TESTIMONY OF JOHN A. VEIL, ARGONNE NATIONAL LABORATORY

BEFORE THE HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY SUBCOMMITTEE ON ENERGY AND ENVIRONMENT

CONCERNING: "RESEARCH TO IMPROVE WATER-USE EFFICIENCY AND CONSERVATION: TECHNOLOGIES AND PRACTICE"

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Mr. Chairman and Members of the Subcommittee, I am John Veil, Manager of the Water Policy Program in the Environmental Science Division of Argonne National Laboratory (Argonne). I appreciate the opportunity to speak to you on produced water associated with oil and gas production, an important source of water for our Nation. I am appearing today as a subject matter expert on produced water. With support from the Department of Energy (DOE), Argonne developed the Produced Water Management Information System (PWMIS) web site (web.evs.anl.gov/pwmis) that opened for public use in June 2007. I initiated and led that project and wrote most of the technical content. I have collaborated with several universities on produced water research and have spoken at numerous technical conferences on different produced water topics.

My statements reflect my own experience and opinions and are not necessarily those of DOE or Argonne. I want to share with you some information about produced water, some ways in which it is currently being beneficially reused, and the need for additional research to allow further reuse of produced water. I hope that you will consider the value and importance of produced water as you deliberate over H.R. 3957.

What is Produced Water?

Produced water is water trapped in underground formations that is brought to the surface along with oil or gas. Because the water has been in contact with the hydrocarbon-bearing formation for centuries, it contains some of the chemical characteristics of the formation and the hydrocarbon itself. It may include water from the reservoir, water injected into the formation, and any chemicals added during the production and treatment processes. Produced water is also called "brine" and "formation water." The major constituents of concern in produced water are:

- Salt content (salinity, total dissolved solids, electrical conductivity);
- Oil and grease (this is a measure of the organic chemical compounds);
- Various natural inorganic and organic compounds or chemical additives used in drilling and operating the well; and

- Naturally occurring radioactive material (NORM).

Produced water is not a single, constant commodity. The physical and chemical properties of produced water vary considerably depending on the geographic location of the field, the geological formation from which it comes, and the type of hydrocarbon product being produced. Produced water properties and volume can even vary throughout the lifetime of a reservoir.

How Much Produced Water is Generated?

Produced water is by far the largest volume byproduct stream associated with oil and gas exploration and production. Approximately 15 to 20 billion bbl (barrels; 1 bbl = 42 U.S. gallons) of produced water are generated each year in the United States from about 900,000 wells. This is equivalent to a volume of 1.7 to 2.3 billion gallons per day. Other countries around the world generate more than 50 billion bbl of produced water each year (nearly 6 billion gallons per day).

The international oil and gas industry generates about 2 or 3 bbl of water for each bbl of oil. Producing fields in the United States are older and consequently, they produce water at a higher rate (about 7 bbl of water per bbl of oil).

For the sake of comparison, the District of Columbia (D.C.) Water and Sewer Authority provides 135 million gallons per day of drinking water to D.C. residents, businesses, and other users. The Washington Suburban Sanitary Commission provides an additional 167 million gallons per day of drinking water to the D.C. regional area.

Why is Produced Water Important to the Oil and Gas Industry?

The cost of managing produced water is a significant factor in the profitability of wells. The total cost (ranging from less that 1 cent/bbl to more than $5/bbl) includes:

- The cost of constructing treatment and disposal facilities, including equipment acquisitions;
- The cost of operating those facilities, including chemical additives and utilities;
- The cost of managing any residuals or byproducts resulting from the treatment of produced water;
- Permitting, monitoring, and reporting costs; and
- Transportation costs.

How is Produced Water Managed?

As indicated in the PWMIS web site, responsible management of produced water follows a three-tiered pollution prevention hierarchy. Where possible, technologies that minimize the volume of water generated should be employed first. Next, options that reuse or recycle produced water should be considered. When neither of those tiers is practical, disposal remains the only viable option. I will focus my remarks on ways in which produced water can be reused.

