INITIAL REPORT ON THE GEOCHEMICAL IDENTIFICATION OF THE SOURCE OF SALINITY IN GROUNDWATERS IN NORTHWESTERN HARVEY COUNTY

A report for
Equus Beds Groundwater
Management District No. 2

by

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INTRODUCTION

Groundwaters in parts of the unconsolidated aquifer of the "Equus Beds" in northwestern Harvey County (T22S, R3W) have been found to be saline. A network of observation wells has been installed in this area by the Equus Beds Groundwater Management District to monitor the quality of the water. There are 18 observation well sites, each with a shallow and a deep well screened within the aquifer. Dissolved chloride concentrations have been greater than 100 mg/L in water samples obtained from 8 of the 36 wells. At one site (EB34, located in SW SW SW sec. 20, T22S, R3W) the chloride content of the waters from both the shallow and deep wells have been over 2000 mg/L. The deep well at another site (EB35, located at NE NE NE sec. 19, T22S, R3W) has yielded water containing from several hundred to 1000 mg/L dissolved chloride.

The major source of the salinity is thought to be similar to that reported in the Burrton area to the south, i.e., oilfield brines from old surface-disposal pits and more recent leaks from disposal lines (Burrton Task Force, 1984). Geochemical identification of the salinity source for a sample collected from the deep observation well at site EB35 in 1980, confirmed this pollution source for this location (Whittemore, unpublished). Oil has been produced for many years from the Hollow-Nikkel Field in the northwestern part and from the Burrton NE Field in the southeastern portion of T22S, R3W. However, the Permian Wellington Formation underlies the unconsolidated aquifer in this township and is a natural source of salinity to aquifers in some areas of Kansas, although not to any appreciable extent in the Burrton area. Thus, the question of whether oilfield brine pollution or natural saltwater contamination is the predominant salinity source needs to be answered for other areas of the township.

The particular area of concern reported here includes sections 19, 20, 29, and 30 in T22S, R3W. Samples from an observation well and from different depths in two test wells were supplied by a board member of the Equus Beds Groundwater Management District. The wells are located in sections 20 and 29, T22S, R3W. Unless noted otherwise, other samples discussed in this report were collected by the manager of Groundwater Management District No. 2 and provided to the Kansas Geological Survey, or collected and analyzed by the Kansas Department of Health and Environment. The source of salinity was identified by the bromide/chloride ratio and mixing curve method of Whittemore et al. (1981) and Whittemore (1984).

PROCEDURE

Samples were filtered through 0.45 μm membrane filter paper before analysis. Concentrations of chloride and bromide were determined in all samples at the Kansas Geological Survey by automated methods on a Technicon Auto-Analyzer. A phenol red method was used for bromide (Basel et al., 1982).

RESULTS AND DISCUSSION

Data used for the identification of saltwater sources contaminating groundwaters in the study area are listed in Table 1. The identification procedure involves the location of sample points relative to mixing zones on a plot of weight ratios of bromide/chloride versus chloride concentration (Figure 1). The individual curves were calculated using endpoints that bracket the range in composition of freshwaters and oilfield brines from the area and halite solution brines from the Permian

TABLE 1. Location, chemical analyses, and chemical weight ratios of groundwater samples analyzed at the Kansas Geological Survey.

Well Description	Legal Location[a]	Sample Date	Depth feet	Cl mg/L	Br mg/L	Br/Cl x 10^4
Test hole 1-A	22S-3W-20CBDD	12-30-83	100-110	3160	13.1	41.5
			120-130	5220	21.8	41.8
			130-140	6040	24.8	41.1
			140-150	2600	10.8	41.5
			150-160	714	3.0	42.0
Test hole 1-B	22S-3W-29BBAA	1-08-84	30-40	21	0.20	96
			43-53	25	0.18	72
			60-70	12	0.17	140
			86-96	280	1.30	46
			97-107	6490	26.9	41.4
			131-141	18	0.16	88
			141-151	77	0.38	49.1
			151-161	235	0.70	29.9
Observation well	22S-3W-29BBAA	2-16-84	135-165	275	0.53	19.3
Observ. EB-34B	22S-3W-20CCCC	10-25-82	125-128	2820	ND	-
Observ. EB-35B	22S-3W-19AAAA	10-17-80	77-80	1000[b]	4.1	41

[a] Township, range, section, quarter section, quarter-quarter section, etc., based on A = NE quarter, B = NW quarter, C = SW quarter, D = SE quarter.

[b] Chloride determined by the Kansas Department of Health and Environment.

ND = not determined.

