EPWM - 004

GENERAL CORRESPONDENCE

2005 - 2007

ALTELA

8/15/2007

Mr. Brad Jones
Enviornmental Engineer
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Dear Mr. Jones:

On behalf of everyone at Altela, Inc. and Merrion Oil and Gas Corporation, I want to thank you for taking time out of your day to attend the demonstration at the Blackshawl Facility in Farmington on August 9, 2007. We enjoyed the opportunity to meet with you and demonstrate the AltelaRain[SM] technology at work.

It is with the support of people such as yourself that this technology has a future cleaning highly-challenged produced water, as well as other brackish water – and converting it to extremely clean distilled water, around the state and the country.

I have enclosed a copy of the article that ran in the *Farmington Times* after the event. Should you have additional questions or if you're ever in Albuquerque and want to take a look at our manufacturing facility, please call us at 505-923-4140.

Sincerely,
Ned Godshall, CEO, and the Altela Team

Enclosure

Tel: (505) 923-4140
Fax: (505) 923-4130

Altela, Inc.
2450 Alamo Ave. SE, Suite 200
Albuquerque, NM 87106

info@altelainc.com
www.altelainc.com

The Daily Times

FRIDAY
August 10, 2007

LOCAL/REGION

FARMINGTON•AZTEC•BLOOMFIELD•SHIPROCK

Eric Fisher, managing editor, (505) 564-4620

From industry byproduct to usable resource

Company unveils water purification system for natural gas wells

— By Lindsay Whitehurst —
The Daily Times

FARMINGTON — As it draws energy from the earth, a natural gas well also brings up about 35 barrels of water a day. Laced with salt and other contaminants, the water is trucked out and pumped back in a two-mile deep hole in the ground.

An Albuquerque company wants to change that with its new purification system. It allows water to be treated at the site, eliminating the trucking and recycling the water.

Altela, Inc. unveiled its first system in New Mexico at a Merrion Oil and Gas well site in Farmington Thursday. In front of about 50 company and government officials, including U.S. Rep. Tom Udall, D-N.M., Altela officials said the technology could both save gas companies money on water disposal and open up a new source of water for desert communities.

"This is really what we need in the West, there's no doubt about it," Udall said. "We're moving into a new era."

The water from the trailer-sized purification unit will be pumped back into the city of Farmington's sewer system. But for the time being, the city can only send the water, which Altela CEO Ned Godshall said is 20 times cleaner than city water, into the San Juan River and collect reverse flow credits.

U.S. Rep. Tom Udall, left, shares a laugh with Ned Godshall, CEO of Altela, Inc., after drinking water treated by Altela's natural gas water purifier. The company unveiled the system, the first in New Mexico, on Thursday.

Lucas Ian Coshenet
The Daily Times

The city couldn't use it because it doesn't have the water rights. Purified water hasn't been, and still isn't, a big enough part of the water supply in New Mexico to be covered by water rights deals, Jim Dunlap, chair of the Interstate Stream Commission, said.

"It should be determined before it becomes a major industry," he said.

The system will save Merrion about 20 percent on water disposal costs, drilling and production said manager Steve Dunn.

"We basically spend a bunch of money to pump it back into the ground, never to be used again," he said. "That's a shame."

By early fall, Altela will put four other wells belonging to Artesia-based Yates Petroleum and located about 26 miles outside Farmington on purification systems, company officials said. If the system works, Dunn said Merrion will consider expanding it to their other approximately 280 wells in the Farmington area.

Each trailer-sized purification system can treat about 100 barrels of water a day; one is enough to handle a few wells within a two-mile radius. Altela officials declined to say how much the system costs; gas companies pay for the service by the amount of water it treats.

The system is "a new twist on something called distillation," Godshall said, that uses plastic parts to distill water using less energy and money. The technology was developed at Arizona State University. The two-and-a-half-year-old Altela took advantage of Gov. Bill Richardson's late-2005 push for new water technology to help develop and market it.

The Merrion system went online on March 14; a $300,000 state grant paid for the installation and first month of operation.

"I've been drinking this water from our unit," Godshall said, holding up a blue plastic cup. "This is the stuff that's coming out of the ground."

Lindsay Whitehurst: lwhitehurst@daily-times.com

Post Independent

Bills aim to find ways to make water from gas drilling useable for agriculture

Donna Gray
Glenwood Springs, CO Colorado
June 5, 2007

GLENWOOD SPRINGS, Colo. — Two new bills making their way through the U.S. Congress could set the stage for treating water produced by oil and gas drilling and making it useable by farmers and ranchers for irrigation.

The "More Water and More Energy Act," House bill 902, sponsored by U.S. Rep. Mark Udall (D-Eldorado Springs), would fund research and development pilot programs in several western states to find ways to use produced water for agriculture. If it passes, it would require the Department of Interior to carry out the study and provide $5 million in funding.

A companion bill, "More Water, More Energy, Less Waste Act of 2007," Senate bill 1116, is sponsored by U.S. Sen. Ken Salazar (D-Colorado).

The bills are now making their way through the House and Senate.

"Every day, 2 million gallons of produced water are wasted in this nation, unfit for use," Salazar said in a prepared statement. "Recovering that water could help lift a huge burden off the backs of farmers, ranchers, communities and recreation users."

Produced water comes up with natural gas from deep underground and contains hydrocarbons - crude petroleum - and dissolved solids including salts that in most instances could not be used for irrigation, to water livestock or for domestic use.

Across the state, water produced by oil and gas drilling is either recycled or injected into deep wells.

In 2003, EnCana Oil & Gas (USA), one of the top natural gas producers in the Piceance Basin of northwest Colorado, built a water treatment plant on Hunter Mesa south of Rifle. Originally, it processed water produced not only from its typical local wells, but also from 24 experimental coal bed methane wells, which have since been capped. The plant continues to treat produced water from its other wells.

Coal bed methane development poses its own problems with water disposal because coal seams must be dewatered in order to release the gas.

The Hunter Mesa plant, as well as two plants added in 2004 in the Parachute area, removes hydrocarbons and dissolved solids, especially salts, and is then reused for drilling operations. The treated water meets state water quality standards for discharge into the Colorado River, although no water was disposed of in that way, said EnCana spokeswoman Wendy Wiedenbeck.

"EnCana recycles 90 percent of its produced water," she said. In 2006, its drilling activity produced 7.7 million barrels of water.

As more wells are drilled each year, gas developers are reaching their capacity to use what water they produce. "Currently our water handling facilities are at maximum capacity," Wiedenbeck said.

Williams, also a top gas producer in the Piceance, does not have water treatment plants and recycles all of its produced water, said Williams spokeswoman Susan Alvillar. "In about 10 years we will have to have a disposal plan," she said.

Energy trade groups in Colorado have come out in support of the Salazar and Udall bills. The Colorado Oil and Gas Association endorsed the bills, said Denver attorney Ken Wonstolen, who represents COGA.

"There is interest in the arid West to make a beneficial use of produced water," he said. "The bill would identify the legal and institutional barriers to using it."

As a waste product, produced water does not come under state water law. Under the law water rights are established by the doctrine of prior appropriation commonly known as "first in time, first in right."

"If you treat produced water as waste and dispose of it, you're outside the water right system," Wonstolen said. "There's a disincentive to do anything but treat it as waste" because putting it to beneficial use would create legal and financial hurdles.

Because it comes from deep underground, produced water would not be subject to state water law because it is not tributary to surface waters, said Dave Merritt, chief engineer with the Glenwood Springs-based Colorado River Water Conservation District. "Essentially, it would be administered outside the priority system," he said.

But gas operators would have to prove that in water court, said Division 5 engineer Alan Martellaro of the Division of Water Resources, which administers state water law. Once that water is turned to a beneficial use, such as irrigating a farmer's crop, it would be subject to state water law.

Martellaro said buying treated produced water could prove too costly for farmers and ranchers. "Under current laws (gas developers) would need a well permit" that is established in state water court. The attendant legal and engineering fees would add to the selling price of the water.

"Can a farmer afford to pay for this water" that could cost hundreds of dollars per acre foot, "when he (now) pays $5 an acre foot or less?" Martellaro asked.

Municipalities could afford to make use of such water to augment water diverted from other sources, he added.

In the long run, water produced from oil and gas drilling won't make much of a dent in the state's need to meet its compact obligations to downstream states along the Colorado River, he said. "We're talking about" thousands of acre feet (of produced water) as opposed to a need for tens of millions of acre feet to meet the state's downstream obligations. "It's a small amount in the grand scheme of things."

Contact Donna Gray: 945-8515, ext. 16605
dgray@postindependent.com

Post Independent, Glenwood Springs Colorado CO

BACK

United States Senate
United States House of Representatives

For Immediate Release
April 18 , 2007

CONTACTS: Cody Wertz (Salazar) - 303-350-0032
Jude McCartin (Bingaman) - 202-224-1804
Hannah VanderBush (Domenici) - 202-224-7073
Cameron Hardy (Thomas) - 202-224-6441
Lawrence Pacheco (Udall) - 202-225-2161

Senators, Congressman Fight to Recover "Useable" Water in Arid West

WASHINGTON, D.C. - Across the West, "useable" water is one of the most valuable natural resources, and also one of the scarcest. Each day, more than two million gallons of useable groundwater are wasted, turned into what is known as "produced water," after becoming contaminated beyond use as it is brought to the surface during oil and gas drilling or coal bed methane extraction. However, United States Senator Ken Salazar has taken the lead in the Senate on a bipartisan solution that could allow the recovery and use of many gallons of "produced" water every day.

Yesterday, along with Senate Energy Committee Chairman Jeff Bingaman (D-NM), Senate Energy Committee Ranking Member Pete Domenici (R-NM), and Senator Craig Thomas (R-WY), Senator Salazar introduced the "More Water, More Energy, Less Waste Act of 2007." The bill initiates a feasibility study on recovering the "produced water" and a grant program to test technologies that would convert it to "useable" water. It is the Senate companion to H.R. 902 which passed unanimously in the U.S. House on March 19, 2007. H.R. 902 is sponsored by Rep. Mark Udall (D-Eldorado Springs).

United States Senator Ken Salazar (D-CO) – **"In the water-short West, increasing the amount of waters that can be used without adversely affecting water quality or the environment can increase water supplies for irrigation of crops, livestock watering, wildlife habitat, and recreational opportunities. Farmers, ranchers, communities and recreation users will benefit from increased supplies of 'useable water'."**

United States Senator Jeff Bingaman (D-NM) – **"Treating and using produced water is one of many tools we need to meet the ever-increasing demands on limited water resources in the West. This bill will help determine how best to make use of that resource in an environmentally sensitive manner, as well as help increase the efficiency of oil and gas production by limiting the amount of produced water disposed of as waste."**

United States Senator Pete Domenici (R-NM) – **"The nexus between energy and water is critical to addressing our nation's current and long term energy and water security. I look forward to working on this bill and further tackling the energy-water challenge during this session," said Domenici, who was an architect of the Energy Policy Act of 2005 which authorized R&D and commercial applications to address the management and efficient use of water in the production of energy.**

United States Senator Craig Thomas (R-WY) – **"This effort is a win-win situation because it takes water from energy production and makes it useful for folks who need it most. I was pleased to include provisions aimed at improving the efficiency of water use for energy production, in addition to the treatment of water, in this bill."**

Congressman Mark Udall (CO-2) -- **"I think the bill will change an energy-industry problem into an opportunity, not just for oil and gas producers but for everyone else who would benefit from increased supplies of useable water. Developing beneficial uses for produced**

water could reduce costs of oil and gas development, while also easing demand for water by alleviating drought conditions in Colorado and the west and providing water for agriculture, industry, and other uses. Energy and water are two of our most important resources, so it makes sense to pursue ways to produce more of both. Last month, the House passed a similar bill that I authored and I am pleased that Senator Salazar has taken the lead in the Senate on this issue."

The study provision of the bill would direct the Commissioner of the Bureau of Reclamation, the Director of the U.S. Geological Survey, and the Director of the Bureau of Land Management to evaluate the feasibility of recovering and cleaning "produced water" for use in irrigation and other purposes, all while protecting and conserving the water quality and natural surroundings. It also requires those agencies to study ways to increase the efficiency of energy production by reducing the quantity of produced water that must be treated or reinjected.

The grant provision of the bill provides a maximum 50 percent federal match of up to $1 million to construct, but not operate, test project sites. In order to test the recovery systems across a variety of geological and climatic conditions, the grant portion of S. 1116 requires test projects be built in at least five locations:

- One in each of the Upper Basin states of the Colorado River: Colorado, Utah, Wyoming, and New Mexico; and
- One in at least one of the Lower Basin states of the Colorado River: Arizona, Nevada or California.

The quality and volume of the recovered "produced water" will depend upon the technology to be tested under S. 1116.

The full legislative text of S. 1116, the "More Water, More Energy, Less Waste Act of 2007," can be viewed by clicking here.

# # #

110TH CONGRESS
1ST SESSION

S. ______

To facilitate the use for irrigation and other purposes of water produced in connection with development of energy resources.

IN THE SENATE OF THE UNITED STATES

Mr. SALAZAR (for himself and Mr. BINGAMAN) introduced the following bill; which was read twice and referred to the Committee on

A BILL

To facilitate the use for irrigation and other purposes of water produced in connection with development of energy resources.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE, FINDINGS, AND PURPOSE.

(a) SHORT TITLE.—This Act may be cited as the "More Water, More Energy, and Less Waste Act of 2007".

(b) FINDINGS.—The Congress finds that—

(1) development of energy resources, including oil, natural gas, coalbed methane, and geothermal

resources, frequently results in bringing to the surface water extracted from underground sources;

(2) some of that produced water is used for irrigation or other purposes, but most of the water is returned to the subsurface or otherwise disposed of as waste;

(3) reducing the quantity of produced water returned to the subsurface and increasing the quantity of produced water that is made available for irrigation and other uses—

(A) would augment water supplies;

(B) could reduce the costs to energy developers for disposing of the water; and

(C) in some cases, could increase the efficiency of energy development activities; and

(4) it is in the national interest—

(A) to limit the quantity of produced water disposed of as waste;

(B) to optimize the production of energy resources; and

(C) to remove or reduce obstacles to use of produced water for irrigation or other purposes in ways that will not adversely affect water quality or the environment.

(c) PURPOSES.—The purposes of this Act are—

(1) to optimize the production of energy resources—

(A) by minimizing the quantity of produced water; and

(B) by facilitating the use of produced water for irrigation and other purposes without adversely affecting water quality or the environment; and

(2) to demonstrate means of accomplishing those results.

SEC. 2. DEFINITIONS.

In this Act:

(1) LOWER BASIN STATE.—The term "Lower Basin State" means any of the States of—

(A) Arizona;

(B) California; and

(C) Nevada.

(2) PRODUCED WATER.—The term "produced water" means water from an underground source that is brought to the surface as part of the process of exploration for, or development of—

(A) oil;

(B) natural gas;

(C) coalbed methane; or

(D) any other substance to be used as an energy source.

(3) SECRETARY.—The term "Secretary" means the Secretary of the Interior.

(4) UPPER BASIN STATE.—The term "Upper Basin State" means any of the States of—

(A) Colorado;

(B) New Mexico;

(C) Utah; and

(D) Wyoming.

SEC. 3. IDENTIFICATION OF PROBLEMS AND SOLUTIONS.

(a) STUDY.—The Secretary, acting through the Commissioner of Reclamation, the Director of the United States Geological Survey, and the Director of the Bureau of Land Management shall conduct a study to identify—

(1) the technical, economic, environmental, and other obstacles to reducing the quantity of produced water;

(2) the technical, economic, environmental, legal, and other obstacles to increasing the extent to which produced water can be used for irrigation and other purposes without adversely affecting water quality or the environment;

(3) the legislative, administrative, and other actions that could reduce or eliminate the obstacles identified in paragraphs (1) and (2); and

(4) the costs and benefits associated with reducing or eliminating the obstacles identified in paragraphs (1) and (2).

(b) REPORT.—Not later than 1 year after the date of enactment of this Act, the Secretary shall submit to the Committee on Natural Resources of the House of Representatives and the Committee on Energy and Natural Resources of the Senate a report describing the results of the study under subsection (a).

SEC. 4. IMPLEMENTATION.

(a) GRANTS.—Subject to the availability of appropriations, the Secretary shall provide financial assistance for the development of facilities, technologies, and processes to demonstrate the feasibility, effectiveness, and safety of—

(1) optimizing energy resource production by reducing the quantity of produced water generated; or

(2) increasing the extent to which produced water may be recovered and made suitable for use for irrigation, municipal, or industrial uses, or other

purposes without adversely affecting water quality or the environment.

(b) LIMITATIONS.—Assistance under this section—

(1) shall be provided for—

(A) at least 1 project in each of the Upper Basin States; and

(B) at least 1 project in at least 1 of the Lower Basin States;

(2) shall not exceed $1,000,000 for any project;

(3) shall be used to pay not more than 50 percent of the total cost of a project;

(4) shall not be used for the operation or maintenance of any facility; and

(5) may be in addition to assistance provided by the Federal Government pursuant to other provisions of law.

SEC. 5. CONSULTATION, ADVICE, AND COMMENTS.

In carrying out this Act, including in preparing the report under section 3(b) and establishing criteria to be used in connection with an award of financial assistance under section 4, the Secretary shall—

(1) consult with the Secretary of Energy, the Administrator of the Environmental Protection Agency, and appropriate Governors and local officials;

(2)(A) review any relevant information developed in connection with research carried out by others, including research carried out pursuant to subtitle J of title IX of the Energy Policy Act of 2005 (42 U.S.C. 16371 et seq.); and

(B) to the extent the Secretary determines to be advisable, include that information in the report under section 3(b);

(3) seek the advice of—

(A) individuals with relevant professional or academic expertise; and

(B) individuals or representatives of entities with industrial experience, particularly experience relating to production of oil, natural gas, coalbed methane, or other energy resources (including geothermal resources); and

(4) solicit comments and suggestions from the public.

SEC. 6. RELATION TO OTHER LAWS.

Nothing in this Act supersedes, modifies, abrogates, or limits—

(1) the effect of any State law or any interstate authority or compact relating to—

(A) any use of water; or

(B) the regulation of water quantity or quality; or

(2) the applicability or effect of any Federal law (including regulations).

SEC. 7. AUTHORIZATION OF APPROPRIATIONS.

There are authorized to be appropriated—

(1) $1,000,000 to carry out section 3; and

(2) $7,500,000 to carry out section 4.

ALTELA

Altela, Inc.

Cordially invites you to join
U.S. Representative Tom Udall,
Ned Godshall, CEO, Altela, Inc.,
T. Greg Merrion, Merrion Oil and Gas Corporation,
Michael Sullivan, Director, Community Development Department in Farmington
and other invited
State of New Mexico, City of Farmington, and San Juan County Officials

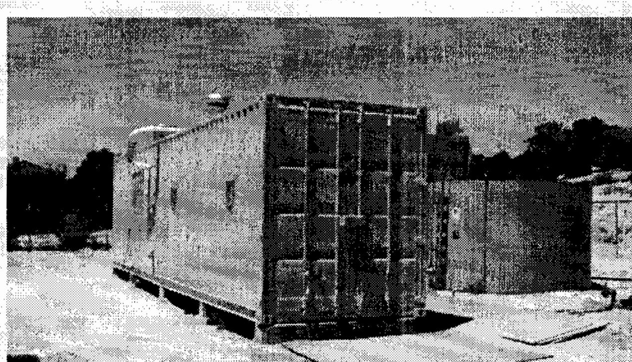
AT THE DEMONSTRATION AND ANNOUNCEMENT OF THE FIRST-EVER EPA-APPROVED CENTRALIZED PRODUCED WATER TREATMENT FACILITY IN NEW MEXICO

The AltelaRain^{SM} water purification system is a U.S. technology that inexpensively removes 100 percent of the dissolved salts and other contaminants from produced water, converting this waste product into a new source of water in New Mexico, while also reducing 90% of water-hauling trucking. Altela transforms the liability of waste water into the asset of clean water.

Date: Thursday, August 9, 2007
Time: 10:00 a.m.
Place: Farmington, New Mexico

RSVP: Please call Córdova Public Relations at (505) 266-5637 or email info@cordovapr.com

DIRECTIONS: From Bloomfield, left on Highway 64, 13 miles to Farmington. Right at the light onto Browning Parkway. Right at the light onto East Main. Travel on East Main past the Animas Valley Mall on the right and Wal-Mart on the left. Turn left onto English Road, straight through the light at Pinon Hills Boulevard, onto dirt road past the road closure barricade. Approximately 300 feet, turn left into the Blackshawl gas well location.



ALTELA

Article in The Albuquerque Journal Business Outlook

MONDAY, AUGUST 6, 2007

Doing the impossible

Even after the water has spent 30 million years soaking in crude oil, salts and other compounds miles below the earth's surface, and has been belched out in a natural gas well, Albuquerque's Altela Inc. can make the water clean.

Now the Environmental Protection Agency says the Albuquerque company can pour this water right into the city of Farmington's sewer. From there, it goes to the city's treatment plant, where it will offset water claims and help replenish subsurface fresh water aquifers.

"Every gallon we put down there is a gallon the city doesn't have to pull from the San Juan River," says Altela founder and CEO Ned Godshall.

Altela's Farmington Treatment Facility, at a gas well operated by Merrion Oil and Gas Corp., was built with state funds issued in 2004 and 2005 to support water purification and conservation projects proposed by private companies and local governments.

Altela's system, which fits into customized truck shipping containers, has been in operation near Farmington since March.

The company was founded to solve a vexing problem for oil and gas producers — what to do with the thousands of gallons of brackish, polluted water produced by wells every day as a byproduct of extraction.

In most cases, that waste is trucked, at high cost, to disposal sites where the water is injected back into the ground.

Altela's AltelaRain system, based on technology developed at Arizona State University, can desalinate and purify that water at very low cost, often using waste energy produced right at the wellhead.

The system leaves about 90 percent of the water clean and drinkable. The remaining superconcentrated 10 percent is disposed of by conventional means.

One Altela system can process up to 4,000 gallons of water per day.

The venture capital-backed company has already received a state surface discharge permit for the purified water.

Tech Bytes

ANDREW WEBB
Of the Journal

The technology will also allow wells to last longer, increasing domestic energy reserves, said T. Greg Merrion, president of Merrion Oil and Gas.

"This new technology lowers our costs, while at the same time creating a new water supply in New Mexico and decreasing waste that must be hauled away and disposed of," he said.

Officials from Altela, Merrion and local and state governments are expected to be on hand this Thursday for an official unveiling and demonstration of the device.

Godshall said Altela plans four similar treatment facilities at nearby wells on the Navajo Reservation. Purified water produced there will be given free to the Navajos, he said.

Altela employs 23.

ALTELA™

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2008 MAR 31 PM 2 26

2450 Alamo Ave. SE, Suite
Albuquerque, New Mexico
T: 505.923.4140
F: 505.923.4130

Denver Technology Center
Belleview Tower
7887 E. Belleview Ave.
Englewood, Colorado
T: 303.228.1605
F: 303.228.1655

March 27, 2008

Mr. Wayne Price
Mr. Brad Jones
Environmental Bureau Chief
NM Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Altela, Inc. – Renewal of Temporary Approval to Store and Use Produced Water for R&D of the AltelaRain℠ Technology

VIA FIRST CLASS MAIL & ELECTRONIC MAIL

Dear Wayne and Brad,

This letter follows your request for additional information with respect to Altela, Inc.'s request for renewal of the temporary approval to store and use produced water for R&D of the AltelaRain℠ technology as outlined in New Mexico Oil Conservation Division's renewal approval letter.

Your letter noted that the Produced Water Tracking Summary did not indicate where the initial 300 gallons of produced water was taken for disposal or if it was taken to an OCD approved facility. I have confirmed with M&R Trucking, Inc., the approved C-133 produced water permitted hauler, that the initial 300 gallons of produced water was taken and disposed of at Pretty Lady 30-11-34 Well No. 1, an OCD- approved reinjection facility. In addition, the Produced Water Tracking Summary has been updated accordingly and a copy attached hereto.

Second, you noted that Altela only provided results of one testing event of the produced water, suggesting that only one treatment cycle using the produced water had been performed. That is correct; Altela only conducted one treatment cycle where the water quality results were sent to an independent third-party laboratory for analysis was performed on the produced water. Condition No. 6, provides *"Altela will provide the OCD copies of the water quality test results received from third party water quality laboratories with respect to tests using the produced water at the Alamo facility"*. The corresponding Energy Laboratories, Inc. laboratory analytical report was included in our renewal request.

Finally, you indicated that OCD's review of the analytical results indicate some concern regarding the concentration of certain constituents. We would like to address any such concerns at your earliest convenience.

We certainly value and appreciate OCD's continued assistance and support of the AltelaRain^{SM} technology and its related environmental stewardship application. Following your review, we look forward to addressing any remaining questions with respect to the renewal.

Sincerely,

Altela, Inc.

Matthew Bruff
CDO

cc: Altela Day File

Enclosures as noted

ALTELA

Alamo Produced Water Tracking Summary

No	Date	Transport Company Name	Contact at Company	Address	Phone Number	Fax Number	C133 Permit No.	Name of Originating Well or Disposal Well/Facility	Owner of Well	Delivered / Taken Away	Balance
1	2/22/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	Blackshawl Com. #001 (San Juan Basin)	Merrion Oil and Gas Corporation	300 Gallons Delivered	+300 gallons
2	11/19/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	Pretty Lady 30 11 34 Well No. 1	Merrion Oil and Gas Corporation	300 Gallons Taken Away	0 gallons
3	11/19/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	Blackshawl Com. #001 (San Juan Basin)	Merrion Oil and Gas Corporation	300 Gallons Delivered	+300 gallons
4											
5											
6											
7											
8											
9											
10											
11											
12											

Jones, Brad A., EMNRD

From: Matthew J. Bruff [matthew.bruff@altelainc.com]
Sent: Wednesday, November 28, 2007 10:47 AM
To: Price, Wayne, EMNRD; Jones, Brad A., EMNRD
Subject: Altela, Inc. PW Use at Alamo
Attachments: Alamo PW Renewal Request, 28 Nov 07.pdf; Alamo Produced Water Tracking Summary.pdf; Alamo PW Water Quality Report.pdf

Wayne and Brad,
Please find attached Altela, Inc.'s written request to renew Altela's temporary approval to store and use produced water for R&D of the AltelaRain^{SM} technology at our Alamo design, research, and manufacturing facilities. A hard copy will follow via USPS First Class Mail.
Thanks,
Matt

Matthew Bruff
Altela, Inc.
Denver Technology Center
7887 E. Belleview Ave., Ste. 1100
Englewood, CO 80111
T (303) 228-1605
F (303) 228-1655
www.altelainc.com

ALTELA™

November 28, 2007

Mr. Wayne Price
Mr. Brad Jones
Environmental Bureau Chief
NM Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Altela, Inc. – Renewal of Temporary Approval to Store and Use Produced Water for R&D of the AltelaRain^{SM} Technology

VIA FIRST CLASS MAIL & ELECTRONIC MAIL

Dear Wayne and Brad,

This letter serves as written request to renew Altela, Inc.'s (Altela) temporary approval to store and use produced water for R&D of the AltelaRain^{SM} technology. A copy of the original NM Oil Conservation Division (OCD) approval letter dated January 16, 2007 has been attached. Pursuant to the terms of the original approval letter, we hereby submit this renewal request forty-five (45) prior to the expiration date of the original approval.

Altela requests a one-year renewal to use real oilfield produced water for testing and development of the AltelaRain^{SM} technology at Altela's design, research, and manufacturing facilities. These facilities are located at 2450 Alamo SE, Albuquerque, New Mexico 87106 ("Alamo"). Altela continues to agree to the following conditions with respect to use of the produced water at Alamo:

1. The produced water approved for storage and the testing and development of the AltelaRain^{SM} technology will only occur at Altela's design, research, and manufacturing facility (Alamo), located at 2450 Alamo SE, Albuquerque, New Mexico 87106;

2. Only haulers authorized (OCD approved C-133) to move produced water may provide transport of produced water to the Alamo facility;

3. No produced water shall be disposed at the Alamo facility. All produced water must be removed from the Alamo facility by a hauler authorized (OCD approved C-133) to move produced water and properly disposed at an OCD approved facility;

4. Altela must retain records documenting all produced water received and removed from the Alamo facility;

5. Altela must report all unauthorized discharges of produced water pursuant to OCD Rule 116 to the OCD within 24 hours of determining a release; and

6. Altela will provide the OCD copies of the water quality test results received from third party water quality laboratories with respect to tests using the produced water at the Alamo facility.

Enclosed, please find a copy Altela's Produced Water Tracking Summary used to ensure that all produced water is accounting for as well as delivered by approved C-133 permitted water haulers and removed by approved C-133 permitted water haulers for disposal. Please also find a copy of the water quality analytical report with respect to the produced water by Energy Laboratories, Inc.

Thank you in advance for your continued assistance and support of the AltelaRain[SM] technology. Please do not hesitate to contact me if the need arises.

Sincerely,

Altela, Inc.

Matthew Bruff
CDO

cc: Altela Day File

Enclosures as noted

ALTELA

Alamo Produced Water Tracking Summary

No	Date	Transport Company Name	Contact at Company	Address	Phone Number	Fax Number	C133 Permit No.	Name of Originating Well (If Taken Away - NA)	Owner of Well	Delivered / Taken Away	Balance
1	2/22/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	Blackshawl Com. #001 (San Juan Basin)	Merrion Oil and Gas Corporation	300 Gallons Delivered	+300 gallons
2	11/19/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	NA		300 Gallons Taken Away	0 gallons
3	11/19/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	Blackshawl Com. #001 (San Juan Basin)	Merrion Oil and Gas Corporation	300 Gallons Delivered	+300 gallons
4											
5											
6											
7											
8											
9											
10											
11											
12											

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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-001	**DateReceived:**	03/02/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
MAJOR IONS							
Calcium	ND	mg/L		0.5		E200.7	03/07/07 15:38 / ts
Chloride	ND	mg/L		1		A4500-Cl B	03/06/07 14:17 / jl
Fluoride	1.0	mg/L		0.1		A4500-F C	03/05/07 15:23 / jaj
Magnesium	ND	mg/L		0.5		E200.7	03/07/07 15:38 / ts
Nitrogen, Ammonia as N	7.3	mg/L		0.1		E350.1	03/08/07 11:14 / eli-b
Nitrogen, Kjeldahl, Total as N	7.7	mg/L		0.5		E351.2	03/06/07 10:32 / eli-b
Nitrogen, Nitrite as N	ND	mg/L	H	0.1		A4500-NO2 B	03/06/07 15:32 / jal
Phosphorus	ND	mg/L		0.1		E200.7	03/07/07 15:38 / ts
Phosphorus, Orthophosphate as P	ND	mg/L		0.010		E365.1	03/06/07 14:59 / eli-b
Sodium	ND	mg/L		0.5		E200.7	03/07/07 15:38 / ts
Sulfate	ND	mg/L		1		A4500-SO4 E	03/05/07 17:44 / ljl
NON-METALS							
Cyanide, Free	NA	mg/L		0.2		A4500-CN-F	03/07/07 12:00 / eli-b
Phenolics, Total Recoverable (Distilled)	0.105	mg/L		0.010		E420.1	03/05/07 14:43 / jl
Cyanide, Weak Acid Dissociable	ND	mg/L		0.005		D2036	03/06/07 10:42 / eli-b
Sulfide	ND	mg/L		0.50		E376.1	03/07/07 10:27 / jl
- The Total Automated Cyanide was analyzed, and was < 200 ug/L, the detection limit for Free Cyanide. Free Cyanide was not analyzed.							
PHYSICAL PROPERTIES							
Chlorine, Residual Total	ND	mg/L		0.01		H8021	03/05/07 16:09 / jl
Conductivity	35.3	umhos/cm		1.0		A2510 B	03/05/07 14:49 / lm
Hardness as CaCO3	ND	mg/L		6.5		A2340 B	03/08/07 11:15 / sec
pH	8.95	s.u.		0.01		A4500-H B	03/05/07 14:49 / lm
Solids, Total Dissolved TDS @ 180 C	ND	mg/L		10		A2540 C	03/05/07 13:51 / lm
Solids, Total Suspended TSS @ 105 C	ND	mg/L		1.0		E160.2	03/05/07 10:32 / lm
METALS - TOTAL							
Aluminum	ND	mg/L		0.01		E200.7	03/07/07 15:38 / ts
Antimony	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Arsenic	ND	mg/L		0.001		E200.8	03/08/07 00:43 / sml
Barium	ND	mg/L		0.1		E200.8	03/08/07 00:43 / sml
Beryllium	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Boron	ND	mg/L		0.1		E200.7	03/07/07 15:38 / ts
Cadmium	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Chromium	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Copper	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Lead	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Mercury	ND	mg/L		0.001		E200.8	03/08/07 00:43 / sml
Nickel	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Selenium	ND	mg/L		0.001		E200.8	03/08/07 00:43 / sml
Silver	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Thallium	ND	mg/L		0.1		E200.8	03/08/07 00:43 / sml
Zinc	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	Report Date:	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	Collection Date:	03/01/07 11:52
Lab ID:	C07030114-001	DateReceived:	03/02/07
Client Sample ID:	P-38	Matrix:	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/QCL	Method	Analysis Date / By
RADIONUCLIDES - QUICK COUNT - TOTAL							
Radium 226	ND	pCi/L		0.2		E903.0	03/08/07 11:05 / trs
RADIONUCLIDES - TOTAL							
Radium 226	ND	pCi/L		0.2		E903.0	03/13/07 09:16 / trs
Radium 228	ND	pCi/L		1.0		RA-05	03/08/07 10:35 / plj
VOLATILE ORGANIC COMPOUNDS							
1,1,1,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1,1-Trichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1,2,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1,2-Trichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1-Dichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1-Dichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1-Dichloropropene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2,3-Trichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dibromoethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dichlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,3-Dichlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,3-Dichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,4-Dichlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
2,2-Dichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
2-Chloroethyl vinyl ether	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
2-Chlorotoluene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
4-Chlorotoluene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Acetone	433	ug/L		20.0		E624	03/07/07 04:35 / dkh
Acetonitrile	ND	ug/L		10.0		E624	03/07/07 04:35 / dkh
Acrolein	ND	ug/L		10.0		E624	03/07/07 04:35 / dkh
Acrylonitrile	ND	ug/L		10.0		E624	03/07/07 04:35 / dkh
Benzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromochloromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromodichloromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromoform	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromomethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Carbon disulfide	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Carbon tetrachloride	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chlorodibromomethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chloroform	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chloromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh

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LABORATORY ANALYTICAL REPORT

Client:	Alteia Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-001	**DateReceived:**	03/02/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
cis-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
cis-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Dibromomethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Dichlorodifluoromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Ethylbenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
m+p-Xylenes	ND	ug/L		2.00		E624	03/07/07 04:35 / dkh
Methyl ethyl ketone	23.4	ug/L		20.0		E624	03/07/07 04:35 / dkh
Methyl isobutyl ketone	ND	ug/L		20.0		E624	03/07/07 04:35 / dkh
Methyl tert-butyl ether (MTBE)	ND	ug/L		2.00		E624	03/07/07 04:35 / dkh
Methylene chloride	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Naphthalene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
o-Xylene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Styrene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Tetrachloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Toluene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
trans-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
trans-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Trichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Trichlorofluoromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Vinyl acetate	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Vinyl chloride	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Xylenes, Total	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Surr: 1,2-Dichlorobenzene-d4	102	%REC			80-120	E624	03/07/07 04:35 / dkh
Surr: Dibromofluoromethane	104	%REC			80-120	E624	03/07/07 04:35 / dkh
Surr: p-Bromofluorobenzene	99.0	%REC			80-120	E624	03/07/07 04:35 / dkh
Surr: Toluene-d8	99.0	%REC			80-120	E624	03/07/07 04:35 / dkh
ORGANIC CHARACTERISTICS							
Organic Halides, Total	ND	mg Cl/L		0.1		SW9020B	03/09/07 11:03 / cjs
Oil & Grease (HEM)	ND	mg/L		5.0	10	SW1664A	03/06/07 10:35 / bah
SYNTHETIC ORGANIC COMPOUNDS							
1,2,4-Trichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
1,2-Dichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
1,3-Dichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
1,4-Dichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4,6-Trichlorophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4-Dichlorophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4-Dimethylphenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4-Dinitrophenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
2,4-Dinitrotoluene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,6-Dinitrotoluene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2-Chloronaphthalene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b

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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-001	**DateReceived:**	03/02/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SYNTHETIC ORGANIC COMPOUNDS							
2-Chlorophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2-Nitrophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
3,3'-Dichlorobenzidine	ND	ug/L		20		E625	03/07/07 06:11 / eli-b
4,6-Dinitro-2-methylphenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
4-Bromophenyl phenyl ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
4-Chloro-3-methylphenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
4-Chlorophenyl phenyl ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
4-Nitrophenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
Acenaphthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Acenaphthylene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Anthracene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Azobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzidine	ND	ug/L		20		E625	03/07/07 06:11 / eli-b
Benzo(a)anthracene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(a)pyrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(b)fluoranthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(g,h,i)perylene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(k)fluoranthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(-2-chloroethoxy)Methane	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(-2-chloroethyl)Ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(2-chloroisopropyl)Ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(2-ethylhexyl)Phthalate	190	ug/L		20		E625	03/07/07 20:05 / eli-b
Butylbenzylphthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Chrysene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Dibenzo(a,h)anthracene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Diethyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Dimethyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Di-n-butyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Di-n-octyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Fluoranthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Fluorene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Hexachlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Hexachlorobutadiene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Hexachlorocyclopentadiene	ND	ug/L		20		E625	03/07/07 06:11 / eli-b
Hexachloroethane	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Indeno(1,2,3-cd)pyrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Isophorone	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Naphthalene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Nitrobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
n-Nitrosodimethylamine	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
n-Nitroso-di-n-propylamine	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
n-Nitrosodiphenylamine	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Pentachlorophenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
Phenanthrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b

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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-001	**DateReceived:**	03/02/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SYNTHETIC ORGANIC COMPOUNDS							
Phenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Pyrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Surr: 2,4,6-Tribromophenol	92.0	%REC			26-116	E625	03/07/07 06:11 / eli-b
Surr: 2-Fluorobiphenyl	82.0	%REC			25-94	E625	03/07/07 06:11 / eli-b
Surr: 2-Fluorophenol	28.0	%REC			11-67	E625	03/07/07 06:11 / eli-b
Surr: Nitrobenzene-d5	70.0	%REC			19-102	E625	03/07/07 06:11 / eli-b
Surr: Phenol-d5	19.0	%REC			15-54	E625	03/07/07 06:11 / eli-b
Surr: Terphenyl-d14	69.0	%REC			39-106	E625	03/07/07 06:11 / eli-b
PESTICIDES							
4,4'-DDD	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
4,4'-DDE	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
4,4'-DDT	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Aldrin	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
alpha-BHC	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
alpha-Chlordane	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
beta-BHC	ND	ug/L	D	0.080		E608	03/06/07 14:45 / eli-b
Chlordane	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
delta-BHC	ND	ug/L	D	0.065		E608	03/06/07 14:45 / eli-b
Dieldrin	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endosulfan I	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endosulfan II	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endosulfan sulfate	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endrin	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endrin aldehyde	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endrin Ketone	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
gamma-BHC (Lindane)	ND	ug/L	D	0.10		E608	03/06/07 14:45 / eli-b
gamma-Chlordane	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Heptachlor	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Heptachlor epoxide	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Methoxychlor	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Toxaphene	ND	ug/L		5.0		E608	03/06/07 14:45 / eli-b
Aroclor 1016	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1221	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1232	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1242	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1248	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1254	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1260	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1262	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1268	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Surr: Decachlorobiphenyl	37.0	%REC	S		44-119	E608	03/06/07 14:45 / eli-b
Surr: Tetrachloro-m-xylene	57.0	%REC			40-120	E608	03/06/07 14:45 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D - RL increased due to sample matrix interference.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.
S - Spike recovery outside of advisory limits

ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-002	**DateReceived:**	03/02/07
Client Sample ID:	Trip Blank	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
1,1,1,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1,1-Trichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1,2,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1,2-Trichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1-Dichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1-Dichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1-Dichloropropene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2,3-Trichloropropene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dibromoethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dichlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dichloropropane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,3-Dichlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,3-Dichloropropane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,4-Dichlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
2,2-Dichloropropane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
2-Chloroethyl vinyl ether	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
2-Chlorotoluene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
4-Chlorotoluene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Acetone	ND	ug/L		20.0		E624	03/06/07 18:09 / dkh
Acetonitrile	ND	ug/L		10.0		E624	03/06/07 18:09 / dkh
Acrolein	ND	ug/L		10.0		E624	03/06/07 18:09 / dkh
Acrylonitrile	ND	ug/L		10.0		E624	03/06/07 18:09 / dkh
Benzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromochloromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromodichloromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromoform	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromomethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Carbon disulfide	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Carbon tetrachloride	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chlorodibromomethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chloroform	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chloromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
cis-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
cis-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Dibromomethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Dichlorodifluoromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Ethylbenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
m+p-Xylenes	ND	ug/L		2.00		E624	03/06/07 18:09 / dkh
Methyl ethyl ketone	ND	ug/L		20.0		E624	03/06/07 18:09 / dkh
Methyl isobutyl ketone	ND	ug/L		20.0		E624	03/06/07 18:09 / dkh

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-002	**DateReceived:**	03/02/07
Client Sample ID:	Trip Blank	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
Methyl tert-butyl ether (MTBE)	ND	ug/L		2.00		E624	03/06/07 18:09 / dkh
Methylene chloride	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Naphthalene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
o-Xylene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Styrene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Tetrachloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Toluene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
trans-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
trans-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Trichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Trichlorofluoromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Vinyl acetate	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Vinyl chloride	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Xylenes, Total	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Surr: 1,2-Dichlorobenzene-d4	101	%REC			80-120	E624	03/06/07 18:09 / dkh
Surr: Dibromofluoromethane	97.0	%REC			80-120	E624	03/06/07 18:09 / dkh
Surr: p-Bromofluorobenzene	98.0	%REC			80-120	E624	03/06/07 18:09 / dkh
Surr: Toluene-d8	97.0	%REC			80-120	E624	03/06/07 18:09 / dkh

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level
ND - Not detected at the reporting limit.