Underground Injection for Increasing Oil Recovery

The most widely used approach for managing onshore produced water is reinjection into an underground formation. Although some produced water is injected solely for disposal, most produced water is injected to maintain reservoir pressure and to hydraulically drive oil toward a producing well. This practice is referred to as enhanced oil recovery (EOR), water flooding, or, if the water is heated to make steam, as steam flooding. When used to improve oil recovery, produced water ceases to be a waste and becomes a resource. If operators did not have that produced water, they would need to rely on other surface or groundwater supplies for the water or steam flood.

Several years ago, while preparing a widely cited white paper on produced water, I interviewed representatives from the oil and gas regulatory agencies in three states with large petroleum production to gather statistics on underground injection of produced water. In early 2003:

- California had nearly 25,000 produced water injection wells. The annual injected volume was approximately 1.8 billion bbl, distributed as follows: disposal wells — 360 million bbl, water flood — 900 million bbl, and steam flood — 560 million bbl.
- New Mexico had 903 permitted disposal wells, with 264 of them active. It had an additional 5,036 wells permitted for EOR, with 4,330 of those active. The approximate annual volume of produced water injected for disposal was 190 million bbl, and the annual volume injected for EOR was about 350 million bbl.
- Texas had 11,988 permitted disposal wells, with 7,405 of them active. It had an additional 38,540 wells permitted for EOR, with 25,204 of those active. The approximate volume of produced water injected in 2000 (there were similar well counts in 2000 and 2003) was 1.2 billion bbl disposed into nonproducing formations, 1 billion bbl disposed into producing formations, and 5.3 billion bbl injected for enhanced recovery.

Injection for Future Use

When produced water has a very low salinity level, it may serve as a source of drinking water. A project near Wellington, Colorado, is treating produced water from oil wells as a raw water resource that will be used to augment shallow groundwater aquifers to ensure adequate water supplies for holders of senior water rights. The oil company is undertaking this project to increase oil production. A separate company will then purchase and utilize this water as an augmentation water source. This water will eventually be used to allow the Wellington and northern Colorado water users to increase their drinking water supplies by 300 percent.

Use for Hydrological Purposes

In addition to having value as water, produced water can also occupy space or resist earth or fluid movement. Beyond its hydrological value for EOR, other potential hydrological uses of injected produced water include:

- Controlling surface subsidence in the wake of large withdrawals of groundwater or oil and gas;
- Blocking salt water intrusions in aquifers in coastal environments; and
- Augmenting the regional groundwater or local stream flows.

One of the most compelling examples of subsidence resulting from oil and gas extraction involves the Wilmington oil field in Long Beach, California. Since the 1930s, more than 1,000 wells withdrew about 2.5 billion bbl of oil and a large volume of produced water. Between the1940s and the 1960s, this field experienced a total of 29 feet of subsidence, caused primarily by the withdrawal of hydrocarbons. Subsidence in the Wilmington oil field caused extensive damage to Long Beach port industrial and naval facilities. A massive repressurization program, based on the injection of water into the oil reservoirs, reduced the subsidence area from approximately 50 km^2 to 8 km^2. Approximately 2.3 billion bbl of water were reinjected through 1969.

Produced water is being considered for control of salt water intrusion in the Salinas River valley in California. This area has overdrawn ground water for domestic and agricultural uses, resulting in the salt water/fresh water interface moving six miles upstream. In this project, produced water would be discharged to the Salinas River or used locally for irrigation, thereby avoiding groundwater withdrawal and reducing the driving force of the salt water intrusion.

Produced water can potentially be used to augment stream flows. Where discharges are permitted, treated produced water meeting applicable discharge standards could be directly discharged to surface water bodies. Produced water could also be injected into formations exhibiting hydrologic interconnection with surface water bodies, or allowed to infiltrate to the water table through holding ponds.

Agricultural Use

Many oil and gas wells are located in areas of the country that are characterized by arid climates and scarce fresh water resources. Produced water meeting the water quality requirements of agricultural users offers the potential to supplement and replace existing water supplies.

