

Overview of Texas A&M's Program for the Beneficial Use of Oil Field Produced Water

David Burnett, Petroleum Engineering, Texas A&M University

William E. Fox, Ph.D. Rangeland Ecology & Management, Texas A&M University

Gene L. Theodori, Ph.D. Department of Rural Sociology, Texas A&M University

Biographical Information

David B Burnett is the Director of Technology for GPRI and a member of the graduate faculty of the Petroleum Engineering Department at Texas A&M University. He has extensive experience in technology related to oil field produce water management. For the past two years he has been working with a team of scientists and engineers recovering fresh water from oil field brine and using it for beneficial purposes.

Mr. Burnett has been at the University since 1995. Prior to that he was a Project Manager for Westport Technology developing and managing research programs for oil and gas joint ventures. He is a reservoir engineer addressing produced water issues. He also manages a research program at the University addressing horizontal well completion technology for high performance wells. He has a B. S. and M.S. in Chemistry from Sam Houston State University and an MBA from Pepperdine.

Abstract

Texas A&M University's produced water treatment research program is developing a "new found" fresh water resource in arid and semi-arid regions of the Western U.S. This fresh water resource is created from oil field produced brine, treated in the field by mobile units to remove contamination and dissolved salts. To demonstrate the value of this resource we are planning restoration of degraded rangelands and wildlife habitats along with environmental monitoring of soils, plants and wildlife. In addition, recognizing that oil and gas producers sell petroleum and not water, A&M has initiated a new community development program to study the market mechanisms and incentives for utilization of this new resource by landowners and local community and business enterprises.

The water treatment technology being used by the A&M group provides fresh water at a cost competitive with the transportation costs of salt water removal or fresh water delivery. To prove the utility of the concept, we have designed portable units to deliver fresh water to field sites to restore degraded lands and wildlife habitats by rainfall augmentation. Units will be instrumented to (1) determine operating costs more accurately and (2) to ensure safe operation and delivered water quality. The sites will also be monitored to take into account the effect of fresh water application on desert soils and the effect on native grasses and wildlife. Demonstrating such technology should benefit efforts to develop restoration strategies for arid and semi-arid rangelands throughout the western United States.

Restoration of such degraded lands offers one way of utilizing this resource in a beneficial manner. To find other potential benefits of produced water treatment and re use, A&M is adapting practices developed by the Department of Rural Sociology to work with rural communities. The Department offers programs to assist rural communities in capacity building and improving their community employment, service and industrial bases. Our objective is to identify mechanisms whereby oil and gas producers will recover the cost of water treatment when it is used in a beneficial manner for the public sector. We will discuss examples of economic incentives whereby such industry/public collaboration could be achieved.

Overview of Texas A&M's Program for the Beneficial Use of Oil Field Produced Water

David Burnett, Petroleum Engineering, Texas A&M University
 William E. Fox, Ph.D. Rangeland Ecology & Management, Texas A&M University
 Gene L. Theodori, Ph.D. Department of Rural Sociology, Texas A&M University
 Sefa Koseoglu, Ph.D. Chemical Engineering, Texas A&M University
 Maria Barrufet, Ph.D. Petroleum Engineering Texas A&M University

Can produced water be considered a resource rather than a pollutant? At Texas A&M University, the Department of Petroleum Engineering and the Texas Water Research Institute (TWRI) established a program in produced water management in 1999. Our motivation has been to find ways to offset the cost of produced water disposal in oil and gas fields, particularly in the western United States where oil and gas regions are also areas experiencing severe water shortages.

New water treatment technology offers a way to remove contaminants from the produced brine, but there are numerous problems. First, the cost of such treatments is uncertain. Second, there is a lack of scientific evidence that discharge of treated water to the environment is beneficial rather than a waste. Finally regulatory guidelines for such treatments are unclear. A coordinated research program is needed.

Our research group, composed of petroleum engineering personnel, irrigation specialists, and rangeland and wildlife specialists believes that the potential impact of a new "found" fresh water resource in arid areas of the country makes the effort worthwhile. If we can show that treatment costs are competitive with other methods of water disposal, and that the water can be used in a beneficial manner, then a tremendous opportunity becomes available, both from the oil and gas operator perspective and from the community's viewpoint as well.

