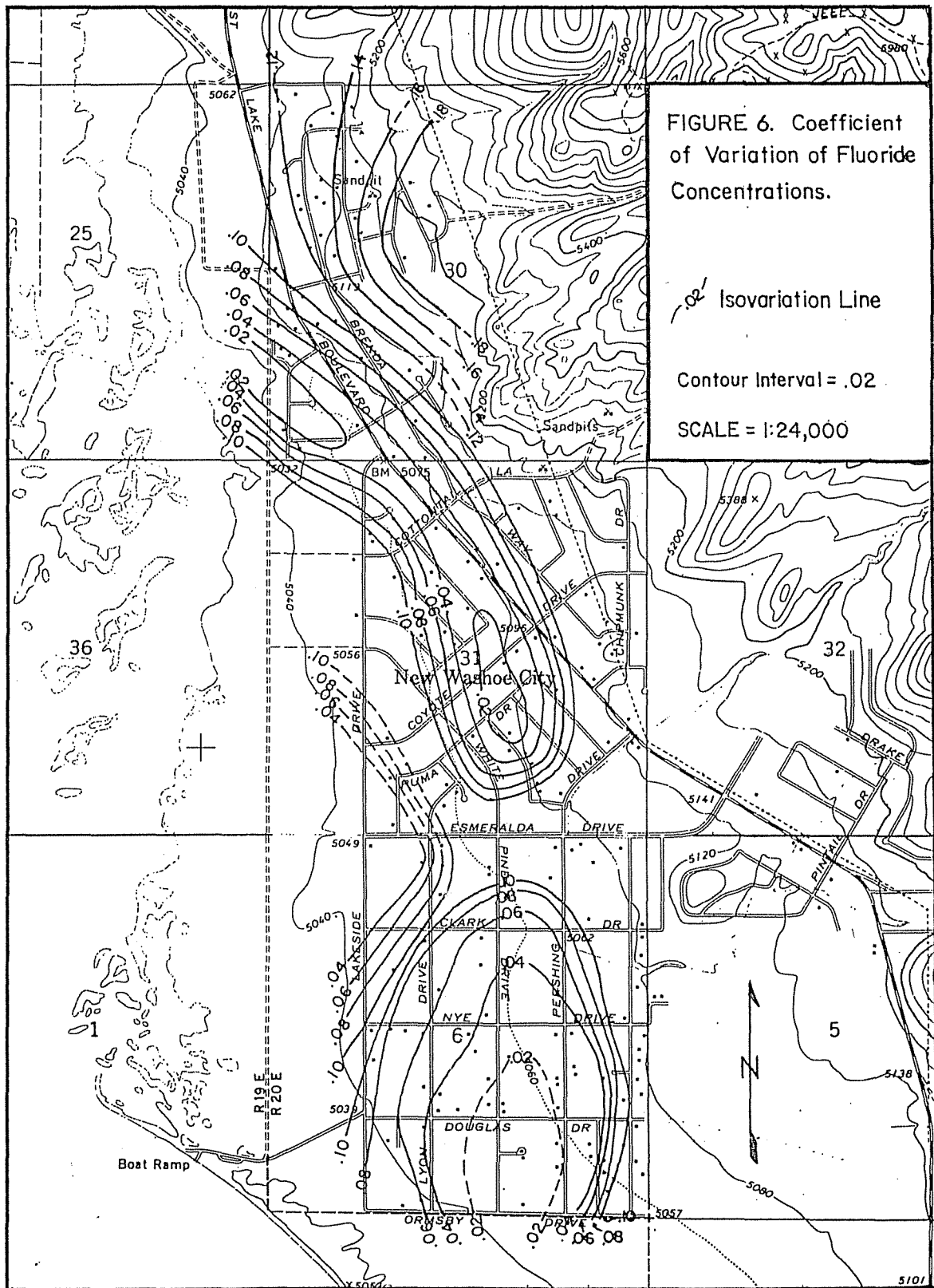
The coefficient of variation (standard deviation of fluoride level, divided by mean fluoride concentration) was calculated for each well sampled. These values were then plotted on the base map and contoured (Figure 6). The pattern described resembles, very closely, the pattern of fluoride concentration (Figure 5) with the smallest amount of variation corresponding to the areas of highest fluoride concentration. This map indicates in areas where fluoride is a problem, the concentration of fluoride varied only slightly during the course of the study.