DATA CHEM LABORATORIES, INC.

3/7/07

SUBMITTED TO:

Roger Garling
Energy Laboratories
P.O. Box 3258
Casper, WY 82602-3258

REFERENCE DATA:

Client Sample Nos.:	C07030114-001N
P.O. Number:	1770
Sample Location:	P38DW6
Sample Type:	Drinking Water
Method Reference:	Asbestos in Potable Water by TEM EPA 600/4-83-043, Method 100.1
DCL Set ID No.:	07-T-1167
DCL Sample ID Nos.:	07-07053

The samples indicated on the following data sheet(s) were analyzed by Transmission Electron Microscopy (TEM) for asbestos using the method EPA 600/4-83-043, Method 100.1 Each sample was ultrasonically treated in its original container for 15 minutes to suspend the solids. An aliquot of this suspension was added to 100 mL of de-ionized water and filtered onto a 0.1μm pore size polycarbonate filter. Portions of this filter were coated with carbon and mounted on grids for TEM analysis. Analysis was performed on a Philips CM-12 TEM with EDAX Genesis System providing energy dispersive X-ray analysis (EDXA) capabilities.

Results apply only to portions of samples analyzed and are tabulated on the following data sheet(s). Representative EDXA spectra and selected area electron diffraction (SAED) measurements of asbestos types detected (if any) are included and are referenced to the structure identification numbers listed on the count sheets. The limit of detection (LOD) for this method has been determined to be one asbestos fiber in the total number of grid openings analyzed. The number of openings analyzed is dependent on the sample volume filtered (4 minimum).

Angela Sohn
Analyst

Anna Marie Ristich
Section Manager

CINCINNATI OFFICE
4388 GLENDALE-MILFORD ROAD
CINCINNATI, OHIO 45242-3706
513 733-5336, FAX 513 733-5347

WEST COAST OFFICE
11 SANTA YORMA COURT
NOVATO, CALIFORNIA 94945
800 280-8071 FAX 415 893-9469

DataChem Laboratories Test Report
Asbestos in Drinking Water by TEM

DCL Sample Set ID. 07-T-1167
Client: Energy Laboratories
Sample Location: P38DW6

SAMPLE PREP DATA		*ANALYSIS DATA*	
Date Received:	3/2/2007	Date Analyzed:	3/7/2007
Date Filtered:	3/2/2007	Magnification:	9,720 X
Time Filtered:	15:00	Calibration Constant:	1 cm = 1.05 µm
Filter Type:	PC, 0.1 µm	EDXA Resolution:	160.9 eV
Filter Size:	47 mm	Accelerating Voltage:	100 keV
Collection Area:	1075 mm^2	Camera Constant:	31.97 mm-Å

SAMPLE IDENTIFICATION	
Client ID:	C07030114-001N
DCL ID:	07-07053
Date Sampled:	3/1/2007
Time Sampled.	11:24
Volume (L):	0.100
No. Grid Openings Analyzed:	6
Average Grid Opening Area.	0.0102
LOD (MFL):	0.18
Asbestos Fibers ≥ 10 microns	
Chrysotile:	0
Amosite:	0
Crocidolite:	0
Actinolite-Tremolite:	0
Anthophyllite.	0
TOTAL ASBESTOS	
Count:	0
Concentration (MFL):	<LOD

ND = None Detected LOD = Limit of Detection MFL = Millions of Fibers per Liter

Angela Sohn
Analyst

Anna Marie Ristich
Section Manager

LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	02/28/07 15:20
Lab ID:	C07030045-008	**DateReceived:**	03/01/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifier	RL	MCL/ QCL	Method	Analysis Date / By
MAJOR IONS							
Nitrogen, Nitrate+Nitrite as N	ND	mg/L		0.1		E353.2	03/05/07 15:11 / jal
NON-METALS							
Organic Carbon, Total (TOC)	28.4	mg/L		1.0		A5310 B	03/08/07 12:29 / jl
Sulfite	ND	mg/L		2.0		E377.1	03/01/07 15:05 / jl
PHYSICAL PROPERTIES							
Oxygen Demand, Chemical (COD)	100	mg/L		1.0		HACH 8000	03/08/07 07:40 / jal
BOD, 5-Day	61	mg/L		2.0		A5210 B	03/01/07 15:46 / jrf

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

NEW MEXICO ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT

BILL RICHARDSON
Governor
Joanna Prukop
Cabinet Secretary

Mark E. Fesmire, P.E.
Director
Oil Conservation Division

January 16, 2007

Mr. Matthew J. Bruff
Altela, Inc.
Denver Technology Center
Belleview Tower
7887 E. Belleview Ave, Suite 1100
Englewood, CO 80111

Re: Application for temporary approval to store and use produced water for R&D of the AltelaRain™ technology
2450 Alamo SE' Albuquerque, New Mexico 87106

Dear Mr. Bruff:

The New Mexico Oil Conservation Division (OCD) has received and reviewed Altela, Inc.'s request to store and use oilfield produced water for testing and development of the AltelaRain™ technology at Altela, Inc.'s design, research, and manufacturing facility. Altela, Inc.'s design, research, and manufacturing facility (Alamo) is located at 2450 Alamo SE' Albuquerque, New Mexico 87106. This request is hereby approved with the following understandings and conditions:

1. The produced water approved for storage and the testing and development of the AltelaRain™ technology will only occur at Altela, Inc.'s design, research, and manufacturing facility (Alamo), located at 2450 Alamo SE' Albuquerque, New Mexico 87106.

2. Only haulers authorized (OCD approved C-133) to move produced water may provide transport of produced water to the Alamo facility.

3. No produced water shall be disposed at the Alamo facility. All produced water must be removed from the Alamo facility by a hauler authorized (OCD approved C-133) to move produced water and properly disposed at an OCD approved facility.

4. Altela, Inc. must retain records documenting all produced water received and removed from the Alamo facility.

5. Altela, Inc. must report all unauthorized discharges of produced water pursuant to OCD Rule 116 to the OCD within 24 hours of determining a release.

6. Altela, Inc. will provide the OCD copies of the water quality test results received from third party water quality laboratories with respect to tests using the produced water at the Alamo facility.

This authorization is approved for a period of one (1) year. **This temporary approval will expire January 16, 2008.** Renewal requests for temporary approvals shall be submitted 45 days prior to the expiration date. Temporary approval may be revoked or suspended for violation of any applicable provisions and/or conditions.

Please be advised that authorization of this approval does not relieve the owner/operator (Altela, Inc.) of responsibility should operations result in pollution of surface water, ground water or the environment. Nor does approval of the permit relieve the owner/operator (Altela, Inc.) of its responsibility to comply with any other applicable governmental authority's rules and regulations.

If you have any questions, regarding this matter, please do not hesitate to contact Brad Jones at (505) 476-3487 or brad.a.jones@state.nm.us.

Sincerely,

Wayne Price
Environmental Bureau Chief

WP/bj

cc: OCD District IV Office, Santa Fe

ALTELA™

One Technology Center
1155 University Blvd. SE
Albuquerque, New Mexico 87106
T: 505.843.4197
F: 505.843.4198

Denver Technology Center
Belleview Tower
7887 E. Belleview Ave., Suite 1100
Englewood, Colorado 80111
T: 303.228.1605
F: 303.228.1635

December 5, 2006

Mr. Wayne Price
Environmental Bureau Chief
NM Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Altela, Inc.

VIA FIRST CLASS MAIL

Dear Mr. Price,

Following our recent discussion, this letter serves as written request to use real oilfield produced water for testing and development of the AltelaRain™ technology at Altela, Inc.'s ("Altela") design, research, and manufacturing facilities. These facilities are located at 2450 Alamo SE, Albuquerque, New Mexico 87106 ("Alamo"). Altela agrees to the following conditions with respect to use of the produced water at Alamo:

1. The produced water transported to Alamo will be done using New Mexico Oil Conservation Division approved C-133 permitted water haulers.
2. No produced water will be disposed of at Alamo using the municipal drain/sewer system. All produced water at Alamo will be taken away by an approved C-133 permitted water hauler for disposal.
3. All incoming produced water brought to Alamo will be accounted for to ensure the same amount of produced water is removed.
4. Altela will report any unauthorized discharges of the produced water at Alamo to the Oil Conservation Division.
5. Altela will provide the Oil Conservation Division with a copy of water quality test results received from third party water quality laboratories with respect to tests using the produced water at Alamo.

Thank you for your assistance. Please do not hesitate to contact me if the need arises.

Sincerely,

ALTELA, INC.

Matthew Bruff
Chief Development Officer

cc: Altela Day File

Jones, Brad A., EMNRD

From: Matthew J. Bruff [matthew.bruff@altelainc.com]
Sent: Tuesday, December 05, 2006 2:54 PM
To: Price, Wayne, EMNRD; Jones, Brad A., EMNRD
Subject: Altela, Inc.
Attachments: NM OCD Letter.pdf

Wayne and Brad,
Following our recent discussion, please find attached the letter request to use produced water for testing and development of the AltelaRain^{TM} technology at our design, research and manufacturing facilities.
A hard copy of the letter follows in the mail. Please do not hesitate to contact me if the need arises.
Thanks,
Matt

Matthew J. Bruff
Altela, Inc.
Denver Technology Center (DTC)
7887 East Belleview Ave., Suite 1100
Englewood, Colorado 80111

w: 303.228.1605
f: 303.228.1655

ALTELA™

One Technology Center
1155 University Blvd SE
Albuquerque, New Mexico 87106
T: 505.843.4197
F: 505.843.4198

Denver Technology Center
Belleview Tower
7887 E. Belleview Ave., Suite 1100
Englewood, Colorado 80111
T: 303.228.1605
F: 303.228.1655

December 5, 2006

Mr. Wayne Price
Environmental Bureau Chief
NM Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Altela, Inc.

VIA FIRST CLASS MAIL

Dear Mr. Price,

Following our recent discussion, this letter serves as written request to use real oilfield produced water for testing and development of the AltelaRain™ technology at Altela, Inc.'s ("Altela") design, research, and manufacturing facilities. These facilities are located at 2450 Alamo SE, Albuquerque, New Mexico 87106 ("Alamo"). Altela agrees to the following conditions with respect to use of the produced water at Alamo:

1. The produced water transported to Alamo will be done using New Mexico Oil Conservation Division approved C-133 permitted water haulers.
2. No produced water will be disposed of at Alamo using the municipal drain/sewer system. All produced water at Alamo will be taken away by an approved C-133 permitted water hauler for disposal.
3. All incoming produced water brought to Alamo will be accounted for to ensure the same amount of produced water is removed.
4. Altela will report any unauthorized discharges of the produced water at Alamo to the Oil Conservation Division.
5. Altela will provide the Oil Conservation Division with a copy of water quality test results received from third party water quality laboratories with respect to tests using the produced water at Alamo.

Thank you for your assistance. Please do not hesitate to contact me if the need arises.

Sincerely,

ALTELA, INC.

Matthew Bruff
Chief Development Officer

cc: Altela Day File

NEW MEXICO ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT

BILL RICHARDSON
Governor
Joanna Prukop
Cabinet Secretary

Mark E. Fesmire, P.E.
Director
Oil Conservation Division

December 7, 2007

Mr. Matthew J. Bruff
Altela, Inc.
Denver Technology Center
Belleview Tower
7887 E. Belleview Ave, Suite 1100
Englewood, CO 80111

Re: Application for temporary approval to store and use produced water for R&D of the AltelaRain™ technology
2450 Alamo SE' Albuquerque, New Mexico 87106

Dear Mr. Bruff:

The New Mexico Oil Conservation Division (OCD) has received and reviewed Altela, Inc.'s (Altela) request to renew Altela's temporary approval to store and use oilfield produced water for testing and development of the AltelaRain™ technology at Altela, Inc.'s design, research, and manufacturing facility, which expires January 16, 2008. The initial temporary approval was granted by OCD to serve certain purposes and achieve certain results. One purpose was to allow Altela the opportunity to use real produced water in a controlled environment to assist in the research and development of the AltelaRain™ technology. OCD's anticipated result of the temporary approval was to obtain testing results of the treatment of the produced water in order to demonstrate the capability of the AltelaRain™ technology. Such analytical results would represent the initial test/source water concentrations prior to treatment and the concentrations present after treatment. The November 28, 2007 renewal request only provided results of one testing event, which would suggest that only one treatment cycle using the produced water has been performed. OCD's review of the analytical results indicates some concern regarding the concentration of certain constituents.

The November 28, 2007 renewal request also provided a Produced Water Tracking Summary sheet. The sheet provides such information as the transporter, the source of the produced water, the volume delivered and the volume taken away. OCD would like to remind Altela of condition #3 of the January 16, 2007 temporary approval. Condition #3 states:

> *"No produced water shall be disposed at the Alamo facility. All produced water must be removed from the Alamo facility by a hauler authorized (OCD approved C-133) to move produced water and properly disposed at an OCD approved facility."*

The Produced Water Tracking Summary does not indicate where the initial 300 gallons of produced water was taken for disposal or if it was taken to an OCD approved facility, as required by the condition.

OCD's consideration of the continuance of this temporary approval is based on Altela's commitment to resolve the issues and concerns stated above. This request is hereby approved with the following understandings and conditions:

1. The produced water approved for storage and the testing and development of the AltelaRain™ technology shall only occur at Altela, Inc.'s design, research, and manufacturing facility (Alamo), located at 2450 Alamo SE' Albuquerque, New Mexico 87106.

2. Only haulers authorized (OCD approved C-133) to move produced water shall provide transport of produced water to the Alamo facility.

3. No produced water shall be disposed at the Alamo facility. All produced water shall be removed from the Alamo facility by a hauler authorized (OCD approved C-133) to move produced water and properly disposed at an OCD approved facility.

4. Altela, Inc. shall retain records documenting all produced water received and removed from the Alamo facility.

5. Altela, Inc. shall report all unauthorized discharges of produced water pursuant to OCD Rule 116 to the OCD within 24 hours of determining a release.

6. Altela, Inc. shall provide the OCD copies of the water quality analytical test results received from third party water quality laboratories with respect to tests using the produced water at the Alamo facility.

This authorization is approved for a period of one (1) year. **This temporary approval will expire January 16, 2009.** Renewal requests for temporary approvals shall be submitted 45 days prior to the expiration date. Temporary approval may be revoked or suspended for violation of any applicable provisions and/or conditions.

Please be advised that authorization of this approval does not relieve the owner/operator (Altela, Inc.) of responsibility should operations result in pollution of surface water, ground water or the environment. Nor does approval of the permit relieve the owner/operator (Altela, Inc.) of its responsibility to comply with any other applicable governmental authority's rules and regulations.

If you have any questions, regarding this matter, please do not hesitate to contact Brad Jones at (505) 476-3487 or brad.a.jones@state.nm.us.

Sincerely,

Wayne Price
Environmental Bureau Chief

WP/bj

Cc: OCD District IV Office, Santa Fe

ALTELA™

RECEIVED

2007 DEC 3 PM 1 34

2450 Alamo Ave. SE, Suite [illegible]
Albuquerque, New Mexico [illegible]
T: 505.923.4140
F: 505.923.4[illegible]

Denver Technology Center
Belleview Tower
7887 E. Belleview Ave. [illegible]
Englewood, Colorado [illegible]
T: 303.228.1605
F: 303.228.1655

November 28, 2007

Mr. Wayne Price
Mr. Brad Jones
Environmental Bureau Chief
NM Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Altela, Inc. – Renewal of Temporary Approval to Store and Use Produced Water for R&D of the AltelaRain℠ Technology

VIA FIRST CLASS MAIL & ELECTRONIC MAIL

Dear Wayne and Brad,

This letter serves as written request to renew Altela, Inc.'s (Altela) temporary approval to store and use produced water for R&D of the AltelaRain℠ technology. A copy of the original NM Oil Conservation Division (OCD) approval letter dated January 16, 2007 has been attached. Pursuant to the terms of the original approval letter, we hereby submit this renewal request forty-five (45) days prior to the expiration date of the original approval.

Altela requests a one-year renewal to use real oilfield produced water for testing and development of the AltelaRain℠ technology at Altela's design, research, and manufacturing facilities. These facilities are located at 2450 Alamo SE, Albuquerque, New Mexico 87106 ("Alamo"). Altela continues to agree to the following conditions with respect to use of the produced water at Alamo:

1. The produced water approved for storage and the testing and development of the AltelaRain℠ technology will only occur at Altela's design, research, and manufacturing facility (Alamo), located at 2450 Alamo SE, Albuquerque, New Mexico 87106;

2. Only haulers authorized (OCD approved C-133) to move produced water may provide transport of produced water to the Alamo facility;

3. No produced water shall be disposed at the Alamo facility. All produced water must be removed from the Alamo facility by a hauler authorized (OCD approved C-133) to move produced water and properly disposed at an OCD approved facility;

4. Altela must retain records documenting all produced water received and removed from the Alamo facility;

5. Altela must report all unauthorized discharges of produced water pursuant to OCD Rule 116 to the OCD within 24 hours of determining a release; and

6. Altela will provide the OCD copies of the water quality test results received from third party water quality laboratories with respect to tests using the produced water at the Alamo facility.

Enclosed, please find a copy Altela's Produced Water Tracking Summary used to ensure that all produced water is accounting for as well as delivered by approved C-133 permitted water haulers and removed by approved C-133 permitted water haulers for disposal. Please also find a copy of the water quality analytical report with respect to the produced water by Energy Laboratories, Inc.

Thank you in advance for your continued assistance and support of the AltelaRain^{SM} technology. Please do not hesitate to contact me if the need arises.

Sincerely,

Altela, Inc.

Matthew Bruff
CDO

cc: Altela Day File

Enclosures as noted

ENERGY LABORATORIES
ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-001	**DateReceived:**	03/02/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
MAJOR IONS							
Calcium	ND	mg/L		0.5		E200.7	03/07/07 15:38 / ts
Chloride	ND	mg/L		1		A4500-Cl B	03/06/07 14:17 / jl
Fluoride	1.0	mg/L		0.1		A4500-F C	03/05/07 15:23 / jaj
Magnesium	ND	mg/L		0.5		E200.7	03/07/07 15:38 / ts
Nitrogen, Ammonia as N	7.3	mg/L		0.1		E350.1	03/08/07 11:14 / eli-b
Nitrogen, Kjeldahl, Total as N	7.7	mg/L		0.5		E351.2	03/06/07 10:32 / eli-b
Nitrogen, Nitrite as N	ND	mg/L	H	0.1		A4500-NO2 B	03/06/07 15:32 / jal
Phosphorus	ND	mg/L		0.1		E200.7	03/07/07 15:38 / ts
Phosphorus, Orthophosphate as P	ND	mg/L		0.010		E365.1	03/06/07 14:59 / eli-b
Sodium	ND	mg/L		0.5		E200.7	03/07/07 15:38 / ts
Sulfate	ND	mg/L		1		A4500-SO4 E	03/05/07 17:44 / ljl
NON-METALS							
Cyanide, Free	NA	mg/L		0.2		A4500-CN-F	03/07/07 12:00 / eli-b
Phenolics, Total Recoverable (Distilled)	0.105	mg/L		0.010		E420.1	03/05/07 14:43 / jl
Cyanide, Weak Acid Dissociable	ND	mg/L		0.005		D2036	03/06/07 10:42 / eli-b
Sulfide	ND	mg/L		0.50		E376.1	03/07/07 10:27 / jl
- The Total Automated Cyanide was analyzed, and was < 200 ug/L, the detection limit for Free Cyanide. Free Cyanide was not analyzed.							
PHYSICAL PROPERTIES							
Chlorine, Residual Total	ND	mg/L		0.01		H8021	03/05/07 16:09 / jl
Conductivity	35.3	umhos/cm		1.0		A2510 B	03/05/07 14:49 / lm
Hardness as CaCO3	ND	mg/L		6.5		A2340 B	03/08/07 11:15 / sec
pH	8.95	s.u.		0.01		A4500-H B	03/05/07 14:49 / lm
Solids, Total Dissolved TDS @ 180 C	ND	mg/L		10		A2540 C	03/05/07 13:51 / lm
Solids, Total Suspended TSS @ 105 C	ND	mg/L		1.0		E160.2	03/05/07 10:32 / lm
METALS - TOTAL							
Aluminum	ND	mg/L		0.01		E200.7	03/07/07 15:38 / ts
Antimony	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Arsenic	ND	mg/L		0.001		E200.8	03/08/07 00:43 / sml
Barium	ND	mg/L		0.1		E200.8	03/08/07 00:43 / sml
Beryllium	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Boron	ND	mg/L		0.1		E200.7	03/07/07 15:38 / ts
Cadmium	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Chromium	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Copper	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Lead	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Mercury	ND	mg/L		0.001		E200.8	03/08/07 00:43 / sml
Nickel	ND	mg/L		0.05		E200.8	03/08/07 00:43 / sml
Selenium	ND	mg/L		0.001		E200.8	03/08/07 00:43 / sml
Silver	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml
Thallium	ND	mg/L		0.1		E200.8	03/08/07 00:43 / sml
Zinc	ND	mg/L		0.01		E200.8	03/08/07 00:43 / sml

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
H - Analysis performed past recommended holding time.
MCL - Maximum contaminant level.
ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-001	**DateReceived:**	03/02/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
RADIONUCLIDES - QUICK COUNT - TOTAL							
Radium 226	ND	pCi/L		0.2		E903.0	03/08/07 11:05 / trs
RADIONUCLIDES - TOTAL							
Radium 226	ND	pCi/L		0.2		E903.0	03/13/07 09:18 / trs
Radium 228	ND	pCi/L		1.0		RA-05	03/08/07 10:35 / plj
VOLATILE ORGANIC COMPOUNDS							
1,1,1,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1,1-Trichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1,2,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1,2-Trichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1-Dichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1-Dichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,1-Dichloropropene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2,3-Trichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dibromoethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dichlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dichloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,2-Dichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,3-Dichlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,3-Dichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
1,4-Dichlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
2,2-Dichloropropane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
2-Chloroethyl vinyl ether	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
2-Chlorotoluene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
4-Chlorotoluene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Acetone	433	ug/L		20.0		E624	03/07/07 04:35 / dkh
Acetonitrile	ND	ug/L		10.0		E624	03/07/07 04:35 / dkh
Acrolein	ND	ug/L		10.0		E624	03/07/07 04:35 / dkh
Acrylonitrile	ND	ug/L		10.0		E624	03/07/07 04:35 / dkh
Benzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromochloromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromodichloromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromoform	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Bromomethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Carbon disulfide	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Carbon tetrachloride	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chlorobenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chlorodibromomethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chloroethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chloroform	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Chloromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

LABORATORY ANALYTICAL REPORT

Client:	Alteia Inc	Report Date:	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	Collection Date:	03/01/07 11:52
Lab ID:	C07030114-001	DateReceived:	03/02/07
Client Sample ID:	P-38	Matrix:	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
cis-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
cis-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Dibromomethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Dichlorodifluoromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Ethylbenzene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
m+p-Xylenes	ND	ug/L		2.00		E624	03/07/07 04:35 / dkh
Methyl ethyl ketone	23.4	ug/L		20.0		E624	03/07/07 04:35 / dkh
Methyl isobutyl ketone	ND	ug/L		20.0		E624	03/07/07 04:35 / dkh
Methyl tert-butyl ether (MTBE)	ND	ug/L		2.00		E624	03/07/07 04:35 / dkh
Methylene chloride	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Naphthalene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
o-Xylene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Styrene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Tetrachloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Toluene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
trans-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
trans-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Trichloroethene	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Trichlorofluoromethane	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Vinyl acetate	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Vinyl chloride	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Xylenes, Total	ND	ug/L		1.00		E624	03/07/07 04:35 / dkh
Surr: 1,2-Dichlorobenzene-d4	102	%REC			80-120	E624	03/07/07 04:35 / dkh
Surr: Dibromofluoromethane	104	%REC			80-120	E624	03/07/07 04:35 / dkh
Surr: p-Bromofluorobenzene	99.0	%REC			80-120	E624	03/07/07 04:35 / dkh
Surr: Toluene-d8	99.0	%REC			80-120	E624	03/07/07 04:35 / dkh
ORGANIC CHARACTERISTICS							
Organic Halides, Total	ND	mg Cl/L		0.1		SW9020B	03/09/07 11:03 / cjs
Oil & Grease (HEM)	ND	mg/L		5.0	10	SW1664A	03/06/07 10:36 / bah
SYNTHETIC ORGANIC COMPOUNDS							
1,2,4-Trichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
1,2-Dichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
1,3-Dichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
1,4-Dichlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4,6-Trichlorophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4-Dichlorophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4-Dimethylphenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,4-Dinitrophenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
2,4-Dinitrotoluene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2,6-Dinitrotoluene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2-Chloronaphthalene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	Report Date:	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	Collection Date:	03/01/07 11:52
Lab ID:	C07030114-001	DateReceived:	03/02/07
Client Sample ID:	P-38	Matrix:	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SYNTHETIC ORGANIC COMPOUNDS							
2-Chlorophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
2-Nitrophenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
3,3´-Dichlorobenzidine	ND	ug/L		20		E625	03/07/07 06:11 / eli-b
4,6-Dinitro-2-methylphenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
4-Bromophenyl phenyl ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
4-Chloro-3-methylphenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
4-Chlorophenyl phenyl ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
4-Nitrophenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
Acenaphthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Acenaphthylene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Anthracene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Azobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzidine	ND	ug/L		20		E625	03/07/07 06:11 / eli-b
Benzo(a)anthracene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(a)pyrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(b)fluoranthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(g,h,i)perylene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Benzo(k)fluoranthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(-2-chloroethoxy)Methane	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(-2-chloroethyl)Ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(2-chloroisopropyl)Ether	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
bis(2-ethylhexyl)Phthalate	190	ug/L		20		E625	03/07/07 20:05 / eli-b
Butylbenzylphthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Chrysene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Dibenzo(a,h)anthracene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Diethyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Dimethyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Di-n-butyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Di-n-octyl phthalate	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Fluoranthene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Fluorene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Hexachlorobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Hexachlorobutadiene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Hexachlorocyclopentadiene	ND	ug/L		20		E625	03/07/07 06:11 / eli-b
Hexachloroethane	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
indeno(1,2,3-cd)pyrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Isophorone	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Naphthalene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Nitrobenzene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
n-Nitrosodimethylamine	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
n-Nitroso-di-n-propylamine	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
n-Nitrosodiphenylamine	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Pentachlorophenol	ND	ug/L		50		E625	03/07/07 06:11 / eli-b
Phenanthrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b

Report Definitions:
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QCL - Quality control limit.
MCL - Maximum contaminant level.
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LABORATORY ANALYTICAL REPORT

Client:	Altela Inc		**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW		**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-001		**DateReceived:**	03/02/07
Client Sample ID:	P-38		**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
SYNTHETIC ORGANIC COMPOUNDS							
Phenol	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Pyrene	ND	ug/L		10		E625	03/07/07 06:11 / eli-b
Surr: 2,4,6-Tribromophenol	92.0	%REC			26-116	E625	03/07/07 06:11 / eli-b
Surr: 2-Fluorobiphenyl	82.0	%REC			25-94	E625	03/07/07 06:11 / eli-b
Surr: 2-Fluorophenol	28.0	%REC			11-67	E625	03/07/07 06:11 / eli-b
Surr: Nitrobenzene-d5	70.0	%REC			19-102	E625	03/07/07 06:11 / eli-b
Surr: Phenol-d5	19.0	%REC			15-54	E625	03/07/07 06:11 / eli-b
Surr: Terphenyl-d14	89.0	%REC			39-106	E625	03/07/07 06:11 / eli-b
PESTICIDES							
4,4'-DDD	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
4,4'-DDE	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
4,4'-DDT	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Aldrin	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
alpha-BHC	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
alpha-Chlordane	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
beta-BHC	ND	ug/L	D	0.060		E608	03/06/07 14:45 / eli-b
Chlordane	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
delta-BHC	ND	ug/L	D	0.065		E608	03/06/07 14:45 / eli-b
Dieldrin	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endosulfan I	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endosulfan II	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endosulfan sulfate	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endrin	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endrin aldehyde	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Endrin Ketone	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
gamma-BHC (Lindane)	ND	ug/L	D	0.10		E608	03/06/07 14:45 / eli-b
gamma-Chlordane	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Heptachlor	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Heptachlor epoxide	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Methoxychlor	ND	ug/L		0.050		E608	03/06/07 14:45 / eli-b
Toxaphene	ND	ug/L		5.0		E608	03/06/07 14:45 / eli-b
Aroclor 1016	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1221	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1232	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1242	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1248	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1254	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1260	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1262	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Aroclor 1268	ND	ug/L		0.50		E608	03/06/07 14:45 / eli-b
Surr: Decachlorobiphenyl	37.0	%REC	S		44-119	E608	03/06/07 14:45 / eli-b
Surr: Tetrachloro-m-xylene	57.0	%REC			40-120	E608	03/06/07 14:45 / eli-b

Report Definitions:
RL - Analyte reporting limit.
QCL - Quality control limit.
D RL increased due to sample matrix interference.
MCL Maximum contaminant level.
ND - Not detected at the reporting limit.
S Spike recovery outside of advisory limits.

ENERGY LABORATORIES, INC. • 2393 Salt Creek Highway (82601) • P.O. Box 3258 • Casper, WY 82602
Toll Free 888.235.0515 • 307.235.0515 • Fax 307.234.1639 • casper@energylab.com • www.energylab.com

LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	03/01/07 11:52
Lab ID:	C07030114-002	**DateReceived:**	03/02/07
Client Sample ID:	Trip Blank	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
1,1,1,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1,1-Trichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1,2,2-Tetrachloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1,2-Trichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1-Dichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1-Dichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,1-Dichloropropene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2,3-Trichloropropane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dibromoethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dichlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dichloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,2-Dichloropropane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,3-Dichlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,3-Dichloropropane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
1,4-Dichlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
2,2-Dichloropropane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
2-Chloroethyl vinyl ether	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
2-Chlorotoluene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
4-Chlorotoluene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Acetone	ND	ug/L		20.0		E624	03/06/07 18:09 / dkh
Acetonitrile	ND	ug/L		10.0		E624	03/06/07 18:09 / dkh
Acrolein	ND	ug/L		10.0		E624	03/06/07 18:09 / dkh
Acrylonitrile	ND	ug/L		10.0		E624	03/06/07 18:09 / dkh
Benzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromochloromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromodichloromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromoform	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Bromomethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Carbon disulfide	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Carbon tetrachloride	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chlorobenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chlorodibromomethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chloroethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chloroform	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Chloromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
cis-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
cis-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Dibromomethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Dichlorodifluoromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Ethylbenzene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
m+p-Xylenes	ND	ug/L		2.00		E624	03/06/07 18:09 / dkh
Methyl ethyl ketone	ND	ug/L		20.0		E624	03/06/07 18:09 / dkh
Methyl isobutyl ketone	ND	ug/L		20.0		E624	03/06/07 18:09 / dkh

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

ENERGY LABORATORIES, INC. - 2393 Salt Creek Highway (82601) P.O. Box 3258 Casper, WY 82602
Toll Free 888.235.0515 307.235.0515 Fax 307.234.1639 casper@energylab.com · www.energylab.com

LABORATORY ANALYTICAL REPORT

Client:	Altela inc	Report Date:	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	Collection Date:	03/01/07 11:52
Lab ID:	C07030114-002	DateReceived:	03/02/07
Client Sample ID:	Trip Blank	Matrix:	Aqueous

Analyses	Result	Units	Qualifiers	RL	MCL/ QCL	Method	Analysis Date / By
VOLATILE ORGANIC COMPOUNDS							
Methyl tert-butyl ether (MTBE)	ND	ug/L		2.00		E624	03/06/07 18:09 / dkh
Methylene chloride	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Naphthalene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
o-Xylene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Styrene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Tetrachloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Toluene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
trans-1,2-Dichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
trans-1,3-Dichloropropene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Trichloroethene	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Trichlorofluoromethane	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Vinyl acetate	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Vinyl chloride	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Xylenes, Total	ND	ug/L		1.00		E624	03/06/07 18:09 / dkh
Surr: 1,2-Dichlorobenzene-d4	101	%REC			80-120	E624	03/06/07 18:09 / dkh
Surr: Dibromofluoromethane	97.0	%REC			80-120	E624	03/06/07 18:09 / dkh
Surr: p-Bromofluorobenzene	98.0	%REC			80-120	E624	03/06/07 18:09 / dkh
Surr: Toluene-d8	97.0	%REC			80-120	E624	03/06/07 18:09 / dkh

Report Definitions: RL - Analyte reporting limit. QCL - Quality control limit. MCL - Maximum contaminant level. ND - Not detected at the reporting limit.

