Water-related issues affecting conventional oil and gas recovery and potential oil shale development in the Uinta Basin, Utah

TECHNOLOGY STATUS ASSESSMENT

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TABLE OF CONTENTS

STATEMENT OF THE PROBLEM

On March 27, 2008, the Utah Geological Survey (UGS) hosted a meeting with oil and gas operators in the Uinta Basin to discuss industry needs relevant to the National Energy Technology Laboratory's research solicitation. The operators clearly indicated that saline water disposal is the single most pressing issue with regard to increasing petroleum production. Conventional oil fields in the Uinta Basin provide 67% of Utah's total crude oil production, while the basin's natural gas fields provide 71% of Utah's total natural gas, the latter of which has increased 175% in the last 10 years (Figure 1) (Utah Division of Oil, Gas and Mining, 2008). As petroleum production increases, so does saline water production, creating an increased need for economic and environmentally responsible disposal plans. Current water disposal wells are near capacity and permitting for new wells is being delayed because of a lack of technical data regarding potential disposal aquifers and questions concerning contamination of fresh water sources. Many companies are reluctantly resorting to evaporation ponds as a short-term solution, but these come at an environmental price. Evaporation ponds concentrate the brine often creating a more hazardous product that still requires underground sequestration. Evaporation ponds are also prone to leakage, which could potentially cause contamination of surface streams and shallow fresh water aquifers. Many Uinta Basin operators claim that petroleum production cannot reach its full potential until a suitable, long-term saline water disposal solution is determined.

The second part of our study will focus specifically on the most critical priorities identified during the 2007 Oil Shale Environmental Workshop. Currently, insufficient data are available about how a potential oil shale industry would affect local Uinta Basin surface- and ground-water sources. Specifically, a baseline study of water quality and quantity needs to be completed for lands set aside by the U.S. Bureau of Land Management (BLM) as having oil shale development potential. Also, there are many questions as to how process-specific in-situ oil shale development technologies might impact local ground water and what options producers have for managing produced waters. Water availability and produced water quality will all be major operational and regulatory concerns facing oil shale development companies in Utah.

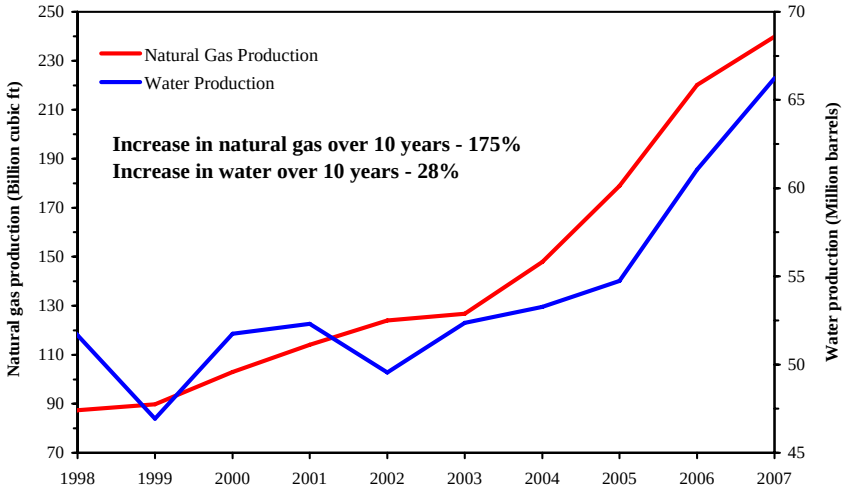

Figure 1. Water and natural gas production in Duchesne and Uintah Counties, 1998-2007. (Utah Division of Oil, Gas and Mining, 2008)