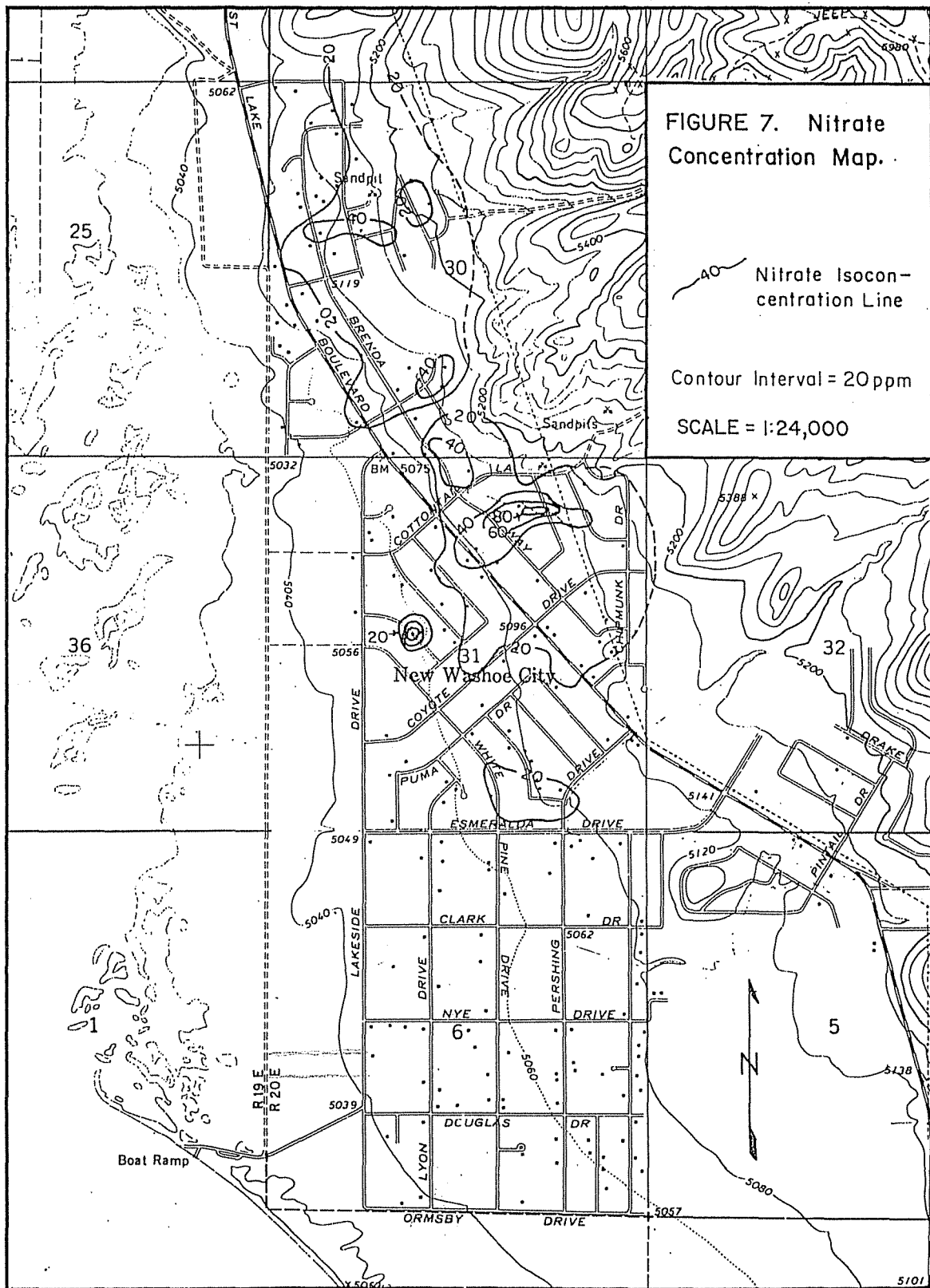
NITRATE IN GROUNDWATER

Figure 7 shows the nitrate concentration determined from the well network. From this it can be seen that the areas of high nitrate, greater than 40 ppm, are confined to several small areas in the northern portion of the New Washoe City-Washoe Farms area. These localized occurrences of high nitrate seem to suggest three possible sources from which they may be derived: 1) a history of grazing in this particular portion of the valley; 2) the existence of a localized organic layer in the aquifer system; or 3) improper or inefficient disposal of domestic wastes.

Each of these possibilities were considered. If the high levels were related to grazing prior to development one would expect a much more uniform concentration throughout the area, but this is not the case. For example, two adjacent wells, No 16 and No 27, both the same depth exhibit quite different NO_3 levels, 0 to 2.0 ppm for the former and 5 to 19 ppm for the latter. Also an examination of water chemistry of several wells on the other side of the valley where irrigation and grazing are currently taking place shows only small values for nitrate (less than 10 ppm) which would further indicate that this is not the nitrate source.

The existence of localized organic layers in the aquifer system is a second possibility. There are no surface manifestations such as spring mounds but there is a possibility that these may be present in the subsurface. After consideration of the highly variable nature of nitrate concentrations in adjacent wells it was believed that this was a rather remote possibility.



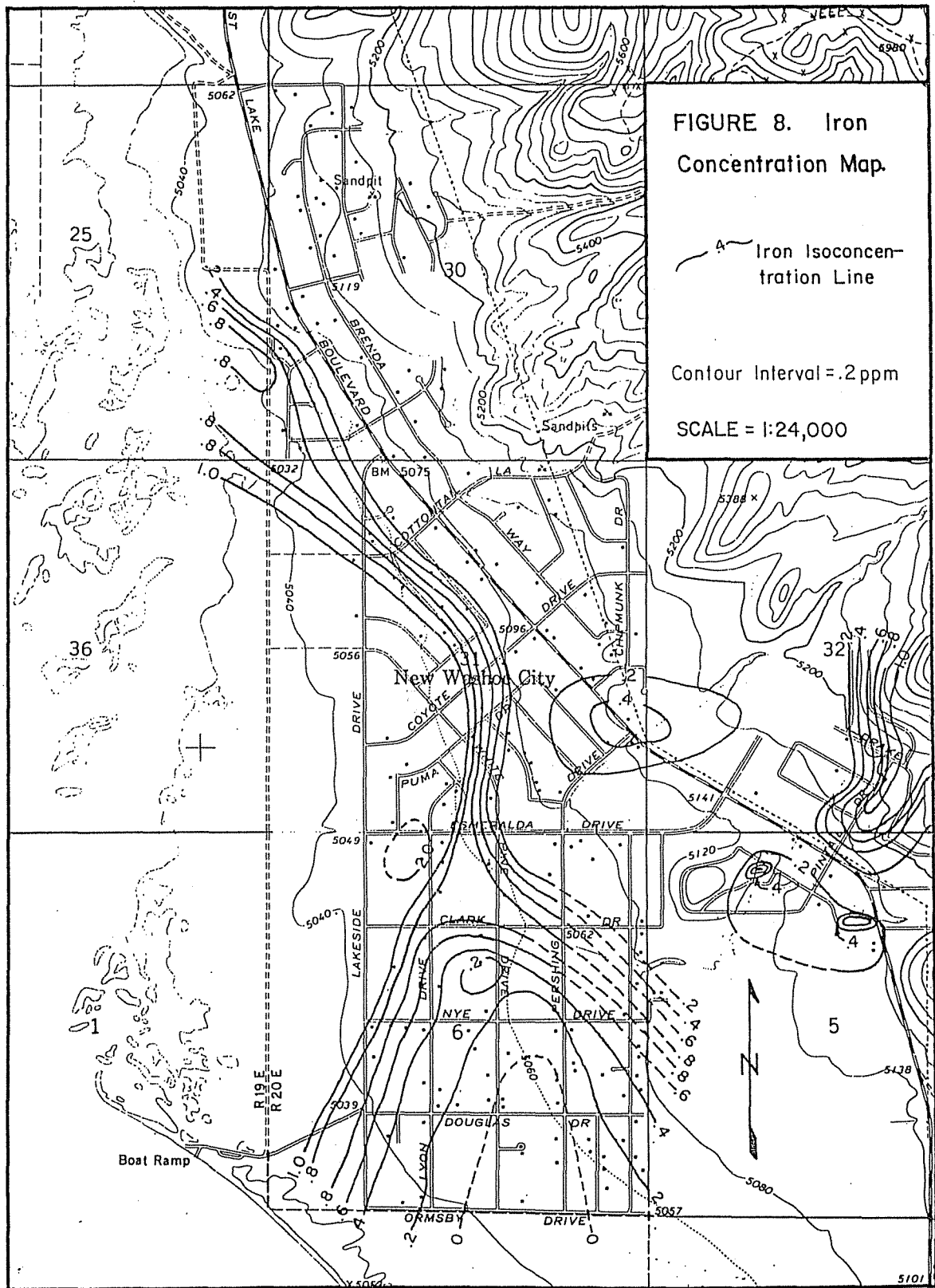


The third and most likely source is from improper domestic waste disposal. All homes in the study area are on individual septic systems and individual water wells. Total nitrogen pickup of domestic sewage ranges between 20 and 40 ppm (Feth, 1966) which could easily account for values of nitrate (NO_3) in excess of the 80 ppm exhibited by a couple of wells in the study area. From the localized occurrence of these high levels it appears that they are related to improper domestic waste disposal.

IRON IN GROUNDWATER

Natural waters may contain iron from the leaching of soluble iron salts from soil and rocks. The USPHS limits on iron in water are not based upon physiological considerations, but on esthetic and taste considerations. The taste threshold has been given by Anon (1957) as 0.1 and 0.2 ppm of iron from ferrous sulfate and ferrous chloride respectively which is below the level for almost the entire New Washoe City-Washoe Farms area (Figure 8).