DATA CHEM LABORATORIES, INC.

3/7/07

SUBMITTED TO:

Roger Garling
Energy Laboratories
P.O. Box 3258
Casper, WY 82602-3258

REFERENCE DATA:

Client Sample Nos.:	C07030114-001N
P.O. Number:	1770
Sample Location:	P38DW6
Sample Type:	Drinking Water
Method Reference:	Asbestos in Potable Water by TEM EPA 600/4-83-043, Method 100.1
DCL Set ID No..	07-T-1167
DCL Sample ID Nos..	07-07053

The samples indicated on the following data sheet(s) were analyzed by Transmission Electron Microscopy (TEM) for asbestos using the method EPA 600/4-83-043, Method 100.1 Each sample was ultrasonically treated in its original container for 15 minutes to suspend the solids. An aliquot of this suspension was added to 100 mL of de-ionized water and filtered onto a 0.1µm pore size polycarbonate filter. Portions of this filter were coated with carbon and mounted on grids for TEM analysis. Analysis was performed on a Philips CM-12 TEM with EDAX Genesis System providing energy dispersive X-ray analysis (EDXA) capabilities.

Results apply only to portions of samples analyzed and are tabulated on the following data sheet(s). Representative EDXA spectra and selected area electron diffraction (SAED) measurements of asbestos types detected (if any) are included and are referenced to the structure identification numbers listed on the count sheets. The limit of detection (LOD) for this method has been determined to be one asbestos fiber in the total number of grid openings analyzed. The number of openings analyzed is dependent on the sample volume filtered (4 minimum).

Angela Sohn
Analyst

Anna Marie Ristich
Section Manager

CINCINNATI OFFICE
4388 GLENDALE-MILFORD ROAD
CINCINNATI, OHIO 45242-3706
513 733-5336, FAX 513 733-5347

WEST COAST OFFICE
11 SANTA YORMA COURT
NOVATO, CALIFORNIA 94945
800 280-8071 FAX 415 893-9469

DataChem Laboratories Test Report
Asbestos in Drinking Water by TEM

DCL Sample Set ID. 07-T-1167
Client: Energy Laboratories
Sample Location: P38DW6

SAMPLE PREP DATA		*ANALYSIS DATA*	
Date Received:	3/2/2007	Date Analyzed:	3/7/2007
Date Filtered:	3/2/2007	Magnification:	9,720 X
Time Filtered:	15:00	Calibration Constant:	1 cm = 1.05 µm
Filter Type:	PC, 0.1 µm	EDXA Resolution:	160 9 eV
Filter Size:	47 mm	Accelerating Voltage:	100 keV
Collection Area:	1075 mm^2	Camera Constant:	31.97 mm-Å

SAMPLE IDENTIFICATION	
Client ID:	C07030114-001N
DCL ID:	07 07053
Date Sampled:	3/1/2007
Time Sampled.	11:24
Volume (L):	0.100
No. Grid Openings Analyzed:	6
Average Grid Opening Area.	0.0102
LOD (MFL):	0.18
Asbestos Fibers ≥ 10 microns	
Chrysotile:	0
Amosite:	0
Crocidolite:	0
Actinolite-Tremolite:	0
Anthophyllite.	0
TOTAL ASBESTOS	
Count:	**0**
Concentration (MFL):	**<LOD**

ND = None Detected   LOD = Limit of Detection   MFL = Millions of Fibers per Liter

Angela Sohn
Analyst

Anna Marie Ristich
Section Manager

ENERGY LABORATORIES, INC. * 2393 Salt Creek Highway (82601) * PO Box 3258 * Casper, WY 82602

LABORATORY ANALYTICAL REPORT

Client:	Altela Inc	**Report Date:**	03/13/07
Project:	Alamo Lab P-38 DW from Blackshawl PW	**Collection Date:**	02/28/07 15:20
Lab ID:	C07030045-008	**DateReceived:**	03/01/07
Client Sample ID:	P-38	**Matrix:**	Aqueous

Analyses	Result	Units	Qualifier	RL	MCL/ QCL	Method	Analysis Date / By
MAJOR IONS							
Nitrogen, Nitrate+Nitrite as N	ND	mg/L		0.1		E353.2	03/05/07 15:11 / jal
NON-METALS							
Organic Carbon, Total (TOC)	26.4	mg/L		1.0		A5310 B	03/08/07 12:29 / jl
Sulfite	ND	mg/L		2.0		E377.1	03/01/07 15:05 / jl
PHYSICAL PROPERTIES							
Oxygen Demand, Chemical (COD)	100	mg/L		1.0		HACH 8000	03/08/07 07:40 / jal
BOD, 5-Day	61	mg/L		2.0		A5210 B	03/01/07 15:46 / jrf

Report Definitions:
RL - Analyte reporting limit
QCL - Quality control limit
MCL - Maximum contaminant level
ND - Not detected at the reporting limit

ALTELA

Alamo Produced Water Tracking Summary

No	Date	Transport Company Name	Contact at Company	Address	Phone Number	Fax Number	C133 Permit No.	Name of Originating Well (If Taken Away - NA)	Owner of Well	Delivered / Taken Away	Balance
1	2/22/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	Blackshawl Com. #001 (San Juan Basin)	Merrion Oil and Gas Corporation	300 Gallons Delivered	+300 gallons
2	11/19/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	NA		300 Gallons Taken Away	0 gallons
3	11/19/07	M&R Trucking, Inc.	John Davis	Post Office Box 600, Farmington, NM 87499	(505) 326-5541	(505) 326-6002	C-133-66	Blackshawl Com. #001 (San Juan Basin)	Merrion Oil and Gas Corporation	300 Gallons Delivered	+300 gallons
4											
5											
6											
7											
8											
9											
10											
11											
12											

BILL RICHARDSON
Governor
Joanna Prukop
Cabinet Secretary

Mark E. Fesmire, P.E.
Director
Oil Conservation Division

January 16, 2007

Mr. Matthew J. Bruff
Altela, Inc.
Denver Technology Center
Belleview Tower
7887 E. Belleview Ave, Suite 1100
Englewood, CO 80111

Re: Application for temporary approval to store and use produced water for R&D of the AltelaRain™ technology
2450 Alamo SE' Albuquerque, New Mexico 87106

Dear Mr. Bruff:

The New Mexico Oil Conservation Division (OCD) has received and reviewed Altela, Inc.'s request to store and use oilfield produced water for testing and development of the AltelaRain™ technology at Altela, Inc.'s design, research, and manufacturing facility. Altela, Inc.'s design, research, and manufacturing facility (Alamo) is located at 2450 Alamo SE' Albuquerque, New Mexico 87106. This request is hereby approved with the following understandings and conditions:

1. The produced water approved for storage and the testing and development of the AltelaRain™ technology will only occur at Altela, Inc.'s design, research, and manufacturing facility (Alamo), located at 2450 Alamo SE' Albuquerque, New Mexico 87106.

2. Only haulers authorized (OCD approved C-133) to move produced water may provide transport of produced water to the Alamo facility.

3. No produced water shall be disposed at the Alamo facility. All produced water must be removed from the Alamo facility by a hauler authorized (OCD approved C-133) to move produced water and properly disposed at an OCD approved facility.

4. Altela, Inc. must retain records documenting all produced water received and removed from the Alamo facility.

5. Altela, Inc. must report all unauthorized discharges of produced water pursuant to OCD Rule 116 to the OCD within 24 hours of determining a release.

6. Altela, Inc. will provide the OCD copies of the water quality test results received from third party water quality laboratories with respect to tests using the produced water at the Alamo facility.

This authorization is approved for a period of one (1) year. **This temporary approval will expire January 16, 2008.** Renewal requests for temporary approvals shall be submitted 45 days prior to the expiration date. Temporary approval may be revoked or suspended for violation of any applicable provisions and/or conditions.

Please be advised that authorization of this approval does not relieve the owner/operator (Altela, Inc.) of responsibility should operations result in pollution of surface water, ground water or the environment. Nor does approval of the permit relieve the owner/operator (Altela, Inc.) of its responsibility to comply with any other applicable governmental authority's rules and regulations.

If you have any questions, regarding this matter, please do not hesitate to contact Brad Jones at (505) 476-3487 or brad.a.jones@state.nm.us.

Sincerely,

Wayne Price
Environmental Bureau Chief

WP/bj

cc: OCD District IV Office, Santa Fe

ALTELA

AltelaRain™ – State of the Art Produced Water Treatment Technology

INTERNATIONAL PETROLEUM ENVIRONMENTAL CONFERENCE

October 17-20, 2006
San Antonio, Texas

Ned A. Godshall, Ph.D.
Altela, Inc.
One Technology Center
1155 University Blvd. SE
Albuquerque, NM 87106
Voice: (505) 843-4197
Fax: (505) 843-4198
ned.godshall@altelainc.com

Abstract

Altela, Inc. provides products and services to customers in need of creating pure water from highly brackish and contaminated water sources. Altela has developed a fundamentally new water desalination product, the AltelaRain™ System, that inexpensively removes 100% of the dissolved salts and other contaminants from industrial waste waters and undrinkable brackish waters found throughout the world – representing the first new low-cost water desalination technology in the last 50 years. Altela has initially targeted the multi-billion dollar market for disposal of salt water co-produced with oil and natural gas production. By removing all contaminants from this dirty oilfield produced water, Altela converts these contaminated water liabilities into clean water assets, thereby removing our customer's high disposal costs and environmental liability by the present oilfield methods of reinjecting the water back into the ground or storage in large 'pits'. The AltelaRain™ System has successfully completed real-world oilfield beta testing. The beta water quality test results received from an independent water quality lab demonstrate the very high quality of treated water obtained from this simple, elegant technology for the treatment of highly challenged produced water. Total dissolved solids were reduced from 41,700 mg/L to 106 mg/L. Chloride was reduced from 25,300 mg/L to 59 mg/L. Similarly, benzene levels were reduced from 450 ug/L to non-detectable following AltelaRain™ treatment.

The Problem

Produced water is water trapped in underground formations which comes to the surface during oil and gas exploration and production. It occurs naturally in formations where oil and gas are found and, along with the oil and gas, is millions of years old. When oil or gas is produced, they are brought to the surface along with this produced water as a combined produced fluid. The composition of this produced fluid includes a mixture of either liquid or gaseous hydrocarbons, produced water, dissolved or suspended solids, produced solids such as sand or silt, and recently injected fluids and additives that may have been placed in the formation as a result of exploration and production activities.

Produced water indicators vary across (and even within) formation basins, depending on the depth of the well, geology, and environment of the deposit. In addition, formation hydrology often causes the quality of the produced water to change intermittently as the production well ages. The volume of produced water from oil and gas wells also does not remain constant with time. Traditionally, the water-to-oil ratio is the lowest when the well is new. As the well ages, the water-to-oil ratio increases, while the percentage of oil and gas similarly declines. For both oil and gas, the well's economic life is usually dictated by the amount of water produced – and its cost of disposal – rather than by the true end of oil or gas underground at the well. That is, by reducing the cost of produced water disposal, the economic reserves of oil and gas are increased in the U.S. Produced water is by far the largest volume of waste generated in oil and gas extraction operations. An average of over 7 barrels of produced water is co-produced with each barrel of oil produced in the United States, and, as oil wells age, the proportion of produced water co-produced continues to increase beyond that figure, sometimes to as much as 98% of the material brought to the surface. Oil wells in the U.S. may therefore be more realistically viewed as "dirty water wells", with the byproduct of oil representing only about 2% to 12% of the actual fluids lifted to the surface. Wells elsewhere in the world average about 3 barrels of produced water per barrel of oil, but still illustrate the point that, at most, only about 25% of an oil well's output is oil. Similar high ratios of gas to produced water production exist for production of natural gas. Overall, it is estimated that the United States oil and gas industry generates 15 to 20 billion barrels of produced water every year. To help put this in perspective, this is equivalent to about one-quarter-million acre-feet of water.

Produced water handling and treatment represents an $18 billion cost to the oil and gas industry in the U.S. alone. The cost of disposing of oil and gas produced water ranges from a low of $0.002 per gallon ($0.10/barrel) to a high of $0.24 a gallon ($10.00/barrel). By contrast, water for agricultural irrigation costs in the range of $0.0001 per gallon ($0.004/barrel) and municipal drinking water costs in the range of $0.003 per gallon ($0.13/barrel). The price of cleaning produced water is therefore as much as 80 times greater than municipal water, and as much as 2,600 times greater than agricultural irrigation water. The separation, handling, and disposal of produced water represent the single largest waste stream challenge facing the oil and gas production industry.

The Solution

Altela's patented AltelaRain™ technology uniquely cleans oil and gas industry produced water by removing its salts, residual oils and other contaminants - allowing it to be used on-site rather than requiring disposal in costly reinjection wells or evaporation ponds. In the arid western United States, purified produced water represents a new water supply and very desirable asset. Altela-cleaned water is attractive to ranch and farm landowners leasing their mineral rights to oilfield producers. In addition, drilling operators need clean water for fractionation and tertiary recovery operations. Presently, many producers are paying for dirty produced water to be trucked out and, at the same time, paying for clean water to be trucked in – the AltelaRain™ technology can eliminate both.

The Technology

The basic Altela technology is a simple and elegant process based on thermal distillation, which desalinates and decontaminates salty and polluted water in a fundamentally different way than the more familiar reverse osmosis and other membrane-based desalination technologies. In simple terms, the technology mimics nature's process of making pure rain water from seawater. What positions it as the first, truly new and disruptive water desalination/decontamination technology in over 50 years, however, is a scientifically complex, but inexpensively implemented, internal heat transfer process that allows the re-use of the latent heat of condensation over and over again to greatly offset the total latent heat of evaporation required in conventional thermal distillation. This internal heat transfer technology recaptures the energy used to evaporate water, thus yielding approximately 4 times the amount of distilled water per energy input as traditional distillation/evaporation techniques. Consequently, the AltelaRain™ technology yields energy costs that are approximately only 25% of comparable distillation/evaporation processes.

The water vapor from the evaporation chamber is transferred to the condensation chamber by a carrier gas, with the ability to absorb and desorb pure water from the produced water several times over, resulting in extremely high energy efficiencies, Figure 1. Ambient air is brought into the bottom of the tower on the evaporation side of a heat transfer wall. The wall is wetted by saline feed water, which is fed into the evaporation side at the top of the tower. As the air moves from the bottom to the top of the tower, low-temperature heat is transferred into the evaporation side through the heat transfer wall, allowing the air to rise in temperature and evaporate water from the wet saline liquid which coats the heat transfer wall. Water concentrated in contaminates leaves from the bottom of the tower and warm saturated air rises to the top of the tower. Heat is added to this hot air by an external heat source (low grade, atmospheric pressure steam). This hotter saturated air is then sent back down through the tower on the condensation side of the heat transfer wall. The evaporation side of the tower, being slightly cooler than the condensation side, allows the air to cool and transfer the latent heat condensation from the condensation side to the evaporation side. Pure distilled water condensate leaves the condensation side of the tower at the bottom of the tower.

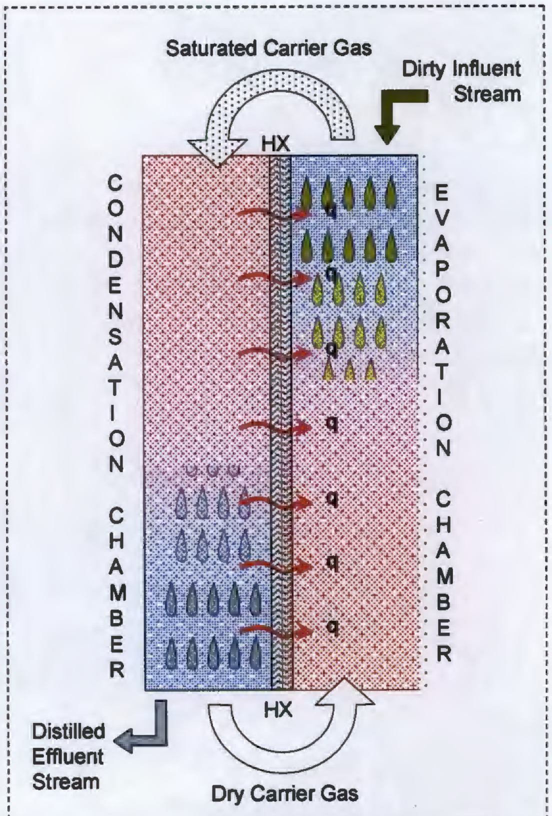

Figure 1: AltelaRain™ Process

Individual AltelaRain™ towers are approximately the size of a residential water heater and are capable of processing approximately 330 gallons per day (8 BPD) of water with salt concentration in excess of 150,000 ppm. The AltelaRain™ System can reduce effluent disposal volumes by as much as 90%. Since the treated water stream is distilled water, the quality of water from the AltelaRain™ System is extremely high. In summary, the key advantages of the AltelaRain™ technology include:

- Extremely high quality of treated water
- Relatively low cost

- High thermal efficiency
- Unattended operation
- No fouling
- No scaling
- No membranes to replace
- Near ambient temperature operation
- Operates at ambient pressure
- Uses waste heat to operate
- No pre-treatment
- No post-treatment

The AltelaRain™ System is highly scalable in size and can be produced in a variety of configurations to fit individual on-site needs. A smaller capacity system can be built and installed in a single 8 by 40 foot container. For higher volume applications, larger 180 to 250 BPD systems can be joined together to double or triple production capacity. Scaling up the volume of the system in this manner yields some cost savings on a per-barrel cost basis. The AltelaRain™ System is designed to minimize maintenance and operation costs. The use of plastics minimizes or eliminates many of the maintenance issues related to scaling, fouling or corrosion of metal systems. The moving parts in the system are few, and consist of proven, robust, off-the-shelf components, such as low pressure water pumps and air blowers. The system operates at ambient pressures and modest temperatures, and as such, has few mechanical failures in plumbing and related systems. The ability to remotely monitor the system allows field operators to detect system problems early and take remedial action before major failures take place.

Summary of Field Results

A beta pilot test using real oil-field produced water was conducted by Altela, Inc. employing the AltelaRain™ System for a conventional oil well located in southeastern New Mexico in early 2006. Coincident with this, Altela received from the New Mexico environmental regulatory authorities the first-ever permit issued for the surface discharge, on site, of clean water extracted from the highly brackish and contaminated produced water pumped from an oil or gas wellhead. The water quality test results received from an independent water quality lab demonstrate the very high quality of treated water obtained from this simple technology for the treatment of highly challenged produced water. Total dissolved solids were reduced from 41,700 mg/L to 106 mg/L. Chloride was reduced from 25,300 mg/L to 59 mg/L. Similarly, benzene levels were reduced from 450 ug/L to non-detectable following AltelaRain™ treatment. Detailed water quality data following AltelaRain™ treatment is outlined below in Table 1.

Table 1: AltelaRain™ Produced Water Pilot Test

	Water Contaminant (Analyte)	Symbol	Before Altela (mg/L) *except for Radium 226 and 228 which is in pCi/L	After Altela (mg/L) *except for Radium 226 and 228 which is in pCi/L
	Salts:			
1	Total Dissolved Solids	TDS	41,700	106
2	Chloride	Cl	25,300	59
3	Sulfate	SO4	81	0
	Metals:			
4	Arsenic	As	0.036	0
5	Barium	Ba	19.1	0
6	Cadmium	Cd	0	0
7	Chromium	Cr	0	0
8	Cyanide	CN	0	0
9	Fluoride	F	0.6	0
10	Lead	Pb	0	0
11	Total Mercury	Hg	0	0
12	Nitrate	NO3 as N	0	0
13	Selenium	Se	0.096	0.001
14	Silver	Ag	0	0
15	Uranium	U	0	0
16	Copper	Cu	0.02	0
17	Iron	Fe	38.1	0
18	Manganese	Mn	0.72	0
19	Zinc	Zn	0.01	0.03
20	Aluminum	A	0	0.3
21	Boron	Ba	44.8	0.2
22	Cobalt	Co	0	0
23	Molybdenum	Mo	0	0
24	Nickel	Ni	0	0
25	**BTEX:**			
26	Benzene		0.45	0
27	Toluene		0.45	0.0078
28	Ethylbenzene		0	0
29	Total Xylenes		0.76	0
	Radialogical:			
30	Radium 226		423	1.1
31	Radium 228		587	1.1

	Other:			
32	pH	pH	7.17	8.74

Conclusion

Oil and gas companies need lower cost methods for handling and disposing of produced water. Produced water handling and disposal is generally very expensive due to the large volumes of water that must be lifted to the surface, separated from the petroleum product, treated, and then injected into the ground or disposed of in surface evaporation ponds. In addition, environmental concerns are making it increasingly difficult to permit new surface ponds or injection wells. Historically, the produced water generated at an oil or gas site is stored on-site in large tanks. Oil and gas companies must pay for disposal trucking companies to visit the site multiple times per week, pump the produced water out of the storage tanks and transport the waste to commercial underground reinjection sites. These disposal trucks must often travel great distances to the reinjection sites. When these trucks are unavailable or during periods of poor weather, many well sites must be shut down due to the inability to store and/or dispose of the produced water on-site.

In addition, many oil and gas wells are simply "pinching back" production due to the inability of the on-site infrastructure to handle produced water volumes. Trucking costs alone can be in excess of \$3.00 per barrel (bbl) and a disposal reinjection well can cost upwards of \$4,000,000 to drill (assuming the ever increasing and costly regulatory compliance and environmental protests can be satisfied). In many locations, total produced water disposal costs are greater than \$5.00 per barrel. Stated differently, the oil and gas industry spends as much as 80 times as much, per gallon, to get rid of dirty produced water as individuals pay for clean municipal water. Unfortunately, based on the high degree of complexity of produced water chemistry, produced water treatment technologies are presently not in wide use. Those that are have historically been applied only to mildly saline waters (almost drinkable before treatment, such as some coal bed methane produced water), and they have largely been developed by oil and gas operators on a case-by-case basis. Recent field tests of the AltelaRain™ System, conversely, demonstrate the technology's unique ability to successfully treat and purify a myriad of complex produced water chemistries while delivering the following inherent advantages to the produced water treatment industry:

Removal of Contaminants: AltelaRain™ represents a simple solution to removing all produced water contaminants, even in highly-challenged and extremely high-TDS conditions. Like all distillation based processes, the liquid water generated on the condensation side of the heat exchanger is pure and contains virtually no dissolved or suspended solids. The vapor phase water formed during evaporation is free of chemical compounds which have boiling points greater than or equal to that of water (at atmospheric conditions). As a closed-loop thermal process, the clean water vapor then condenses in the form of a very high-purity water stream. Like most thermal processes, water chemistry has only mild effects on system performance. Real world testing of the technology has revealed that highly volatile BTEX compounds typically found in produced waters do not condense in the distillate stream.

Flexibility: The low cost, scale-resistant materials used to fabricate AltelaRain™ towers enable AltelaRain™ Systems to be built that are modular and mobile, easily maintained, and capable of processing water with highly variable influent compositions. The modular design of an AltelaRain™ based system enables customization of each treatment system with little or no additional cost to oil and gas customers. For example, a system can be installed to minimize the effluent brine reject stream simply by re-configuring the physical layout of the primary system towers into differing series/parallel configurations.

Cost Effectiveness: Like other thermal processes, AltelaRain^{TM} is simple, easy to maintain, and can operate unattended for long periods of time. However, unlike other desalination methods like RO, MSF, or MED, the primary treatment components are fabricated entirely from polymer (plastic) materials. This eliminates the need for costly influent pre-treatment components (such as filters, flocculants, and anti-scalant chemical additives). No metal is present on which corrosion and scaling can occur. Also, similar to other thermal processes, the major operating expense is the energy required to evaporate the influent water. Since the system operates at low temperatures, typically 180°F or less, it is possible to employ low grade sources of waste heat. Such operating scenarios dramatically increase the operating efficiency by further reducing the operating costs by virtue of the technology's unique ability to repeatedly 're-use' this low-grade heat multiple times by applying the exothermic heat of condensation to the endothermic heat of evaporation in a continual loop process.

Equity Considerations: AltelaRain^{TM} based treatment systems typically require more physical space to treat a given volume of water than comparable reverse osmosis systems. This is a function of the low thermal conductivity of plastics relative to that of metal. This is generally a minor consideration in oil and gas locations, since well sites are located remotely with ample land available for the system's installation. Furthermore, many low cost construction techniques can be employed to erect temporary or permanent structures. Operation noise is minimal. A system that treats 90 BPD requires an area of 40' by 8'.

Environmental: The AltelaRain^{TM} technology mimics nature's rain cycle and is inherently environmentally friendly. There are no pre- or post-treatment chemicals requiring handling or disposal. The pure distilled water stream that is generated can be reused for numerous beneficial uses.

STATE OF NEW MEXICO

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Produced Water Demonstration Project

Submitted to:
State of New Mexico Department of Finance and Administration
Capital Projects Division
410 Don Gaspar
Santa Fe, New Mexico 87504

Submitted by:

ALTELA

Altela, Inc.
One Technology Center
1155 University Blvd. SE
Albuquerque, New Mexico 87016

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EXECUTIVE SUMMARY

Continuing growth in demand for New Mexico's nearly fully appropriated water supply (coupled with recent severe drought conditions) has increased the need for the development and adoption of novel water supply technologies to enhance and augment New Mexico's water supply. Nowhere is there both a greater need and opportunity for the application of new water supply-enhancing technologies than in the field of produced water. Approximately 593 million barrels of produced water were generated in New Mexico in 1999 alone. This produced water volume equals approximately **76,500 acre-feet** of water per annum. The water-to-oil ratio now stands at 6.5 barrels of water to every 1 barrel of oil produced in New Mexico, and increasing every year. Since 1982, produced water volumes have increased nearly 80 percent even as recoverable oil and gas resources have decreased. Presently, this water is being re-injected into the ground, at great cost to the oil and gas industry, and a great loss to the people of New Mexico who are not able to benefit from it.

The goal of the State of New Mexico Water Plan is to move forward with 21st century technology aimed at conserving and increasing the State's water supply. By purifying produced water on site at individual wells, a vast new water resource becomes available to expand the state's existing water supply. Although the overall goal of cleaning produced water is not new, there previously has never existed a technology that could be scaled down to a size that could economically treat produced water at individual oil and gas wells. Because of this, the produced water in all other treatment schemes had to be trucked or piped to a central location, thereby not solving the single largest cost of produced water: its water hauling cost.

However, this report identifies two exciting proposed projects where newly patented, revolutionary produced water purification technology can be immediately applied to treatment of produced water from oil and gas wells. This clean water could then be utilized for municipal, agricultural, and irrigation purposes. Once proven successful, this new technology could similarly be applied at thousands of wells throughout New Mexico, turning significant amounts of the water presently wastefully re-injected into the ground into clean beneficial water in our arid state. The technology can also be equally applied to cleaning the water present in "Reserve Pits", thus eliminating this increasing environmental problem throughout the state.

Preliminary Background Research

The legal framework associated with produced water is broadly summarized in three major federal laws, coupled with a compliment of attendant state laws and regulations. Oil and gas exploration and production waste, including produced water, is exempt from the hazardous waste management requirements of the Resource Conservation and Recovery Act (RCRA). Produced water is traditionally either reinjection back into the ground via reinjection wells or discharged. Underground Injection Control programs regulate reinjection of produced water. The Clean Water Act requires that all discharges of produced water and other pollutants to surface waters be authorized by a permit issued under the National Pollutant Discharge Elimination System (NPDES).

Technical Assessment

Based on the high degree of complexity of produced water chemistry, produced water treatment technologies are presently not in wide use. Those that are have historically been applied only to mildly saline waters (almost drinkable before treatment, such as some coal bed methane produced water), and they have largely been developed by oil and gas operators on a case-by-case approach. In those few applications where the treated produced water is placed to beneficial use, applicable effluent standards come into play in selecting the optimum technology platform. Traditionally, produced water treatment attempts have focused on the removal of the following impurities:[1]

1. Total Dissolved Solids (TDS) – salts;
2. Oil and grease;
3. BTEX (benzene, toluene, ethyl-benzene, and xylene);
4. Concentrations of biological oxygen demand arising from soluble organics;
5. Suspended solids;
6. Hydrogen sulfide;
6. Total and fecal coliforms in final effluent streams;

This report identifies, summarizes, and evaluates nine (9) produced water treatment technologies that either have been, or are being, investigated by industry and/or regulators as an alternative to down-hole injection. For each of the nine technologies investigated in this study, a brief overview of the treatment process is provided along with a summary of key advantages and disadvantages. Where applicable, pilot/case studies have been provided for each technology.

The nine technologies are:
1. Membrane Separation Technologies (RO)
2. Ion Exchange (IE)
3. Electrodialysis (ED)
4. Capacitive Deionization (CD)
5. Rapid Spray Evaporation (RSE)
6. Freeze Thaw Evaporation (FTE)
7. Packed Bed Absorption
8. Constructed Wetlands (CW)
9. Carrier-Gas Dewvaporation (CGD)

Evaluation

The above nine (9) water treatment technologies were evaluated for their ability to treat the highly-challenged water co-produced with the production of oil and gas in New Mexico. Some of these technologies are, or may be, suitable for less difficult desalination applications such as low-TDS brackish water or seawater desalination. In these cases, the primary contaminant is

[1] Arthur, D.: "Technical Summary of Oil & Gas Produced Water Treatment Technologies" March 2005.

usually sodium-chloride (table salt). Produced water, however, is often composed of not only salt concentrations far higher than conventional brackish water or seawater – but composed of much more difficult salts (e.g. calcium sulfate) to filter out, as well non-salt contaminants such as organics, oil condensates, hydrogen sulfide, etc.

To assist in selecting the optimum produced water demonstration treatment approach, each treatment technology has been reviewed and analyzed according to a six-point criterion. It should be noted that the effectiveness and overall performance of each treatment technology often depends on a combination of criteria. For example, a technology's overall effectiveness in removing contaminates may improve dramatically as more energy is applied to the system. However, the overall effectiveness of the treatment technology, when viewed against the amount of energy input (cost), may fall substantially. Basic engineering judgment and experience have been relied on in applying this fundamental evaluation criterion.

The six criteria used in this evaluation of the nine competing technologies were:

1. Overall Effectiveness to treat the produced water
2. Flexibility Over Time
3. Cost Effectiveness
4. Equity Considerations
5. Potential Harmful Side Effects
6. Scalable to Individual Well Sites

Table 9 of the report illustrates a comparison of these various technologies for their likelihood to be successful in treating produced water in New Mexico. The above Evaluation Criteria were used to evaluate each technology.

Although all of the nine technologies have applications in one or more conventional desalination applications, only two were found to be applicable to the harsh water chemistry and remoteness of produced water applications in New Mexico: Capacitive Deionization (CD) and Carrier-Gas Dewvaporation (CGD). All other technologies were not scalable down to sizes small enough to economically treat produced water at individual well sites. Although in some locations produced water could be gathered from several surrounding wells and possibly treated by one of the other seven technologies, this would require high-cost trucking of the water, or gathering pipes to be laid – severely reducing their likelihood of economic success. Furthermore, the highly-challenged and well-to-well variable nature of NM produced waters make any of the membrane technologies unrealistic. Membranes will foul in such an environment, even with the use of expensive pre-treatments.

Both Capacitive Deionization (CD) and Carrier-Gas Dewvaporation (CGD) are non-membrane technologies. However, of the two, only CGD is a largely non-electric technology – operating on either waste heat or waste gas found at nearly all well sites. Capacitive Deionization, conversely, requires very large amounts of electricity, a utility not found at most well sites. CGD furthermore uses no metal surfaces in contact with the highly corrosive produced waters found in NM, so is expected to have much longer lifetimes in the real-world application of treating NM's high-TDS produced waters. For these reasons, CGD was selected as the most tenable technology for New Mexico to pursue in funding a produced water purification demonstration project.

Recommendations

We recommend that the State of New Mexico fund the demonstration of Carrier-Gas Dewvaporation (CGD) for the treatment of oil and gas produced water conversion to beneficial uses within New Mexico. This new technology (patented less than six months ago in June of 2005) represents the best new technology for the conversion of highly-variable produced water into clean water throughout the state. It is novel in its energy efficiency, yet elegant in its simplicity. Of the nine water treatment technologies evaluated in this report, we feel that it represents the most economical and practical solution yet devised for the distillation and desalination of the complex contaminants found in produced water. The Dewvaporation product has already undergone a beta-site real-world test in New Mexico, and it has already been evaluated by New Mexico's Oil Conservation Division.

Of the nine (9) water treatment technologies evaluated in this report, the Dewvaporation technique is the most well-suited to the challenge of treating diverse produced water contaminants, so that produced water can be converted to beneficial use in New Mexico. It is also ideal in that it can economically be placed at individual wellsites, thus totally eliminating the need to truck produced water from individual well sites to a central treatment plant. In place such as Farmington, this is especially important, since the hauling of produced water in large heavy tanker trucks throughout the city represents an unnecessary burden on the town's roads and citizens.

Dewvaporation represents a simple solution to removing all produced water contaminants, even in highly-challenged and extremely high-TDS conditions. Like all distillation based processes, the water vapor generated on the condensation side of the heat exchanger is pure and contains no dissolved or suspended solids. The vapor phase water is also free of chemical compounds which have boiling points greater than or equal to that of water (at atmospheric conditions). As a thermal process, the vapor then re-condenses in the form of a very high-purity effluent stream. Like most thermal processes, water chemistry has only mild effects on system performance. Finally, recent testing of the technology has revealed that highly volatile BTEX compounds typically found in produced waters do not re-condense in the distillate stream, making the process by far the highest quality water of the 9 technologies evaluated in this report.

Another major advantage of thermal processes is their inherent flexibility and modularity. The dewvaporation process is no different in this regard. The low cost, scale-resistant materials used to fabricate dewvaporation towers enable treatment systems to be built that are both modular and mobile, easily maintained, and capable of processing water with highly variable influent compositions. The modular design of a dewvaporation based system enables installers to customize each treatment system with little or no additional cost to oil and gas companies. For example, a dewvaporation system can be installed to minimize the effluent brine reject stream simply by re-configuring the physical layout of the primary system towers into differing series/parallel configurations.

Like other thermal processes, dewvaporation is simple, easy to maintain, and can operate unattended for long periods of time. However, unlike other desalination methods the primary treatment components are fabricated entirely from plastic. This eliminates the need for costly influent pretreatment components (such as filters, flocculants, and anti-scalant additives). This technology is unique of the nine evaluated here, in that no metal is present for which corrosion and scaling can exist.

Also, similar to other thermal processes the major operating expense is the energy required to evaporate the influent water. However, dewvaporation has another inherent advantage in that the process operates at low temperatures, typically 180°F or less. This makes it possible for a dewvaporation based produced water treatment systems to use low grade sources of waste heat. Such operating scenarios dramatically increase the operating efficiency by further reducing the operating costs by virtue of the technique's unique ability to 're-use' this low-grade heat multiple times by applying the exothermic heat of condensation (dew formation) to the endothermic heat of evaporation in a continual loop process.

Dewvaporation based treatment systems typically require more physical space to treat a given volume of water than comparable RO systems. This is a function of the low thermal conductivity of plastics relative to that of metal. This is generally a minor consideration since wellsites are located remotely with ample land available for the system's installation. Furthermore, many low cost construction techniques can be employed to erect temporary or permanent structures. Operation noise is minimal.

The Dewvaporation technology is also one of only two of the nine techniques evaluated here that has the advantage of being able to be scaled down small enough to operate at individual wellsites. A typical well generating only 10-20 barrels per day (BPD) of produced water is not practical for high throughput technologies such as RO or other membrane technologies. Dewvaporation's product treats 1,000 gallons per day, which is equivalent to 24 BPD – ideal for typical oil and gas wellsites in New Mexico. In fact, Potential Project No. 2, recommended herein, has been chosen based on the small volume of extremely challenged (greater than 120,000 TDS) produced water.

We further recommend that the State fund a *Carrier Gas Dewvaporation Produced Water Demonstration Project* at two individual well sites identified in this report. The first well site is located within the city limits of Farmington New Mexico, in the northwest portion of the state in the rich San Juan gas basin. The second well site is located near Carlsbad New Mexico, in the southeast portion of the state in the rich Permian oil and gas basin. Total cost of this proposed demonstration project is $611,754. Detailed cost included in this report for these two demonstration projects using the above-identified CGD technology are $284,159 and $327,595 respectively. The proposed project incorporates both sites to fully demonstrate that the carrier gas dewvaporation technology can treat the broad spectrum of constitutes present in produced water production (ranging from 120,000 TDS to 32,600 TDS). Many current technologies are only able to treat a very narrow spectrum of constitutes and therefore do not provide a complete solution.

The former site, Blackshawl#1, is a representative gas well producing about 1,260 gallons per day (30 barrels per day) of produced water of about 32,600 TDS concentration. Water treated by the CGD process could be immediately used at the well-site, thereby freeing up the equivalent 1.4 acre-feet of water that is presently coming from the Farmington municipal water system. The later site, Boise, was specifically chosen because of it very high TDS concentration of 120,000, coupled with high radionuclides and chloride levels.

Aerial photographic surveys and United States Geological Survey (USGS) topographic map slides have been included for each proposed site in Appendix D of this report. In addition, comprehensive independent water quality laboratory analytical reports of the produced water found at each site have been included in Appendices B and C. The water quality reports include all analytes as outlined within the New Mexico Water Quality Control Commission Groundwater Standards, Section 3-103 (A-C). Finally, approval and authorization letters from each well site owners have been included in Appendix E.

