Kansas Geological Survey
A Division of
The University of Kansas

Chemical Quality Series 11
Plate 2

Atlas of chemical-quality data for irrigation waters of western Kansas

by
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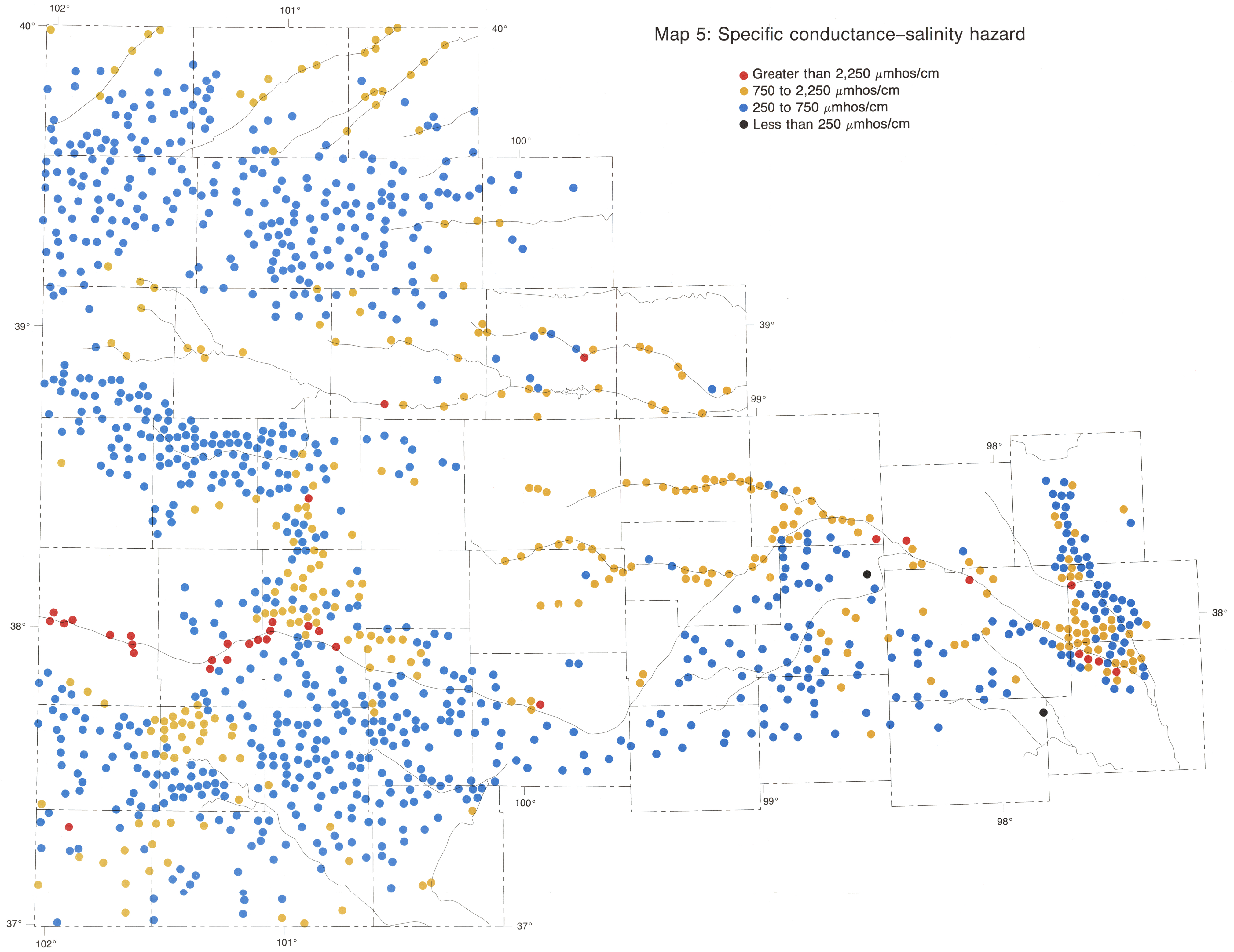
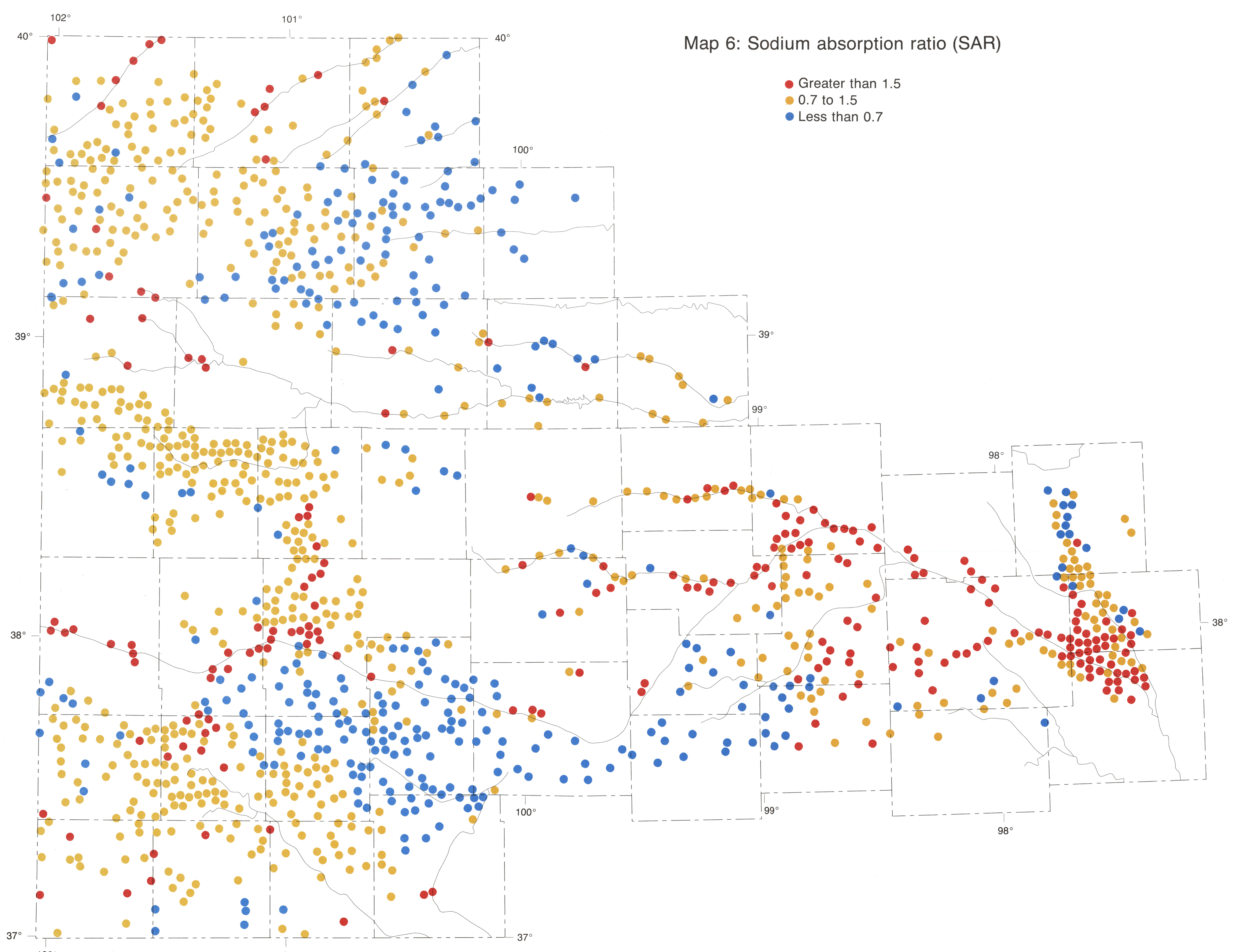
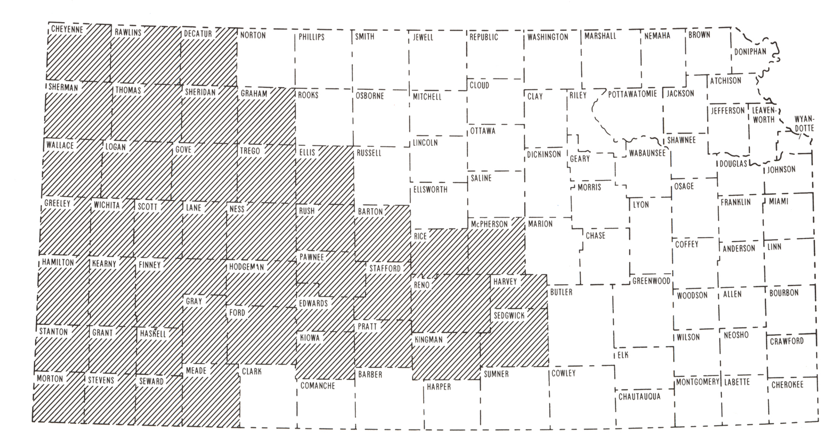
1985



