

# **KANSAS GEOLOGICAL SURVEY OPEN-FILE REPORT 1982-5**

Initial Report

Identification of Saltwater Sources Affecting  
Groundwater in the Burrton Area, Harvey County, Kansas

by

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## INTRODUCTION

A public hearing has been set for August 4, 1982 by the Kansas State Board of Agriculture, Division of Water Resources, to consider the proposed designation of an intensive groundwater use control area surrounding Burrton, Harvey County, Kansas (Figure 1). Designation of the control area was requested by the Board of Directors of the Equus Beds Groundwater Management District No. 2. Analyses of waters from monitoring, domestic, and irrigation wells in Harvey and eastern Reno counties indicate an area of saline groundwater around Burrton. A study made by Sophocleous (1982) on a proposed irrigation well in the southern part of the area projected the saline water could move southeast in the next several years. The groundwater management district requested the control area to try to slow the movement of any saltwater (Equus Beds Groundwater Management District, 1982). The district has also asked the Division of Water Resources, Kansas Department of Health and Environment, Kansas Geological Survey, and Kansas Corporation Commission to help conduct a thorough study of all activities in the area.

Previous investigations have indicated that the source of the saltwater pollution derives from oil-field activities. Williams and Lohman (1949) documented the intrusion of saltwater into the aquifer from surface disposal ponds filled with oil-field brine. They also reported that large volumes of oil brine had been injected under pressure in the 1930's through shallow disposal wells into the "lost-circulation zone" of the Wellington Formation. The high pressure forced brine up to the surface around casings of nearby wells or through poorly plugged boreholes. The brine would probably have consisted of a mixture of the oil-brine and the saltwater derived from solution of evaporites, primarily halite, in the Hutchinson Salt Member.

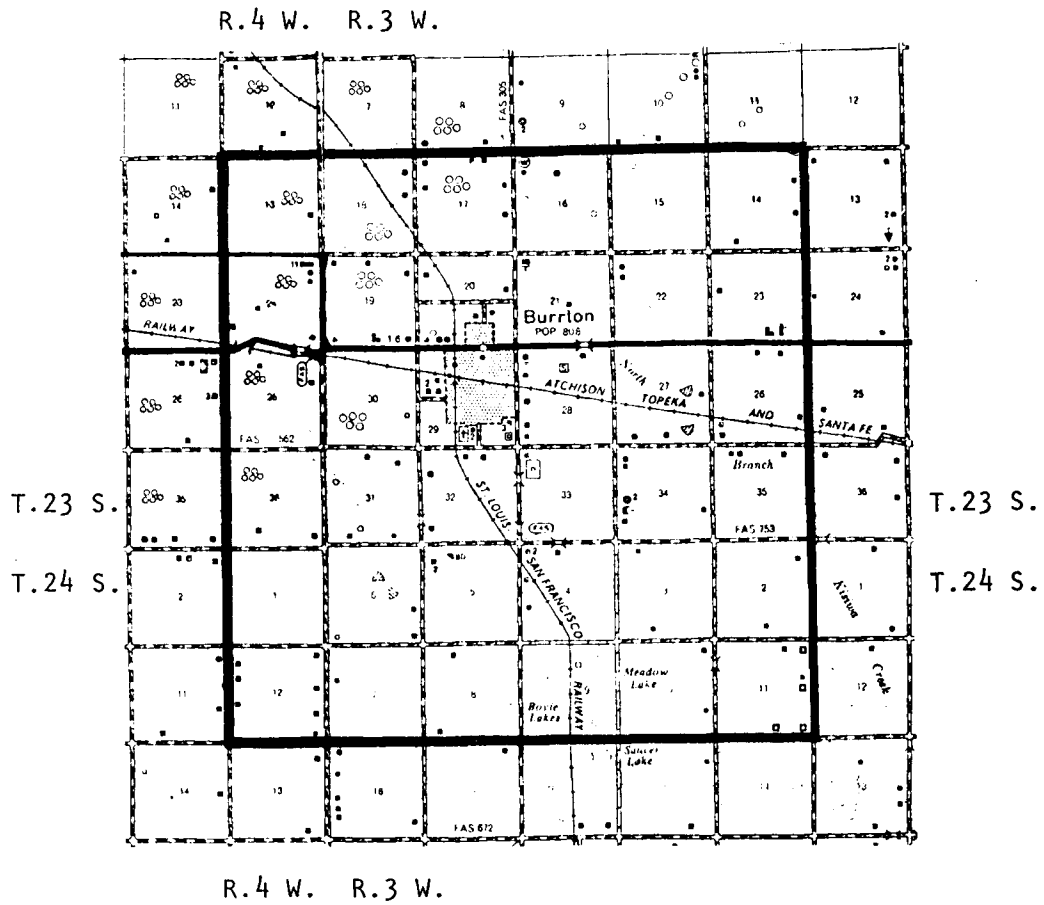


Figure 1. Area Proposed for Intensive Groundwater Use Control in Western Harvey and Eastern Reno Counties, Kansas.

