May 28, 2004

Comments on the proposed amendment of 19.15.1 NMAC to adopt a new section 19.15.21.

RECEIVED

JUN 01 2004

OIL CONSERVATION DIVISION

Donald A. Neeper, Ph.D., representing
New Mexico Citizens for Clean Air & Water, Inc.
2708 B. Walnut St.
Los Alamos, NM 87544-2050

Most of Section A(2) defines exceptions by Range and Township as inclusive areas. However, the last clause in that Section uses Range and Township as lines to define a presumably enclosed area. The term, "Township" is usually employed to mean an area of 36 sections lying between two meridian lines. It is not clear whether the "area bounded by Range 9 East ..." includes the areas of the townships specified as parts of the boundary. In other words, on which side of the township is the boundary drawn? We suggest a clarification of language here.

We find that the proposed prohibition of pits in the Chihuahuan Desert area will provide significantly better environmental protection than would occur if the existing pit rules were to govern this area. In particular, we expect that the proposed rule would eliminate the burial of drilling fluids, hydrocarbons, and other contaminants that is currently allowed throughout most of the state.

We commend OCD for proposing that all tanks be placed on impermeable secondary containment. We suggest that any underground lines that penetrate the containment should be sealed to that impermeable containment, much as, for example, the surface of a roof is sealed to a vent or a chimney.. This suggestion arises from our observation of a produced water tank at which a continuous trickle from a leaking fitting simply followed the outer surface of the inlet pipe down into the ground, within the containment berm.

We support the proposed protection of fresh aquifers with two cemented casing strings. We support the proposal that injection wells be cemented with circulation continuously to the surface.

We commend OCD for proposing that produced water lines must be of double-walled pipe if not laid adjacent to roads. We suggest that *all* produced water lines not subject to visible inspection be double-walled. In other terms, if a produced water pipeline is laid underground adjacent to a road, it should be of double-walled construction because evidence of a subsurface leak might not be discovered for many years.

STATEMENT OF INTENT TO PRESENT TECHNICAL TESTIMONY
at the Oil Conservation Division hearing to adopt Rule 19.15.21, regarding the Chihuahuan Desert Area.

Witness: Donald A. Neeper, Ph.D.

Representing: New Mexico Citizens for Clean Air and Water, Inc.

Address: of Witness
2708 B. Walnut St.
Los Alamos, New Mexico 87544-2050
phone (voice): (505) 662-4592
e-mail: dneeper@aol.com

Qualifications: Dr. Neeper earned a doctorate in low-temperature physics from the University of Wisconsin in 1964. From 1968 to 1993, he was employed at the Los Alamos National Laboratory (LANL) where he conducted research in thermal physics and thermal engineering. During his last three years at LANL, he conducted professional research on contaminant migration and vapor extraction for the remediation of contaminated soils. He also managed a RCRA Facility Investigation of a disposal site containing radioactive and hazardous wastes, including subsurface plumes of organic vapors and tritium. In 1993, Dr. Neeper retired from LANL. He continues research and consulting related to subsurface air motion and its relationship to the transport of volatile organic compounds.

Length of Testimony: Approximately 25 minutes.

Summary of Testimony: Dr. Neeper will present technical testimony and photographic evidence supporting the need for regulatory protection of soils and landscape from damages that may occur during petroleum exploration and production. In particular, he will address unsaturated transport in the vadose zone, reasons for prohibiting pits, and reasons for prohibiting on-site disposal or burial of wastes containing offensive soluble substances, such as salts.

PO Box 419
El Prado, NM 87529
June 2, 2004

Ms. Florene Davidson
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Dear Ms. Davidson,

In response to an Executive Order issued by Governor Richardson, the New Mexico Oil Conservation Division (OCD) has proposed new, stricter rules that would apply to oil and gas development in the Chihuahuan Desert Area (almost all of Otero and Sierra counties).

While we would like to see the Otero Mesa, Nutt Grasslands and other sensitive areas <u>completely protected</u> from oil and gas development, the proposed rules would provide protection for the water, wildlife and habitat where oil and gas exploration and production could ultimately proceed. In general, this new rule prohibits pits and places stricter criteria on injection wells and related facilities used to dispose of produced water in the Chihuahuan Desert Area.

Thank you for supporting stricter regulations agianst drilling and protecting our beautiful state for generations to come,

Ross and Kristin Ulibarri

Ross and Kristin Ulibarri

1400 Saiz Rd.
Bloomfield, NM 87413
June 3, 2004

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JUN 04 2004

Oil Conservation Division
1220 S. Saint Francis Drive
Santa Fe, NM 87505

Ms. Florene Davidson
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Dear Ms. Davidson,

We understand that the Oil Conservation Division in response to Governor Richardson has proposed new, stricter rules that will apply to oil and gas development in the Chihuahuan Desert area of our state. Our first preference would be the protection of Otero Mesa and other sensitive areas from oil and gas development altogether. However, when and where development is allowed to proceed, we strongly support more stringent rules to adequately protect the area's water, wildlife and wildlife habitat.

We support the overall protection of Otero Mesa from oil and gas development. In the areas that can be safely developed, the best methods and technologies must be required to prevent pollution and protect wildlife, clean groundwater, and solitude. Pits should be banned; closed loop systems should be required; and injection wells should be prohibited because of the risk they pose to groundwater.

We believe that the Oil Conservation Commission should start the rulemaking process which would mandate future oil and gas activity to minimize and, when possible, eliminate industry impacts to air, water, grasslands, habitat, and wildlife. We support the prohibition of sumps and on-site disposal of waste, the drilling of multiple wells from one pad to minimize surface disturbance and reduce habitat and forage loss, the limitation of oil-field traffic, the use of the best standards to properly reclaim areas disturbed by oil/gas activity, and establishing improved standards for netting, fencing and tank coverings.

The oil and gas industry is one of the wealthiest industries in the nation; the industry can well afford to do things right.

Sincerely,

Janet Rees
John Rees

Janet Y. Rees
John W. Rees

SUZY T. KANE
109 Leroux Road
P. O. Box 1017
El Prado, NM 87529
505-776-5974
suzytkane@taosnet.com

June 3, 2004

Fax: (505) 476-3462

Ms. Florene Davidson
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Dear Ms. Davidson:

I am writing today because I believe that all of New Mexico deserves protection from dirty, toxic oil and gas pits that pollute our soil and groundwater. Over the past 20 years, our state agencies have documented at least 6,700 cases of contaminated soils and water caused by oil and gas pits in the state. We need better practices to protect New Mexico and, fortunately, these practices exist.

For example, closed loop systems are effectively being used within New Mexico's municipalities, such as Lovington, and throughout other areas of the country to protect water resources, environmentally sensitive areas, and public health. While these systems may cost industry slightly more than constructing pits, they are a proven method of environmental protection that industry will employ if made to do so. At a minimum, our statewide rules regulating pits should incorporate the use of closed loop systems, prohibit unlined pits without exception, and ban on-site disposal of oil and gas wastes.

-continued-

The oil and gas industry is an important part of our economy. However, unlined, open pits threaten our soil, groundwater, livestock and wildlife with toxic and carcinogenic materials, and leave New Mexico taxpayers bearing the risks of pollution and the burden of future remediation. Please instruct the Oil Conservation Commission to initiate future rulemakings that protect all of New Mexico by expanding the use of closed loop systems, and prohibiting, without any exception, unlined pits and the on-site burial of waste. The oil and gas industry generates billions of dollars worth of oil and gas in New Mexico each year, and they can afford to "do it right" for the benefit of all New Mexicans.

Sincerely,

Suzy T. Kane

Suzy T. Kane

RECEIVED

JUN 0 8 2004

OIL CONSERVATION DIVISION

June 3, 2004

Ms. Florence Davidson
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Dear Ms. Davidson,

I am writing today because I believe that all of New Mexico deserves protection from dirty, toxic oil and gas pits that pollute our soil and groundwater. Over the past 20 years, our state agencies have documented at least 6,700 cases of contaminated soils and water caused by oil and gas pits in the state. We need better practices to protect New Mexico and, fortunately, these practices exist.

For example, closed loop systems are effectively being used within New Mexico's municipalities, such as Lovington, and throughout other areas of the country to protect water resources, environmentally sensitive areas, and public health. While these systems may cost industry slightly more than constructing pits, they are a proven method of environmental protection that industry will employ if made to do so. At a minimum, our statewide rules regulating pits should incorporate the use of closed loop systems, prohibit unlined pits without exception, and ban on-site disposal of oil and gas wastes.

The oil and gas industry is an important part of our economy. However, unlined, open pits threaten our soil, groundwater, livestock and wildlife with toxic and carcinogenic materials, and leave New Mexico taxpayers bearing the risks of pollution and the burden of future remediation. Please instruct the Oil Conservation Commission to initiate future rulemakings that protect all of New Mexico by expanding the use of closed loop systems, and prohibiting, without any exception, unlined pits and the on-site burial of waste. The oil and gas industry generates billions of dollars worth of oil and gas in New Mexico each year, and they can afford to "do it right" for the benefit of all New Mexicans.

Thank you for your attention.

Sincerely,

Linda Moscarella

Linda Moscarella
POB 572, El Prado, NM 87529

Attn: Florene Davidson

PLEASE CONSIDER THE POINTS OUTLINED BELOW – DO WHAT YOU CAN TO HELP US PROTECT NEW MEXICO -

- Over all, Otero Mesa is a unique and fragile area that should be protected from oil and gas development.
- For those limited areas that can safely sustain development, the most protective measures and state of the art technology should be utilized to prevent pollution and protect Otero Mesa's unique qualities such as wildlife, clean groundwater and solitude.
- Protective measures, including banning pits, requiring closed loop systems and prohibiting injection wells, are responsible ways to achieve a balance between development and protection.
- Ask the Oil Conservation Commission to prohibit injection wells on Otero Mesa. While the stricter requirements proposed in this rule are an improvement on the current regulation, Otero Mesa's fragile environment and groundwater resources cannot tolerate injection wells at all.
- In addition to prohibiting pits and injection wells, the Oil Conservation Division should initiate further rulemakings to ensure that any future oil and gas activity minimize impacts to water resources, delicate grasslands, fragmentation of habitat and risks to wildlife.
- Additional rulemakings that should be initiated include: prohibiting sumps and on-site disposal of waste; promoting the drilling of multiple wells from one pad; minimizing the size of well pads; limiting roads and imposing limitations on oil-field traffic to protect wildlife and wilderness opportunities; setting specific criteria for netting, fencing and tank coverings; and implementing the highest standards in restoration of well sites.

Sincerely,
Cyndy Gimble
Taos County

FASKEN OIL AND RANCH, LTD.

303 WEST WALL AVENUE, SUITE 1800
MIDLAND, TEXAS 79701-5116

(432) 687-1777
jimmyc@forl.com

Jimmy D. Carlile
Regulatory Affairs Coordinator

June 7, 2004

Ms. Gail MacQuesten
New Mexico Oil Conservation Division
1220 S. St. Francis Drive
Santa Fe, NM 87505

Dear Ms. MacQuesten,

Re: Fasken Oil and Ranch, Ltd.
Comments on Proposed Chihuahuan Desert Regulations

Fasken Oil and Ranch, Ltd. appreciate the opportunity to comment on the proposed regulations to govern oil and gas exploration and development in Otero and Sierra Counties. The oil and gas industry and the New Mexico Oil Conservation Division (NMOCD) have a long history of working together to propagate regulations that provide for preventing waste of natural resources, protecting correlative rights, providing a safe environment for both the public and our workers, and for protection of our environment, our air, our soil and our precious water resources. Together we have been able to develop good regulation based on identifying and filling a need, reviewing historical operating practices for adequacy, and applying good, sound science to have a solid basis for regulatory efforts. These regulations are defensible based on this existing sound review process and the science which confirms the validity of the regulations. Good science allows us to develop good regulation.

We have been blessed over the years with regulators who have a good understanding of our extractive industry and understand the need for a sound energy policy for New Mexico. The result has been a very solid regulatory climate in which industry participates and understands. Environmental problems concerning groundwater resources are virtually non-existent as a result of the existing protective regulations and consistent enforcement of these regulations. We believe there are very few in our industry who intentionally ignore regulations and statutes. These people have the potential to harm our environment and place a huge negative shadow on our industry. Make no mistake. We want bad actors identified and prosecuted to the full extent possible under existing regulations and statutes.

With the above comments being made, we are greatly concerned the historical process that has been such a tremendous regulatory tool was abandoned in the development of the Chihuahuan Desert regulations. We are unable to ascertain the need for these regulations based on an identified need or a historical problem where groundwater resources have been contaminated. In discussions with NMOCD staff in Santa Fe during the development of the recent Pit Rule, there were no cases identified where a drilling pit was linked to groundwater contamination. With the many thousands of wells drilled in New Mexico, this stands as a tremendous record and, unquestioned, confirms the adequacy of existing regulations and operating practices. And, no issues of contamination were identified as a result of improper injection well operation and practice either. Again, this stands as a tremendous record and confirms the adequacy of the existing regulations. So why are we adding significant cost and potential safety burdens on industry when the existing regulations are obviously working very well?

We also do not understand why all stakeholders were not involved in the initial development of these regulations. Industry has partnered with regulators and other stakeholders on many regulatory issues to develop good, sound regulations. We have not always been able to gain a consensus on each and every issue, but we have all had an opportunity to put on record our concerns and gain an understanding of all stakeholder concerns. The process allows for development of sound, working regulations based on good science. This process must always be utilized as the first step in the development of regulations.

Fasken Oil and Ranch, Ltd. believes strongly in good regulation of our industry. Development of sound, workable regulation and protecting our environment are not mutually exclusive concepts. The existing regulatory structure provided by the NMOCD is proven to be effective in protecting the environment. These existing regulations are reasonable for industry to abide by. With oil and natural gas prices at near record highs, our country cannot afford to place off-limits to exploration and production any area within our country's borders. Every barrel of oil we can produce within our borders is a barrel we do not have to import.

Our specific comments on the proposed Chihuahuan Desert regulations are attached.

Yours truly,

Jimmy D. Carlile
Regulatory Affairs Coordinator

Fasken Oil and Ranch, Ltd.

Comments of Proposed Regulations for The Chihuahuan Desert Area Of Southwestern New Mexico

1. **19.15.1.21, Section A The proposed rule name should be changed from "Special Provisions for the Chihuahuan Desert Area" to " Special Provisions for Otero and Sierra Counties".**

The Chihuahuan Desert covers a large geographical area beyond the borders of Otero and Sierra Counties, and well beyond the borders of New Mexico. As these rules are very area specific, the title of the rule should be as well.

2. **19.15.1.21, Section B The use of pits is banned under this proposal. We believe pits should be allowed.**

There is no evidence where groundwater contamination has occurred as a result of the use of drilling and workover pits. These are temporary pits that are now subject to extreme closure standards under the new Pit Rule. Banning all pits provides no additional layer of protection for groundwater since there has been no history of contamination in the first place. And drilling operations in Otero and Sierra Counties will be conducted using air or water based muds. These processes are benign and the cuttings have been shown to not be toxic.

There are extreme safety issues associated with the concept of closed loop steel pit systems. Venting of gas and cuttings into a steel tank is a potential explosion hazard which can result in loss of life and a well that is out of control. Utilizing earthen pits allows for safe venting of gas away from the rig and work areas, and provides for an ample supply of water to control the well should a "kick" occur.

3. **19.15.1.21, Section C.1 Injection well permits should not have to be approved through the hearing process.**

Current regulations for the approval of injection wells in New Mexico already provide for Notice and Opportunity for Hearing. Affected parties are provided notice of the proposed injection well through the application process, and can request a hearing to protect their interest. There is no additional benefit to add this burden on industry or on NMOCD Hearings Examiners in Santa Fe.

4. **19.15.1.21 Section C.2 Current Area of Review requirement of ¼ is adequate.**

Good regulation looks at what is required to achieve the intent of the regulation. There has been no evidence provided that explains the need or historical problems caused by injection wells that justifies adding the use of the EPA formula for determining the zone of endangering influence around an injection well. The current UIC regulations require a ¼ mile area of review around injection wells. With no problems identified, this potential change in regulations adds a burden that provides no benefit.

5. **19.15.1.21, Section C. 3 Concerning ground water resource data**

It is not possible to log and identify fresh ground water using conventional drilling methods for oil and gas. Electric logs are run in wells that can identify potential water bearing zones, but cannot measure whether or not the zone is a fresh water zone. Fresh water zones need to be identified through the drilling of water wells. This data needs to be gathered under other means.

6. **19.15.1.21, Section C.4 Three degrees of protection currently provided under existing federal and state regulations already provide adequate protection for usable quality ground water.**

Dual casing strings and tubing with the use of a packer has proven to be adequate in the protection of usable quality groundwater. There is no history identified by the NMOCD where leaking injection wells are causing groundwater contamination. This requirement adds additional cost and operational complexity on industry where no additional layer of protection is justified.

7. **19.15.1.21, Section C.5 Existing practices concerning the adequacy of cementing practices are sufficient.**

Current industry practices have shown the adequacy of cementing practices in the protection of groundwater resources. Adding a requirement to run a Cement Bond Log after every cement job is unnecessary, adds costs, and provides no additional layer of protection to groundwater.

8. **19.15.1.21, Section C.6 Single walled produced water flowlines are adequate in preventing spills and releases.**

Produced water flowlines have not been shown to be a source of groundwater contamination. These type flowlines have low failure rates and account for a very small percentage of all releases, less than 1% according to a NMOGA study. Single wall flowines allow a company to readily identify a leak and promptly make repairs and perform remediation measures as mandated by the NMOCD. Double walled pipe would make identifying the location of a leak virtually impossible, and would slow down repairs and remediation. Industry routinely inspects flowlines as part of normal business practices. The requirement for double walled produce water flowlines will provide no real environmental benefit.

9. **19.15.1.21, Section C.7 The requirement to place all tanks on impermeable pads surrounded by lined berms is unreasonable and unnecessary.**

The intent of NMOCD and federal SPCC regulations are that any spills are properly contained and prevented from reaching surface and ground water in the time frame that it takes to discover and remove such spills and conduct appropriate remediation. Experience shows that the base and walls of containment zones need not be absolutely impermeable, but *sufficiently impermeable* to prevent reaching surface and ground water.

The USEPA has stated "the proper method of secondary containment is a matter of good engineering practice, so we do not prescribe any particular method." We believe this is the proper language that should be utilized in this regulation.

10. **19.15.1.21, Section C.8 and C.9 Annual mechanical integrity tests and daily recordkeeping are unnecessary.**

No evidence is provided that show testing the mechanical integrity of injection wells on a five year basis has caused ground water contamination. There is no evidence that shows daily recording of injection pressures and volumes is needed to prevent ground water contamination. If fact, just the opposite is true. The excellent history of protecting ground water under the existing UIC rules and regulations shows the adequacy of the existing requirements.

JOHN SHOMAKER & ASSOCIATES, INC.
WATER-RESOURCE AND ENVIRONMENTAL CONSULTANTS
2703 BROADBENT PARKWAY NE, SUITE B
ALBUQUERQUE, NEW MEXICO 87107
(505) 345-3407, FAX (505) 345-9920

June 7, 2004

Ms. Davidson
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Written comments on the proposed amendment to the New Mexico Oil Conservation Division Rule Book titled *19.15.1.21 Special provisions for the Chihuahuan Desert area*

Dear Ms. Davidson:

John Shomaker & Associates, Inc. (JSAI) was contracted by The Wilderness Society to evaluate the proposed BLM Resource Management Plan (RMP) for the Otero Mesa and Salt Basin areas in New Mexico, and to provide comments on the proposed amendment to the New Mexico Oil Conservation Division Rule Book.

The focus of our evaluation of the BLM RMP was to determine if the water resources beneath Otero Mesa had been adequately described and if proper consideration had been made to protect the water resources. In our February 5th, 2004 report titled *Evaluation of potential water-resources impacts from BLM proposed resource management plan amendment from federal fluid minerals leasing and development in the Salt Basin, New Mexico*, (copy of report is enclosed) we concluded the following:

1. The proposed plan leaves approximately 70 percent of the public land open with standard lease terms and conditions, and no special provisions for protection of ground-water resources (public water supply). Proposed activities may include oil and gas exploration and development, with the potential for injection wells to dispose waste. Proposed activities and protection of identified water resources (public water reserves) would be regulated under standard lease terms and conditions (BLM, 2003).
2. Depth to water in the central part of the basin is around 200 ft, and many of the wells that produce from shallow perched ground water may have depth to water less than 100 ft (see well data in Appendix A). The BLM RMP and Environmental Impact Statement (EIS) do not include the shallow depth to water data in the analysis of water-resource impacts.
3. The majority of the Salt Basin is underlain by limestone (carbonate) rock that is fractured, and considered as a regional aquifer (Mayer, 1995; Mayer and Sharp, 1998).

4. The regional aquifer is similar to the Edwards Aquifer in Texas, where the recharge zone is sensitive to contamination and requires controlled surface use for protection. Oil and gas exploration and development activities should not be allowed in these areas where the aquifer is highly susceptible to contamination.
5. The Silurian-age Fusselman Dolomite has been reported by the oil and gas exploration industry as having "fresh" water in the Otero Mesa and Diablo Plateau areas. The Fusselman Dolomite is generally found at depths greater than 2,000 ft below land surface (Pearson, 1980; Harder, 1982).
6. The possibility of injection wells should be omitted from the RMP given the widespread distribution of fresh "public ground water beneath the Salt Basin, and the fractured nature of the aquifer(s)."

Proposed Amendment

The proposed amendment to the New Mexico Oil Conservation Division Rule Book titled *19.15.1.21 Special provisions for the Chihuahuan Desert area* covers the entire Otero Mesa area (19.15.1.21.A). The proposed amendment (19.15.1.21.B) does not allow for pits associated with oil and gas drilling, as described in 19.15.2.50 NMAC and 19.15.9.711 NMAC, although it is unclear if above-ground self-contained pits will be allowed or if there are exemptions to the proposed amendment. Special provisions have been proposed for produced water injection wells under amendment 19.15.1.21.C. The provisions are designed in good faith to protect fresh-water resources by requiring tests to identify fresh-water aquifers, and to isolate fresh-water aquifers from the injection well and associated facilities.

