

**GEOCHEMICAL CHARACTERIZATION OF SALTWATER
CONTAMINATION AT THE SELZER SITE, MCPHERSON COUNTY**

a report for the
Kansas Corporation Commission

by

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INTRODUCTION

Ground water has been found to be saline by the Kansas Corporation Commission (KCC) in southeastern McPherson County. The contaminated area (Selzer site) is located in the SE sec. 2, T. 20 S., R. 1 W. about 4 miles south-southeast of Canton. Chloride concentrations in the ground-water contamination plume delineated by 6 monitoring wells of the KCC range up to 15,000 mg/L. Geologic cross sections of the "Equus Beds" area (Williams and Lohman, 1949) suggest that the contaminated aquifer in the area comprises sands and gravels of Pleistocene age and is underlain by the Wellington Formation. The aquifer is relatively thin in the area with a saturated thickness probably less than 40 ft based on the location relative to the saturated thickness map of Leonard and Kleinschmidt (1976). The KCC measured water levels in the monitoring wells and determined that the ground-water flow direction is to the west towards West Emma Creek. The quality of uncontaminated water in the unconsolidated sediments of the general area is fresh, with total dissolved solids <500 mg/L, chloride <40 mg/L, and sulfate concentration <60 mg/L based on data in Williams and Lohman (1949).

The KCC believes that a poorly plugged, D&A borehole for oil and gas exploration located in the NE NE SE sec. 2, T. 20 S., R. 1 W. is acting as a conduit for Mississippian brine (or saltwater from another zone) to rise and enter the shallow aquifer. The closest oil and gas fields currently producing petroleum are located about a mile to the east (Bitikofer Field) and north (Ritz Canton E Field) based on an oil and gas field map (Kansas Geological Survey, 1989). The oil and gas drilling records of the KGS contain information for 11 boreholes (one of which was reentered) in sec. 1, T. 20 S., R. 1 W., and 5 boreholes in sec. 2 of the same township. The records include the borehole suspected as the contamination source. The suspected borehole was drilled to a depth of 3,505 ft into the siliceous lime (Arbuckle Group) and completed and abandoned as a dry hole on September 21, 1936. The borehole is the second oldest on record for sec. 1 and 2; the oldest was a D&A drilled to 3,470 ft in the NEc of sec. 2 and completed September 21, 1935. These two wells appear to be the deepest boreholes in sec. 1 and 2. Other wells drilled in sec. 1 and 2 were completed within the period 1940-1982 generally at depths ranging from the Mississippian to the Viola Limestone. Wells completed in Mississippian strata in sec. 1 and 2 are approximately in the depth range 2,900-3,000 ft below land surface.

The KCC requested that the Kansas Geological Survey (KGS) geochemically characterize the salinity. The characterization would determine whether the saltwater is derived from dissolved evaporites in the Permian Wellington Formation or from deeper formation brine. The KCC collected water samples from 3 monitoring wells and a brine from an active well (SE SE NW sec. 1, T. 20 S., R. 1 W., Bitikofer Field) producing from Mississippian strata. The KGS determined the specific conductance, chloride, sulfate, and bromide concentrations of the samples and identified the salinity source based on constituent ratios and mixing-curve graphs.

PROCEDURE

The water and brine samples were filtered through 0.45 µm membrane filter paper before analysis. Chloride, sulfate, and bromide concentrations were determined using automated colorimetric methods on a Technicon AutoAnalyzer II, except for sulfate in the brine which was measured by a turbidimetric procedure. The chloride concentration was corrected for the presence of bromide and the bromide content corrected for the presence of iodide. These corrections amounted to <1% for the chloride and <2% for the bromide concentrations. The estimated maximum errors in the chloride, sulfate, and bromide determinations are 3%, 4%, and 5%, respectively. The salinity source contaminating the ground water was identified using the geochemical methods of Whittemore (1984, 1988).