The efforts of the Department of Health and Environment (the former State Board of Health) resulted in the conversion of most of the brine disposal to injection through deep wells by the middle 1940's. The use of many shallow wells in the Wellington Formation for oil-brine disposal continued to the 1970's, but the injection was made under gravity-flow conditions (Leonard and Kleinschmidt, 1976).

Although most of the saltwater pollution appears to have occurred during the 1930's and early 1940's, occasional leaks or breaks in pipes carrying oil-brine have contributed to the problem (Thomas Bell, oral commun., 1982). A possible, additional source of recent saltwater contamination might be brine forced up poorly plugged boreholes nearby to enhanced oil-recovery operations which inject greater amounts of fluid into the producing horizons than removed. Such occurrences have been found in other areas by the Kansas Department of Health and Environment (1982). Within the Burrton oil field north of the Arkansas River there is one enhanced oil-recovery operation which has been injecting both freshwater and oil-brine into the producing zones. The injection wells are located in sections 17 and 18, T23S, R4W, in the northwestern part of the proposed area for groundwater use control. Since the start of the enhanced recovery project in 1963 to the end of 1981, the net additional water injected sums to 47,000,000 barrels or 6060 acre ft. (computed using data from the Kansas Geological Survey and Division of Water Resources). However, no evidence presently exists that any pollution is occurring from brine forced up abandoned boreholes near to this operation.

Gogel (1981) determined that the area of the Wellington saltwater aquifer immediately to the south and southwest of Burrton and extending to several miles southeast of Hutchinson has a potentiometric surface higher in altitude

than the water table of the overlying freshwater aquifer. This suggests the possibility that halite-solution brine could migrate to the bottom of the freshwater deposits through fractures or unplugged boreholes penetrating the shale overlying the saltwater zone. If saltwater flow from the Wellington aquifer does occur, it would be most pronounced during periods when water tables were lower due to drought and large irrigation withdrawals.

The objectives of the present study are

- (1) identify the predominant source(s) of the saltwater contaminating the freshwater aquifer in the Burrton area, i.e., whether derived from oil-field brine or halite-solution brine, and
- (2) outline further research needed for the identification of saltwater to aid in improving groundwater quality models and in determining management or regulation procedures to control the saltwater.

#### PROCEDURES

Water samples from the Equus Beds monitoring well network were obtained from Thomas Bell during 1979 and 1980. Samples from several U.S. Geological Survey test wells in the Equus Beds and the alluvium of the Arkansas River valley were provided by J.B. Gillespie and Michael Haley. Major dissolved constituents in many samples were determined at the Kansas Geological Survey using inductively coupled plasma spectrophotometry (for cations), automated methods on a Technicon Autoanalyzer (for chloride and sulfate), and argentometric titration (for chloride) by Truman Waugh, Karmie Galle and the authors, respectively. Bromide concentrations were measured by an automated phenol red method on the Autoanalyzer (Basel, et al., 1982). This method gives

results which agree excellently with bromide determinations made using x-ray fluorescence spectrophotometry (by Gerald James, Kansas Geological Survey), and ion-chromatography (by Kirk Nordstrom, U.S. Geological Survey, Menlo Park, California). Iodide was determined by an automated colorimetric method in which iodide catalyzes the reduction of ceric ions by arsenious acid. Analytical data for major cations and/or anions for many samples were obtained from the Equus Beds Groundwater Management District and the U.S. Geological Survey.

#### RESULTS AND DISCUSSION

Chloride concentrations have ranged from 6-2890 mg/L during 1979-1981 in observation well waters within the proposed area for groundwater use control. In the western part of the area most monitoring wells yield waters containing high chloride concentrations (>250 mg/L) at both shallow and deep depths within the Equus Beds aquifer; in the central and eastern portions high concentrations tend to be present deeper in the sediments.

