Milestone Report

Preliminary Findings on the Inorganic Geochemical Evolution of Ground Water in the Vicinity of the Pantex Plant

(Activity No. 7 of Appendix C, Supplement to Scope of Work, 1992–1993)

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INTRODUCTION

Since 1991, the Bureau of Economic Geology has sampled 29 wells in the vicinity of the Pantex Plant for hydrochemical analyses (Figure 1). Analyses were conducted of the following constituents (Tables 1 and 2): dissolved metals (cations), metalloids, anions, and inorganic carbon; ammonia; stable isotopes (deuterium [^{2}H], boron-11, carbon-13, nitrogen-15, oxygen-18, and sulfur-34); radiogenic isotopes (tritium [^{3}H] and carbon-14); and unstable parameters such as temperature, Eh (oxidation-reduction potential), pH, alkalinity (as bicarbonate), and dissolved oxygen. Nine of the wells sampled are located in one or more perched aquifers (referred to subsequently as the perched aquifer[s]) above the Ogallala aquifer water table: two private wells offsite (one to the north of the Pantex Plant, one to the west) and seven monitoring wells onsite. In the Ogallala aquifer itself, 19 wells were sampled: nine private wells upgradient from the Pantex Plant (two to the southwest, seven to the south) and ten wells onsite (six water-supply wells and four monitoring wells). In addition, we sampled a nearby private well identified by the Texas Water Development Board as being completed in the underlying (Permian-age) Quartermaster Formation. In the perched aquifer, three wells have been sampled three times and one has been sampled twice; in the Ogallala aquifer, four wells have been sampled three times and two have been sampled twice.

From the results of these analyses (Tables 1 and 2), this report identifies different sources of ground water on the basis of distinctive chemical compositions and demonstrates how those compositions vary along flow paths. Using mineral saturation indices calculated with the numerical speciation program SOLMINEQ.88 (Kharaka and others, 1988) and information on the mineralogy of the Ogallala Formation (McGrath, 1984; Avakian, 1988), the controls on such variations (reactions and mixing of water from different sources) are inferred.

METHODS

Sampling and analyses for unstable parameters, metals and metalloids, anions, deuterium, and oxygen-18, and preparation of inorganic isotopes of carbon and sulfur, were conducted in accordance with the Bureau's Technical Program Manual. Unstable parameters were measured in the field, whereas dissolved metals and metalloids, anions, alkalinity, ammonia, deuterium, and oxygen-18 were analyzed by the Bureau's Mineral Studies Laboratory (MSL). Analyses of dissolved inorganic carbon were conducted by MSL or by Controls for Environmental Pollution, Santa Fe, New Mexico. Analyses for tritium were conducted at the Tritium Laboratory of the University of Miami, Florida. Dr. R. L. Bassett, Department of Hydrology and Water Resources, The University of Arizona, Tucson, performed analyses for boron-11. Carbon-13 (inorganic) and -14 analyses were conducted by Beta Analytic, Miami, Florida, except for samples from wells OM-46, -47, and -48, which were analyzed at the Laboratory of Isotope Geochemistry, The University of Arizona. Dr. Stephen Macko, Department of

Environmental Sciences, The University of Virginia, Charlottesville, performed analyses for carbon-13 (total and organic) and nitrogen-15. Sulfur-34 was measured at the Laboratory of Isotope Geochemistry, The University of Arizona. Supplemental notes on the analyses are given in the appendix.

RESULTS

Ionic and Isotopic Analyses

As illustrated on the Piper diagram (Figure 2), which represents the relative molal concentrations of major cations and anions, ground water in the Ogallala aquifer in the study area is predominantly of mixed cation-bicarbonate (HCO_3^-) composition. This result is consistent with the findings of Nativ (1988) for the northern half of the Southern High Plains. In comparison with the Ogallala aquifer, the water sample from the Quartermaster Formation also exhibits a mixed-cation composition, but the dominant cation is sodium (Na^+) rather than calcium (Ca^{2+}). A majority of the samples from the perched aquifer(s) exhibit a Ca^{2+}-HCO_3^- composition; Ca^{2+} concentrations are higher and magnesium (Mg^{2+}) concentrations are lower in the perched aquifer(s) than in the Ogallala aquifer (Figure 3). With exceptions of the Ogallala well belonging to B. Kinzer and the Quartermaster well, the seven highest chloride (Cl^-) values are for samples from the perched aquifer(s) (Figure 4). Dissolved silicon (Si) concentrations are lower in the perched aquifer(s) than in the Ogallala aquifer at equivalent water level elevations (Figure 5). Among minor dissolved constituents, the five lowest values of fluoride (F^-) occur in the perched aquifer(s). Dissolved species other than Ca^{2+}, Mg^{2+}, Cl^-, Si, and F^- appear to exhibit no systematic differences in concentrations between the perched and Ogallala aquifers.

Isotopic abundances appear to be less useful than ionic concentrations in differentiating between the perched and Ogallala aquifers. A plot of $\delta^{18}O$ (oxygen-18) versus δD (deuterium) (Figure 6) illustrates that all waters sampled fall on or slightly below the global meteoric water line (reflecting the average isotopic composition of precipitation worldwide; Craig, 1961), in keeping with the findings of Nativ (1988) for Ogallala ground water. Values of $\delta^{13}C$ (carbon-13) obtained by different methods are inconsistent, but the isotopically lightest (most negative) values of inorganic carbon occur in the perched aquifer(s). Levels of the radioisotopes ^{3}H and ^{14}C (carbon-14) are higher in the perched aquifer(s) than in the underlying Ogallala aquifer at the Pantex Plant, but such levels are comparable between the perched aquifer(s) and the Ogallala aquifer where it is upgradient and shallower to the south and southwest (Figure 7a–d).

Speciation Modeling

The Ogallala Formation in various locations consists of pebble- and cobble-sized clasts of igneous, metamorphic, and sedimentary rock fragments; sand- and silt-sized grains (primarily quartz, with lesser amounts of feldspar and accessory minerals); clay-sized grains (phyllosilicates and iron and manganese oxides); and caliche, consisting of calcite, with minor amounts of opal, chalcedony, and dolomite (Avakian, 1988). Speciation modeling has been conducted for some of these minerals to determine the saturation index:

$$SI = \log (IAP\ K_T^{-1})$$

where IAP is the ion activity product for the ions comprising each mineral, and K_T is the equilibrium solubility constant of the mineral at the temperature of the solution.

Supersaturation (SI >0) indicates that precipitation of a compound is thermodynamically favorable, whereas undersaturation (SI <0) indicates that dissolution is favored; saturation occurs at SI = 0. However, precipitation does not automatically accompany supersaturation; slow rates of reaction can inhibit precipitation.

SOLMINEQ.88 calculations indicate that ground water in the study area is supersaturated with respect to quartz (SiO_2) but is undersaturated with respect to amorphous silica (analogous to opal). Reflecting the difference in distribution of dissolved Si, saturation indices for amorphous silica and quartz in the perched aquifer(s) are less than in the Ogallala aquifer at comparable elevations (Figure 8). Determining the saturation state of aluminosilicates (such as feldspars and clay minerals) is limited by the fact that, in all but one instance, aluminum concentrations in solution are below the detection limit of 0.24 to 0.27 mg L^{-1}. Assuming that aluminum concentrations are equal to the detection limit results in saturation indices for illite, kaolinite, and sodium and calcium smectites as high as 10 (indicating supersaturation by a factor of 10 orders of magnitude). Conversely, setting aluminum equal to 0 gives solutions which are infinitely undersaturated with respect to aluminosilicates (a theoretical impossibility). The non-aluminous phyllosilicate sepiolite ($Mg_4Si_6O_{15}(OH)_2{\bullet}6H_2O$), while globally uncommon, has been identified as a major clay mineral in parts of the Ogallala Formation (McGrath, 1984). Water samples from the perched aquifer(s) exhibit both the lowest and highest saturation indices for sepiolite (Figure 9). Ground water in the area is generally undersaturated with respect to sepiolite, with perched ground water more undersaturated than Ogallala ground water. No systematic differences between the perched and Ogallala aquifers are evident regarding the saturation indices of calcite ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) (Figure 10). These ground-water samples are invariably supersaturated with respect to dolomite, with most having a saturation index between 1 and 2. Most are slightly supersaturated with respect to calcite; saturation indices generally fall between 0 and 0.5.

DISCUSSION

Ca^{2+}:Mg^{2+} molal ratios in perched ground water appear to decline away from playa 1 toward the ratio of approximately 1:1 observed in the Ogallala aquifer. This decline, which is reflected in the shift from Ca^{2+}-HCO_3^- to mixed cation-HCO_3^- hydrochemical facies, may be a function of the residence time of water in the perched aquifer(s). Figure 11 illustrates the decline in Ca^{2+}:Mg^{2+} ratios as a function of dissolved carbon-14, which is a useful gauge of travel time if decreases in isotopic abundance along flowpaths result primarily from radioactive decay. However, dissolved carbon-14 could also decrease as a result of the dissolution of relatively old carbonate minerals in the perched aquifer(s), so the correlation of isotopic abundance with residence time should be viewed with caution.

Based on speciation modeling and published descriptions of Ogallala mineralogy, two plausible explanations for the Ca^{2+}:Mg^{2+} shift emerge: (1) dissolution of a magnesium silicate mineral such as sepiolite and precipitation of a calcium silicate mineral such as calcium smectite or (2) exchange of Ca^{2+} in perched ground water for Mg^{2+} on clay minerals as a consequence of the precipitation and dissolution of caliche. The first scenario is supported by the strong negative correlation between the saturation index of sepiolite and carbon-14 in the perched aquifer(s) (Figure 12), discounting the calculated saturation indices for sepiolite in PM-106 and PM-103. The saturation index calculated for PM-106 (11.6) is suspect because it is based on a measured pH (9.88) which is unusually high, perhaps because of contamination by cement during well construction (Lin-Hua and Atkinson, 1991). PM-103, with a saturation index of 0.473, is discounted because it was not sampled for carbon-14. The increase in the saturation index of sepiolite with travel time appears to be largely a result of the increase in the concentration of Mg^{2+}. It seems that dissolution of sepiolite would have to be accompanied by precipitation of a calcium silicate, such as calcium smectite, in order to maintain the relatively uniform concentrations of Si observed in the perched aquifer(s). However, as noted above, it is difficult to determine the saturation index for calcium smectite because of the lack of data on aluminum concentrations.

The second explanation for the cation shift, Ca^{2+}-Mg^{2+} exchange, is simpler because, unlike sepiolite dissolution, this process does not directly affect Si concentrations. Potratz (1980) attributed shifts in the $Ca^{2+}:Mg^{2+}$ ratio of Ogallala ground water for the northern half of the Southern High Plains to the precipitation and dissolution of caliche. With the precipitation of caliche, the $Ca^{2+}:Mg^{2+}$ ratio in soil solution would have decreased, permitting increased adhesion of Mg^{2+} onto clay minerals in the sediments comprising the present-day perched aquifer(s). Subsequent dissolution of caliche under changed climatic conditions would lead to elevated concentrations of Ca^{2+} (and elevated $Ca^{2+}:Mg^{2+}$ ratios) in water entering the perched aquifer(s), thus driving ion exchange.

The differences in Si concentrations between ground water in the perched aquifer(s) and in the shallow Ogallala aquifer may reflect differences in the depositional settings of the aquifers. Beneath the Pantex Plant, the Ogallala Formation occupies a paleovalley; fluvial sands and gravels are interbedded with and overlain by aeolian deposits (Gustavson and Winkler, 1988). To the south and southwest of the Pantex Plant, on the flank of the paleovalley, the base of the Ogallala Formation becomes shallower and the fluvial deposits are (in the absence of core data) assumed to be absent. The very fine aeolian sands are likely to have lower values of hydraulic conductivity than the relatively coarse-grained fluvial sediments (Nativ, 1988), as well as higher mineral surface areas. Therefore, the relatively high concentrations of dissolved Si south and southwest of the Pantex Plant presumably result from prolonged ground-water residence times and/or relatively low water to sediment ratios. Conversely, lower-Si water in the perched aquifer(s) may reflect the presence of coarser clastic assemblages, as observed in core from well OM-105 (formerly BEG-PTX No. 2) (T. C. Gustavson, Bureau of Economic Geology, personal communication, 1993). The linear decline in Si concentrations downgradient in the Ogallala aquifer may result from (1) precipitation of quartz along flowpaths and/or (2) dilution of high-Si water from the south and southwest by low-Si water percolating downward from the perched aquifer(s).

The occurrence of tritium in the perched aquifer(s) indicates the presence of water younger than 1952, the start of global atmospheric nuclear testing (Domenico and Schwartz, 1990). The apparent lack of tritium in the underlying Ogallala aquifer may mean either that post-1952 water in the perched aquifer(s) has not yet arrived at the Ogallala water table or that such water is being diluted by mixing with Ogallala ground water. In the absence of data from multiple depths in a single Ogallala monitoring well, neither explanation can be discounted. However, levels of tritium indicate that recharge to the Ogallala aquifer to the south and southwest has occurred since 1952. The scatter of oxygen-18 and deuterium data along the global meteoric water line indicates that evaporative concentration of recharge waters is minimal. This supports the hypothesis that recharge in the study area is focused through playa basins (Nativ, 1988).