RESULTS AND DISCUSSION

The sample identification and chemical results for the waters analyzed are listed in Table 1. The ground waters range from slightly to very saline. The sulfate concentrations are in the range of freshwaters and do not change substantially with increase in chloride content.

Table 1. Specific conductance, constituent concentrations, and bromide/chloride mass ratios for ground-water and brine samples from the Selzer contamination site

Sample description	KGS lab no.	Lab Sp.C., uS/cm	Cl, mg/L	SO ₄ , mg/L	Br, mg/L	Br/Cl x 10 ⁴
Monitor well no. 1	950030	15,090	5,140	41.2	17.6	34.24
Monitor well no. 3	950031	29,200	10,830	53.8	37.3	34.44
Monitor well no. 5	950032	2,120	406	33.6	1.59	39.16
Produced oil brine from Mississippian, Bitikofer Field	950033	112,000	49,200	<10	170	34.55

The salinity sources were identified using constituent ratios and mixing curves on plots of bromide/chloride and sulfate/chloride ratios versus chloride concentration. The bromide/chloride plot (Figure 1) contains 4 mixing curves, each of which is calculated from the conservative mixing of two end-member waters. Conservative mixing refers to the simple mixing of waters without chemical reactions, such as mineral precipitation or adsorption, that could alter the concentrations of one or both of the constituents. The two dashed curves in Figure 1 enclose a zone representing the mixing of freshwater with natural Permian saltwater. The freshwater end members for the dashed curves are based on fresh ground waters from the Equus Beds area (Whittemore, 1984). The saltwater end members for the dashed curves are for saltwaters from the Wellington Formation in the Smoky Hill River valley (Whittemore, et al., 1981). Points for the monitoring well waters plot at substantially higher bromide/chloride ratios than for Wellington salt-dissolution brine. Therefore, the saltwater source is not from the Wellington Formation.

Formation brines in strata not containing rock salt in Kansas have substantially higher bromide/chloride ratios than for brine primarily derived from dissolution of rock salt. The brine sample from the Mississippian strata (Table 1) has a bromide/chloride mass ratio close to that of the value for seawater (0.00347). The two most saline ground waters from the contamination site have bromide/chloride ratios nearly identical to that of the Mississippian brine.

The two solid lines in Figure 1 were drawn from end members bracketing the least saline ground water and end members bracketing the Mississippian oil brine. The maximum analytical error was used for the range in the bromide/chloride ratios for the end members above and below the points for the monitoring well 5 water and the oil brine. The salinity for all of the ground waters fits the Bitikofer Field brine from Mississippian strata as the source.

Although the chemistry of the contaminated ground water matches very closely the Mississippian brine sampled less than a mile to the east of the apparent origin of the plume, a question could be asked as to whether other formations below the Permian and above or below Mississippian strata could be the primary source of the saltwater or could be contributing saltwater to the source. The borehole suspected as the contamination origin was drilled below the Mississippian into the Simpson Group as indicated above. Figure 2 is the same as Figure 1 but also includes points for 12 saltwaters produced with oil from other formations, as well as Mississippian strata, from locations within a square block of 16 townships centered about the