Perhaps the most significant barrier to using produced water for agricultural purposes involves the salt content of the water. Most crops do not tolerate much salt, and sustained irrigation with salty water can damage soil properties. In addition, if livestock drink water containing too much salt, they can develop digestive disorders.

However, not all produced water is equally salty. For example, some of the coal bed methane (CBM) fields in Wyoming's Powder River Basin generate relatively fresh water. However, in addition to the salt content, the relative proportion of sodium to other ions is important, because excessive sodium is harmful to soils. Soil scientists use the term “sodium adsorption ratio” (SAR) to characterize the ionic proportions.

Since produced water in the Powder River Basin frequently exhibits relatively high sodium concentrations compared to those of calcium and magnesium, the SAR of that water tends to be high. These waters can be used for some purposes without treatment, but often require either treatment of the produced water or application of soil supplements to control the SAR.

Although most of the irrigation projects using produced water are located in the Rocky Mountain CBM fields, at least one large irrigation project involving the use of treated produced water can be found in the Kern River field in central California. There, a treatment system provides about 480,000 bbl/day of water for irrigating fruit trees and other crops and for recharging shallow aquifers.

Industrial Applications

In areas where traditional surface and groundwater resources are scarce, produced water can become a significant replacement resource in some industrial processes, as long as the quality of the produced water meets the requirements of the user. Produced water is already being used in some industrial applications; it may also be suitable for others.

For example, produced water is already being reused in some oil field applications. One company in New Mexico has treated produced water and then used it to make up drilling fluids. This beneficial reuse of produced water saves more than 4 million bbl per year of local groundwater. Produced water can also be used in oil fields as fluid to hydraulically fracture tight shale formations, enhancing natural gas production. Each “frac job” requires huge volumes of water, in many cases more than 1 million gallons per frac job. In areas where natural gas fields are expanding rapidly (e.g., the Barnett Shale in Texas and the Fayetteville Shale in Arkansas), local water supplies may not be adequate to meet the demand for frac water. Produced water or “flow-back water” — the water returning from the formation following a frac job — can be treated and reused for new frac jobs.

The electric power industry also uses a tremendous volume of water for cooling and other purposes. Many new or expanded power plants are facing challenges in finding adequate water supplies for use in cooling towers. Several years ago, DOE funded a project to evaluate the feasibility of CBM produced water to meet some of the cooling water needs at the San Juan Generating Station in northwestern New Mexico. The economics of using produced water at that specific plant did not appear favorable. Therefore, the utility decided not to move forward with implementation. Other applications may prove more productive.

Produced water has been used for dust control on dirt roads in some states. In another innovative application, firefighters near Durango, Colorado used CBM produced water impoundments as sources of water to fill air tankers (i.e., helicopters spraying water onto fires) while fighting forest fires during the summer of 2002.

Use for Drinking Water

In the past, the treatment costs to reduce salinity and remove other constituents from produced water for purposes of meeting drinking water standards were prohibitively high. However, in recent years, costs to develop and deploy treatment technology have dropped. At the same time, communities running out of water are willing to pay higher prices for clean water. Treatment costs are approaching water prices in some cases. These developments provide the crucial incentive for many water treatment technology developers deciding to enter the marketplace. A related but important issue involves managing the concentrated byproduct stream that results from treating the produced water.

Texas A&M University developed a portable produced water treatment system that can be moved into oil fields to convert produced water to potable water. This can be used to augment scarce water supplies in arid regions, while also providing economic paybacks to operators in the form of prolonged productive lives of their wells. During the past few years, the desalination trailer developed by the university conducted pilot tests using produced water from several locations in Texas. The water treated by the trailer met the applicable drinking water standards.

What Can be Done to Further Promote Reuse of Produced Water?

In the preceding paragraphs, I have summarized the resource value of produced water. In spite of the many actual uses for produced water today, a large proportion of produced water is being disposed of in ways that offer little beneficial reuse. I would like to give some thoughts on efforts that the federal government could consider to encourage and promote broader reuse of produced water.