Map 5: Specific conductance–salinity hazard



Map 6: Sodium absorption ratio (SAR)



Index map of study area.

The specific conductance of a water sample is a measure of the sample's ability to conduct an electrical current and is related to the nature and concentration of ionic species present in the sample. Thus, maps of specific conductance (Map 5) and total residue (Map 2) will tend to mirror one another. The plotting intervals used in Map 5 correspond to those employed in the salinity-hazard classification of water for irrigation usage.

Specific-conductance values in the range of 250–750 μmhos are dominant for ground waters of the study area. Values above 750 μmhos typically are found in areas associated with shallow water-table conditions, drainageways, Permian-age bedrock directly below the aquifer, or contamination from oil-gas activity. The very high salinity-hazard classification associated with ground water from the western portion of the Arkansas River valley in the study area reflects accumulation of salts in the alluvium which are derived from weathering processes active in the Colorado reaches of the river system. The decrease of specific-conductance values below 2250 μmhos in the Arkansas River valley in western Gray County may be related to an influx of better-quality ground water from the sandy area south of the river. Eastward of Gray County, poorer-quality waters delivered by tributaries to the Arkansas River tend to increase specific-conductance levels in the main river-valley system.

The sodium-adsorption ratio (SAR) is a parameter that is calculated from general water-quality data. SAR is used to estimate the extent to which the irrigation water will undergo cation-exchange reactions with the clay minerals of the soil. As sodium from the water displaces calcium and magnesium from the clay minerals, the structure of the soil is broken down, resulting in reduced movement of water through the soil. Higher SAR values in irrigation waters are more tolerable if the total-residue level of the water is low and the soil is well drained and/or fairly sandy.

Map 6 shows that most ground water in the study area has a SAR value that is less than 1.5, reflecting a dominance of calcium and magnesium over sodium in the dissolved load of the ground water. The effects of alluviation during Pleistocene times may be reflected in the zone of <0.7 SAR values south of the Arkansas River. The low SAR values in the northeastern third of the study area probably reflect an eastward thinning of the unconsolidated aquifer and the presence of a carbonate bedrock unit. Locations with SAR values above 1.5 reflect areas of near-surface accumulations of sodium-rich salts or areas where sodium-rich fluids reach the unconsolidated aquifer from sources below. Areas of shallow water-table conditions and drainage ways represent the near-surface condition; whereas, areas overlying halite or Na–Cl water-bearing Permian-age bedrock and sites contaminated by oil brine may reflect the effects of the deeper sources. However, cation-exchange reactions with clay minerals may serve to temper the SAR value of ground water contaminated by brine.

Salinity–sodium (alkali)-hazard classifications are used to assess the compatibility of an irrigation water's chemistry with local soil conditions and crop tolerance. Salinity-hazard classes are defined by specific-conductance intervals (Map 5). Sodium (alkali)-hazard classes are defined by intervals in a relationship that is linear in specific conductance and logarithmic in SAR. Map 7 depicts the distribution of ground-water sodium (alkali)-hazard classes within the study area and, together with Map 5, provides a means for visualizing regional changes in the salinity–sodium (alkali)-hazard classifications.