Weight ratios of sodium/chloride ranged from 0.21-0.50 for samples with chloride contents exceeding 250 mg/L in the Burrton area. The sodium/chloride ratio expected for halite-solution brines is 0.65. The ratios observed for brines (>19,000 mg/L chloride) naturally occurring within the Wellington saltwater aquifer in Kansas and mineralized waters (>5000 mg/L chloride) deriving their salinity from these brines average 0.65 and range from 0.63-0.68 (Whittemore, et al., 1981). Oil-field brines in Kansas generally have sodium/chloride ratios of  $0.5 \pm 0.1$  (Whittemore and Pollock, 1979; Whittemore, et al., 1981; Leonard, 1964). Thus, the main source of saltwater in the Burrton area appears to have been oil-field brine pollution. It is noted, however, that

exchange of sodium for calcium and magnesium ions on clays can lower the sodium/chloride ratios of groundwaters. This may explain the low ratios occurring in some of the groundwaters and also indicates that an additional, more conclusive identification of the saltwater source is needed.

Plots of the ratio bromide/chloride versus chloride concentration have been found to best distinguish between oil-field and halite-solution brines and waters contaminated with these brines. Such a plot for the groundwaters of the Burrton area (the entire area of Figure 1) is shown in Figure 2 along with curves that are the boundaries of mixing zones of freshwaters with oil-field brines and halite solutions (Wellington aquifer brines). Points for all except two of the Equus Beds monitoring wells yielding waters with chloride concentrations above 250 mg/L fall within the freshwater and oil-field-brine mixing zone. The two exceptions are the shallow and deep wells EB5A and EB5B at T.23S., R.4W., sec. 24AAA in the northwestern part of the proposed control area. Here a mixture of halite-solution brine and oil-brine is indicated as the saltwater source. Values for waters from two USGS wells to the west and southwest of the Burrton area plot within the freshwater and halite-solution mixing zone, showing that the origin of saltwater in the Arkansas River valley area is predominantly from salt dissolution.

Similar graphs of iodide/chloride versus chloride concentration have also been used successfully to differentiate between oil-field and halite-solution brines (Whittemore, et al., 1981). However, unlike bromide, some iodide in saline waters can be adsorbed on clays and iron oxyhydroxides in sediments. Therefore, as a brine is dispersed through a freshwater aquifer, ratios of iodide/chloride may decrease relative to those of bromide/chloride.