The proposed amendment does not prohibit the installation and use of injection wells and associated facilities in areas where fresh-water aquifers are highly sensitive to contamination via surface spills or factures and preferential pathways.

The main concern regarding the proposed amendment is that is does not include provisions to protect fresh-water recharge areas by completely omitting the potential of contamination from pits (above or below ground), injection wells, and associated facilities. As a result, JSAI was requested to address additional questions regarding details about the migration of potential contaminants from oil and gas development on Otero Mesa, New Mexico, such as:

A. How vulnerable are existing and proposed water supply wells to potential contamination from Oil and Gas development activities on Otero Mesa?
B. What hydrogeologic issues are there in relation to oil and gas production activities? (i.e., impacts to aquifer)

Provided below is a discussion on vulnerability of the fresh-water resources in the Otero Mesa area.

Vulnerability of Water Supply Beneath Otero Mesa

The vulnerability of the aquifer beneath the Otero Mesa can be inferred from fracture mapping performed by Mayer (1995), the direction of ground-water flow, and the proximity of water-supply wells to the BLM land proposed for oil and gas development (shown on the attached map). In many areas there are existing or proposed water-supply wells in the same area as BLM land proposed for oil and gas development.

The areas of highest vulnerability for contamination of the regional aquifer beneath Otero Mesa are in the areas where the fracture density is highest in the central part of the Salt Basin (shown on the attached map).

Potential for Contaminant Migration in Salt Basin

The aquifer beneath Otero Mesa (Salt Basin) is composed of carbonate rocks of the Permian-age Bone Springs Victorio Peak Formation. This rock unit has been tectonically altered by the Otero Break; a region of numerous faults and fractures. These faults and fractures relay ground water recharge from the Sacramento Mountains to the Dell City area, where extensive ground water development has occurred.

In addition to being fractured by the Otero Break, the Bone Springs Victorio Peak aquifer has been characterized as a "karst" aquifer containing solution-cavities and caverns. There are two flow regimes that occur in karst settings, which are as follows:

1. Pipe Flow – fluids completely fill the solution cavities and channels, and the fluid movement may be described as non-turbulent pipe flow.
2. Open-Channel Flow – fluid movement occurs as subterranean streams through modest to large solution cavities and caverns (Gorelick and Others, 1993)

Either flow regime results in a tracer velocity greater than that observed in porous media such as sand and gravel.

There are no known case studies of contaminant migration for the Bones Springs Victorio Peak aquifer, although case studies and other information on the comparable Edwards Aquifer in central Texas may suggest possible examples of contaminant migration beneath Otero Mesa. Tracer velocities of 30 ft/day have been calculated for the Edwards Aquifer by Maclay and Small (1986), but the actual tracer velocity in the Bone Springs Victorio Peak aquifer would depend on the quantity of recharge and discharge driving the flow.

In summary, water supply beneath Otero Mesa is highly vulnerable to contamination by proposed oil and gas development because of the proximity of existing water supply wells and the porous nature of the regional aquifer. Due to the potential for rapid migration of contaminants, remediation would be very difficult, and permanent degradation of water quality would be likely. There is also a lack of data on the fresh-water resources for making long-term decisions about oil and gas development and associated activities. For these reasons, oil and gas exploration and development activities should be omitted from the Otero Mesa area where fractured carbonate rocks at the surface and at depth are highly susceptible to potential spills and leaks of contaminated fluids from pits and injection wells. In addition, permitting of pits and injection wells in other parts of the Chihuahuan Desert area should require detailed hydrogeologic analysis of the proposed facility and demonstrate contamination will not occur.

Based on the findings from our analysis of the hydrogeologic setting beneath Otero Mesa, we recommend prohibiting pits, injection wells, and the facilities associated with oil and gas exploration and development in the Otero Mesa area, particularly the area of high fracture density shown on the attached map. This is particularly appropriate at this time, given the lack of detailed hydrogeologic analysis and demonstration that contamination will not occur.

Sincerely,

JOHN SHOMAKER & ASSOCIATES, INC.

Steven T. Finch, Jr.
V.P. - Senior Geochemist/Hydrogeologist

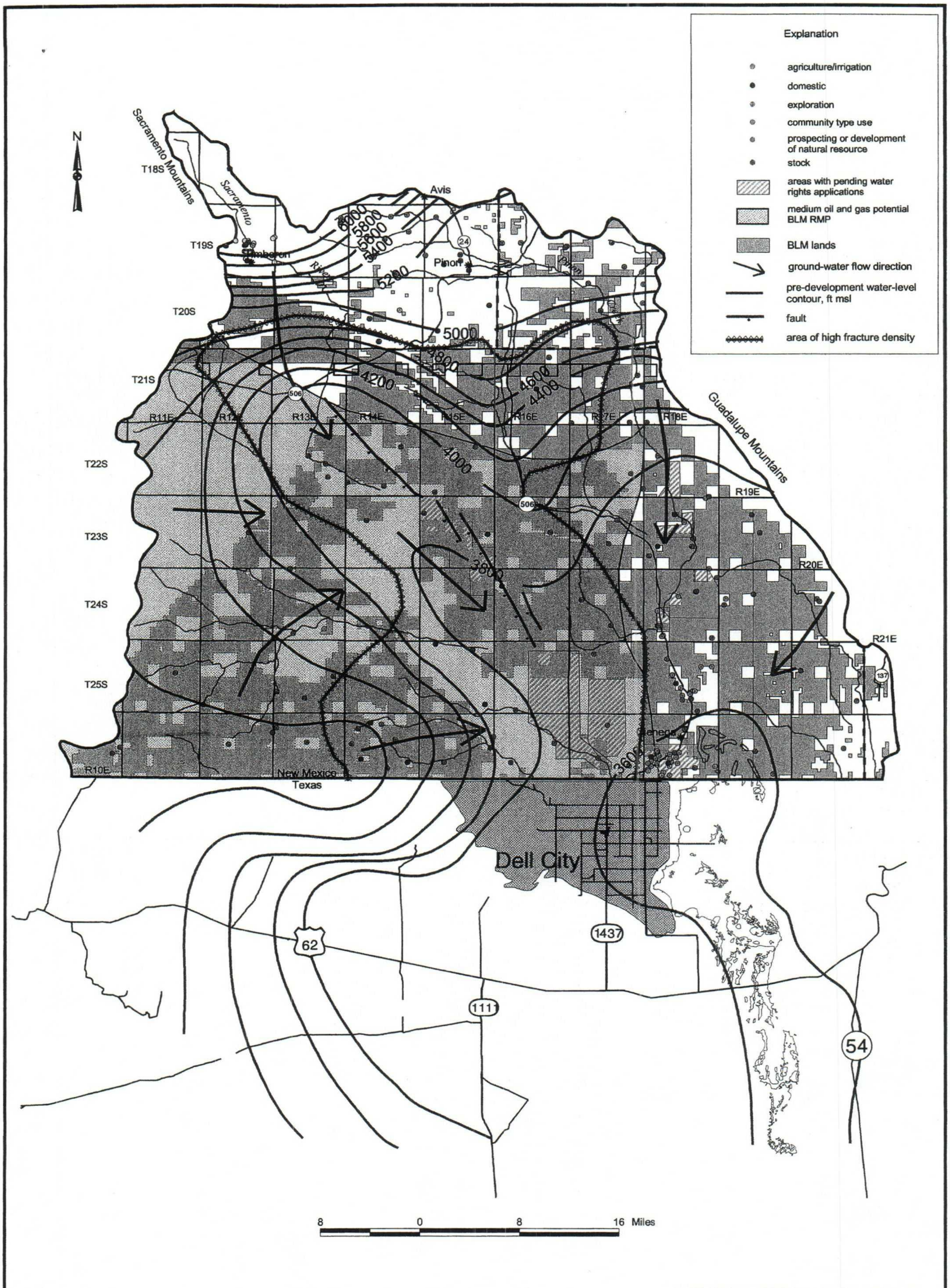
STF:sf

Encl: Report prepared by JSAI
Map of Otero Mesa

References

Gorelick, S. M., Freeze, R. A., Donohue, D., and Keely, J. F., 1993, Groundwater Contamination Optimal Capture and Containment: Lewis Publishers, Boca Raton, Florida, pp. 228-229.

Maclay, R. W., and Small, T. A., 1986, Carbonate geology and hydrology of the Edwards Aquifer in the San Antonio area, Texas: Texas Water Development Board Report 296, 90 p.



JOHN SHOMAKER & ASSOCIATES, INC.

EVALUATION OF POTENTIAL WATER-RESOURCE IMPACTS FROM BLM PROPOSED RESOURCE MANAGEMENT PLAN AMENDMENT FOR FEDERAL FLUID MINERALS LEASING AND DEVELOPMENT IN THE SALT BASIN, NEW MEXICO

prepared by

Steven T. Finch, Jr., CPG

JOHN SHOMAKER & ASSOCIATES, INC.

Water-Resource and Environmental Consultants

Albuquerque, New Mexico 87107

prepared for

Otero Mesa Coalition

February 6, 2004

EVALUATION OF POTENTIAL WATER-RESOURCE IMPACTS FROM BLM PROPOSED RESOURCE MANAGEMENT PLAN AMENDMENT FOR FEDERAL FLUID MINERALS LEASING AND DEVELOPMENT IN THE SALT BASIN, NEW MEXICO

prepared by

Steven T, Finch, Jr., CPG

JOHN SHOMAKER & ASSOCIATES, INC.
Water-Resource and Environmental Consultants
Albuquerque, New Mexico 87107

prepared for

Otero Mesa Coalition

February 6, 2004

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CONTENTS

TABLES

ILLUSTRATIONS

(follow text)

APPENDICES

(follow illustrations)

EVALUATION OF POTENTIAL WATER-RESOURCE IMPACTS FROM BLM PROPOSED RESOURCE MANAGEMENT PLAN AMENDMENT FOR FEDERAL FLUID MINERALS LEASING AND DEVELOPMENT IN THE SALT BASIN, NEW MEXICO

1.0 INTRODUCTION

John Shomaker & Associates, Inc. (JSAI) was contracted by the Otero Mesa Coalition to provide a technical opinion on the U.S. Department of Interior Bureau of Land Management (BLM) proposed resource management plan for the Otero Mesa area. The BLM document is titled *Proposed Resource Management Plan Amendment and Final Environmental Impact Statement for Federal Fluid Mineral Leasing and Development in Sierra and Otero Counties* (BLM, 2003).

The primary area of concern and review is the Otero Mesa and surrounding area within the Salt basin, New Mexico (Fig. 1). As stated in the Resource Management Plan (RMP), some of the criteria in developing the plan included (but was not limited to) the following:

1. Provide for the protection of water resources
2. Maintain public health and safety
3. Consider social and economic effects

1.1 BLM Proposed Plan

According to the proposed plan, the majority of public land in the Salt Basin part of Otero County would remain open to fluid mineral leasing. The BLM (public land) in the Salt Basin is shown on Figure 1, and comprises more than 70 percent of the basin (approximately 850,000 acres). The proposed plan leaves approximately 70 percent of the public land open with standard lease terms and conditions and no special provisions for protection of ground-water resources (public water supply). Proposed activities may include oil and gas exploration and development, with the potential for injection wells to dispose waste. Proposed activities and protection of identified water resources (public water reserves) would be regulated under standard lease terms and conditions (BLM, 2003).

1.2 Objective and Purpose

The objective and purpose of this report is to address the following issues:

- Identify water resources underlying Otero Mesa that the BLM has not recognized or adequately addressed
- Identify areas of the aquifer that could potentially be impacted from surface disturbances (i.e., recharge zones)
- Identify activities and methods related to oil and gas exploration and development that could affect the existing aquifer(s)

2.0 DESCRIPTION OF REGIONAL AQUIFER(S)

The Salt basin is a large, internally drained basin covering about 5,900 square miles, of which 4,000 square miles are in Texas and the remaining 1,900 square miles are located just across the state line in New Mexico (Bjorklund, 1957). The water in the Salt Basin originating in New Mexico flows toward Texas. The portion of the Salt Basin in New Mexico includes Crow Flats and Otero Mesa. The Crow Flats portion of the basin drains to a series of alkali flats or playas to the south, just above the state line (Bjorklund, 1957). Irrigation with ground water has occurred in the Salt Basin near the New Mexico-Texas border, an extension of the agricultural area referred to as the Hudspeth County Underground Water District No. 1 (HCUWD#1) in Dell City, Texas.

Major watersheds within the New Mexico portion of the Salt Basin include the Sacramento River, Piñon Creek, and Shiloh Draw (Fig. 1). The Sacramento River drains the southern end of the Sacramento Mountains, where elevations of the upper watershed range from 8,000 ft to 9,500 ft.

Depth to water in the central part of the basin is around 200 ft, and many of the wells have depth to water less than 100 ft (see well data in Appendix A).

2.1 Structure and Framework

The Salt Basin is an extensional basin that widens to the south and is bordered on the east by the Guadalupe and Brokeoff Mountains and on the west by the Hueco Mountains and Otero Mesa. The Salt Basin is a block-faulted graben bounded by faults that extends 260 miles from the Sacramento River south into Texas (Fig. 1). The Crow Flat area is at lower elevation than the surrounding mesas, plateaus, and mountains, and is the site of the salt flats where ground-water discharges and evaporates.

Faults and associated folds on the eastern side of the basin represent the eastern extent of the Rio Grande Rift portion of the Basin and Range physiographic province. A good description of the hydrogeologic setting for the Salt Basin can be referenced from TWDB/NMWRRI (1997).

Ground-water flow in the limestone rocks of the Salt Basin is largely controlled by regional fracture systems (Mayer and Sharp, 1998). The most significant regional fracture system in the Salt Basin area is referred to as the Otero Break, trending from the Sacramento River to Dell City, Texas.

The Otero Break structural feature "graben" formed in late Paleozoic time along a northwest fault zone from right-lateral shear and extensional forces (Mayer, 1995). This fault zone was reactivated during the development of Basin and Range extension (Salt Basin), and extensively fractured the Permian-age carbonate rocks (Yeso Fm., San Andres Fm., etc) that occupy the majority of the Salt Basin and Otero Mesa area (Fig. 2).

2.2 Geologic Units

A summary of the geologic units found in the study area is presented as Table 1, and shown on Figures 2 through 4. Tertiary igneous intrusions of both andesitic and basaltic composition are present in the Cornudas Mountains and Dell City area (Dietrich et al. 1995). Quaternary-age basin fill in the form of alluvium and piedmont deposits, as well Santa Fe Group sediments, can be more than 500 ft thick, but in most places range from 25 to 300 ft thick (Bjorklund, 1957).

The principal bedrock aquifer units in the New Mexico portion of the Salt Basin are the San Andres Limestone, Yeso Formation, and Abo (Hueco) Formation, which together make up the bulk of the water bearing strata. In the Dell City area, the carbonate rock aquifer is referred to as the Victorio Peak-Bone Spring. Older formations (pre-Permian-age rocks), such as the Fusselman Dolomite, are water bearing and may possibly contain a viable public water supply.

Table 1. Summary of geologic units for the Salt Basin

age	symbol	stratigraphic unit	thickness, ft	description
Quaternary	Qal	alluvium	200 - 500	basin fill - unconsolidated clay, silt, sands, and gravels
	Qts	Upper Santa Fe Group	500 - 2000	basin fill - silts, sands, and gravels
Tertiary	Ti	intrusives	10 - 100	igneous intrusives - dikes and sills
Permian	P	Permian undivided	2000 - 5000	shale, limestone, mudstone, gypsum
	Psa/ Pvp	San Andres/ Victorio Peak	200 - 1000	limestone
	Pbs	Bone Spring	900 – 1,700	limestone
	Py	Yeso Formation	1200 - 1800	interbedded limestones and shales
	Pa/ Ph	Abo/ Hueco Formations	200 - 500	mudstones and conglomerates
	Pb	Bursum Formation	400 - 600	interbedded siltstones, sandstones, shales and conglomerates
Pennsylvanian	IPh	Holder Formation	500 - 900	interbedded limestones and conglomerates
		Gobbler Formation	1200 - 1600	sandstones and conglomerates
Mississippian	M	Lake Valley Formation	350 - 450	interbedded limestones and shales
Devonian	D	Percha Shale	40 - 80	black noncalcareous shale
Silurian	Sf	Fusselman Dolomite	20 - 100	massive dolomite with chert
Ordovician	Om	Montoya Formation	190 - 225	massive dolomite
Cambrian	Ce	El Paso Formation	350 - 450	dolomitic sandstone
		Bliss Sandstone	100 - 150	quartz sandstone
Precambrian	pC	granite	--	granites and granodiorites

Figure 2 is a map showing the distribution of major geologic units that make up the aquifer(s) in the study area. On Figure 2, the basin-fill deposits (Qal) refer to alluvium and Upper Santa Fe Group listed in Table 1; other Permian-age rocks are equivalent to Permian undivided. Cretaceous rocks refer to the Cox Sandstone and other overlying and underlying rocks of similar age.

The upper sequence of Permian-age rocks, Yeso, San Andres, Bone Spring, and Victorio Peak Formations, were deposited in a shallow sea environment behind the reef margin of the Delaware Basin. These carbonate rocks typically become more permeable toward the reef margin (Capitan reef in the Guadalupe Mountains), which would suggest increasing permeability to the southeast in the New Mexico portion of the Salt Basin. The lower member of the San Andres Formation grades to the southeast toward the Permian reef facies into the Victorio Peak Formation (Black, 1975). Therefore, the Victorio Peak is equivalent, in time of deposition, to the upper Yeso and lower San Andres. Cross-sections showing the relationship of major geologic units from west to east, across the New Mexico portion of the Salt Basin, are provided as Figures 3 and 4.

The San Andres Limestone and Yeso Formation cover most of the upper portion of the Salt Basin (Fig. 2). The San Andres Formation is composed of limestone, with sandstone at the base of the formation. The Yeso consists of sandstone, limestone, dolomite, siltstone, shale, and evaporites (Pray, 1961). The Yeso Formation is approximately 1,000 ft thick in the southern Sacramento Mountains (Kelly, 1971). Many of the springs in the southern Sacramento Mountains discharge from the contact between the San Andres and Yeso Formations. Most wells that yield water from the Yeso Formation are completed in the upper 500 ft of the formation in fractured limestone and dolomite where the permeability has been enhanced by solution. In the Timberon area, wells drilled into the lower Yeso Formation are typically low yielding (<5 gpm) as compared with wells in the upper Yeso, which produce more than 100 gpm.

The Bone Spring-Victorio Peak aquifer extends from Crow Flat in an arc to the south around the edge of the Permian-age Delaware Basin. The Bone Spring-Victorio Peak aquifer is present under most of the east part of the Diablo Plateau (Fig. 2). High-yield irrigation wells that produce from the Bone Spring-Victorio Peak aquifer commonly intercept fractures that have been opened by the percolation of ground water from overlying alluvium (Scalapino, 1950; Bjorklund, 1957). Scalapino (1950) reported that approximately 50 percent of the wells drilled are high-yield (> 1,000 gpm) and the other half are low-yielding (< 500 gpm).

Rocks older than Permian include (1) Pennsylvanian- and Mississippian-age limestone and shale, (2) shale, dolomite, and sandstone of Devonian-, Silurian-, Ordovician-, and Cambrian-age, and (3) Precambrian-age granite and metamorphic rocks (see Table 1).

Exploration drilling has indicated biogenic gas is associated with the Pennsylvanian- and Mississippian-age organic shale, which is formed by decomposition of organic matter by fresh water microbes.

The Silurian-age Fusselman Dolomite has been reported by the oil and gas exploration industry as having "fresh" water in the Otero Mesa and Diablo Plateau areas. The Fusselman Dolomite is generally found at depths greater than 2,000 ft below land surface (Black, 1975; Pearson, 1980; Harder, 1982).

2.3 Recharge

Due to the absence of perennial streams in the basin center, ground-water recharge is mainly infiltration of precipitation from melting snowpack and during flash flooding of ephemeral channels (Bjorklund, 1957). Most of the water for recharge originates from the higher elevations of the Sacramento River and Piñon Creek watersheds. The total annual average yield of these watersheds is approximately 35,000 ac-ft/yr (Table 2). The area of these watersheds is approximately 20-percent of the total area for the New Mexico portion of the Salt Basin.

Table 2. Watersheds in the Salt Basin, and summary of watershed data and estimated yield

name	mean annual precipitation, in./yr	mean elevation, ft amsl	area, mi^2	estimated watershed yield, ac-ft/yr
Sacramento River	22.8	7,795	135	17,580
Piñon Creek	20.0	7,100	99	8,872
small un-named watersheds and mountain front on Otero Mesa and Cornudas and Brokeoff Mountains	17.2	6,500	124	8,626
Salt Basin total			358	35,078

in./yr inches per year
mi^2 square miles
ft amsl feet above mean sea level
ac-ft/yr acre-feet per year

The watershed yield analysis was performed by evaluating monthly precipitation and potential evaporation data collected from weather stations in the region (Livingston Associates and John Shomaker & Associates, Inc., 2001).

The watershed yield analysis indicates that aerial recharge does not occur below an elevation of 5,860 ft, although below an elevation of 5,860 ft recharge from storm-water runoff occurs along arroyos and highly fractured rock where infiltration rates are high. Total watershed yield calculated for the Salt Basin area is 35,000 ac-ft/yr (Table 2), with approximately one-half originating from the Sacramento River Watershed.

Due to the fractured conditions of the rocks, all of the 35,000 ac-ft/yr plus storm-water runoff infiltrates into the ground-water system and can be considered as recharge.

Mayer (1995) estimated a total average annual rate of recharge at 58,000 ac-ft/yr for the Salt Basin, which included part of the Diablo Plateau in Texas.

2.4 Direction of Ground-Water Flow

Ground-water elevation contour maps for only parts of the study area have been developed by Ashworth (1995), Mayer (1995), and TWDB/NMWRRI (1997). The water-level contour maps from Ashworth (1995) and TWDB/NMWRRI (1997) are limited to the Dell City area and are representative of near present pumping conditions. The water-level contouring by Mayer (1995) was limited to a few data points in New Mexico, and implied a relatively flat hydraulic gradient throughout the study area.