The TAMU project uses portable water treatment units placed in the field at production batteries to convert a portion of the produced water to fresh water. Work has been underway for more than a year in the a pilot set-up at the TAMU Separation Sciences Laboratory using actual produced water from a Grimes County, Texas waste water disposal facility. Figure 1 shows a schematic of the brine treatment process train. Figure 2 is photograph of a number of portable units used in filtration tests in the Laboratory. Units can be loaded as necessary into the Separation Science truck shown.

FIGURE - 1 Brine Treatment Process Train

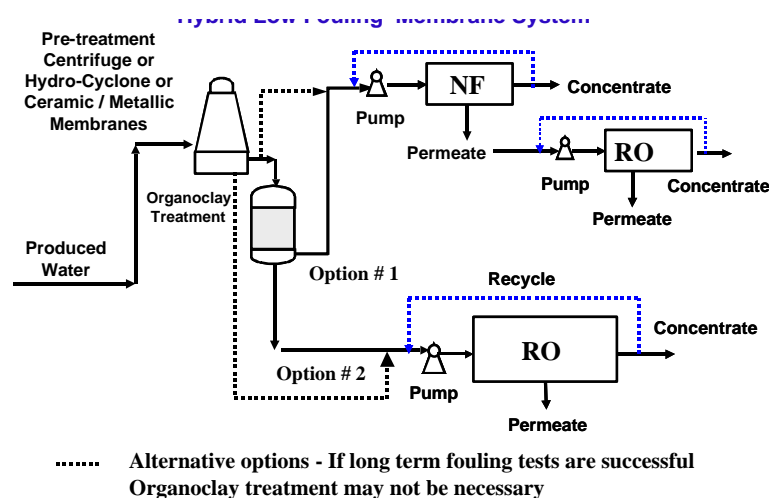


Figure –2 Mobile Testing Unit



The treatment unit planned for the field site contains pretreatment organoclay canisters to remove oil, followed by nanofiltration and reverse osmosis to reduce salinity. Wastewater is returned to the produced water holding tank for regular disposal. Test results indicate that we can convert approximately 25% of the produced water to fresh water with removal of all other contaminants to be disposed of in the remaining brine to be reinjected into the reservoir.

Engineering estimates based on the performance of the prototype unit show that produced water typical of West Texas fields can be treated for essentially the same cost as transporting water from remote sites to disposal wells. The estimated operating costs for a 2,500-gallon-per-day mobile unit at Yates is expected to be less than \$0.05 cents per gallon (\$1.60 per barrel).

Output from this unit would be agriculture -quality water of less than 500 ppm total dissolved solids (TDS) and less than 0.05 mg/l hydrocarbon. The project will use this fresh water to treat specially monitored sites for rangeland and habitat restoration. Marathon believes that this type of produced water management will add years of productive life to Yates (currently producing 26,000 bopd).

We expect that an increasing number of operators will use this technology to extend lifetimes of mature producing fields. Coal-bed methane production in New Mexico (estimated to be more than 2 tcf reserves) are at risk unless operators find more environmentally acceptable ways to dispose of the brine co-production. Our efforts are supporting evidence for those working to get similar legislation passed in Texas similar to that passed by the New Mexico state government. If tax incentives are obtained, then co-production of fresh water would offset disposal costs to operators and provide millions of barrels of additional reserves in areas such as the Permian Basin.

Economics of Treatment

Table 1 gives the total cost for treating 15,000 ppm TDS produced water to primary irrigation quality water. It is seen that for a 3-year amortization schedule the cost of treating water is the highest in all cases and is uneconomical. 3-year life for the water treatment unit is very small. It is expected that the water treatment unit will be functional for at least a period of 5 years, assuming it is compared to an ordinary automobile. On the other hand if the water

treatment unit is compared to any normal industrial equipment, the life of the mobile unit can be approximated to 10 years

TABLE 7.8. Total cost for treating water for 14,000 and 6,000 gpm produced water treatment units