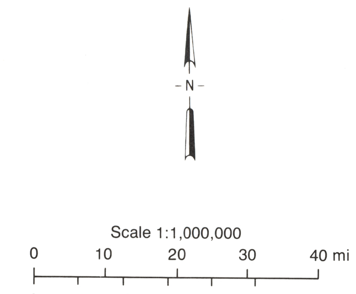
Most ground water of the study area, except that in the western one-third and eastern one-third of the Arkansas River valley, falls into the low sodium (alkali)-hazard class. The accumulation of soluble salts, which are enriched in sodium, in the alluvium of the river valley accounts for the medium- to high-hazard classes noted in the valley system. The potential for increased sodium (alkali)-hazard classification of irrigation waters exists in regions where oil-brine contamination of the aquifer exists or in areas where bedrock units may contribute halite brine to the unconsolidated aquifer. Fields that have been irrigated with waters having a medium sodium (alkali)-hazard classification or greater may require periodic soil-amendment procedures such as addition of gypsum in order to maintain productivity.

Map 8 depicts sodium-chloride (Na/Cl) mass ratios for ground waters of the study area. The Na/Cl ratio of halite is 0.65, whereas that for Kansas oil brine is of the order of 0.50 ± 0.1. In theory, this ratio should serve to distinguish the type of brine pollution involved at a given well site. However, cation-exchange reactions may reduce the Na/Cl ratio of the polluted ground water making source identification difficult. Detailed studies of the variations in concentration of trace constituents such as iodide and bromide are more useful in brine-source identification.

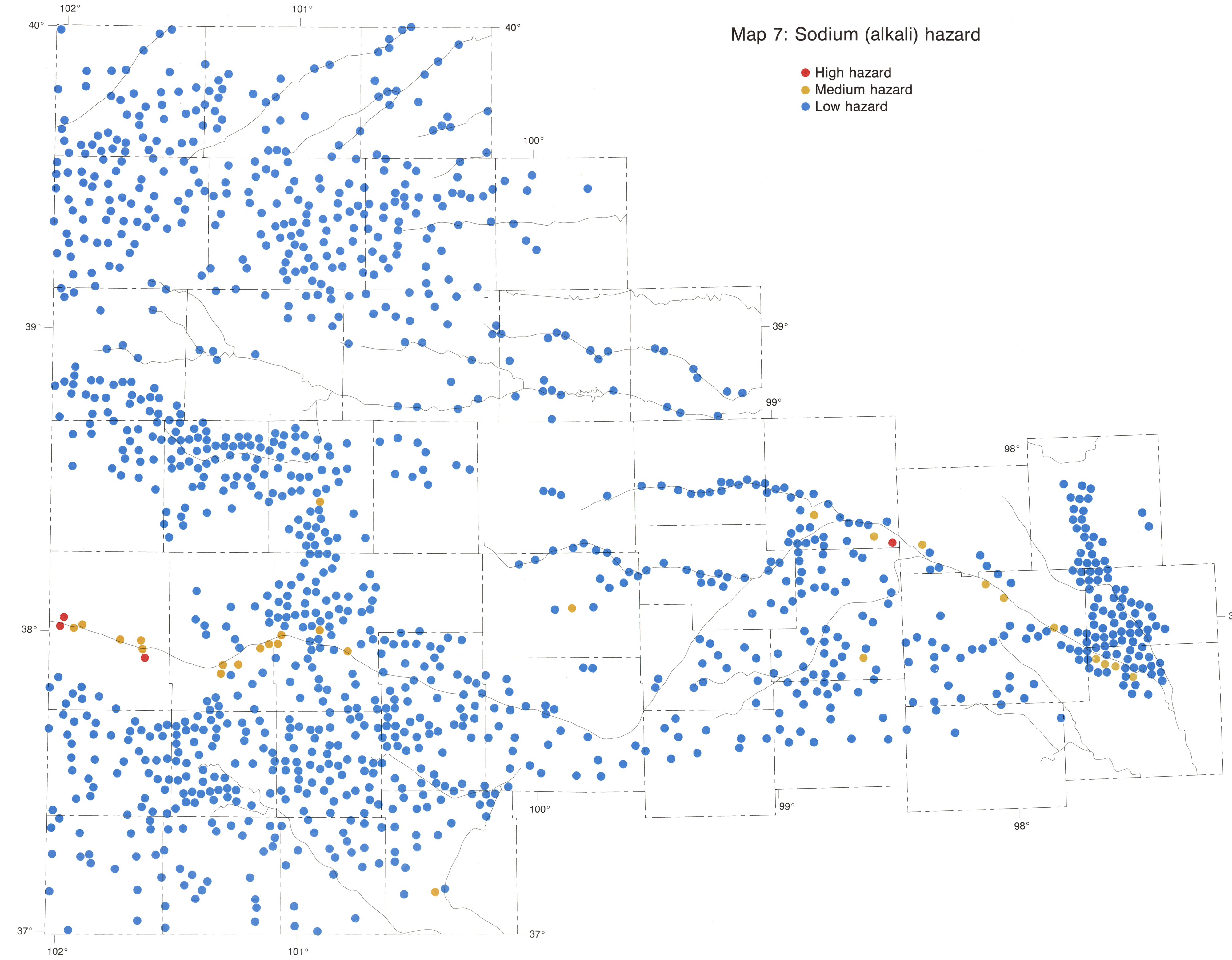
The intervals selected for Map 8 correspond approximately to an oil-brine interval ($Na/Cl < 0.55$), a halite-brine interval (Na/Cl 0.55–0.75), and an interval in which the sodium content of the ground water is tied to anions other than just chloride. Most ground waters of the study area fall into this latter class. General brine contamination of the freshwater aquifer may be indicated if low Na/Cl ratios are accompanied by chloride concentrations substantially elevated above background levels.