The ground-water elevation contour map shown as Figure 5 was constructed from data from existing reports, the Texas Water Development Board (TWDB) database, and the New Mexico Office of the State Engineer (NMOSE) WATERS database. There are several areas where water-level data are absent, and extrapolation between data points 10 to 20 miles apart was made. Additional data are needed for Otero Mesa, Diablo Plateau, and the northern fringes of Otero Break to have a more accurate ground-water elevation contour map of the study area.

Regional ground-water flow is from the northern Salt Basin, Otero Mesa, and Diablo Plateau toward the Salt Flats near Dell City (Fig. 5). Ground-water elevation contours along the northern watershed boundary of the Salt Basin, between Timberon and Piñon, indicate ground-water flow from the Peñasco Basin to the Salt Basin.

The direction of ground-water flow from Otero Mesa and the Sacramento watershed area is toward the highly fractured region referred to as Otero Break. The fractured rocks of Otero Break have very high permeability and, as a result, effectively transport water to the

Dell City area and Salt Flats. Figure 6 is an aerial photograph of a portion of the Otero Break area (T23S, R16E), showing the visibility and northwest orientation of the regional fracture system.

Ground-water flows radially away from the Cornudas Mountains, presumably as a result of recharge there. Mayer (1995) suggested the water levels in the Cornudas Mountains indicate a perched water table, but data from nearby deep wells still show radial flow from the Cornudas Mountains.

2.5 Current and Historic Use

The primary uses of ground water in the New Mexico portion of the Salt Basin have been for domestic supply, stock watering, and irrigation. Irrigation has primarily been in the Crow Flat area. Bjorklund (1957) reported 3,000 acres of irrigated land from 17 wells in 1956, all in the Crow Flats area with most of it near the New Mexico-Texas state line.

Stock wells are scattered throughout the Salt Basin, and several of them are converted oil and gas exploration wells. A list of well data from the NMOSE WATERS database is provided in Appendix A. Existing wells are shown on the map provided as Figure 7.

Timberon Water & Sanitation District has approximately 1,500 ac-ft/yr of surface-water rights associated with Carriza Spring, tributary to the Sacramento River. Table 3 summarizes the declared water rights in the Salt Basin.

Table 3. Summary of declared water rights in Salt Underground Water Basin, New Mexico

use	declared water rights, ac-ft/yr
domestic	80
stock	566
municipal	1,499
irrigation*	47,595
total	49,740

* Hunt Development Corp. has declared 35,290 ac-ft/yr for irrigation of 3,600 acres
ac-ft/yr acre-feet per year

The majority of pumping from the Salt Basin occurs in the Dell City area, in Texas. Ashworth (1995) and Scalapino (1950) have summarized the acre-feet pumped for the HCUWD#1 (Dell City area), as listed in Table 4. Irrigation in the Dell City area began in 1947, and approximately 26,000 acres are currently irrigated for growing alfalfa, cotton, and chile. The HCUWD#1 claims 36,000 acres can potentially be irrigated, which would require about 180,000 ac-ft/yr of pumping at the current application rate of about 5 acre-feet per acre. Wilson and Lucero (1997) estimated a total pumping for irrigation in the New Mexico side of the Salt Basin at 10,171 ac-ft/yr in 1995.

Table 4. Summary of historic pumping for irrigation in the Dell City area

year	acre-feet pumped
1948[a]	7,500
1949[a]	18,000
1958[b]	67,000
1964[b]	91,500
1974[b]	132,700
1979[b]	144,600
1984[b]	102,000
1989[b]	94,700
1994[c]	100,000
1999[c]	100,000

a from Scalapino (1950)
b from Ashworth (1995)
c from HCUWD#1

2.6 Future Use

Recognizing the importance of the public ground-water reserve, the New Mexico State Engineer declared the Salt Underground Basin in September 13, 2000. After the basin was declared, several applications have been filed to further develop the water resources in Crow Flat and Otero Break (Fig. 7).

The Tularosa-Salt Basin Regional Water Plan was adopted by the New Mexico Interstate Stream Commission in May 2002, which defines the water resources of the Salt Basin and outlines current and future use. Even though the Salt Basin is sparsely populated and remote, the vast water supply in the Salt Basin is an important alternative resource for the future of New Mexico. Alternatives include development and importation to areas of need, as well as, preservation for use beyond the 40-year planning horizon.

The State Water Plan for New Mexico (selected pages in Appendix C) contains the following discussion on the Salt Basin and associated water resources:

- The availability of safe and adequate drinking water supplies for all New Mexicans is of paramount importance to the health and safety of the State's citizens (pg 6).
- Little development of the Salt Basin has occurred in New Mexico, but pressure to develop this resource is growing (appendix A, A-36)
- Steps must be taken to ensure that water from the basin is preserved to meet growing demands in southern New Mexico (appendix A, A-37)

3.0 DEFICIENCIES IN BLM RMP AND EIS

3.1 Identification of Water Resources and Potential Impacts

The BLM RMP and EIS did not review and include key publications on the water resources for the impact assessment (see references Section 5.0, and Appendix B).

- The majority of the Salt Basin is underlain by limestone (carbonate) rock that is fractured, and considered a regional aquifer (Mayer, 1995; Mayer and Sharp, 1998). Detailed description of this regional aquifer can be obtained from the references provided in Appendix B.
- The shallow alluvial aquifer is localized to arroyo and stream channels where recharge occurs. The alluvial aquifer is used for domestic and stock purposes. Depth to water is shallow in the alluvial aquifer rendering it susceptible to contamination from surface disturbances.
- There are potentially significant fresh water resources above and below the target formations for oil and gas development.
- The full extent of the water resources in the Salt Basin has not been defined.

3.2 Characterization of Aquifer(s) and Sensitivity to Management Alternatives

The BLM RMP and EIS did not identify the regional fractured carbonate rock aquifer beneath the Salt Basin and its susceptibility to surface disturbances related to oil and gas development.

- The regional aquifer is similar to the Edwards Aquifer in Texas, where the recharge zone is sensitive to contamination and requires controlled surface use for protection.
- The majority of the Salt Basin has fractured Permian-age carbonate rocks exposed at the surface, which is part of the regional aquifer. The fracture density has been quantified by Mayer and Sharp (1998), in which fracture density can be as high as 15,800 ft per square mile; in some cases fractures are no more than one meter apart (see discussion and photographic documentation by Mayer (1995) in Appendix B). Fractures are exposed at the land surface and potentially provide pathways for contaminant migration to the regional aquifer.
- The hydraulic conductivity for the Otero Break area is estimated to average 100 ft/d, and the hydraulic gradient estimated from Figure 5 is 0.002 ft/ft. Using Darcy's Law to calculate the tracer velocity, an average value of 20 ft/d was calculated for the fractured part of the aquifer at Otero Break (assuming an effective porosity of 0.01). With in a particular facture, the tracer velocity may be several orders of magnitude greater. This indicates how rapid contaminants could travel once introduced into the aquifer.

3.3 Ground-Water Protection Measures

Additional ground-water protection measures need to be implemented to insure protection of water resources in the Salt Basin.

- The possibility of injection wells should be omitted from the RMP given the widespread distribution of fresh "public ground water beneath the Salt Basin, and the fractured nature of the aquifer(s)."
- The fracture density study performed by Mayer (1995) could provide guidance for determining areas of the aquifer susceptible to contamination from surface disturbances. It is likely a more detailed fracture evaluation will need to be undertaken before land management decisions are made.

3.4 Economic and Ranking Evaluation of Resources

The BLM RMP and EIS should review existing water plans for the Salt Basin and incorporate those into resource evaluation and protection of water resources identified for future use. (excerpts from the State Water Plan can be referenced in Appendix C).

- The value of the water resources and fluid mineral resources should be evaluated, and appropriate methods should be used to rank resources based on impacts, value, and sustainability.

4.0 CONCLUSIONS AND FINDINGS

1. The proposed plan leaves approximately 70 percent of the public land open with standard lease terms and conditions and no special provisions for protection of ground-water resources (public water supply). Proposed activities may include oil and gas exploration and development, with the potential for injection wells to dispose waste. Proposed activities and protection of identified water resources (public water reserves) would be regulated under standard lease terms and conditions (BLM, 2003).
2. Depth to water in the central part of the basin is around 200 ft, and many of the wells that produce from shallow perched ground water may have depth to water less than 100 ft (see well data in Appendix A). The BLM RMP and EIS does not include the shallow depth to water data in the analysis of water-resource impacts.
3. The majority of the Salt Basin is underlain by limestone (carbonate) rock that is fractured, and considered as a regional aquifer (Mayer, 1995; Mayer and Sharp, 1998).
4. The regional aquifer is similar to the Edwards Aquifer in Texas, where the recharge zone is sensitive to contamination and requires controlled surface use for protection.

5. The Silurian-age Fusselman Dolomite has been reported by the oil and gas exploration industry as having "fresh" water in the Otero Mesa and Diablo Plateau areas. The Fusselman Dolomite is generally found at depths greater than 2,000 ft below land surface (Black, 1975; Pearson, 1980; Harder, 1982).

6. The possibility of injection wells should be omitted from the RMP given the widespread distribution of fresh "public ground water beneath the Salt Basin, and the fractured nature of the aquifer(s)."

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ILLUSTRATIONS

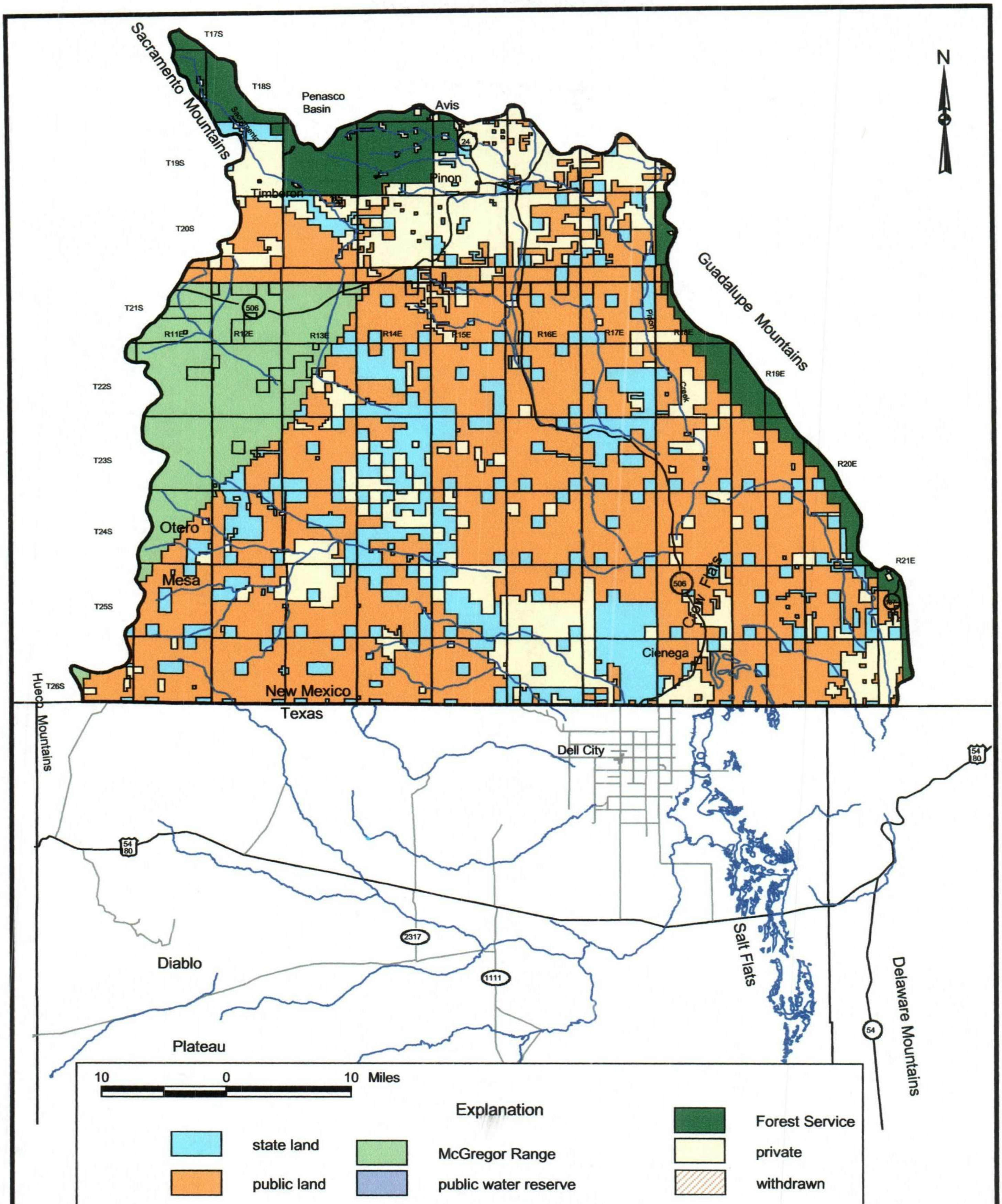

Figure 1. Map showing location of study area, land ownership, and geographic features within the Salt Basin and Diablo Plateau.

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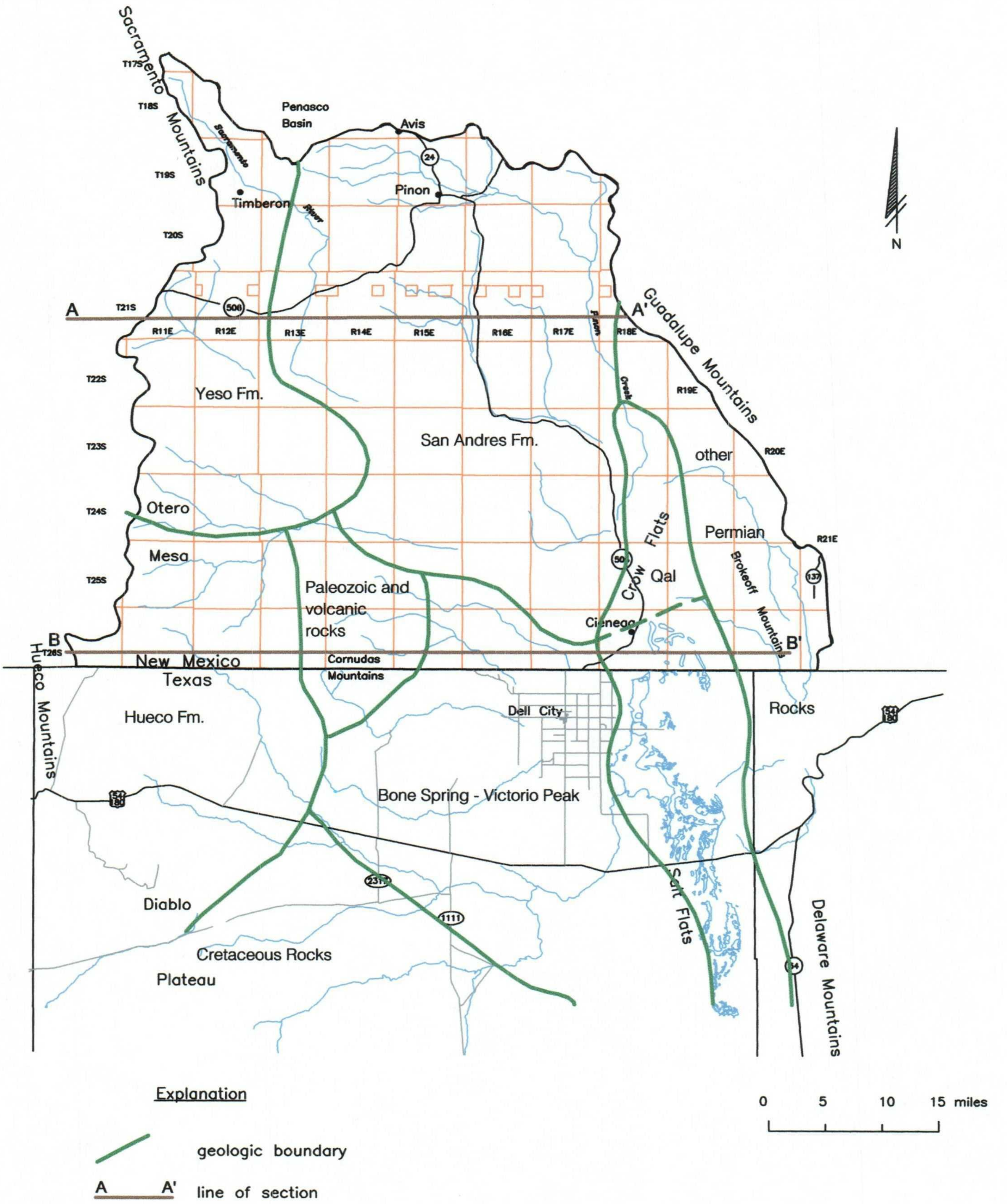

Figure 2. Map showing regional geology of the Northern Salt Basin and Diablo Plateau.

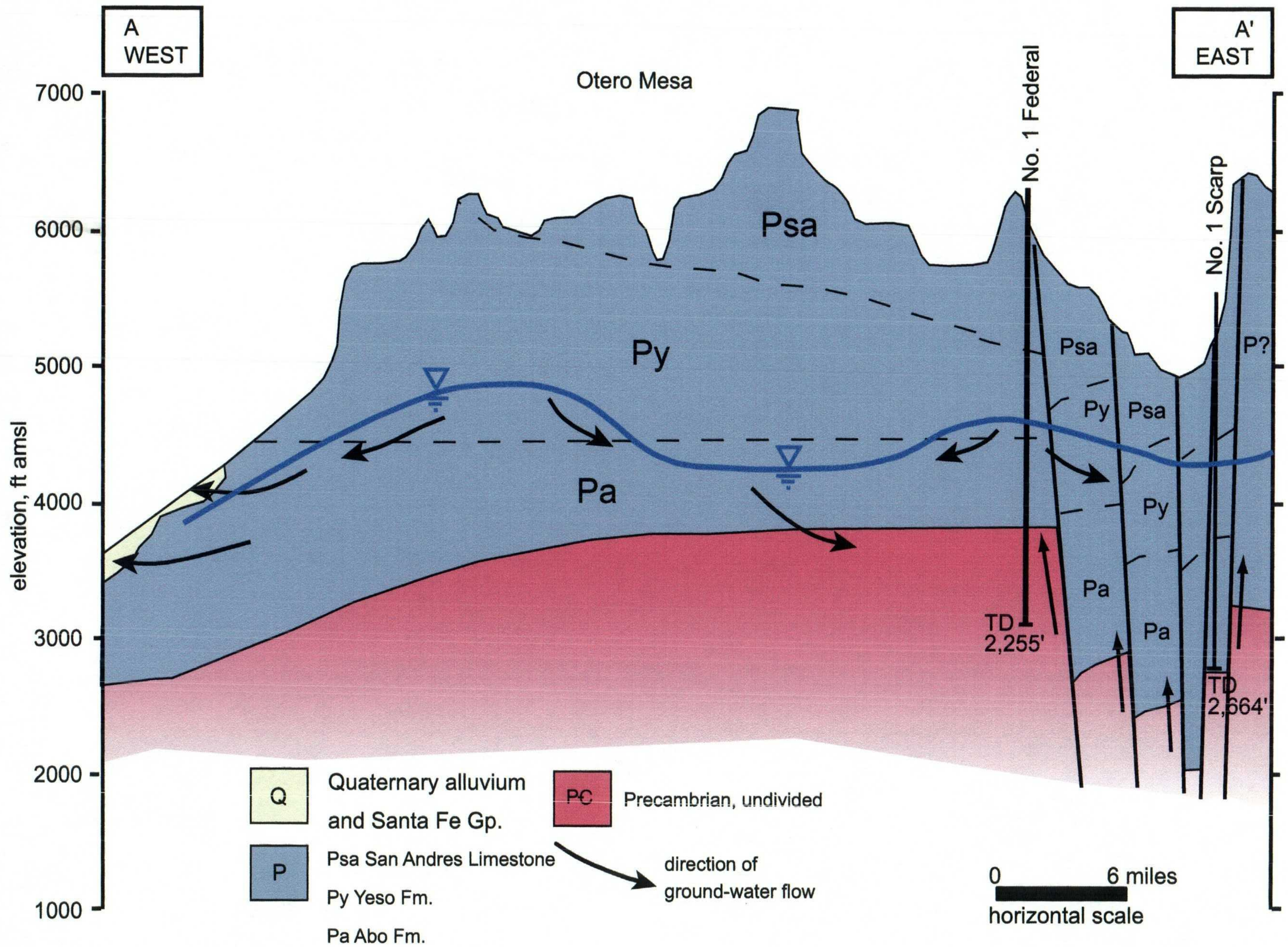

Figure 3. Hydrogeologic cross-section, A-A', Salt Basin.