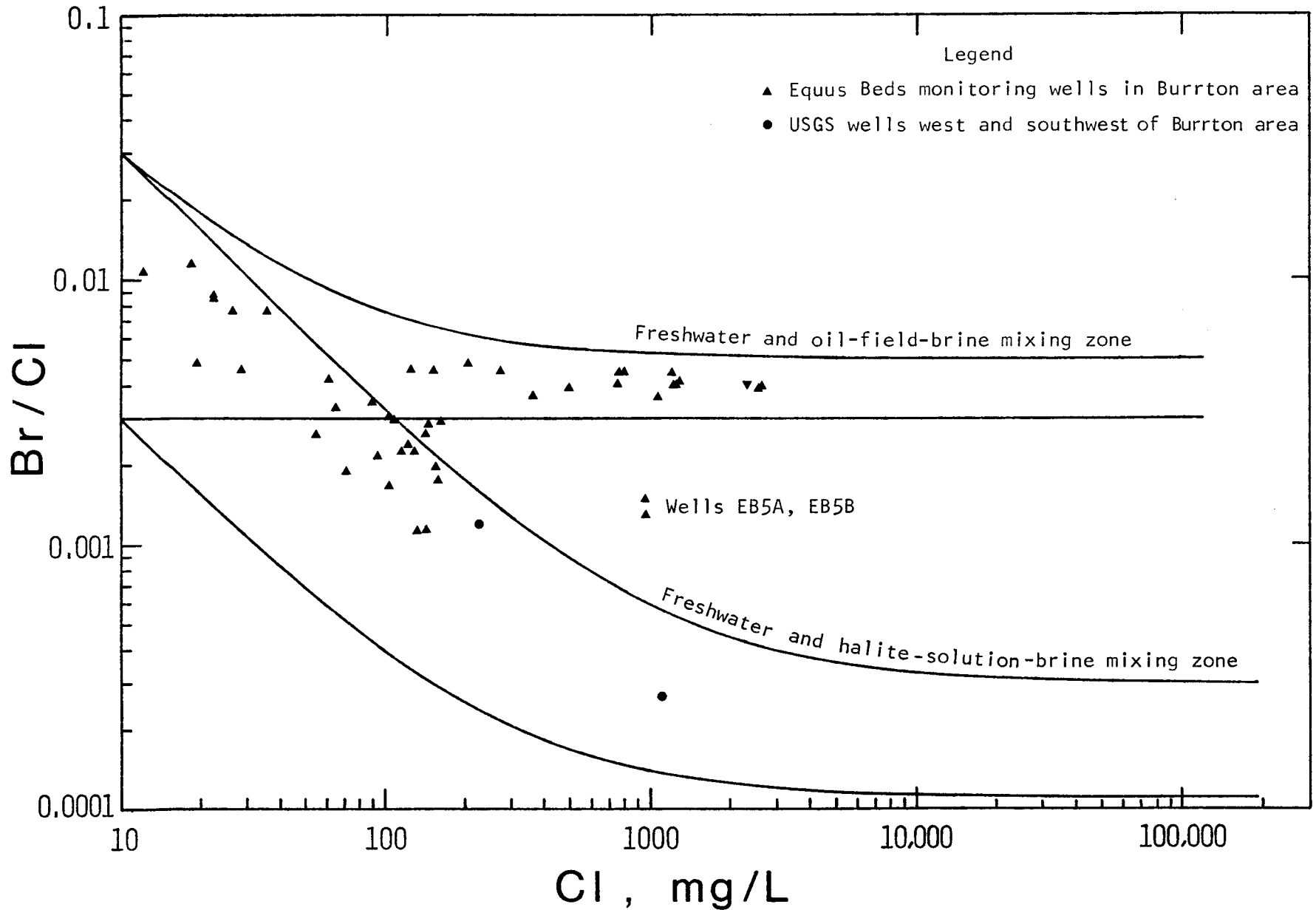


Figure 2. Identification of Saltwater Sources in the Burrton Area. The predominant source of saltwater in the Burrton area is oil-field brine. Halite-solution brine is the predominant source of saltwater in the Arkansas River valley to the west and southwest of the Burrton area.

Values of iodide/chloride for waters containing chloride concentrations exceeding 250 mg/L in shallow monitoring wells in the Burrton area generally plotted within a freshwater and oil-field brine mixing zone. Deep well waters gave lower iodide/chloride ratios falling below the mixing zone. This suggests that oil-brine pollution originated primarily at shallow depths in the aquifer and moved downwards with time. Such evidence supports past leakage from surface disposal ponds and near surface pipes carrying oil-brine as the major saltwater source. Samples from wells EB5A and EB5B in the northwestern part of the proposed control area had even lower iodide/chloride ratios at similar chloride concentrations than the deeper group of other wells. Again, this suggests that halite-solution brine has contributed to the dissolved solids of groundwaters at this location.

#### CONCLUSIONS

Geochemical evidence based primarily on bromide/chloride ratios and supported by sodium/chloride and iodide/chloride ratios indicates that the main source of salinity in Equus Beds groundwaters near Burrton is oil-field brine. Iodide/chloride ratios suggest that the saltwater originated at or near the surface and flowed downwards through the freshwater aquifer. This supports the belief that old surface disposal ponds were the primary source of pollution. A mixture of oil-brine and halite-solution brine appears to be the origin of saline water from Equus Beds monitoring wells EB5A and EB5B in the northwestern part of the Burrton area. The mixture could have been derived from saltwater in the "lost-circulation zone" of the Wellington Formation. During the 1930's pressure injection of oil brine into disposal wells in this formation forced saltwater up nearby boreholes to the surface.

## RECOMMENDED RESEARCH

1. At least three new pairs of shallow and deep monitoring wells should be constructed in the Equus Beds to the west and northwest of Burrton just outside the proposed groundwater use control area. Suggested locations for the three sites are the NW $\frac{1}{4}$  of sec. 14, the west-central part of sec. 23, and the SW $\frac{1}{4}$  of sec. 26, T. 23S., R. 4W. These wells would intercept water entering the northwestern part of the proposed control area, as the general groundwater flow direction is to the east-southeast. Samples from the wells should be analyzed to determine whether additional oil brine and/or mixtures of oil brine and halite-solution brine such as at wells EB5A and EB5B are entering the Burrton area.

2. Additional samples from the monitoring wells in the northwestern part of the proposed control area should be analyzed to verify the saltwater sources indicated at wells EB5A and EB5B compared to those for the other wells.

3. A spatial and historical accounting of groundwater quality in the Equus Beds around and to the west of Burrton should be prepared to determine the time and location of saltwater introduced to the aquifer by anthropogenic activities and the presence of any saltwater entering naturally. Parts of such an accounting are included in the present research of J.B. Gillespie, U.S. Geological Survey and Marios Sophocleous, Kansas Geological Survey. The portions of these investigations concerning the identification of the saltwater sources need to be coordinated. Relevant conclusions could be related to the geochemical identification data in an expanded version of this initial report.

4. The possibility of brine being forced up poorly plugged boreholes nearby to the enhanced oil-recovery operation in sections 17 and 18, T.23S., R.4W. needs to be investigated. Although no evidence presently exists that any pollution from this source is occurring, 6060 acre ft. more water has been injected into the oil-producing horizon than total fluid removed.

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