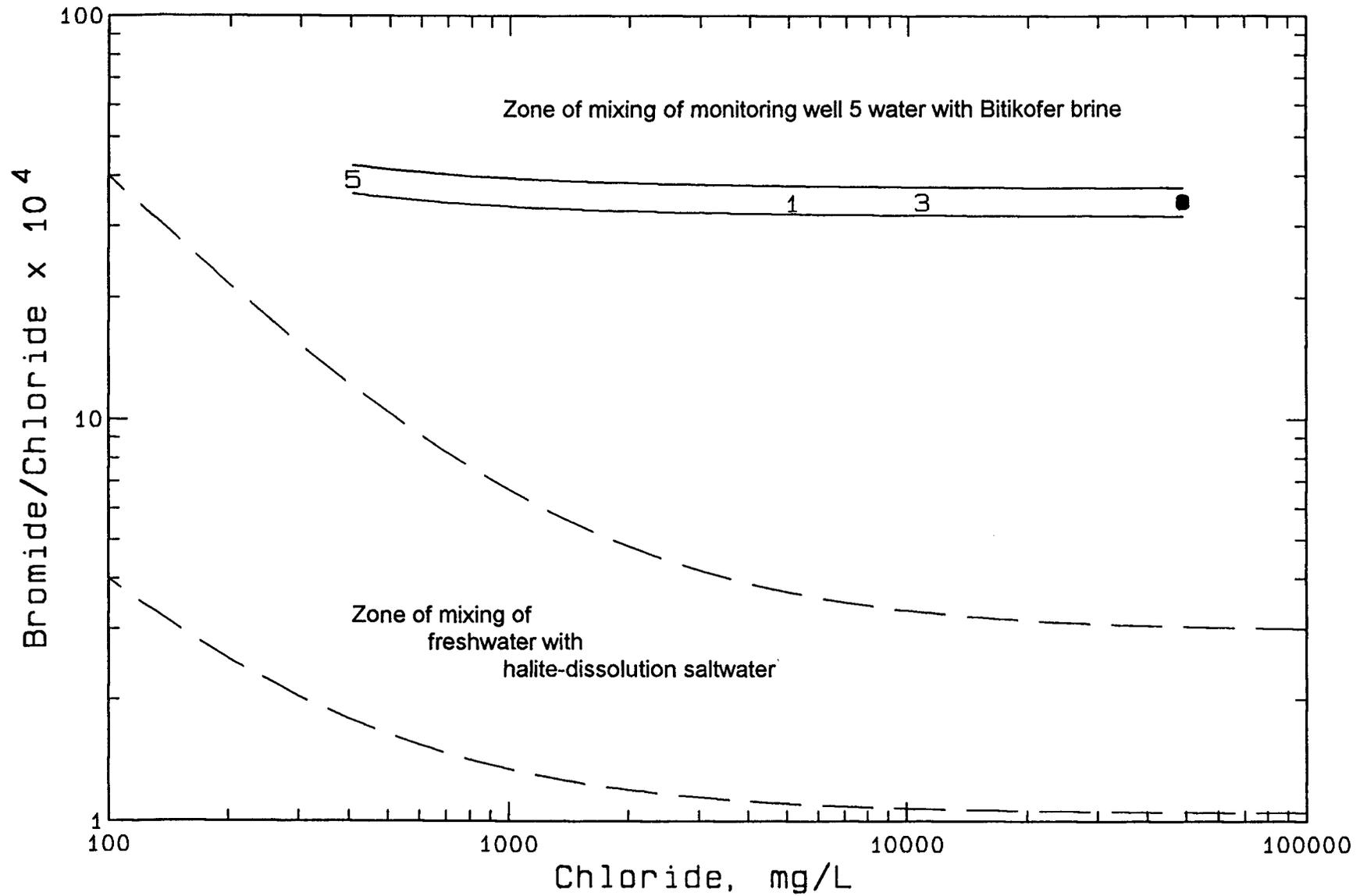


Figure 1. Bromide/chloride mass ratio versus chloride concentration for ground waters from monitoring wells at Selzer contamination site and Bitikofer Field oil brine. Key: 1, 3, 5 monitoring well water; ● Bitikofer brine.