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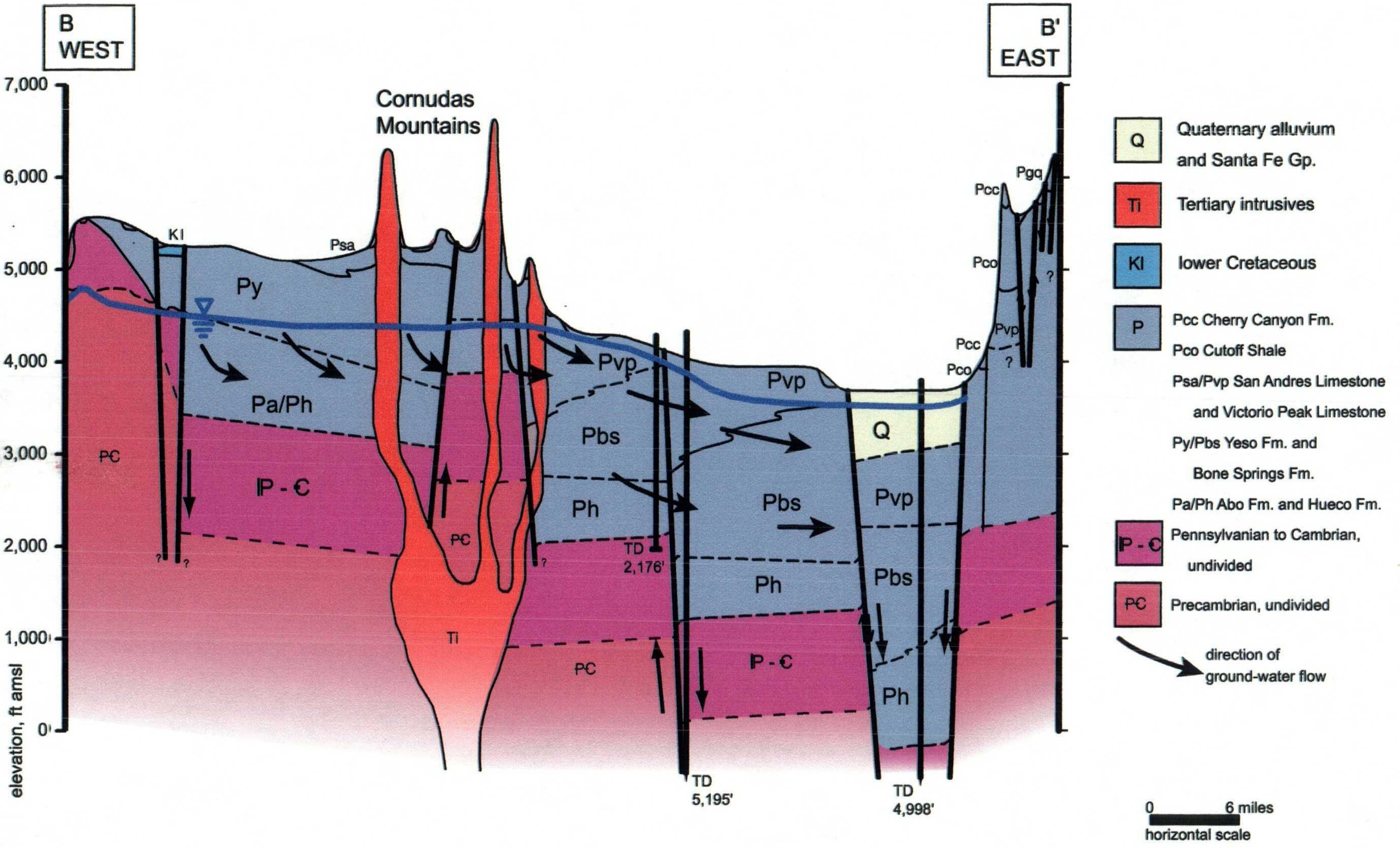

Figure 4. Hydrogeologic cross-section, B-B', Salt Basin.

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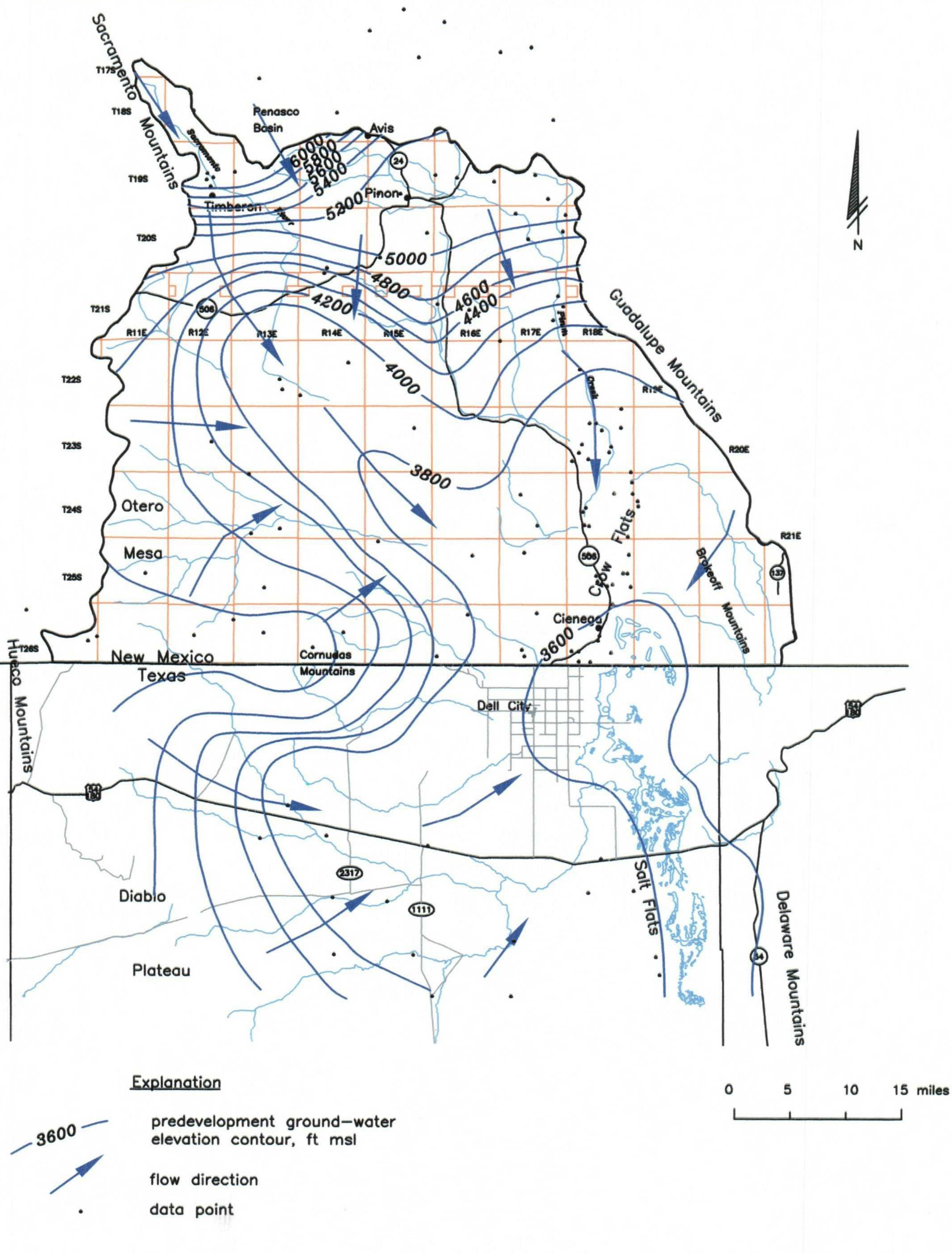

Figure 5. Predevelopment ground-water elevation contours and direction of ground-water flow for the study area.

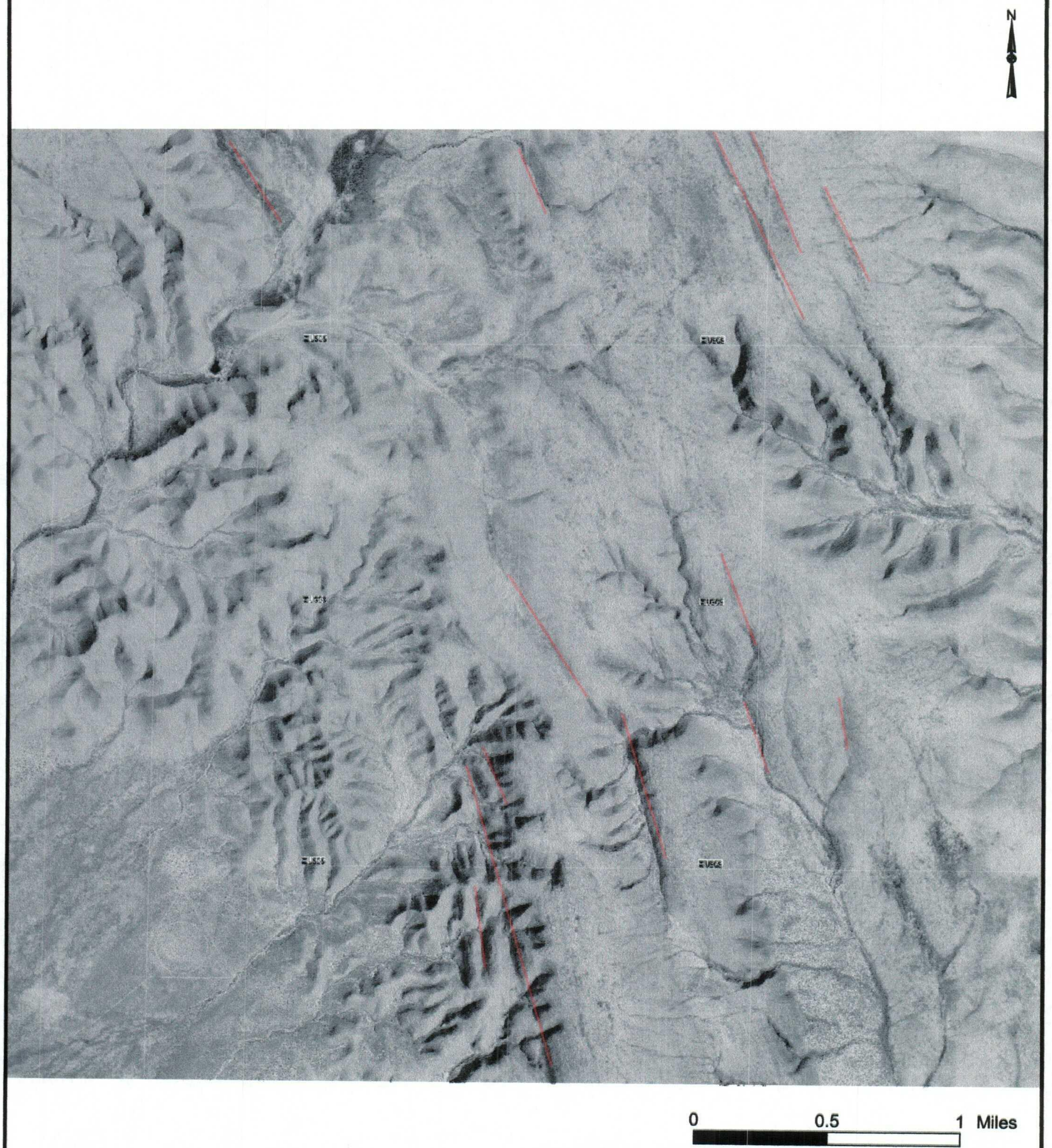

Figure 6. Aerial photograph mosaic from September 21, 1996, of southeastern Otero Mesa, showing system of northwest-trending lineaments.

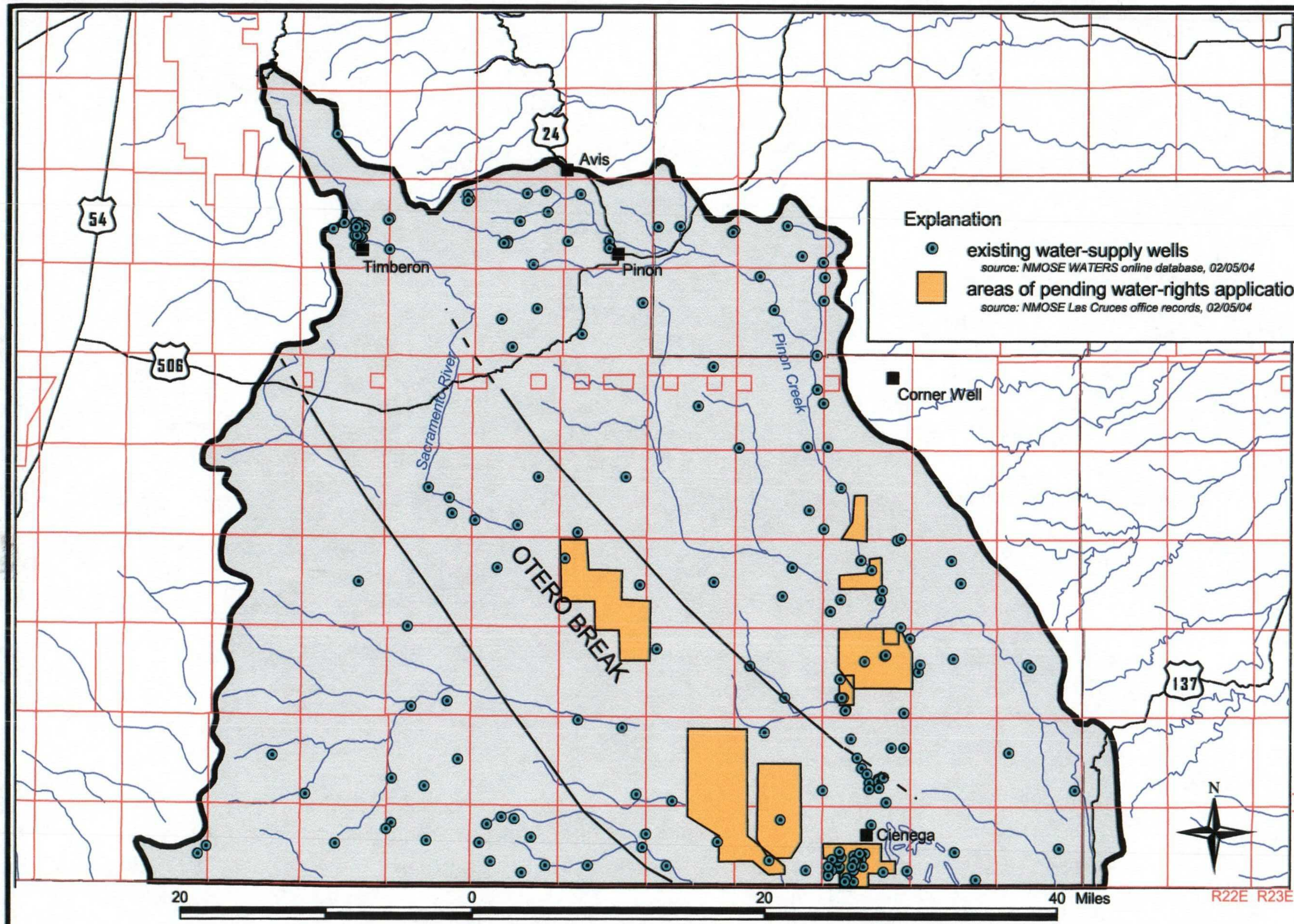

Figure 7. Map of Salt Basin, southern New Mexico, showing existing wells and locations of pending water-right applications.

JOHN SHOMAKER & ASSOCIATES, INC.
WATER-RESOURCE AND ENVIRONMENTAL CONSULTANTS

APPENDICES

Appendix A.

List of Water-Supply Wells in the Salt Basin

Appendix A. List of wells in Salt Basin from NMOSE WATERS online database 02/05/04.

Well Number	Use	Diver-sion (ac-ft/yr)	Owner	Tws	Rng	Sec	q q q	Easting	Northing	Date Completed	Well Depth (ft bgl)	Water Depth (ft bgl)
ST 00001	STK	3	J.P. CAUHAPE, INC.	19S	17E	36	4 1 4	485546	3607919	12/31/1929	15	4
ST 00002	STK	3	J.P. CAUHAPE, INC.	20S	17E	1	4 2 3	485746	3606310	7/31/1957	450	300
ST 00003	STK	3	J.P. CAUHAPE, INC.	20S	17E	5	3 2	478599	3606417	12/31/1914	1100	1020
ST 00004	STK	3	J.P. CAUHAPE, INC.	20S	17E	16	3 4	480207	3602796	12/31/1918	650	550
ST 00005	DOM	3	IRA DEE & BARBARA ELAINE TIDWE	19S	17E	22	1	481623	3611849	12/31/1940	1150	1000
ST 00006	STK	3	IRA DEE & BARBARA ELAINE TIDWE	19S	17E	35	1	483230	3608626	12/31/1965	860	600
ST 00007	STK	3	OLIN D. JR. & DOROTHY A. HAMMA	20S	17E	13	2	485640	3603796	12/31/1965	585	460
ST 00008	STK	3	VAN CLEVE FAMILY TRUST	19S	16E	20	2	469835	3611813	12/31/1929	975	935
ST 00009	STK	3	VAN CLEVE FAMILY TRUST	19S	16E	19	1	467425	3611767	12/31/1946	1210	1150
ST 00010	STK	3	DREW OR CINDY GOSLIN	19S	16E	24	4 1 1	475813	3611359	12/31/1984	120	60
ST 00011	DOM	3	JAMES O. OR JEANETTE R. COUPLA	20S	15E	29	3 1 2	459089	3600142	12/31/1939	1040	150
ST 00012	DOM	5	GLENN OR MINNIE STEVENSON	19S	16E	24	3 2	475604	3611202	12/31/1927	350	
ST 00013	STK	3	W.W.JR. OR ORA MCDANIELS	19S	16E	24	3 2	475604	3611202	12/31/1944	35	30
ST 00014	DOM	6	ELDO LEWIS	23S	18E	29	1 1 1	487613	3571455	12/31/1906	300	110
ST 00015	STK	3	ELDO LEWIS	24S	18E	11	3 3	492536	3565319	12/31/1905	180	100
ST 00016	STK	3	ELDO LEWIS	23S	18E	30	3 4	486508	3570154	12/31/1950	300	140
ST 00017	STK	2	ELDO LEWIS	23S	17E	22	3 3	481221	3571776	12/31/1961	660	450
ST 00018	STK	3	J.P. CAUHAPE, INC.	21S	16E	2	1 4 3	473525	3596629	6/30/1954	1280	1150
ST 00019	STK	3	J.P. CAUHAPE, INC.	21S	17E	31	3 3	476414	3587873	7/31/1947	1035	950
ST 00020	STK	3	VAN CLEVE FAMILY TRUST	19S	14E	34	4	453734	3607679	12/31/1964	1080	650
ST 00021	DOM	3	SAM TOM LEWIS	20S	15E	13	1 4 3	465743	3603531	12/31/1952	1430	1400
ST 00022	DOM	3	TOM WOODS RUNYAN	21S	16E	22	1 2 1	471907	3592408	12/31/1961	2700	1390
ST 00023	DOM	3	TOM WOODS RUNYAN	21S	16W	18	3 2 2	168307	3598778	12/31/1914	1440	1400
ST 00024	STK	0	CAMBALACHIE ENTERPRISES	26S	13E	7	1	438219	3547223	12/31/1966	560	535
ST 00025	STK	0	CAMBALACHIE ENTERPRISES	25S	11E	14	3	425153	3554603	12/31/1965	540	500
ST 00026	STK	0	CAMBALACHIE ENTERPRISES	25S	13E	30	1	438279	3552047	12/31/1959	200	150
ST 00027	STK	0	CAMBALACHIE ENTERPRISES	25S	13E	28	4	441859	3551227	12/31/1948	550	490
ST 00028	STK	140651	CAMBALACHIE ENTERPRISES	25S	13E	13	3 3 3	445590	3554122	12/31/1946	200	185
ST 00029	STK	3	WILLIAM T. JONES	26S	15E	29	2 2 2	459867	3542590	12/31/1959	700	670
ST 00030	STK	3	WILLIAM T. JONES	26S	14E	27	3 2 2	452570	3541812	12/31/1963	317	300
ST 00031	DOM	3	WILLIAM T. JONES	26S	14E	25	1 1 1	455193	3542611	12/31/1947	150	116
ST 00032	STK	3	WILLIAM T. JONES	26S	14E	14	1 1 3	453595	3545633	12/31/1961	310	186
ST 00033	IRR	75	COLQUET WARREN	25S	18E	27	2 2 2	492226	3552145	1/31/1956	300	40

Well Number	Use	Diver-sion (ac-ft/yr)	Owner	Tws	Rng	Sec	q q q	Easting	Northing	Date Completed	Well Depth (ft bgl)	Water Depth (ft bgl)
ST 00034	DOM	3	THOMAS S. COOPER	26S	14E	20	3 4 1	449159	3543034	12/31/1945	600	550
ST 00035	DOM	0	SNOW LAND AND CATTLE, INC.	23S	15E	24	1 2 4	465541	3573042	12/31/1916	650	600
ST 00036	DOM	0	SNOW LAND AND CATTLE, INC.	24S	16E	7	2 3 3	467409	3566080	12/31/1961	550	480
ST 00037	STK	0	JOHN V. WHITE	24S	19E	16	2 2 2	500056	3565008	8/21/1963	900	707
ST 00038	DOM	3	ALTON JONES	25S	15E	5	1	458784	3558365	12/31/1908	1000	600
ST 00039	STK	3	ALTON JONES	26S	14E	8	1 3 1	448775	3547065	12/31/1947	350	280
ST 00040	STK	3	ROBERT A. JONES	25S	16E	32	4 1 4	469167	3549592	12/31/1920	600	500
ST 00041	DOM	0	ROBERT A. JONES	26S	14E	4	3 3 1	450387	3547863	12/31/1952	300	250
ST 00042	STK	3	ROBERT A. JONES	25S	15E	2	3	463609	3557547	12/31/1915	600	500
ST 00043	DOM	0	ROBERT A. JONES	25S	15E	36	1	465211	3550310	12/31/1906	800	600
ST 00044	STK	3	JAMES W. BENNETT	26S	15E	12	4 4 4	466306	3545981	12/31/1961	800	488
ST 00045	DOM	3	JAMES W. BENNETT	26S	15E	13	4 3 2	465899	3544574	12/31/1963	860	350
ST 00046	STK	3	JAMES W. BENNETT	26S	16E	14	2 4 3	474196	3545151	12/31/1900	425	350
ST 00047	STK	3	JAMES W. BENNETT	26S	16E	29	1 2 1	468548	3542556	12/31/1908	420	390
ST 00048	STK	2	JAMES RAY EVRAGE	24S	18E	1	4 2 3	495254	3567220	12/31/1904	112	95
ST 00049	STK	2	JAMES RAY EVRAGE	24S	18E	36	3 2 4	494645	3559187	12/31/1921	90	83
ST 00050	STK	2	JAMES R. EVRAGE	24S	19E	18	4 3 3	496235	3563604	12/31/1904	200	
ST 00051	STK	3	ELMER CLIFFORD AKERS	26S	14E	4	4 4 4	451795	3547655	7/15/1976	260	205
ST 00052	STK	3	ELDO LEWIS PARTNERSHIP	22S	18E	36	3 3 4	494255	3578071	12/31/1960	450	400
ST 00052	STK	2	ELDO LEWIS	22S	18E	36	3 3 4	494255	3578071	12/31/1960	450	400
ST 00053	STK	3	ELDO LEWIS	23S	18E	22	2 4 4	492242	3572447	12/31/1973	330	185
ST 00053				23S	18E	22	2 4 4	492242	3572447	12/31/1973	330	185
ST 00054	DOM	0	PEARL P. LEWIS FAMILY TRUST	25S	18E	21	2 3 3	490013	3553159	12/31/1952	300	75
ST 00055	STK	0	PEARL P. LEWIS RANCH, LLC	22S	13E	23	1 4	444603	3582444	12/31/1959	1018	920
ST 00055	STK	0	PEARL P. LEWIS FAMILY TRUST	22S	13E	23	1 4	444603	3582444	12/31/1959	1018	920
ST 00056	STK	0	PEARL P. LEWIS RANCH, LLC	22S	14E	30	3 3	447402	3580022	9/30/1960	900	775
ST 00056	STK	0	PEARL P. LEWIS FAMILY TRUST	22S	14E	30	3 3	447402	3580022	9/30/1960	900	775
ST 00057	IRR	5000	CIMARRON AGRICULTURAL, LTD	26S	18E	21	2 2 3	490393	3543903	12/31/1949	156	78
ST 00057 S				26S	18E	21	2 2 3	490393	3543903	12/31/1949	93	70
ST 00058	IRR	8000	CIMARRON AGRICULTURAL, LTD.	26S	18E	21	4 1 1	489987	3543299	12/31/1949	430	73
ST 00058 S				26S	18E	21	4 1 1	489987	3543299	12/31/1949	430	73
ST 00058 S-2				26S	18E	28	2 1 2	490184	3542493	12/31/1949	130	
ST 00059	IRR	11000	CIMARRON AGRICULTURAL, LTD	26S	18E	21	1 3 1	489183	3543704	12/31/1949	430	81