Selected readings

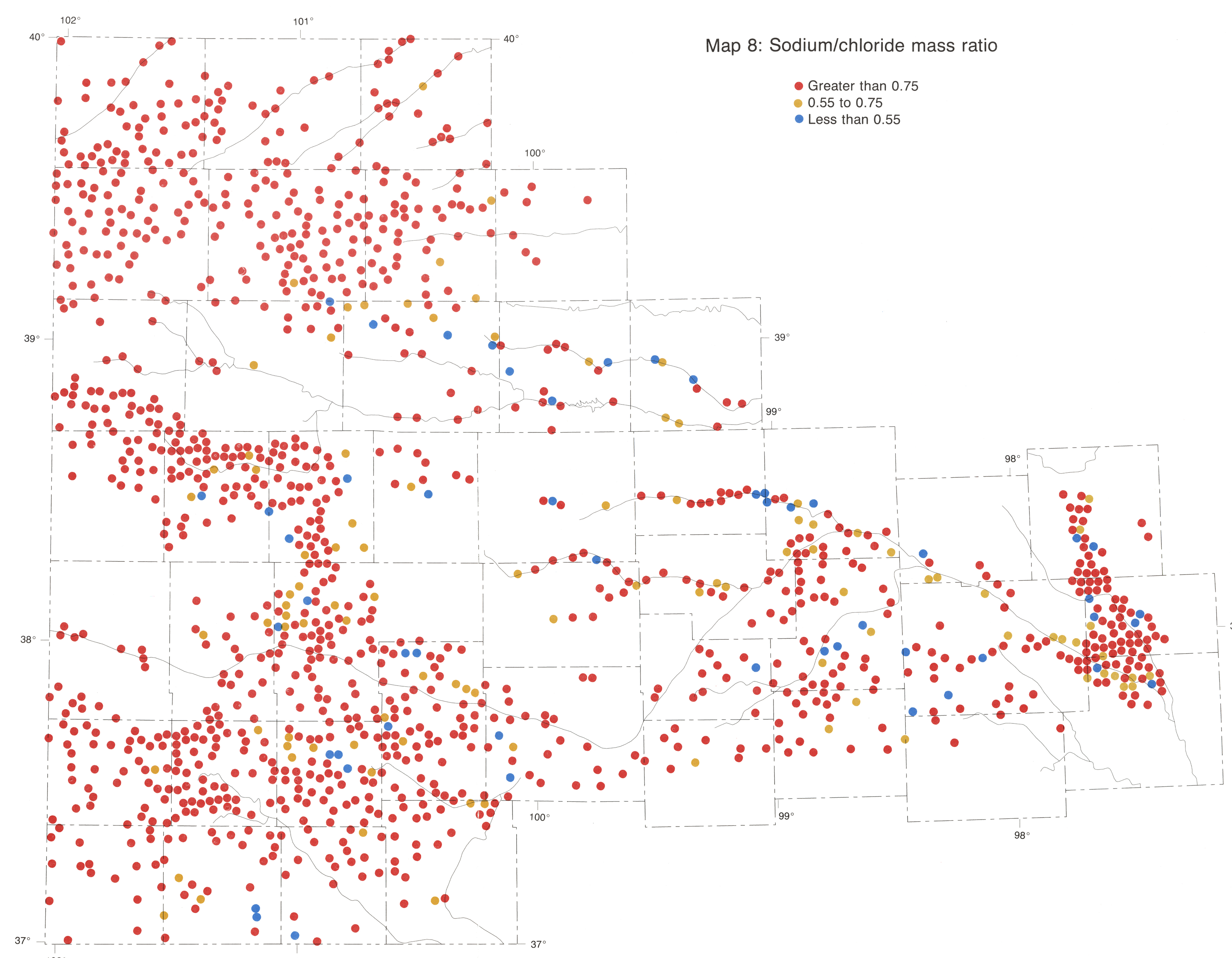
1. Berendsen, P., and Hathaway, L. R., 1981, Uranium in unconsolidated aquifers of western Kansas: Kansas Geological Survey, Mineral Resources Series 9, 43 p.
2. Hathaway, L. R., Carr, B. L., Flanagan, M. A., Galle, O. K., Waugh, T. C., and Dickey, H. P., 1978, Chemical quality of irrigation waters in southwestern Kansas: Kansas Geological Survey, Chemical Quality Series 6, 33 p.
3. Hathaway, L. R., Carr, B. L., Galle, O. K., Magnuson, M. L., Waugh, T. C., and Dickey, H. P., 1977, Chemical quality of irrigation waters in Hamilton, Kearny, Finney, and northern Gray counties: Kansas Geological Survey, Chemical Quality Series 4, 33 p.
4. Hathaway, L. R., and Dickey, H. P., 1978, Soil associations of southwestern Kansas: Kansas Geological Survey, Map M–8A.
5. ———, 1980, Soil associations of northwestern Kansas: Kansas Geological Survey, Map M–8B.
6. ———, 1982, Soil associations of south-central Kansas: Kansas Geological Survey, Map M–8C.
7. Hathaway, L. R., Galle, O. K., Waugh, T. C., and Dickey, H. P., 1978, Chemical quality of irrigation waters in Ford County and the Great Bend Prairie of Kansas: Kansas Geological Survey, Chemical Quality Series 7, 41 p.