SUMMARY AND CONCLUSIONS

Hydrochemical analyses indicate that ground water in the perched aquifer(s) can be differentiated from Ogallala ground water in the study area on the basis of several parameters, the most reliable of which appears to be the concentration of Si. In perched ground water adjacent to playas, Ca:Mg molal ratios and Cl^- concentrations are higher than elsewhere. In addition, radioisotope levels in the perched aquifer(s) are higher than in the Ogallala aquifer beneath the Pantex Plant. However, as noted by Mullican and others (1993), it is not possible to differentiate among perched aquifers geochemically, except perhaps between the perched aquifer on the Clarence Wink homestead, with its unusually low concentrations of Na^+ and Cl^-, and the perched aquifer(s) at the Pantex Plant.

Ca^{2+}:Mg^{2+} molal ratios appear to evolve with travel time in the perched aquifer(s) toward the ratio of approximately 1:1 observed in the Ogallala aquifer. Based on speciation modeling and published descriptions of Ogallala mineralogy, two plausible explanations for this shift emerge: (1) dissolution of a magnesium silicate mineral such as sepiolite and precipitation of a calcium silicate mineral such as calcium smectite or (2) exchange of Ca^{2+} in perched ground water for Mg^{2+} on clay minerals as a consequence of the precipitation and dissolution of caliche. The differences in Si concentrations between the perched aquifer(s) and the upgradient Ogallala aquifer to the south and southwest may result from differences in the depositional settings of the aquifers. The decrease in Si concentrations along Ogallala flow paths can be explained by the precipitation of quartz or by the mixing of separate sources of recharge to the Ogallala. Although percolation from the perched aquifer(s) to the Ogallala aquifer beneath the Pantex Plant is suggested by Si data, the timing of such percolation cannot be conclusively determined by tritium data at present.

The inferences regarding the chemical evolution of ground water will be expanded above the water table with the acquisition of additional data from water samples (rainfall, playa water, and soil solution) and sediment samples (to be analyzed at various depths for whole-rock mineralogy, clay mineralogy, exchangeable cations, and stable isotopes).

These inferences will then be tested by reaction-path modeling, wherein dissolution, precipitation, ion exchange, and mixing will be simulated along flow paths.

REFERENCES

Avakian, A. J., 1988, Mineralogy of the Ogallala Formation, Southern High Plains: new lithologic, petrographic, and X-ray diffraction data from West Texas cores: The University of Texas at Austin, Bureau of Economic Geology, unpublished report, 46 p.

Craig, H., 1961, Isotopic variations in meteoric water: Science, v. 133, p. 1702–1703.

Domenico, P. A., and Schwartz, F. W., 1990, Physical and chemical hydrogeology: New York, John Wiley & Sons, 824 p.

Gustavson, T. C., and Winkler, D. A., 1988, Depositional facies of the Miocene–Pliocene Ogallala Formation, northwestern Texas and eastern New Mexico: Geology, v. 16, p. 203–206.

Kharaka, Y. K., Gunter, W. D., Aggarwal, P. K., Perkins, E. H., and DeBraal, J. D., 1988, SOLMINEQ.88: a computer program for geochemical modeling of water-rock interactions: U.S. Geological Survey, Water-Resources Investigations Report 88-4227, 420 p.

Lin-Hua, Song, and Atkinson, T. C., 1991, Chemical reaction between concrete and natural groundwater and its implications for the commissioning of observation boreholes in chalk: Quarterly Journal of Engineering Geology, v. 24, p. 221–229.

McGrath, D. A., 1984, Morphological and mineralogical characteristics of indurated caliches of the Llano Estacado: Lubbock, Texas, Texas Tech University, Master's thesis, 209 p.

Mullican, W. F., III, Fryar, A. E., and Johns, N. D., 1993, The areal extent and hydraulic continuity of perched ground water in the vicinity of the Pantex Plant: The University of Texas at Austin, Bureau of Economic Geology, report prepared for the U.S. Department of Energy under subgrant to DOE grant no. DE-FG04-90AL65847, 17 p.

Nativ, Ronit, 1988, Hydrogeology and hydrochemistry of the Ogallala aquifer, Southern High Plains, Texas Panhandle and Eastern New Mexico: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 177, 64 p.

Potratz, V. Y., 1980, Ground-water geochemistry of the Ogallala aquifer in the Southern High Plains of Texas and New Mexico: Lubbock, Texas, Texas Tech University, Master's thesis, 107 p.

APPENDIX. Notes on Tables 1 and 2

1. The notation "<" indicates a value below the analytical detection limit.

2. For pH and HCO_3^-, the notations "(lab)" and "(field)" indicate where the measurements were taken.

3. Nitrate values are reported in mg/L as NO_3^-; the conversion to concentration in mg/L as N is $N = 0.226 \times NO_3^-$.

4. "MSL #" refers to the sample ID assigned by the Bureau's Mineral Studies Laboratory, where most analyses were performed. "Sample #" refers to the order in which the well was sampled, relative to other Pantex-project wells, in a given month and year.

5. Analyses of metals and metalloids were conducted on unfiltered and 0.45-micron filtered splits for samples 0593-1 through 0593-5, and on unfiltered, 0.45-micron filtered, and 0.2-micron filtered splits for samples 0693-1 and 0893-1; graphs represent 0.45-micron filtered values.

6. Apart from Figures 2 and 7a–b, in which the most recent data for each well are presented, all figures represent the values of ionic and isotopic constituents obtained at the time each well was initially sampled.

7. In instances where the concentration of a constituent was reported as below the analytical detection limit, a value of 0 was typically input to the program.

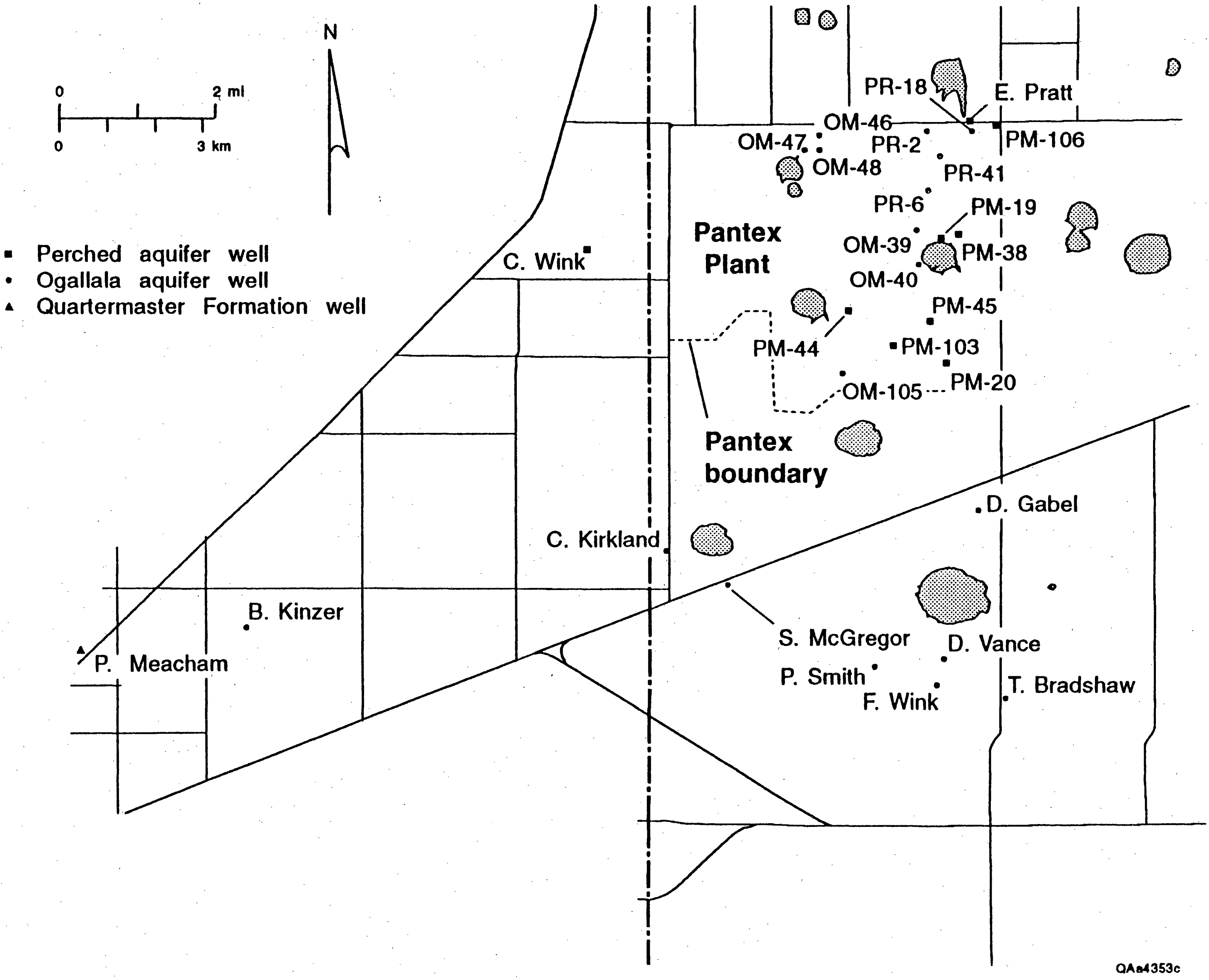


Figure 1. Location map of wells sampled by the Bureau of Economic Geology in the area of the Pantex Plant. Landowners and/or tenants of private properties are indicated.

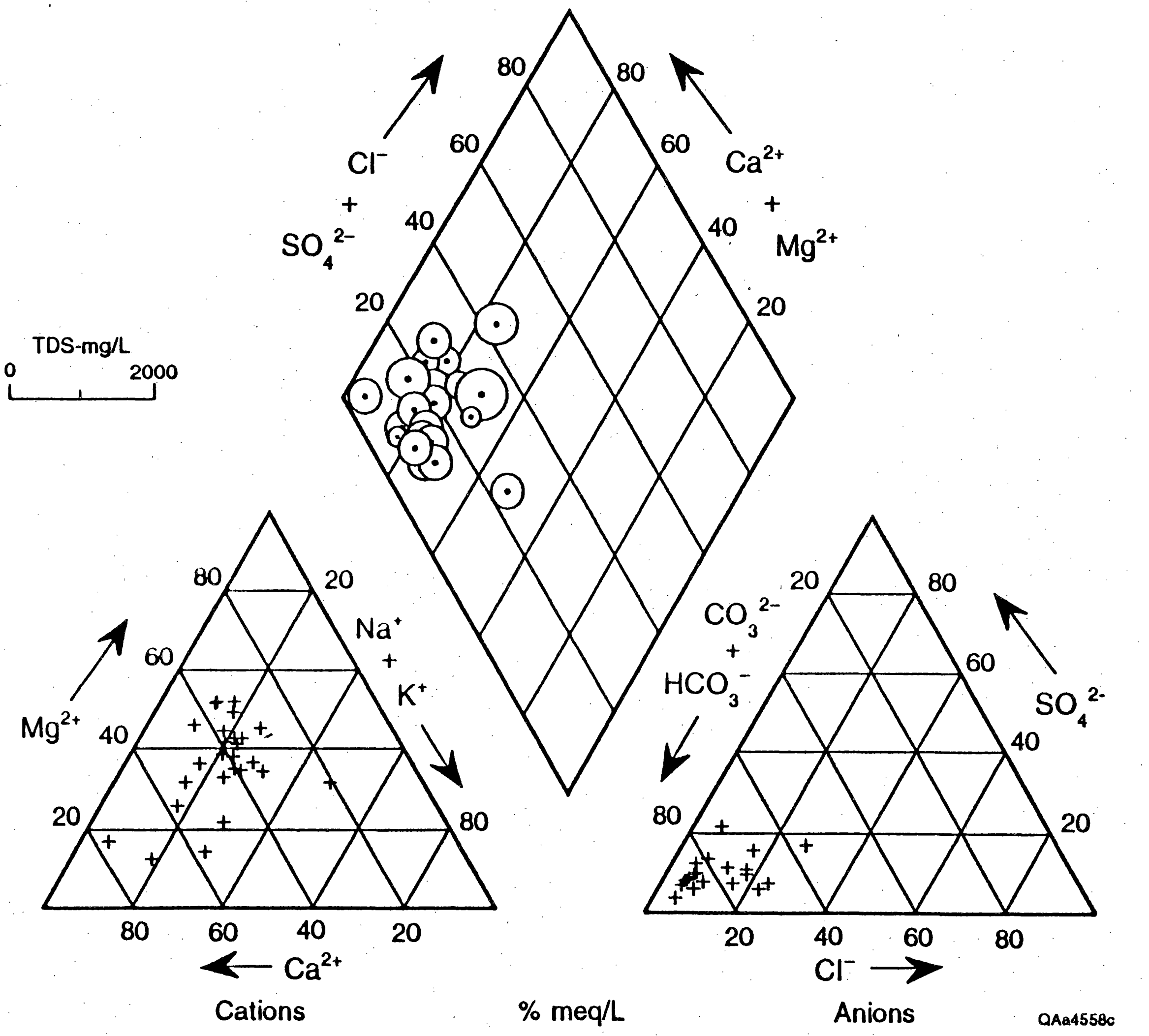


Figure 2. Piper diagram of all wells sampled through June 1993. Diameter of circles is proportional to concentration of total dissolved solids (TDS; see scale at upper left).