Well Number	Use	Diver-sion (ac-ft/yr)	Owner	Tws	Rng	Sec	q q q	Easting	Northing	Date Completed	Well Depth (ft bgl)	Water Depth (ft bgl)
ST 00059 S				26S	18E	28	1 3 1	489176	3542092	12/31/1949	430	81
ST 00059 S-2				26S	18E	21	3 3 1	489180	3542898	12/31/1949		
ST 00059 S-3				26S	18E	21	3 3 4	489380	3542698	12/31/1949	1008	70
ST 00060	IRR	8500	CIMARRON AGRICULTURAL, LTD	26S	18E	29	1 1 3	487567	3542299	12/31/1950	520	81
ST 00060 S				26S	18E	29	1 1 3	487567	3542299	12/31/1950	520	81
ST 00060 S-2				26S	18E	29	1 1 1	487567	3542499	12/31/1950	550	85
ST 00061	IRR	2000	CIMARRON AGRICULTURAL, LTD.	26S	18E	33	1 3 3			12/31/1950	300	65
ST 00061 S				26S	18E	33	1 1 1	489170	3540881	12/31/1949	86	46
ST 00062	DOM	3.25	RICHARD LESSENTINE	18S	12E	21	1 2 1	432181	3621776	6/30/1980	290	224
ST 00062	DOM	0	RICHARD P. LESSENTINE	18S	12E	21	1 2 1	432181	3621776	6/30/1980	290	224
ST 00064	STK	3	THE DIAMOND A CATTLE CO.	26S	19E	35		502566	3541090	12/31/1946		
ST 00065	STK	3	THE DIAMOND A CATTLE CO.	26S	18E	26	1 3 3	492400	3541884	12/31/1963		
ST 00066	STK	3	THE DIAMOND A CATTLE CO.	26S	19E	22	1 1 1	500254	3544081	12/31/1946	72	
ST 00067	DOM	0	T.A. TANNER	21S	17E	13	4 4	485672	3592683	12/31/1947	228	203
ST 00068	DOM	0	T.A. TANNER	21S	17E	13	4 4	485672	3592683	12/31/1947	244	219
ST 00069	STK	7	GEORGE WESLEY RAUCH	23S	19E	9	2 4 3	499834	3575648	12/31/1982	940	900
ST 00070	STK	20	GEORGE WESLEY RAUCH	23S	19E	15	3 4 4	500845	3573238	12/31/1961	750	725
ST 00071	IRR	800	GEORGE W. RAUCH	23S	18E	15	1 1 2	491038	3574663	12/31/1968	600	225
ST 00072	IRR	0	GEORGE W. RAUCH	23S	18E	2	2 2 2	493854	3577866	12/31/1968	500	300
ST 00073	STK	5	GEORGE W. RAUCH	23S	18E	36	3 3 4	494248	3568426	12/31/1961	500	450
ST 00074	IRR	3520	GEORGE W. RAUCH	24S	19E	18	2 3 4	496435	3564407	12/31/1954	450	148
ST 00075	STK	10	GEORGE W. RAUCH	22S	18E	17	3 1 1	487621	3583522	12/31/1940	500	400
ST 00076	STK	5	GEORGE W. RAUCH	23S	18E	27	2 2 1	492040	3571442	12/31/1961	600	500
ST 00077	STK	5	GEORGE W. RAUCH	24S	20E	16	1 3 4	508261	3564389	12/31/1978	1250	1100
ST 00078	DOM	10	GEORGE W. RAUCH	23S	18E	9	1 4 4	489831	3575671	12/31/1902	300	225
ST 00079	DOM	2.02	WILLIAM J. & DORTHEY BUDAGHER	20S	15E	29	3 1 2	459089	3600142	12/31/1939	1000	150
ST 00080	STK	16.13	WESTERN BANK	20S	14E	33	1 4 4	451456	3598756	12/31/1948	1150	1130
ST 00081	STK	8.06	BRYAN & JUDY L. PRATHER	22S	14E	11	3 4 4	454340	3584720	12/31/1950	650	635
ST 00083	IRR	7	JOHN G. SCHAFER	24S	18E	29	3 1 4	487796	3560800	2/13/1967	200	110
ST 00084	IRR	0	JOHN G. OR L. JANE SCHAFER	24S	18E	29	3 1 4	487796	3560800	6/7/1982	235	110
ST 00085	STK	2	JOHN G. OR L. JANE SCHAFER	24S	18E	29	3 2 3	487999	3560800	12/31/1932	100	110
ST 00086	STK	4	JOHN G. OR L. JANE SCHAFER	24S	18E	11	3 3 2	492635	3565418	12/31/1958	180	110
ST 00087	DOM	5	JOHN G. OR L. JANE SCHAFER	24S	18E	29	3 1 3	487596	3560800	7/10/1964	200	110

Well Number	Use	Diver-sion (ac-ft/yr)	Owner	Tws	Rng	Sec	q q q	Easting	Northing	Date Completed	Well Depth (ft bgl)	Water Depth (ft bgl)
ST 00088	IRR	1260	JOHN G. OR L. JANE SCHAFER	24S	18E	20	1 3 3	487598	3562810	6/3/1974	350	110
ST 00089	IRR	560	JOHN G. OR L. JANE SCHAFER	24S	18E	29	3 2 3	487999	3560800	7/1/1964	425	110
ST 00090	STK	3	CAMBALACHIE ENTERPRISES	26S	10E	13	4 4 3	417933	3544699	12/31/1930	200	160
ST 00091	STK	3	CAMBALACHIE ENTERPRISES	26S	10E	24	1 3 4	416921	3543902	12/31/1967	900	710
ST 00092	DOM	3	CAMBALACHIE ENTERPRISES	24S	13E	35	1 2 1	444414	3560430	12/31/1900	800	600
ST 00093	DOM	4	DOROTHY G. LEWIS	25S	18E	27	2 1 4	491823	3551947	12/31/1963	130	
ST 00094	IRR	574	DOROTHY G. LEWIS	25S	18E	27	2 2 2	492226	3552145	12/31/1958	152	
ST 00095	STK	3	HFR CORP.	24S	20E	16	3 2	508563	3564086	12/31/1975	1050	
ST 00096	STK	3	HFR CORP	25S	20E	25	3 4	513407	3550798	12/31/1975	1750	
ST 00097	STK	46	CAMBALACHIE ENTERPRISES	24S	13E	32	2 4 3	440393	3559861	12/31/1900	500	90
ST 00098	STK	3	KENNETH TIDWELL TRUST	20S	14E	20	4 1 2	450263	3601773	12/31/1950	930	
ST 00099	STK	3	BOB JONES	26S	14E	18	4 1 1	447962	3545055	12/31/1982	200	150
ST 00100	STK	3	CAMBALACHIE ENTERPRISE	25S	13E	13	3 3 3	445590	3554122	12/31/1945	190	170
ST 00101	STK	19	CAMBALACHIE ENTERPRISES	26S	13E	16	2 4 4	442132	3545293	12/31/1950	800	610
ST 00102	STK	16	CAMBALACHIE ENTERPRISES	23S	12E	23	1 1 2	434625	3573349	12/31/1916	550	490
ST 00103	STK	48	CAMBALACHIE ENTERPRISES	24S	13E	5	2 1 1	440026	3568508	12/31/1915	560	490
ST 00104	IRR	429	CAMBALACHIE ENTERPRISES	24S	13E	32	2 4 3	440393	3559861	12/31/1978	400	90
ST 00105	STK	77	CAMBALACHIE ENTERPRISES	24S	13E	32	2 4 3	440393	3559861	12/31/1960	400	90
ST 00106	STK	3	THOMAS S. COOPER	26S	12E	12	4 2 2	437711	3546602	7/6/1963	570	420
ST 00107	STK	3	THOMAS S. COOPER	25S	12E	31	1	428753	3550403	8/1/1962	380	280
ST 00108	STK	3	THOMAS S. COOPER	26S	12E	16	3 2 2	432067	3545038	12/31/1945	610	540
ST 00110	IRR	45	JOHN V WHITE	25S	18E	27	2 3 2	491824	3551745	12/31/1966	500	45
ST 00111	MDW	1499	TIMBERON WATER CO., INC.	19S	12E	23	1	435249	3611861	2/13/2001	490	110
ST 00111	EXP	0	TIMBERON WATER & SAN DISTRICT	19S	12E	23	1	435249	3611861	2/13/2001	490	110
ST 00111 S				19S	12E	23	1 3 4	435147	3611559	9/14/2000	400	50
ST 00111 S	MDW	0	TIMBERON WATER & SANTIATION DT	19S	12E	23	1 3 4	435147	3611559	9/14/2000	400	50
ST 00112	EXP	0	TIMBRON WATER & SANITATION DIS	19S	12E	13	4 2 4	437974	3612658	3/28/2001	100	25
ST 00113	EXP	0	TIMBERON WATER & SANITATION	19S	12E	25	4 4 2	437946	3609312	2/3/2001	600	
ST 00114	EXP	0	TIMBERON WATER & SANITATION	19S	12E	13	4 2 4	437974	3612658	1/29/2001	400	
ST 00115	STK	10.61	PINON CATTLE COMPANY	19S	14E	28	1 1 3	450906	3610180		700	
ST 00115 S				19S	13E	12	1 4 2	446708	3614798		700	
ST 00115 S-10				19S	13E	12	1 2 1	446510	3615199	5/13/2003	1005	740
ST 00115 S-2				19S	13E	12	1 4 3	446508	3614598		700	

Well Number	Use	Diver-sion (ac-ft/yr)	Owner	Tws	Rng	Sec	q q q	Easting	Northing	Date Completed	Well Depth (ft bgl)	Water Depth (ft bgl)
ST 00115 S-3				19S	14E	28	1 3 1	450837	3609983		700	
ST 00115 S-4				19S	14E	3	3 4 3	453042	3615369		700	
ST 00115 S-5				19S	14E	16	4 4 1	452257	3612358		700	
ST 00115 S-6				19S	14E	2	4 3 1	455105	3615607		700	
ST 00115 S-7				19S	15E	7	2 2 2	458891	3615291		700	
ST 00115 S-8				19S	14E	14	2 1 4	455316	3613358		700	
ST 00115 S-9				19S	14E	29	2 4 1	450454	3609982		700	
ST 00116	IRR	760.5	LOLA BETH BULLARD	26S	18E	19	4 2 4	487368	3543106	5/31/1950	180	110
ST 00116 A	IRR	1320	CIMARRON AGRICULTURAL, LTD.	26S	18E	19	4 2 4	487368	3543106	12/31/1950	180	110
ST 00116 A	IRR	0	L.N. SAUL	26S	18E	19	4 2 4	487368	3543106	12/31/1950	180	110
ST 00116 A-S				26S	18E	19	4 3 3	486764	3542704	12/31/1958	120	110
ST 00116 B				26S	18E	20	1 3 4	487772	3543508	1/31/1996	253	113
ST 00116 S				26S	18W	19	4 3 3	148674	3548957	5/31/1958	120	110
ST 00118	DOM	3	CIMARRON AGRICULTURAL, LTD.	26S	18E	19	4 1 1	486765	3543308	12/31/1950		
ST 00119	DOM	3	JAMES P. & CYNTHIA D LIVERS	19S	15E	28	2 2	462031	3610256		1500	
ST 00120	IRR	874.5	VIRGINIA L BROWNFIELD	26S	18E	30	2 3 1	486760	3542098	12/31/1950	250	90
ST 00121	IRR	0	HUNT BUILDING CORP.	26S	18E	21	3 1 3	489181	3543101			
ST 00123	STK	40	CIMARRON AGRICULTURAL, LTD.	26S	18E	21	1 2 4	489788	3543906	12/31/1949	234	70
ST 00125	DOM	14.8	HUNT BUILDING CORP.	26S	18E	29	2 2 2	488975	3542496	12/31/1949		170
ST 00127	IRR	3	CIMARRON AGRICULTURAL, LTD.	26S	18E	29	4 3 1	488367	3541288	12/31/1949		
ST 00129	IRR	12.9	CAMBALACHIE ENTERPRISES	24S	13E	35	1 2 1	444414	3560430	12/29/1890	710	647
ST 00130	EXP	0	TIMBERON WATER & SAN DISTRICT	19S	12E	13	4 4 1	437770	3612511	3/29/2001	60	25
ST 00131	STK	8.46	LAHEETA L. HARVEY	22S	13E	16	4 2 4	442296	3583559	12/31/1970	1080	
ST 00132	STK	8.46	LAHEETA L. HARVEY	22S	13E	26	2 3 3	444896	3580734	12/31/1970	925	877
ST 00133	STK	9.94	LAHEETA L. HARVEY	22S	14E	34	1 1 3	452103	3579501	12/31/1970	600	475
ST 00134	STK	8.96	LAHEETA L. HARVEY	22S	15E	11	3 4 4	463957	3584709	12/31/1950	635	
ST 00135	STK	16.44	LAHEETA L. HARVEY	22S	15E	32	3 1 4	458711	3578679	12/31/1900	480	
ST 00136	STK	25.35	LAHEETA L. HARVEY	23S	14E	17	2 1 2	449872	3574887	12/31/1970	730	
ST 00137	STK	9.94	LAHEETA L. HARVEY	23S	15E	7	1 4 3	457305	3575866	12/31/1970	445	
ST 00138	STK	3	MARTHA W. SKEEN	25S	20E	18	2 4	506164	3554844	12/31/1971	2800	
ST 00138	STK	0	MILTON A. HUGHES	25S	20E	18	2 4	506164	3554844	12/31/1971	2800	
ST 00141	IRR	525	ELMER W. HEPLER	24S	18E	32		488296	3559494	2/28/1964	900	
ST 00141 S				24S	18E	32	2 3			4/30/1966	350	

Appendix A. List of wells in Salt Basin from NMOSE WATERS online database 02/05/04.

Well Number	Use	Diver-sion (ac-ft/yr)	Owner	Tws	Rng	Sec	q q q	Easting	Northing	Date Completed	Well Depth (ft bgl)	Water Depth (ft bgl)
ST 00142	DOM	3	GARRY R & BONNIE G STARR	19S	12E	22	2 3 3	434132	3611573	7/20/2001	400	172
ST 00143	DOM	0	STUART C BROWN	19S	12E	26	1 1 1	434919	3610544		600	
ST 00144		0	TIMBERON WATER & SANITATION	19S	12E	22	4 3 3	434118	3610761		450	
ST 00145		0	TIMBERON WATER & SANITATION	19S	12E	27	4 1 2	434262	3609755		450	
ST 00146	IRR	480	LENDAL C. BARKER	26S	18E	30	3 2 1	486355	3541696	4/30/1955	446	
ST 00146 S				26S	18E	30	3 2 3	486355	3541496	4/30/1955	178	
ST 00147	IRR	0	B.V. BALLARD, JR.	25S	18E	16	3	489509	3554267	12/31/1957	472	
ST 00148	IRR	0	B.V. BALLARD, JR.	24S	18E	16	2	490320	3564718	8/31/1957	600	
ST 00149	DOM	3	JOHN PAUL FAIN	26S	18E	30	1 2 1	486359	3542502	12/31/1956	150	
ST 00150	IRR	420	JOHN PAUL FAIN	26S	18E	30	1 2 1	486359	3542502	12/31/1956	376	
ST 00151	IRR	705	CHARLES W. DICE	25S	18E	27	1 3 3	490819	3551548	7/31/1962	500	
ST 00152	IRR	20	ANDY A. LEWIS	25S	18E	21	4 4 2	490616	3552553	12/31/1934	250	
ST 00152 S				25S	18E	21	4 4 2	490616	3552553	12/31/1936	100	
ST 00153	STK	0	ANDY A. LEWIS	25S	17E	25	4 4 4	485729	3550766	12/31/1961	500	
ST 00154	STK	0	VIRGINIA LEWIS	26S	18E	10	1	491110	3547022	12/31/1908	70	
ST 00155	STK	0	VIRGINIA LEWIS	25S	18E	27	4	491926	3551042	12/31/1917	60	
ST 00156	STK	0	VIRGINIA LEWIS	25S	18E	35	3	492726	3549431	12/31/1917	50	
ST 00157	STK	0	VIRGINIA LEWIS	25S	18E	27	4	491926	3551042	12/31/1955	60	
ST 00158	STK	0	VIRGINIA LEWIS	25S	18E	35	3	492726	3549431	12/31/1956	60	
ST 00159	IRR	300	RAY LEWIS	26S	18E	25	2 3 2	495016	3542080	12/31/1955	500	
ST 00160	STK	3	MILTON A. HUGHES	26S	20E	14	3 4 1	511713	3544466	12/31/1964	2880	2510
ST 00161	STK	0	W.L. "PETE" LEWIS	24S	17E	18	4 2 2	477685	3564245	12/31/1948	810	500
ST 00162	STK	0	W.L. "PETE" LEWIS	24S	17E	27	3 2 3	481503	3560813	12/31/1958	448	400
ST 00163	STK	0	W.L. "PETE" LEWIS	25S	17E	8	2 2 2	479287	3556996	12/31/1945	505	450
ST 00164	STK	0	W.L. "PETE" LEWIS	25S	18E	8	2 4 3	488802	3556377	12/31/1903	125	67
ST 00165	STK	3	SPRING MESA LTD PARTNERSHIP	19S	15E	30	1 1 3	457516	3610173	12/31/1947	1425	1080
ST 00166	DOM	0.5	SPRING MESA LTD PARTNERSHIP	19S	15E	28	4 2	462034	3609436	12/31/1945	1370	1150
ST 00168	EXP	0	TIMBERON WATER & SANITATION DT	19S	12E	22	2 2 1	434545	3612170	9/5/2001	600	374
ST 00169	EXP	0	TIMBERON WATER & SANITATION DT	19S	12E	21	2 2 1	432925	3612185			
ST 00172				19S	12E	22	4 4 4	434728	3610756	8/30/2001	440	158
ST 00172	EXP	0	TIMBERON WATER & SANITATION DI	19S	12E	22	4 4 4	434728	3610756	8/30/2001	440	158
ST 00173	EXP	0	TIMBERON WATER & SAN DIST	19S	12E	22	2 1 1	434139	3612179	9/6/2002	1200	540
ST 00180 S	AGR	0	CHESTER WALKER	24S	18E	32	3 2 2	488196	3559392	12/31/1963	600	70

Well Number	Use	Diver-sion (ac-ft/yr)	Owner	Tws	Rng	Sec	q q q	Easting	Northing	Date Completed	Well Depth (ft bgl)	Water Depth (ft bgl)
ST 00182	IRR	960	BRYAN ODIE PRATHER	25S	18E	26	1 1 1	492428	3552144	12/31/1957	150	50
ST 00183	EXP	0	TIMBERON GOLF ASSOCIATION	19S	12E	22	4 3 3	434118	3610761			
ST 00184	EXP	0	TIMBERON GOLF ASSOCIATION	19S	12E	22	4 3 4	434318	3610761	9/19/2002	700	560
ST 00185	DOM	3	ROSS AND LINDA L DORAN DURANT	19S	12E	21	1 3 3	431708	3611547		600	
ST 00186	IRR	77	L.N. SAUL	26S	18E	20	1 1 3	487574	3543912	12/31/1910	250	110
ST 00186 S				26S	18E	20	1 1 1	487574	3544112	11/7/1954	275	191
ST 00187	STK	3.46	L. N. SAUL	26S	17E	21	3 2 3	479863	3543123	7/28/1914	250	174
ST 00187 S				26S	17E	3	3 3 3	481094	3547555	1/4/1954	342	273
ST 00187 S-2				26S	17E	26	2 4 1	483885	3542103	1/12/1958	392	242
ST 00187 S-3				26S	17E	21	3 2 3	479863	3543123	12/31/1914		
ST 00187 S-4				26S	17E	26	2 4 1	483885	3542103	12/31/1958		
ST 00188	IRR	0	L. N. SAUL	26S	18E	32	1 2 2	488163	3540886	2/10/1953	260	55
ST 00189	DOM	3	CHARLES A & DONNA S RANDLEMAN	19S	12E	21	1 3 3	431708	3611547		400	
ST 00190	DOM	3	WILLIAM J & GERTRUDE C MERCHAN	19S	12E	22	2 2 3	434545	3611970	1/20/2003	167	60
ST 00191	IRR	700	BETTY ANN OLSEN	25S	18E	13	1 2 2	494642	3555359	12/31/1959	300	61
ST 00192	IRR	400	BETTY ANN OLSEN	25S	18E	14	2 1 1	493234	3555361	12/31/1959	300	61
ST 00194	STK	8	PAUL L. OR YVONNE R. MOTT	21S	17E	12	3 4 4	484967	3594192	12/31/1930		150
ST 00194 S				20S	17E	36	3 4 3	484926	3597862	12/30/1980	900	850
ST 00194 S-2				21S	17E	12	3 4 4	484967	3594192	12/31/1982		150
ST 00195	STK	3	FRANK D STEWART, II	22S	17E	26	2 2 2	484148	3581118	12/31/1918	450	439
ST 00196	STK	3	FRANK D STEWART, III	21S	18E	31	3 3 2	486169	3587953	12/31/1961	767	740
ST 00197	STK	3	FRANK D STEWART, II	23S	17E	10	4 4 3	482329	3574888	12/31/1946	550	525
ST 00198	STK	3	FRANK D STEWART, II	22S	17E	36	2 4 2	485753	3579106	12/31/1948	371	350
ST 00199	STK	3	FRANK D STEWART, II	23S	16E	14	3 4 4	473662	3573302	12/31/1960	800	775
ST 00200	STK	3	FRANK D STEWART, II	21S	17E	35	4 4 1	483958	3587956	12/31/1985	720	700
ST 00201	DOM	3	DAVID C PIETZ	19S	12E	27	4 2 3	434472	3609541		300	
ST 00205	DOM	3	ROY AND VIRGINIA SMITH	19S	12E	22	2 3	434233	3611674		300	
ST 00208	MUL	3	MARJORIE FLEMING	20S	14E	14	3 3	454174	3602885		800	
ST 00212	PRO	0	DAVID E. DICE	25S	18E	27	3 3 1	490820	3550943		500	
ST 00213	PRO	0	JANE SCHAFER	24S	18E	29	3 1 4	487796	3560800		235	

Appendix B.