1. INTRODUCTION

Produced water is water trapped in underground formations which comes to the surface during oil and gas exploration and production. It occurs naturally in formations where oil and gas are found and, along with the oil and gas, is millions of years old. When oil or gas is produced, both are brought to the surface as a produced fluid. The composition of this produced fluid includes a mixture of either liquid or gaseous hydrocarbons, produced water, dissolved or suspended solids, produced solids such as sand or silt, and recently injected fluids and additives that may have been placed in the formation as a result of exploration and production activities. Studies indicate that the produced waters associated with gas/condensate platforms are approximately ten times more toxic than the produced waters discharged from traditional oil platforms.[2] Production of coal bed methane (CBM) often involves signification amounts of produced water. CBM operators typically drill surface wells into coal seams. These coal seams usually contain deep bedrock aquifers and large volumes of water. CBM operators pump this water from the seam causing a reduction in pressure, thereby releasing methane to the surface with the formation (produced) water. Produced water nearly always contains salt, and is therefore brackish or saline water.

The American Petroleum Institute (API) defines produced water as "the saline water brought to the surface with oil and gas."[3] U.S. Environmental Protection Agency (EPA) guidelines define produced water as "water (brine) brought up from the hydrocarbon-bearing strata during the extraction of oil and gas, and can include formation water, injection water, and any chemical added downhole or during the oil/water separation process."[4]

In general, neither the amount of produced water nor the quality of the water can be predicted prior to bringing the water to the surface. Produced water indicators vary across and even within formation basins, depending on the depth of the well, geology, and environment of the deposit. In addition, formation hydrology often causes the quality of the produced water to change intermittently as the production well ages.

The volume of produced water from oil and gas wells also does not remain constant with time. Traditionally, the water-to-oil ratio is the lowest when the well is new. As the well ages, the water-to-oil ratio increases, while the percentage of oil and gas similarly declines. For crude oil wells approaching the end of their production and/or economic life, produced water can comprise as much as 98% of the fluids pumped. CBM wells, by contrast, typically generate the most

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[2] Jacobs, R.P.W.M., R.O.H. Grant, J. Kwant, J.M. Marqueine, and E. Mentzer, "The Composition of Produced Water from Shell Operated Oil and Gas Production in the North Sea," Produced Water, J.P. Ray and F.R. Englehart (eds.), Plenum Press, New York, 2002

[3] See ICF Consulting, Inc., API, Overview of Exploration & Production Waste Volumes & Waste Management Practices in the United States, tbl. 3.2 (2000) at 4 (discussing waste generated by onshore and coastal oilfield exploration and production operations). The survey was the result of self-reporting by industry participants.

[4] 40 C.F.R. §§ 435.41(bb), 435.11(bb)). [Recently the Ninth Circuit Court of Appeals found that CBM water qualified as "produced water" under these same guidelines. *See generally* Northern Plains Resource Council v. Fidelity Exploration and Development Co., 325 F.3d 1155 (9th Cir.) cert. denied, 124 S. Ct. 434 (2003).]

produced water early in the life of the well, with the water quantity declining as the well ages. In both cases however, for both oil and gas, the well's economic life is usually dictated by the amount of water produced – and its cost of disposal – rather than by the true end of oil or gas underground at the well. That is, by reducing the cost of produced water disposal, the economic reserves of oil and gas are increased in the U.S.

Produced water is by far the largest volume of waste generated in oil and gas extraction operations. Typically, in the United States 7 to 10 barrels of produced water are pumped for each barrel of oil produced. It is estimated that the United States oil and gas industry generates 20 to 30 billion barrels of produced water every year. This is equivalent to one-fifth of the entire flow of the Colorado River. Produced water streams are usually separated from the oil and gas at the wellhead and must be disposed of in a manner appropriate for the protection of human health and the environment. In the United States, produced water comprises approximately 80% of the total volume of oil and gas production and exploration waste generated by the oil and gas industry. In the natural gas industry, more than 60% of the produced water generated is currently re-injected back into the ground. This percentage rises to 90% when traditional oil and gas produced water volume is added. While re-injection wells are currently an approved regulatory disposal method, certain Rocky Mountain states are already experiencing limited re-injection capabilities as more stringent environmental regulations develop. Increasingly, alternative produced water disposal and treatment methods are needed.

The goal of the State of New Mexico Water Plan is to move forward with 21st century technology aimed at conserving and increasing the State's water supply. By purifying produced water on site, a vast new water resource becomes available to expand the state's existing water supply. In addition, purifying produced water for beneficial use, rather than treating it as a waste by reinjecting it back into the ground (potentially harming groundwater aquifers), supports the State Water Plan by promoting conservation and the efficient use of the State's waters. As an additional, side, benefit – the state would also reap larger oil and gas revenues from existing wells, since wells are typically limited in life by the cost of produced water disposal, rather than by the true end of oil or gas underground at a given wellsite.

2. REVIEW OF LEGAL FRAMEWORK

In order to identify potential projects where produced water can be employed for reuse, an understanding of the legal and regulatory framework associated with produced water has been undertaken. The legal framework associated with produced water is broadly summarized in three major federal laws, coupled with a compliment of attendant NM state laws and regulations.

2.1 Resource Conservation and Recovery Act (RCRA)

Congress enacted the Resource Conservation and Recovery Act of 1976 (RCRA) as "a comprehensive environmental statute that empowers the Environmental Protection Agency to regulate hazardous wastes from cradle to grave, in accordance with rigorous safeguards and waste management procedures of Subtitle C."[5] In 1980, Congress conditionally exempted oil and gas industry waste, including drilling fluids, produced waters, and other wastes associated with the exploration, development, or production of crude oil or natural gas or geothermal energy, from the hazardous waste management requirements of Subtitle C of RCRA (Section 3001(b)(2)(A) of RCRA and Section 8002(m) of RCRA)[6]. In addition to directing the EPA to study these wastes and submit a report to Congress on the status of their management, Congress required the Agency either to promulgate regulations under Subtitle C of RCRA or make a determination that such regulations were unwarranted.

On July 6, 1988, the EPA published its Regulatory Determination for Oil and Gas and Geothermal Exploration, Development, and Production Wastes in the Federal Register (FR) at 53 FR 25447. EPA continued to exempt oilfield wastes from regulation stating that regulation of E&P wastes under RCRA Subtitle C was "unwarranted because of the relatively low risk of these wastes and the presence of generally effective state and federal regulatory programs."[7] In order to define the exact scope of the continued oilfield waste exemption under RCRA, EPA outlined the materials that it considered within the initial exemption including tank bottoms, pit sludges, produced water, drilling fluids and other wastes associated with oil and gas drilling and production.[8] Produced water ranks first on the list of exempt wastes and the EPA states that produced wastewater is considered "solid wastes which are not hazardous wastes".[9]

In 1993, the EPA published the Clarification of the Regulatory Determination for Wastes from the Exploration, Development and Production of Crude Oil, Natural Gas, and Geothermal Energy in the Federal Register (FR) at 58 FR 15284 (March 22, 1993). The Clarification states that "[F]or a waste to be exempt from regulation as hazardous waste under RCRA Subtitle C, it must be associated with operations to locate or remove oil or gas from the ground or to remove

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[5] City of Chicago v. EDF, 511 U.S. 328, 331 (1194) (citing RCRA tit. II, subtit. C, 42 U.S.C. §§ 6921-6934).

[6] Act of Oct. 21, 1980, 42 U.S.C. § 6921(b)(2)(A).

[7] See EPA Regulatory Determination for Oil & Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25,446 (July 6, 1988) at 25,459.

[8] Id at 25,453-54.

[9] 40 C.F.R. §261.4(b)(5)).

impurities from such substances and it must be intrinsic to and uniquely associated with oil and gas exploration, development or production operations ... [and] must not be generated by transportation or manufacturing operations.[10] EPA further notes that the off-site transport of exempt waste from a primary field site for treatment, reclamation, or disposal does not negate the exemption. ... Thus, the off-site transport and/or sale of exempt oil-field wastes to crude oil reclaimers for treatment does not terminate the exempt status either of the wastes or the residuals from a reclamation process applied to these wastes.[11]

In 2002, the EPA published an information booklet entitled Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste Regulations. The federal E&P RCRA Subtitle C exemption, however, does not preclude these wastes from control under other federal regulations and state regulations (including oil and gas conservation programs and some hazardous waste programs).

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. Section 101(14) of CERCLA sets forth the petroleum exclusion.[12] That provision states, "[t]he term [hazardous substance] does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance."[13]

Historically, onshore produced water disposal has fallen within two general categories (1) surface impoundment and/or surface discharge, or (2) ground reinjection. Surface discharge of produced water is regulated largely by the Clean Water Act. Ground reinjection is largely regulated by Underground Injection Control (UIC) regulation provided under the Safe Drinking Water Act.

2.2 Clean Water Act (CWA)

Produced water which is not reinjected into the ground may be alternatively surface discharged pursuant to regulatory oversight. Surface discharge of produced water is governed by the United States Clean Water Act (CWA), also known as the Federal Water Pollution Control Act. In 1972, Congress enacted the CWA, "to restore and maintain the chemical, physical and biological integrity of the Nation's waters."[14] The CWA created both state and federal roles for the attainment of these goals. The EPA Administrator must "establish and enforce technology-based

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[10] EPA Clarification of the Regulatory Determination for Wastes From the Exploration, Development and Production of Crude Oil, Natural Gas and Geothermal Energy, 58 Fed. Reg. 15,284, (Mar. 22, 1993) at 15,284.

[11] Id. at 15,285.

[12] See CERCLA, 42 U.S.C. § 9601(14) (excluding petroleum from definition of "hazardous substance").

[13] Id.

[14] 33 U.S.C. §§ 1251-1376; 33 U.S.C. § 1251(a) (2002).

limitations on individual discharges into the country's navigable waters from point sources," while each state must establish water quality standards with accompanying goals for all intrastate waters."[15] Section 401 of the CWA requires E&P companies to apply for a National Pollution Discharge Elimination System (NPDES) permit if they are discharging produced water into surface waters of the state. Clean water regulations provide that there will be no discharge of water pollutants into navigable waters from any source associated with production, field exploration, drilling, well completion, or well treatment (i.e. produced water) without an NPDES permit.[16]

2.3 National Pollution Discharge Elimination System (NPDES)

The EPA has published federal NPDES regulations under the CWA, and may authorize states – as well as territories and tribes – to implement all or parts of the national program. Currently, the EPA has authorized thirty-seven states to implement and monitor the NPDES program. New Mexico is not currently authorized. NPDES permits set specific requirements regulating the characteristics of the discharged water based on national technology-based effluent limitations and applicable water quality standards. The permits establish the level of performance the discharger must maintain and specify monitoring, inspection, and reporting requirements and other actions necessary to achieve compliance. However, the EPA retains the opportunity to review the permits issued by the state, and formally object to elements deemed in conflict with federal requirements. NPDES permits are specifically tailored to individual facilities. General NPDES permits cover multiple facilities within a certain category located in a specific geographical area. The applicant must submit a complete application for a permit, which includes the application form and any supplemental information completed to the satisfaction of the Regional Administrator (NM – Region 6, South Central), who may seek further information by issuing a notice of deficiency.[17]

The primary mechanism for regulating discharges of pollutants to receiving waters is through numerical effluent limits. The effluent limits describe the pollutants subject to monitoring as well as quantity (concentration) of pollutants. Permit writers derive effluent limits from the applicable technology-based Effluent Limitation Guidelines (ELGs) and water quality-based standards. The more stringent of the two will be written into the permit. For oil and gas operations, the EPA has codified the ELGs in the Code of Federal Regulations (CFR) at 40 CFR Part 435—Oil and Gas Extraction Point Source Category.

2.4 Effluent Limitation Guidelines (ELG) Exceptions

Subpart C of 40 CFR Part 35 states that oil and gas companies located onshore may not discharge produced water into navigable waters of the United States. However, two exceptions exist:

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[15] PUD No. 1 of Jefferson County v. Wash. Dept. of Ecology, 511 U.S. 700, 704 (1994).

[16] 40 C.F.R. § 435.32

[17] 40 CFR § 122.21(e).

1. Subpart E – Allows for onshore discharge for those facilities located in the continental United States located west of the 98th meridian. Produced water with a maximum oil and grease limit of 35 mg/L may be discharged from such sites, provided that the produced water is of good enough quality to be used for wildlife or livestock watering or other agricultural uses. The produced water also has to be put to these uses during actual discharge.

2, Subpart F – Allows for onshore discharge for facilities that produce 10 barrels of day or less of crude oil (stripper well exception). The EPA published no discharge standards for this subcategory - rather leaving oversight to the states or regional EPA offices.

In addition, Coal Bed Methane (CBM) production was not considered when the EPA established the above ELGs. CBM is a form of natural gas that is trapped within coal seams. Methane attaches to the surface areas of coal and is held in place by water pressure. To date, the EPA has not yet revised the ELGs to include CBM discharges. Therefore, states have been able to issue NPDES permits allowing discharges of CBM water using each state's "best professional judgment". Each state authorized to issue NPDES permits adopts its own discharge standards and permitting procedures.

2.5 Federal Safe Drinking Act (SDWA)

Regulatory control of the injection of produced water into injection wells is governed by the Federal Safe Drinking Water Act, Underground Injection Control (UIC) Program. The charter of this federal act is to ensure high quality of drinking water by limiting the injection of produced water to injection zones that geologically will never serve as an Underground Source of Drinking Water (USDW). A USDW is an aquifer or portion of an aquifer that supplies any public water system or contains sufficient quantity of groundwater to supply a public water system; currently supplies drinking water for human consumption or contains fewer than 10,000 milligrams/liter total dissolved solids; and is not an aquifer exempted from UIC regulations.[18] Class I wells are used for the injection of hazardous and non-hazardous fluids (industrial and municipal wastes). Class II wells inject brines and other fluids associated with oil and gas production. Class III wells inject mining fluids. Class IV wells deal with the injection of hazardous or radioactive wastes. Class V wells govern injection not covered above.

The EPA's regulations establish minimum standards for state programs to receive primacy for the UIC program under Section 1422 of the SDWA. In 1981, the federal government added Section 1425 to the SDWA to relieve oil and gas re-injection well programs in the states of having to meet the technical requirements of the federal UIC program. The New Mexico Oil Conservation Division (OCD) regulates Class II wells, as well as Class I, III, and V wells related to oil and gas development activities, geothermal activities, and brine solution mining.

[18] 40 C.F.R § 144.3.

2.6 Additional Regulatory Jurisdiction of Produced Water

As noted above, the EPA can delegate jurisdiction to the states thereby creating a regulatory environment of interwoven federal, state and local laws and regulations. The following serves as a brief summary of additional agencies retaining jurisdiction(s) in the State of New Mexico concerning the regulation of produced water.

1. *Bureau of Land Management (BLM)*: The BLM approves disposal of produced water on BLM-managed land and evaluates environmental impacts of proposed action (National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.); Mineral Leasing Act of 1920 (30 U.S.C. 181 et seq.); 43 CFR 3164; Onshore Oil and Gas Order No. 7; CWA 401 certification by state under 33 U.S.C. 1341). BLM is also required to protect/preserve wetlands and floodplains (Exec. Order 11990 (May 24, 1977), BLM Manual Section 1737, rel. 1-1611 (12/10/92); Exec. Order 11988 of 1977.

2. *U.S. Fish and Wildlife Service (USFWS)*: The USFWS retains jurisdiction over the coordination, consultation and impact review for federally listed threatened and endangered species. The USFWS also deals with migratory bird impact coordination. (Fish and Wildlife Coordination Act (16 U.S.C. 661-666c), Section 7 of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1536); enforcement of other ESA provisions and other specialty wildlife protection acts including Migratory Bird Treaty Act (MBTA) (16 U.S.C. 703, 1918 as amended). The USFWS administers and enforces regulations promulgated under the MBTA (see 50 C.F.R. Subchapter B). The MBTA provides that it is unlawful, among other things, "to take, capture, [or] kill...by any means or in any manner" any migratory bird. Produced water disposal operators must be cognizant of this law and USFWS regulations when disposing of produced water in an evaporation pit and must take measures to ensure that such disposal does not endanger migratory birds.

3. *Bureau of Indian Affairs (BIA)*: The BIA is responsible for the efficient and timely development and production of tribal oil and gas leases and is also responsible for handling consultations for impacts to tribal lands or resources from off-reservation activities (Indian Minerals Leasing Act of May 11, 1938, 25 U.S.C. 396a-396q, 25 CFR, Part 211. Act of March 3, 1909, 25 U.S.C. 396, 25 C.F.R. Part 212. Indian Mineral Development Act of December 22, 1982, 25 U.S.C. 21-02-2108, 25 CFR, Part 225.)

4. *U.S. Army Corps of Engineers (COE)*: The COE oversees Section 404 permits and coordination regarding dams and dikes or placement of dredged or fill material in jurisdictional waters and adjacent wetlands (Section 404 of the Clean Water Act of 1972, as amended (33 U.S.C. 1344).

2.7 *State of New Mexico Legal Framework*

The New Mexico Constitution provides that "[a]ll existing rights to the use of any waters in this state for any useful or beneficial purpose are hereby recognized and confirmed."[19] There is no specific constitutional provision applying to ground water, although for all water "[b]eneficial use shall be the basis, the measure and the limit of the right to the use.[20] In New Mexico, underground water is "declared to be public water and to belong to the public and to be subject to appropriation for beneficial use."[21] Anyone wishing to appropriate ground water must submit a permit application to the New Mexico State Engineer stating the beneficial purpose, the amount to be used, and other particulars. The State Engineer will issue a finding that the proposed diversion is not contrary to the public's interest in the conservation of water within the state and that the diversion is not detrimental to the public welfare prior to issuance of a permit.[22] It is unlawful for any person, including a corporation, to begin drilling a well for reasonably ascertainable water from an underground source without a valid existing permit from the State Engineer.[23]

In New Mexico, when drilling for oil and gas occurs below 2,500 feet and the byproduct water is nonpotable, i.e., a TDS of 1,000 ppm or higher, the water is, by law, "nonascertainable" and not subject to permit requirements.[24] In addition, New Mexico grants regulatory jurisdiction of "the disposition of water produced . . . with the drilling . . . of oil or gas" to the state Oil Conservation Division (NMOCD).[25]

New Mexico's Mine Dewatering Act states that the diversion of water to permit mineral production is in the public interest and that the "existing principles of prior appropriation, beneficial use and impairment of water rights, when applied to the diversion of water to permit mineral production, may cause severe economic hardship and impact to persons engaged in mineral production."[26] While mine dewatering, is defined to include "the diversion and discharge of ground water developed by mining activities by means of depressurizing wells," no reported legal case has explicitly held the Mine Dewatering Act applicable to oil and gas production.

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[19] N.M. Const. art. XVI, § 1.

[20] Id. § 3.

[21] N.M.S.A. 1978 § 72-12-1 (2003).

[22] N.M.S.A. 1978 § 72-12-3(E) (2001).

[23] N.M.S.A. 1978 § 72-12-12 (1957).

[24] N.M.S.A. 1978 Id. § 72-12-25 (1967).

[25] N.M.S.A. § 70-2-12(B)(15) (2004)

[26] N.M.S.A. 1978 § 72-12A-2(A)(2), (3) (1980).

2.8 New Mexico Statutes

The following New Mexico statutes govern produced water recovery, handling, storage and transportation.

CHAPTER 7. TAXATION ARTICLE 2. INCOME TAX ACT § 7-2-18.9 (2002).
Credit for produced water (Individuals)

A. An operator who files an individual New Mexico income tax return who is not a dependent of another taxpayer may take a tax credit in an amount equal to one thousand dollars ($1,000) per acre-foot of produced water not to exceed four hundred thousand dollars ($400,000) per year if the following conditions are met:

(1) the operator delivers the water to the interstate stream commission at the Pecos river in compliance with the applicable requirements of New Mexico's Water Quality Act, New Mexico's water quality control commission regulations and federal clean water acts;

(2) the operator delivers the water solely in a manner approved by the interstate stream commission to contribute to delivery obligations pursuant to the Pecos River Compact; and

(3) upon delivery to the interstate stream commission at the Pecos river, title is transferred to the interstate stream commission, which shall indemnify the operator from future liability.

CHAPTER 7. TAXATION ARTICLE 2A. CORPORATE INCOME AND FRANCHISE TAX ACT § 7-2A-20 (2002).
Credit for produced water (Business/corporations)

A. An operator that files a New Mexico corporate income tax return may take a tax credit in an amount equal to one thousand dollars ($1,000) per acre-foot of produced water not to exceed four hundred thousand dollars ($400,000) per year if the following conditions are met:

(1) the operator delivers the water to the interstate stream commission at the Pecos river in compliance with the applicable requirements of New Mexico's Water Quality Act, New Mexico's water quality control commission regulations and federal clean water acts;

(2) the operator delivers the water solely in a manner approved by the interstate stream commission to contribute to delivery obligations pursuant to the Pecos River Compact; and

(3) upon delivery to the interstate stream commission at the Pecos river, title is transferred to the interstate stream commission, which shall indemnify the operator from future liability.

CHAPTER 30. CRIMINAL OFFENSES ARTICLE 16. LARCENY § 30-16-47 (1981).
Documentation required

CHAPTER 30. CRIMINAL OFFENSES ARTICLE 16. LARCENY § 30-16-48 (1981).
Penalty; further investigation

These two statutes outline the legal requirement that any person in possession of crude petroleum oil or any sediment, water or brine produced in association with the production of oil or gas or both for transportation by motor vehicle from or to storage, disposal, processing or refining must also possess specific documentation required by regulation of the oil conservation division of the energy and minerals department, hereinafter in this act called division, which substantiates his right to be in possession of the estimated volume of crude petroleum oil carried in that vehicle.

CHAPTER 70. OIL AND GAS ARTICLE 2. OIL CONSERVATION COMMISSION; DIVISION; REGULATION OF WELLS § 70-2-12 (2004).
Enumeration of powers

This statute provides power to the Oil Conservation Division to "regulate the disposition of water produced or used in connection with the drilling for or producing of oil or gas or both and to direct surface or subsurface disposal of the water, including disposition by use in drilling for or production of oil or gas, in road construction or maintenance or other construction, in the generation of electricity or in other industrial processes, in a manner that will afford reasonable protection against contamination of fresh water supplies designated by the state engineer"

CHAPTER 70. OIL AND GAS ARTICLE 2. OIL CONSERVATION COMMISSION; DIVISION; REGULATION OF WELLS § 70-2-12.1 (2004).
Disposition of produced water; no permit required

This statute provides that no permit shall be required from the state engineer for the disposition of produced water in accordance with rules promulgated pursuant to Section 70-2-12 NMSA 1978 by the oil conservation division of the energy, minerals and natural resources department.

CHAPTER 70. OIL AND GAS ARTICLE 2. OIL CONSERVATION COMMISSION; DIVISION; REGULATION OF WELLS § 70-2-33 (2004).
Definitions

This statute provides the Oil and Gas Act's definition of produced water as "produced water" means water that is an incidental byproduct from drilling for or the production of oil and gas.

CHAPTER 71. ENERGY AND MINERALS ARTICLE 5. GEOTHERMAL RESOURCES CONSERVATION ACT § 71-5-3 (1975).
Definitions

This statute provides definition of geothermal resources means the natural heat of the earth or the energy, in whatever form, below the surface of the earth present in, resulting from, created by or which may be extracted from this natural heat and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas and other hydrocarbon substances

CHAPTER 72. WATER LAW ARTICLE 12A. MINE DEWATERING § 72-12A-3 (1980).
Definitions

This statute provides the definition of substitute water supply as a supply of water adequate in quality and made available at a point of diversion or use in a sufficient quantity to prevent impairment of an affected water right and may include water produced by mine dewatering

CHAPTER 74. ENVIRONMENTAL IMPROVEMENT ARTICLE 4. HAZARDOUS WASTE § 74-4-3 (2002).
Definitions

CHAPTER 74. ENVIRONMENTAL IMPROVEMENT ARTICLE 4A. RADIOACTIVE AND HAZARDOUS MATERIALS § 74-4A-4 (1991).
Definitions

CHAPTER 74. ENVIRONMENTAL IMPROVEMENT ARTICLE 4C. HAZARDOUS WASTE FEASIBILITY STUDIES § 74-4C-3 (1985).
Definitions

These statutes outline the legal exemptions for produced water with respect to hazardous waste: Hazardous waste does not include any of the following, until the board determines that they are subject to Subtitle C of the federal Resource Conservation and Recovery Act of 1976, as amended, 42 U.S.C. 6901 et seq.: drilling fluids, produced waters and other wastes associated with the exploration, development or production of crude oil or natural gas or geothermal energy; fly ash waste; bottom ash waste; slag waste; flue gas emission control waste generated primarily from the combustion of coal or other fossil fuels; solid waste from the extraction, beneficiation or processing of ores and minerals, including phosphate rock and overburden from the mining of uranium ore; or cement kiln dust waste;

CHAPTER 74. ENVIRONMENTAL IMPROVEMENT ARTICLE 4F. HAZARDOUS MATERIALS TRANSPORTATION § 74-4F-4 (1996).
Exemptions

This statute provides the legal exemption for produced water under the Hazardous materials Transportation Act.

CHAPTER 74. ENVIRONMENTAL IMPROVEMENT ARTICLE 9. SOLID WASTE ACT § 74-9-3 (1990).
Definitions

Provides that produced water is not considered a solid waste under the Solid Waste Act.

CHAPTER 74. ENVIRONMENTAL IMPROVEMENT ARTICLE 9. SOLID WASTE ACT § 74-9-43 (2001).
Authority to accept nondomestic oil, gas and geothermal wastes

This statute defines nondomestic waste as waste associated with the exploration, development, production, transportation, storage, treatment or refinement of crude oil, natural gas, carbon dioxide gas or geothermal energy, but does not include drilling fluids, produced waters, petroleum liquids, petroleum sludges or, except in the event of an emergency declared by the director of the oil conservation division of the energy, minerals and natural resources department, petroleum-contaminated soils associated with the exploration, development, production, transportation, storage, treatment or refinement of crude oil or natural gas.

2.9 New Mexico Administrative Code (NMAC)

New Mexico law vests jurisdiction over produced water in the Oil Conservation Division. Section 70-2-12(B)(15) of the New Mexico Oil & Gas Act noted above provides: "the [OCD] is authorized to make rules, regulations and orders for the purposes [of] and with respect to... regulat[ing] the disposition of water produced or used in connection with the drilling for or producing of oil or gas or both and to direct surface or subsurface disposal of the water in a manner that will afford reasonable protection against contamination of fresh water supplies designated by the state engineer." New Mexico Administrative Code Title 19, Natural Resources and Wildlife, Chapter 15, Oil and Gas, Parts 1-15 outline relevant rules. Additional authority stems from § 19.15.1.3 N.M. Admin. Code (NMAC) (statement of statutory authority) and 19.15.1.12 (charging OCD with the "duty and obligation of enforcing all rules and statutes of the State... relating to the conservation of oil and gas including the protection of public health and the environment").

Highlighted sections of NMAC, Chapter 15 include:

- *General Requirement of Operators Not to Pollute.* Section 19.15.1.13(B) NMAC provides: "All operators... shall at all times conduct their operations... in a manner that will prevent... the contamination of fresh waters..."

- *Disposal of Produced Water in Pits or Tanks.* Section 19.15.1.18 NMAC provides for the containment of produced water in lined pits and below grade tanks. Such pits and tanks must be approved by application to, and constructed in conformity with the rules of, the OCD.

- *Surface Disposal of Produced Water.* Section 19.15.1.19 NMAC would appear to apply to discharges of produced water to the surface. If so, such discharges would have to be made pursuant to an approved abatement plan or an approved ground-water discharge plan designed to prevent surface and subsurface water pollution as provided in the rule.

- *Underground Injection. Section 19.15.9.701 NMAC* provides: "The injection of... water into any formation for the purpose of water disposal shall be permitted only by order of the Division after notice and hearing, unless otherwise provided..." in the rule. Currently, a majority of CBM produced water in New Mexico is disposed of by underground injection. See Darin, p. 195.

- *Removal of Produced Water from Site.* Sections 19.15.9.709 and .710 address the transportation of produced water "by motor vehicle from any lease, central tank battery, or other facility..." Section 19.15.9.709 states that such removal of produced water must be authorized pursuant to the OCD's Form C-133, available on the OCD website. Section 19.15.9.710 addresses the disposition of transported produced water. The water may not be disposed of in any manner that would present "a hazard to any fresh water supplies."

- *Surface Waste Management.* Section 19.15.9.711. This Rule outlines the procedures and requirements for surface discharge of produced water.

In addition, the following portions of the New Mexico Administrative Code outside of the OCD's Rules have some applicability to produced water, including:

- Chapter 2, State Trust Lands outlines the regulations required for lessees on state lands. 19.2.100.61 SALT WATER DISPOSAL: Lessees are expected to comply with all lawful Rules of the New Mexico oil conservation division pertaining to prevention of waste, which includes disposal of produced salt water or brine. If state lands are needed for a salt water disposal operation, then application for a salt water disposal easement site shall be made to the 'oil and gas division' or application for a business lease shall be made to the 'land surface division' of the state land office, depending upon whether underground or surface disposal, respectively, is desired. Ordinarily, water produced on lease may be disposed of on lease without the commissioner's permission if the disposal operation otherwise meets the approval of the oil conservation division and is otherwise reasonable and accepted practice in the industry.

- Chapter 14. Geothermal Power

  → Part 35 Disposal of Produced Water: The disposal of highly mineralized waters produced from geothermal resources wells shall be in such a manner as to not constitute a hazard to surface waters or underground supplies of useable water.

  → Part 92 – Geothermal Disposal Wells: Geothermal disposal wells are those wells used for the purpose of disposing of waters produced from a geothermal reservoir when disposal is into a zone or formation not classified as a geothermal reservoir. No well shall be utilized as a geothermal disposal well until authority for such use has been obtained on an approved form G-112, application to place well on injection-geothermal resources area. Form G-112 shall be filed in accordance with Rule G-503 [now 19.14.93 NMAC] below.

2.10 Western State Survey

A brief survey and related summary of other Rocky Mountain states' regulation of produced water follows. Emphasis is placed on the ever increasing coal bed methane (CBM) produced water production which currently falls outside of the EPA's ELGs. The legal framework surrounding the production, handling and use of CBM produced water is not well developed. Produced water from CBM wells has recently received much attention due to the exploding demand for natural gas, coupled with the increasing lawsuits surrounding the adequacy of environmental protections, the regulation of development by local governments, and conflicts between surface owners and gas production companies. There has been great disagreement over what impacts CBM regulation is having on water quality, local ecosystems, and water supplies. There is also much debate over what are the best uses for the produced water.

All western states have adopted the 'prior appropriation' doctrine. Under 'prior appropriation', ownership of land does not translate into ownership of the appurtenant water rights. Rather, water rights are created when water is diverted and placed (or appropriated) to "beneficial use."[27] There are no limits to the quantity used but state statutes typically require that they will not be wasted in support of the principal tenant that water is a scarce, precious resource.

Utah

The Utah Constitution states "[a]ll existing rights to the use of any of the waters in this State for any useful or beneficial purpose, are hereby recognized and confirmed."[28] Utah's statutes provides "[a]ll waters in this state, whether above or under the ground, are hereby declared to be the property of the public" and "[b]eneficial use shall be the basis, the measure and the limit of all rights to the use of water. . . ."[29] The Utah State Engineer has authority over all ground and surface water appropriations and each appropriation must be for a beneficial use.[30] However, akin to New Mexico, produced water does not fall under the jurisdiction of the State Engineer. Rather, "the disposal of salt water and oil field wastes," including water associated with natural gas development, is under the jurisdiction of the Utah Board and Division of Oil, Gas, and Mining (DOGM).[31] Byproduct water is managed according to rules designed to "regulate . . . the

[27] In New Mexico, "[b]eneficial use shall be the basis, the measure and the limit of the right to the use. 'N.M. Cost. Art. XVI, § 1. See also Frank J. Trelease, Law, Water and People: The Role of Water Law in Conserving and Developing Natural Resources in the West, 18 Wyo. L.J. 3, 4-5 (1963) (water to be put to beneficial use); George W. Pring & Karen A. Tomb, License to Waste: Legal Barriers to Conservation and Efficient Use of Water in the West, 25 Rocky Mtn. Min. L. Inst. 25-1, 25-17, 25-18 (1979) ("There exists ... a duty to use water beneficially.").

[28] Utah Const. of 1896, art. XVII, § 1.

[29] Utah Code Ann. §§ 73-1-1, 73-1-3 (1935).

[30] Utah Code Ann. § 73-2-1(3)(a)(b)(iii)(B) (2005).

[31] Utah Code Ann § 40-6-5(3)(d) (1988).

disposal of these wastes in a manner which protects the environment, limits liability to producers, and minimizes the volume of waste."[32] Methods of handling the water are lined pits; unlined pits (surface reservoirs) if the disposed water's TDS are not higher than any ground water that could be affected, or if all or a substantial portion of the water is being used for a beneficial purpose such as irrigation or livestock watering, or if the produced water is less than five barrels per day.[33] Safe Drinking Water Act Class II injection wells are also permitted provided that the disposal aquifers do not contain suitable drinking water.[34] No requirement for beneficial use is required for produced water. The water is treated as a waste stream.

Colorado

The Colorado Constitution only outlines water appropriation, beneficial use, and priority provisions in relation to "natural streams."[35] Ground water is outlined within the 1965 Ground Water Management Act.[36] Under the Act, a critical initial determination is whether the ground water diversion comes from a designated ground water basin and whether the diversion is from a tributary or non-tributary source. If the diversion derives from a designated ground water basin, a person seeking to appropriate water must put it to a beneficial use and obtain approval from the Ground Water Commission.[37] If the diversion is outside a designated ground water basin, and is non-tributary, a permit from the State Engineer is required; non-tributary ground water is not considered part of the natural stream that brings Colorado's constitution into play for natural streams or surface waters.[38] Colorado also exempts oil and gas byproduct water from State Engineer regulation: In the case of dewatering of geologic formations by removing nontributary ground water to facilitate or permit mining of minerals:

> (a) No well permit shall be required unless the nontributary ground water being removed will be beneficially used; and
>
> (b) [T]he state engineer shall allow the rate of withdrawal stated by the applicant to be necessary to dewater the mine; except that, if the state engineer finds that the proposed dewatering will cause material injury to the vested water rights of others, the applicant may propose, and the permit shall contain, terms and conditions which will prevent such injury. The reduction of hydrostatic pressure level or water level alone does not constitute material injury.[39]

Produced water must be treated prior to placement in a pit (lined or unlined) to prevent crude oil and condensate contamination. The rules allow five types of byproduct water handling: (1)

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[32] Utah Admin. Code R649-9-1.1 (2005)

[33] Id. § R649-9-3 et al.

[34] Id § R649-5-2.1.

[35] Colo. Const. art. XVI, §§ 5, 6.

[36] Colo. Rev. Stat. Ann. §§ 37-90-101 to -143 (2005).

[37] Colo. Rev. Stat. Ann. § 37-90-107(1) (2003).

[38] Id. § 37-90-137(4)(a) (2004).

[39] Colo. Rev. Stat. Ann. § 37-90-137(7)(a)-(b) (2004)

injection into a Class II Safe Drinking Water Act disposal well; (2) evaporation/percolation in a properly lined or unlined pit; (3) disposal at permitted commercial facilities; (4) road-spreading on leased roads (to control fugitive dust) when less than 5000 ppm TDS (with approval by the surface owner); and (5) discharge into state waters pursuant to a Clean Water Act section 402 permit.[40] Colorado aligns with both New Mexico and Utah in treating produced water as a waste stream.

Montana

Montana's constitution regarding water rights states that "[a]ll surface, underground, flood, and atmospheric waters within the boundaries of the state are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law."[41] Similar to the water codes of Utah, New Mexico, Colorado and Wyoming, Montana's water code contains an oil and gas byproduct exception to its ground water appropriation requirements.[42] Up until 2001, Montana's water code prohibited waste of this precious resource: "Waste and contamination of ground water prohibited. . . . No ground water may be wasted."[43] In 2001 this waste-preventing provision was amended to address CBM byproduct water quantity issues. As the Montana water code now reads, "the management, discharge, or re-injection of ground water produced in association with a coalbed methane well in accordance with 85-2-521(2)(b) through (2)(d)" may not be construed as waste.[44] Four disposal alternatives are available for handling produced water (1) use the water for irrigation or stock water or for other beneficial uses; (2) inject the water into an acceptable subsurface strata or aquifer pursuant to applicable law; (3) discharge it to the surface or surface waters, or (4) managed through other methods allowed by law.[45]

Wyoming

The Wyoming Constitution states "Control of Water: Water being essential to industrial prosperity, of limited amount, and easy of diversion from its natural channels, its control must be in the state, which, in providing for its use, shall equally guard all the various interests involved."[46] In addition "Priority of appropriation for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interest."[47] As such the regulation of produced water in Wyoming is significantly different that that of other western states. Produced water falls under the primary jurisdiction of the state engineer instead of the Wyoming Oil and gas Conservation Commission. Produced water receives the same

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[40] Colo. Oil & Gas Conservation Comm'n, Rules and Regulations § 907(c)(2)(A)-(E)

[41] Mont. Const. art. IX, § 3(3).

[42] Mont. Code Ann. § 82-11-111(2)(a) (1989)

[43] Mont. Code Ann. § 85-2-505(1) (2001).

[44] Id. § 85-2-505(1)(e).