In general, iron levels in the study area decrease away from the shoreline of Washoe Lake. In addition to this trend there are at least three separate areas of high iron concentrations. These areas of high iron do, however, occur in the same general location. There appear to be at least two sources of iron contamination in the study area. One is the concentration of iron compounds in or near Washoe Lake which tend to become more dilute as the iron compounds are dispersed down gradient. There also appears to be, superimposed upon the trend just described, very localized sources of iron-rich water which mix with waters of less iron content. In addition to the high iron found in the groundwater several streams flowing into Washoe Lake from the southwest exhibit high (0.5 ppm) iron concentrations. The general presence of iron in the groundwater system and concentration in the lake, most likely due to evaporation, indicate that this problem has been widespread throughout the natural system and will continue due to the geologic character of the source areas.



CONCLUSIONS

In response to water quality problems in the New Washoe City-Washoe Farms portion of the Washoe Valley, Nevada, an area of 200 dwellings, a water quality study was initiated in November 1974 by the Water Resources Center. During the course of the study, 257 water samples were collected for chemical analysis from domestic wells and streams flowing into the valley. In addition, approximately 260 well analyses were available from other sources. Also, the rates of flow were measured, on a monthly basis, of inflowing streams for a period of one year.

The study has yielded knowledge not previously available. This information is, however, subject to revision and refinement as more wells are sampled by other interested parties. The major points are:

1. Surface inflow may be eliminated as the direct source of contamination in the groundwater of the New Washoe City-Washoe Farms area.
2. A more accurate estimate of the volume of surface inflow to the valley than was previously possible has been made.
3. The areal occurrence of fluoride, nitrate and iron, which constitute the major water quality problems is described as well as numerous other constituents of interest and areas of deleterious levels delineated.
4. Although there appears to be sufficient quantity of groundwater to make a community water supply feasible, quality problems persist which presently make this idea infeasible in the New Washoe City area. The iron problem can be handled chemically, but the fluoride and nitrate occurrence present major problems. In areas where high fluoride is not a problem high nitrate is and visa versa.
5. Areas to the south of the presently developed land should be investigated to check ground water quality for possible community supply.

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APPENDIX A

LIST OF WELLS SAMPLED

Well numbers 1 - 27 were sampled specifically for this study.

Well numbers greater than 50 were sampled by other agencies.

<u>Well Number</u>	<u>Owner or Resident</u>	<u>Address</u>	<u>Number of Samples Used in Study</u>
1	M. Cox	3550 Hawk	6
2	Allen	3485 Clark	4
3	Mary Aronson	3730 Lyon	6
4	Tom Ashworth	3405 Whitepine	3
5	Edward Bailey	3415 Whitepine	4
6 (spring)	Bowers Mansion	Old U.S. 395	1
7	Chetty	1515 E. Lake	6
8	J. Darrah	3685 Ormsby	6
9 (spring)	J. Darrah	3685 Ormsby	3
10	Mrs. T.L. Friberg	1005 Dunbar	6
11	J.W. Giles	220 Druce	6
12	George Hirsch	3355 Ormsby	5
13	Brent Muhlenberg	2050 Rabbit	6
14	Lou Kokal	220 Hickok	7
15	Lewis	3000 Whitepine	5
16	Leslie Machen, Sr.	3675 Elko	3
17	Edward J. Markovich	275 Puma	6
18	M.M. Mitchell	2240 Ox Circle	6
19	I.L. Nelleman	1745 Karin	6
20	O'Neil	1250 Coyote	1
21	Peterson	3320 Lakeshore	6
22	Bill Radford	3810 Lyon	6
23	L.M. Stecker	3005 Lyon	6
24	Otis Turner	3455 Pershing	1
25	Weimar	3410 Esmeralda	5
26	Thodson	3655 Elko	2
27	Leslie Machen, Sr.	3675 Elko	5
50	Reynolds	2080 Antelope	2
52	Reynolds	2305 Antelope	1
53	Simmons	2110 Beaver	1
54	Ballard	2210 Beaver	4
58	Keith	2280 Beaver	1

<u>Well Number</u>	<u>Owner or Resident</u>	<u>Address</u>	<u>Number of Samples Used in Study</u>
59	Adamson	1430 Brenda	1
60	Riolo	1470 Brenda	1
61	Ballard	1830 Brenda	1
61-2		1835 Brenda	1
62	Dixon	1920 Brenda	1
63		1970 Brenda	4
67	Keith	1975 Brenda	1
68	Wilford	2090 Brenda	2
70		2475 Brenda	2
71		2480 Brenda	1
72	Lewis	230 Brooks	1
73	Savage	215 Bruce	1
74	Keith	2035 Buckskin	2
76	Keith	2075 Buckskin	1
77	Keith	2155 Buckskin	6
83	Martin	2320 Chipmunk	1
84	Kiner	2345 Chipmunk	1
85	Linscott	2015 Chuckar	1
86	Ballard	2135 Chuckar	3
89		2320 Chuckar	1
90	O'Rourke	2365 Chuckar	1
91	Vicktorson	3005 Churchill	1
92	Nixon	3485 Churchill	1
92-2		3820 Churchill	1
93	Boy	3475 Clark	2
96	Boy	3495 Clark	1
96-2		155 Coyote	1
97	Keith	175 Coyote	1
98	Keith	286 Coyote	2
100	Steinhauser	310 Coyote	1
101		380 Coyote	1
102	Amesquita	4075 Drake	2
104	Dawson	4080 Drake	2
104-2		4305 Drake	1

<u>Well Number</u>	<u>Owner or Resident</u>	<u>Address</u>	<u>Number of Samples Used in Study</u>
106	Rauls	1125 Dunbar	1
107	Cooper	1305 Dunbar	1
108	Chism	1345 Dunbar	2
110	Keith	2930 Eagle	1
111	Roth	2965 Eagle	1
112	Wilcox	2985 Eagle	1
113	Schlatter	1555 Eastlake	3
116	Keith	1570 Eastlake	1
117	Keith	1620 Eastlake	1
118	Keith	1650 Eastlake	1
119	Lingenfelt	1735 Eastlake	2
120		1840 Eastlake	1
121		1845 Eastlake	1
122	Keith	1950 Eastlake	1
123	Keith	1960 Eastlake	1
124		1975 Eastlake	1
125	Keith	1990 Eastlake	1
126	Siesmore	2085 Eastlake	1
127	Dixon	2090 Eastlake	1
128		2180 Eastlake	3
131	Johnson	2215 Eastlake	2
133		2265 Eastlake	2
134	Johnson	3005 Eastlake	2
136	Simmons	3015 Eastlake	1
137	Cadle	3030 Eastlake	1
138	Iveson	3075 Eastlake	1
139	Heinselman	4035 Eastlake	1
140	Heinselman	4045 Eastlake	1
141	Stella	4100 Eastlake	1
142	Smith	4220 Eastlake	1
143	Reynolds	4240 Eastlake	1
144	Hammond	4260 Eastlake	1
145	Dawson	4280 Eastlake	1
146	Harvey	315 Esmeralda	1