Selected Pages and Figures from Mayer, 1995

THE ROLE OF FRACTURES IN REGIONAL GROUNDWATER FLOW: FIELD EVIDENCE AND MODEL RESULTS FROM THE BASIN-AND-RANGE OF TEXAS AND NEW MEXICO

by

JAMES ROGER MAYER, B.S., M.S.

DISSERTATION

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PHILOSOPHY

THE UNIVERSITY OF TEXAS AT AUSTIN

December, 1995

THE ROLE OF FRACTURES IN REGIONAL GROUNDWATER FLOW: FIELD EVIDENCE AND MODEL RESULTS FROM THE BASIN-AND-RANGE OF TEXAS AND NEW MEXICO

Publication No.______________

James Roger Mayer, Ph.D.
The University of Texas at Austin, 1995

Supervisor: John M. Sharp, Jr.

This study integrates fracture mapping and groundwater flow modeling to assess the role of fractures in regional groundwater flow. This is an important topic because fractures play a prominent role in groundwater flow in many aquifers. Furthermore, few studies have addressed quantitatively the regional hydrogeological implications of fractures.

The study area is located in west Texas and southern New Mexico, between the Salt Basin and the Tularosa Valley. The region is largely undeformed, but the Permian carbonate bedrock is cut by many extensional faults and fractures. Air-photo analysis and field mapping reveal a broad fracture zone extending from the Sacramento Mountains to the Salt Basin near Dell City, Texas. Most fractures roughly parallel major normal faults and are oriented

approximately N20W. The most intense fracturing coincides with a prominent trough in the potentiometric surface and an apparent "plume" of relatively fresh groundwater. Flow simulation and chemical modeling suggest that fracturing has created a high permeability zone that funnels recharge from the Sacramento Mountains at least 80 km southeastward to discharge points in the Salt Basin and the Dell City irrigation district.

To estimate the regional transmissivity and to test the role of fractures in regional flow, a steady-state finite-element flow model was constructed in which fracture data are used to constrain a spatially distributed transmissivity. Given the probable range of recharge, discharge and other hydrologic parameters, fractures are the most important single constraint on the configuration of the potentiometric surface.

Major results include: (1) fracturing can control groundwater flow over large (>1000 km^2) areas, (2) effective recharge areas and regional groundwater chemistry trends are strongly influenced by fractures, and (3) through fracture studies, *a priori* inferences about aquifer properties and regional flow are possible. Finally, this study demonstrates one mechanism by which the timing and nature of tectonic events can affect regional subsurface fluid flow and, perhaps more importantly, related processes such as hydrothermal mineralization, diagenesis, and hydrocarbon transport and entrapment.

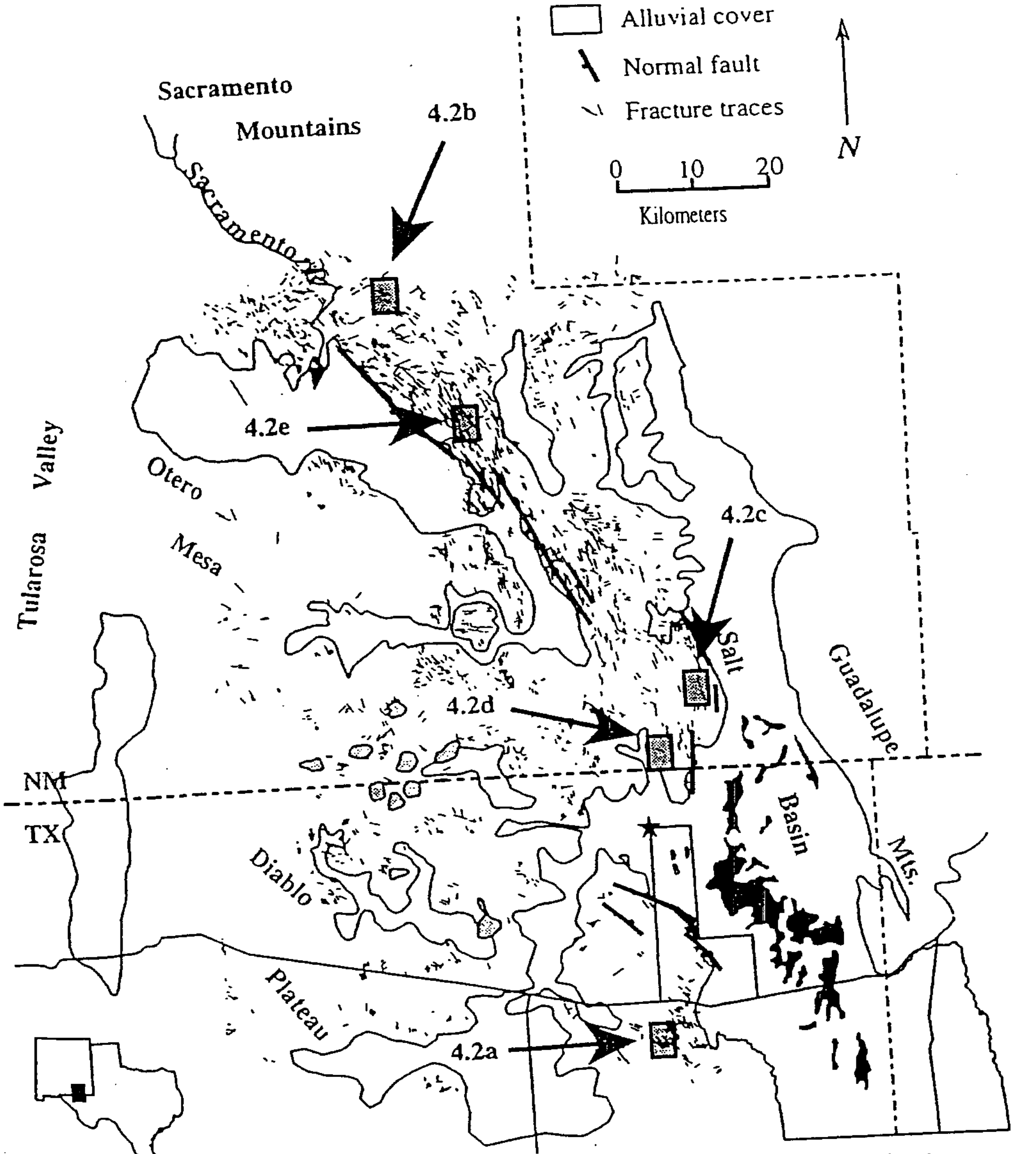

Figure 4.3: Locations of photographs of figure 4.2. Fine line segments represent lineations identified in this study. Note that very few lineations occur in areas covered by alluvium.

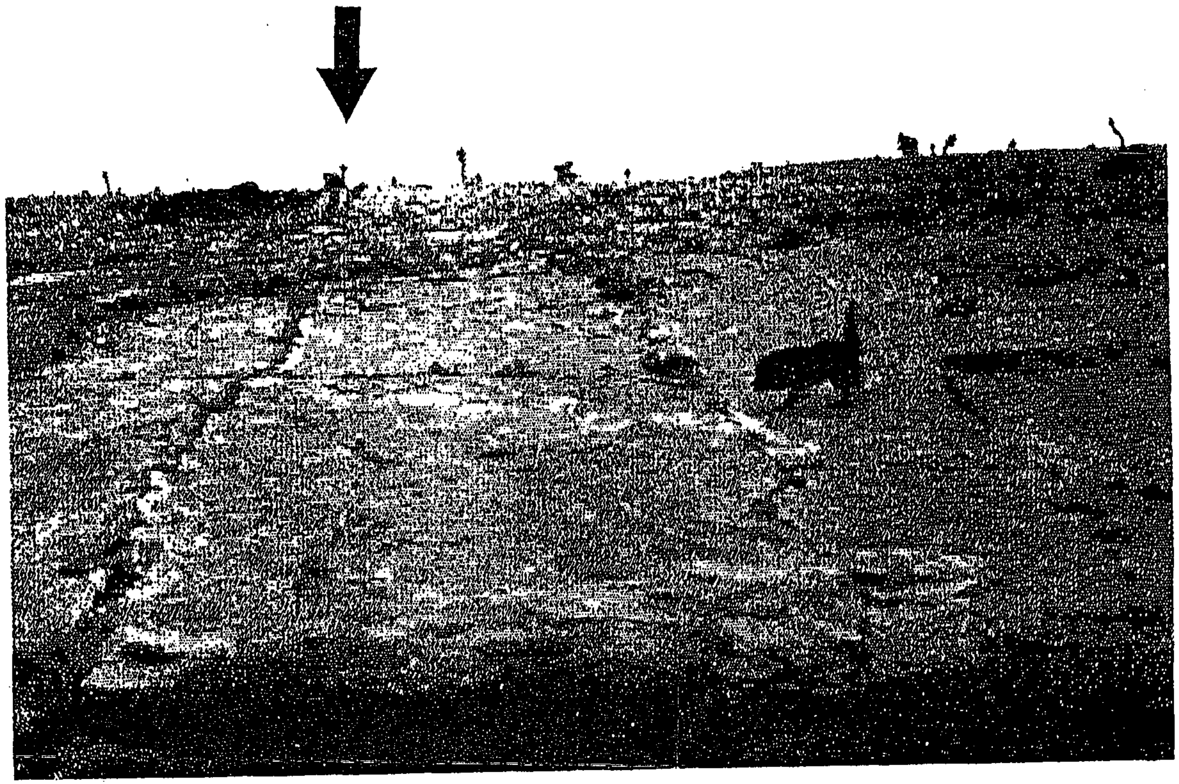

Figure 4.4: A fracture zone in the Otero Mesa. Picture is taken looking toward the southeast; 45-lb dog for scale. Note the alignment of large yucca plants along the left-most fracture trace (arrow) where soil covers the bedrock.

in the western Otero Mesa is probably lithologically controlled. The western Otero Mesa is underlain by the gypsum-rich Yeso Formation, and therefore it is less prone to fracturing than the more brittle strata of the carbonate-dominated units present throughout the rest of the area. The correlation between fractures and normal faults suggests that they formed as the result of the same tectonic events.

Fracture Zones

Based primarily on fracture density, but also on fracture orientation, the study area may be divided into distinct fracture zones (Figure 4.10). The boundaries of these zones are used to constrain hydraulic conductivity in a groundwater flow model in Chapter 6. Zone 1 is located along the Otero Break and is the most heavily fractured zone. There is a very strong preferred fracture orientation within this zone of approximately N20W, parallel with the normal faults of the Otero Break. Zones 2 and 3 each have significant fracture density and a dominant fracture orientation similar to Zone 1. In Zone 3 there appear to be two additional fracture sets not observed elsewhere. These are oriented approximately N40W and N50E. Zone 4 includes primarily the western Otero Mesa and Diablo Plateau and is characterized by relatively sparse fractures and no single, dominant fracture orientation. In this zone there are either additional fracture sets, or a largely random component of orientation. Zone 5 is composed of Salt Basin alluvium and no lineaments were mapped there.

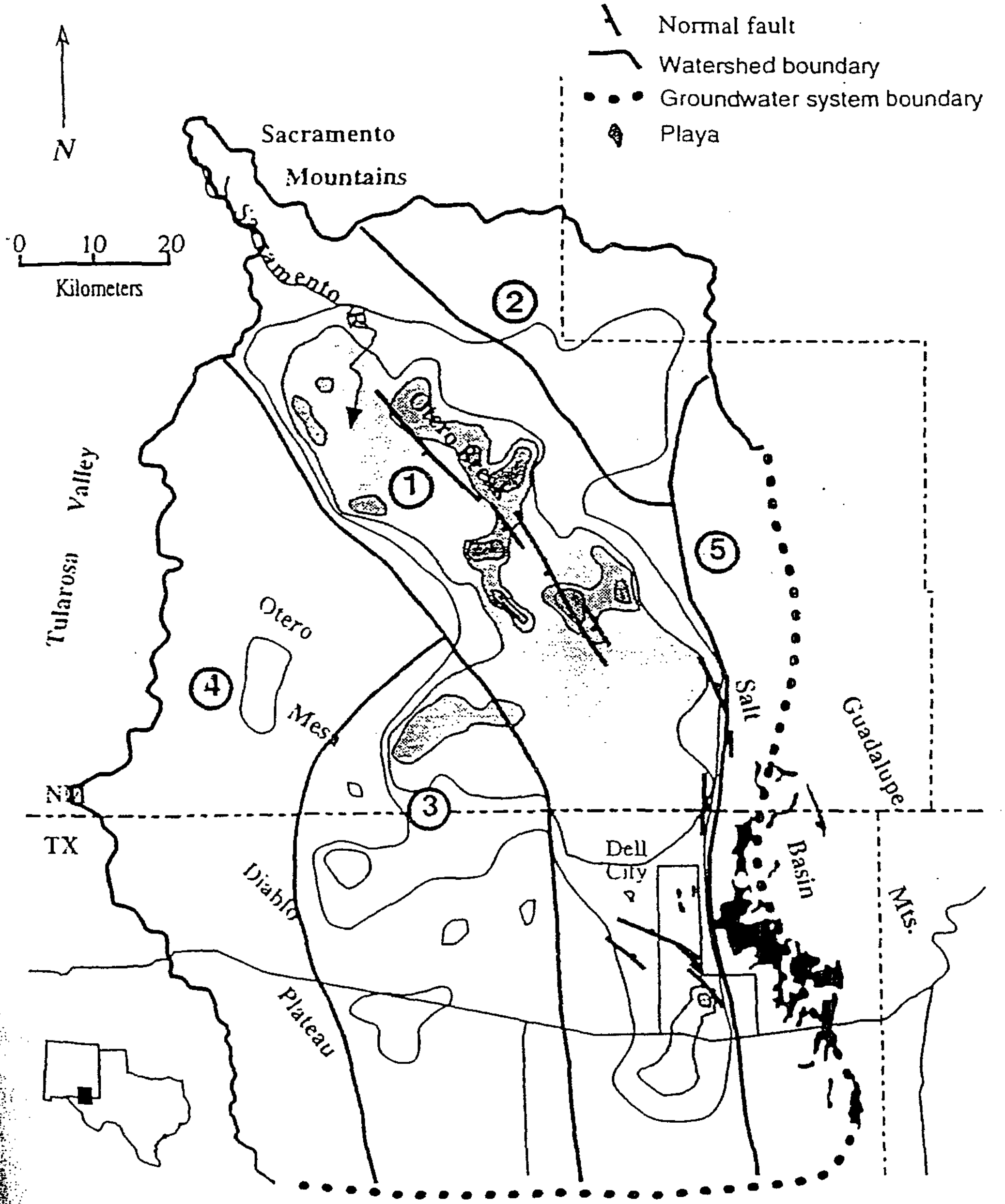

Figure 4.13: Fracture zones.

Fracture control of regional ground-water flow in a carbonate aquifer in a semi-arid region

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ABSTRACT

We integrate fracture mapping and numerical modeling to assess the role of fractures in regional ground-water flow. Although the importance of fractures in ground-water flow and solute transport is accepted generally, few studies have addressed quantitatively the regional hydrogeological implications of fractures. The field-study area in west Texas and southeastern New Mexico consists primarily of subhorizontal Permian carbonate rocks cut by extensional faults and fractures. Air-photo analysis and field mapping reveal a broad fracture zone extending from the Sacramento Mountains of New Mexico to the Salt Basin near Dell City, Texas. Most fractures are subparallel to major normal faults. The most intense fracturing coincides with a prominent trough in the potentiometric surface and an apparent "plume" of relatively fresh ground water. Flow models, corroborated by geochemical data, indicate that fracturing has created a high-permeability zone that funnels recharge from the Sacramento Mountains at least 80 km southeastward to its discharge zone.

A steady-state finite-element flow model uses fracture data to predict the spatial transmissivity distribution. Given the probable range of recharge, discharge, and other hydrologic parameters, fractures are the most important factor affecting the potentiometric surface configuration. Our study implies that: (1) fractures can control ground-water flow over large (>1000 km^2) areas; (2) effective recharge areas and regional ground-water chemistry trends are strongly influenced by fractures; and (3) a priori inferences about aquifer properties and regional flow are possible by means of fracture studies. This study demonstrates that the timing and nature of fracturing can affect regional subsurface fluid flow, as well as related processes such as hydrothermal mineralization, diagenesis, and hydrocarbon transport and entrapment.

INTRODUCTION

Fluid flow in fractures is important in ground-water resource development, the isolation, disposal, and cleanup of hazardous waste, petroleum migration, and hydrothermal mineral formation. Although the reservoir-scale hydraulics and the regional structural implications of fractures have been extensively studied, few studies address the regional hydrogeological implications of fractures (Mayer and Sharp, 1995) and fewer use fracture data when modeling regional flow and solute transport.

The main contribution of this study is to show that fracture data can improve our understanding of regional ground-water flow, especially in areas for which there are sparse hydrogeologic data. This is important because fractures commonly provide the only significant effective porosity and permeability of carbonate rocks, igneous and metamorphic rocks, and shales. In some aquifers, ground-water flow direction is determined as much by fracture-related anisotropy as by hydraulic gradient. In these situations, many common assumptions about flow and transport are inappropriate. In addition, high-permeability trends caused by preferential fracturing can create large-scale variations in flow rates and can determine if and where interbasin flow will occur and, thus, the extent of regional flow systems.

At the regional scale, fractured aquifers are typically modeled as equivalent porous media, and fracture data are ignored. For example, the Edwards aquifer in central Texas, a fractured carbonate aquifer that has been extensively studied, is generally modeled as a homogeneous (and often isotropic) system, even though fracture-related anisotropy is clearly indicated (Slade et al., 1985; Senger and Kreitler, 1984; McKinney and Sharp, 1995; Uliana and Sharp, 1996). On the other extreme, discrete fracture models (e.g., Dershowitz and Einstein, 1988), widely used for reservoir-scale modeling, require a level of subsurface characterization not normally feasible at the regional scale. For example, studies in mine tunnels (e.g., Long and Billaux, 1987) show that even if fracture orientation and apertures are known, we cannot predict a priori which fractures are conductive, perhaps because of their connectedness or channeling.

The goals of this study are to evaluate how regional fracture systems affect regional ground-water flow and to develop a conceptual framework for regional ground-water flow in fractured aquifers that allows use of fracture data. Specifically, we evaluate: (1) if regionally pervasive fracture systems create permeability trends and regional anisotropy that are manifest through hydraulic potential and water chemistry trends; (2) if fractured aquifers can be conceptualized in terms of fracture domains, each domain defined by internally consistent fracture patterns and hydraulic properties; and (3) if a priori fracture analysis significantly improves the predictive power of regional ground-water flow models.

STUDY AREA

The study area includes 9000 km^2 in Hudspeth County, Texas, and Otero County, New Mexico (Fig. 1). We refer to the study area as the Otero-Diablo region because most of it is on the Otero Mesa and the Diablo Plateau. Study-area boundaries generally coincide with the watersheds of the northern Salt Basin and the Sacramento River. Important physical features include the Sacramento Mountains, the Sacramento River, the Otero Mesa–Diablo Plateau, and the Salt Basin. Elevations range from 1095 m in the Salt Basin

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to more than 2750 m in the Sacramento Mountains. In the vicinity of Dell City, Texas, there is extensive irrigation where there is arable land.

The Otero-Diablo region is within the Basin and Range physiographic province. There are several distinct morphologic subdivisions within the study area (Fig. 2), the largest of which is the Diablo Plateau-Otero Mesa, which is a gently eastward-sloping plateau at an elevation between 1250 and 1500 m. Within the Diablo Plateau–Otero Mesa are Tertiary igneous intrusive rock bodies, including the Cornudas Mountains, that form distinctive, isolated landmarks on the otherwise low-relief plateau.

The Salt Basin is a major Basin and Range graben extending from south of Van Horn, Texas, north into New Mexico, where it terminates between the Sacramento and Guadalupe Mountains. The topographic floor of the Salt Basin is nearly planar and slopes gently to the south. The Salt Basin contains alluvial fill as thick as 750 m that is overlain by evaporites, primarily gypsum (Veldhuis and Keller, 1980). The Sacramento Mountains occupy the northernmost portion of the study area where they rise steeply from the Otero Mesa to elevations greater than 2750 m.

The Otero-Diablo region is characterized by a subtropical arid climate; most of the area is within the northern Chihuahuan Desert (Dick-Peddie, 1975). Summers are hot and dry; winters are generally mild, although short periods of severe winter weather are common. Weather and climate vary considerably across even small areas; most variation is a function of elevation. As elevation increases, precipitation increases, whereas potential evaporation and temperature decrease.