[45] Mont. Code Ann. § 85-11-175.1 (2003)

[46] Wyo. Const. art. I, § 31.

[47] Id. § 3.

treatment as all other groundwater in Wyoming instead of being considered a waste byproduct of oil and gas production. Byproduct water is defined as, "water which has not been put to prior beneficial use, and which is a by-product of some non-water-related economic activity. . . . By-product water includes, but is not limited to, water resulting from the operation of oil well separator systems or mining activities such as dewatering of mines."[48] In Wyoming, traditional deep oil and gas byproduct water is treated in this fashion, with no beneficial use permit required by the state engineer.[49] However, state officials have not applied the byproduct provision to CBM water and have required a beneficial use permit in order to monitor groundwater depletion rates in protecting water rights. In addition to the regulations of the State Engineer requiring an appropriation permit for all water produced from CBM wells, other regulations apply depending on the disposal of the produced water. Surface discharges into waters of the state are allowed pursuant to a WPDES permit issued by the Wyoming Department of Environmental Quality (WDEQ).[50] In addition, a Class II injection well permit issued by the Wyoming Oil & Gas Conservation Commission (WOGCC) is required for underground injection of produced water and WOGCC permits are required for disposal of produced water in an evaporation pit or percolation pit.

Selected Case Law
In *Mathers v. Texaco, Inc.*, 421 P.2d 771 (N.M. 1966) the New Mexico Supreme Court discussed the requirements that all ground water diverters – even those for oil – had to receive a State Engineer beneficial use permit when appropriating from a declared underground basin. This suggests that all byproduct water should be permitted through the State Engineer. A key distinction is that the water needing a beneficial use permit in Mathers was used in oil field flooding – it was not byproduct water. Id. at 773. This suggests that for oil and gas production, water is only considered a beneficial use when it is being used to facilitate production subsequent to its initial diversion from the ground (as opposed to merely being pumped out of the ground as a byproduct of production). In the latter instance, western water law has treated this as byproduct waste and the water itself not a beneficial use.

In *Wyoming Outdoor Council v. United States Army Corps of Engineers*, 351 F. Supp 2d. 1232 (Jan. 7, 2005), environmental groups challenged a general permit under the Clean Water Act issued by the United States Army Corp of Engineer (Corp) decision. The general permit, GP-9808) was issued on June 20, 2000 to address the growing need for permits to discharge dredge and filling materials associated for large increases in coalbed methane gas production. The District Court held that the failure of Corps to consider cumulative impact from permit's issuance on non-wetland environmental resources was arbitrary and capricious and remanded the case for further review.

A recent Ninth Circuit Court of Appeals case recently provided insight into whether produced water (in this case CBM produced water) can be classified as a pollutant under the Clean Water

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[48] Wyo. Stat. Ann. § 41-3-903 (1973).

[49] Id.

[50] Wyo. Stat. Ann. § 35-11-301 (1997).

Act. In *Plains Resource Council v. Fid. Exploration and Dev. Co.,* 325 F.3d 1155 (2003), the Ninth Circuit First, concluded CBM water is industrial waste, one classification of pollution under the CWA. Using the ordinary meaning of the term, the Court defined industrial waste as "any useless byproduct derived from the commercial production and sale of goods and services."[51] The Court emphasized that industrial waste is not confined to the most heinous and toxic forms of industrial by-products.[52] Because Fidelity sells CBM commercially and CBM water is an unwanted by-product of the extraction process, the court determined "CBM water falls squarely within the ordinary meaning of 'industrial waste.'" The Ninth Circuit found CBM water to be a pollutant because it is produced water derived from gas extraction – another classification of pollutant under the CWA. Fidelity argued that because it adds no chemicals to the water, CBM water is not produced water. The Court rejected this argument finding that CBM water is "produced" because it is pumped from the coal seams underlying the basin during the methane gas extraction process. The Court reasoned,

> [t]he CWA contemplates that produced water, as defined by EPA regulations is a pollutant within the meaning of the Act. The CWA only exempts water derived from gas extraction from regulation when the water is disposed of in a well and will not result in the degradation of other water bodies. The Court held CBM water discharged by Fidelity was a pollutant by virtue of its being produced by extraction from coal seams and subsequently discharged into the Tongue River – as opposed to a state-approved well.[53]

The tendency of oilfield production pits and saltwater disposal pits to contaminate surface and groundwater resources is well-documented.[54] In EPA's Report to Congress that accompanied the publication of its Regulatory Determination, EPA observed a number of instances in which groundwater had become contaminated by the contents of oilfield waste pits. In July 1985, a study was undertaken [in New Mexico] to analyze the potential for unlined produced water pit contents, including hydrocarbons and aromatic hydrocarbons, to migrate into the ground water. Upon analysis, the study group found volatile aromatic hydrocarbons were present in both the soil and water samples of test pits down-gradient, demonstrating migration of unlined produced water pit contents into the ground water.[55]

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[51] Plains Resource Council v. Fid. Exploration and Dev. Co., 325 F.3d 1155, 1161 (2003).

[52] Id.

[53] Id.

[54] See, e.g., Union Tex. Petroleum Corp. v. Jackson, 909 P.2d 131, 144-45 (Okla. Ct. App. 1995) (stating Mobil Oil Corporation was responsible for polluted saltwater pits); U.S. Geological Survey, Report 86-4087, Brine Contamination of Shallow Ground Water and Streams in the Brookhaven Oil Field, Lincoln County, Mississippi (1986).

[55] See Office of Solid Waste and Emergency Response, U.S. Envtl. Prot. Agency, Pub. No. EPA/530-SW-88-003A, Report to Congress: Management of Wastes from the Exploration, Development, and Production of Crude Oil, Natural Gas, and Geothermal Energy, (1987)

3. PRODUCED WATER QUANTITY AND QUALITY

3.1 Quantity

The American Petroleum Institute (API) concluded that approximately 18 billion barrels (bbl) of produced water was generated by U.S. onshore operations in 1995.[56] This amount of water could cover all of Washington D.C. to a height of 53 feet – each year. Additional large produced water streams are generated offshore and at thousands of other wells worldwide. It is estimated that in 1999, an average of 210 million bbl of water was produced each day worldwide representing approximately 77 billion bbl of produced water for the entire year.[57] Worldwide, produced water equals approximately 3 bbl of water for every barrel of oil. Shell Oil Co. has reported that its produced water volume has increased from 2.1 million bbl per day in 1990 to 6.0 million bbl per day in 2002.[58]

Wells in the United States produce, on average, 7.50-9.50 barrels of water for each barrel of oil.[59] The volume of produced water tends to increase with the age of the oil well. For wells reaching the end of their economic lives, produced water can often constitute 98% of the material pumped to the surface. In comparison, volumes of CBM produced water are just the opposite. The water production cycle for CBM starts out high as the hydrostatic pressure is reduced in the coal seam and gradually declines with the age of the well. Oil and gas producers in the Rocky Mountain Region (Wyoming, New Mexico, Colorado, Utah and Montana) reported over three billion barrels of water were produced in the year 2000.

New Mexico

Produced water production in New Mexico has dramatically increased over the last 30 years [Figure 1]. Recent increases are driven by increased natural gas production in the state. Approximately 593 million barrels of produced water were generated in New Mexico in 1999. This produced water volume equals approximately 76,434 acre-feet of water per annum. The water-to-oil ratio now stands at 6.5 barrels of water to every 1 barrel of oil produced in New Mexico. Since 1982, produced water volumes have increased nearly 80 percent as recoverable oil and gas resources have decreased.[60] A new record for produced water production in the state will likely be recorded this year based, in part, on the increase of natural gas development in the state.

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[56] American Petroleum Institute, 2000.

[57] Khatib, Z., and P. Verbeek, "Water to Value – Produced Water Management for Sustainable Field Development of Mature and Green Fields," *Journal of Petroleum Technology*, Jan. 2003

[58] Id.

[59] Lee R., Seright R., Hightower M., Sattler A., Cather M., McPherson B., Wrotenbery L., Martin D., and Whitworth M.: "Strategies for Produced Water Handling in New Mexico," paper presented at the 2002 Ground Water Protection Council.

[60] See Follow-up Review, Oil Conservation Division (OCD) August 2001.

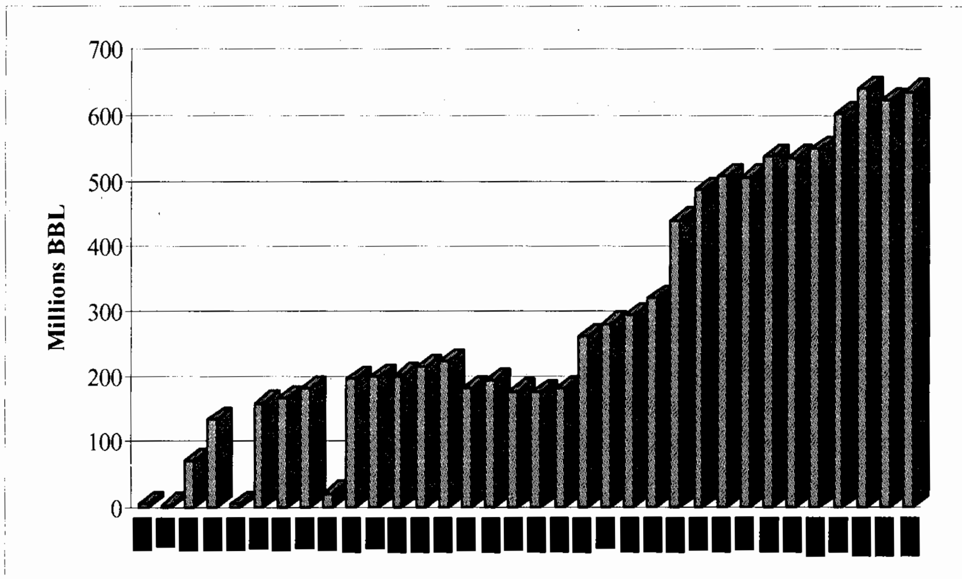


Figure 1: Annual Produced Water Production 1970 – 2004. (Source OCD, 2005)

In New Mexico, general produced water data is available through the NM WAIDS database provided by the Petroleum Recovery Research Center (PRRC), a division of New Mexico Institute of Mining and Technology. This raw data is provided in spreadsheet format. For the purposes of this report, focus was placed on New Mexico's two prolific oil and gas producing regions, (1) northwestern New Mexico near Farmington, and (2) southeastern New Mexico near Artesia/Carlsbad.

Highlighted produced water quantity and quality data has been downloaded from PRRC and summarized in Figures 2 and 3. A complete copy of the source "raw" data has been included in Appendix A for more detailed review.

Energy production within New Mexico is heavily centered within two areas of the State; the Northwest [OCD District 3 Aztec] and the Southeast [OCD districts 1 Hobbs and 2 Artesia]. As such, it is no surprise that produced water production in New Mexico is also heavily centered within these areas. Although produced water production is dispersed statewide, the above two districts still account for over two-thirds of the total produced water as recently as 2004 [See Figure 2].

District 3 (Aztec) produced water production has decreased in recent years. Recent drilling in the San Juan basin will likely reverse this trend [Figure 3].

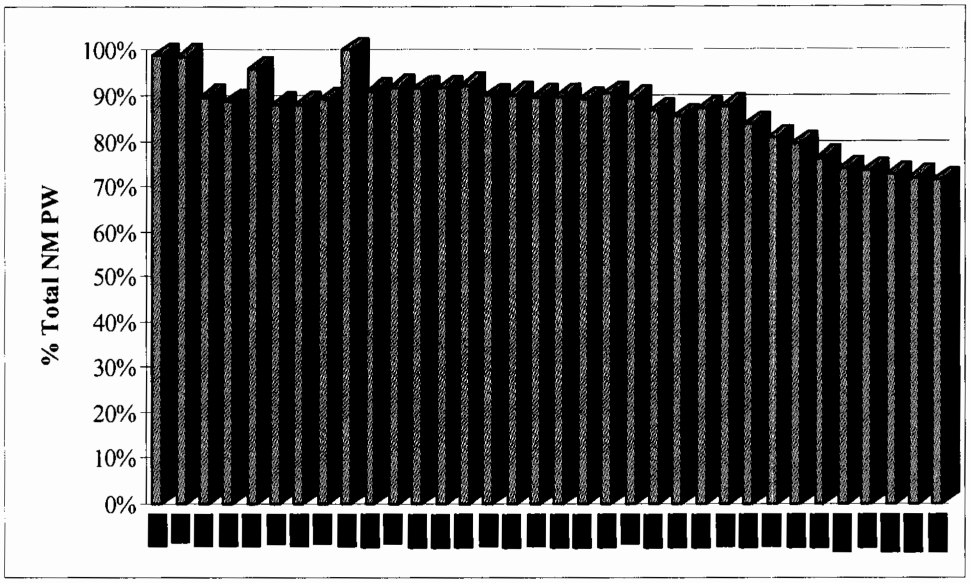


Figure 2: Percent annual production of produced water in NM (Districts 1, 2, and 3 combined). [Source: OCD, 2005]

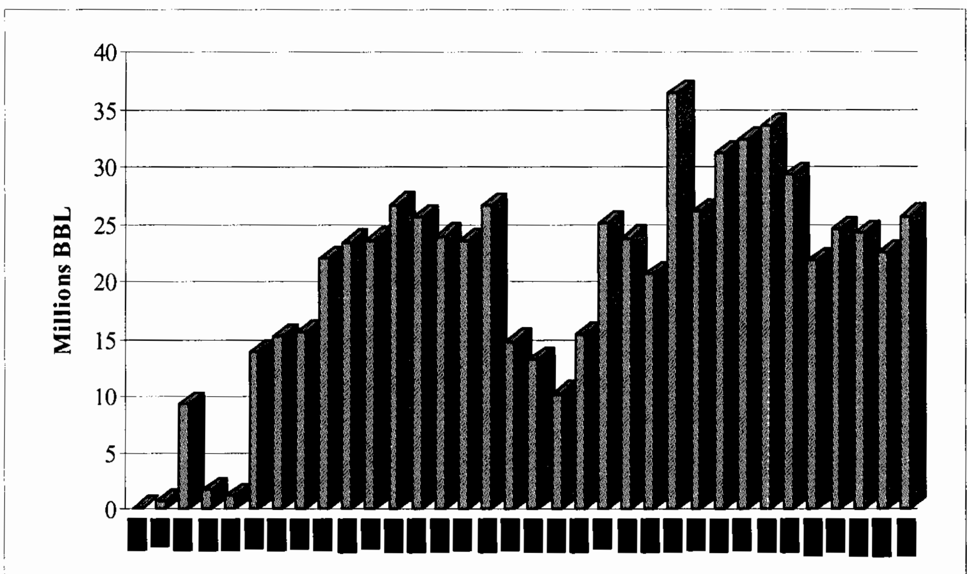


Figure 3: Annual District 3 (Aztec) produced water production. [Source: OCD, 2005]

Districts 1 and 2 [Hobbs and Artesia] show a more steady increase over the last thirty years as a result of increased energy production and aging of wells in production [Figure 4]. This area accounts for over half of the total produced water production in New Mexico.

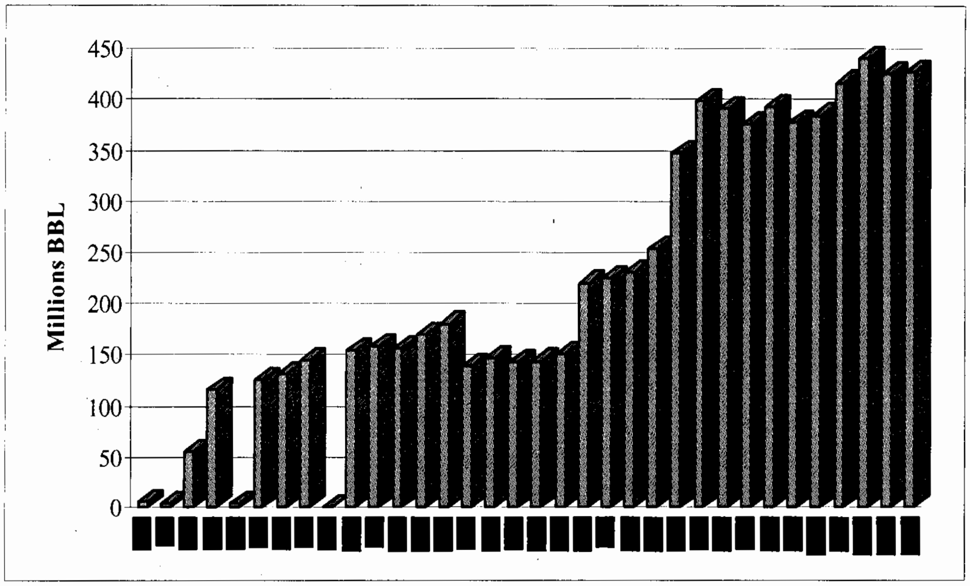


Figure 4: Annual District 1 & 2 (Hobbs and Artesia) produced water production [Source: OCD, 2005].

3.2 Quality

The water produced with conventional oil or gas operations is generally unsuitable for most domestic or agricultural purposes, either because it is extremely salty or due to the presence of toxic or radioactive compounds, or both. The composition of produced water is highly well-dependent and includes a variety of inorganic and organic compounds. Produced water contains small amounts of emulsified oil, organic compounds including dissolved hydrocarbons, organic acids, phenols and traces of chemicals added during production, inorganic compounds, suspended solids, dissolved solids, and natural low-radioactive elements.

Figure 5 through 8 represent summarized water quality data in the form of TDS [Total Dissolved Solids] from most of the actively produced formations within the State of New Mexico. Although it is not uncommon to produce from multiple formations simultaneously, the data presented below is from single formation production wells only. Figures 5 through 8 demonstrate that the variation within any formation is extremely large.

The formations that appear to have a tight tolerance on TDS are largely a result of having only one or two samples in the data. Where more than five samples are available per formation, the range is typically more than 100% of the mean: salt concentrations vary widely even in wells close to each other. These data help demonstrate that in advance of an actual water quality test, it is difficult (if not impossible) to actually predict the water quality of a new well based solely upon knowing the formation from which it is producing.

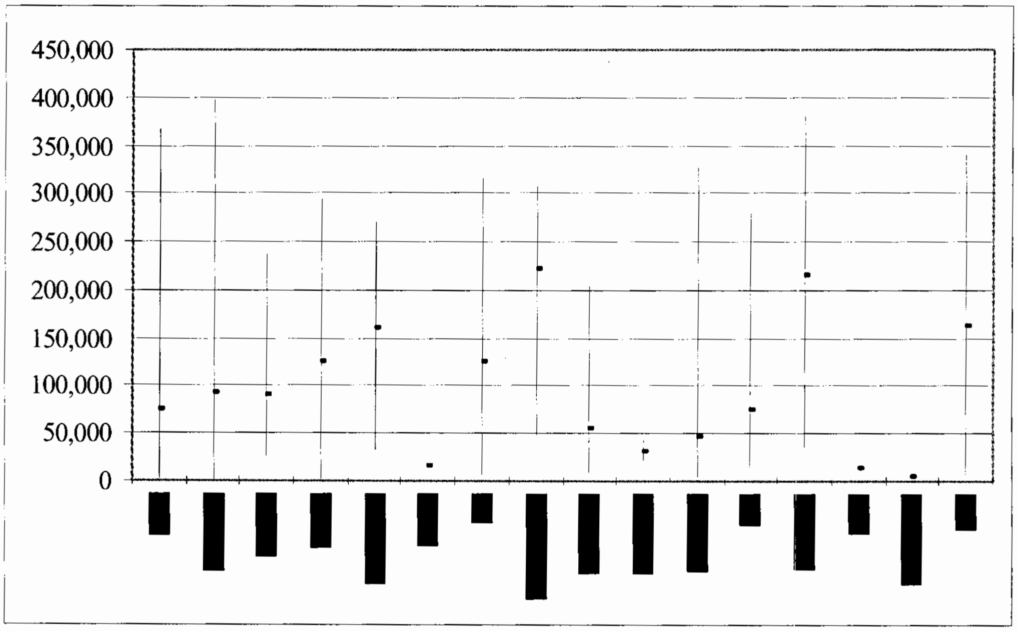


Figure 5: NM TDS Levels by Formation [Source: NM WAIDS, 2005]

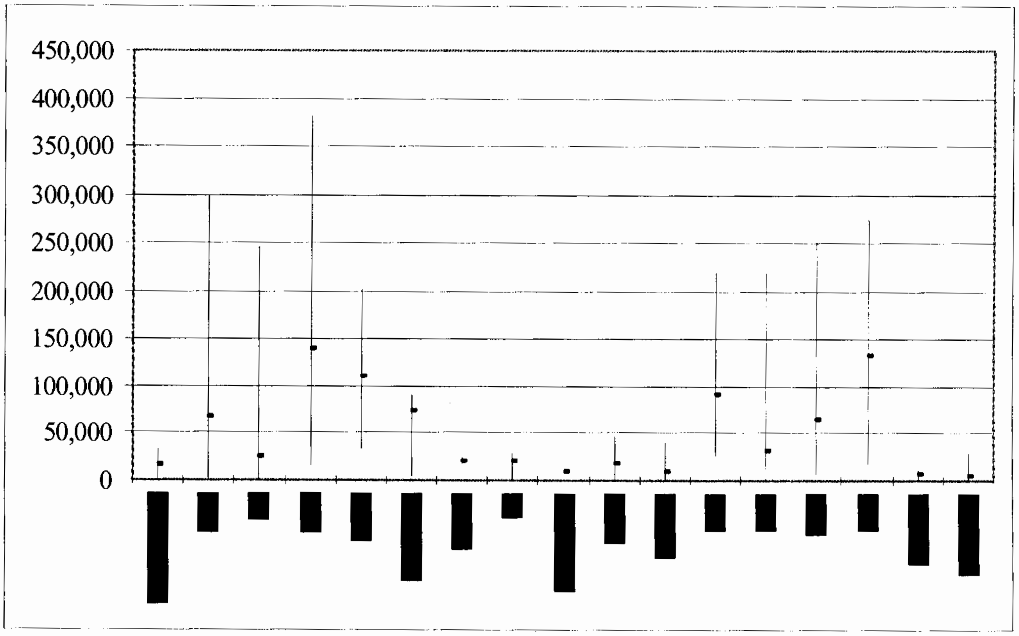


Figure 6: NM TDS Levels by Formation [Source: NM WAIDS, 2005]

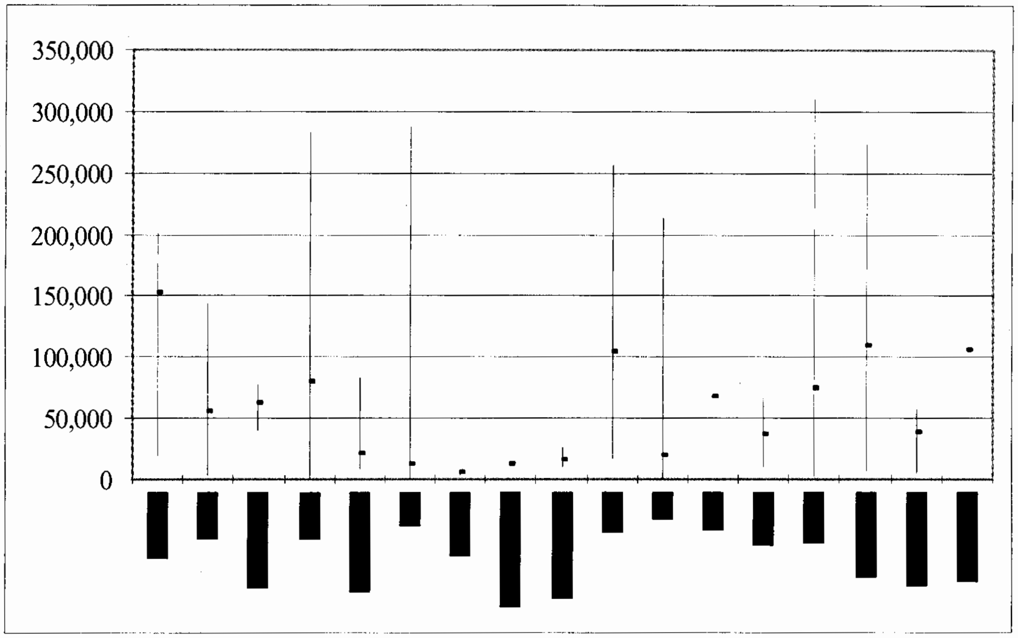


Figure 7: NM TDS Levels by Formation [Source: NM WAIDS, 2005]

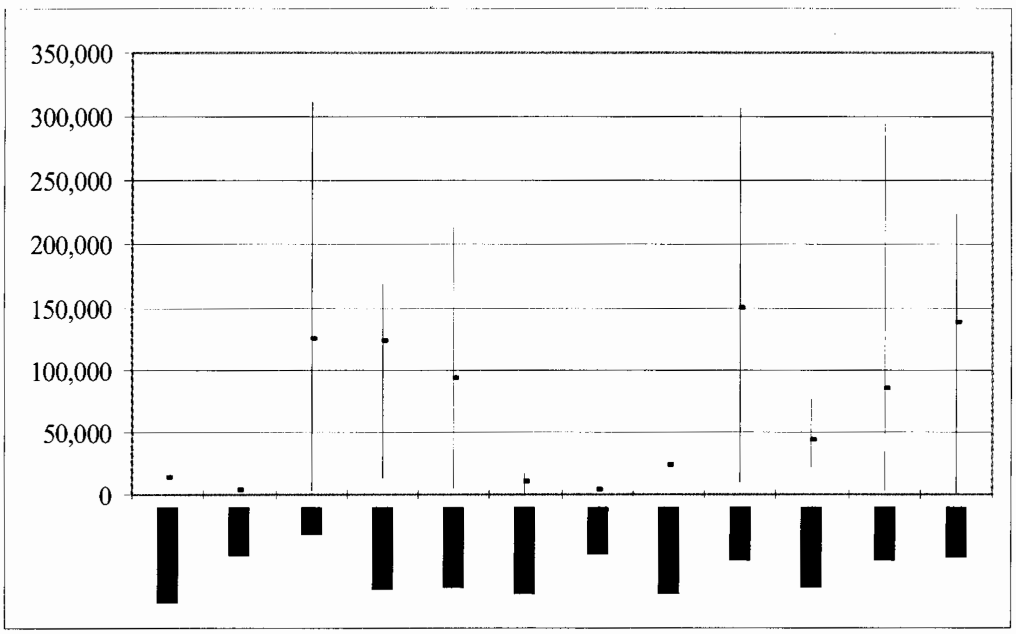
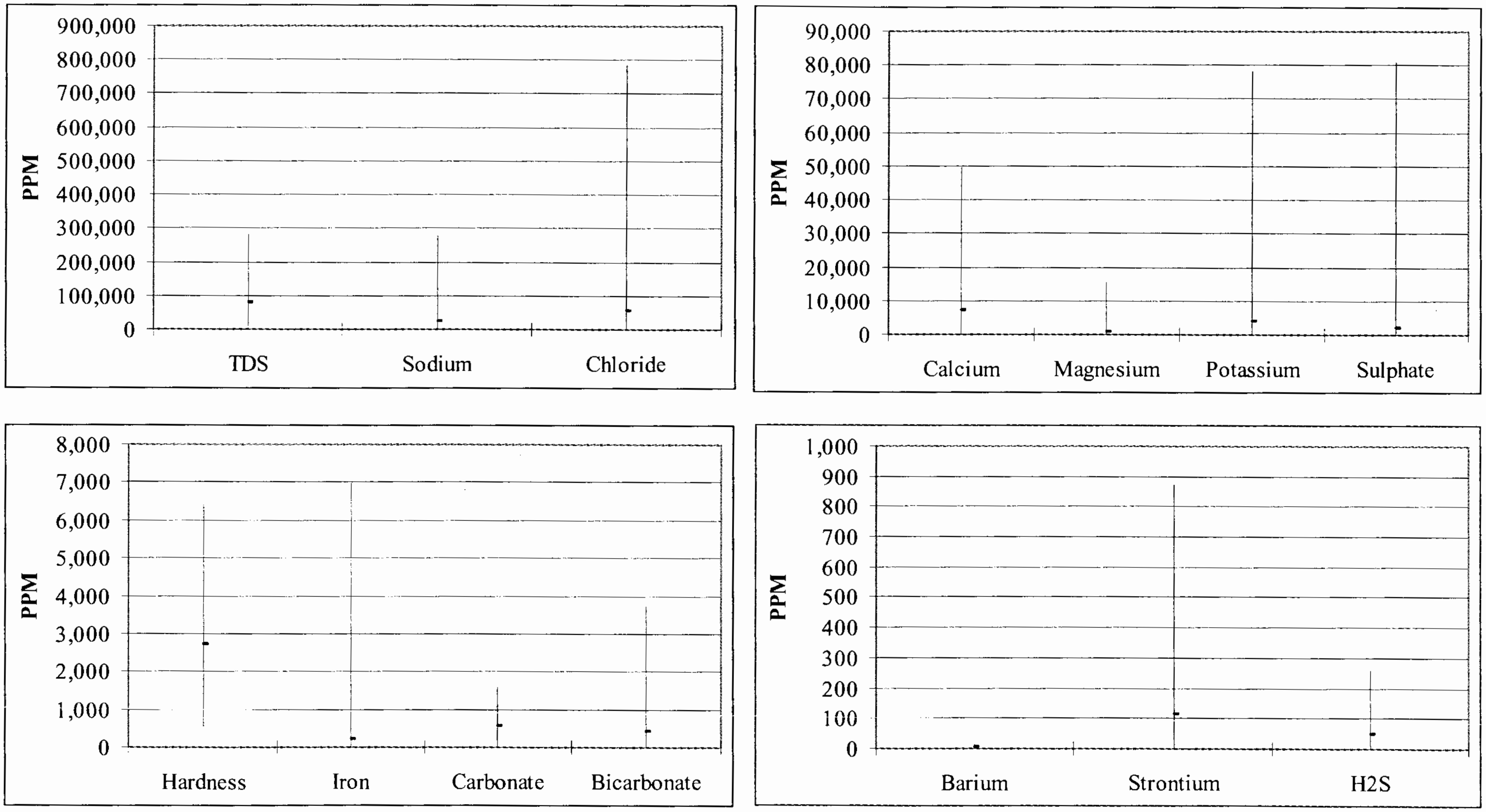


Figure 8: NM TDS Levels by Formation [Source: NM WAIDS, 2005]

Produced water quality from different wells within the same formation also varies considerably. Figure 9 outlines specific water quality constituents found within the Morrow formation.



Note: The vertical lines in each chart indicate the range of concentrations; the hatch marks indicate the average concentration.

Figure 9: Morrow Formation Water Quality [Source: NM WAIDS, 2005]

Overall produced water quality within the Morrow Formation is summarized in Table 1. In addition, produced water quality from an individual well, the Boise Federal No. 001Q is also summarized in Table 1. The Boise Federal No. 001Q is a traditional gas well located within the OCD's Artesia District No. 2. The well is located within the East Carlsbad Morrow formation. A complete water quality analysis was recently performed on this well for this report. New Mexico Water Quality Control Commission Ground Water Standards, Section 3-1-3 (A-C), were used for the water quality analysis. Highlighted portions of the independent water quality Laboratory Analytical Report has been included in Appendix B. Comparing the individual Boise well results with the average Morrow Formation results clearly demonstrates the wide variance found between wells located within the same basin [See Table 1].

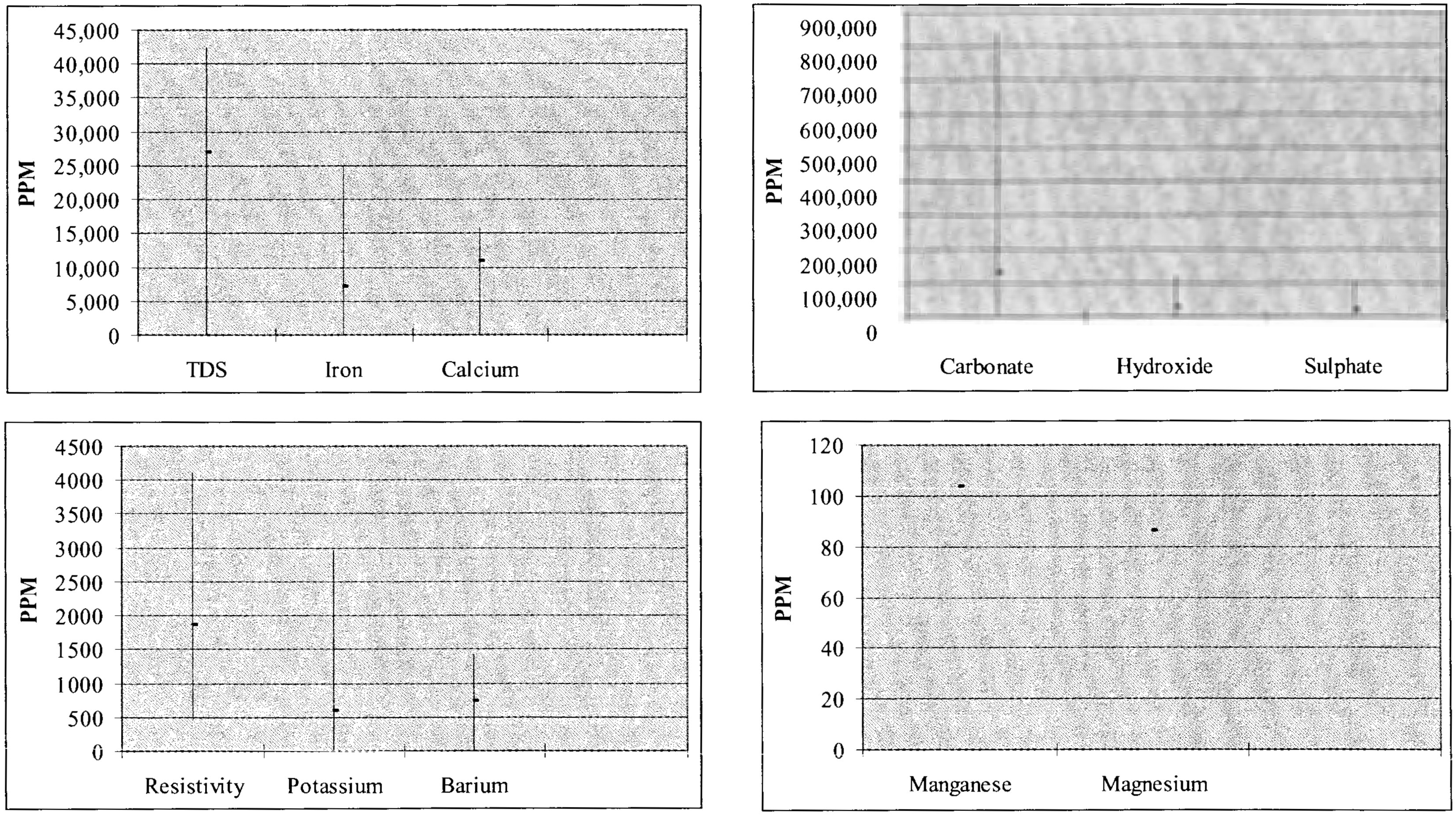
Table 1: Morrow Formation vs. Boise Well Produced Water Quality

	Morrow Formation			Boise
Constituent	Max	Min	AVG	11-Nov-05
TDS	282,741	630	80,265	120,000
Chloride	783,511	40	53,780	84,100
Sulfate	80,690	1	1,892	168
Iron	6,980	1	212	123
Barium	13	0	3	11

Overall produced water quality within the Fulcher Kutz Formation is summarized in Table 2, and specific water quality constituents found within the Fulcher Kutz Formation are outlined in Figure 10. In addition, produced water quality from an individual well, the Blackshawl Com No. 001 is also summarized in Table 2. The Blackshawl Com No. 001 is a gas well located within the OCD's Aztec District No. 3. The well is located within the Fulcher Kutz formation. A complete water quality analysis was recently performed on this well for this report. New Mexico Water Quality Control Commission Ground Water Standards, Section 3-1-3 (A-C), were used for the water quality analysis. Highlighted portions of the independent water quality Laboratory Analytical Report has been included in Appendix C. Comparing the individual Blackshawl well results with the average Fulcher Kutz Formation results clearly demonstrates the wide variance found between wells located within the same basin. See Table 2.

Table 2: Fulcher Kutz Formation vs. Blackshawl Well Produced Water Quality

	Fulcher Field			Blackshawl #1
Constituent	Max	Min	AVG	14-Nov-05
TDS	107,923	488	20,024	9
Chloride	42,403	2	27,017	32,600
Sulfate	24,870	155	7,191	19
Iron	1,424	2	726	67
Barium	104	104	104	0



Note: The vertical lines in each chart indicate the range of concentrations; the hatch marks indicate the average concentration.

Figure 10: Fulcher Kutz Formation Water Quality [Source: NM WAIDS, 2005]

4. COORDINATION WITH NEW MEXICO PRODUCED WATER PROGRAMS

4.1 Petroleum Recovery Research Center

The Petroleum Recovery Research Center (PRRC) is a division of New Mexico Institute for Mining and Technology located in Socorro, New Mexico. Its mission is to serve as New Mexico's focal point for improved oil and gas recovery research, to assist others in their efforts to recover petroleum, and to transfer new and existing technology from research labs to the oil and gas industry.