Figure 3. Dissolved calcium and magnesium in ground water

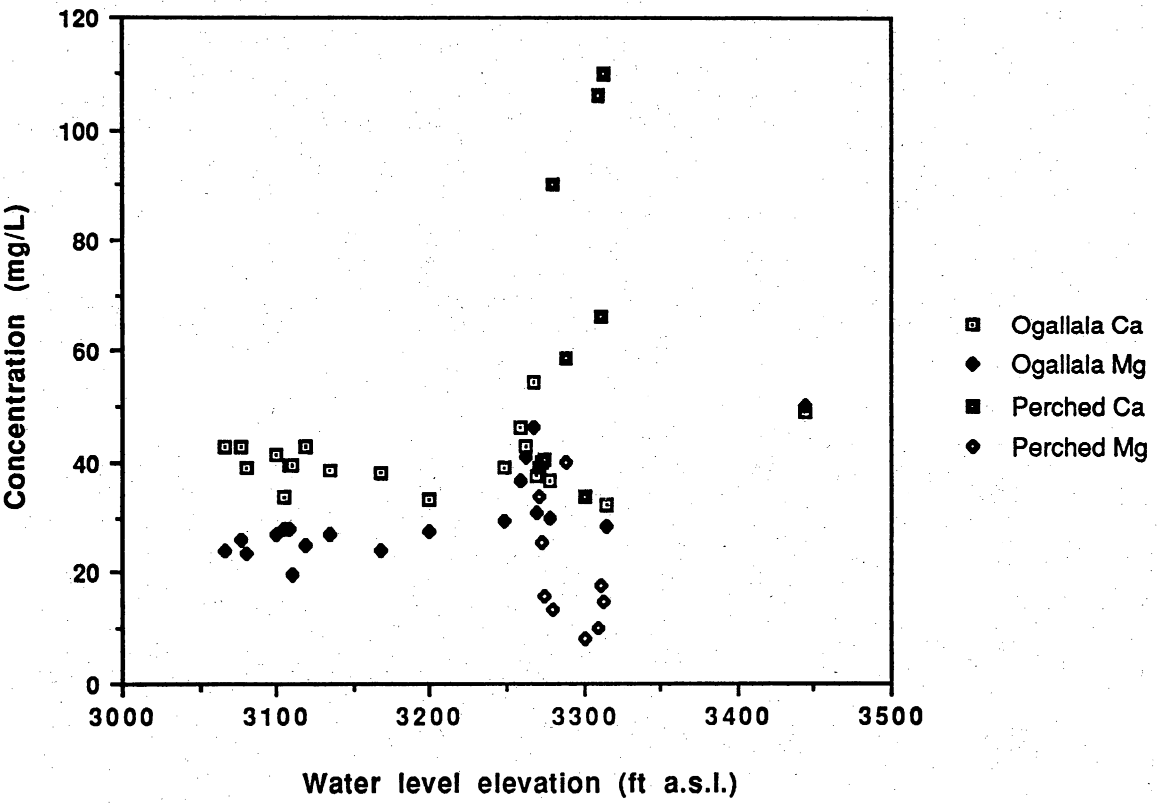


Figure 4. Chloride in perched and Ogallala ground water

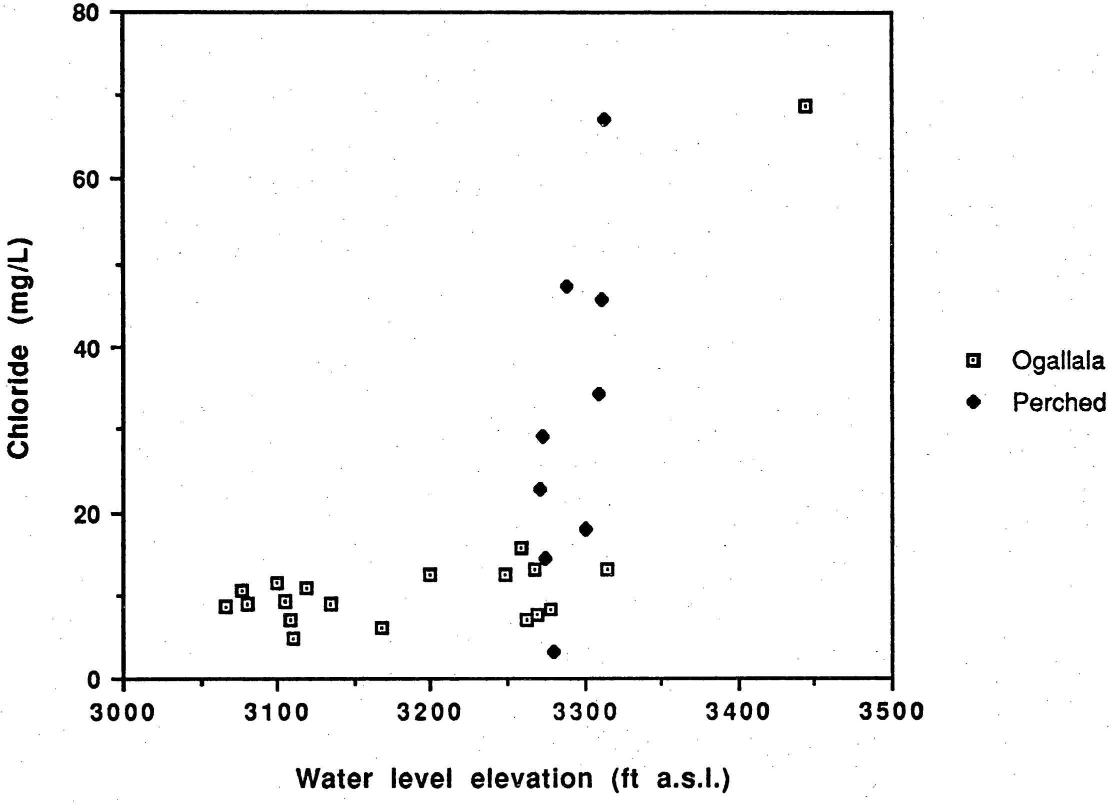


Figure 5. Silicon in perched and Ogallala ground water

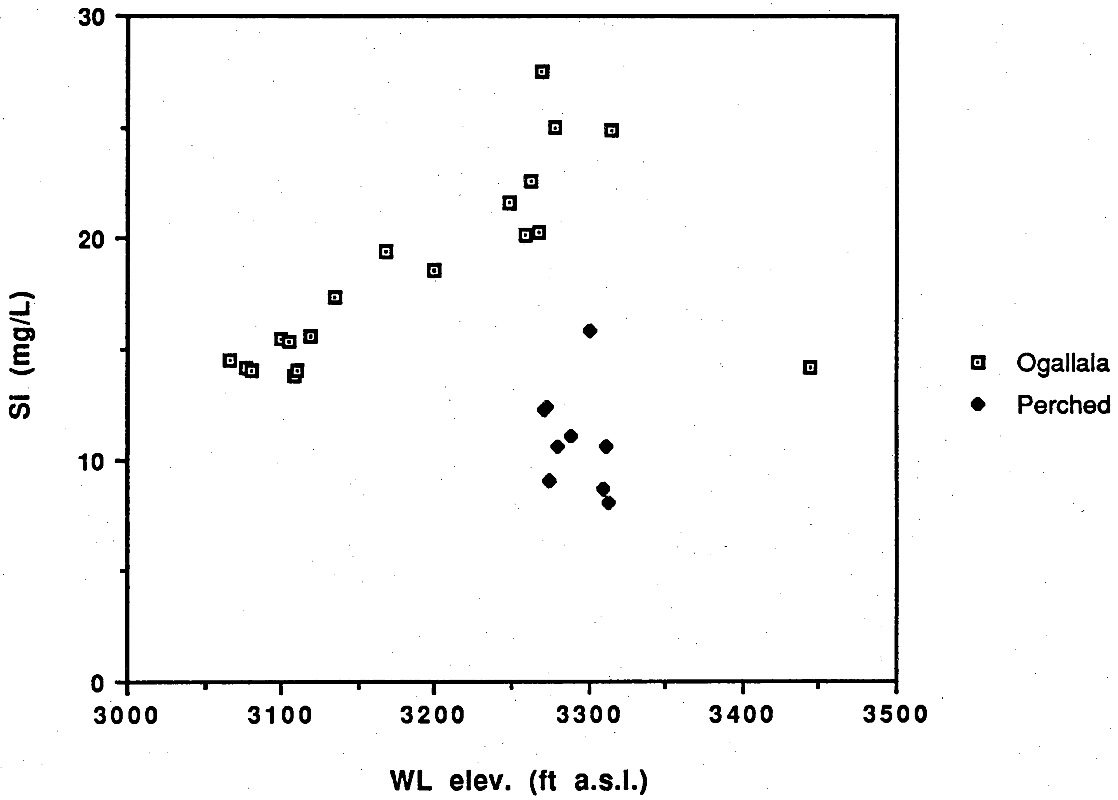
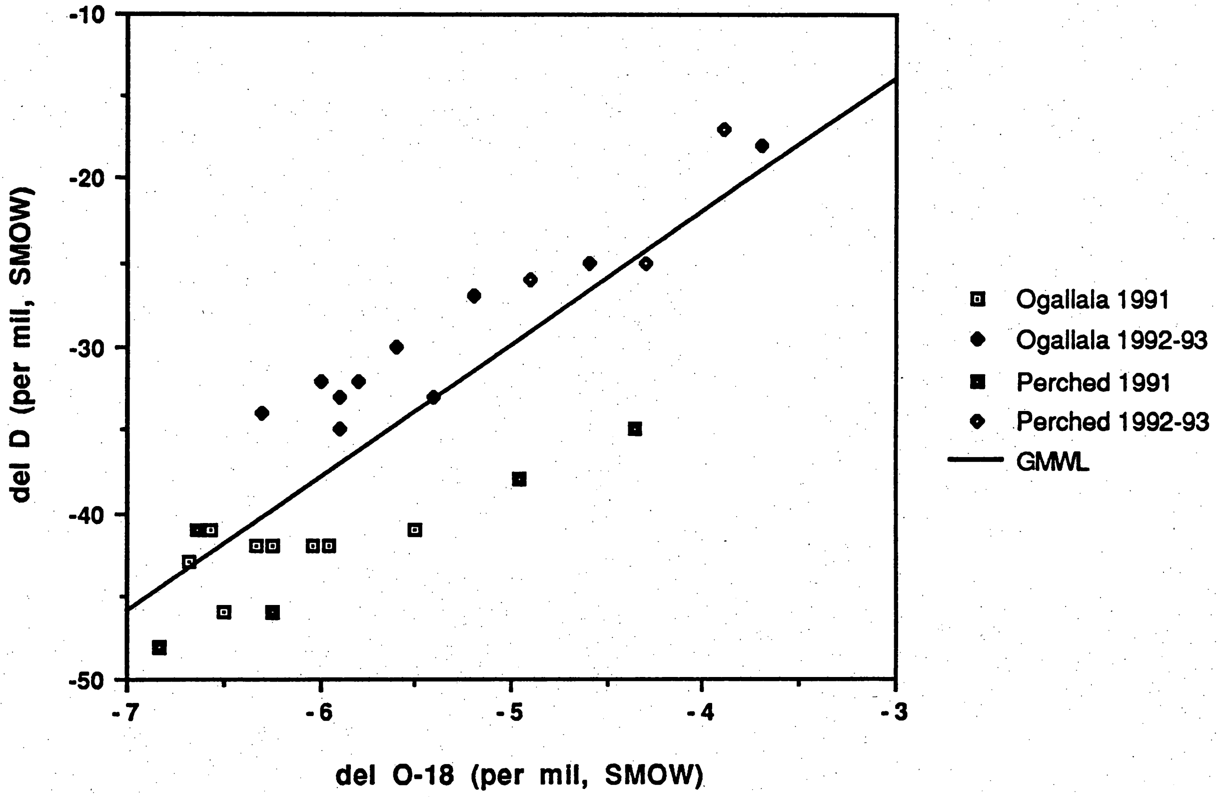


Figure 6. Deuterium vs. oxygen-18 in perched and Ogallala ground water



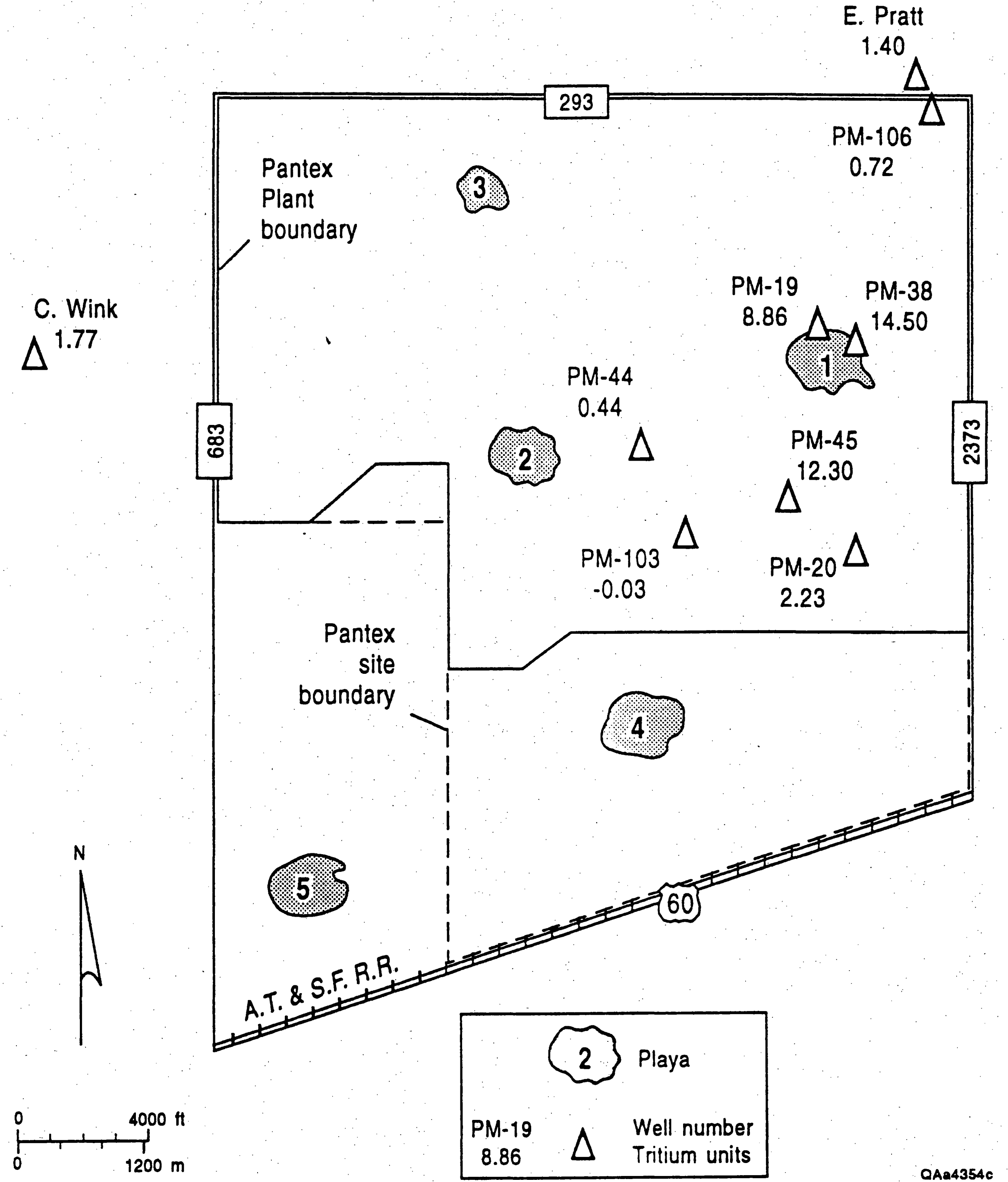


Figure 7 (a). Tritium distributions in the perched aquifer(s).