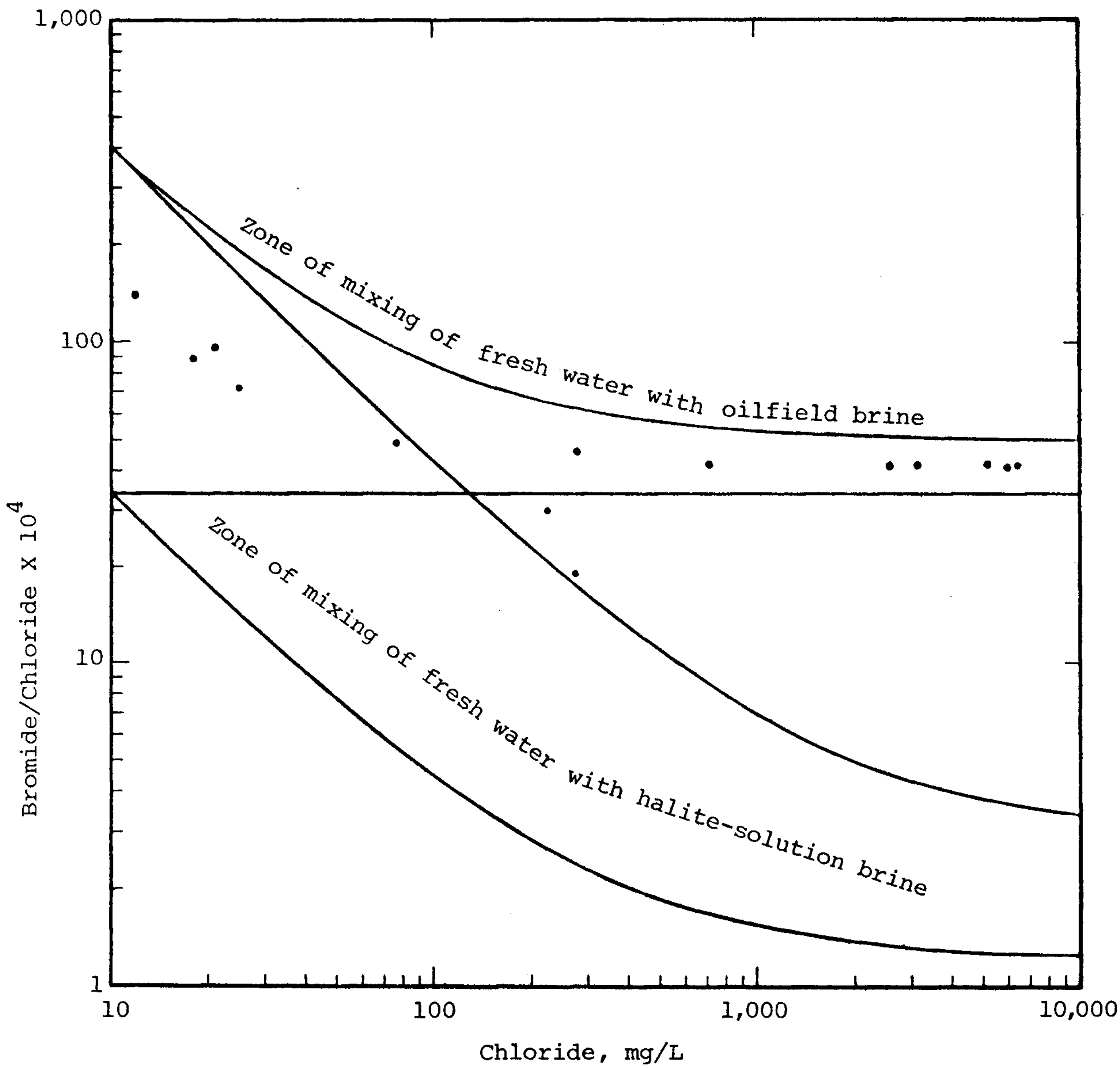

Figure 1. Weight Ratio of Bromide/Chloride versus Chloride Concentration for Groundwaters from Monitoring Wells and Test Holes in Northwest Harvey County.

Wellington Formation. Data for oilfield brines from the Hollow-Nickel Field and from the northeastern corner of the Burrton Field in T22S, R3W are given in Table 2. The chemistry of halite solution brines from the Wellington has been documented in reports such as Whittemore et al. (1981). Figure 1 is essentially the same as a similar graph for the Burrton area several miles to the south. See Figure 23, page 83, of the report of the Burrton Task Force (1984). The only difference is a slightly narrower zone for the mixing of freshwaters with oilfield brines in Figure 1. The endpoints used for oilfield brine were bromide/chloride ratios of 0.0050 and 0.0034 (based on a ratio of 0.0042 ± 20 percent) at a chloride concentration of 100,000 mg/L.

Chloride concentrations in the groundwater increase to the depth interval 130-140 feet in test hole 1-A, then steadily decrease to the bottom of the hole. In test hole 1-B, the dissolved chloride in the water remains relatively constant at shallow depths, increases sharply to the depth interval 97-107 feet, decreases even more sharply below that level, and then steadily increases but to a much lower chloride content than at the intermediate depth. All of the sample points for test hole 1-A and the points for depths down to 107 feet in test hole 1-B fall within the zone of mixing of freshwaters and oilfield brines on Figure 1. The values for the deepest sample from test hole 1-B and the sample from the observation well drilled later next to this hole lie between the zones of mixing of freshwater with oilfield brine and freshwater with halite-solution brine.