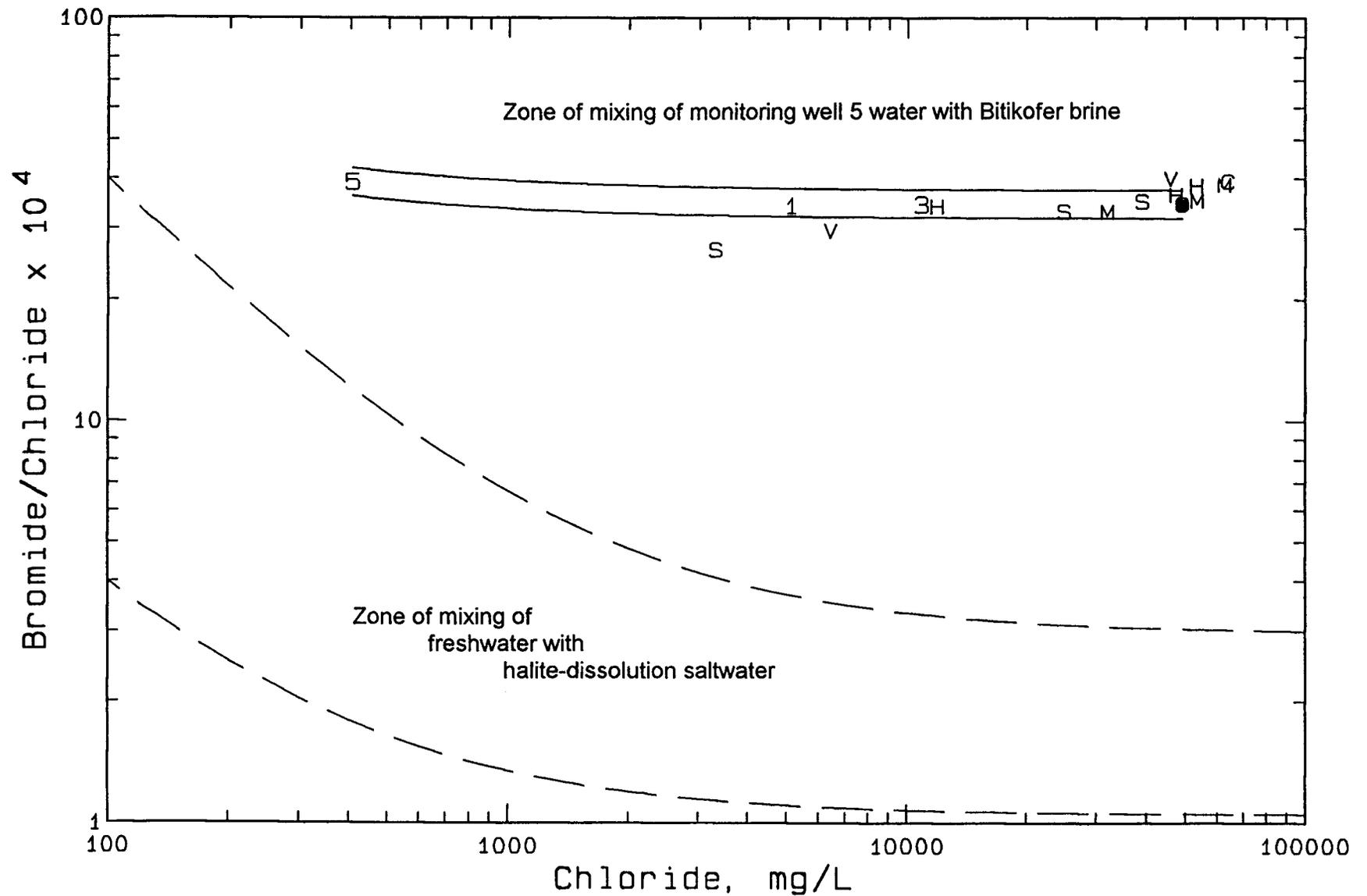


Figure 2. Bromide/chloride mass ratio versus chloride concentration for ground waters from monitoring wells at Selzer contamination site, Bitikofer Field oil brine, and oil-field brines from the surrounding area. Key: 1, 3, 5 monitoring well water; ● Bitikofer brine; C Cherokee brine; M Mississippian brine; H Hunton brine; V Viola brine; S Simpson brine.

location of the brine sample from the Bitikofer Field. Information on the location and geologic strata for the saltwaters is listed in Table 2. Figure 2 suggests that Cherokee (Pennsylvanian) brine may not be an important possible source of brine within the borehole because the bromide/chloride ratio is higher than the Mississippian brines. Some of the other formation brines from depths below the Mississippian strata have similar bromide/chloride ratios as that of the Mississippian brine and, thus, could possibly be a source of saltwater from the borehole.