Although some sources of produced water have low enough dissolved solids that they can be used for irrigation or drinking with minimal treatment, most U.S. produced water has high enough dissolved solids that significant treatment must be provided before the water can be reused. Government and corporate research has helped to develop and improve technologies for removing dissolved solids and other undesirable constituents from produced water. While the cost of these technologies has dropped in recent years, they are still expensive compared to the alternative of injecting produced water underground for disposal. Oil and gas operators have little incentive to spend more money to treat and reuse produced water when they can manage the produced water through other means. When produced water is injected for enhanced recovery, it is being put to a beneficial reuse. However, when water is injected to a non-producing formation solely for disposal, the produced water is permanently lost as a water resource.

I suggest that the federal government support a significant research program to develop and improve technologies for treating produced water so that it can be reused. In particular, the program should support development of technologies that can remove dissolved solids so that produced water can be reused for agriculture, irrigation, or human consumption. This will help to provide valuable fresh water resources for areas that have insufficient fresh water.

Most technologies that treat produced water to remove dissolved solids start with salty water as the input and end with a clean water stream and a concentrated brine stream as outputs. Management or disposal of the concentrated brine stream is another important consideration that can have a substantial impact on both cost and feasibility of the technology. Any produced water technology research program should include evaluation of brine management.

Expanded reuse of produced water can be expedited not only by technology improvement, but also by careful evaluation of several policy aspects. One barrier to reuse is potential liability to the oil or gas company. If an oil or gas company treats its produced water, then gives or sells the water to an end user (e.g., a municipality or a rancher), the company may later be sued by the end user if a person or a farm animal suffers ill effects. I hosted an oil and gas industry water meeting in 2005. The final session was an open discussion of how to turn produced water into a resource. Representatives of several oil companies indicated that the largest barrier was the corporate concern of liability. Corporate legal staff have been reluctant to approve some beneficial reuse projects because of the concern for litigation. As part of Congress' evaluation of legislation to enhance reuse of produced water, consideration of liability issues may help to expand reuse applications.

A second potential barrier is the interplay of water rights with ownership or control of the produced water before and after treatment. As long as produced water is perceived as a waste or a byproduct, there is little demand for it. However, after the water has been treated so that it has a value, there may be competing demands for the water, potentially creating disincentives for treating the water.

How Does Produced Water Relate to H.R. 3957?

The bill under consideration in today's hearing is H.R. 3957, the Water Use Efficiency and Conservation Research Act. The bill promotes "research, development, education, and technology transfer activities related to water use efficiency and conservation technologies." I fully support those goals. However, H.R. 3957 does not include any mention or consideration of produced water. As I attempted to explain in the preceding paragraphs, produced water is available in large volume, often in some of the most arid parts of the United States. It represents a valuable water resource. With suitable treatment, produced water can be beneficially reused to support various end uses. I encourage the Subcommittee to carefully consider produced water as an additional source of water that can be part of the research programs envisioned by H.R. 3957.

Thank you again for the opportunity to address the Subcommittee. If you have additional questions for me, please contact me at 202-488-2450 or jveil@anl.gov. My mailing address is Argonne National Laboratory, 955 L'Enfant Plaza, SW, Suite 6000, Washington, DC 20024.

Biographical Information

John A. Veil
Manager Water Policy Program
Argonne National Laboratory
955 L'Enfant Plaza, SW
Suite 6000
Washington, DC 20024
202-488-2450
jveil@anl.gov

John Veil is the manager of the Water Policy Program for Argonne National Laboratory in Washington, DC, where he holds the rank of senior scientist. He analyzes a variety of energy industry water and waste issues for the Department of Energy.

Mr. Veil has a B.A. in Earth and Planetary Science from Johns Hopkins University, and two M.S. degrees -- in Zoology and Civil Engineering -- from the University of Maryland.

Before joining Argonne, Mr. Veil managed the Industrial Discharge Program for the State of Maryland government where he had statewide responsibility for industrial water pollution control permitting through the National Pollutant Discharge Elimination System (NPDES), Underground Injection Control (UIC), and oil control programs. Mr. Veil also served as a faculty member of the University of Maryland, Department of Zoology for several years.

Mr. Veil has published many articles and reports and has made numerous presentations on environmental and energy issues.