<i>Prod. Water Flow Rate</i>	6000 gpd (9.72 gpm)							
<i>Treated Water (Permeate) Flow Rate</i>	3000 gpd (2.08 gpm)							
<i>Total Capital Investment</i>	75,000 \$							
<i>TOC before Organoclay</i>	30 ppmC				80 ppmC			
<i>Unit Life (years)</i>	3	5	7	10	3	5	7	10
<i>Capital Cost (\$/yr)</i>	25,000	15,000	10,714	7,500	25,000	15,000	10,714	7,500
<i>Capital Cost (\$/gal perm.)</i>	0.0228	0.0137	0.0098	0.0068	0.0228	0.0137	0.0098	0.0068
<i>Operation Cost (\$/gal perm.)</i>	0.0086	0.0086	0.0086	0.0086	0.0119	0.0119	0.0119	0.0119
<i>Total Water Cost (\$/gal perm.)</i>	0.0314	0.0223	0.0184	0.0155	0.0348	0.0256	0.0217	0.0188
<i>Capital Cost (\$/bbl perm.)</i>	0.9589	0.5753	0.4110	0.2877	0.9589	0.5753	0.4110	0.2877
<i>Operation Cost (\$/bbl perm.)</i>	0.3614	0.3614	0.3614	0.3614	0.5016	0.5016	0.5016	0.5016
<i>Total Water Cost (\$/bbl perm.)</i>	1.3203	0.9368	0.7724	0.6491	1.4605	1.0770	0.9126	0.7893

Habitat Restoration Impacts

This aspect of the project is managed by TWRI and scientists from the Department of Rangeland Ecology and Management and Wildlife Science personnel. Wise use of water resources is a specialty of the TWRI and its partner, the New Mexico Water Resources Research Institute, a collaborator of this project.ⁱ TWRI has estimated that more than 10% of the total water usage in Texas will be recycled by the year 2020. If 10% of the produced water in West Texas is reused each day, this represents more than *40 million gallons per day* savings to local agriculture, industry and community activities.

Rangeland functions and processes rely on three main variables: soils, water, and biodiversity. The successful restoration of degraded rangeland systems requires a system that addresses each of these critical characteristics and integrates management to improve the sustainability of each.. One of the major constraints to effectively restoring arid and semi-arid rangelands is the lack of water for establishment of vegetation. The proposed research seeks to take advantage of a “resource” yet untapped in the effort to restore rangeland systems, treated produced water from oil and gas production.

A key part of this project will be the monitoring of test plots to illustrate the beneficial uses of treated produced water from oil and gas production. Two programs are planned, the first being the rangeland monitoring and the second being the wildlife monitoring. The proposed project will follow a framework for repairing damaged wildlands defined by Whisenantⁱⁱ (1999) that includes a process-oriented approach that seeks to initiate autogenic repair and considers landscape interactionsⁱⁱⁱ.

Environmental monitoring will be used to observe genotoxic effects of treated produced water in wildlife populations taken from control (untreated) and treated plots using tissue samples taken from rodents. In all experiments flow cytometry will be used to measure DNA content in cells (spleen and/or bone marrow) by use of previously developed protocols.

Goals: Finding Value Links Between Industry and the Community

The Department of Rural Sociology has proposed a new research project to the U.S. EPA under that agency's Market Mechanisms and Incentives for Environmental Management. The goals of our project are: (1) identify and evaluate the individual, institutional, technical, legal, and regulatory obstacles to successful implementation of market mechanisms and incentives (MM&I) for produced water management; (2) provide empirical estimates of MM&I cost-savings relative to existing produced water regulatory programs; and (3) show how the MM&I approach to produced water can be transferred or generalized to other environmental problems and/or geographic/political scales.

ⁱ New Mexico Water Resources Research Institute letter of support, April 3, 2002, (Appendix)

ⁱⁱ Whisenant, S.G. 1999. Repairing damaged wildlands: A process-oriented, landscape scale approach. Cambridge University Press. pp. 312

ⁱⁱⁱ Archer, S.L. Have southern Texas savannas been converted to woodlands in recent history? *American Naturalist*. (1989) 134:545-561