8. Hathaway, L. R., Magnuson, L. M., Carr, B. L., Galle, O. K., and Waugh, T. C., 1975, Chemical quality of irrigation waters in west-central Kansas: Kansas Geological Survey, Chemical Quality Series 2, 45 p.
9. Hathaway, L. R., Waugh, T. C., Galle, O. K., and Dickey, H. P., 1979, Chemical quality of irrigation waters in northwestern Kansas: Kansas Geological Survey, Chemical Quality Series 8, 45 p.
10. ———, 1981, Chemical quality of irrigation waters in the Equus Beds area, south-central Kansas: Kansas Geological Survey, Chemical Quality Series 10, 45 p.
11. Chemical-quality data for ground waters from the Smoky Hill River, Pawnee River, and Walnut Creek valleys: Kansas Geological Survey, Open-file Report 80–18 (available from L. R. Hathaway).



The county boundaries, streams, contours of saturated thickness shown on Plate 1, and color-separated dot symbols on all five plates were produced by computer in the Automated Cartography Laboratory of the Kansas Geological Survey. Dot symbols were generated from supplied locations. Software used to perform these tasks is a part of GIMMAP (Geodata Interactive Management Map Analysis and Production), a computer-assisted cartography system developed at the Kansas Geological Survey. All other preparation and layout by Renate Hensiek.



Map 7: Sodium (alkali) hazard



Map 8: Sodium/chloride mass ratio