The relatively low sulfate concentrations, and resultant very low sulfate/chloride ratios in the ground waters also fit the Mississippian brine as the saltwater source. Wellington saltwaters have much higher sulfate/chloride ratios than the Mississippian brine (Whittemore, et al., 1981). Figure 3 is constructed in a similar manner as for the bromide/chloride graphs, except that the range for the sulfate/chloride end points above and below the least saline ground water include possible natural variation in the ratio in addition to analytical error, and the end points for the brine were selected for a range in chloride concentrations greater and less than that of the brine at a sulfate/chloride mass ratio of 0.0001. Figure 3 suggests that there may be an additional source of sulfate from other formations because the waters from monitoring wells 1 and 3 shift progressively to sulfate/chloride ratios that are higher than the middle of the mixing zone at the chloride of the samples. However, the amount of sulfate that would need to be added for this shift is small (<30 mg/L), and could easily come from a very little Permian water which would be expected to have a high sulfate content in the area from dissolution of gypsum and/or anhydrite.

CONCLUSIONS

The source of saline ground water at the Selzer contamination site fits formation brine derived from Mississippian strata. The saltwater source is not salt-dissolution brine from the Permian. However, there is a possibility that saltwaters from formations below the Mississippian could also contribute to the saltwater source, assuming that the brine is derived from the D&A well in the NE NE SE sec. 2, T. 20 S., R. 1 W., which was completed in 1935 in the top of the Arbuckle Group.

ACKNOWLEDGMENTS

The report was conducted in cooperation with Doug Louis of Conservation Division District II of the Kansas Corporation Commission in Wichita. Lawrence Hathaway, Chief of the Analytical Services Section of the Kansas Geological Survey, analyzed the water samples.

Table 2. Location, producing zone, and concentrations of chemical constituents for oil brines in area surrounding Selzer property and Bitikofer Field. The brines are listed in the order of the geologic column.

Field	Lease	Producing zone	Legal location	Cl, mg/L	SO ₄ mg/L	Br, mg/L
Round Hill	#1 Johnson	Cherokee	SW SW SW 28-18S-1W	63990	3	251
Koehn	#1 Koehn	Miss. Chat	SW SW NE 2-19S-1W	53590	4	189
Lehigh N.	#2 Shroeder	Mississippian	CN2 SE SE 22-19S-1E	31980	139	106
Ritz-Canton	#3 Maude Smith	Mississippian	CSE SW 15-19S-2W	62770	2	242
Graber	#6 Goering	Hunton	NW SE SE 17-21S-1W	53380	20	205
Graber	#1 Chavez	Hunton	SE SE SW 8-21S-1W	11840	1584	40.4
Winsinger West	#1 M. Stucky	Hunton	NE NW SE 23-21S-2W	47460	17	173
Ritz Canton	#B-1 Ratzlaff	Viola	NW NW NE 36-19S-2W	46040	222	184
Scully	#1-15 C. Meisinger	Viola	NE NE NW 15-18S-1E	6400	648	19
French Creek	#1 P.G. Jost	Simpson	SW SW NWSW 22-19S-2E	39100	82	137
Reuben	#D-1 Paterson	Simpson	NE SW NE 17-18S-2W	24890	647	82.4
Scully	#1-10 V. Dudeck	Simpson	SW SE NE 10-18S-1E	3307	17	8.8