The state of New Mexico recognized a need to help oil and gas producers who could not afford high priced software and data subscriptions to conduct oil and gas operations in New Mexico. GO-TECH, the Gas and Oil Technology Exchange and Communication Highway, was founded in 1994 as a free access website to New Mexico oil and gas production information to address this problem. Creation of GO-TECH and continued funding to respond to the requirements of New Mexico producers for fast, efficient, accurate and low-cost data and software is funded by the State of New Mexico and grants from the U. S. Department of Energy and the Petroleum Technology Transfer Council (PTTC). In addition to GO-TECH, the PRRC recently announced a new web-based service named NM WAIDS. This resource is devoted to making NM water quality data available on the Internet. The target audience is the oil and gas community. The two primary data sets are for (1) produced water samples from wells throughout the state and (2) a groundwater database for southeast New Mexico only. Information about corrosion, some calculation and conversion tools, and a map-based query are included. Lastly, an inactive oil and gas well database is also accessible through the PRRC website.

See: http://baervan.nmt.edu/

4.2 New Mexico Water Resources Research Institute

The New Mexico Water Resources Research Institute (WRRI), authorized by the 1964 Water Resources Act, was formed in 1963 and was one of the first institutes approved under the Act in the United States. The overall mission of the WRRI is to develop and disseminate knowledge that will assist the state and nation in solving water problems. Through the funding of research and demonstration projects, the institute utilizes the knowledge and experience of researchers throughout the state to solve New Mexico's pressing water problems. Research is conducted by faculty and students within the departmental structure of each New Mexico university campus. In-house staff administers the institute's programs, conducts special research projects, and produces a variety of issue reports. The WRRI's library contains produced water resources stemming from past conferences and seminars.

See: http://wrri.nmsu.edu/

4.3 ZeroNet Water-Energy Initiative

The ZeroNet Water-Energy Initiative is comprised of a broad range of industry, academia, national laboratories, and environmental groups aimed at delivering new electric power capacity with "zero-net" freshwater withdrawals in New Mexico by 2010. In FY04, $750,000 funding was received with much of the work being done in FY05. The Initiative has developed a "quick scenario tool" to assist with what-if planning within the San Juan Basin. The tool can be used for scenario planning to assist in building consensus across varying stakeholder groups.[61] The New Mexico ZeroNet pilot program will serve as a template for a national program of water management for power generation. One of the Initiative's elements is to develop alternative or degraded water sources to be used in energy cooling systems. Produced water from the oil/gas/coal industry is a major focus of this effort. The Public Service Company of New Mexico (PNM) and Burlington Resources recently compiled a produced water report aimed at determining the feasibility of using produced water for electrical generation cooling. See: http://www.pnm.com/environment/pdf/zero_net.pdf

4.4 Sandia National Laboratories

Sandia National Laboratories (SNL) is leveraging its energy, engineering, geotechnical engineering, and research capabilities to provide valuable support for research and treatment of produced water. SNL's Produced Water Project is aimed at working in partnership with private industry and state and federal agencies on several projects to address the economic and environmental issues associated with produced water reuse and disposal. SNL is providing technical assistance to the Soil Conservation Service on the regulatory and policy issues of treatment and reuse of produced water. The lab is also focusing on produced water treatment, including:

- "Supporting state and federal agencies and producers in evaluating the use of desalination technologies for the treatment of produced water for beneficial reuse for surface water discharge applications.
- Supporting state agencies and producers in evaluating commercial treatment and pretreatment technologies for reuse of produced water.
- Working with federal and state agencies and producers in evaluating novel treatment and pretreatment technologies for treatment of Coal Bed Methane produced water for beneficial reuse for rangeland rehabilitation and livestock watering in northern New Mexico.
- Coordination with the Bureau of Reclamation to develop the roadmap for future produced water pretreatment, treatment, and desalination research and development. Coordination of the development of a National Desalination Research Facility in New Mexico to coordinate inland desalination technology development and testing to address inland applications, like produced water treatment."[62]

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[61] Information provided per telephone discussion with Dan Macuga, Los Alamos National Laboratories, November 14, 2005.

[62] http://www.sandia.gov/water/FactSheets/WIFS_ProducedWaterNew.pdf, November 11, 2005

4.5 Tularosa Basin National Desalination Center

A federal partnership between Sandia National Laboratories and the Bureau of Reclamation has been established to lead the development of a new test and evaluation facility for novel desalination technologies, including produced water treatments. When finished, the approximately 15,000 square foot Tularosa Basin National Desalination Center will include pilot-scale testing to evaluate innovative concepts for:

1. application of renewable energy techniques to reduce desalination costs,
2. cost-effective application for small-scale or portable systems,
3. application to large surface flows at low cost,
4. *produced water* treatment and beneficial use, and
5. the environmental concerns of inland desalination brine and salt use or disposal.

The 40-acre facility is located within the Tularosa Basin of New Mexico. This basin has been extensively studied and has extensive brackish and saline water resources. Within a 5-mile radius, water with salinity from 2000 ppm TDS to over 100,000 ppm TDS is available. Additionally, a wide range of water chemistries including sodium-chloride, carbonate, and sulfate based brine waters are available. This provides a unique opportunity to be able to evaluate new technologies over a wide range of natural water qualities. Numerous groundwater test wells have already been completed ranging from 1,200 ppm TDS (120 gpm) to 5,000 ppm TDS (160 gpm). Completion of the Center is scheduled for late 2006. All treated water at the Center will be used by the City of Alamogordo for reuse. The Center will provide the State of New Mexico with an opportunity to be at the cutting edge of national desalination research and evaluation.

5. EVALUATION CRITERIA OF DEMONSTRATION PROJECT TECHNOLOGIES

To assist in selecting the optimum produced water demonstration treatment approach, each treatment technology has been reviewed and analyzed according to a six-point criterion. It should be noted that the effectiveness and overall performance of each treatment technology often depends on a combination of criteria. For example, a technology's overall effectiveness in removing contaminates may improve dramatically as more energy is applied to the system. However, the overall effectiveness of the treatment technology, when viewed against the amount of energy input (cost), may fall substantially. Basic engineering judgment and experience have been relied on in applying this fundamental evaluation criterion. For example, the flexibility of freeze thaw evaporation is directly related to the technology's geographic locale. In areas of the west where yearly sub-freezing days are low, the technology's flexibility will very low.

5.1 Criterion 1 – Overall Effectiveness

Which produced water treatment technologies do the best job of addressing the required water quality issues with respect to municipal, agricultural or aquifer recharge? The simplest measure is to rank the technology's ability to remove contaminants required to meet regulatory discharge limits. Where applicable, New Mexico Water Quality Control Commission (WQCC) Regulations, Section 3101, A (Human Health Standards); B (Other Standards for Domestic Water Supply); and C (Standards for Irrigation Use) have been used as a general basis. The WQCC standards can be found at http://www.emnrd.state.nm.us/emnrd/ocd/Tab3Att1_000.htm. Finally, for evaluation purposes, the analysis here assumed and incorporated a water feed quality baseline of 35,000 ppm (TDS), approximately that of seawater. Finally, recovery is a key component of selecting an optimum treatment technology. For this analysis, recovery is defined as the ratio of cleaned water produced vs. the influent water processed. Virtually all of these processes evaluated here are essentially concentration processes, whereby most of the contaminants in the influent source are concentrated to produce both a treated product stream and a reject stream (requiring disposal).

Estimated Removal of Contaminants (%)	Rank
Greater than 95	5
90-95	4
75-89	3
50-75	2
Less than 50	1

5.2 Criterion 2 – Flexibility Over Time

Additionally, any treatment technology must have the ability to perform over a long period of time in the face of changing feed qualities due to natural modals, production enhancement operations [fractionating, multi-zone completions, etc], and the simple production requirement of operating twenty-four hours a day, seven days a week. What treatment technologies offer the ability to be readily modified over time in response to changing conditions and new information? How flexible is the technology to changing weather conditions, increases in feed water amounts or concentrations, changes in feed constituents (e.g., scalability), overall durability, mobility, etc.?

Amount of Flexibility	Rank
High	5
Moderately high	4
Moderate	3
Moderately low	2
Low	1

5.3 Criterion 3 – Cost Effectiveness

Which treatment technologies deliver "the most bang for the buck?" Cost is viewed not only in capital outlay, but also in the amount of other resources such as the amount of energy required to treat the water, the amount of time required, and the amount of total cost required to meet acceptable treatment standards. Capital costs are generally considered in terms of dollars per barrel per day capacity ($/BPD). Operating costs are generally considered in terms of dollars per barrel ($/B).

Treatment cost information is very difficult to pinpoint. A primary cost ingredient is the cost of energy, which varies greatly depending on (1) treatment time, (2) geography, and (3) effluent concentration levels. In addition, other costs such as the degree of pretreatment required also vary considerably by technology (e.g., RO membranes require very high levels of pre-treatment and consumable chemicals; other techniques such as Dewvaporation require no pre-treatment). Finally, the size (economies of scale) also plays a significant role in bottom line cost.

To aid in sustaining a low operating cost, technologies that support an unattended operation platform are preferred. If the technology solution cannot treat the produced water on an unattended basis, the process must alternatively treat extremely large volumes of water with attended supervision, to make up for the additional human cost. Currently, few well site activities require an attendant operator. Well sites pump oil and gas unattended, except for the occasional visit from the pump reader or produced water hauler. Unattended operation is defined as requiring no operator interface beyond that of an oil-field HPS [High Pressure Separator] for 90 days. Typical operator interface of an HPS is daily visual examination for leaks and minor adjustments to operating pressures and levels. In addition, many oil and gas wells are located in remote locations, often far away from one another. The labor cost to visit these wells on a daily basis is prohibitively high. In addition, well processes must be simple, reliable and durable in order to ensure that production does not cease if left unattended.

Amount of Resource	Rank
Low	5
Moderately low	4
Moderate	3
Moderately high	2
High	1

5.4 Criterion 4 – Equity Considerations

What are the differing effects on communities and economic activities of the proposed treatment technology in the project's proposed area? (i.e. footprint, noise, environmental impact, ability to reduce current community water usage or water-hauling truck travel, etc.)

Equity Considerations Positives	Rank
High	5
Moderately high	4
Moderate	3
Moderately low	2
Low	1

5.5 Criterion 5 – Potential Harmful Side Effects

Do some of the potential treatment technologies for the proposed projects create new problems and/or interact negatively with existing water supply and quality issues? Does the process require the addition of pre-treatment or post-treatment chemicals or acids, which could potentially leak into ground-water?

Amount of Harmful Side Effects	Rank
Low	5
Moderately Low	4
Moderate	3
Moderately High	2
High	1

5.6 Criterion 6 – Scalable to Individual Well-sites

The cost to transport the water to and from a treatment facility is not only highly variable, but usually represents the single largest cost of present disposal or treatment costs. A given technology may be rated high in all the above parameters, but is not likely to be effective at treating oil and gas produced waters if it is only economical in large-scale centralized plants for which the produced water must be hauled many miles over roads using tanker trucks. Which technologies can be economically scaled down small enough to operate economically at individual well sites, thus eliminating the need to gather or truck the produced water to a central processing plant?

Scalable to Individual Well-Sites	Rank
High	5
Moderately High	4
Moderate	3
Moderately Low	2
Low	1

6. TECHNICAL ASSESSMENT OF TREATMENT TECHNOLOGIES

Based on the high degree of complexity of produced water chemistry, produced water treatment technologies are presently not in wide use. Those that are have historically been applied only to mildly saline waters (almost drinkable before treatment, such as some CBM produced water), and they have largely been developed by oil and gas operators on a case-by-case approach. In those few applications where the treated produced water is placed to beneficial use, applicable effluent standards come into play in selecting the optimum technology platform. Traditionally, produced water treatment attempts have focused on the removal of the following impurities:[63]

1. Total Dissolved Solids (TDS) – salts;
2. Oil and grease ;
3. BTEX (benzene, toluene, ethyl-benzene, and xylene);
4. Concentrations of biological oxygen demand arising from soluble organics;
5. Suspended solids;
6. Hydrogen sulfide;
6. Total and fecal coliforms in final effluent streams;

In addition, environmental and economic factors dictate treatment options with respect to:

1. Reduction in brine volumes requiring disposal;
2. Special constituents of concern (i.e. boron) that restrict usage of the effluent (i.e. irrigation);
3. Adjustment of the Sodium Absorption Ratio parameter (SAR) to avoid soil damage in land application (irrigation, infiltration, groundwater recharge, etc.)

The following represents a brief survey of nine (9) produced water treatment technologies and options that either have been, or are being, investigated by industry and/or regulators. For each of the nine technologies investigated in this study, a brief overview of the treatment process is provided along with a summary of key advantages and disadvantages. Where applicable, pilot/case studies have been provided for each technology.

6.1 Pressure Driven Membrane Separation Technologies

Microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) have been employed for the treatment of produced water and represent the most common techniques attempted for produced water purification. In particular, these hyperfiltration technologies have been utilized as a means of achieving brine reduction for low-TDS CBM produced water as well as conventional gas well produced water. Each utilizes high pressure across the membranes to

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[63] Arthur, D.: "Technical Summary of Oil & Gas Produced Water Treatment Technologies" March 2005.

accomplish filtration of contaminants from the produced water, concentrating it into a reject stream that then requires disposal.

Figure 11 outlines particular membrane characteristics:

	Reverse Osmosis	Nanofiltration	Ultrafiltration	Micro filtration
Membrane	Asymmetrical	Asymmetrical	Asymmetrical	Symmetrical Asymmetrical
Thickness Thin film	150 μm 1 μm	150 μm 1 μm	150 - 250 μm 1 μm	10-150 μm
Pore size	<0.002 μm	<0.002 μm	0.2 - 0.02 μm	4 - 0.02 μm
Rejection of	HMWC, LMWC sodium chloride glucose amino acids	HMWC mono-, di- and oligosaccharides polyvalent neg. ions,	Macro molecules, proteins, polysaccharides vira	Particles, clay bacteria
Membrane material(s)	CA Thin film	CA Thin film	Ceramic PSO, PVDF, CA Thin film	Ceramic PP, PSO, PVDF
Membrane Module	Tubular, spiral wound, plate-and-frame	Tubular, spiral wound, plate-and-frame	Tubular, hollow fiber, spiral wound, plate-and-frame	Tubular, hollow fiber
Operating pressure	15-150 bar	5-35 bar	1-10 bar	<2 bar

Figure 11: Characteristics of Membrane Separation Technologies
[Source: J. Wagner, Membrane Filtration Handbook, 2nd Ed. R 2, 2001}

MF, UF and NF reject contaminates larger than the pore size of the membrane whereas RO uses an operating pressure higher than the osmotic pressure of the salt present in the water to drive pure water through the membrane, thereby rejecting most of the salts. The rate of flow of pure water through the membrane is dependant upon the salt concentration, temperature of the water and the net driving pressure (provided by a high pressure pump). At higher pressures, the permeate quality improves due to a greater increase in water flux than the increase in solute flux. The physical strength of the membrane and support material limits the practical maximum operating pressure. All membrane techniques require high amounts of electricity that are often not present at many wellsites.

In gas-liquid separation, the pressure difference across a selective membrane deals with pore size of approximately 0.03 micrometers (30 nm). Gas penetrates into the membrane at a rate based on diffusivity and solubility of molecules to attain the equilibrium between the gas phase and the solute gas in liquid. The pressure difference is a result of vacuum or gas sweep through the membrane.

Recently, there have been many new membrane technologies applied to produced water treatment. Osmonics, Inc. has developed a spiral wound membrane. These spiral wound membranes were advertised to offer the most efficient packing of membrane area to provide higher membrane contact area in a very limited space. The performance of these membranes is reduced by higher temperatures – optimum temperature is between 113-122°F. Higher temperatures up to 194°F can be used but requires more energy to achieve the desired separation. Ionics, Inc. has developed a HERO membrane to provide higher water recovery, higher quality permeate and higher operating flux than conventional RO treatment. Yet the HERO membrane still requires pretreatment of the feed water prior to RO operation to raise the pH of the feed water to obtain optimum efficiency by removing boron and reducing membrane fouling. The PRRC of New Mexico Institute of Mining and Technology has developed inorganic membranes for use with produced water treatment of greater than 50,000 ppm in the San Juan Basin, as well as greater than 100,000 ppm in the Permian basin. These inorganic membranes are made up of zeolite and provide higher flux, pH compatibility and both thermal and chemical stability. Finally, New Logic Research, Inc. has created a vibrating membrane (VSEP) to address fouling and scaling of the membranes.[64] Continual and incremental improvements in membrane design will likely continue; however membrane technologies have not overcome the costly pre-treatment processes required for complete produced water purification.

Advantages

- Compact, small footprint
- Higher volume recovery - 3:1 reduction in brine volume
- Deionized produced stream of good quality water can be achieved

Disadvantages

- High requirement of high quality (electrical) energy
- Can only treat low-TDS produced waters, below 35,000 TDS
- Extensive, specific well-customized, non-modular pre-treatment required including:
    - → oil and grease
    - → boron
    - → monovalent salts
    - → organics
- Complexity of operation and maintenance
- Need for qualified operator to maintain and operate systems
- Not easily scaled down to small operation

Pilot/Case Study

In 2001, Osmonics conducted a produced water pilot study using membrane technology. The goal of the study was to treat produced water that met federal and statue surface discharge quality standards employing Osmonics' spiral wound membrane modules. The oil well was

[64] www.vsep.com, November 11, 2005

located in southern California near Bakersfield. The produced water occurs at 185 F with an approximately 10,000 ppm salt content with suspended solids. The produced water was also saturated with iron, silica and boron. The pilot study was operable for six months and processed approximately 20 gallons of produced water per minute for a total of approximately 1,700 hours of operation. The three step membrane treatment process, combined with an ion exchange step, yielded water suitable pursuant to land application regulatory requirements. Unfortunately, the 0.75 ppm limit for boron was not met. Following Osmonics' treatment, the boron amount still registered between 5-10 ppm. Therefore, an ion-exchange post treatment process had to be added to reduce boron limits to acceptable land discharge limits. Additional pre-treatment included pH adjustment to 5.8 using sulfuric acid; suspended solids were settled in a conical bottom tank, CO2 and H2S were degassed from the top of the tank and were passed through a cartridge filter.[65]

Another membrane-based produced water treatment pilot was conducted at Placerita Canyon Oil Field in California. This pilot treatment process used warm softening, coconut shell filtration, fin-fan cooling, tricking filter, ion exchange and reverse osmosis. The warm softening process (utilizing MgCL2 and an ionic polymer) removed approximately 95% of the hardness of the water. Silica levels were 80 and 20 mg/l at a pH of 8.5 and 9.5 respectively in the softening effluent. Approximately 90% of the boron was removed using a pH of 10.5 or above. Ammonia removal using a pH of 8.7 or below came in at 80%.[66]

In 2002, a membrane-based produced water treatment pilot was tested by Yates Petroleum Corporation in southeastern New Mexico. The pilot plant aimed to treat up to 100,000 bbls/day of produced water.[67] The pilot was taken out of service in February 2005 because of produced water pre-treatment issues associated with membrane fouling. Recent experimental work has been re-initiated to evaluate different pre-treatment processes.

Governor Richardson's Water Innovation Fund I (2004) funded two produced water treatment proposals. R.I. Sullivan & Associates and NA Water Systems are both involved in produced water treatment projects. No public information is available at this time.

6.2 Ion Exchange

The ion exchange process effectively removes arsenic, heavy metals, nitrates, radium, salts, uranium, and other elements from produced water. Ion-exchange is a rapid and reversible process in which impurity ions present in the water are replaced by ions released by an ion-exchange resin. The impurity ions are taken up by the resin, which must be periodically regenerated to restore it to the original ionic form. (An ion is an atom or group of atoms with an electric charge. Positively-charged ions are called cations and are usually metals; negatively-

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[65] http://www.gewater.com/library/tp/1159_Produced_Water.jsp, November 11, 2005.

[66] Funston R., Ganesh R., and Leong Lawrence Y.C.: "Evaluation of Technical and Economic Feasibility of Treating Oilfield Produced Water to Create a New Water Resource," paper presented at the 2002 Groundwater Protection Council (GWPC) Meeting.

[67] See http://wrri.nmsu.edu/conf/forum/Yates.pdf, November 19, 2005

charged ions are called anions and are usually non-metals). The following ions are widely found in raw waters:

Cations	Anions
Calcium (Ca^{2+})	Chloride (Cl^-)
Magnesium (Mg^{2+})	Bicarbonate (HCO_3^-)
Sodium (Na^+)	Nitrate (NO_3^-)
Potassium (K^+)	Carbonate (CO_3^{2-})
Iron (Fe^{2+})	Sulfate (SO_4^{2-})

There are two basic types of resin - cation-exchange and anion-exchange resins. Cation exchange resins will release Hydrogen (H^+) ions or other positively charged ions in exchange for impurity cations present in the water. Anion exchange resins will release hydroxyl (OH^-) ions or other negatively charged ions in exchange for impurity anions present in the water. A residential water softener is an example of a cation-exchange process – replacing 'hard' water cations of calcium and iron with sodium.

Advantages

- Easily modified
- Secondary pollutants and waste shifting from one media to another (i.e. membrane) usually avoided
- Components are easier to access than membrane systems
- Relatively cheap operating costs
- Process is considered non-polluting

Disadvantages

- Cannot treat all produced water constitutes, especially organics or suspended solids
- Extensive pre-treatment as in RO membranes
- Effectiveness highly dependent on initial constituent concentrations
- Often post-treatment requirements for produced water feeds
- SAR adjustments often required (i.e. divalent ions are removed preferentially to sodium)
- Produce higher volume effluent concentrate
- Need for operator, constant monitoring

Case/Pilot Study

Ion exchange has several applications in produced water treatment including hardness removal, desalination, alkalinity removal, radioactive removal, ammonia removal and heavy metal removal. EMIT Water Discharge Technology, LLC has developed a new treatment process that uses DOWEX G-26 (strong acid cation exchange resin manufactured by DOW Chemical Co.) G-26 resin has sulfonic acid (SO_3H^+) group that exchanges Na^+, Ba^+, Ca^{2+} and Mg^{2+} with H^+ ions. This ion exchange process is accomplished with a Higgins Loop operation (Figure 12). Produced water containing high Na levels is fed to the adsorption zone within the Higgins Loop where it contacts strong acid cation resin which loads Na ions in exchange for hydrogen (H) ions. Treated water exits the loop containing less than 10 mg/L Na. Concurrent with adsorption and in the lower section, Na-loaded resin is regenerated with either hydrochloric or sulfuric acid to produce a small, concentrated spent brine stream. Regenerated resin is rinsed with water prior to reentering the adsorption zone to remove acid from its pores. As resin in the upper layer of the adsorption zone becomes loaded with Na, the flows to the Higgins Loop are momentarily interrupted to allow advancement of the resin bed (pulsing) through the loop in the opposite direction of liquid flow. Liquid flows are restarted after resin pulsing is complete. Treated water is slightly acidic due to its increased H ion strength, and it is neutralized with limestone which also increases its calcium concentration so that the water's sodium adsorption ratio (SAR) is less than 1.0.[68]

This treatment technology was field tested on a CBM well in the Powder River Basin of Wyoming. Emphasis was on the removal of sodium ions and reduction of SAR using the calcium addition and the Higgins Loop. Test results are outlined in Table 3. The increase in calcium, chloride and sulfate levels were due to chemical addition during SAR adjustment. Throughput was 200 GPM during the field trial.[69]

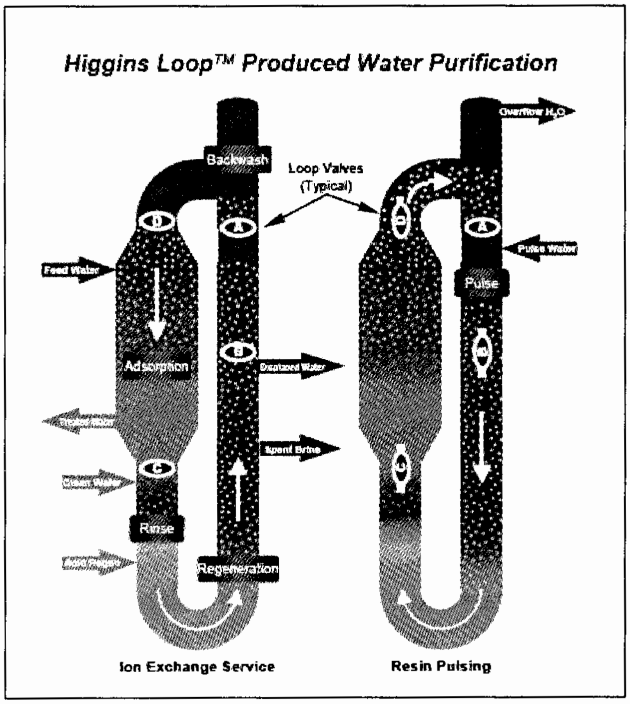

Figure 12: Higgins Loop Technology (Source: Seven Trent Services)

[68] http://www.severntrentservices.com/water_purification/filtration_products/ion_exchange/higgins_loop.jsp

[69] "A Low Cost Option to Reduce Sodium Levels in Coal Bed Methane Co-produced Wastewater Using DOWEX G-26 Resin", DOWEX Ion Exchange Resins, The Dow Chemical Company.

Table 3: Ion Exchange Treatment Results Using a Higgins Loop

Analyte	Influent Produced Water	Treated Water	Removal (%)
Na (ppm)	486	12	97.53
Ca (ppm)	22.2	113	-407
Mg (ppm)	13.2	< 1	>93
K (ppm)	13.5	<1	>93
Ba (ppm)	0.72	ND	100
Carbonate (ppm)	<1	<1	-
Bicarbonate (ppm)	1,430	311	78.52
Chloride (ppm)	18	42	-133.33
Sulfate (ppm)	1	1.1	-10
SAR	20.2	0.3	98.51
pH	8.1	6.5	19.75

Source: Dow Chemical Company

Sandia National Laboratories has reported use of Hydrotalcite (HTC), an anion exchanger, and Permutite, a cation exchanger. These ion exchangers are comprised of inorganic oxides which provide stability over a large range of pH. Based on the results of various experiments, SNL reports average ion exchange capacity of HTC and Permutite of 2.5 mEg/gram (measured with Na_2SO_4) and 1.7-2.7 mEg/gram (measured with NaOH). SNL further attempted to determine the effects of regeneration on the ion exchange capacity. Permutite demonstrated ability to regain ion exchange capacity without significant loss. Regeneration of HTC at low temperatures, however, was not promising. Regeneration at higher temperatures was cost-prohibitive.[70]

6.3 Electrodialysis (ED)

Electrodialysis (ED) is an electrically-driven process, traditionally operating at very low pressure drops of approximately 25 pounds per square inch (psi) across the process. This compares with the typical pressure drop across an RO platform of between 400-1,400 psi which translates into higher energy consumption and operating costs. Electrodialysis reduces salinity by transferring ions from feed-water compartments, through membranes, under the influence of an electrical potential difference (Figure 13). The positively and negatively charged ions of the dissolved salts in saline feed-water will move towards oppositely charged electrodes immersed in the solution. An electrodialysis 'stack' consists of multiple pairs of membranes between two electrodes with a spacer assembly between each pair to collect the dilute and concentrated solutions. The electrodialysis reversal system (EDR) reverses the polarity periodically.

[70] Managing Coal Bed Methane Produced Water for Beneficial Uses, Initially Using the San Juan and Raton Basins as a Model, Sandia National Laboratories, Interim Report prepared for NETL, 2004.

Therefore each flow channel has low-salinity dilute streams washing away any scale left by the high-salinity stream of the other polarity.

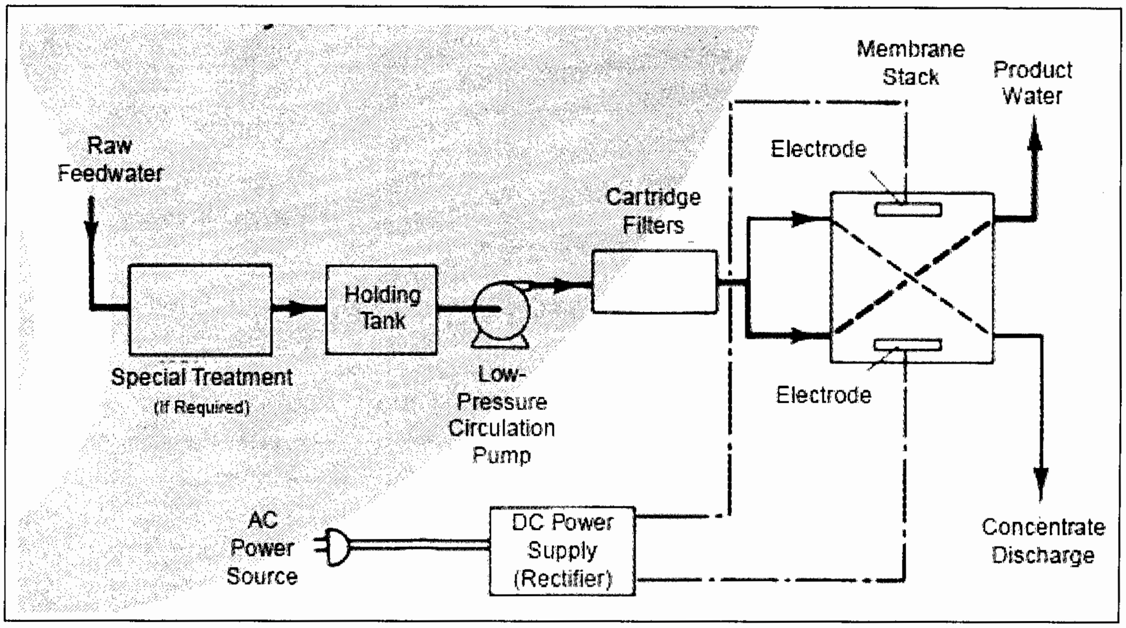

Figure 13: Basic Components of an Electrodialysis Unit (Source: US Agency for International Development)

The major parts of an electrodialysis unit are the rectifier (to produce direct current), a membrane stack and a low pressure pump to circulate water through the system (Fig 1). Recent technological advances consist of the commercial introduction of the electrodialysis reversal process and increased reliability due to minor process design changes. Though more complex than reverse osmosis, only standard lower pressure pumps are required. Stacks can be disassembled, hand-cleaned and reassembled, which though time and labor intensive, may be preferred to purchasing new units, as often required in reverse osmosis.

Advantages

- Can sustain higher temperatures of produced water from the well-head
- Higher temperature allowances result in reduced viscosity
- ED accepts silt density index values of 12 vs. 3 for RO
- Design of ED components allow for greater flexibility in addressing (cleaning) fouling problems
- Clean technology, no chemical additives
- High mobility of technology

Disadvantages

- Requires regeneration of membranes
- Fouling problems
- Does not remove non-ionic contaminants, like organics
- Less Efficient with high concentrations

- High quality power requirements increase proportionately to feed TDS.
- Extensive pre-treatment as in RO membranes.

Case/Pilot Study

An ED produced water pilot project took place at a conventional well in the Wind River basin of Wyoming near the town of Lysite. The well contained H_2S, oil, acid, BTEX, dissolved solids and a TDS of 10,000 ppm. The oil and grease content was about 65 ppm and the biological oxygen demand value was more than 330 ppm including acetates and volatile acids. The mobile platform consisted of a gas flotation de-oiling unit, two fluidized bed reactors for dissolved solid removal and a desalting/demineralization component using an ED unit. The ED removed approximately 89% of TDS from the produced water.[71] Table 4 summarizes the results.

Table 4: Results of Electrodialysis Treatment of Produced Water

Analyte	Influent (ppm)	Effluent (ppm)	% Removal
Oil and grease	90	4	95.5
Biological oxygen demand	330	51	84.5
BTEX	11	0.1	99.1
TDS (using ED)	9,100	1,000	88.9

Source: Hayes T. "The Electrodialysis Alternative for Produced Water Management", Gas Technology Institute (2004).

6.4 Capacitive Deionization

Capacitive deionization technology is similar to ED, except that no membranes are employed. Capacitive deionization is centered about a multi layer capacitor often referred to as a flow-through capacitor (FTC). The following summary of flow through capacitor technology was taken largely from the Biosource Inc. technology description. Biosource has developed and has shown the potential of this engineered technology. (Sandia National Laboratories has further investigated the promise of this technology, in the laboratory, with a Biosource demonstration unit.)

The flow through capacitor/capacitive deionization is simply a capacitor of the electric double layer type designed to provide a flow path for water. Due to the capacitance, a very strong field gradient exists right at the conductive surface. The ionic contaminants are pulled perpendicular to the flow path, down into the electrodes presently made of carbon. Upon applying a DC voltage, ionic contaminants electrostatically adsorb to the conductive high surface area carbon, with an equivalent amount of electronic charge (Step 1 of Figure 14). The flow-through capacitor is regenerated by short circuiting its leads through a load and reversing the voltage. This neutralizes and then reverses the charge, repelling the absorbed contaminants into a concentrated waste stream (Step 2 of Figure 14).

[71] Hayes T.: "The Electrodialysis Alternative for Produced Water Management", Gas Technology Institute (2004).

The ability to turn the surface charge off electronically allows for chemical free regeneration. To prevent fouling, the polarity of the flow through capacitor electrodes can be reversed every charge cycle. This tends to drive off foulants that might tend to favorably attract on one polarity electrode. The flow through capacitor holds a charge and stores energy when disconnected from the power source, just like an ordinary capacitor. Simultaneously, stored energy is released as DC current. The electronic charge of the flow-through capacitor is not fixed. It can be turned on and off, or modulated electronically.

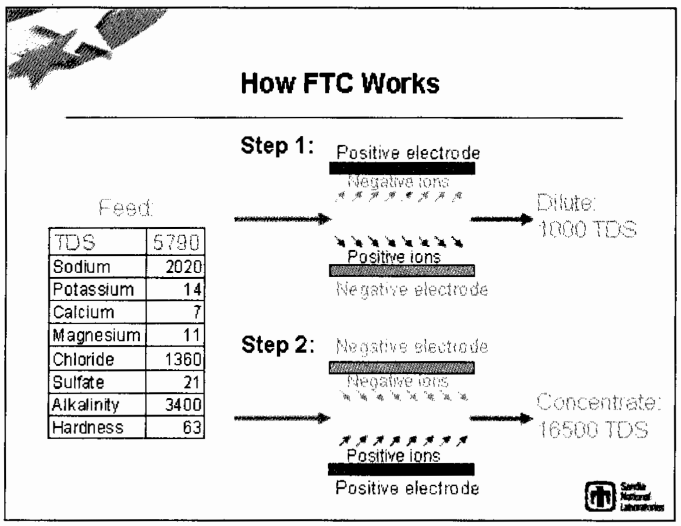

Figure 14: How Capacitive Deionization Works
[Source: Sandia National Laboratories]

Advantages

- Lower energy required compared to standard ED
- No membranes
- Higher throughputs

Disadvantages

- Expensive electrodes required
- Fouling an issue
- Only low-TDS produced water treatable
- High electrical cost
- Extensive pre-treatment as in RO membranes.

Pilot/Case Study

Sandia National Laboratories has acquired funding (through DOE) to install a capacitive deionization pilot unit at a Conoco Phillips well site. The proposed pilot will be capable of desalinating between 0.40 to 1.0 barrels of brackish coal bed methane brine per hour. The input brine is estimated to be approximately 6,000 TDS and the target output stream will be approximately 1,500 TDS. The duration of the field operation will be two months. The capacitive unit is to be built by Biosource (inventor/manufacturer).

6.5 Rapid Spray Evaporation

Rapid Spray Evaporation (RSE) is a desalination process of ejecting contaminated water at high velocities through a specialized injector-nozzle into a heat source. The unit employs a heating element for a heat source across which air is blown into the evaporation chamber. Very small droplets of saltwater are rapidly evaporated in a heated air stream. The evaporation results in water vapor and precipitated salt particles. The salt particles are collected in a slurry or dried form; and the water vapor is condensed, resulting in potable water.

Advantages

- Unlike reverse osmosis, RSE does not use membrane technology, which requires expensive periodic maintenance
- Higher conversion efficiency
- High quality of treated water stream

Disadvantages

- High energy required (low "f" value); high cost
- Required handling of solid (waste in sludge form at end of evaporation)
- Seasonal performance variations
- Weather performance variations.

Pilot/Case Study

Westwater Resources, Inc., using a RSE bench unit, conducted a test with feed water containing up to 13% salt. In the demonstration trial using real wastewater from a power plant evaporation pond, a single pass though the RSE bench unit dropped the total dissolved solid concentration from 130,000 milligrams per liter to 440 milligrams per liter. Additional test results are summarized in Table 5.[72]

Table 5: Results of Rapid Spray Evaporation Treatment of Produced Water

Analyte	Untreated	Treated	Concentrate
Calcium	79	1.6	20
Magnesium	490	1.7	600
Sodium	25,000	160	57,000
Potassium	610	1.9	1,100
Chloride	5,000	90	8,400
Sulfate	31,000	150	35,000
Bicarbonate	5,700	20	2,900
Phosphate	1,200	0	-
Carbon Dioxide	3,100	0	-
TDS	130,000	440	180,000

Source: Westwater, Inc.