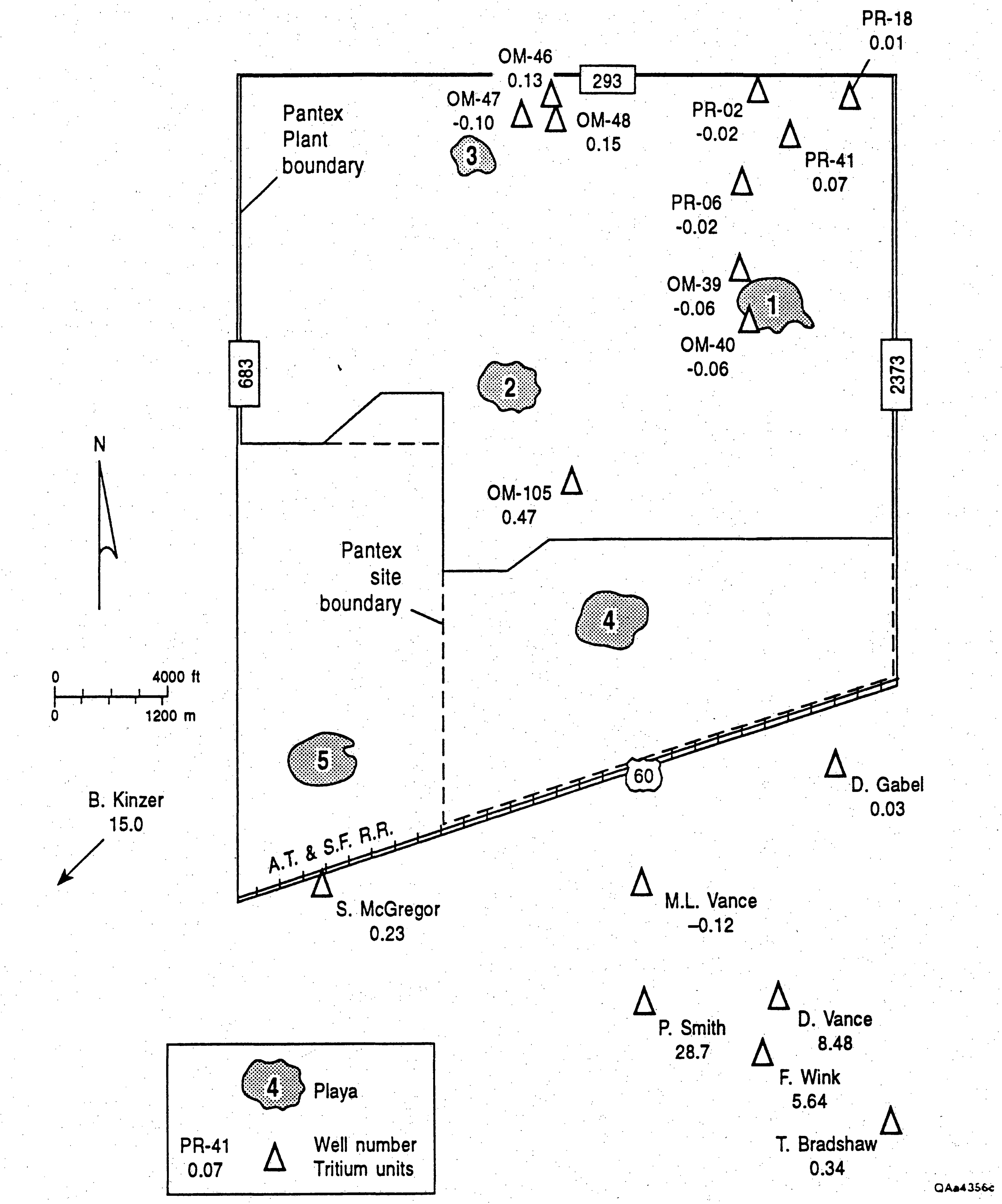


Figure 7 (b). Tritium distributions in the Ogallala aquifer.

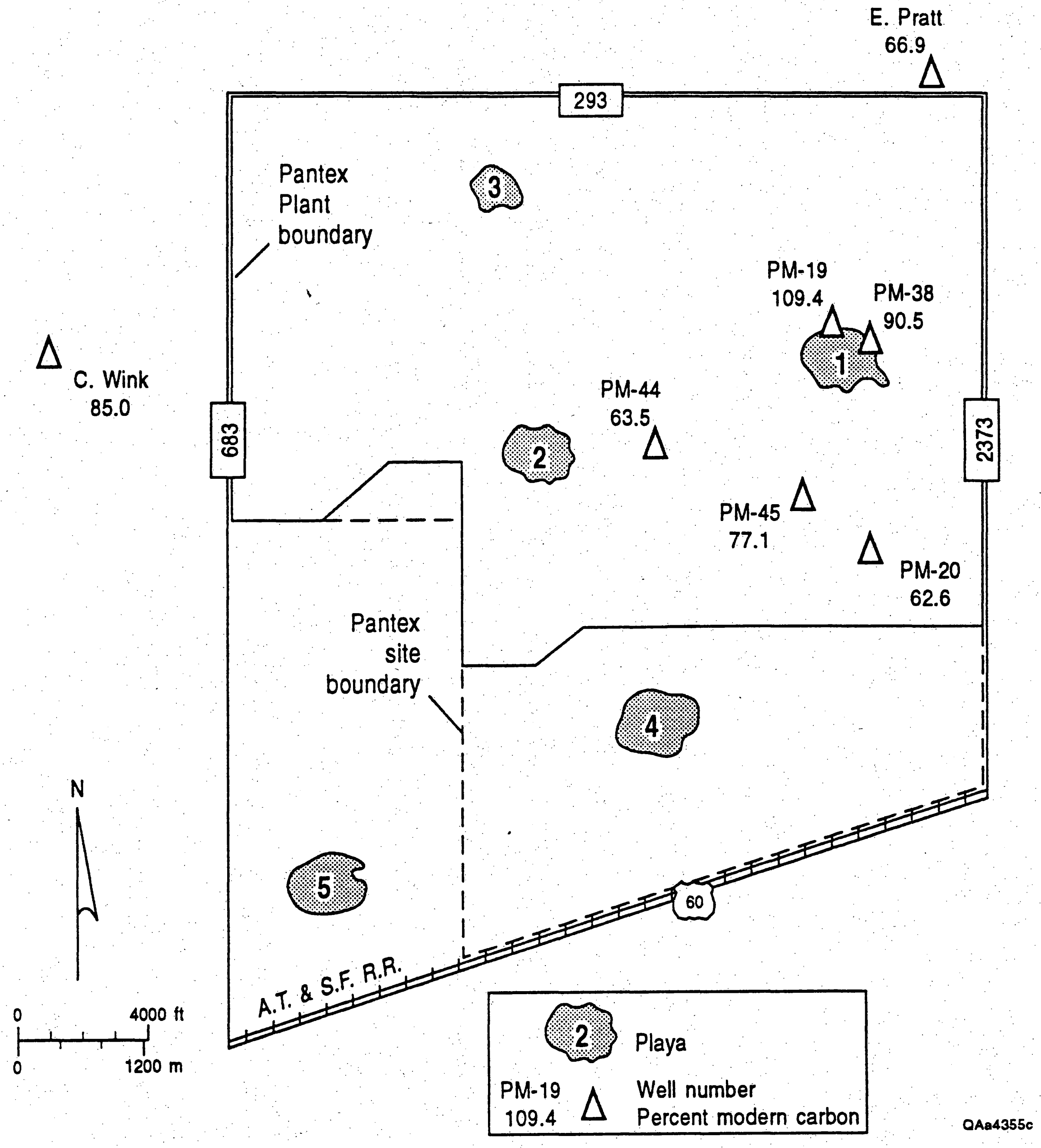


Figure 7 (c). Carbon-14 distributions in the perched aquifer(s).

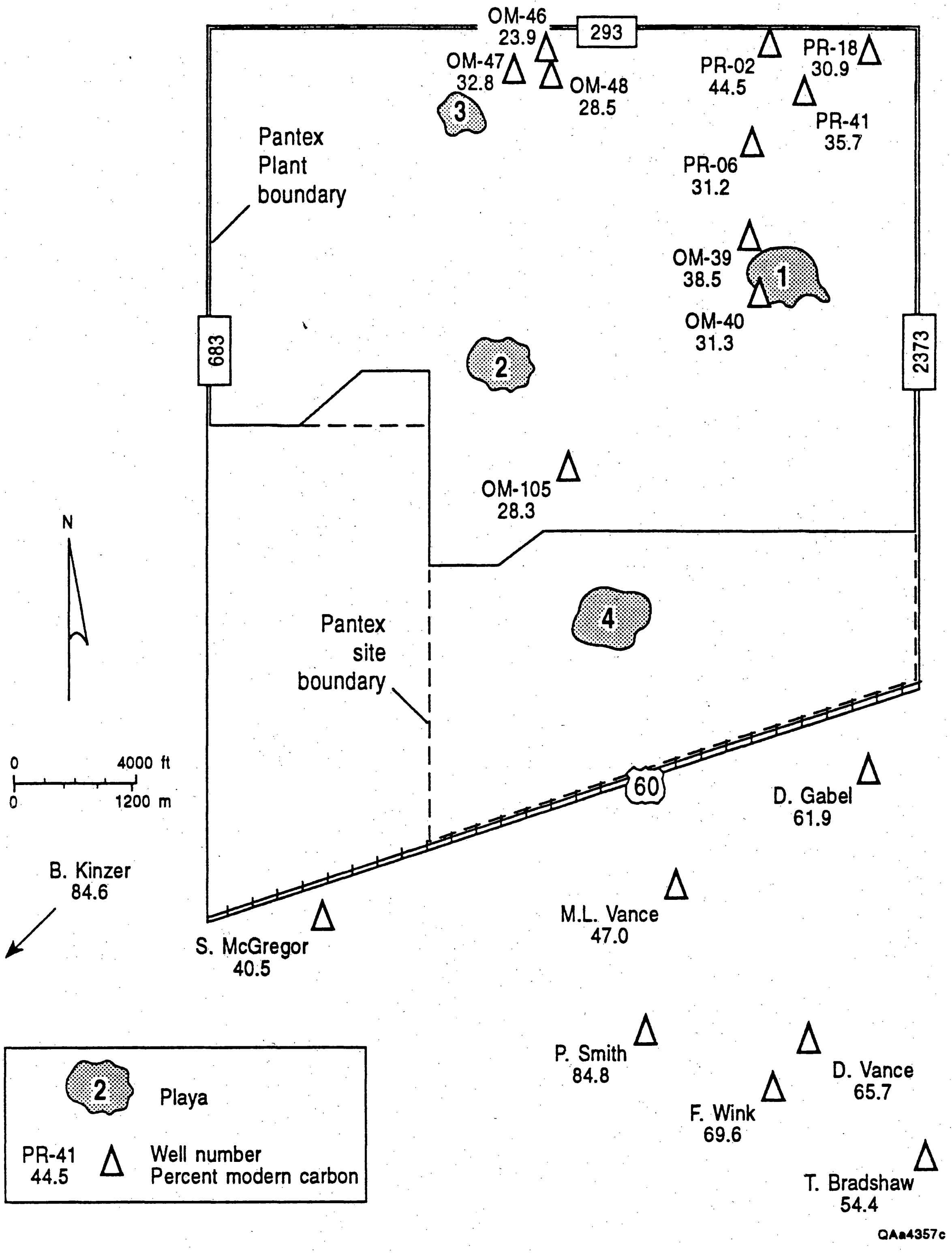


Figure 7 (d). Carbon-14 distributions in the Ogallala aquifer.