<u>Well Number</u>	<u>Owner or Resident</u>	<u>Address</u>	<u>Number of Samples Used in Study</u>
147	Foreman	325 Esmeralda	3
151	McBrayer	335 Esmeralda	1
152	Deitz	1613 Esmeralda	1
153	Stevens	1464 Eunice	1
154	Jones	2435 Falcon	1
154-2		315 Flicker	1
155	Niemi	400 Flicker	1
155-2		4325 Gander	1
156	Heun	1400 Guffy	1
156-2		1405 Guffy	1
157		1490 Guffy	1
158	Troutman	1640 Guffy	1
158-2		2990 Hawk	1
160	Johnson	1685 S. Irving	1
161	Keith	120 Jackdaw	1
161-2		170 Jackdaw	1
162	Reynolds	1630 Karin	3
165	Shanks	1635 Karin	1
166	Callahan	1645 Karin	1
167a	Cattich	1665 Karin	1
167b	Odynski	1665 Karin	2
170	Marshall	1694 Karin Circle	1
171	Southerland	1704 Karin Circle	2
173	Ballard	2010 Lakeshore	1
174	Beaulieu	2060 Lakeshore	2
176	Sartos	2940 Lakeshore	1
177	Tinberg	3060 Lakeshore	1
178	Chestnut	3790 Lakeshore	1
179	Baillard	1395 Lord	2
181	Norton	1415 Lord	4
185	Keith	1440 Lord	1
186	Chism	1485 Lord	1
187		3055 Lyon	3
190	Brown	3320 Lyon	1

<u>Well Number</u>	<u>Owner or Resident</u>	<u>Address</u>	<u>Number of Samples Used in Study</u>
191	Jones	3505 Lyon	2
193	Brown	3725 Lyon	2
195	Dunn	3875 Lyon	1
195-2		210 Magpie	1
197	Warner	3720 Nye	2
198	Jordan	4145 Old U.S. 395	1
199	Gash	Slide Mtn. Ranch	1
200	Wood	3825 Ormsby	1
201	Duarte	Ox Circle	1
202	Keith	4060 Partridge	1
203	Keith	4080 Partridge	1
204	Keith	4090 Partridge	1
204-2		290 Pershing	1
205	Nelson	2975 Pershing	6
210	Ballard	2995 Pershing	1
211	Brown	3040 Pershing	1
211-2		3315 Pershing	1
211-3		3495 Pershing	1
211-4		3705 Pershing	1
211-5		3707 Pershing	1
211-6		3735 Pershing	1
212a		3995 Pershing	1
212b		3995 Pershing	1
214	Parks	215 Pintail	1
215	Keith	275 Puma	1
216	Brown	395 Puma	1
217	Allen	460 Puma	1
218		3545 Puma	2
220	Tipton	3575 Puma	1
221	Berry	2265 Rabbit	1
222	Poe	120 Sinclair	1
223	Imrisek	340 Sparrow	1
224	Washoe County	Boat landing	2

<u>Well Number</u>	<u>Owner or Resident</u>	<u>Address</u>	<u>Number of Samples Used in Study</u>
226	Scarsborough	2105 Whitepine	1
226-2		2265 Whitepine	1
227	Walsh	2380 Whitepine	2
229	Keith	2900 Whitepine	1
230	Keith	2910 Whitepine	2
232	Cattich	2975 Whitepine	1
233	Allen	2995 Whitepine	3
236	Jennings	3025 Whitepine	1
237a	Kitterman	3110 Whitepine	1
237b	Kitterman	3110 Whitepine	1
239	Hoden	3285 Whitepine	1
240		3650 Whitepine	3
243	Lunberg	3845 Whitepine	1
244	Reynolds	4060 Woodcock	1
245	Dawson	4070 Woodcock	1
246	Keith	4095 Woodcock	1
247	Ballard	4100 Woodcock	1
159	Keith	1645 S. Irving	1

APPENDIX B

Well Chemistry

EXPLANATION

The following is a complete list of chemical data from wells which were sampled specifically for this study. Entries marked with an asterisk have not been included in the computation of mean values at a particular well site.

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	1	1	1	1	1	1	
Date	121074	60575	091175	122375	022976	032376	
State Lab Number	35427	36469	37215	37850	38305	38447	
Depth (meters)	31.0						Mean Values (1)
Temperature(°C)	13.6	16.0	17.0	14.5	13.0	13.0	
pH	7.41	7.56	7.4	7.73	7.92	7.68	
E.C.	215	217	205	243*	205	204	7.61
Ca	23	23	23	22	23	22	23
Mg	4	4	3	3	5	3	4
Na	17	18	17	29*	13	12	15
K	1	1	1	2	2	1	1
Cl	3	3	5	14*	4	5	4
SO ₄	18	19	18	19	17	18	18
HCO ₃	88	85	85	98	88	85	88
PO ₄	.55	.44	.59	.27	.38	.43	.44
F	.20	.21	.18	.15	.14	.18	.17
CO ₃	0	0	0	0	0	0	0
Fe	.01	0	.09*	.04	.04	.01	0
Mn	0	0	0	.07*	0	0	0
NO ₃	9.6	10.4	9.4	8.5	9.1	9.3	9.38
As	0	0	0	.005	0	0	0
% EPM Error	3.6	5.0	1.7	2.1	2.4	4.8	
Excess	C	C	C	C	C	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	2	2	2	2			
Date	012775	061875	091875	123075			
State Lab Number	35647	36578	37247	37925			
Depth (meters)	29.52				Mean Values (2)		
Temperature(°C)	11.5	16.0	16.5	6.0			
pH	7.87	7.61	8.0	7.8			
E.C.	304	300		295	300		
Ca	6	8	8	6	7		
Mg	1	1	1	1	1		
Na	62	59	65	64	63		
K	1	1	1	1	1		
Cl	5	8	9	8	8		
SO ₄	7	6	9	6	7		
HCO ₃	151	156	156	163	157		
PO ₄	.48	.52	.46	.57	.51		
F	6.44	6.56	6.73	6.08	6.45		
CO ₃	0	0	0	0	0		
Fe	.86	.74	.75	1.24	.90		
Mn	.19	.14	.13	.15	.15		
NO ₃	.1	.1	.1	.5*	.1		
As	.005	0	0	0	0		
% EPM Error	.39	2.6	.03	1.9			
Excess	C	A	A	A			

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	3	3	3	3	3	3	
Date	022875	061975	091675	122375	022676	033076	
State Lab Number	35839	36584	37235	37851	38270	38495	
Depth (meters)	21.55						Mean Values (3)
Temperature(°C)	20.0	17.8	21.0	6.0	6.0	8.5	
pH	8.37	8.35	8.40	7.96	7.48	8.35	8.15
E.C.	380	375		370	390	342	371
Ca	11	12	11	10	10	10	11
Mg	1	1	1	0	0	1	1
Na	61	63	65	63	59	64	63
K	2	2	2	2	2	2	2
Cl	9	12	11	11	5	1*	10
SO ₄	46	47	52	46	46	45	47
HCO ₃	102	61	90	122	98	90	94
PO ₄	.17	.12	.18	.15	.09	.12	.14
F	6.12	6.48	6.68	6.30	6.28	6.0	6.31
CO ₃	8	26	14	0	0	16	11
Fe	.01*	.17	.27	.28	.24	.24	.24
Mn	.03	.30	.02	.03	.01*	.02	.03
NO ₃	.1	0	.2	.3	.2	0	.1
As	.005	.005	0	0	0	0	0
% EPM Error	2.1	.69	2.4	4.4	1.3	2.0	
Excess	A	A	A	A	C	C	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	4	4*	4	Bowers Mansion			
Date	041875	070975	091675		041775		
State Lab Number	36191	36704	37233		36188		
Depth (meters)	41.03			Mean Values(4) spring			
Temperature(°C)	18.5	22.0	20.0		35.0		
pH	8.84	8.55	8.79	8.73	8.91		
E.C.	372	390		381	266		
Ca	2	4	3	3	2		
Mg	0	0	0	0	0		
Na	84	71*	84	84	55		
K	1	1	1	1	1		
Cl	10	12	11	11	8		
SO ₄	15	15	16	15	36		
HCO ₃	137	120	142	133	29		
PO ₄	.25	.17	.20	.21	.11		
F	7.20	6.76	7.24	7.07	3.32		
CO ₃	18	24	12	18	24		
Fe	.16*	.08	.08	.08	.03		
Mn	.02	.03	.01	.02	0		
NO ₃	0	.2	.1	.1	.4		
As	.005	0	0	0	0		
% EPM Error	.54	6.5	.96		1.7		
Excess	A	A	A		C		