Annual precipitation varies from less than 25 cm in the Salt Basin to greater than 90 cm in the Sacramento Mountains (Fig. 3). Most precipitation occurs during violent but short-lived thunderstorms during July and August. Estimating average annual precipitation in the Otero-Diablo region is problematical because of the paucity of climate recording stations. However, precipitation is strongly dependent upon elevation. In Figure 4, precipitation values in the vicinity of recording stations are based on recorded values; far from recording stations, where most of this study is located, precipitation is based on elevation using the regression shown in Figure 3. Annual potential evaporation ranges from 190 cm at high elevations to 250 cm at low elevations (Hydrosphere Data Products, Inc., 1992). Because precipitation is greater and potential evapotranspiration is less, the most intense recharge occurs in the Sacramento Mountains.

The Sacramento River is the only perennial surface water in the region. It originates in the Sacramento Mountains and disappears into alluvial fans adjacent to the Otero Mesa (Fig. 5). There is a well-developed system of ephemeral streams throughout the region. Salt Basin playas are primarily ground-water discharge areas, but short-duration floods generated by storm runoff from surrounding areas occasionally fill them (Boyd and Kreitler, 1986). There are several Pleistocene lake beds in the Otero Mesa (Hawley, 1993) attesting to the effects of climate change in this region.

STRATIGRAPHY

The study area is composed almost exclusively of Permian carbonate rocks and associated clastic and evaporite rocks (Fig. 6). There are minor outcrops of pre-Permian sedimentary rocks, Tertiary and Precambrian igneous rocks, and Cretaceous sedimentary rocks, and there is a thin veneer of unconsolidated Quaternary deposits. The following discussion focuses on Permian stratigraphy.

The lower Permian Hueco Formation is the oldest unit that crops out extensively in the study area. It crops out in the western part of the Diablo Plateau and is composed primarily of limestone, dolomite, sandstone, mudstone, and conglomerate (Barnes, 1975).

The Yeso, Victorio Peak, and Bone Spring Formations are equivalent Leonardian to earliest Guadalupian formations that record deposition in the

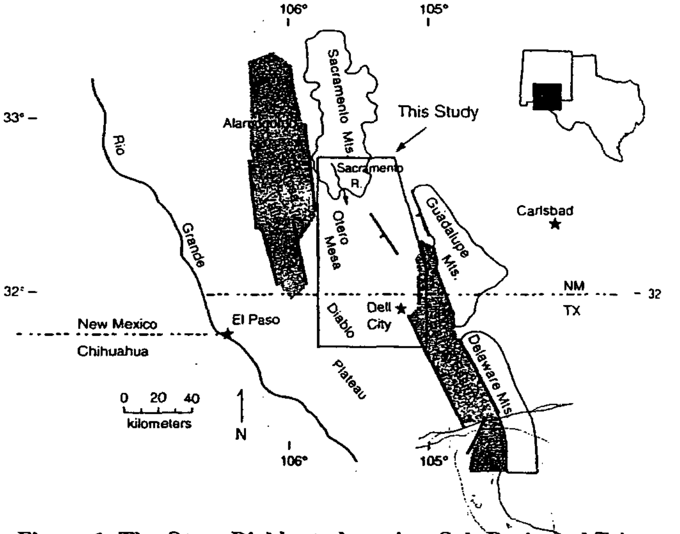

Figure 1. The Otero-Diablo study region. Salt Basin and Tularosa Valley are grabens of the Basin and Range physiographic province. Most of region occupies Otero Mesa and Diablo Plateau and is within the northern Chihuahuan Desert.

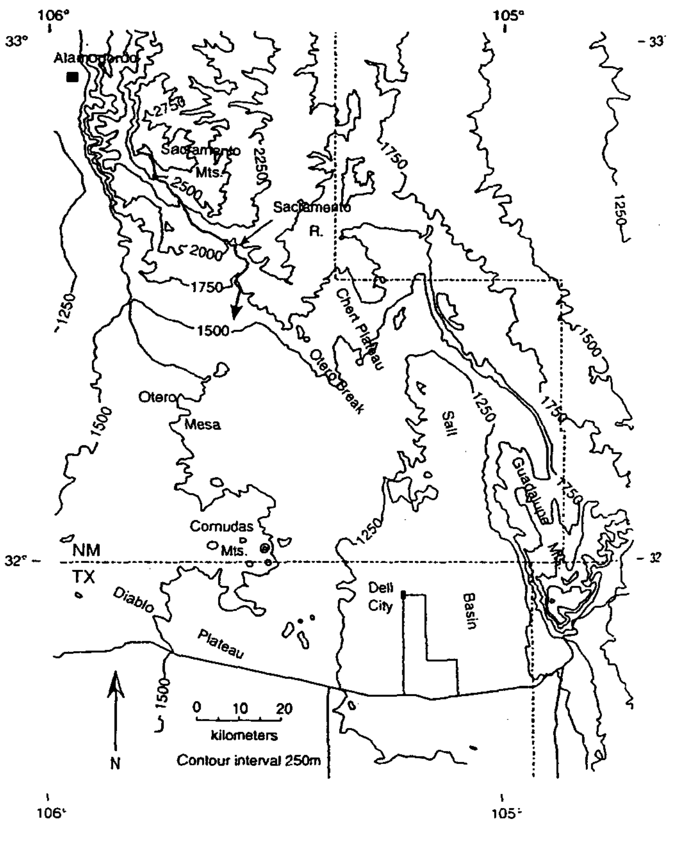

Figure 2. Geomorphological regions and topographic map of Otero-Diablo region. Elevations range from more than 2750 m in the Sacramento Mountains to 1095 m in the Salt Basin. The Sacramento River rises from base flow in the Sacramento Mountains and sinks into alluvial fans at base of the mountains.

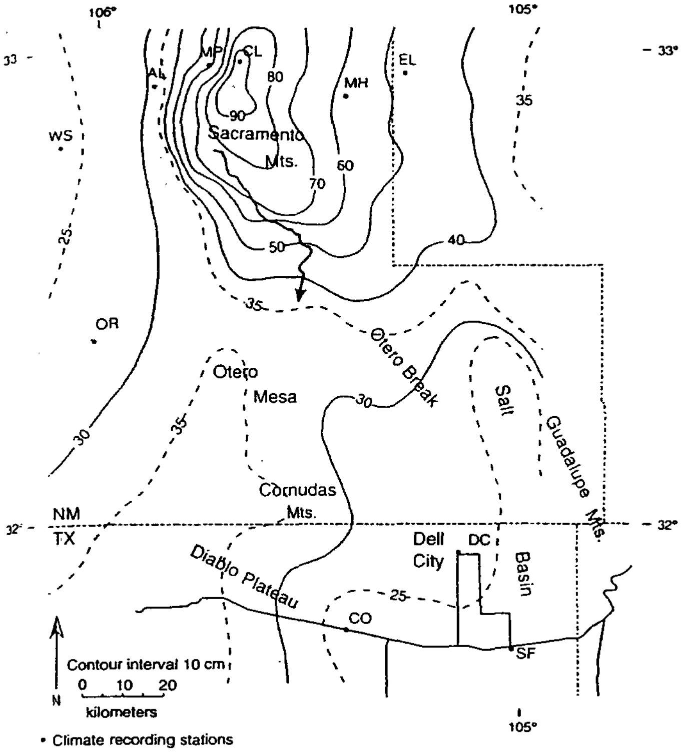

Figure 3. Precipitation (centimeters) in the Otero-Diablo region. Data distant from recording stations are calculated by elevation relationship illustrated in Figure 3. Note that the greatest precipitation by far (and thus the most intense recharge) occurs in the Sacramento Mountains. Recording stations: AL—Alamogordo; CL—Cloudcroft; CO—Cornudas; DC—Dell City; EL—Elk; MH—Mayhill; MP—Mountain Park; OR—Orogrande; SF—Salt Flat; WS—White Sands.

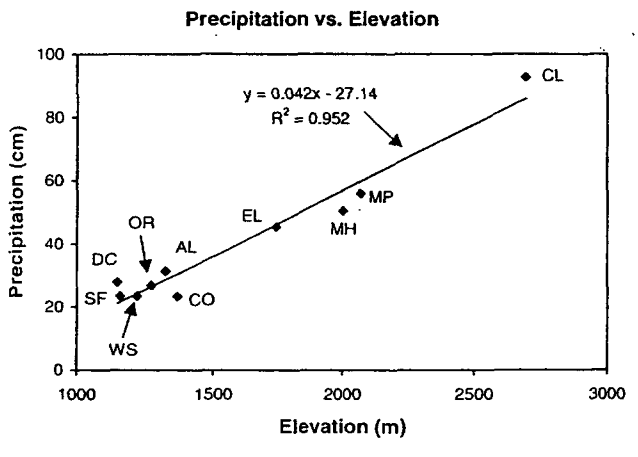

Figure 4. Precipitation (centimeters) as function of elevation (meters) from recording stations in and near the study area. Note strong dependence of precipitation on elevation. This relationship is used to calculate precipitation at points distant from recording stations. Recording station abbreviations as for Figure 3.

Delaware basin and the northwest shelf of the Delaware basin. The Bone Spring Formation is a deep-water limestone unit that crops out primarily to the south and east of the study area. However, there are minor outliers that crop out near the Cornudas Mountains; the formation is also present in the subsurface. The Bone Spring Formation is a thin-bedded, dark gray limestone unit, in part cherty, and has interbedded dolomite, sandstone, and shale. The Victorio Peak Formation, the shelf equivalent of the basinal Bone Spring Formation, crops out in the eastern Diablo Plateau and consists of limestone, dolomite, sandstone, and siltstone (Barnes, 1975).

The Yeso Formation is a heterogeneous unit of limestone, shale, gypsum, dolomite, sandstone, and minor halite, and was deposited in a transitional marine-terrestrial environment (Pray, 1961). The Yeso Formation is hydrogeologically significant because it contains abundant evaporites, primarily gypsum. Because of this, ground water in the Yeso Formation generally has a higher salinity than in other strata. Furthermore, the Yeso Formation is less fractured than other Permian carbonate formations.

The Leonardian–lower Guadalupian San Andres Formation is the most extensive unit to crop out in the study area. It is a gray, massive to thin-bedded limestone with increasing amounts of dolomite and gypsum to the

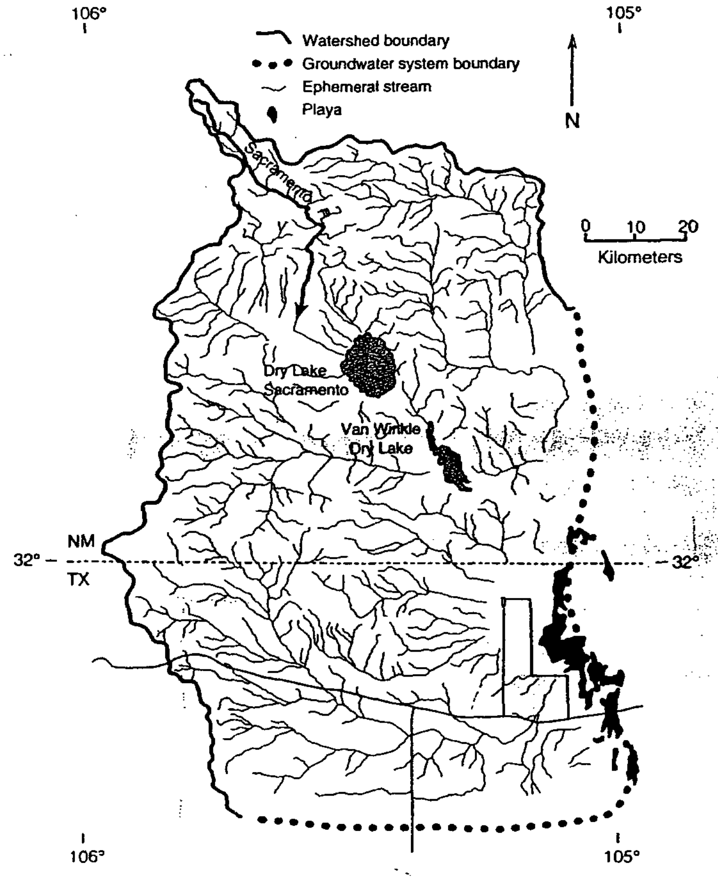

Figure 5. Hydrogeologic features of the Otero-Diablo region. Southern and eastern boundaries of the figure are symmetry boundaries defined by ground-water flow; other boundaries correspond to surface water divides. The only perennial surface water is the Sacramento River. Playas, dry lakes, and streams hold water only after heavy rains. Natural discharge for ground water is through evapotranspiration in Salt Basin playas; a significant amount of ground water is also withdrawn for irrigation in the Dell City area.

north. The lowermost San Andres is equivalent to the upper Victorio Peak (Lucia et al., 1992), and a poorly defined transitional boundary is present between the two formations on the west flank of the Salt Basin near the Texas–New Mexico border. In Figure 6, strata north of the Texas–New Mexico border are mapped primarily as San Andres Formation; strata to the south are mapped primarily as Victorio Peak.

STRUCTURAL GEOLOGY

The most prominent structural feature of the Otero-Diablo region is the Salt Basin, a 420-km-long north-northwest–trending graben (Fig. 7), which is the easternmost margin of the Basin and Range structural province (Goetz, 1977). The structural floor of the graben dips to the southwest and is buried by as much as 750 m of alluvium (Veldhuis and Keller, 1980). There were two phases of deformation: right-lateral shear and extension during late Paleozoic time along a northwest-oriented fault zone; and west-oriented extension, beginning in the Tertiary (Goetz, 1985; Dickerson, 1985). The second phase of deformation created the Basin and Range province and was widespread over a large area of southwestern North America. Fault scarps in recent alluvium suggest that Basin and Range extension is still active (Goetz, 1985).

The Sacramento Mountains consist of a large, east-tilted fault block with gentle folds and numerous normal faults (Black, 1975; Pray, 1961). Extending southeastward from the Sacramento Mountains is a prominent topographic and structural feature, herein named the Otero Break, consisting of a series of down-to-the-west normal faults and a zone of intense fracturing (Fig. 7). It extends from just north of Dell City, Texas, to the Sacramento Mountains, where a series of faults defines the course of the Sacramento River. The Otero Break roughly parallels major Paleozoic structures in Texas and New Mexico, including the Babb flexure, Kelley's shear, and the subsurface Otero fault, which is probably a reactivated Paleozoic feature (Black, 1976).

HYDROGEOLOGY

Previous hydrogeological studies in this region address either irrigation water quantity and quality or the suitability of the area for hazardous waste disposal. Scalapino (1950) documented the early ground-water irrigation development in the Dell City area, and he speculated that the Sacramento River drainage area might be a significant source of recharge for Dell City. Bjorklund (1957) compiled water-level data in the vicinity of Crow Flats in the northern Salt Basin in Texas and New Mexico, but at that time, elevation data for wells were not available and he was unable to map the hydraulic head. Davis and Leggat (1965), Sharp et al. (1993), and Mayer and Sharp (1994) documented water-level and water-quality changes in the Dell City

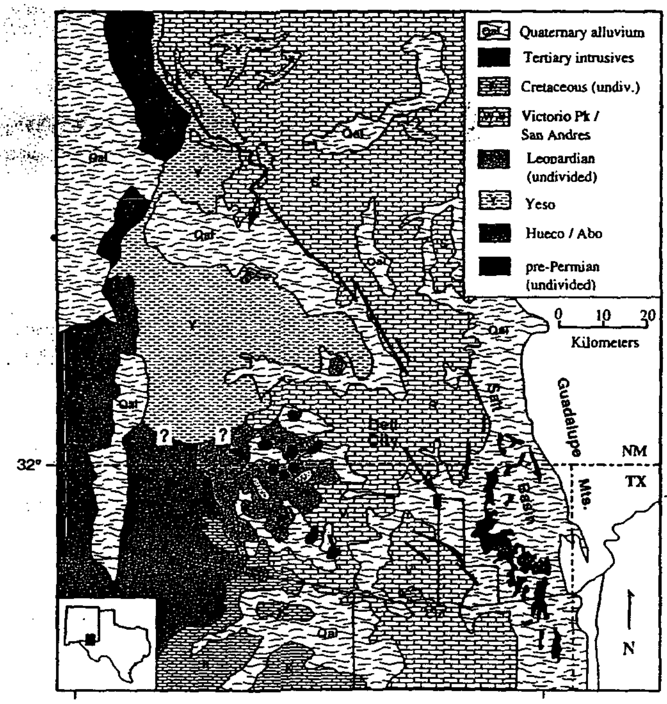

Figure 6. Simplified geologic map (adapted from many sources, including Barnes, 1975; New Mexico Geological Society, 1982; Pray, 1961; Kerans et al., 1994; and Muehlberger and Dickerson, 1989). The region is dominated by carbonate rocks and variable amounts of interbedded clastic and evaporite rocks. Note that the area receiving the most intense recharge (Sacramento Mountains) and the natural discharge area (Salt Basin playas) are at opposite ends of a prominent northwest-southeast–aligned fault trend (Otero Break). This arrangement appears to be the result of conduit flow along fractures, which are concentrated along the Otero Break fault trend. Thus, fracturing appears to exert a major control over the gross geometry of the regional flow system.

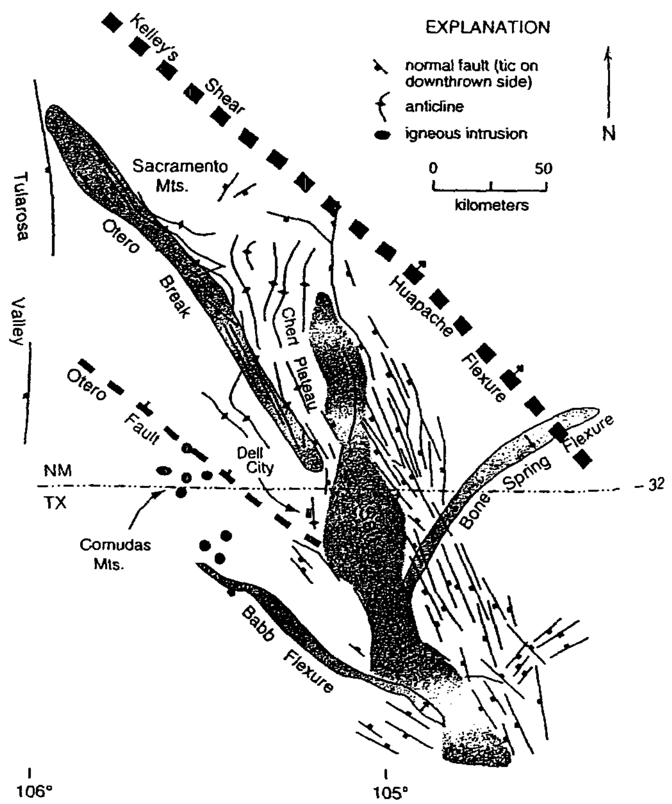

Figure 7. Tectonic features map of Otero-Diablo region (after Goetz, 1985; Black, 1976).

area created by irrigation. Ashworth (1995) provided a review of the water resources of the Dell Valley area. Regional studies by Hiss (1980) and Motts (1968) examined the role of facies and highlighted the role of Permian carbonate facies in channeling regional flow. An implied common theme in these studies is the role of geologic structure and stratigraphy in controlling regional ground-water flow.

Kreitler et al. (1987) mapped the regional potentiometric surface in northern Hudspeth County, Texas, and sampled wells for major ions, trace constituents, tritium, and ^{14}C to assess the feasibility of two potential low-level radioactive waste disposal sites on the Diablo Plateau. Sharp (1989) mapped regional ground-water flow systems in Hudspeth, Culberson, and Reeves Counties, Texas. Boyd (1982), Boyd and Kreitler (1986), and Chapman and Kreitler (1990) studied the Salt Basin unsaturated zone and concluded that sediments there were deposited primarily by ground-water discharge and mineral precipitation and not by a preexisting lake, as had been suggested by King (1948).

Hydrostratigraphy

The Otero-Diablo aquifer consists primarily of Victorio Peak, San Andres, and Yeso Formations strata (Fig. 8). The prolific Dell City irrigation district obtains its water from undifferentiated Bone Spring–Victorio Peak rocks (Scalapino, 1950). Hydrostratigraphic details are not known; in particular, there is little known about aquifer thickness. Most wells penetrate only tens of meters to approximately 100 m of saturated thickness. Several wells near Dell City penetrate as much as 430 m of aquifer. In the central part of the region the San Andres Formation overlies the less-permeable Yeso Formation. Here the Yeso Formation probably serves as the base of the flow system. In other areas there is no clear basal unit.

Ground-Water Recharge and Discharge

Recharge in the Otero-Diablo region is from areal infiltration of precipitation (Kreitler et al., 1987); infiltration of the Sacramento River (Scalapino, 1950); and irrigation return flow in the Dell City irrigation district (Logan, 1984). Recharge other than irrigation return flow is assumed to be negligible within the Salt Basin because soil permeability is low and potential evaporation is more than 10 times greater than precipitation (Boyd and Kreitler, 1986).

The Salt Basin is the natural discharge area for regional ground-water flow. Evaporation occurs directly from the water table, which is located at a depth of between 0.8 and 1.8 m (Boyd and Kreitler, 1986). Since about 1950, however, pumping in the Dell City irrigation district has discharged significant volumes of ground water. According to Texas Water Development Board figures (Ashworth, 1995), total annual discharge for the period 1958 to 1992 averaged approximately 1.0×10^8 m^3 (85 000 acre ft).

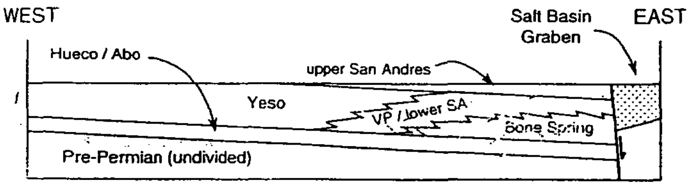

Figure 8. Schematic cross section showing relationships among major formations of the Otero-Diablo region (adapted from Black, 1975; Lucia et al., 1992). VP—Victorio Peak Formation; SA—San Andres Formation.