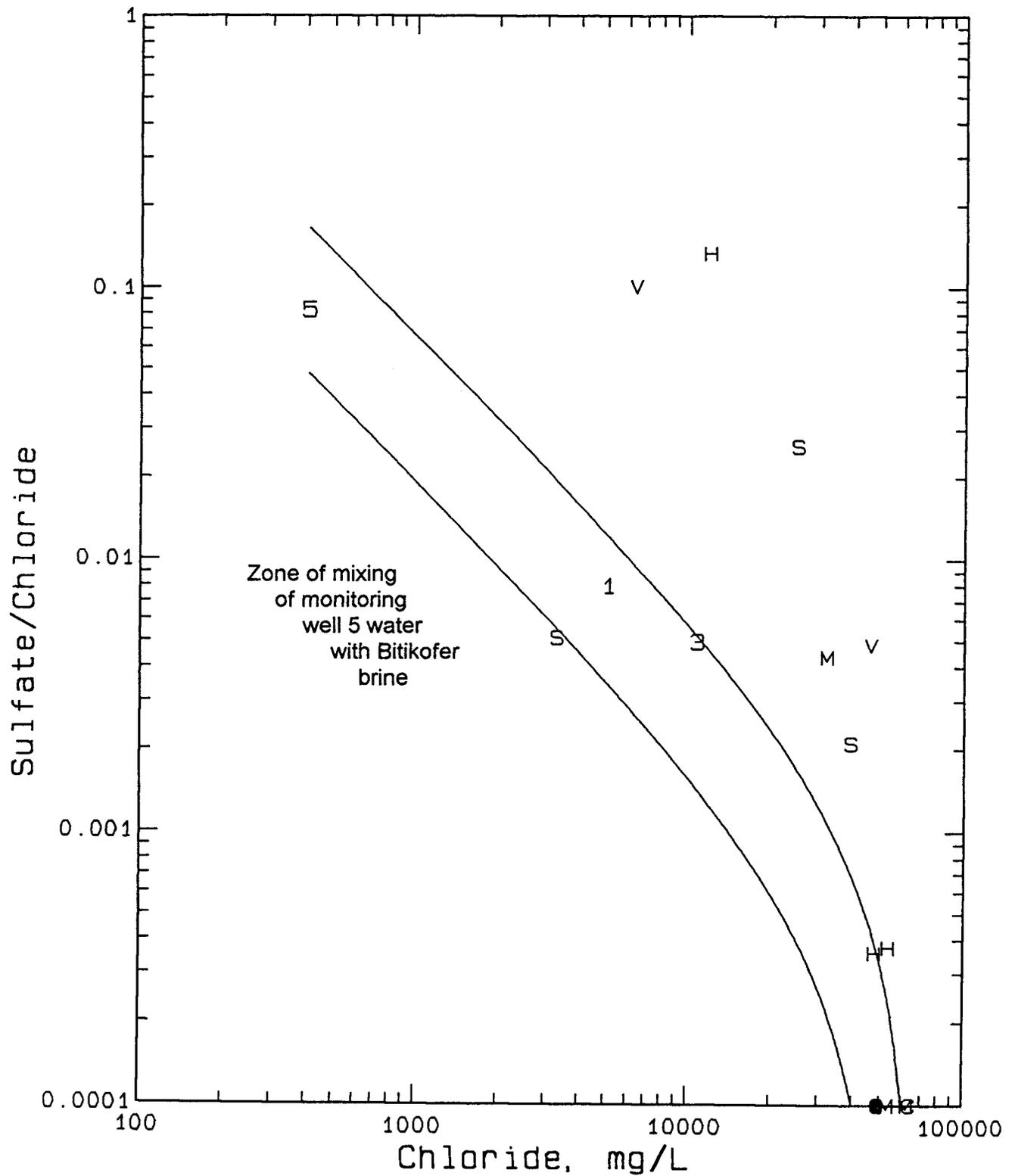


Figure 3. Sulfate/chloride mass ratio versus chloride concentration for ground waters from monitoring wells at Selzer contamination site, Bitikofer Field oil brine, and oil-field brines from the surrounding area. Key: 1, 3, 5 monitoring well water; ● Bitikofer brine; C Cherokee brine; M Mississippian brine; H Hunton brine; V Viola brine; S Simpson brine.

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