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	5	5*	5	5			
Date	041876	070975	091675	122375			
State Lab Number	36190	36705	37234	37852			
Depth (meters)	24.21				Mean Values (5)		
Temperature(°C)	15.5	23.0	17.0	5.5			
pH	8.2	8.10	8.15	8.10	8.14		
E.C.	383	380		360	374		
Ca	3	4	4	3	4		
Mg	0	1	0	0	0		
Na	78	53*	79	75	77		
K	1	0	1	1	1		
Cl	11	12	11	10	11		
SO ₄	29	26	25	27	27		
HCO ₃	137	137	110	159	136		
PO ₄	.49	.50	.50	.66	.58		
F	5.92	5.60	6.08	5.60	5.8		
CO ₃	8	4	20	0*	11		
Fe	.22	.11*	.28	.40	.30		
Mn	.10	.08	.08	.10	.09		
NO ₃	0	0	0	.1	0		
As	.005	0	.005	.005	.004		
% EPM Error		15.8	.53	4.3			
Excess		A	C	A			

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	7	7	7	7	7	7	
Date	121074	060575	090475	122375	022976	032376	
State Lab Number	35426	36466	37144	37853	38277	38441	
Depth (meters)	29.52						Mean Values (7)
Temperature(°C)	15.3	17.0	18.0	12.5	13.0	15.5	
pH	7.92	7.89	7.90	8.10	8.17	8.04	8.00
E.C.	370	376	350	350	345	360	359
Ca	11	13	12	11	12	12	12
Mg	1	1	1	1	1	1	1
Na	68	70	69	66	70	72	69
K	1	1	1	1	1	1	1
Cl	9	8	9	7	6	9	8
SO ₄	15	18	17	16	14	15	16
HCO ₃	173	183	171	181	181	181	178
PO ₄	.50	.42	.44	.66	.42	.44	.48
F	2.20	2.14	1.90	2.00	2.08	1.76	2.01
CO ₃	0	0	0	0	0	0	0
Fe	.06	.03	.03	.10	.08	.03	.06
Mn	.27	.22	.21	.16	.18	.22	.21
NO ₃	13.1	14.0	20.0	12.8	10.5	13.2	13.9
As	0	.005	0	.005	.005	0	.005
% EPM Error	1.6	1.8	1.7	4.0	.56	.06	
Excess	A	A	A	A	C	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	8	8	8	8	8	8	
Date	022875	061975	091875	123075	022276	033076	
State Lab Number	35837	36582	37251	37926	38272	38447	
Depth (meters)	38.38						Mean Values (8)
Temperature(°C)	41.0	37.8	34.0	11.0	14.0	23.0	
pH	7.92	8.10	8.00	7.80	8.21	8.04	8.02
E.C.	390	385		365	360	360	372
Ca	11	11	11	9	10	10	10
Mg	1	1	0	1	0	0	1
Na	57	60	64	63	57	62	61
K	3	3	3	3	3	3	3
Cl	10	9	10	11	5	10	9
SO ₄	48	53	55	49	53	49	51
HCO ₃	127	124	129	124	98	127	122
PO ₄	.21	.21	.18	.18	.18	.22	.20
F	5.48	5.68	6.16	5.76	5.08	5.38	5.59
CO ₃	0	0	0	0	.10	0	0
Fe	0*	.13	.21	.33	.30	.27	.25
Mn	.03	.03	.02	.03	.03	.03	.03
NO ₃	0	0	0	.1	.2*	0	0
As	.020	.025	.030	.025	.025	.025	.025
% EPM Error	6.9	5.3	6.2	4.4	6.0	5.6	
Excess	A	A	A	A	A	A	

*at well number indicates presence of cation not tested for

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	9 (spring)	9 (spring)	9 (spring)				
Date	022875	061975	091875				
State Lab Number	35838	36583	37250				
Depth (meters)				Mean Values (9)			
Temperature(°C)	17.0	18.5	21.5				
pH	8.33	8.40	9.30				
E.C.	440	540		490			
Ca	2	3	3	3			
Mg	0	0	0	0			
Na	91	112	146	116			
K	1	2	0	1			
Cl	10	13	15	13			
SO ₄	57	69	89	70			
HCO ₃	139	171	78	129			
PO ₄	.27	.26	.39	.31			
F	7.00	8.70	10.3	8.67			
CO ₃	0	0	62	21			
Fe	0	.13	.23	.18			
Mn	.06	.02	.01*	.04			
NO ₃	.2*	.5	.5	.5			
As	.050	.065	.095	.07			
% EPM Error	.5	.02	3.4				
Excess	A	A	C				

