Mineral Intrusion Issues and Implications for Monitoring and Management

Kansas Geological Survey Open-File Report 94-28g

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A cooperative investigation by

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Big Bend Groundwater Management District No. 5

Introduction:

The contract between the Kansas Water Office and the Kansas Geological Survey calls for reports on the implications of the scientific findings for monitoring and management activities in the Mineral Intrusion area. Project background information may be found in OFR 94-28a; this document is a preliminary summary of those issues that it may be appropriate for management agencies to consider.

We stress that this is not a prescription for specific activities on the part of other agencies. Water resource monitoring and management programs commonly address issues of available water quantity (including sustainable yield), water quality, variability, and vulnerability. The Mineral Intrusion project is generating information on all of these issues, and this report gives an initial overview of some findings of potential interest.

We solicit feedback from interested agencies on the presentation and development of these topics in future reports.

Overview of relevant observations:

Technical findings are summarized in more detail in the other chapters of the Fiscal Year 1994 report (OFR 94-28). This section briefly summarizes key findings as background for the monitoring and management discussions to follow.

The depth and general form of the saltwater interface, if not close to a pumping well, are relatively stable features -- over the 1993-94 year, during which water levels changed by several feet due to unusual recharge, only a few salt sites showed variation as large as a foot in the 100 mS/m field conductivity depth (OFR 94-28c). Estimated total salt inventories in the Great Bend Prairie aquifer (GBPA) changed by less than one percent (OFR 94-28b). No significant changes in the conductivity profiles of freshwater wells were observed.

Test wells close to an irrigation site showed some of the most significant variations in salinity profiles on time scales of weeks to months, apparently due to the interactions of pumping stress and local stratigraphy. Work is in progress on the detailed analysis of conductivity log shifts, but the deeper changes seen by logging also correlate with observed water quality changes in the water pumped (OFR 94-28c). These observations are supported by the initial results of computer simulation (OFR 94-28f).

The lower limit of sensitivity of the focused-EM logging tool is in the range of detection of slightly saline groundwater (i.e., several hundred to a few thousand mg/L Cl -- Young et al., 1993). For reliable characterization of water quality in the general range of drinking water and usable irrigation water, and for determination of probable salt sources (see below), chemical analyses continue to be necessary although they can be augmented by conductivity log curve-fitting techniques (OFR 94-28b).

The distribution of saltwater in the GBPA shows some definite overall patterns. For example, OFR 94-28e summarizes findings indicating that northern Stafford County is the most heavily salt-affected area by any measure, that well-site salt inventories tend to be higher close to the Cedar Hills formation subcrop, and that the mass of salt decreases but the volume of water affected by salt increases in a generally west to east direction. These patterns give us reason to hope that some predictive relationships can be developed. However, there is substantial variation in the distribution of salt detections and especially in the amount and distribution of salt present at a given site that cannot currently be attributed to any readily measured parameters (e.g., head, permeability, formation).

Anthropogenic salt sources -- both oil brine contamination and enhanced Permian outflow due to old wells, coreholes or subsidence features -- probably account for a minor component of the total salt load, but are prevalent enough to complicate monitoring and interpretation (see OFR 94-28c). These can generally be identified by detailed chemical analysis.

Monitoring implications:

Monitoring schedules and time scales: The general intermediate-term stability of the saltwater interface suggests that where the goal is long-term characterization of regional saltwater inventory and distribution, conductivity logging of wells in areas of general stability without known stresses or hydrologic change can probably be safely done on an annual or even biennial schedule. However, the observation of significant (although sometimes subtle) changes in profile characteristics in response to local pumping suggests that changes occurring in areas of known problems and fluctuating groundwater quality, and/or in response to local pumping, may need to be monitored on at least a monthly basis or on some schedule with variable but comparable frequency if the goal of the monitoring is to identify short-term changes.

Logging and other monitoring methods: Because many of the changes observed to date are at or near the sensitivity limit of the logging tool, accuracy and precision are important, and the tool calibration, field measurements, and data processing must be designed to maximize repeatable sensitivity. Although logging is uniquely able to detect changes in the deep salinity structure, it will be most effective as part of a program that includes chemical monitoring (conductivity/chloride measurements) for sensitive tracking of small changes and salt content at "freshwater" locations, and to fill in gaps in the widely-spaced network of deep monitoring wells .

Source characterization: Because both management and monitoring strategies may be different for cases of anthropogenic contamination compared to natural brine contamination, it will be desirable to have a program of characterization of monitoring program "hits" (new problems or significant changes in salinity). This might include review of KCC and other data, and/or chemical fingerprinting to distinguish between anthropogenic and natural salt contamination.

Monitoring network: At least one additional well will be added to the monitoring network in the coming year. Further findings of the Mineral Intrusion study will suggest the areas that are in greatest need of monitoring or additional data from a research standpoint. Management agencies may wish to consider these findings to determine if additional assessment/monitoring sites may be needed to validate models, support proposed regulations, or to assess the actual or potential effects of changes in pumpage.

Management Implications:

Large-scale pumping in locations where poorly-confined salt water is present in the GBPA results in local salt upconing and degradation of water quality (OFR 94-28c, f). The need for careful site assessment in considering water right applications in areas potentially subject to salt contamination has already been recognized by the Board of Big Bend Groundwater Management District #5 (GMD5) by establishment of a temporary moratorium on applications in the salt-affected areas of northern Stafford County, and by consideration of deep aquifer water quality as a potential condition for application approval.

In addition to site assessment, further development of conceptual and numerical models (OFR 94-28e, f) may provide information that can be used to inform water users as well as managers on techniques of well construction, pumping rates and schedules, and water quality monitoring that can be used to minimize the potential for salt contamination.

In areas where there is a substantial regional inventory of saltwater in the GBPA (e.g., northeastern Stafford County -- OFR 94-28c, e), the saturated thickness of usable freshwater is substantially less than estimates based on depth to bedrock. Over much of this area, water use (and applications for appropriation) tend to be self-limiting because of the widely recognized absence of good water. However, on the fringes of this area or in regions of patchy or non-predictable salt contamination (such as much of eastern GMD5 south of the Rattlesnake Creek), water use may be possible, but carries with it a potential risk of contamination. In such areas, careful site assessment, continued or expanded monitoring, and possibly the use of simple models may be important tools for management of the water resource within the safe yield requirements imposed by water quality as well as water quantity considerations.

A key approach to management in regions of variable or uncertain contamination and water quality is a system for classifying areas in terms of probable water quantity, quality, and vulnerability. If management agencies consider it appropriate, this type of classification system is easily combined with a structured hierarchy of assessment and monitoring requirements and management policy options depending on the classification of land and water. Because ongoing monitoring and assessment activities will increase the data base and understanding of the salt problem, both the classification system itself and the programs and policies keyed to it should be structured to permit administrative incorporation of additional data and resulting modifications of site classification and applicable rules.

GMD5 has already embarked on a program to develop both the technical and the policy tools needed for an effective monitoring and management program in the mineral intrusion area. A major goal of the Mineral Intrusion project is to provide data and technical recommendations that can effectively support this development.