Figure 8. Saturation indices for quartz (qtz.) and amorphous (am.) silica in the perched (Pc.) and Ogallala (Og.) aquifers

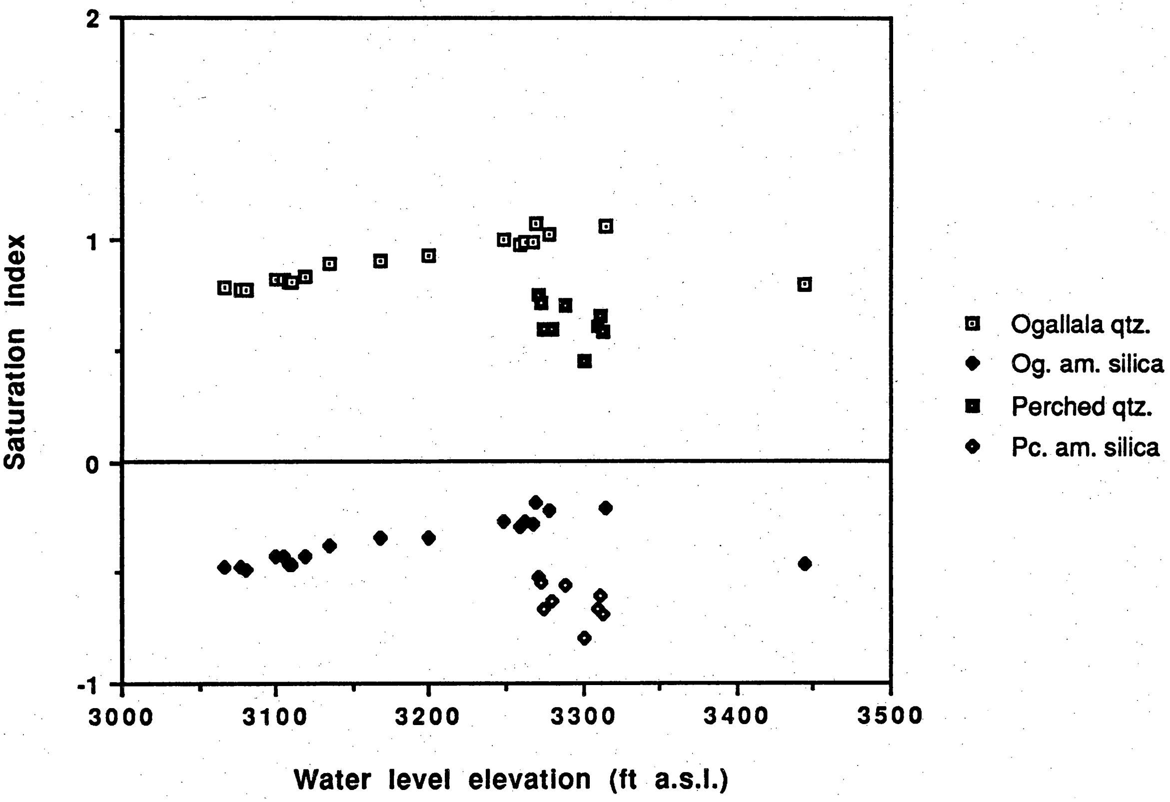


Figure 9. Saturation index for sepiolite in the perched and Ogallala aquifers

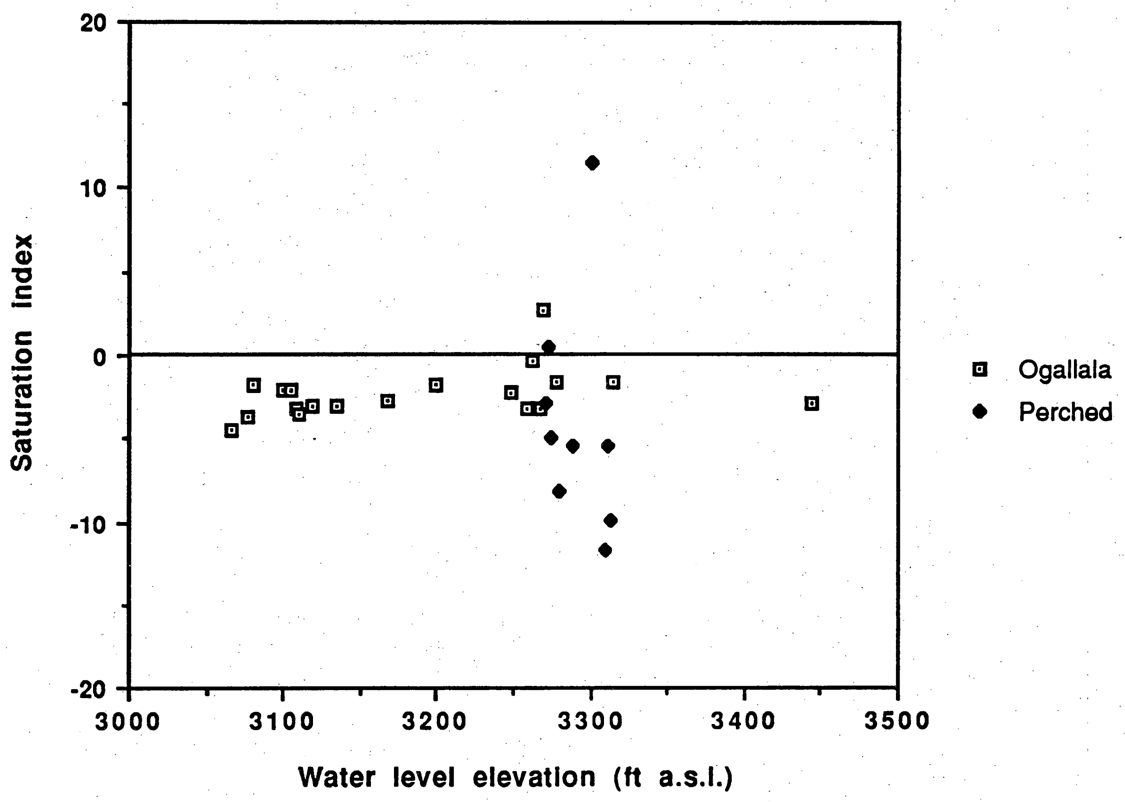


Figure 10. Saturation indices for carbonate minerals calcite (cal.) and dolomite (dol.) in the perched and Ogallala aquifers

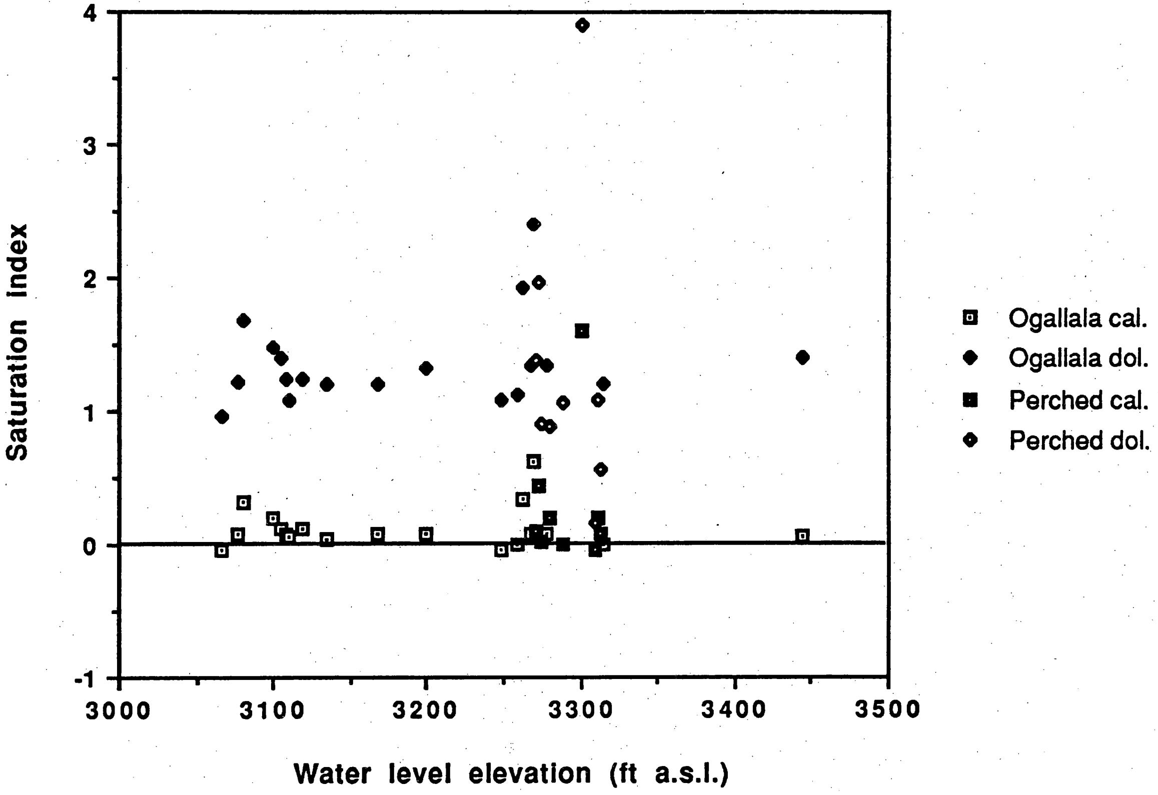


Figure 11. Calcium to magnesium molal ratio as an inferred function of travel time in the perched and Ogallala aquifers

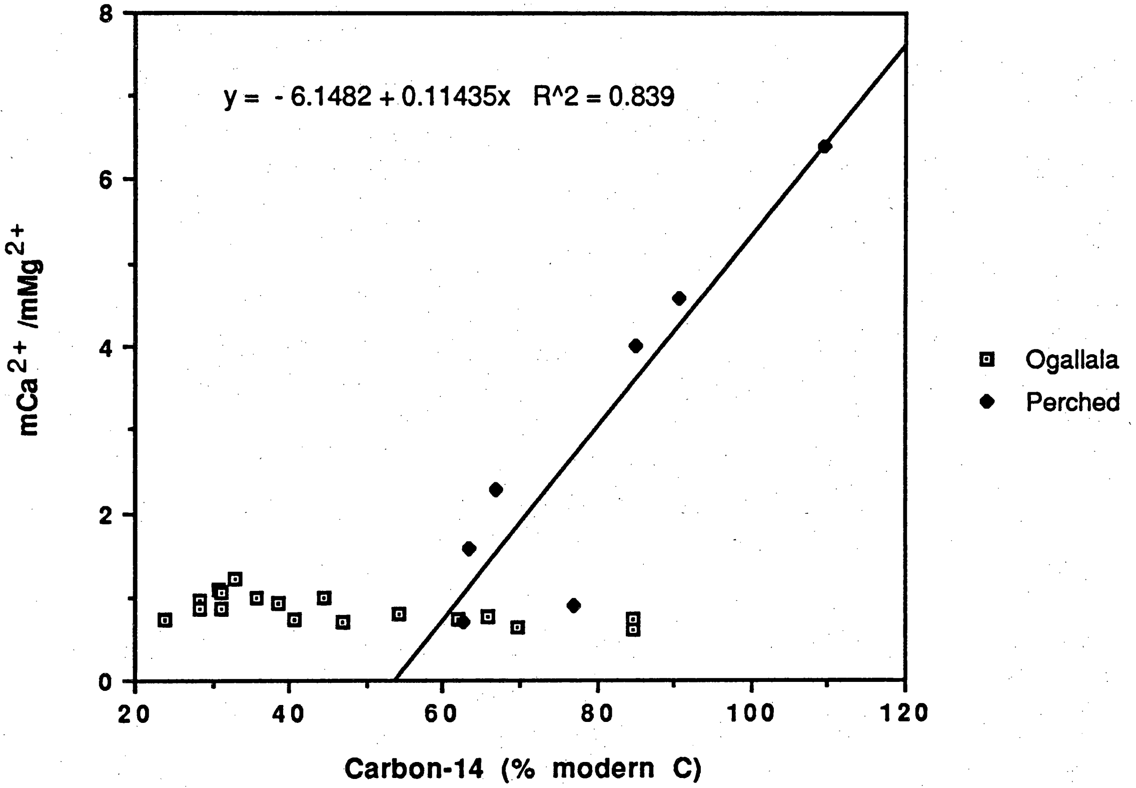


Figure 12. Saturation index of sepiolite as an inferred function of travel time in the perched and Ogallala aquifers