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	10	10*	10	10	10	10	
Date	112674	060375	090475	122375	022976	032376	
State Lab Number	35397	36430	37854	37854	38300	38450	
Depth (meters)	33.95						Mean Values (10)
Temperature(°C)	14.1	16.0	17.5	16.0	19.0	14.0	
pH	7.28	7.29	7.29	7.62	7.79	7.61	7.52
E.C.	330	323	300	310	310	285	307
Ca	29	33	31	30	30	30	30
Mg	4	5	4	4	5	5	4
Na	29	30	30	32	27	28	29
K	1	2	1	2	2	1	1
Cl	8	7	8	10	9	10	9
SO ₄	25	25	26	23	24	24	24
HCO ₃	122	110	115	112	115	115	116
PO ₄	.07	.15	.13	.09	.09	.14	.09
F	.32	.21	.25	.28	.25	.25	.27
CO ₃	0	0	0	0	0	0	0
Fe	.01	.02	.01	.03	.03	.01	.02
Mn	0	0	.01	.02	.01	.01	.01
NO ₃	26.9	28.2	26.4	30.8	29.7	29.4	28.5
As	.020	.020	.020	.015	.015	.015	.017
% EPM Error	2.2	6.6	1.8	2.5	.03	.09	
Excess	A	C	C	C	C	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	11	11	11	11	11	11	
Date	120674	060375	090475	122375	022976	032376	
State Lab Number	35424	36431	37145	37855	36301	38442	
Depth (meters)	38.38						Mean Values (11)
Temperature(°C)	11.0	18.0	19.0	16.0	12.0	15.5	
pH	7.83	7.89	7.81	7.89	8.08	7.96	7.91
E.C.	355	380	361	370	370	360	366
Ca	6	8	7	7	7	6	7
Mg	1	1	1	0	1	0	1
Na	78	79	82	76	84	79	80
K	2	2	2	2	2	2	2
Cl	9	7	10	10	9	10	9
SO ₄	1	2	2	0	0	0	1
HCO ₃	222	207	227	220	227	220	221
PO ₄	1.70	1.60	1.60	1.80	1.70	1.80	1.70
F	3.12	3.28	3.07	3.12	3.16	3.06	3.14
CO ₃	0	4	0	0	0	0	0
Fe	.93	.65	.84	1.40	1.17	.88	.98
Mn	.07	.09	.08	.09	.08	.08	.08
NO ₃	.3	.2	.8	.6	.3	.4	.4
As	.005	.010	.010	.010	.005	.010	.008
% EPM Error	3.4	.05	202	4.5	.21	3.7	
Excess	A	C	A	A	A	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	12	12	12	12	12		
Date	120975	061975	091875	123075	022276		
State Lab Number	35709	36581	37252	37927	38273		
Depth (meters)						Mean Values	(12)
Temperature(°C)	14.5	15.5	16.5	12.0	9.0		
pH	7.69	8.05	8.00	7.70	8.03	7.89	
E.C.	360	375		340	340	354	
Ca	26	30	31	29	30	29	
Mg	6	6	6	6	6	6	
Na	39	41	41	41	40		
K	2	2	2	2	2	2	
Cl	4	7	5	6	5	5	
SO ₄	34	35	33	35	36	35	
HCO ₃	166	171	166	163	163	166	
PO ₄	.21	.22	.19	.12	.17	.18	
F	1.62	1.27	1.46	1.30	1.40	1.41	
CO ₃	0	0	0	0	0	0	
Fe	.01	.03*	0	.01	0	.01	
Mn	0	0	0	.06*	0	0	
NO ₃	3.1	2.4	2.2	2.4	2.3	2.5	
As	.005	0	0	0	0	0	
% EPM Error	2.0	.20	2.8	1.3	1.4		
Excess	A	A	C	C	C		

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	13*	13	13*	13	13	13	
Date	121374	061875	091175	122375	022976	032376	
State Lab Number	35451	36577	37212	37860	38303	38445	
Depth (meters)	19.48						Mean Values (13)
Temperature(°C)	13.1	14.1	16.5	14.5	9.5	14.0	
pH	8.07	8.08	8.10	7.71	8.00	7.72	7.95
E.C.	336	340	307	317	330	330	327
Ca	17*	20	17*	19	19	19	19
Mg	1	3	1	2	2	1	2
Na	48*	50	48*	50	53	52	52
K	3	2	2	3	3	3	3
Cl	6	7	12*	7	6	7	7
SO ₄	4*	2*	0	0	0	0	0
HCO ₃	190	195	195	203	210	207	200
PO ₄	.45	.53	.42	.36	.55	.48	.47
F	1.79	1.88	1.70	1.55	1.88	2.08	1.81
CO ₃	0	0	0	0	0	0	0
Fe	.18	.13	.34	.29	.24	.23	.24
Mn	.06	.07	.07	.08	.08	.08	.07
NO ₃	0	0	.1	.4	.2	.1	.2
As	0	0	0	0	0	0	0
% EPM Error	5.6	1.0	8.2	3.5	3.1	4.7	
Excess	A	A	A	A	A	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	14	14*	14	14	14	14	14*	Mean Values
Date	112674	060375	090475	122375	022976	032376	040576	
State Lab Number	35398	36429	37143	37856	38276	38440	38551	
Depth (meters)	32.47							
Temperature(°C)	14.2	15.5	16.5	19.0	14.5	15.0		
pH	6.98	6.98	6.84	7.33	7.37	7.30	7.11	7.16
E.C.	330	195	191	200	195	200		223
Ca	13	16	15	15	16	16	15	15
Mg	3	5	4	4	5	5	4	4
Na	18	18	18	21	13	13	13	17
K	1	1	1	1	1	1	1	1
Cl	3	5	5	5	5	5	7	5
SO ₄	7	6	6	6	7	6	7	5
HCO ₃	51	49	54	59	59	59	54	56
PO ₄	.17	.17	.21	.28	.14	.14		.19
F	.31	.25	.29	.30	.27	.21	.20	.28
CO ₃	0	0	0	0	0	0	0	0
Fe	.01	.03	0	.01	.05	.02	.02	.02
Mn	0	0	0	.01	.01	.02	.01	.01
NO ₃	40.0	37.2	37.0	36.3	38.2	40.0	42.0	38.3
As	0	0	0	0	0	0	0	0
% EPM Error	.83	9.0	3.2	4.5	2.4	2.5	6.9	
Excess	A	C	C	C	A	A	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	15	15*	15	15	15		
Date	012975	061875	091175	122375	032376		
State Lab Number	35708	36580	37214	37856	38448		
Depth (meters)	29.52					Mean Values	(15)
Temperature(°C)	11.5	14.5	16.0	13.5	16.5		
pH	7.36	7.89	7.39	7.76	7.73	7.63	
E.C.	252	225	205	204	200	216	
Ca	23	26*	24	21	22	23	
Mg	6	7*	4	3	4	4	
Na	14	16	14	20	13	15	
K	1	1	1	2	1	1	
Cl	4	7	5	5	5	5	
SO ₄	14	9*	9	16	18	14	
HCO ₃	85	88	88	89	85	87	
PO ₄	1.20	.90	.92	.76	.56	.87	
F	.28	.26	.26	.29	.26	.27	
CO ₃	0	0	0	0	0	0	
Fe	0	.02	.01	.02	.02	.01	
Mn	0	0	0	.01	0	0	
NO ₃	31.3	24.9	25.1	10.5	9.9	20.3	
As	.005	0	0	0	0	0	
% EPM Error	1.7	6.7	1.3	1.8	.97		
Excess	A	C	A	C	A		

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	16	16	16				
Date	041175	091875	033076				
State Lab Number	36187	37253	38499				
Depth (meters)	22.14			Mean Values (16)			
Temperature(°C)	17.0	20.5	14.0				
pH	7.95	8.20	8.11	8.09			
E.C.	435		405	420			
Ca	4	6	3	4			
Mg	0	1	0	0			
Na	94	98	97	96			
K	1	1	1	1			
Cl	9	8	9	9			
SO ₄	37	34	32	34			
HCO ₃	190	163	215	189			
PO ₄	.68	.59	.72	.66			
F	6.84	5.92	6.08	6.28			
CO ₃	0	14	0	5			
Fe	.32	.06*	.23	.28			
Mn	.27	.25	.26	.25			
NO ₃	0	2.2*	0	0			
As	.010	.015	.015	.013			
% EPM Error	2.1	2.7	4.1				
Excess	A	C	A				