72 http://www.aquasonics.com/news.html, November 12, 2005

6.6 Freeze Thaw Evaporation

Freeze-Thaw Evaporation (FTE) relies on nature's freezing and evaporation cycles. The principle behind freeze-thaw is based on the fact that salts dissolved in water lower the freezing point of the solution below 32 degrees F. Partial freezing occurs when the solution is cooled below 32 degrees F, but held above the depressed freezing point of the solution. In that range, relatively pure ice crystals form, and an unfrozen brine solution containing elevated concentrations of the dissolved salts can be drained away from the ice. When the ice melts, it is essentially pure water. The produced water is frozen by spraying onto a lined pond (freezing pad) when winter temperatures reach the appropriate level (see Figure 15). The concentrated brine is drained from the pad during the freezing cycle, and the purified melt water is collected during the thaw cycle.

Figure 15: FTE Unit
[Source: Hart Energy Productions]

Advantages

- Little energy required
- Natural process
- Relatively cheap to operate

Disadvantages

- Limited geographical applicability (temperature-wise)
- Low conversion efficiency
- Long operation cycle
- Seasonal performance variations.
- Large area requirements.

Pilot/Case Study

A joint venture between the Gas Technology Institute (GTI) and BC Technologies has achieved commercial operation of its proprietary Freeze-Thaw/Evaporation (FTE) process for produced-water handling. Crystal Solutions has been operating its own produced-water treatment facility, which is now operating near capacity. The facility serves operators in the Red Desert/Great Divide basin near Wamsutter, Wyoming. The company also operates a similar facility owned by McMurry Oil.

The technology was previously evaluated by BP in New Mexico's San Juan basin and by McMurry Oil in the Green River basin of Wyoming. In 1999-2000, field data show that a feed water with 14,000 mg/l of total dissolved solids (TDS) is converted to a brine with 64,300 mg/l TDS and a melt water with only 924 mg/l TDS. Roughly 55% of the feed is converted to melt water, about 30% is lost to evaporation and/or sublimation, and only about 15% of the original feed remains as concentrated brine – which in this particular case, due to the brine having a potassium chloride concentration in excess of 2%, results in a usable product for drilling applications.[73]

6.7 Packed Bed Absorption

ET Ventures, LLC, located in South Carolina, conducted a packed bed adsorption field test for the treatment of produced water at Rocky Mountain Oilfield Testing Center in July 1996. Test goal of the test was to determine the effectiveness in adsorbing hydrocarbons from produced water through polymer modified bentonite. The produced water was atmospherically cooled to 90F and then flowed through a three-stage packed bed adsorption treatment system. The first two stages contained a sodium bentonite modified organically. The final stage contained granular activated carbon (GAC). The test system operated at 10 GPM with a maximum 10 psi pressure drop. Table 6 outlines the results obtained during the field test. The Packed Bed Adsorption removed total petroleum hydrocarbon (TPH) below detectable limits. Oil and grease values were also below detectable limits. BTEX was removed to below detectable levels after GAC adsorption treatment.[74]

Advantages

- Compact footprint (packed bed modules)
- Relatively cheap to operate
- Efficient
- Low maintenance

Disadvantages

- Only treats one contaminant; does not remove salt from produced water
- High retention time for treatment
- Less efficient at higher volume feed rates

[73] Lang, K. "Managing Produced Water" Excerpts in PTTC Network (4th Quarter 2000)

[74] Doyle D.H., Daniel F., and Brown A.B.: "Field Test of Produced Water Treatment with Polymer Modified Bentonite," paper SPE 38353 presented at the 1997 Rocky Mountain Regional Meeting, Casper WY.

- Less efficient at higher concentrate feed rates
- Extensive pre-treatment as in RO membranes.

Table 6: Results of Packed Bed Absorption Treatment of Produced Water

Analyte	Before Treatment (ppm)	After Treatment (ppm)
Total petroleum hydrocarbons	159	1.1
Oil and grease	151	1.2
Benzene	3.14	<0.5
Toluene	4.97	<0.5
Ethylbenzene	4.95	<0.5
Xylene	29.70	<1.0

Source: Doyle D.H., Daniel F., and Brown A.B.: "Field Test of Produced Water Treatment with Polymer Modified Bentonite"

6.8 Constructed Wetlands

The Navel Petroleum Reserve No. 3 (Department of Energy) has a bio-treatment facility located in Natrona County in east central Wyoming. The average volume is approximately 35,000 barrels per day of produced water. This wetland treatment facility commenced operation in January 1996 to provide industry with a more cost effective alternative to re-injection and to benefit local wildlife through purified water discharge. The technology is based on a thin film bioreactor that utilizes various species of plants and microbes along with sands that oxidize contaminates found in the produced water. The system is comprised of a cooling tower, cooling trench, netted pond, wetland, and oxidation stage. Once complete, the water is discharged into a nearby creek for wildlife beneficial use.[75] Particular steps include:

1. Cooling tower followed by a shallow cooling trench to reduce produced water temperature from approximately 190F to below 100F.

2. A netted/skimming pond is utilized to further cool the water as well as remove any suspended solids and oil. Dispersed oil is skimmed off periodically.

3. Various types of flora and fauna including hydrocarbon decomposing bacteria, sulfate reducing bacteria, nitrifying and denitrifying bacteria, iron related bacteria, and algae are used to biodegrade produced water contaminates.

4. Various microorganisms in the wetlands degrade remaining contaminates; any additional traces of hydrocarbons are removed via an oxidation process.

[75] Myers J.E., Jackson L.M., Bernier R.F., and Miles D.A.: "An Evaluation of the Department of Energy naval Petroleum Reserve No. 3 Produced Water Biotreatment Facility", paper SPE 66522 presented at the 2001 SPE/EPA/DOE Exploration and Production Environmental Conference, San Antonio, TX.

Treatment results are summarized in Table 7. Although TDS levels were not appreciably affected, numerous produced water contaminates including organics, alkalinity, and ammonia were reduced.

Table 7: Results of Constructed Wetlands Treatment of Produced Water

Analyte	Influent (ppm)	Effluent (ppm)	% Removal
NH_3	2.03	0.54	73
NO_3	<0.1	<0.1	-
Phosphorus	1.83	0.46	75
BOD	28	2.3	92
Chemical oxygen demand (COD)	48	29	40
Total organic carbon (TOC)	32.7	3.6	90
TPH	112	5.8	95
Oil and grease	71.9	4.2	94
Benzene	0.143	<0.001	100
Toluene	0.135	<0.001	100
Ethylbenzene	0.035	<0.001	100
Xylene	0.162	<0.001	100
Turbidity	45.4	4.76	90
TDS	4380	4010	9
Alkalinity	713	190	73

Source: Myers J.E., Jackson L.M., Bernier R.F., and Miles D.A.: "An Evaluation of the Department of Energy naval Petroleum Reserve No. 3 Produced Water Biotreatment Facility"

Advantages

- Cheap operation (using natural environment)
- Efficient removal of suspended contaminates

Disadvantages

- Only treats some contaminant; does not remove salt from produced water
- High retention time required for treatment
- Relatively expensive to maintain
- Susceptible to temperate and pH effects
- Seasonal performance variations
- Very, very large area requirements.

6.9 Carrier-Gas Dewvaporation

The Carrier-Gas Dewvaporation process was recently developed and patented at Arizona State University. This revolutionary technique is a derivative of the humidification-dehumidification desalination process. Dewvaporation is a highly efficient, low cost alternative to common industrial distillation methods as a multi-stage flash and vapor compression distillation. The process uses low grade steam as the energy source and can be operated at standard atmospheric temperature and pressure. Due to these low temperature requirements, the system can be fabricated from inexpensive plastics such as extruded polypropylene. These low cost plastics eliminate the need for expensive and labor intensive pretreatment of highly turbid, corrosive, or scale forming contaminates. Since the wetted surfaces of a dewvaporation unit are fabricated entirely from plastic, the technology is inherently resistant to scaling, and is well suited for complex, produced water treatment.

Dewvaporation towers are approximately the size of a residential water heater and a single unit is capable of processing 150-250 gallons per day of water with salt concentration in excess of 150,000 ppm. Dewvaporation towers are available for purchase as stand alone units but are typically used as integral components of large volume water treatment systems. Dewvaporation-based treatment systems can process 1,000 to 2,000 gallons per day of produced water, and can reduce effluent disposal requirements by as much as 80%. Since the treated water stream is distilled water, the quality of water from Dewvaporation is extremely high.

A diagram of the dewvaporation system is shown in Figure-16. The water vapor from the evaporation chamber is transferred to the condensation chamber by a carrier gas, with the ability to absorb and desorb pure water from the produced water several times over resulting in extremely high efficiencies.

Ambient air is brought into the bottom of the tower on the evaporation side of a heat transfer wall. The wall is wetted by saline feed water, which is fed into the evaporation side at the top of the tower. As the air moves from the bottom to the top of the tower, heat is transferred into the evaporation side through the heat transfer wall allowing the air to rise in temperature and evaporate water from the wetting saline liquid which coats the heat transfer wall. Concentrated liquid leaves from the bottoms of the tower and hot saturated air leaves the tower from the top. Heat is added to this hot air by an external heat source (low grade, atmospheric stream). This hotter saturated air is sent back into the top of the tower on the dew formation side. The dew formation side of the tower, being slightly hotter than the evaporation side, allows the air to cool and transfer condensation heat from the dew formation side to the evaporation side. Finally, pure water condensate and saturated air leave the dew formation side of the tower at the bottom.

Advantages

- Extremely high quality of treated water
- Relatively low cost
- High thermal efficiency
- Unattended operation
- No fouling

- No scaling
- No membranes to replace
- Operates at ambient temperature
- Operates at ambient pressure
- Uses waste heat to operate
- No pre-treatment
- No post-treatment

Disadvantages
- Waste in sludge (concentrate) form for disposal (required handling)
- Larger footprint than RO

Pilot/Case Study
A beta field test using real produced water was conducted by Altela, Inc. employing the carrier-gas dewvaporation on a conventional oil well located in southeastern New Mexico in August 2005. The test results received from an independent water quality lab demonstrate the very high quality of treated water obtained from of this simple, elegant technology for the treatment of produced water. Total dissolved solids were reduced from 40,620 mg/L to a 27.0 mg/L. Chloride was reduced from 28,900 mg/L to 5.64 mg/L. Fluoride was non-detectable following treatment from an original 18.6 mg/L. Similarly, benzene levels were reduced from 260 mg/L to non-detectable following dewvaporation treatment. Detailed water quality data following dewvaporation treatment is outlined below in Table 8.

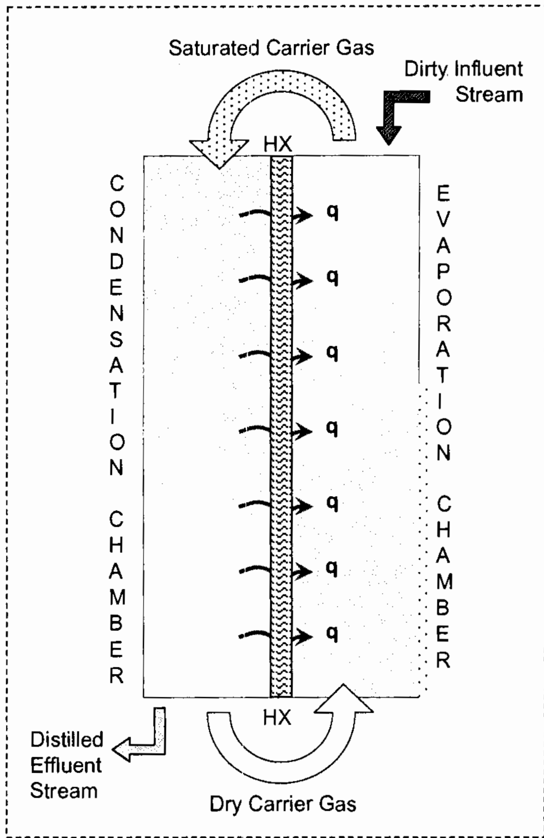

Figure 16: Carrier Gas Dewvaporation Schematic

Economic analysis indicates that a 1,000 gal/day unit could be built for as little as $1,397, and operated with natural gas for $3.35/day or with waste heat for $1.52/day[76]. A small unit (20 ft^2 of heat transfer surface) has been constructed out of thin water-wettable plastic and operated with a pressure drop of less than 0.1 inch of water. A gained output ratio (energy reuse) of 11 has been demonstrated with this unit.[77]

[76] J.R. Beckman, "Innovative Atmospheric Pressure Desalination" U.S. Bureau of Reclamation Water Treatment Technology Program Report No. 59, June 2000.

[77] Id.

Table 8: Carrier-Gas Dewvaporation Produced Water Beta Pilot Data from Oil Well

Analyte	Influent (Produced Water)	Effluent	% Removal
Total Dissolved Solids	40,620 mg/L	27.0 mg/L	>99
Chloride	28,900 mg/L	5.64 mg/L	>99
Fluoride	18.6 mg/L	ND	100
Sulfate	22.8 mg/L	4.12 mg/L	82
Aluminum	1.56 mg/L	ND	100
Arsenic	ND	ND	100
Barium	14.9 mg/L	0.005 mg/L	>99
Cadmium	ND	ND	100
Chromium	0.0008 mg/L	ND	100
Cobalt	ND	ND	100
Copper	0.392 mg/L	ND	100
Iron	51.7 mg/L	ND	100
Lead	0.011 mg/L	ND	100
Boron	118 mg/L	1.14 mg/L	> 99
Manganese	0.975 mg/L	ND	100
Molybdenum	0.011 mg/L	ND	100
Nickel	0.011 mg/L	0.002 mg/L	82
Selenium	ND	ND	-
Silver	ND	ND	-
Zinc	0.754 mg/L	0.172 mg/L	77
Radium 226	65.45 +/- 1.02	0.13 +/- 0.06	>99
Radium 228	300.74 +/- 4.38	0.74 +/- 0.51	>99
Phenanthrene	3.2 ug/L	ND	100
Fluorine	4.4 ug/L	ND	100
Benzene	260	ND	100
1-Methylnaphthanlene	34 ug/L	ND	100
2- Methylnaphthalene	49 ug/L	ND	100
Toluene	210	ND	100
Ethylbenzene	ND	ND	100
o –Xylene	130 ug/L	ND	100
p/m – Xylene	380 ug/L	ND	100

Source Altela, Inc.)

7. EVALUATION OF COMPETING TECHNOLOGIES

The above nine (9) water treatment technologies were evaluated for their ability to treat the highly-challenged water co-produced with the production of oil and gas. Some of these technologies are, or may be, suitable for less difficult desalination applications such as low-TDS brackish water or seawater desalination. In these cases, the primary contaminant is usually sodium-chloride (table salt). Produced water, however, is often composed of not only salt concentrations far higher than seawater – but composed of much more difficult salts (e.g. calcium sulfate) to filter out, as well non-salt contaminants and organic compounds including dissolved hydrocarbons, organic acids, phenols and traces of chemicals added during production, inorganic compounds, suspended solids, dissolved solids, and natural low-radioactive elements.

Table 9 illustrates a comparison of these various technologies for their likelihood to be successful in treating produced water. The Evaluation Criteria of Section 5 were used to evaluate each technology using the six criteria identified there.

7.1 Pressure Driven Separation Technologies

Removal of Contaminants: Membrane technologies do a good job of removing contaminants, particularly if used in series stages. For TDS = 35,000 feed water to attain a product quality of less than TDS=1,000ppm, it is likely that 2 or possibly 3 stages would be required for most of these technologies.

Flexibility: The major pitfall of the membrane technologies is their pre-treatment requirements. Pretreatment is required to insure stable, long-term system performance and membrane life. Pretreatment may include clarification, filtration, Ultrafiltration, pH adjustment, and removal of chlorine and organics. Produced water feed water chemistry is neither consistent from well to well, nor over time due to hydrology based changes. To account for all possibilities, this requires a very large pre-treatment set of processes, and highly trained operators and chemists. This can be done with sufficient water chemistry data, but at a high cost.

Cost Effectiveness: Membrane-based solutions (RO) have been traditionally viewed as a low cost method for treating for simple brackish waters composed only of low-TDS sodium chloride. RO can be further used to desalinate seawater, but it performs poorly in most other complex salt situations. Most previously published pilot studies focusing on reverse osmosis operations on produced water have required an on-site operator (attended operation). Second, reverse osmosis is not the best technological option for TDS streams greater than 35,000. Such concentrations, however, represent the great majority of produced water streams. Fouling and scaling related costs and replacement requirements are often not included as direct costs. As pressure increases, the concentration of brine passing along the membrane also increases. The subsequent buildup (scaling/fouling) requires continual increases in energy to pass the pure water through the membrane. Such energy requirements are needed on-site, and coupled with the indirect costs of membrane replacement, dramatically increase per barrel treatment costs. Many membrane technologies become prohibitively expensive with respect to produced water with TDS levels greater than 35,000. Although there have been recent advancements in membranes, there are

Table 9: Produced Water Technology Treatment Overview
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TECHNOLOGY	Removal of Contaminates	Flexibility	Cost Effectiveness	Equity Considerations	Potential Side Effects	Scalable for Individual Well Sites	Overall Average
Membrane Separation (RO)	(-) extensive pretreatment, (-) difficulty with oil and grease, boron, organics, (+) good overall quality water post treatment	(-) extensive customization required for each influent (pre and post treatment), (-) high volume recovery (-) complexity of operation, attendant required	(-) high energy req., (-) fouling and scaling, (-) operator required (+) high volume treatment (-) low cost for low concentration water ($6/1,000G), but not PW	(-) large pumps increase noise (-) high electrical requirement (+) relatively small footprint	(-) extensive chemicals used in pre an post treatment (-) reject stream requires disposal	(-) not suitable to small wellsite operations (<100,000 GPD)	2.8
Rank	3	2	3	4	3	2	2.8
Ion Exchange	(-) cannot treat all PW constituents incl. organics (-) extensive pretreatments (-) SAR adjustment post treatment due to divalent ions removal preferentially to sodium	(-) extensive customization required for each influent (pre and post treatment) (+) process components readily modifiable (easy to access) (+) mobile	(+) lower energy consumption (-) Relatively high material replacement (regeneration of resin) (-) low cost for seawater ($6/1,000G), but not PW	(-) waste stream requires disposal (+) waste shifting from one media to another avoided unlike RO (-) yet waste stream volume higher	(-) handling of pre-treatment chemicals hazardous, (-) waste stream disposal	(-) not suitable to small wellsite operations (<100,000 GPD)	3.0
Rank	2	3	3	4	4	2	3.0
Electrodialysis	(-) cannot treat all PW constituents (-) SAR adjustment post treatment required (-) removal efficiencies low with >5,000 ppm TDS influent (+) accepts higher silt density for treatment	(+) pretreatment required, less than ion exchange (+) high mobility (-) can sustain higher feed temperatures directly from wellhead (+) mobile	(+) self cleaning characteristics increase efficiency, extend lifetime (-) less efficient at higher concentrations increase cost (-) membrane regeneration req. (-) high power (energy)	(+) no chemical additives, clean technology (-) reject stream requires disposal	(-) reject stream requires disposal	(-) not suitable to small wellsite operations (<100,000 GPD)	3.0
Rank	1	4	3	4	4	2	3.0
Capacitive Deionization	(-) cannot treat all PW constituents (-) Optimum TDS limits approx. 2,500 ppm (-) cannot treat high PW concentrations	(-) pretreatment required (+) mobile	(+) lower energy consumption (+) relatively high throughput (-) expensive electrodes (-) fouling	(+) no chemical additives, clean technology (-) reject stream requires disposal	(-) reject stream requires disposal	(+) suitable to small wellsite operations, as low as 1,000 GPD	3.3
Rank	1	4	3	4	4	4	3.3
Rapid Spray Evaporation	(+) mimics natural rain cycle, high treatment purity	(+) no pre or post treatment required (+) high mobility (+) some unattended operation (-) attended operation	(-) low gained output ratio (energy reuse) vs. carrier-gas dewvaporation (-) high energy costs (-) higher capital costs vs. carrier gas dewvaporation	(+) no chemical additives, clean technology (+) higher conversion ratio reduced waste stream (-) relatively large footprint	(-) sludge waste concentrate requires handling and disposal	(-) not suitable to small wellsite operations (<100,000 GPD)	3.5
Rank	5	4	2	4	4	2	3.5

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Table 9: Produced Water Technology Treatment Overview
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TECHNOLOGY	Removal of Contaminates	Flexibility	Cost Effectiveness	Equity Considerations	Potential Side Effects	Scalable for Individual Well Sites	Overall Average
Freeze Thaw Evaporation	(+) thermal process, high treatment purity	(-) only operates in selected sub-freezing climes; not NM friendly (+) unattended operation (-) seasonal performance variations (-) not mobile	(+) low energy cost (-) low conversion ratios (-) long operational cycle	(-) natural cycle, green technology (-) relatively large footprint	(-) Reject stream (pond sludge) requires handling and disposal	(-) not suitable to small wellsite operations (<100,000 GPD)	3.0
Rank	5	1	3	3	4	2	3.0
Packed Bed Absorption	(-) cannot treat all PW constituents (-) less efficient at higher feed rates	(-) pretreatment required (-) feed water often needs to be cooled (-) footprint and design not conducive to quick design changes (+) mobile	(+) low energy costs (+) relatively low treatment cost (+) low maintenance	(+) environmentally focused, green technology (-) Waste shifting from one media to another (+) compact footprint (packed bed modules)	(-) waste stream comprised of used adsorbent media needs to be disposed	(-) not suitable to small wellsite operations (<100,000 GPD)	3.5
Rank	3	3	5	4	4	2	3.5
Constructed Wetlands	(-) cannot treat all PW constituents incl. organics (-) susceptible to temperate and pH effects	(-) treatment capacity not easily scaled (-) changes in feed stream not easily addressable (+) unattended operation (-) not mobile (-) seasonal treatment variations	(+) relatively low treatment cost (-) total treatment capacity low (-) high maintenance costs	(+) environmentally focused, green technology via use of flora and fauna (-) large footprint	(-) sludge waste requires handling and disposal	(-) not suitable to small wellsite operations (<100,000 GPD)	3.2
Rank	3	2	3	5	4	2	3.2
Carrier-Gas Dewvaporation	(+) thermal process, extremely high treatment purity (< 50 ppm) (+) water quality independent of different wellsite PW feed quality (+) no pre-treatment required	(+) highly modular design (+) highly mobile (+) unattended operation (+) no pre or post treatments (-) throughput relatively fixed	(+) unique, patented high gained output ratio (energy reuse) (+) no fouling/scaling (+) low energy (+) low capital cost	(-) relatively large footprint per amount of water treated (+) quiet operation (+) operates on waste heat or waste flash gas	(-) sludge waste concentrate requires handling and disposal (+) very high recovery rates obtainable (>80%), minimizing waste stream	(+) suitable to small wellsite operations, as low as 1,000 GPD (24 BPD)	4.7
Rank	5	5	5	4	4	5	4.7

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currently none yet available that have been engineered to withstand the wide spectrum of contaminants present in produced water.

Equity Considerations: The large pumps involved will need proper shelter for noise and the reject stream will need disposal. Both of these are minor considerations.

Potential Side Effects: The reject stream should be able to be disposed of in the same method that the entire feed stream is now [re-injection]. Given that the stream will be 80% less than the original, no complications are foreseen. The chemical injections used in pretreatment will need care in handling as many of them are corrosive or toxic.

7.2 Ion Exchange

Removal of Contaminants: Ion Exchange technologies will struggle with the chemistries present and the high TDS levels. The Ion Exchange process can effectively remove low-level salts, heavy metals, radium, nitrates, arsenic, and uranium but is unable to effectively remove organics or non-ionic species. The effectiveness of Ion Exchange is highly dependent on initial feed constituent concentrations. For this reason, this technology is frequently used only as a pretreatment step for the above membrane solution, not as a stand alone process with feeds of high complexity.

Flexibility: The major pitfall of the IE technology is its pre-treatment and post-treatment requirements. Produced water feed chemistry is not consistent well to well nor over time. To account for all possibilities, this requires a very large set of pre-treatment processes. Similar to RO, this can be done with sufficient water chemistry data, but at a high cost following pre- and post-treatments.

Cost Effectiveness: A high cost solution, to meet the flexibility requirements and the recovery requirements for different produced waters. The limiting factors are the high material usage and the scaling factor to account for the regeneration time in the process.

Equity Considerations: The reject stream will need disposal. This is a minor consideration. Ion Exchange requires relatively low energy, a clear equity related advantage.

Potential Side Effects: The reject stream should be able to be disposed of in the same method that the entire feed stream is now [injection]. Given that the stream will be 80% less than the original, no complications are foreseen. The chemical injections used in pretreatment will need care in handling as many of them are corrosive or toxic.

7.3 Electrodialysis

Removal of Contaminants: Electrodialysis technologies struggle with high TDS levels in excess of 5,000 TDS. The high TDS levels present require extremely high voltages to drive the process, in addition to more frequent regeneration. For this reason, this technology is frequently used only as a late pretreatment step for the above RO membrane solution, not as a stand alone process with feeds of high complexity.

Flexibility: The major pitfall of the ED technologies is their power requirements being directly proportional to the feed TDS. Thus as the chemistry changes, the attendant power requirements will also change. This variability affects both operations and initial design. Treatment costs for de-oiling, dissolved organic removal and partial demineralization pose significant challenges.

Cost Effectiveness: To meet the flexibility requirements and the recovery requirements, this turns out to be a high cost solution. The limiting factors are the high power requirements and the treatment costs.

Equity Considerations: The reject stream will need disposal. This is a minor consideration.

Potential Side Effects: The reject stream should be able to be disposed of in the same method that the entire feed stream is now [re-injection]. Given that the stream will be 80% less than the original, no complications are foreseen. The chemical injections used in pretreatment will need care in handling as many of them are corrosive or toxic.

7.4 Capacitive Deionization

Removal of Contaminants: Capacitive Deionization technologies are similar to ED. Current TDS limits for this technology are approximately 2,500 ppm, however on-going development hopes to increase this to 15,000 ppm. However, based on this limitation, Capacitive Deionization will still struggle with the chemistries present in most produced water. The pretreatment steps required are significant, and for this reason, this technology is still only considered as a late pretreatment step for the above RO membrane solution, not as a stand alone process with feeds of high complexity.

Flexibility: The major pitfall of the CD technologies is its required pretreatment, as organics and multi-valent ions present almost insurmountable challenges. CD can only remove ionic contaminants, not organics or non-ionic solids.

Cost Effectiveness: To meet the flexibility requirements and the recovery requirements, the technology's requisite operating costs are prohibitively high. However, on-going development is occurring and should reduce energy and capital requirements in the future.

Equity Considerations: Since the capacitive deionization process does not require membranes or the regeneration of ion exchangers with acids and bases, any associated secondary waste present with conventional ion exchange is eliminated. The reject stream will need disposal. This is a minor consideration.

Potential Side Effects: The reject stream should be able to be disposed of in the same method that the entire feed stream is now [injection]. Given that the stream will be 60% less than the original, no complications are seen. The chemical injections used in pretreatment will need care in handling as many of them are corrosive or toxic.

7.5 Rapid Spray Evaporation

Removal of Contaminants: Rapid Spray Evaporation represents a simple solution to removing contaminants. Just like clouds forming over oceans, the water evaporated is pure and all of the contaminants remain behind. As a thermal process, a very high purity effluent stream is attained. Like most thermal processes, water chemistry has only mild effects on the process performance and no pretreatment is necessary.

Flexibility: Lack of pretreatment and post treatment processes increase flexibility of Rapid Spray Evaporation.

Cost Effectiveness: High energy costs associated with heating both air and water decrease the overall cost effectiveness of RSE. Unlike carrier-gas based technologies below, this thermal process does not reuse the heat energy, and thus is simple but expensive.

Equity Considerations: Rapid Spray Evaporation has a high conversion efficiency (recovery rate), potentially as high as 95%, which favorably reduces concentrate volumes.

Potential Side Effects: A small concentrate stream in the form of sludge at the end of the evaporation cycle is present and requires handling.

7.6 Freeze Thaw Evaporation

Removal of Contaminants: Freeze Thaw Evaporation represents a simple solution to removing contaminants. As a thermal process, very high purity product is attained. Like most thermal processes, water chemistry has only mild effects on the process performance and no pretreatment is necessary.

Flexibility: The major pitfall of the Freeze Thaw Evaporation technology is its requirement to be used only in near-freezing conditions and its susceptibility to temperature changes and weather patterns. The technology needs to be either located in cold weather climes or else utilize large energy expenditures for optimal treatment. New Mexico does not support the optimal climate for this process.

Cost Effectiveness: The lower conversion efficiency and long operational cycle of the Freeze Thaw Evaporation technology makes it a high cost solution, and one not suitable in New Mexico.

Equity Considerations: Natural freeze cycle supports green technology. However, the footprint and environmental siting issues may represent significant equity considerations. The pond area requires safety and wildlife protection as these are high salt ponds.

Potential Side Effects: The reject stream [pond sludge] should be able to be disposed of in the same method that the entire feed stream is now [re-injection]. Given that the stream will be +90% less than the original, no complications are seen. Alternatively, it could be disposed of in land fills or land farmed.

7.7 Packed Bed Absorption

Removal of Contaminants: Packed Bed Absorption technologies have difficulty effectively treating high feed concentrations, since they do not treat salt contaminants. This technology is sometimes used as a pretreatment step for RO membrane solutions, not as a stand alone process with feeds of this complexity.

Flexibility: The major pitfalls of the Packed Bed Absorption technology are that it does not treat the water's salinity and that it itself often requires additional pre-treatment requirements. Produced water feeds are often cooled to atmospheric pressures since higher temperatures affect the removal efficiency of the adsorbent in the packed beds. This can be done with sufficient water chemistry data, but at a high cost. Also, the footprint and design of the system does not facilitate rapid design changes.

Cost Effectiveness: The treatment cost of Packed Bed Absorption is relatively low; however, as noted above, effectiveness as a total solution is also very low.

Equity Considerations: Environmental-based focus of the technology supports a green approach. The waste stream consisting of used adsorbent media needs to be disposed. This is a minor consideration.

Potential Side Effects: The reject stream should be able to be disposed of in the same method that the entire feed stream is now [injection]. Given that the stream, after RO, will be 80% less than the original, no complications are seen. The chemical injections used in pretreatment will need care in handling as many of them are corrosive or toxic.

7.8 Constructed Wetlands

Removal of Contaminants: Constructed Wetlands represents a simple, nature-based solution to removing contaminants. Treatment is not effective at removing all produced water constituents, such as organics. Past research indicates that water conductance, chloride concentrations, alkalinity, hardness, sulfate and nitrate reductions are negligible. This technique is suitable only for produced waters so low in salinity and other contaminants as to be almost potable before entry into the wetland.

Flexibility: Constructed Wetland treatment capacity is not easily scaled up or down depending on changes in produced water feeds. In addition, changes in produced water quality feeds are not readily addressable by the technology.

Cost Effectiveness: An advantage of Constructed Wetlands is their relatively low construction and operation costs. However, the rate of operation and purification of produced water is very low causing total, overall treatment cost to increase. Total treatment capacity is similarly low.

Equity Considerations: The technology is environmentally focused, the natural oxidation and decomposition of contaminants by flora and fauna support green approach to purifying produced water.

Potential Side Effects: Sludge waste at the end of the treatment must be removed and disposed.

7.9 Carrier-Gas Dewvaporation

Removal of Contaminants: Dewvaporation represents a simple solution to removing all produced water contaminants, even in highly-challenged and extremely high-TDS conditions. Like all distillation based processes, the water vapor generated on the condensation side of the heat exchanger is pure and contains no dissolved or suspended solids. The vapor phase water is also free of chemical compounds which have boiling points greater than or equal to that of water (at atmospheric conditions). As a thermal process, the vapor then re-condenses in the form of a very high-purity effluent stream. Like most thermal processes, water chemistry has only mild effects on system performance. Finally, recent testing of the technology has revealed that highly volatile BTEX compounds typically found in produced waters do not re-condense in the distillate stream, making the process by far the highest quality water of the 9 technologies evaluated in this report.

Flexibility: Another major advantage of thermal processes is their inherent flexibility and modularity. The dewvaporation process is no different in this regard. The low cost, scale-resistant materials used to fabricate dewvaporation towers enable treatment systems to be built that are both modular and mobile, easily maintained, and capable of processing water with highly variable influent compositions. The modular design of a dewvaporation based system enables installers to customize each treatment system with little or no additional cost to oil and gas companies. For example, a dewvaporation system can be installed to minimize the effluent brine reject stream simply by re-configuring the physical layout of the primary system towers into differing series/parallel configurations.

Cost Effectiveness: Like other thermal processes, dewvaporation is simple, easy to maintain, and can operate unattended for long periods of time. However, unlike other desalination methods the primary treatment components are fabricated entirely from plastic. This eliminates the need for costly influent pretreatment components (such as filters, flocculants, and anti-scalant additives). This technology is unique of the nine evaluated here, in that no metal is present for which corrosion and scaling can exist.

Also, similar to other thermal processes the major operating expense is the energy required to evaporate the influent water. However, dewvaporation has another inherent advantage in that the process operates at low temperatures, typically 180°F or less. This makes it possible for a dewvaporation based produced water treatment systems to use low grade sources of waste heat. Such operating scenarios dramatically increase the operating efficiency by further reducing the operating costs by virtue of the technique's unique ability to 're-use' this low-grade heat multiple times by applying the exothermic heat of condensation (dew formation) to the endothermic heat of evaporation in a continual loop process.

Equity Considerations: Dewvaporation based treatment systems typically require more physical space to treat a given volume of water than comparable RO systems. This is a function of the low thermal conductivity of plastics relative to that of metal. This is generally a minor consideration since wellsites are located remotely with ample land available for the system's installation. Furthermore, many low cost construction techniques can be employed to erect temporary or permanent structures. Operation noise is minimal.

The Dewvaporation technology is also one of only two of the nine techniques evaluated here that has the advantage of being able to be scaled down small enough to operate at individual wellsites. A typical well generating only 20 barrels per day (BPD) of produced water is not practical for high throughput technologies such as RO or other membrane technologies. Dewvaporation's product treats 1,000 gallons per day (GPD), which is equivalent to 24 BPD – ideal for typical oil and gas wellsites in New Mexico.

Potential Side Effects: The Carrier-Gas Dewvaporation technology mimics nature's rain cycle and is environmentally friendly. There are no pre- or post-treatment chemicals requiring handling or disposal. The pure distilled effluent stream can be reused for numerous beneficial uses. Sludge waste at the end of the treatment must be removed and disposed.

Non-thermal technologies in general are at a real disadvantage in this comparison largely due to their high pretreatment costs and the inability to run autonomously. An assumed TDS level of 35,000 further restricts many of the non-thermal processes. As previously noted, the integrated technical solution for a non-thermal process could include four or more pre-treatment technologies run in series, resulting in a complex, expensive, and operator intensive solution. Such solutions are especially not adaptable to individual well sites, where only 20 to 50 barrels per day of produced water may be generated.

This leaves a number of thermal technologies open for consideration. As previously stated, thermal based technologies do not require pretreatment and can run autonomously for extended periods of time. Key distinguishing factors include flexibility to operate within many climates, modular ability, and scalability down to unit sizes more in line with the needs of NM oil and gas wells.

8. RECOMMENDATIONS

We recommend that the State of New Mexico fund the demonstration of Carrier-Gas Dewvaporation for the treatment of oil and gas produced water conversion to beneficial uses within New Mexico. This new technology (patented less than six months ago in June of 2005) represents the best new technology for the conversion of highly-variable produced water into clean water throughout the state. It is novel in its energy efficiency, yet elegant in its simplicity. Of the nine water treatment technologies evaluated in this report, we feel that it represents the most economical and practical solution yet devised for the distillation and desalination of the complex contaminants found in produced water. The Dewvaporation technology has already undergone a beta-site real-world test in New Mexico, and it has already been evaluated by New Mexico's Oil and Gas Conservation Division.

Two specific well sites have been selected for real-world field testing and application of the Carrier-Gas Dewvaporation treatment technology. The first site is a gas well, the Blackshawl Com No. 001, located in northwestern New Mexico near the City of Farmington. The second site is a gas well, the Boise Federal No. 001Q) located in southeastern New Mexico near the City of Carlsbad. This proposed demonstration project incorporates both sites to fully demonstrate that the carrier gas dewvaporation technology can treat the broad spectrum of constitutes present in produced water production (ranging from 120,000 TDS to 32,600 TDS). Other produced water treatment technologies are only able to treat a very narrow spectrum of constitutes (after considerable pre and post treatments) and therefore do not provide a complete solution

Aerial photographic surveys and United States Geological Survey (USGS) topographic map slides have been included for each proposed site in Appendix D. In addition, comprehensive independent water quality laboratory analytical reports of the produced water found at each site have been included in Appendix B and C. The water quality reports include all analytes as outlined within the New Mexico Water Quality Control Commission Groundwater Standards, Section 3-103 (A-C). Finally, approval and authorization letters from each well site owners have been included in Appendix E.

8.1 Carrier Gas Dewvaporation Produced Water Demonstration Project: Site 1

Name:	Blackshawl Com #001
API number:	30-045-30420
ULSTR:	A-36-30N-13W
Operator:	Merrion Oil & Gas Corp.
NM OCD UL:	A
FTG NS:	493
FTG EW:	743
OGRID_CDE:	14,634
Formation:	Fulcher Kutz
County:	San Juan
Latitude:	36.77562
Longitude:	-108.151

Acres:	160
Section:	36
Township:	30N
Range:	13W

Geographic Locations Affected by the Project

The geographic locations affected by the project include the San Juan River Valley including the City of Farmington, New Mexico. As of the 2000 census, there are 37,844 people, 13,982 households, and 10,095 families residing in the city. The population density is 549.9/km^2 (1,424.5/mi^2). There are 15,077 housing units at an average density of 219.1/km^2 (567.5/mi^2). Farmington is the largest city in the northwest portion of New Mexico, as well as the Four Corners Area. The oil and gas industries are the largest employers in the area. The region is the traditional homeland of a number of Native American Tribes, including the Navajo, Jicarilla Apache, Ute Mountain Ute and the Southern Ute nations. The Navajo Reservation borders Farmington at its west and southwest boundaries.