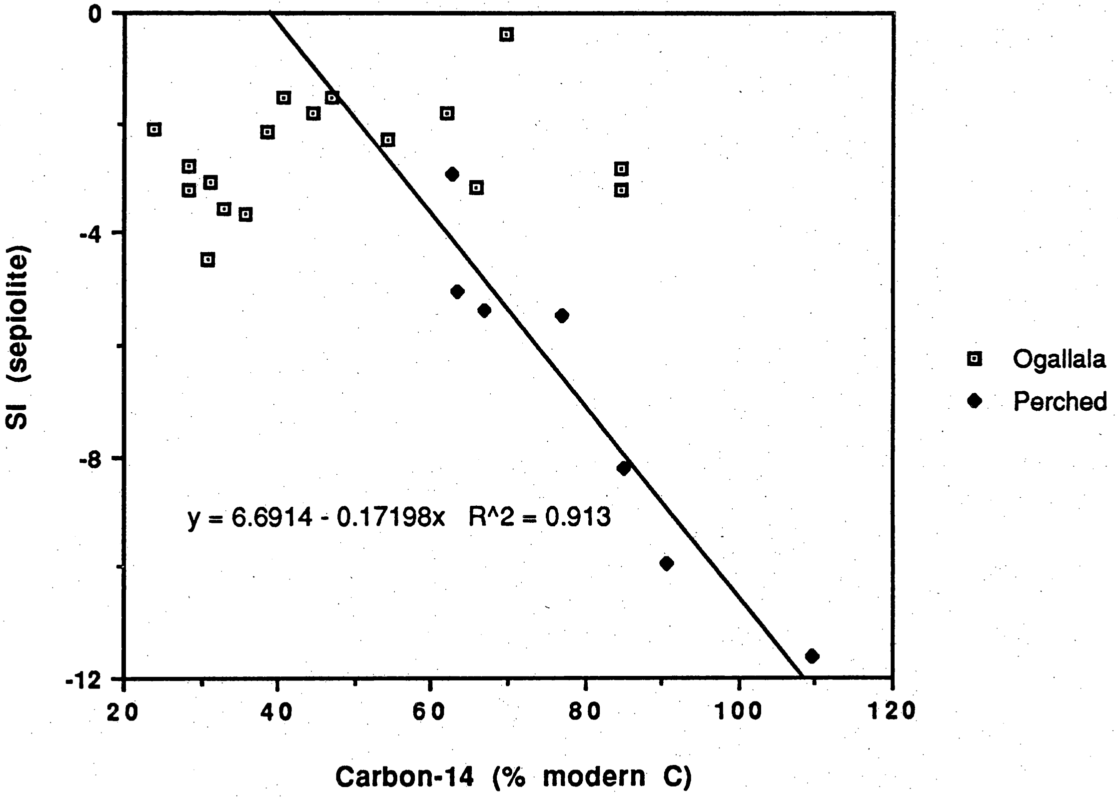


Table 1-1991/1992 Data

WELL #	MSL #	SAMPLE #	MSL #	SAMPLE #	Na(mg/l)	Na(mg/l)
	1991	1991	1992	1992	1991	1992
PM-19	91-628, -642; 93-942	WR-19	92-1022	1092-7	30.4	31.6
PM-20	91-629, -641	WR-20	92-1019	1092-4	13.4	13.1
PM-38	91-630, -643; 93-943	WR-38	92-1017	1092-2	60.2	56.8
OM-40	91-631, -640; 93-940	WR-40	92-1020	1092-5	23.9	23.0
PM-44	91-632, -644; 93-944	WR-44	92-1026	1092-11	13.0	13.1
PM-45	91-633, -649A; 93-941	WR-45	92-1018	1092-3	14.4	15.7
PR-02	91-634, -639; 93-939	WR-02	92-1029	1092-14	30.1	27.2
PR-06	91-635, -647; 93-937	WR-06			21.1	
PR-41	91-636, -648; 93-948	WR-41	92-1024	1092-9	23.8	32.0
OM-39	91-637, -646; 93-946	WR-39	92-1027	1092-12	20.4	20.7
PR-18	91-638, -645; 93-945	WR-18			25.9	
OM-46	91-898, -901	WR-46			25.1	
OM-47	91-899, -902	WR-47			12.1	
OM-48	91-900, -903	WR-48			18.3	
C. WINK			92-1016, -1043; 93-241	1092-1		5.9
P. SMITH			92-1021, -1044; 93-242	1092-6		18.2
PM-106			92-1023, -1045; 93-243, -1411	1092-8		18.3
F. WINK			92-1025, -1046; 93-244	1092-10		20.4
PRATT/SWINDLE			92-1028, -1047; 93-245	1092-13		19.3
OM-105			92-1030, -1048; 93-246	1092-15		25.9

WELL #	K(mg/l) 1991	K(mg/l) 1992	Mg(mg/l) 1991	Mg(mg/l) 1992	Ca(mg/l) 1991	Ca(mg/l) 1992	V(mg/l) 1991	V(mg/l) 1992	Al(mg/l) 1991	Al(mg/l) 1992
PM-19	3.22	3.66	10.1	10.3	106.0	117.0	<0.04	<0.04	<0.24	<0.27
PM-20	6.10	6.52	33.6	35.8	38.9	41.6	<0.04	<0.04	<0.24	<0.27
PM-38	5.63	5.38	14.8	14.2	110.0	110.0	<0.04	<0.04	<0.24	<0.27
OM-40	6.07	5.94	26.9	26.7	38.4	39.0	<0.04	<0.04	<0.24	<0.27
PM-44	4.85	4.74	15.7	15.0	40.3	40.1	<0.04	<0.04	<0.24	<0.27
PM-45	6.70	7.28	39.8	42.5	58.6	62.8	<0.04	<0.04	<0.24	<0.27
PR-02	5.64	5.76	23.4	22.7	38.7	40.1	<0.04	<0.04	<0.24	<0.27
PR-06	5.61		24.9		42.7		<0.04		<0.24	
PR-41	5.68	5.95	26.1	24.3	42.9	40.3	<0.04	<0.04	<0.24	<0.27
OM-39	5.60	6.02	26.9	26.1	41.5	41.5	<0.04	<0.04	<0.24	<0.27
PR-18	5.58		24.0		42.5		<0.04		<0.24	
OM-46	6.81		27.8		33.8		<0.04		<0.27	
OM-47	6.67		19.7		39.6		<0.04		<0.27	
OM-48	6.96		27.6		39.2		<0.04		<0.27	
C. WINK		3.36		13.6		90.3		<0.04		<0.27
P. SMITH		7.10		45.9		54.2		<0.04		<0.27
PM-106		5.73		8.4		33.4		<0.04		<0.27
F. WINK		6.52		40.7		42.6		<0.04		<0.27
PRATT/SWINDLE		5.91		17.6		66.0		<0.04		<0.27
OM-105		6.77		23.9		37.9		<0.04		<0.27

WELL #	Fe(mg/l)	Fe(mg/l)	Ti(mg/l)	Ti(mg/l)	Co(mg/l)	Co(mg/l)	Cr(mg/l)	Cr(mg/l)	Cu(mg/l)	Cu(mg/l)
	1991	1992	1991	1992	1991	1992	1991	1992	1991	1992
PM-19	0.31	0.73	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PM-20	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	*0.05	0.2	<0.03	<0.03
PM-38	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
OM-40	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PM-44	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PM-45	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PR-02	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PR-06	<0.02		<0.08		<0.03		<0.03		<0.03	
PR-41	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
OM-39	<0.02	<0.02	<0.08	<0.09	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PR-18	<0.02		<0.08		<0.03		<0.03		<0.03	
OM-46	<0.02		<0.09		<0.03		<0.03		<0.03	
OM-47	<0.02		<0.09		<0.03		<0.03		<0.03	
OM-48	<0.02		<0.09		<0.03		<0.03		<0.03	
C. WINK		0.44		<0.09		<0.03		<0.03		<0.03
P. SMITH		*0.07		<0.09		<0.03		<0.03		<0.03
PM-106		<0.02		<0.09		<0.03		<0.03		<0.03
F. WINK		<0.02		<0.09		<0.03		<0.03		<0.03
PRATT/SWINDLE		*0.02		<0.09		<0.03		<0.03		<0.03
OM-105		<0.02		<0.09		<0.03		<0.03		<0.03

*Reported value near detection limit

WELL #	Mn(mg/l)	Mn(mg/l)	Ni(mg/l)	Ni(mg/l)	Mo(mg/l)	Mo(mg/l)	Zn(mg/l)	Zn(mg/l)	As(mg/l)
	1991	1992	1991	1992	1991	1992	1991	1992	1991
PM-19	<0.01	*0.02	<0.07	<0.08	<0.05	<0.06	*0.01	*0.01	<0.30
PM-20	<0.01	<0.01	<0.07	<0.08	<0.05	<0.06	*0.03	0.07	<0.30
PM-38	<0.01	*0.01	<0.07	*0.10	<0.05	<0.06	*0.02	*0.01	<0.30
OM-40	<0.01	<0.01	<0.07	<0.08	<0.05	<0.06	0.10	*0.03	<0.30
PM-44	<0.01	<0.01	<0.07	<0.08	<0.05	<0.06	0.10	*0.02	<0.30
PM-45	<0.01	<0.01	<0.07	<0.08	<0.05	<0.06	0.10	*0.01	<0.30
PR-02	<0.01	<0.01	<0.07	<0.08	<0.05	<0.06	0.04	0.06	<0.30
PR-06	<0.01		<0.07		<0.05		0.11		<0.30
PR-41	<0.01	<0.01	<0.07	<0.08	<0.05	<0.06	*0.01	*0.01	<0.30
OM-39	<0.01	<0.01	<0.07	<0.08	<0.05	<0.06	0.22	0.53	<0.30
PR-18	<0.01		<0.07		<0.05		<0.01		<0.30
OM-46	<0.01		<0.08		<0.06		<0.01		<0.33
OM-47	<0.01		<0.08		<0.06		<0.01		<0.33
OM-48	<0.01		<0.08		<0.06		<0.01		<0.33
C. WINK		*0.02		<0.08		<0.06		0.49	
P. SMITH		<0.01		<0.08		<0.06		0.10	
PM-106		*0.01		<0.08		<0.06		*0.01	
F. WINK		<0.01		<0.08		<0.06		0.08	
PRATT/SWINDLE		*0.01		<0.08		<0.06		0.14	
OM-105		<0.01		<0.08		<0.06		*0.03	

*Reported value near detection limit

WELL #	As(mg/l)	Cd(mg/l)	Cd(mg/l)	Pb(mg/l)	Pb(mg/l)	Sb(mg/l)	Sb(mg/l)	Se(mg/l)	Se(mg/l)
	1992	1991	1992	1991	1992	1991	1992	1991	1992
PM-19	<0.33	<0.01	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
PM-20	<0.33	<0.01	<0.01	<0.11	*0.13	<0.80	<0.89	<0.69	<0.77
PM-38	<0.33	<0.01	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
OM-40	<0.33	<0.01	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
PM-44	<0.33	<0.01	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
PM-45	<0.33	<0.01	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
PR-02	<0.33	<0.01	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
PR-06		<0.01		<0.11		<0.80		<0.69	
PR-41	<0.33	0.46	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
OM-39	<0.33	<0.01	<0.01	<0.11	<0.12	<0.80	<0.89	<0.69	<0.77
PR-18		<0.01		<0.11		<0.80		<0.69	
OM-46		<0.01		<0.12		<0.89		<0.77	
OM-47		<0.01		<0.12		<0.89		<0.77	
OM-48		<0.01		<0.12		<0.89		<0.77	
C. WINK	<0.33		<0.01		<0.12		<0.89		<0.77
P. SMITH	<0.33		<0.01		<0.12		<0.89		<0.77
PM-106	<0.33		<0.01		<0.12		<0.89		<0.77
F. WINK	<0.33		<0.01		<0.12		<0.89		<0.77
PRATT/SWINDLE	<0.33		<0.01		<0.12		<0.89		<0.77
OM-105	<0.33		<0.01		<0.12		<0.89		<0.77

*Reported value near detection limit

WELL #	Sn(mg/l) 1991	Sn(mg/l) 1992	Li(mg/l) 1991	Li(mg/l) 1992	Be(mg/l) 1991	Be(mg/l) 1992	Sr(mg/l) 1991	Sr(mg/l) 1992	Ba(mg/l) 1991
PM-19	<0.09	<0.10	<0.04	<0.04	<0.01	<0.01	0.32	0.37	0.20
PM-20	<0.09	<0.10	<0.04	*0.05	<0.01	<0.01	1.16	1.28	0.15
PM-38	<0.09	<0.10	<0.04	<0.04	<0.01	<0.01	0.40	0.41	0.11
OM-40	<0.09	<0.10	*0.05	*0.07	<0.01	<0.01	1.02	1.10	0.14
PM-44	<0.09	<0.10	<0.04	<0.04	<0.01	<0.01	0.54	0.56	0.14
PM-45	<0.09	<0.10	<0.04	<0.04	<0.01	<0.01	1.26	1.43	0.21
PR-02	<0.09	<0.10	<0.04	*0.05	<0.01	<0.01	0.88	0.95	0.13
PR-06	<0.09		*0.05		<0.01		0.99		0.12
PR-41	<0.09	<0.10	*0.04	*0.05	<0.01	<0.01	1.01	1.01	0.12
OM-39	<0.09	<0.10	*0.05	*0.06	<0.01	<0.01	1.00	1.04	0.11
PR-18	<0.09		<0.04		<0.01		0.96		0.14
OM-46	<0.10		<0.04		<0.01		1.07		0.15
OM-47	<0.10		<0.04		<0.01		0.81		0.31
OM-48	<0.10		<0.04		<0.01		1.09		0.17
C. WINK		<0.10		<0.04		<0.01		0.62	
P. SMITH		<0.10		*0.08		<0.01		1.71	
PM-106		<0.10		<0.04		<0.01		0.56	
F. WINK		<0.10		*0.09		<0.01		1.49	
PRATT/SWINDLE		<0.10		<0.04		<0.01		0.68	
OM-105		<0.10		*0.06		<0.01		1.02	