The source of the saline water at all levels in test hole 1-A and to depths at least to 107 feet in test hole 1-B is oilfield brine. The brine has apparently been disposed or leaked from a ground surface or

Table 2. Chemical characteristics of oilfield brines from the Hollow-Nickel Field and northeastern corner of the Burrton Field. Samples were analyzed by the Kansas Geological Survey.

Location	Producing Horizon	Cl, mg/L	Br, mg/L	Br/Cl x 10^4
22S-3W-18	Hunton Group	80,490	345	42.9
22S-3W-31	Mississippian System	103,900	445	42.8
22S-3W-31	Mississippian System	104,500	448	42.9

near-surface location and flowed downwards until reaching less permeable sediments. If the probable point or points of origin of the pollution are not within the immediate vicinity of the test holes, then the brine has also flowed horizontally along the tops of the less permeable strata. During its flow, the saltwater would be diluted by the freshwater in the aquifer. Recharge from infiltrating precipitation would also dilute the saltwaters from above.

The well driller's logs given in Tables 3 and 4 correlate well with the dissolved chloride concentrations found in the waters at the different depths based on the surface source of saltwater. The sediments in test hole 1-A consist of mainly sand and gravel with thin clay beds or clay streaks. More brine has been able to penetrate to a depth of about 140 feet than below, possibly indicating slower vertical flow below this level due to less permeable strata, i.e., a greater percentage of the sediment may be clay. At the location of test hole 1-B a relatively thick clay layer is present from 115-135 feet. As a result, very saline water contaminated by oilfield brine has not been able to affect freshwater immediately below the clay. The points for water samples at the bottom of this hole and in the observation well (which was drilled about 10 feet away from the test hole) indicate a mixture of oilfield brine and halite-solution brine. Thus, at this depth some naturally saline water derived from the underlying bedrock is beginning to affect the groundwater. The oilfield brine source of some of the dissolved solids may have flowed to this depth at a distance from the site where the clay layer was not as thick or continuous. The slightly greater depth of the observation well as compared to test hole 1-B is probably responsible for the higher chloride concentration. The addi-

Table 3. Driller's Log for Test Hole 1-A. The hole was drilled by R. Schenkel of Clarke Well & Equipment Co., Great Bend, Kansas, and is located at T22S, R3W, 20CBDD.

Depth, feet	Description of Formation
0-35	Topsoil and sandy clay
35-40	Sand, fine
40-96	Sand and gravel, fine
96-100	Clay - green, soft, sandy
100-118	Sand and gravel with clay streaks
118-119	Clay - tan
119-139	Sand and gravel with clay streaks
139-145	Sand and gravel with thick clay streaks
145-159	Sand and gravel with thin clay streaks
159-161	Clay - hard, white and tan

Table 4. Driller's Log for Test Hole 1-B. The driller was the same as for test hole 1-A. The location is T22S, R3W, 29BBAA.

Depth, feet	Description of Formation
0-32	Topsoil and brown clay
32-39	Sand and gravel, fine
39-43	Clay - black
43-52	Sand and gravel, fine
52-54	Clay - brown
54-83	Sand and gravel, fine - very fine, thin clay streaks
83-85	Clay - brown, sandy, soft
85-96	Sand and gravel, fine - very fine with thin clay streaks
96-98	Clay - brown, gray
98-104	Sand and gravel, fine - very fine with thin clay streaks
104-106	Clay - brown
106-107	Sand and gravel, fine
107-115	Clay - tan, sandy with sand streaks
115-135	Clay - tan, hard
135-143	Sand and gravel, very fine with thin clay streaks
143-145	Clay - brown, hard
145-155	Clay - brown - black with sandy streak at 153 feet
155-161	Sand and gravel, fine - clean with clay streaks

tional chloride in this sample is derived from halite-solution water as shown by the lower bromide/chloride ratio and closer location of the point to the lower mixing zone in Figure 1. It should be noted, however, that the total chloride content of these deeper groundwaters is much less than that present at the intermediate levels.

CONCLUSIONS

The saltwater source polluting groundwaters in the aquifer of the study area is mainly oilfield brine. Most of the brine has apparently been derived from the surface or near surface of the land, and has penetrated to various depths in the aquifer depending on the thickness and permeability of clay or clay-containing layers in the unconsolidated sediments. A halite-solution source of chloride was found at depths of greater than 150 feet at one site; this salinity source to the aquifer is very small when compared to that of oilfield brine pollution in the area.

ADDITIONAL RESEARCH

Additional samples will be collected from monitoring wells in the study area by the Groundwater Management District. Selected of these will be analyzed for salinity source identification by the Kansas Geological Survey. A further report will be written in cooperation with the Groundwater Management District and appropriate state agencies to assess the results of further analyses, especially with regard to the spatial and temporal variations in the groundwater geochemistry of the aquifer.

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