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	17	17	17	17	17	17	
Date	121374	061775	091175	122375	022976	32376	
State Lab Number	35450	36535	37213	37858	38304	38446	
Depth (meters)	29.52						Mean Values (17)
Temperature(°C)	11.9	14.5	17.5	9.5	3.0	13.5	
pH	7.42	7.65	7.56	7.62	7.75	7.62	7.60
E.C.	470	480	445	430	450	450	454
Ca	21	23	23	22	21	23	22
Mg	3	5	3	4	5	4	4
Na	83	80	82	80	90	89	84
K	2	1	1	2	2	1	2
Cl	7	7	9	10	7	8	8
SO ₄	6	2	4	5	2	6	4
HCO ₃	290	288	293	293	303	295	294
PO ₄	.65	.70	.63	.21	.30	.46	.49
F	3.04	2.96	2.98	3.24	3.00	2.86	3.01
CO ₃	0	0	0	0	0	0	0
Fe	1.90	1.55	1.28	2.24	.14*	1.90	1.77
Mn	.12	.10	.10	.11	.10	.11	.11
NO ₃	.5	.4	.2	.3	.2	.3	.3
As	.015	.010	.005	.005	.005	.015	.009
% EPM Error	2.3	.19	2.7	3.2	.54	.84	
Excess	A	A	A	A	C	C	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	18	18	18	18	18	18	
Date	121074	060575	091175	122375	022276	032376	
State Lab Number	35428	36467	37211	37859	38299	38444	
Depth (meters)	53.14						Mean Values (18)
Temperature(°C)	13.0	17.7	16.5	14.5	16.0	12.0	
pH	6.80	6.75	6.79	7.19	7.54	7.13	7.03
E.C.	312	279	240	310	315	320	304
Ca	25	22	24	24	26	27	25
Mg	9	7	8	9	9	9	9
Na	22	20	19	24	17	17	20
K	2	2	2	3	3	3	3
Cl	12	10	12	14	13	13	12
SO ₄	14	14	15	15	15	15	15
HCO ₃	54	57	54	61	61	61	58
PO ₄	.41	.24	.47	.21	.29	.22	.31
F	.21	.25	.21	.21	.19	.20	.21
CO ₃	0	0	0	0	0	0	0
Fe	0	0	.02	0	.03	.03	.01
Mn	.01	.01	.01	.01	.01	.01	.01
NO ₃	74.0	67.5	69.0	72.2	77.5	74.8	72.5
As	0	0	0	0	0	0	0
% EPM Error	4.6	.42	1.1	2.9	1.6	.05	
Excess	C	A	C	C	A	C	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	19*	19	19*	19*	19	19*	
Date	120674	060575	090475	122375	022976	032376	
State Lab Number	35425	36468	37146	37861	38302	38443	
Depth (meters)	23.62						Mean Values (19)
Temperature(°C)	10.0	15.0	15.0	11.0	9.0	16.5	
pH	7.76	7.60	7.70	7.65	7.45	7.59	7.53
E.C.	290	292	285	280	275	275	284
Ca	9	10	10	9	9	9	10
Mg	1	2	1	1	1	2	2
Na	45	48	50	46	46	46	47
K	3	3	3	3	3	3	3
Cl	5	6	7	5	5	5	6
SO ₄	4	0	0	2	0	0	0
HCO ₃	171	163	171	161	139	166	151
PO ₄	2.40	2.30	2.80	2.30	1.90	1.80	2.10
F	2.64	2.72	2.68	2.80	2.68	2.66	2.70
CO ₃	0	0	0	0	0	0	0
Fe	.84	.65	.62	.95	.70	.20	.68
Mn	.10	.12	.10	.11	.12	.11	.12
NO ₃	.1	0	.7	.5	1.6	.5	.8
As	0	.005	.005	.005	0	0	0
% EPM Error	11.0	3.4	6.3	7.1	.14	6.3	
Excess	A	A	A	A	A	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	20						
Date	041875						
State Lab Number	36189						
Depth (meters)	59.04						
Temperature(°C)	13.7						
pH	7.57						
E.C.	295						
Ca	31						
Mg	6						
Na	22						
K	2						
Cl	6						
SO ₄	17						
HCO ₃	129						
PO ₄	13						
F	16						
CO ₃	0						
Fe	.10						
Mn	.03						
NO ₃	14.5						
As	0						
% EPM Error	2.9						
Excess	C						

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	21	21	21*	21*	21	21	
Date	030575	062075	091875	122375	022976	033076	
State Lab Number	35809	36586	34278	37862	38306	38494	
Depth (meters)	19.78						Mean Values (21
Temperature(°C)	10.5	14.0	15.0	6.5	11.0	10.5	
pH	7.54	7.68	7.85	7.60	7.81	7.81	7.69
E.C.	315	300		300	285	290	298
Ca	15	15	15	14	15	15	15
Mg	5	3	2	3	3	3	3
Na	43	43	44	42	43	44	43
K	2	2	2	2	2	2	2
Cl	1	2	3	5	2	2	2
SO ₄	4	2	4	2	0	0	2
HCO ₃	188	178	183	183	181	183	183
PO ₄	.46	.93	.98	.54	.51	.98	.68
F	.89	1.06	1.15	1.02	1.05	1.15	1.03
CO ₃	0	0	0	0	0	0	0
Fe	.03*	1.13	1.11	1.10	1.10	1.11	1.11
Mn	.68	.70	.68	.70	.68	.68	.69
NO ₃	.4	.2	.1	1.3*	0	.1	.18
As	.005	.005	.005	.005	0	.005	.005
% EPM Error	2.4	2.0	5.1	6.3	1.9	2.0	
Excess	A	A	A	A	A	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	22	22	22	22*	22	22	
Date	012775	061875	091875	122375	022276	033076	
State Lab Number	35648	36579	37249	37863	38271	35888	
Depth (meters)	20.07						Mean Values (22)
Temperature(°C)	19.4	23.0	25.3	1.0	2.0	5.5	
pH	8.73	8.63	8.31	8.55	7.48	8.31	8.29
E.C.	410	410		405	390	395	401
Ca	7	9	8	7	8	8	8
Mg	0	0	0	0	0	0	0
Na	75	73	79	72	78	80	77
K	2	2	1	2	2	2	2
Cl	9	11	10	12	10	10	10
SO ₄	64	66	63	65	65	66	65
HCO ₃	95	66	93	102	110	83	89
PO ₄	.13	.15	.34*	.10	.12	.12	.13
F	6.80	7.08	6.80	6.40	6.58	6.53	6.76
CO ₃	12	24	14	14	0	16	13
Fe	.02	.04	0	0	.04	.06	.03
Mn	0	0	0	.01	0	.01	0
NO ₃	.1	0	0	.1	.1	0	0
As	.020	.030	.030	.025	.025	.030	.027
% EPM Error	3.2	3.5	1.2	8.3	.72	.45	
Excess	A	A	A	A	C	C	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	23	23	23*	23	23*	23	
Date	030575	062075	091675	122375	022276	033076	
State Lab Number	35888	36585	37231	37864	38298	38493	
Depth (meters)	24.50						Mean Values (23)
Temperature(°C)	13.0	15.0	17.5	6.0	14.0	15.5	
pH	7.57	7.48	7.55	7.61	7.93	7.69	7.58
E.C.	360	360		360	340	340	355
Ca	24	23	25	22	22	23	23
Mg	9	7	6	7	6	6	7
Na	38	39	38	39	36	38	38
K	3	3	3	3	3	3	3
Cl	2	3	3	3	2	4	3
SO ₄	3	3	2	2	0	0	2
HCO ₃	227	222	229*	222	220	220	223
PO ₄	.27	.54	.64*	.18	.18	.68	.42
F	.82	.88	.94*	.85	.88	.88	.86
CO ₃	0	0	0	0	0	0	0
Fe	.31*	2.02	2.02	2.15	2.02	2.00	2.05
Mn	.67	.68	.68	.70	.68	.67	.68
NO ₃	.1	.1	.3*	.1	0	.2	.1
As	0	0	0	.010	.005	0	0
% EPM Error	2.5	3.4	5.1	3.6	5.4	4.4	
Excess	3.8	A	A	A	A	A	