*Reported value near detection limit

WELL #	Ba(mg/l) 1992	Zr(mg/l) 1991	Zr(mg/l) 1992	U(mg/l) 1991	U(mg/l) 1992	Th(mg/l) 1991	Th(mg/l) 1992	B(mg/l) 1991	B(mg/l) 1992	P(mg/l) 1991
PM-19	0.21	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	1.07	1.05	<0.62
PM-20	0.17	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.35	0.32	<0.62
PM-38	0.13	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.50	0.39	<0.62
OM-40	0.15	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.16	*0.12	<0.62
PM-44	0.15	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.08	*0.04	<0.62
PM-45	0.23	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.09	*0.05	<0.62
PR-02	0.15	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.15	*0.12	<0.62
PR-06		<0.07		<6.10		<0.38		0.15		<0.62
PR-41	0.12	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.14	*0.12	<0.62
OM-39	0.14	<0.07	<0.08	<6.10	<6.80	<0.38	<0.42	0.15	*0.15	<0.62
PR-18		<0.07		<6.10		<0.38		0.15		<0.62
OM-46		<0.08		<6.80		<0.42		0.17		<0.69
OM-47		<0.08		<6.80		<0.42		0.09		<0.69
OM-48		<0.08		<6.80		<0.42		0.13		<0.69
C. WINK	0.35		<0.08		<6.80		<0.42		<0.04	
P. SMITH	0.18		<0.08		<6.80		<0.42		*0.09	
PM-106	0.11		<0.08		<6.80		<0.42		<0.04	
F. WINK	0.13		<0.08		<6.80		<0.42		*0.12	
PRATT/SWINDLE	0.24		<0.08		<6.80		<0.42		*0.04	
OM-105	0.14		<0.08		<6.80		<0.42		*0.12	

*Reported value near detection limit

WELL #	P(mg/l)	Ce(mg/l)	Ce(mg/l)	La(mg/l)	La(mg/l)	Si(mg/l)	Si(mg/l)	Rb(mg/l)	Rb(mg/l)	F(mg/l)
	1992	1991	1992	1991	1992	1991	1992	1991	1992	1991
PM-19	<0.69	<0.55	<0.61	<0.05	<0.06	8.69	10.6	<7.11	<7.90	0.35
PM-20	<0.69	<0.55	<0.61	<0.05	<0.06	12.20	13.8	<7.11	<7.90	1.30
PM-38	<0.69	<0.55	<0.61	<0.05	<0.06	8.02	9.8	<7.11	<7.90	0.21
OM-40	<0.69	<0.55	<0.61	<0.05	<0.06	17.40	19.5	<7.11	<7.90	1.50
PM-44	<0.69	<0.55	<0.61	<0.05	<0.06	9.01	11.2	<7.11	<7.90	0.92
PM-45	<0.69	<0.55	<0.61	<0.05	<0.06	11.10	13.3	<7.11	<7.90	1.19
PR-02	<0.69	<0.55	<0.61	<0.05	<0.06	14.00	16.0	<7.11	<7.90	1.31
PR-06		<0.55		<0.05		15.60		<7.11		1.71
PR-41	<0.69	<0.55	<0.61	<0.05	<0.06	14.20	15.8	<7.11	<7.90	1.43
OM-39	<0.69	<0.55	<0.61	<0.05	<0.06	15.50	17.3	<7.11	<7.90	1.72
PR-18		<0.55		<0.05		14.50		<7.11		1.39
OM-46		<0.61		<0.06		15.30		<7.90		1.70
OM-47		<0.61		<0.06		14.00		<7.90		0.71
OM-48		<0.61		<0.06		13.80		<7.90		0.98
C. WINK	<0.69		<0.61		<0.06		10.5		<7.90	
P. SMITH	<0.69		<0.61		<0.06		20.3		<7.90	
PM-106	<0.69		<0.61		<0.06		15.8		<7.90	
F. WINK	<0.69		<0.61		<0.06		22.5		<7.90	
PRATT/SWINDLE	<0.69		<0.61		<0.06		10.5		<7.90	
OM-105	<0.69		<0.61		<0.06		19.4		<7.90	

WELL #	F(mg/l)	Cl(mg/l)	Cl(mg/l)	Br(mg/l)	Br(mg/l)	NO3(mg/l)	NO3(mg/l)	SO4(mg/l)	SO4(mg/l)
	1992	1991	1992	1991	1992	1991	1992	1991	1992
PM-19	0.26	34.10	42.00	<0.10	<0.50	5.40	3.63	25.80	27.80
PM-20	1.39	22.60	31.60	<0.10	<0.50	9.83	17.20	20.20	20.90
PM-38	0.28	67.20	48.50	<0.10	<0.50	8.19	6.84	73.20	66.80
OM-40	1.56	8.81	6.91	<0.10	<0.50	5.01	4.47	16.90	16.00
PM-44	1.01	14.40	9.44	<0.10	<0.50	2.79	3.35	11.90	10.70
PM-45	1.01	47.30	56.90	<0.10	<0.50	5.62	6.43	18.50	21.80
PR-02	1.33	8.88	8.44	<0.10	<0.50	4.74	5.23	18.70	18.60
PR-06		11.00		<0.10		4.60		20.10	
PR-41	1.42	10.70	8.78	<0.10	<0.50	5.05	5.92	20.80	19.80
OM-39	1.53	11.40	9.80	<0.10	<0.50	4.20	4.76	21.60	19.20
PR-18		8.61		<0.10		4.22		19.90	
OM-46		9.15		<0.10		5.38		15.80	
OM-47		4.76		<0.10		3.19		9.49	
OM-48		6.88		<0.10		6.44		17.00	
C. WINK	0.29		3.23		*0.13		4.97		8.47
P. SMITH	1.12		13.00		*0.17		19.90		39.80
PM-106	0.49		17.80		*0.19		13.10		15.80
F. WINK	1.46		6.99		*0.14		6.07		18.60
PRATT/SWINDLE	0.32		45.80		0.65		13.70		20.90
OM-105	1.78		6.17		*0.11		3.82		15.10

*Reported value near detection limit

WELL #	HCO3(mg/l)-lab 1991	HCO3(mg/l)-field 1991	HCO3(mg/l)-lab 1992	HCO3(mg/l)-field 1992	DIC(mg/l) 1992
PM-19	280	378	361	366	
PM-20		260	234		31.0
PM-38		349	365		53.0
OM-40		278	282		35.0
PM-44		196	194	227	
PM-45		297	309		38.0
PR-02		278	262	332	
PR-06		257			
PR-41		274	276	293	
OM-39		260	259	279	
PR-18		257			
OM-46	257	256			
OM-47	225	226			
OM-48	262	267			
C. WINK			332	368	
P. SMITH			349	348	
PM-106			133	138	
F. WINK			330	351	
PRATT/SWINDLE			211	248	
OM-105			268	279	

WELL #	Dissolved O2(mg/l)-field 1992	Temperature(°C) 1991	Temperature(°C) 1992	Eh(mv)-field 1991	Eh(mv)-field 1992	pH-lab 1991
PM-19	4.98	16.9	14.9	359		8.19
PM-20	11.30	17.1	16.6	431		
PM-38	5.50	16.8	15.0	374		
OM-40	8.32	18.2	15.6	282		
PM-44	8.22	19.1	17.4	464		
PM-45	8.66	17.3	17.4	361		
PR-02	7.70	19.9	18.4	527		
PR-06		18.6		458		
PR-41	9.54	20.3	19.4	444	473	
OM-39	8.30	19.6	21.8	474		
PR-18		20.2		448		
OM-46		18.4		414		8.10
OM-47		16.8		392		8.16
OM-48		16.9		381		8.13
C. WINK	3.36/3.12		24.0		496	
P. SMITH	7.94		16.0		412	
PM-106	13.30		21.2		365	
F. WINK	7.98		19.5		472	
PRATT/SWINDLE	9.40		19.4		341	
OM-105	9.40		20.4		388	

WELL #	pH-field	pH-lab	pH-field	NH3(mg/l)	NH3(mg/l)	Tritium(TU)	Tritium(TU)	Sulfur-34(per mil)
	1991	1992	1992	1991	1992	1991	1992	1991
PM-19	6.96	7.50	6.60	<0.2	<0.2	7.28/8.39	8.86	-1.0
PM-20	7.66	7.85	7.00	<0.2	<0.2	1.39	2.23	5.2
PM-38	7.12	7.44	6.90	<0.2	<0.2	4.71/4.92	14.5	-2.3
OM-40	7.56	7.61	7.00	<0.2	<0.2	0.11/-0.06		3.2
PM-44	7.62	7.49	7.20	<0.2	<0.2	0.44/0.40		3.0
PM-45	7.34	7.67	6.90	<0.2	<0.2	8.10/8.75	12.3	5.1
PR-02	7.79	7.60	7.10	<0.2	<0.2	-0.02		4.1
PR-06	7.60			<0.2		-0.02/-0.02		1.1
PR-41	7.53	7.54	7.58	<0.2	<0.2	0.11/0.07		3.4
OM-39	7.69	7.75	7.20	<0.2	<0.2	-0.01/-0.06		2.9
PR-18	7.44			<0.2		0.00/0.01		3.6
OM-46	7.71			<0.2		0.13		3.3
OM-47	7.65			<0.2		-0.10		6.2
OM-48	7.63			<0.2		0.15		4.1
C. WINK		7.68	7.15		<0.2		1.77	
P. SMITH		7.68	7.42		<0.2		42.7	
PM-106		8.13	9.88		<0.2		0.72	
F. WINK		7.59	7.71		<0.2		5.64	
PRATT/SWINDLE		7.55	7.51		<0.2		1.40	
OM-105		7.63	7.55		<0.2		0.47	

WELL #	Inorganic Carbon-13(per mil) 1991	Inorganic Carbon-13(per mil) 1992	Total Carbon-13(per mil) 1992
PM-19	-12.9		-5.75
PM-20	-3.1		-9.29
PM-38	-11.5		-8.65
OM-40	-7.7		-7.34
PM-44	0.8		-7.93
PM-45	-9.5		-6.26
PR-02	-1.8		-8.31
PR-06	-7.0		
PR-41	-4.3		-6.99
OM-39	-6.7		-12.03
PR-18	-7.2		
OM-46	-7.8		
OM-47	-8.7		
OM-48	-8.9		
C. WINK		-14.1	-7.69
P. SMITH		-8.2	-5.63
PM-106		-5.26	-14.65
F. WINK		-10.5	-7.21
PRATT/SWINDLE		-9.7	-6.68
OM-105		-7.9	-8.86

WELL #	Carbon-13 DOC(per mil) 1992	Carbon-14(% modern C) 1991	Carbon-14(% modern C) 1992	Oxygen-18(per mil) 1991
PM-19	-16.08	109.4 +/- 1.1		-4.96
PM-20	-12.63	62.6 +/- 0.6		-6.63
PM-38	-17.12	90.5 +/- 1.0		-6.25
OM-40	-16.87	31.3 +/- 0.6		-5.95
PM-44	-13.78	63.5 +/- 0.8		-6.83
PM-45	-17.66	77.1 +/- 0.7		-4.35
PR-02	-16.75	44.5 +/- 1.1		-6.49
PR-06		31.2 +/- 0.4		-6.68
PR-41	-16.75	35.7 +/- 0.4		-6.04
OM-39	-16.74	38.5 +/- 0.4		-6.62
PR-18		30.9 +/- 0.6		-6.24
OM-46		23.9 +/- 0.4		-6.57
OM-47		32.8 +/- 0.6		-6.33
OM-48		28.5 +/- 0.4		-5.51
C. WINK	-16.80		85.0 +/- 1.0	
P. SMITH	-16.82		84.8 +/- 0.9	
PM-106	-18.18			
F. WINK	-16.44		69.6 +/- 0.8	
PRATT/SWINDLE	-16.11		66.9 +/- 0.8	
OM-105	-14.92		28.3 +/- 0.3	

WELL #	Oxygen-18(per mil) 1992	Deuterium(per mil) 1991	Deuterium(per mil) 1992	Nitrogen-15(per mil) 1992
PM-19	-4.7	-38	-27	16.75
PM-20		-41		7.95
PM-38	-5.0	-46	-27	17.80
OM-40	-5.7	-42	-35	13.19
PM-44		-48		19.11
PM-45		-35		16.03
PR-02		-46		16.41
PR-06		-43		
PR-41		-42		16.46
OM-39		-41		16.50
PR-18		-42		
OM-46		-41		
OM-47		-42		
OM-48		-41		
C. WINK	-3.9		-17	16.40
P. SMITH	-4.6		-25	19.46
PM-106	-4.3		-25	13.57
F. WINK	-3.7		-18	14.80
PRATT/SWINDLE	-4.9		-26	16.14
OM-105	-5.4		-33	15.44

WELL #	Boron-11(per mil) 1992
PM-19	17.1
PM-20	24.8
PM-38	-43.1
OM-40	13.2
PM-44	5.8
PM-45	-1.6
PR-02	19.7
PR-06	
PR-41	14.6
OM-39	14.0
PR-18	
OM-46	
OM-47	
OM-48	
C. WINK	18.0
P. SMITH	12.7
PM-106	14.7
F. WINK	7.5
PRATT/SWINDLE	6.9
OM-105	20.0

Table 2-1993 Data

WELL #	SAMPLE #	MSL #	Metals filtered?	Na(mg/l)	K(mg/l)	Mg(mg/l)	Ca(mg/l)
B. Kinzer	**0293-2**	93-109,-109C	0.45	44.8	7.95	50.1	48.9
P. Meacham	**0293-3**	93-110,-110C	0.45	68.4	6.63	24.8	27.0
PR-6	**0293-4**	93-240	0.45	22.2	5.86	21.8	42.8
P. Smith	**0393-1**						
D. Vance	**0593-1**	93-496,-1412	0.45	26.6	6.70	36.7	46.3
D. Vance	**0593-1**	93-1226	no	28.3	6.13	35.1	44.0
M. L. Vance	**0593-2**	93-497,-1413	0.45	16.4	5.95	28.5	32.2
M. L. Vance	**0593-2**	93-1227	no	17.4	6.24	29.3	31.4
T. Bradshaw	**0593-3**	93-498,-1414	0.45	23.5	6.11	29.3	38.7
T. Bradshaw	**0593-3**	93-1228	no	24.3	7.72	30.1	38.4
S. McGregor	**0593-4**	93-499,-1415	0.45	19.5	6.36	29.7	36.5
S. McGregor	**0593-4**	93-1229	no	19.5	6.12	29.9	36.5
D. Gabel	**0593-5**	93-500,-1416	0.45	20.3	6.49	27.4	33.1
D. Gabel	**0593-5**	93-1230	no	22.0	6.49	27.5	32.4
PM-103	**0693-1**	93-934,-1417	0.45	10.6	6.74	25.3	40.0
PM-103	**0693-1**	93-934	no	11.1	6.15	25.0	38.5
PM-103	**0693-1**	93-934	0.20	4.0	5.39	24.4	37.3
C. Kirkland	**0893-1**	93-1418	0.45	24.2	6.06	30.5	37.4
C. Kirkland	**0893-1**	93-1418	no	24.2	6.01	29.4	36.2
C. Kirkland	**0893-1**	93-1418	0.20	25.5	5.82	29.6	36.1

