



Memorandum

Date: June 4, 2007

To: Doug Louis – Kansas Corporation Commission

CC: Jeff Klock – Kansas Corporation Commission
Bob Jenkins – Kansas Corporation Commission

From: David Stous – Burns & McDonnell
Paul McCormick - Burns & McDonnell

Re: Burrton IGUCA Remediation Study 2007 Update

Groundwater in the vicinity of Burrton, Kansas has been impacted by elevated chloride concentrations greater than 2,000 mg/L, primarily caused by historic oil field operations in the region. The plume of high chloride groundwater is expanding and migrating southeast in the Equus Beds Aquifer, threatening to contaminate a larger area of the aquifer which is used for municipal, industrial, and agricultural water supplies. The State of Kansas designated the contaminated area around Burrton as the Burrton Intensive Groundwater Use Control Area (IGUCA) in 1985. The IGUCA is within the boundaries of Equus Beds Groundwater Management District No. 2 (GMD2) which was formed in 1975 to manage the aquifer. The Kansas Corporation Commission (KCC) began a study to address the high chloride groundwater problem in 1996. The objective of the 1996 study was to evaluate remediation scenarios through groundwater and contaminant transport modeling. Results of the evaluation are detailed in *Burrton IGUCA Remediation Study, 1997*.

In 2007, the KCC asked Burns & McDonnell to re-evaluate the groundwater flow and transport model after a ten-year time period had passed. The objectives of this evaluation are to update the model with the current chloride concentration data, evaluate several potential remediation alternatives, revise the chloride impact estimate through the year 2046, and to update the cost estimates for the potential remediation alternatives.

Model Area

The USGS office in Lawrence, Kansas developed a groundwater flow model to study the stream-aquifer system of the Arkansas River and the Equus Beds Aquifer (Myers, 1996). The USGS regional model area includes the current study area for the Burrton IGUCA Remediation Study. In the study conducted by the USGS, the hydrologic and chemical interaction of the Arkansas River with the Equus Beds Aquifer was modeled.

The U. S. Bureau of Reclamation (USBR), under contract with Equus Beds Groundwater Management District No. 2 (GMD2), modified the USGS model in order to conduct a contaminant transport study (Pruitt, 1993). The purpose of the study was to evaluate the potential for the migration of saline water from the Arkansas River, deep

natural saltwater, and brine from the Burrton oil field operations into the Equus Beds Aquifer. To improve the accuracy of the transport modeling, the Bureau of Reclamation refined the model grid spacing and made the grid cells more square-shaped. Burns & McDonnell used a portion of the USGS regional model to develop a subregional model for the 1996 investigation to study the hydrogeology and salt migration in the area..

The subregional model utilized for the 1997 and 2007 studies is covers an area that is approximately 190 square miles and encompasses the majority of chloride impacted groundwater originating from the Burrton oil field. The model area is shown on the figure titled “Study Area Bedrock Surface”. Details of the hydrogeology and model development can be found in the Burns & McDonnell report titled *Burrton IGUCA Remediation Study, 1997*. MT3D (Papadopulos and Associates, Inc., 1992), a modular three-dimensional transport model, was used in conjunction with MODFLOW to predict the migration of chlorides in the Equus Beds Aquifer.

Three major layers of stratigraphy are defined in the model; the surficial aquifer from 0 to 50 feet below grade (fbg), the intermediate aquifer from 51 to 150 fbg, and the deep aquifer from 151 fbg to bedrock. All three layers have chloride impacts. The boundary conditions established in the subregional groundwater flow model were maintained for the contaminant transport model. Year 2006 data obtained from GMD2, KCC, and the City of Wichita was used to update the initial concentration of chloride for the study area.

Modeling Scenarios

The modeling runs for the recovery well simulations were established for a 40-year time period beginning with the 2006 chloride levels. This time period was chosen to duplicate the end date of the 1997 study. The same 1992 pumping conditions that were used in the 1997 study were used in the 2007 update. The stresses and chloride concentrations from the Arkansas River and deep aquifer were assumed to remain constant during the projected time period.