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	24						
Date	012975						
State Lab Number	35710						
Depth (meters)	31.00						
Temperature(°C)	17.6						
pH	9.00						
E.C.	440						
Ca	1						
Mg	0						
Na	93						
K	1						
Cl	11						
SO ₄	66						
HCO ₃	102						
PO ₄	.17						
F	4.52						
CO ₃	12						
Fe	.04						
Mn	0						
NO ₃	.2						
As	.060						
% EPM Error	1.4						
Excess	C						

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	25	25	25	25	25		
Date	071075	091675	122375	022276	032376		
State Lab Number	36707	37232	37865	38264	38449		
Depth (meters)	23.62					Mean Values	(25)
Temperature(°C)	20.5	16.0	2.0	3.0	5.5		
pH	7.50	7.49	7.84	7.95	7.81	7.72	
E.C.	218		210	205	200	208	
Ca	24	24	21	22	22	23	
Mg	4	4	4	4	4	4	
Na	20	18	21	12	13	17	
K	2	2	2	2	1*	2	
Cl	8	4	4	4	5	5	
SO ₄	17	17	16	16	18	16	
HCO ₃	98	98	98	98	90	96	
PO ₄	.45	.33	.33	.33	.36	.36	
F	.24	.17	.17	.19	.14	.18	
CO ₃	0	0	0	0	0	0	
Fe	.01	.01	.01	.01	.01	.01	
Mn	0	.01	.02	.02	.01	.01	
NO ₃	8.1	7.2	6.6	6.5	5.9	6.9	
As	0	0	.005	0	0	0	
% EPM Error	2.2	3.2	3.6	4.2	2.1		
Excess	C	C	C	A	A		

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	26	26					
Date	022276	033076					
State Lab Number	38275	38496					
Depth (meters)	28.04		Mean Values (26)				
Temperature(°C)	8.5	17.0					
pH	8.40	8.18	8.29				
E.C.	450	425	438				
Ca	3	3	3				
Mg	0	0	0				
Na	102	112*	102				
K	1	1	1				
Cl	6	7	7				
SO ₄	24	2*	24				
HCO ₃	198	237	220				
PO ₄	.52	.52	.52				
F	5.32	5.16	5.24				
CO ₃	16	0*	16				
Fe	.38	.59*	.38				
Mn	.10	.10	.10				
NO ₃	.5	.2*	.5				
As	.015	.015	.015				
% EPM Error	1.3	6.9					
Excess	A	C					

OBSERVED VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

Well Number	27	27	27	27	27		
Date	071075	091875	123075	022276	033076		
State Lab Number	36706	37254	37928	38274	38499		
Depth (meters)	23.62					Mean Values	(27)
Temperature(°C)	17.0	17.5	9.0	8.0	9.0		
pH	7.39	7.92	7.80	7.88	7.73	7.74	
E.C.	479		430	430	405	436	
Ca	38	40	34	34	32	36	
Mg	8	8	7	6	5	7	
Na	57	59	61	56	59	58	
K	1	1	1	1	1	1	
Cl	9	7	8	7	7	7	
SO ₄	26	24	24	25	24	25	
HCO ₃	246	244	242	234	239	241	
PO ₄	.24	.30	.24	.19	.27	.25	
F	2.22	2.04	2.18	2.20	2.22	2.17	
CO ₃	0	0	0	0	0	0	
Fe	0	0	.01	0	0	0	
Mn	0	0	.01	0	.01	0	
NO ₃	18.6	17.2	10.0	4.9	2.6	10.7	
As	0	.005	.005	.005	.005	.004	
% EPM Error	1.8	1.5	.65	1.1	1.9		
Excess	A	C	A	A	A		

APPENDIX C

Surface Water Chemistry

MEAN VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

SAMPLE SITE	Unnamed Creek at Historic Marker 17N, 19E, 34 ADBD	Ophir Creek 17N, 19E, 34 DDBB	Bowers Mansion Outlet 16N, 19E, 3 BACB	Unnamed Creek 16N, 19E, 3 BCAD
Temperature (°C)	11.5	8.6	25.4	10
pH	7.69	8.83	8.71	8.09
E.C.	56	60	210	104
Ca	6	6	7	10
Mg	1	1	1	1
Na	7	7	37	13
K	1	2	1	2
Cl	2	2	11	1
SO ₄	4	3	19	2
HCO ₃	29	33	39	58
PO ₄	.07	.09	.17	.10
F	.04	.06	1.75	.10
CO ₃	0	0	14	0
Fe	.10	.11	.03	.09
Mn	0	0	.01	0
NO ₃	.12	.01	.78	.09
As	0	Tr	.01	Tr

MEAN VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

SAMPLE SITE	Browns Creek Diversion 17N, 19E, 23 ADAB	Unnamed Creek 17N, 19E, 23 CDCD	Winters Creek 17N, 19E, 26 BCAA	Davis Creek 17N, 19E, 27 DCDB
Temperature (°C)	3.9	9.6	7.2	15.8
pH	7.78	7.91	7.88	7.96
E.C.	70	101	77	73
Ca	7	8	8	9
Mg	1	2	1	1
Na	9	14	10	10
K	2	2	1	2
Cl	6	5	2	1
SO ₄	4	3	3	4
HCO ₃	34	50	37	43
PO ₄	.08	.08	.07	.07
F	.03	.06	.05	.07
CO ₃	0	0	0	0
Fe	.07	.06	.13	.11
Mn	0	0	0	0
NO ₃	.10	.05	.38	.02
As	Tr	0	Tr	0

MEAN VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

SAMPLE SITE	Franktown Creek 16N, 19E, 3CCDD	Unnamed Creek 16N, 19E, 15 ACAD	Unnamed Creek 16N, 19E, 15 DAAC	Mc Ewen Creek 16N, 19E, 25 OCCC
Temperature (°C)	9.5	9.7	10.8	12.1
pH	7.85	7.72	7.57	7.96
E.C.	70	105	95	274
Ca	6	11	10	19
Mg	1	2	2	6
Na	11	11	11	31
K	1	2	2	6
Cl	2	2	2	6
SO ₄	4	3	3	7
HCO ₃	39	57	53	116
PO ₄	.13	.46	.36	.69
F	.10	.20	.17	.45
CO ₃	0	0	0	5
Fe	.51	.37	.54	.48
Mn	.01	.02	.03	.03
NO ₃	.28	.52	.65	.58
As	Tr	Tr	Tr	Tr

MEAN VALUES OF MEASURED PARAMETERS AND CONCENTRATIONS (ppm)

SAMPLE SITE	Jumbo Creek 16N, 20E, 5 ABCD			
Temperature (°C)	16.2			
pH	8.47			
E.C.	273			
Ca	33			
Mg	6			
Na	18			
K	2			
Cl	3			
SO ₄	14			
HCO ₃	112			
PO ₄	1.23			
F	.15			
CO ₃	12			
Fe	.07			
Mn	.01			
NO ₃	1.88			
As	Tr			