WELL #	V(mg/l)	Al(mg/l)	Fe(mg/l)	Ti(mg/l)	Co(mg/l)	Cr(mg/l)	Cu(mg/l)
B. Kinzer	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
P. Meacham	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
PR-6	<0.04	<0.27	*0.02	<0.09	<0.03	<0.03	<0.03
P. Smith							
D. Vance	<0.04	0.33	*0.04	<0.09	*0.04	<0.03	*0.03
D. Vance	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
M. L. Vance	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
M. L. Vance	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
T. Bradshaw	<0.04	<0.27	*0.03	<0.09	<0.03	<0.03	<0.03
T. Bradshaw	<0.04	<0.27	0.13	<0.09	<0.03	<0.03	<0.03
S. McGregor	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
S. McGregor	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
D. Gabel	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
D. Gabel	<0.04	<0.27	1.99	<0.09	<0.03	<0.03	<0.03
PM-103	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
PM-103	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
PM-103	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03
C. Kirkland	<0.04	<0.27	*0.04	<0.09	<0.03	<0.03	<0.03
C. Kirkland	<0.04	<0.27	0.24	<0.09	<0.03	<0.03	<0.03
C. Kirkland	<0.04	<0.27	<0.02	<0.09	<0.03	<0.03	<0.03

*reported value near detection limit

WELL #	Mn(mg/l)	Ni(mg/l)	Mo(mg/l)	Zn(mg/l)	As(mg/l)	Cd(mg/l)	Pb(mg/l)
B. Kinzer	0.31	<0.08	<0.06	0.45	<0.33	<0.01	<0.12
P. Meacham	0.31	<0.08	<0.06	0.13	<0.33	<0.01	<0.12
PR-6	<0.01	<0.08	<0.06	*0.01	<0.33	<0.01	<0.12
P. Smith							
D. Vance	<0.01	<0.08	<0.06	*0.05	<0.33	<0.01	<0.12
D. Vance	<0.01	<0.08	<0.06	0.05	<0.33	<0.01	<0.12
M. L. Vance	<0.01	<0.08	<0.06	*0.03	<0.33	<0.01	<0.12
M. L. Vance	<0.01	<0.08	<0.06	0.03	<0.33	<0.01	<0.12
T. Bradshaw	<0.01	<0.08	<0.06	0.08	<0.33	<0.01	<0.12
T. Bradshaw	<0.01	<0.08	<0.06	0.07	<0.33	<0.01	<0.12
S. McGregor	<0.01	<0.08	<0.06	*0.01	<0.33	<0.01	<0.12
S. McGregor	<0.01	<0.08	<0.06	0.03	<0.33	<0.01	<0.12
D. Gabel	*0.02	<0.08	<0.06	0.33	<0.33	<0.01	<0.12
D. Gabel	<0.01	<0.08	<0.06	0.71	<0.33	<0.01	<0.12
PM-103	<0.01	<0.08	<0.06	*0.01	<0.33	<0.01	<0.12
PM-103	<0.01	<0.08	<0.06	*0.03	<0.33	<0.01	<0.12
PM-103	<0.01	<0.08	<0.06	*0.05	<0.33	<0.01	<0.12
C. Kirkland	<0.01	<0.08	<0.06	*0.06	<0.33	<0.01	<0.12
C. Kirkland	<0.01	<0.08	<0.06	*0.04	<0.33	<0.01	<0.12
C. Kirkland	<0.01	<0.08	<0.06	0.09	<0.33	<0.01	<0.12

*reported value near detection limit

WELL #	Sb(mg/l)	Se(mg/l)	Sn(mg/l)	Li(mg/l)	Be(mg/l)	Sr(mg/l)	Ba(mg/l)
B. Kinzer	<0.89	<0.77	<0.10	0.10	<0.01	1.88	0.12
P. Meacham	<0.89	<0.77	<0.10	0.10	<0.01	1.05	0.07
PR-6	<0.89	<0.77	<0.10	*0.07	<0.01	1.00	0.12
P. Smith							
D. Vance	<0.89	<0.77	<0.10	0.10	<0.01	1.50	0.11
D. Vance	<0.89	<0.77	<0.10	0.07	<0.01	1.37	0.10
M. L. Vance	<0.89	<0.77	<0.10	0.10	<0.01	1.20	0.14
M. L. Vance	<0.89	<0.77	<0.10	0.08	<0.01	1.15	0.14
T. Bradshaw	<0.89	<0.77	<0.10	0.13	<0.01	1.17	0.07
T. Bradshaw	<0.89	<0.77	<0.10	0.08	<0.01	1.11	0.07
S. McGregor	<0.89	<0.77	<0.10	0.09	<0.01	1.24	0.12
S. McGregor	<0.89	<0.77	<0.10	0.09	<0.01	1.16	0.12
D. Gabel	<0.89	<0.77	<0.10	0.08	<0.01	1.10	0.11
D. Gabel	<0.89	<0.77	<0.10	0.07	<0.01	1.11	0.12
PM-103	<0.89	<0.77	<0.10	*0.05	<0.01	0.95	0.17
PM-103	<0.89	<0.77	<0.10	*0.03	<0.01	0.97	0.19
PM-103	<0.89	<0.77	<0.10	*0.02	<0.01	0.95	0.56
C. Kirkland	<0.89	<0.77	<0.10	0.12	<0.01	1.08	0.10
C. Kirkland	<0.89	<0.77	<0.10	0.12	<0.01	1.09	0.10
C. Kirkland	<0.89	<0.77	<0.10	0.12	<0.01	1.13	0.36

*reported value near detection limit

WELL #	Zr(mg/l)	U(mg/l)	Th(mg/l)	B(mg/l)	P(mg/l)	Ce(mg/l)	La(mg/l)
B. Kinzer	<0.08	<6.8	<0.42	0.16	<0.69	<0.61	<0.06
P. Meacham	<0.08	<6.8	<0.42	0.45	<0.69	<0.61	<0.06
PR-6	<0.08	<6.8	<0.42	0.17	<0.69	<0.61	<0.06
P. Smith							
D. Vance	<0.08	<6.8	<0.42	0.23	<0.69	<0.61	<0.06
D. Vance	<0.08	<6.8	<0.42	0.21	<0.69	<0.61	<0.06
M. L. Vance	<0.08	<6.8	<0.42	0.23	<0.69	<0.61	<0.06
M. L. Vance	<0.08	<6.8	<0.42	0.16	<0.69	<0.61	<0.06
T. Bradshaw	<0.08	<6.8	<0.42	0.17	<0.69	<0.61	<0.06
T. Bradshaw	<0.08	<6.8	<0.42	0.16	<0.69	<0.61	<0.06
S. McGregor	<0.08	<6.8	<0.42	0.19	<0.69	<0.61	<0.06
S. McGregor	<0.08	<6.8	<0.42	0.17	<0.69	<0.61	<0.06
D. Gabel	<0.08	<6.8	<0.42	0.17	<0.69	<0.61	<0.06
D. Gabel	<0.08	<6.8	<0.42	0.17	<0.69	<0.61	<0.06
PM-103	<0.08	<6.8	<0.42	0.12	<0.69	<0.61	<0.06
PM-103	<0.08	<6.8	<0.42	0.11	<0.69	<0.61	<0.06
PM-103	<0.08	<6.8	<0.42	0.13	<0.69	<0.61	<0.06
C. Kirkland	<0.08	<6.8	<0.42	0.18	<0.69	<0.61	<0.06
C. Kirkland	<0.08	<6.8	<0.42	0.18	<0.69	<0.61	<0.06
C. Kirkland	<0.08	<6.8	<0.42	0.17	<0.69	<0.61	<0.06

WELL #	Si(mg/l)	Rb(mg/l)	F(mg/l)	Cl(mg/l)	Br(mg/l)	NO3(mg/l)	SO4(mg/l)
B. Kinzer	14.1	<7.9	1.66	68.9	0.40	32.4	73.6
P. Meacham	22.8	<7.9	2.17	27.5	0.14	7.48	37.4
PR-6	17.3	<7.9	1.58	10.4	0.28	5.51	21.2
P. Smith							
D. Vance	20.1	<7.9	1.66	15.7	0.14	20.8	36.4
D. Vance	19.5	<7.9					
M. L. Vance	24.9	<7.9	1.99	13.0	0.12	5.53	19.0
M. L. Vance	25.3	<7.9					
T. Bradshaw	21.6	<7.9	1.59	12.5	0.12	7.55	53.3
T. Bradshaw	22.4	<7.9					
S. McGregor	25.0	<7.9	1.81	8.44	<0.10	4.63	20.9
S. McGregor	25.0	<7.9					
D. Gabel	18.6	<7.9	1.65	12.5	0.13	6.44	16.6
D. Gabel	19.6	<7.9					
PM-103	12.4	<7.9	1.50	29.1	0.17	6.57	13.7
PM-103	12.5	<7.9					
PM-103	12.7	<7.9					
C. Kirkland	27.5	<7.9	2.79	7.82	*0.15	3.95	19.2
C. Kirkland	27.0	<7.9					
C. Kirkland	27.9	<7.9					

*reported value near detection limit

WELL #	NH3(mg/l)	HCO3(mg/l)-lab	HCO3(mg/l)-field	Eh(mv)-field	Temperature(°C)-field	pH-lab
B. Kinzer	<0.2	272	273	193	18.2	8.12
P. Meacham	<0.2	281	297	209	17.2	8.11
PR-6	<0.2	251	258		15.2	8.09
P. Smith						
D. Vance	<0.2	297	285	240	16.6	7.87
D. Vance						
M. L. Vance	<0.2	238	261	226	17.2	7.83
M. L. Vance						
T. Bradshaw	<0.2	229	235	220	17.5	7.84
T. Bradshaw						
S. McGregor	<0.2	266	286	210	19.4	7.85
S. McGregor						
D. Gabel	<0.2	246	251	164	17.9	7.96
D. Gabel						
PM-103	<0.2	198	180	248	19.9	8.07
PM-103						
PM-103						
C. Kirkland	<0.2	312		366	18.8	7.87
C. Kirkland						
C. Kirkland						

WELL #	pH-field	Dissolved O2(mg/l)-field	Electrical Conductivity(mmho)-lab	Dissolved Inorganic Carbon(mg/l HCO3)	Tritium(TU)
B. Kinzer	7.54	6.34			15.0
P. Meacham	7.97	7.12			
PR-6	7.56	7.88			
P. Smith					28.7
D. Vance	7.46	5.74			8.48
D. Vance					
M. L. Vance	7.63	6.64			-0.12
M. L. Vance					
T. Bradshaw	7.58	6.34			0.34
T. Bradshaw					
S. McGregor	7.59	7.34			0.23
S. McGregor					
D. Gabel	7.69	4.28			0.03
D. Gabel					
PM-103	8.10	8.46			-0.03
PM-103					
PM-103					
C. Kirkland	8.10	7.68	0.505	306	
C. Kirkland					
C. Kirkland					

WELL #	Inorganic Carbon-13(per mil)	Total Carbon-13(per mil)	Carbon-13 DOC(per mil)	Carbon-14(% modern C)	Deuterium(per mil)	Oxygen-18(per mil)
B. Kinzer	-6.2		-19.94	84.6+/-0.7	-35	-5.9
P. Meacham	-6.9			20.6+/-0.2	-53	-8.0
PR-6			-17.29			
P. Smith						
D. Vance	-6.0	-3.82	-12.53	65.7+/-0.5	-30	-5.6
D. Vance						
M. L. Vance	-5.6	-7.84	-12.97	47.0+/-0.4	-32	-6.0
M. L. Vance						
T. Bradshaw	-6.6	-5.59	-12.49	54.4+/-0.5	-34	-6.3
T. Bradshaw						
S. McGregor	-6.4	-5.95	-16.04	40.5+/-0.3	-32	-5.8
S. McGregor						
D. Gabel	-4.8	-3.40	-12.10	61.9+/-0.6	-33	-5.9
D. Gabel						
PM-103		-4.64	-12.93			
PM-103						
PM-103						
C. Kirkland					-27	-5.2
C. Kirkland						
C. Kirkland						

WELL #	Nitrogen-15(per mil)	Sulfur-34(per mil)
B. Kinzer	12.63	
P. Meacham		5.8
PR-6	16.90	
P. Smith		
D. Vance	7.10	3.5
D. Vance		
M. L. Vance	19.29	1.2
M. L. Vance		
T. Bradshaw	16.90	-2.6
T. Bradshaw		
S. McGregor	15.15	1.7
S. McGregor		
D. Gabel	18.79	2.5
D. Gabel		
PM-103	15.95	
PM-103		
PM-103		
C. Kirkland		
C. Kirkland		
C. Kirkland		