CURRENT STATE OF TECHNOLOGY

The primary agencies responsible for regulating the disposal of produced water are the Utah Division of Oil, Gas and Mining and the U.S. Environmental Protection Agency, the latter regulating wells on Tribal Lands. Currently these agencies use 20-year-old data amassed in a publication titled "Base of Moderately Saline Ground Water in the Uinta Basin, Utah" to try and determine zones suitable for water disposal (Howells and others, 1987). This hard copy publication provides a paper map showing the depth of the transition between moderately saline and very saline water (10,000 mg/L), below this depth it is believed saline water can be injected without damage to overlying fresh-water aquifers. Several oil and gas operators working in the basin believe this dated study needs substantial revision. The original map was based solely on calculations of water quality from geophysical logs, a method with several limitations (e.g. tar sands were recognized as fresh water aquifers). Ideally, a new map would be constructed from actual down-hole water quality information, which many operators have collected and are willing to share with UGS. The overall map structure has also been altered over the past 20 years, as more saline water is pumped underground. In order to facilitate more efficient and prudent permitting of water disposal wells, and in order to better protect fresh water resources, this dated map needs to be reconstructed using modern information and GIS technology.

Eastern Uinta Basin gas producers claim that one of the only aquifers suitable for large volume saline water disposal is the Bird's-nest aquifer located in the Parachute Creek Member of the Green River Formation (Figure 2). After an extensive literature search, it was determined

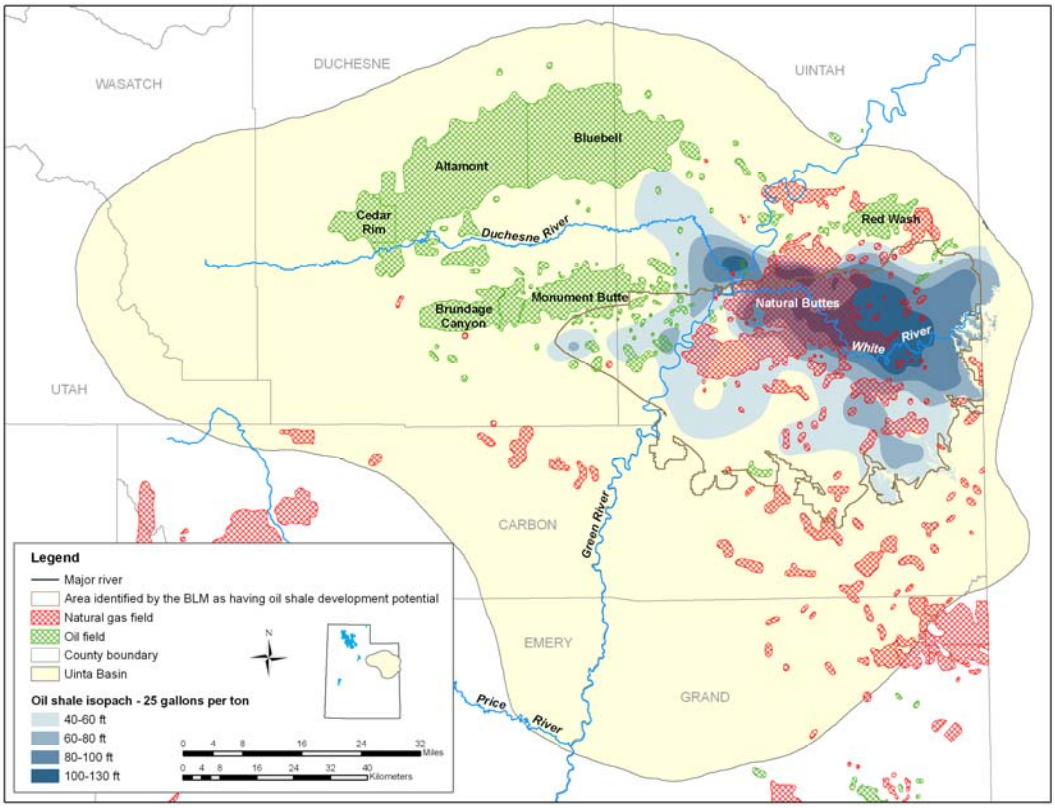

Figure 2. Map showing study area, Uinta Basin, Utah. Note the prime oil shale area overlaps with several natural gas fields.

that the Bird's-nest aquifer is poorly understood and further study is necessary before saline water disposal commences. Near the area of the BLM Research, Development, and Demonstration Oil Shale Lease – awarded to Oil Shale Exploration Company, the Bird's-nest is only slightly saline to moderately saline, ranging from 1000 to 4800 mg/l of total dissolved solids (TDS), while in other areas it is very saline to briny, with TDS concentrations over 30,000 mg/l (Holmes and Kimball, 1987; Dyni, 1996). A more thorough understanding is needed of the extent and nature of these different salinity zones and the barriers between them (e.g. gilsonite veins, non-fractured intervals, etc.). Also, the Bird's-nest is exposed in outcrop, but is poorly mapped. Our study will address whether saline water disposed of into the Bird's-nest aquifer by nearby natural gas operators could migrate to the outcrop and contaminate creeks and streams. Even the areal extent of the Bird's-nest and its lateral continuity, especially to the north and west, are poorly understood (Dyni, 1996).