Four model scenarios were run to demonstrate the migration of chlorides in the aquifer and to evaluate three remedial alternatives. The four scenarios evaluated are as follows:

1. no action undertaken to remediate the plume,
2. 17 plume extraction wells and 6 gradient control wells pumping a total of 4,000 gallons per minute (gpm);
3. 17 plume extraction wells and 6 gradient control wells pumping a total of 4,000 gpm with 1,500 gpm recharged down-gradient of the plume through 4 recharge basins; and,
4. no action taken with addition of the City of Wichita’s Equus Beds Recharge Project.

Modeling Results

Results of the four modeling scenarios were evaluated compared to the 1997 results. A summary of the results of each scenario are provided below:

1. With no action taken to remediate the plume, chloride concentrations spread laterally and migrate generally to the east, toward the City of Wichita Wellfield. The plume also moves deeper into the aquifer. The peak chloride concentrations decrease as the plume is diluted by precipitation and mixing with the surrounding groundwater, however, the area impacted at levels above 100 milligrams per liter (mg/L) increases.
2. With a proposed 17 plume extraction wells and 6 gradient control wells pumping a total of 4,000 gpm, the area impacted with concentrations of chlorides exceeding 100 mg/L is reduced from the no action scenario. However, the plume continues to spread and does impact the City of Wichita Wellfield.
3. With a proposed 17 plume extraction wells and 6 gradient control wells pumping a total of 4,000 gpm and discharging into 4, ½-acre recharge basins located down-gradient of the plume, the area impacted with concentrations of chlorides exceeding 100 mg/L is reduced over two previous scenarios. The artificial recharge from the basins results in increased concentrations of chlorides in Layers B and C, but provides additional control to limit the areal extent of the plume. The plume continues to impact the City of Wichita Wellfield.
4. With no action taken to remediate the plume and the City of Wichita's Equus Beds Recharge Project in place, chloride concentrations spread laterally to the north and south, while migration to the east is significantly slowed by the recharge wells. The City of Wichita Wellfield is impacted, but to a much lesser extent than in any of the other scenarios.

Remedial Alternatives

Three remedial alternatives were taken from the 1997 report and evaluated using these modeling scenarios. The remedial alternatives are as follows:

Alternative 1 – Pumpage from the extraction well network, 2,000 gpm, is continuously directed to four Class II disposal wells. Effluent from the gradient control wells, 2,000 gpm, is pumped to a connection at the Wichita Wellfield and blended with the Wichita water supply.

Alternative 4 – Pumpage from the extraction well network, 2,000 gpm, is routed to a reverse osmosis (RO) treatment plant. RO concentrate is disposed of via one Class II disposal well. RO permeate and gradient control pumpage is blended and discharged at a connection with the Wichita Wellfield.

Alternative 5 – Pumpage from the extraction well network, 2,000 gpm, is routed to a reverse osmosis (RO) treatment plant. RO concentrate is disposed of via one Class II disposal well. RO permeate and gradient control pumpage is blended and discharged to four, 1/2 –acre recharge basins located down-gradient of the plume.

Evaluation of these alternatives indicates that the Burrton brine plume will not be completely remediated by pumping at the rates modeled in these scenarios. However, the model also indicates that increasing the pumping rates will substantially increase the infiltration of additional chloride contamination from the Arkansas River. Based on this information, a substantial increase in the gross amount of water pumped from the aquifer and treated will only result in a small gain in the net chlorides removed from the groundwater.

Remedial Alternative Costs

Cost estimates for these alternatives were developed during the 1997 study. For the purposes of this study, those same cost estimates were revisited and updated to reflect 2007 capital construction and operation and maintenance (O&M) costs. The estimated 2007 costs for each of these alternatives are provided in the table below:

	<u>Total Capital Costs</u>	<u>Total Annual Costs</u>
Alternative 1	\$14,944,000	\$615,000
Alternative 4	\$23,810,000	\$1,870,000
Alternative 5	\$22,920,000	\$2,050,000

The high costs estimated for Alternatives 1, 4 and 5 indicate that these options may be cost prohibitive. Therefore, no further cost analysis (i.e. present worth calculations) was completed. Groundwater modeling demonstrates that the pumpage rates used in these alternatives is not adequate to completely remediate the Burrton brine plume; therefore, complete plume remediation is likely to cost several times those numbers given in the table above.