Project Description

Altela is proposing the prototype development, evaluation and pilot installation of a dewvaporation-based treatment system. The proposed system will remove the dissolved salts and other contaminants from the influent source water, and reduce the high costs and environmental liability of current produced water disposal. There is a particular need to reduce the number of water hauling trucks at this particular well site within the Farmington city limits.

Technical Components

There will be three primary tasks associated with the successful completion of this project. A brief description, preliminary timeline, and proposed budget for each follow:

Task-1, System Design: During this phase of the work the prototype system will be designed and components will be ordered and tested. Components will be integrated and installed in a laboratory environment and tested with simulated produced water. Once the technical performance meets the permitted effluent requirements, the project will advance to the Prototype Evaluation Stage. An estimated period of performance, budget, and list of deliverables for Task-2 is shown below:

Deliverables: Operational laboratory breadboard system.

Timeline for Implementation & Completion: A schedule for completion of Task 1 is provided in Figure 17

Estimated Budget: $85,139 (See Table 10)

Task-2, System Evaluation: The prototyping and evaluation stage will involve fabricating a full-scale mock-up of the actual Blackshawl treatment system. Prior to shipping the primary treatment components the entire system will be built and tested at Altela's facility. Testing will be conducted with simulated produced water.

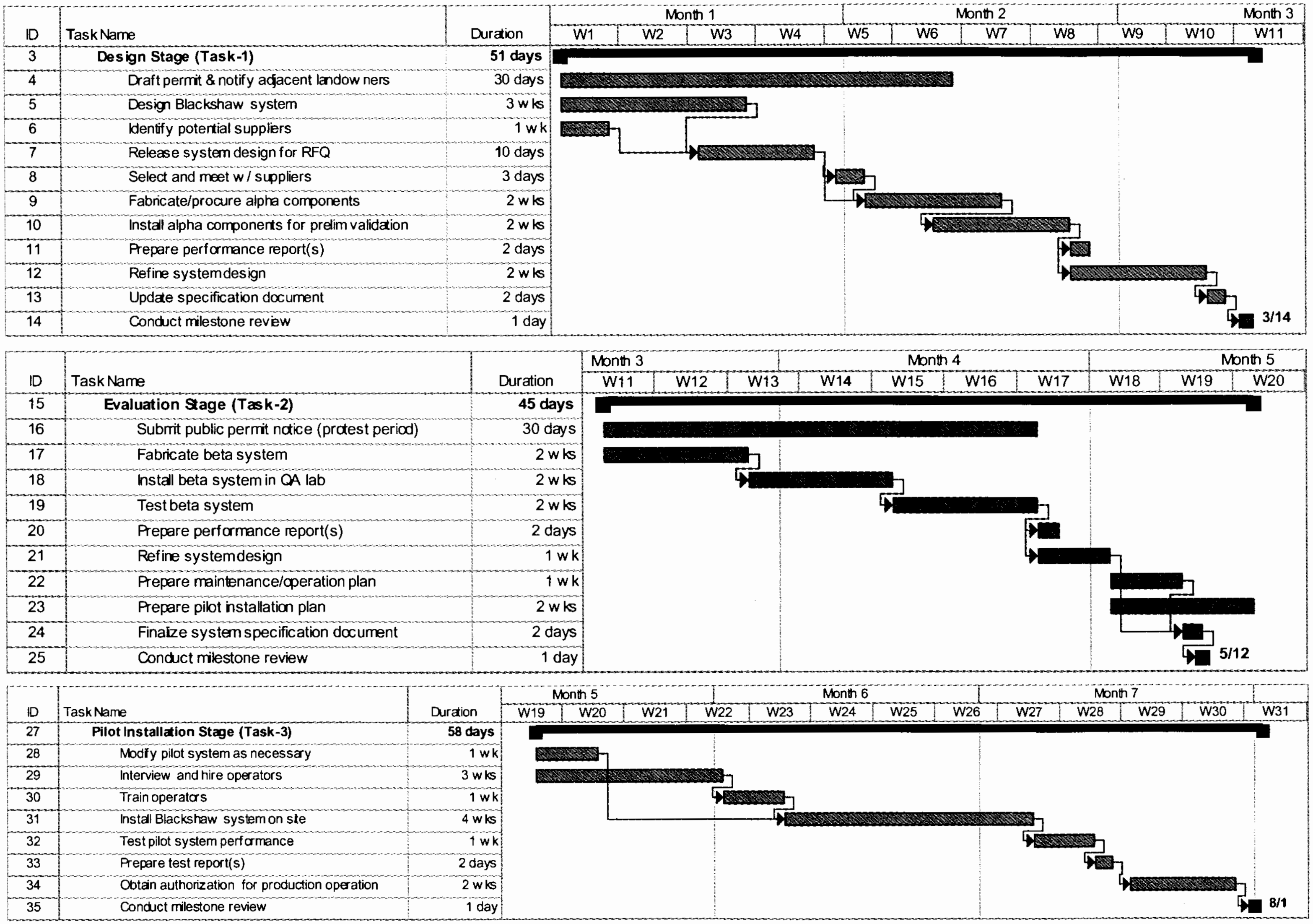


Figure 17: Schedule for Site 1 Produced Water Demonstration Project

Table 10: Estimated Costs for Site 1
Produced Water Demonstration Project

	Cost ($)			
	Task-1, System Design	**Task-2, Prototype Evaluation**	**Task-3, Pilot Installation**	**Total**
Labor	41,027	47,333	44,497	132,857
Materials	--	15,000	7,000	22,000
Travel	810	--	2,700	3,510
Subcontractors	15,500	16,000	1,500	33,000
Indirect	17,201	23,500	16,709	57,410
Fee	5,218	7,128	5,068	17,414
Gross reciepts tax	5,383	7,355	5,230	17,968
Total	85,139	116,316	82,704	284,159
	Total Project Cost			**284,159**

Deliverables: Integrated, mock-up system, performance report, maintenance and operation plan.

Timeline for Implementation & Completion: A schedule for completion of Task 2 is provided in Figure 17.

Estimated Budget: $116,316 (See Table 10)

Task-3, Pilot Installation: Pilot installation will require the packaging and transport of the primary treatment components to the Blackshawl Com. No. 001 treatment facility in Farmington, New Mexico. Once on-site, the system will be integrated with the existing produced water collection equipment and water will be periodically processed, stored, and analyzed for removal of dissolved solids and aromatic organics by an independent third-party laboratory. The primary objective of this task will be to demonstrate the low-cost operation, as well as the low-cost capital basis, of the dewvaporation based system.

Deliverables: Performance report from third party lab and final report on system performance parameters and metrics.

Total Project Cost: $284,159

Timeline for Implementation & Completion: A schedule for completion of Task 3 is provided in Figure 17.

Estimated Budget: $82,704 (See Table 10)

Technical Issues (Current or Foreseen)

Since the carrier-gas dewvaporation is a relatively new technology, commercially available towers which meet the required performance and reliability specifications are only available in limited quantities from a single supplier. To date performance, reliability, and life expectancy testing has been promising but without a long track record, technical issues may arise. Volume of treated water has not been optimized. This provides additional opportunities for cost savings but additional technical work is required.

Potential Stakeholders

Direct potential stakeholders of the proposed Blackshawl Com. No. 001Q include the City of Farmington, its residents, downstream water users on the San Juan River, and Merrion Oil and Gas Corp. By treating and purifying Blackshawl's produced water on-site, potable water usage on-site will decrease. Currently, well-site vegetation and landscaping is irrigated using the City of Farmington's municipal water supply. Once treated, the carrier-gas dewvaporation purified water could be utilized for on-site irrigation. This will reduce use of the City's potable water supply. Any un-used purified produced water will be discharged through the existing sewage lines. Based on the high quality of distilled water, this discharge will facilitate the City's compliance with its NPDES permit. The distilled water discharged into the City's sewage system will dilute other dirtier sources thereby improving overall water quality requiring treatment by the City of Farmington. Additionally, the City of Farmington and San Juan County both have a stake in the success of this demonstration. If successful, the conversion of produced water into irrigation or fresh water at the site will demonstrate that alternative, nearby water sources are available to meet growing water demand. In addition, the State of New Mexico would benefit from verifying produced water can be converted to a new source of water. Other indirect stakeholders include wildlife and environmental interests who will benefit from the reduction in large tanker trucks using access roads to gather produced water for re-injection. Additionally, the City of Farmington and San Juan County both have a stake in the success of this demonstration. If successful, the conversion of produced water into irrigation or fresh water at the site will demonstrate that alternative, nearby water sources are available to meet the City's growing demand. In addition, the State of New Mexico would benefit from verifying produced water can be converted to a new source of water for San Juan River water right constraints.

Opportunities and Constraints

The Blackshawl Com No. 001Q provides a unique opportunity for the reuse of produced water without having to acquire a new water discharge permit. By utilizing the City's current NPDES discharge permit, immediate water supply savings can be realized. By discharging the purified water into the City's sewage system, the City's return flow credits to the San Juan River will increase. In addition, the purified water can be used on site for irrigation, dust suppression following OCD permitting. Current produced water production at Blackshawl is approximately 1,260 gallons per day (30 barrels per day) or approximately 1.41 acre-foot per annum. The relatively small volume of produced water limits the ability to substantially impact the City of Farmington's water supply system. However, 1.41 acre-feet per year per well would offer substantial savings if additional treatment systems were implemented at nearby sites following success of this initial pilot.

Likelihood of Success of the Project
The likelihood of success of the project is high. The carrier-gas dewvaporation technology has proven it can successfully treat and purify produced water for re-use. By utilizing a well within the City of Farmington's water supply service area, benefits will be immediately realized through a reduction in city water on-site, coupled increases in the city's effluent stream.

Identification of Type of Communities to be Served
The type of community to be served is a municipal. The Blackshawl Com No. 001Q produced water demonstration site offers a unique opportunity to immediately apply treated, purified produced water for reuse. Historically, the produced water pumped at the site has been discharged to the City of Farmington's municipal sewage system. Once treated, the City of Farmington discharges its treated effluent directly to the San Juan River. However, based on the high salinity content of the site's produced water, the City of Farmington no longer permits use of its sewage system.

8.2 Carrier Gas Dewvaporation Produced Water Demonstration Project: Site 2

The second proposed demonstration site is a relatively new gas well located in the southeast part of the state. The name of the well is Boise Federal No. 001Q and is owned by MYCO Industries, Inc. The well is located approximately 3-5 miles northeast of Carlsbad, New Mexico, depending on access. This gas well produces approximately 30 barrels of oil. Specific well details follow:

Summary

Name:	Boise Federal #001Q
API number:	30-015-33735
ULSTR:	H-35-21S-27E
Operator:	MYCO Industries, Inc.
NM OCD UL:	H
FTG NS:	1,877
FTG EW:	1,312
OGRID_CDE:	15,445
Formation:	East Carlsbad Morrow
County:	Eddy
Latitude:	32.43866
Longitude:	-104.156
Acres:	320
Section:	35
Township:	21S
Range:	27E

Proposed Geographic Location Affected by the Project
The geographic locations affected by the second proposed project include the Eddy County and the City of Carlsbad. The City of Carlsbad in located in southeast New Mexico on the Pecos River, in a grazing and irrigated farming area. The City was settled in 1888. As of the 2000 census, there are 25,625 people, 9,957 households, and 6,949 families residing in the city. The population density is 348.7/km² (903.3/mi²). There are 11,421 housing units at an average

density of 155.4/km^2 (402.6/mi^2). Potash mining and tourism are important, and retirement homes are multiplying. The Carlsbad reclamation project, begun in 1906, irrigates more than 20,000 acres (8,000 hectares) and provides water recreation. A branch of New Mexico State Univ. is in Carlsbad. Nearby are Carlsbad Caverns National Park and the Living Desert State Park. Outside Carlsbad is the Waste Isolation Pilot Plant, cut deep into rock salt formations as a storage facility for high-level nuclear wastes.

Project Description
Altela is proposing the prototype development, evaluation and pilot installation of a carrier-gas dewvaporation based produced water treatment system. The proposed system will remove the dissolved salts and other contaminants from the influent source water, and reduce the high costs and environmental liability of current PW disposal. Currently, the produced water being pumped from the

Technical Components
There will be three primary tasks associated with the successful completion of this project. A brief description, preliminary timeline, and proposed budget for each follow:

Task-1, System Design: During this phase of the work the prototype system will be designed and components will be ordered and tested. Components will be integrated and installed in a laboratory environment and tested with simulated produced water. Once the technical performance meets the permitted effluent requirements, the project will advance to the Prototype Evaluation Stage. An estimated period of performance, budget, and list of deliverables for Task-2 is shown below:

Deliverables: Operational laboratory breadboard system.

Timeline for Implementation & Completion: A schedule for completion of Task 1 is provided in Figure 18

Estimated Budget: $149,742 (See Table 11)

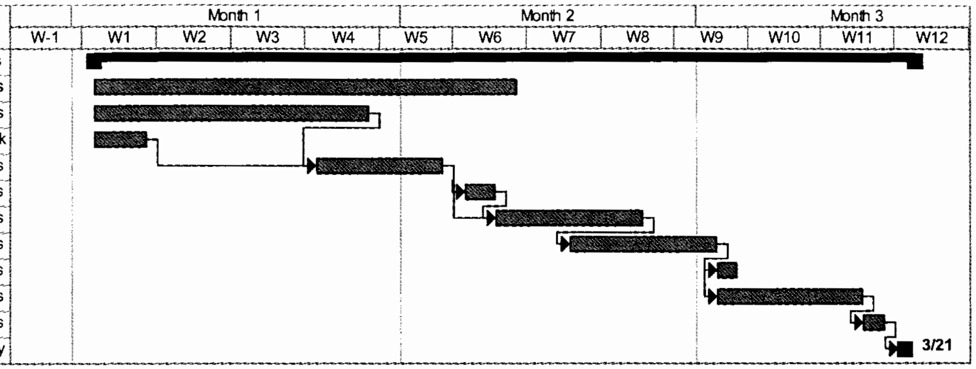
Task-2, System Evaluation: The prototyping and evaluation stage will involve integrating the breadboard system into modular shipping containers. Twenty (20) foot-long shipping containers will be used to minimize size and site footprint. The system will be built and tested in at Altela's facility. Testing will be conducted with simulated PW.

Deliverables: Integrated, containerized system, performance report, maintenance and operation plan.

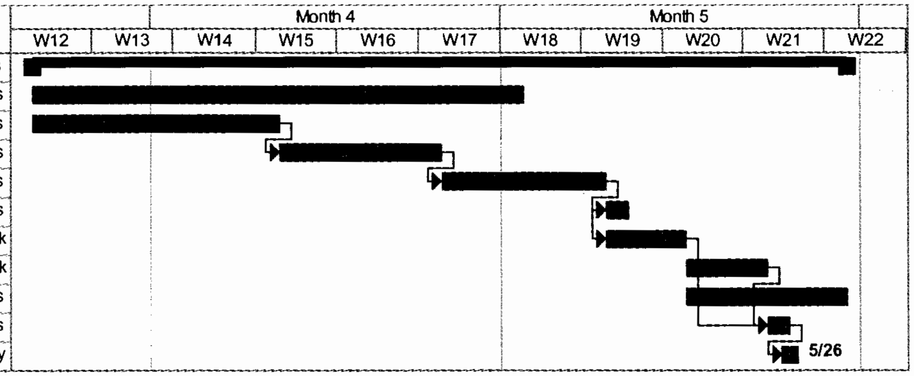
Timeline for Implementation & Completion: A schedule for completion of Task 1 is provided in Figure 18

Estimated Budget: $111,109 (See Table 11)

ID	Task Name	Duration
3	**Design Stage (Task-1)**	**56 days**
4	Draft permit & notify adjacent landow ners	30 days
5	Design site specific system	4 wks
6	Identify potential suppliers	1 wk
7	Release system design for RFQ	10 days
8	Select and meet w/ suppliers	3 days
9	Fabricate/procure alpha components	2 wks
10	Install alpha components for prelim validation	2 wks
11	Prepare performance report(s)	2 days
12	Refine system design	2 wks
13	Update specification document	2 days
14	Conduct milestone review	1 day



ID	Task Name	Duration
16	**Evaluation Stage (Task-2)**	**50 days**
17	Submit public permit notice (protest period)	30 days
18	Fabricate beta system	3 wks
19	Install beta system in QA lab	2 wks
20	Test beta system	2 wks
21	Prepare performance report(s)	2 days
22	Refine system design	1 wk
23	Prepare maintenance/operation plan	1 wk
24	Prepare pilot installation plan	2 wks
25	Finalize system specification document	2 days
26	Conduct milestone review	1 day



ID	Task Name	Duration
28	**Pilot Installation Stage (Task-3)**	**53 days**
29	Modify pilot system as necessary	1 wk
30	Interview and hire operators	3 wks
31	Train operators	1 wk
32	Install pilot system	3 wks
33	Test pilot system performance	1 wk
34	Prepare test report(s)	2 days
35	Obtain authorization for production operation	2 wks
36	Conduct milestone review	1 day

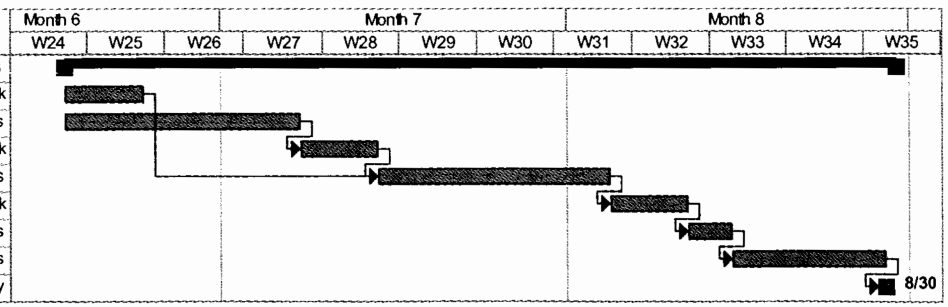


Figure 18: Schedule for Site 2 Produced Water Demonstration Project

Table 11: Estimated Costs for Site 2
Produced Water Demonstration Project

	Cost ($)			
	Task-1, System Design	**Task-2, Prototype Evaluation**	**Task-3, Pilot Installation**	**Total**
Labor	44,533	43,826	33,749	122,109
Materials	40,000	15,000	7,000	62,000
Travel	810	--	2,700	3,510
Subcontractors	15,500	16,000	1,500	33,000
Indirect	30,253	22,448	13,485	66,186
Fee	9,177	6,809	4,090	20,076
Gross reciepts tax	9,468	7,026	4,220	20,714
Total	149,742	111,109	66,745	327,595
	Total Project Cost			**327,595**

Task-3, Pilot Installation: Pilot installation will require the transport of the containerized system to the well-site Boise Federal Well. Once on site, the system will be integrated with the existing produced water collection equipment and water will be periodically processed, stored, and analyzed for removal of dissolved solids and aromatic organics by an independent third-party laboratory. The primary objective of this task will be to demonstrate the low-cost operation, as well as the low-cost capital cost, of the dewvaporation based system.

Deliverables: Performance report from third party lab and final report on system performance parameters and metrics.

Timeline for Implementation & Completion: A schedule for completion of Task 1 is provided in Figure 18

Estimated Budget: $66,745 (See Table 11)

Total Project Cost: $327,595

Project Implementation (in Phases)

To develop the proposed water remediation system, Altela plans to use a four-stage process with mandated milestone reviews between each stage. This process is referred to as the System Development Process (SDP). Following a favorable completion of each milestone review, the project will be given approval to move into the next stage of development. Advancement into each succeeding stage is based on conformity to a predetermined set of specifications driven by the influent water quality, required regulatory framework, and cost targets. Decision metrics will compare evolving performance and remediation criteria against technical benchmarks, manufacturability, system cost (both capital and operating), regulatory requirements, liability risk, and financial models. Communication of project performance to the sponsor, highlighting achievement of cost, schedule, and technical goals, will occur via monthly status reports.

Technical Issues (Current or Foreseen):
Since dewvaporation is a relatively new technology, commercially available towers which meet the required performance and reliability specifications are only available in limited quantities from a single supplier. To date performance, reliability, and life expectancy testing has been promising but further experimentation is warranted and ongoing. Initial beta field-tests of the dewvaporation technology substantiated the technology will work in the oil patch without scaling and fouling issues so prevalent with RO based treatment systems. However, until a full 3-6 month pilot project is completed, unknown technical and environmental challenges cannot be identified and processed.

Potential Stakeholders
Direct potential stakeholders of the proposed Boise Federal #001Q include neighboring ranch owners, neighboring oil and gas production companies, and MYCO Industries, Inc. Each will benefit from reuse of the purified produced water, coupled with a reduction in current off-site produced water re-injection disposal costs. Other indirect stakeholders include wildlife and environmental interests who will benefit from the reduction in large tanker trucks using access road to gather produced water for re-injection. Additionally, the City of Carlsbad and Eddy County both have a stake in the success of this demonstration. If successful, the conversion of produced water into irrigation or fresh water at the site will demonstrate that alternative, nearby water sources are available to meet the City's demand. In addition, the State of New Mexico would benefit from verifying produced water can be converted to a new source of water for Pecos River Compact challenges and future population growth.

Opportunities and Constraints
The Boise Federal #001Q offers a unique opportunity to demonstrate that the dewvaporation technology can effectively and economically treat extremely challenged water produced water. The Boise site produces approximately 250 gallons of water per day of this incredibly toxic produced water, equivalent to approximately 6 barrels of produced water per day. Boise's total dissolved solids are equal to 120,000 mg/L ppm. In addition, the amount of chloride alone at Boise is 84,100 mg/L. Such contaminant levels simply cannot be treated cost effectively with any traditional treatment option. However, these extremely challenged produced water streams are common in the industry. The dewvaporation technology has already demonstrated its ability to purify produced water brine at these levels. In addition, alternative produced water technologies, like reverse osmosis, being piloted and tested all require much higher water production volumes in order to offset the large capital investment and installation/maintenance of the technology. This site provides a very good opportunity to showcase both the modularity and ability to scale down the technology to treat individual, highly challenged produced water sites. The Boise Federal #001Q provides a strong opportunity to demonstrate the beneficial use of produced water. Following successful dewvaporation treatment, the purified water can be reused for nearby surface irrigation of farm and rangeland, livestock watering, as well as dust suppression and road maintenance issues. Small produced water volumes will tend to constrain overall impact of future reuse due to the relatively small purified effluent stream generated by

the pilot. However, following successful demonstration, the dewvaporation modular platform can be sited at many other nearby well sites to leverage impact.

Likelihood of Success of the Project:
The likelihood of success of the project is high. The carrier-gas dewvaporation technology has proven it can successfully treat and purified real oilfield and gas field produced water, even on the highly challenged produced water found at the Boise Federal #001Q site.

Identification of Type of Communities to be Served
(urban v. rural, municipal v. municipal domestic):
The Boise Federal #001Q is located northeast of the City of Carlsbad in a rural, undeveloped are of rangeland. Due to the geographic location of the well site, no municipal water service is directly affected. Therefore, urban v. rural, municipal v. municipal domestic is not directly applicable. However, following successful demonstration of the dewvaporation technology on the extremely challenged produced water located at Boise, additional nearby sites can be inter-connected for treatment and subsequent reuse for livestock water, irrigation and other related beneficial uses.

NEW MEXICO ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT

BILL RICHARDSON
Governor
Joanna Prukop
Cabinet Secretary

Mark E. Fesmire, P.E.
Director
Oil Conservation Division

August 4, 2005

Mr. Matthew J. Bruff
Altela, Inc.
Denver Technology Center
Belleview Tower
7887 E. Belleview Ave, Suite 1100
Englewood, CO 80111

Re: Application for Temporary Discharge Permit
Altela Test Number 08-05
Section 1, Township 22 South, Range 27 East
NMOCD Reference HI-0099

Dear Mr. Bruff:

The New Mexico Oil Conservation Division (NMOCD) has received and reviewed Altela, Inc.'s (Altela) application shown above. This application is hereby approved with the following understandings and conditions:

1. The produced water that will be processed under this permit originates from the Myco Industries Madison 1 Fee Comm #1 well, (API number 30-015-33705).
2. The total discharge will be less than 100,000 gallons.
3. The discharge will be on a portion of the SW/4, NE/4, NW/4 of Section 1, Township 22 South, Range 27 East, in Eddy County, New Mexico.
4. Altela has received permission from the landowner for the discharge.
5. Discharge water will be equal to or better than the Water Quality Control Commission regulations, Section 3103, A, B, and C.
6. This discharge permit will expire on April 4, 2006.
7. Altela will provide the NMOCD with analysis results of both the produced water entering the test system, and the processed water to be discharged.

NMOCD approval of this discharge does not relieve Altela of responsibility should its actions at this site prove harmful to public health or the environment. Nor does it relieve Altela of its responsibility to comply with the rules and regulations of any other federal, state, or local governmental entity.

If you have any questions, contact me at (505) 476-3402 or ed.martin@state.nm.us

NEW MEXICO OIL CONSERVATION DIVISION

Ed Martin

Edwin E. Martin
Environmental Bureau

Cc: NMOCD, Artesia

ALTELA™

One Technology Center
1155 University Blvd. SE
Albuquerque, New Mexico 87106
T: 505.843.4197
F: 505.843.4198

Denver Technology Center
Belleview Tower
7887 E. Belleview Ave., Suite 1100
Englewood, Colorado 80111
T: 303.228.1605
F: 303.228.1655

August 2, 2005

Mr. Edwin E. Martin
Environmental Bureau
NM Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

RE: Application for Temporary Discharge Permit

HAND-DELIVERED

Dear Mr. Martin,

Following our recent discussions, this letter serves as Application for an Oil Conservation Division ("OCD") temporary test water discharge permit for Altela, Inc.'s ("Altela") Test No. 08-05. The test will purify produced water. Altela is a water desalination high-technology company headquartered in Albuquerque, New Mexico. The company is developing its novel, patented water purification technology, AltelaRain™. Additional information on the technology has been attached as Exhibit B. The water test will take place in Eddy County, New Mexico.

1. Name of Test:	Altela Test No. 08-05
2. Brief Description of Test:	Altela will test its AltelaRain™ water purification technology on-site with oil and natural gas produced water to create purified, distilled water.
3. Location of Test:	SE New Mexico in Eddy County, T22S, R27E, Section 1
4. Date of Test:	Commencing August 8, 2005 and concluding within 240 days from date of commencement
5. Volume of Discharge:	Equal to or less than 100,000 gallons
6. Name of Well:	Madison 1 Fee Comm. #1
7. Name of Owner of Well:	Myco Industries, Inc. Post Office Box 840 Artesia, NM 88211

8. Location of Well: T22S, R27E, Section 1: 1980'FNL & 1310' FWL

9. Source of Test Water: Madison 1 Fee Comm. #1

10. Point of Discharge of Test Water: A portion of the SW1/4, NE1/4, NW1/4 of Section 1, T22S, R27E comprising approx. 4 acres more particularly shown on Exhibit A

11. Analysis of Test Water: Altela will sample and analyze initial test water at the inlet and outlet points for water quality. No further sampling and analysis will be required unless the technology process changes. If the process changes, re-sampling and analysis of the test water will be conducted.

12. Name of Discharge Site Landowner: The discharge site landowner, Paul Bond, has provided authorization and approval to the well owner, Myco Industries, Inc.

13. Water Quality of Test Water: Test water quality shall be equal to or better than the Water Quality Control Commission Regulations, Section 3103, A, B and C

14. Length of Test: Up to 240 days

15. Site Monitoring: No dirt berm will be required provided that Altela agrees to monitor system for leaks or spills in accordance with the components of OCD Rule 116

We appreciate your valued assistance with this project. Please do not hesitate to contact our office if the need arises.

Sincerely,

ALTELA, INC.

Matthew J. Bruff
Vice President

MJB:

Enclosures as noted
cc: Altela Day File

EXHIBIT A

WATER PROJECT
T22S, R27E, Section 1
Eddy County, NM

Madison Well

Bond Surface

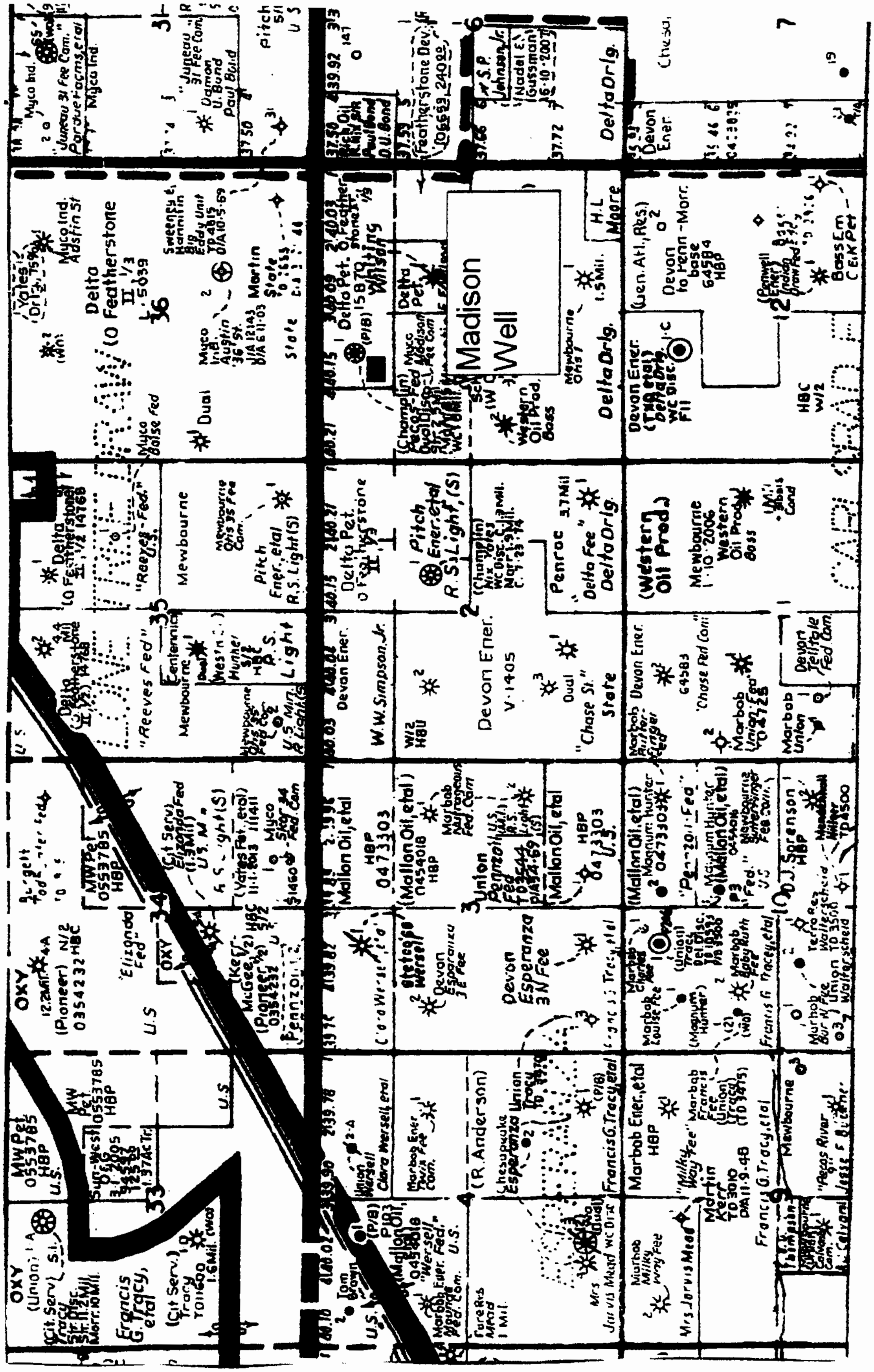


EXHIBIT B

AltelaRain™ Technology

ALTELA's innovative approach to distillation is exactly analogous to nature's rain cycle. In nature, water is evaporated from the world's oceans and reservoirs by energy from the sun. The evaporated water vapor accumulates in the warm atmosphere, but condenses to form clouds as it rises and is cooled. As the air becomes saturated with water, it eventually falls back to earth (as distilled water) in the liquid form we know as rain. ALTELA mimics this process by evaporating salty produced water ("PW") with energy from an adjacent condensation chamber. The endothermic energy required to evaporate the incoming salty PW comes from heat added in the vapor transport plenum and the exothermic phase change occurring in the condensation chamber.

This approach allows for input of minimal amounts of heat in the vapor transport plenum, to drive the distillation process by transferring the naturally occurring heat of vaporization in the condensation chamber to the evaporation chamber. The net result is a system that is 6 times more efficient than a single-pass boiler/condenser. Stated differently, the AltelaRain™ technology produces 6 gallons of distilled water from only the same energy it takes to boil 1 gallon of water. ALTELA holds the exclusive, worldwide patent rights for continued development and commercialization of this technology in the oil/gas and mineral industries.

The AltelaRain system is also unique because it solves two of the biggest challenges in desalination: fouling/scaling and water-soluble organics. Since most PW in New Mexico contains large amounts of dissolved solids (often in excess of 50,000 mg/L TDS), typical desalination techniques such as Reverse Osmosis ("RO") and thermal distillation cannot be used to desalinate PW without including costly pre-filtration, high-pressure tanks, and/or anti-scaling systems. This is due to the tendency of the dissolved solids (such as calcium carbonate) to foul RO membranes and metal heat exchanges as they precipitate out of solution. The AltelaRain™ technology is unique in that it is a thermal distillation process built entirely from plastic that operates at ambient pressure. Our distillation system can be built from plastic because our open system approach limits the operating pressure to atmospheric pressure, and prevents the operating temperature from ever exceeding 212°F. Since the AltelaRain™ system is not membrane-based, fouling of costly pre-filters and RO membranes is not an issue. Additionally, the design of our heat exchangers prevents scaling because they are fabricated from plastic. The AltelaRain™

evaporation process entails a thin boundary layer of liquid on all wetted surfaces. This causes any solid precipitates to be washed away in a concentrated stream of effluent brine before they have a chance to adhere to the heat exchanger walls.

The other common problem with PW is the presence of aromatic organic compounds such as BTEX (Benzene, Toluene, Ethyl benzene, Xylene). Since some BTEX compounds have a vapor pressure lower than water, they are soluble in many PW sources and boil (or condense) at temperatures lower than water. This means that in a closed system, some aromatic organics will remain in the effluent product stream. The open system approach of the AltelaRain™ system prevents this by providing the vapor phase BTEX compounds with an ever-present exhaust portal during our one-step process.

NEW MEXICO ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT

BILL RICHARDSON
Governor
Joanna Prukop
Cabinet Secretary

Mark E. Fesmire, P.E.
Director
Oil Conservation Division

April 6, 2006

Mr. Matthew J. Bruff
Altela, Inc.
Denver Technology Center
Belleview Tower
7887 E. Belleview Ave, Suite 1100
Englewood, CO 80111

RE: Application for Temporary Discharge Permit
Altela Test Number 08-05
NMOCD File Number HI-0099

Dear Mr. Bruff:

The New Mexico Oil Conservation Division has received your request for an extension of time on the above permit. This request is hereby approved. The above permit will expire on October 2, 2006.

If you have any questions, contact me at (505) 476-3492 or ed.martin@state.nm.us

NEW MEXICO OIL CONSERVATION DIVISION

Ed Martin

Edwin E. Martin
Environmental Bureau

Copy: NMOCD, Artesia

NEW MEXICO ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT

BILL RICHARDSON
Governor
Joanna Prukop
Cabinet Secretary

Mark E. Fesmire, P.E.
Director
Oil Conservation Division

October 2, 2006

Mr. Matthew J. Bruff
Altela, Inc.
Denver Technology Center
Belleview Tower
7887 E. Belleview Ave, Suite 1100
Englewood, CO 80111

Re: Application for Temporary Discharge Permit
Altela Test Number 08-05
NMOCD Reference: HI-0099
Section 1, Township 22 South, Range 27 East
Eddy County, New Mexico

Dear Mr. Bruff:

The New Mexico Oil Conservation Division (NMOCD) has received your request for a second extension of time on the above permit. The above permit will expire April 2, 2007. This application is hereby approved with the following understandings and conditions:

1. The produced water that will be processed under this permit originates from the Myco Industries Madison 1 Fee Comm. #1 well, (API number 30-015-33705).
2. The total discharge will be less than 100,000 gallons.
3. The discharge will be on a portion of the SW/4, NE/4, NW/4 of Section 1, Township 22 South, Range 27 East, in Eddy County, New Mexico.
4. Discharge water will be equal to or better than the Water Quality Control Commission regulations (20.6.2 NMAC), Section 3103, A, B, and C.

NMOCD approval of this discharge does not relieve Altela, Inc. of responsibility should its actions at this site prove harmful to public health or the environment. Nor does it relieve Altela of its responsibility to comply with the rules and regulations of any other federal, state, or local governmental entity. If you have any questions, regarding this matter, please do not hesitate to contact me at (505) 476-3487 or brad.a.jones@state.nm.us.

Sincerely,

Brad A. Jones
Environmental Engineer

BAJ/baj

cc: NMOCD, Artesia