Utah's oil shale deposits are also located within the Parachute Creek Member of the Green River Formation. The Bird's-nest aquifer is typically several hundred feet above the richest oil shale interval called the Mahogany zone. A significant concern is that saline water disposal into the Bird's-nest by conventional gas producers may hinder oil shale development by creating unforeseen economic and technical hurdles. In many areas containing rich oil shale deposits, the Bird's-nest contains fresh to slightly saline water (Holmes and Kimball, 1987). With increased saline water disposal, the quality of the water in the Bird's-nest could degrade and create additional water disposal problems for oil shale development companies.

In addition to the water-related problems mentioned above, there is a regulatory need for baseline water quality and quantity data for lands proposed for oil shale development (Figure 2). Water-quality degradation could result from new oil shale developments, via mining and surface retort or in-situ processes. Historic paper-based data needs to be gathered and combined with new data into a GIS database that will facilitate basin-wide hydrologic modeling and manipulation by developers and regulators. This database would provide the baseline water information needed to understand potential impacts of future oil shale development.

Finally, the impacts on underground aquifers from in-situ oil shale extraction techniques need to be fully investigated before any technologies are implemented in the field. The chemistry of the produced water from in-situ processes is poorly understood, as is the potential impact this water could have on nearby aquifers. The proposed laboratory pyrolysis experiments and reservoir modeling, to be performed by researchers at the University of Utah, should generate the data needed to determine the environmental effects of in-situ retort technologies.

FUTURE

Combined together, each successful part of this multi-faceted study will provide the information needed to achieve our two goals: alleviating problems associated with produced water as a means to facilitate increased conventional hydrocarbon production and resolving environmental barriers to possible oil shale development.

Using GIS to map the base of the moderately saline aquifer in the Uinta Basin will help both regulators and oil and gas operators make improved saline water disposal management decisions and protect fresh water resources. If new, appropriate saline water disposal intervals can be identified, like the Bird's-nest aquifer, oil and natural gas production can continue to increase, supplying the nation's growing demand with safe, domestic resources.

Specific deliverables related to this portion of the study will include: (1) a new, fully digital map of the base of the moderately saline aquifer in the Uinta Basin; (2) a database with all relevant water chemistry and log calculation data, including any digitized logs; (3) new color cross sections, one north-south and one east-west, showing the major geologic units, the boundary(s) between moderately saline and very saline water, and possible seals and disposal zones; (4) a fully digital GIS map showing the outcrop expression of the Bird's-nest aquifer, the areal extent, changes in water chemistry, and thickness; (5) a database containing all the information used in the new mapping; and (6) stratigraphic columns showing the geologic relationship of the Bird's-nest to the surrounding geology.

In order to develop environmentally sound water management solutions for a future oil shale industry, we need to assess the sensitivity of the alluvial and bedrock aquifers on lands proposed by the BLM as having oil shale development potential. Our proposed regional baseline water study will provide GIS-based information to help local planners and potential developers to preserve the quality of ground and surface water by establishing best management practices through careful land-use planning.

Specific deliverables related to this portion of the study will include: (1) a GIS database containing historic water quality and quantity information, (2) a GIS database listing results of new water chemistry analyses, and (3) a final report containing chemistry compilation maps and graphs.

Finally, the modeling of in-situ production of oil shale will determine its relationship to potential water transport and disposal in the basin. If significant quantities of water are produced along with shale oil, the concentrations of organic and inorganic constituents in this water will be important in determining what special handling procedures will be needed. Results of this proposed University of Utah in-situ research will be integrated into our overall regional water study.

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