Potentiometric Surface

Data in Texas were compiled from published reports and from records kept by the Texas Water Development Board. Data for New Mexico were obtained from records of the U.S. Department of the Interior, Bureau of Land Management; the New Mexico State Engineer's Office; and from individual well owners. Well locations and water depths in wells were translated to elevation above mean sea level using wellhead elevations estimated from U.S. Geological Survey 7.5 minute topographic maps. Therefore potentiometric data are accurate only to plus or minus several meters. Because the data are widely spaced and potentiometric surface relief is large, this uncertainty does not appreciably affect the interpretation.

The potentiometric surface slopes generally eastward from the Diablo Plateau and Otero Mesa, and southward from the Sacramento Mountains toward Dell City and the Salt Basin (Fig. 9). There is a broad, shallow cone of depression around Dell City. In the west, the potentiometric surface mimics topography. However, near the Otero Break it appears to be almost independent of topography, and in the central part of the study, it is nearly flat. Together with the large amount of water discharged in the Dell City irrigation district, this suggests very high transmissivity. Regional ground-water flow is southward from the Sacramento Mountains and eastward from the Diablo Plateau–Otero Mesa toward the Salt Basin and the Dell City irrigation district.

Ground-Water Chemistry

Ground-water chemistry is only briefly summarized here. Details and data tables are in Mayer (1995). Other data sources include Kreitler et al. (1987), Ashworth (1995), and the Texas Water Development Board for the Dell Valley and Diablo Plateau regions of Texas; and Bjorklund (1957), Hudson and Borton (1980), and the U.S. Department of the Interior, Bureau of Land Management, for the New Mexico regions. Ground water in most of the region is fresh to brackish. Total dissolved solids (TDS) concentrations range from a low of 400 mg/L in the Sacramento River to a local high of 3500 mg/L in the central Otero Mesa (Fig. 10). In the Salt Basin, where ground water discharges by evapotranspiration, TDS concentrations can exceed 250 000 mg/L (Boyd, 1982). Note that in the Dell City area we use only pre-1950 data because more recent data are strongly influenced by irrigation return flow and do not accurately reflect regional trends.

A key observation is the prominent low-salinity trend extending from the Sacramento Mountains southeastward along the Otero Break, terminating near Salt Basin playas and Dell City. Within this corridor TDS concentrations range from less than 500 mg/L to 2000 mg/L. Salinities on either side of this zone increase by as much as several thousand milligrams per liter over short distances (Fig. 10). Hydrochemical facies vary from Ca-SO_4 and Ca-Mg-SO_4-HCO_3 in the Otero Mesa, Otero Break, and Crow Flats regions, to Ca-Mg-Na-SO_4 facies in Dell Valley and the Diablo Plateau. There are also local occurrences of Na-Cl facies in Dell Valley and the Diablo Plateau (Mayer, 1995, p. 60).

FRACTURE CHARACTERIZATION

The Otero-Diablo region is an excellent setting for mapping geologic features through aerial photo analysis. Vegetation is sparse; there are extensive areas of outcrop; and soils, where present, are generally thin. To identify major fracture trends, lineaments were mapped from U.S. Geological Survey black and white, infrared aerial photographs at a scale of 1:58 000. The air-photo database for this study consists of 112 stereo photos covering approximately 6000 km^2.

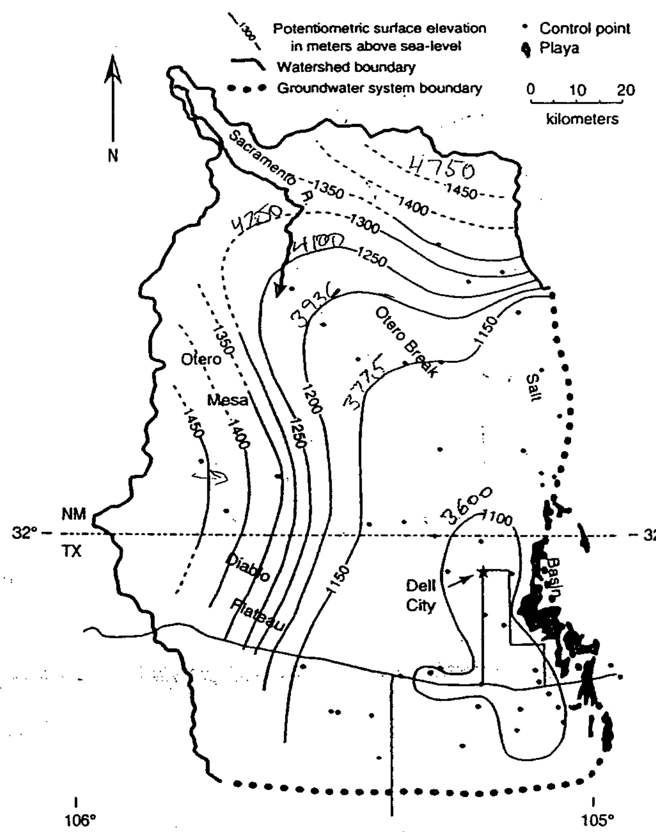

Figure 9. Regional potentiometric surface map. Note low hydraulic gradient in southeastern part of region, and broad, northwest-trending potentiometric trough, coincident with Otero Break. These features correspond to areas of relatively intense fracturing and suggest that fracturing plays a major role in determining ground-water flow in this area. TDS—total dissolved solids.

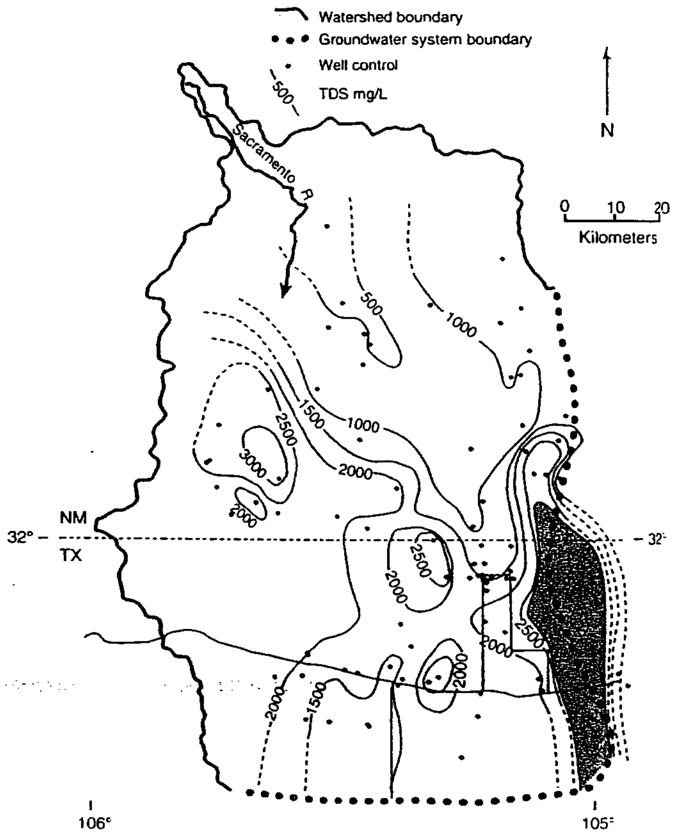

Figure 10. Contour map of total dissolved solids (milligrams per liter). Note apparent plume of fresh water extending from the Sacramento Mountains toward Dell City. Plume is coincident with potentiometric trough shown in Figure 9. It suggests that relatively fresh Sacramento Mountains recharge is funneled along the Otero Break, ultimately to discharge in the Salt Basin, more than 80 km distant. If not for the Otero Break fracture zone, the discharge point for system would probably be much closer to the Sacramento Mountains.

FRACTURE MAPPING

Several classes of lineaments are considered indicative of fracturing. They are summarized here and depicted in Figure 11. The classes are as follows.

1. Sharply defined features cut across and in some cases appear to offset bedding. These features are prominent fracture zones that are directly visible on air-photos (Fig. 11A).

2. Thin, anomalously colored bands are normally darker than surrounding materials. These features appear to be weathered zones overlying fractures and are inferred to be filled with thicker soil than surrounding, less-weathered, unfractured rock (Fig. 11B).

3. Because of thicker soil overlying some fracture zones, vegetation commonly grows preferentially over fractured bedrock (Fig. 11C) and produces linear vegetation trends.

4. Linear depressions or aligned sinkholes apparently formed from preferential dissolution along fractures (Fig. 11D).

5. Additional lineaments are linear stream courses, especially those forming a trellis or rectangular drainage pattern (Fig. 11E).

To establish the feasibility of air-photo mapping in the Otero-Diablo region, we conducted a pilot study to field check probable fracture zones identified on air photos. In every case, lineaments identified on the photos could be correlated with fractures on the ground. It is important to note that individual fractures are not visible on air photos. Fracture-zone (lineament) spacing varies from tens to thousands of meters. Figure 12 shows a fracture zone on the Otero Mesa. Fracture spacing is approximately 2.5 m; adjacent fracture zones are approximately 500 m distant. Figure 13 shows a fracture zone on the Diablo Plateau. Fracture spacing is approximately 1 m; adjacent fracture zones are 150 m distant.

That lineaments represent subvertical fracture zones is supported by observations in the field and on air photos. Fractures observed in cliff-face exposures on the Otero Break are within 10° of vertical. In addition, lineaments maintain a linear trace, even across rugged terrain (Fig. 11B).

Air-photo analyses and field observations demonstrate that the Otero-Diablo region is heavily fractured, and there are many indications that ground-water flow is fracture-dominated. Specific capacities of wells in the Dell City area within 30 m of each other commonly vary by more than an order of magnitude (Scalapino, 1950). This suggests that the high-capacity wells intersect open fractures, whereas the low-capacity wells do not. Ground-water recharge wells drilled in conjunction with a U.S. Soil Con-

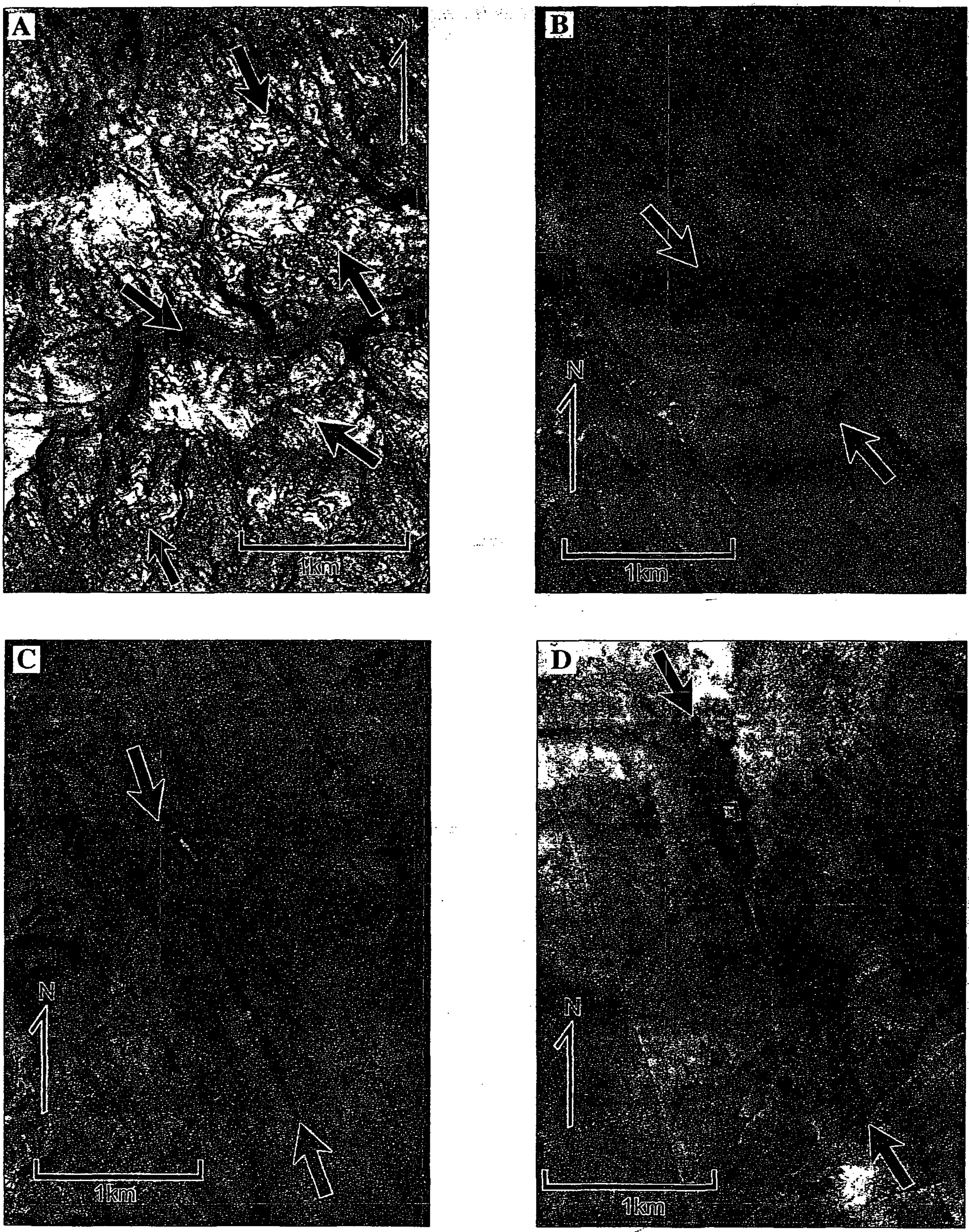

Figure 11. (A) Sharp linear features (examples indicated by arrows) are fracture zones. Also note fracture-controlled ephemeral stream channels. (B) Dark bands between arrows are weathered zones along prominent fractures. Note that bands cut across bedding and are linear over rugged terrain, indicating that fractures are nearly vertical. (C) Linear vegetation trends (examples indicated by arrows) along fracture zones. (D) Lines of elongated sinkholes probably formed by preferential dissolution along fractures.

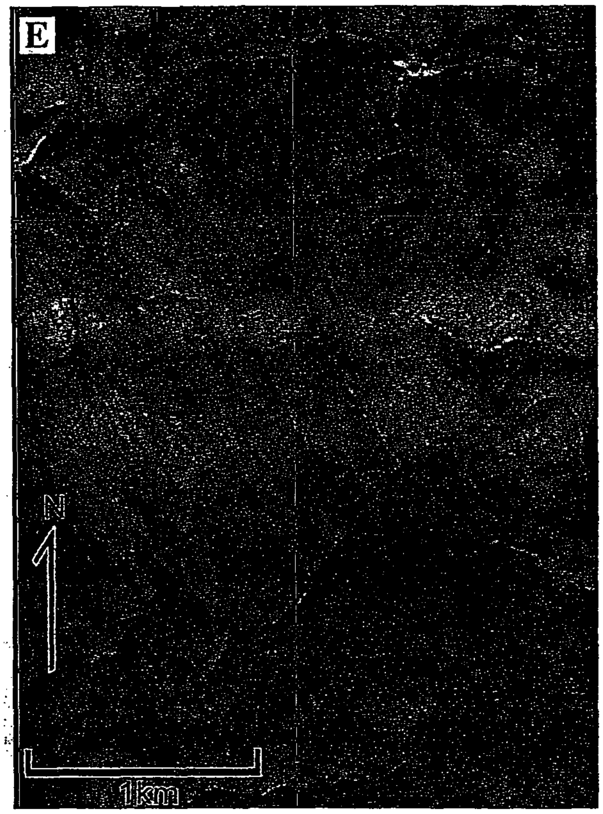

Figure 11. (E) Trellis drainage patterns developed in horizontal, fractured strata. Major streams are aligned north-northwest along the most prominent fracture sets; their tributaries are nearly perpendicular, along less prominent fracture sets.

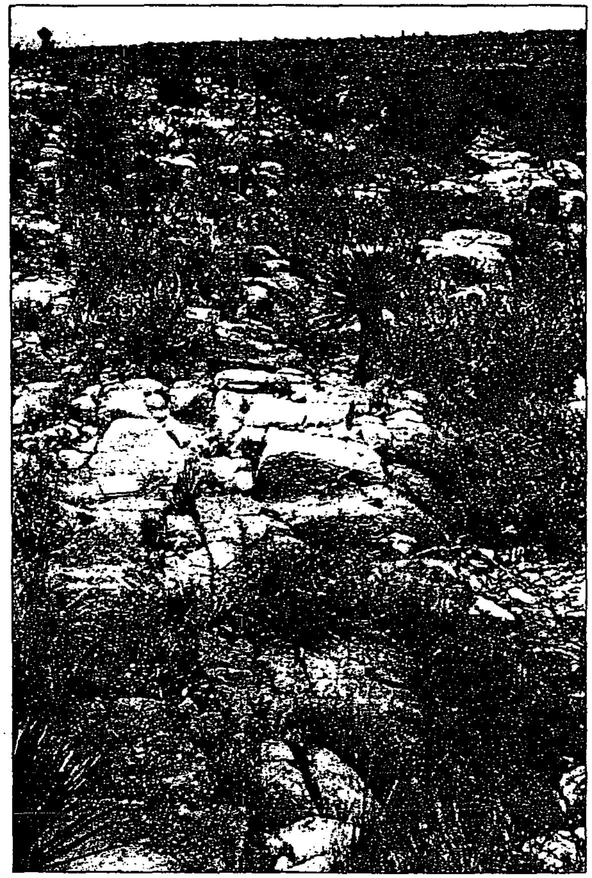

Figure 13. Fracture zone on Diablo Plateau, looking northwestward. Individual fractures spaced approximately 1 m apart; adjacent fracture zones are approximately 150 m distant. Field book on left measures 22 by 30 cm.

Figure 12. Fracture zone on Otero Mesa, looking southeastward. Individual fractures are not visible on air photos but zones of relatively closely spaced fractures are. Fracture spacing within fracture zone is approximately 2.5 m; adjacent fracture zones are approximately 500 m distant. Note alignment of yucca plants along leftmost fracture where soil covers bedrock. Dog (for scale) measures 0.65 m high at shoulder.

servation Service flood-control project west of Dell City were sited with the aid of air-photo analysis and were drilled at the intersections of major lineaments (Logan, 1984). Of 12 wells drilled, 11 had specific capacities greater than 24.8 m^3/min/m (2000 gal/min/ft). This success rate is contrasted to a rate of only 44% for irrigation wells drilled in Dell Valley without the aid of lineament analysis (Scalapino, 1950).

E. McCutcheon (1992, personal commun.) noted linear trends within the irrigation district aligned subparallel to nearby faults, along which ground-water conductivity, temperature, and pH are nearly identical and distinct from nearby wells. This suggests that these wells produce from the same fault or fracture zone. Furthermore, local well drillers reported numerous incidences of lost circulation that indicate large, open fractures or dissolution features.

These observations were confirmed by video well logs that show open fractures intersecting wells (Logan, 1984). Although the rest of the Otero-Diablo region is less suitable for agriculture and has not been drilled as extensively as Dell Valley, local drillers reported indications of fracture-dominated flow throughout the region (L. Perry, 1994, personal commun.). Because most of the region is geologically similar to the Dell City area, and because extensive fracturing is widespread throughout the region, it is reasonable to assume that fracture flow dominates the Otero-Diablo system.

FRACTURE DATA REDUCTION

Discretization

Lineaments were marked on one half of a stereo-photo pair and then transferred to U.S. Geological Survey 7.5 minute topographic maps. Lineaments were then digitized at the University of Texas, Department of Geological Sciences Geographic Information Systems (GIS) lab with the GIS package, Arcinfo. To create a single fracture map, forty 7.5 minute topographic maps were digitized and assembled.

Gridding and Contouring

The study area was overlain with a 3 km by 3 km grid. Fracture density was determined by summing the total length of fractures within a grid cell and dividing by the area of the cell. The cell-wide value of fracture density was then assigned to the center point of the grid cell, and these values were contoured. Some areas of the study are covered by enough alluvium to obscure fractures (Fig. 6). These areas were subtracted from the area of the grid cell. Thus, fracture density represents fracture length per unit area of outcrop rather than per unit area of land surface. Fracture orientations were analyzed similarly; rose diagrams depict fracture orientations.

FRACTURE SYSTEM CHARACTERISTICS

Fracture Geometry

Approximately 2400 lineaments were mapped. Contoured fracture density (Fig. 14) ranges from 0 to 1850 m/km^2, which corresponds to average fracture spacing of 540 m to greater than 3 km. Because the mapped fractures are actually fracture zones (made up of closely spaced individual fractures), the true fracture density is greater than Figure 14 suggests. We assume that fracture density is proportional to fracture-zone density; thus, this figure illustrates relative fracture density. An absolute fracture density cannot be resolved at this scale. Fracture orientations are depicted in Figure 15 by rose diagrams for representative subareas.

Several observations are based on these data. First, except for the western Otero Mesa, there is a strong preferred fracture orientation of approximately N20W. In the western Otero Mesa, there is no single dominant preferred orientation. Second, fractures are most abundant along the Otero Break and least abundant in the western Otero Mesa. Third, fractures closely parallel, and are most abundant near, major normal faults. The scarcity of fractures in the western Otero Mesa may be lithologically controlled. This area is underlain by the gypsum-rich Yeso Formation and may be less prone to fracturing than the carbonate-dominated units present throughout the rest of the Otero Diablo region.

Fracture Domains

On the basis of the above data, the study area may be divided into distinct fracture domains, which are used to develop the numerical model. Domain 1 (Fig. 16) is along the Otero Break. This is the most heavily fractured zone and has a very strong preferred fracture orientation (approximately N20W) parallel to the normal faults of the Otero Break. Domains 2 and 3 have significant fracture densities and dominant fracture orientations similar to those of domain 1. In domain 3 there are two additional fracture sets (oriented approximately N40W and N50E) not observed elsewhere. Domain 4 includes the western Otero Mesa and Diablo Plateau and is characterized by relatively sparse fracturing and no single, dominant fracture orientation. Domain 5 is composed of Salt Basin alluvium. On the basis of fractures observed in nearby outcrops and on abundant subsurface evidence of fractures, the alluvium-covered region surrounding Dell City is included in domain 1.

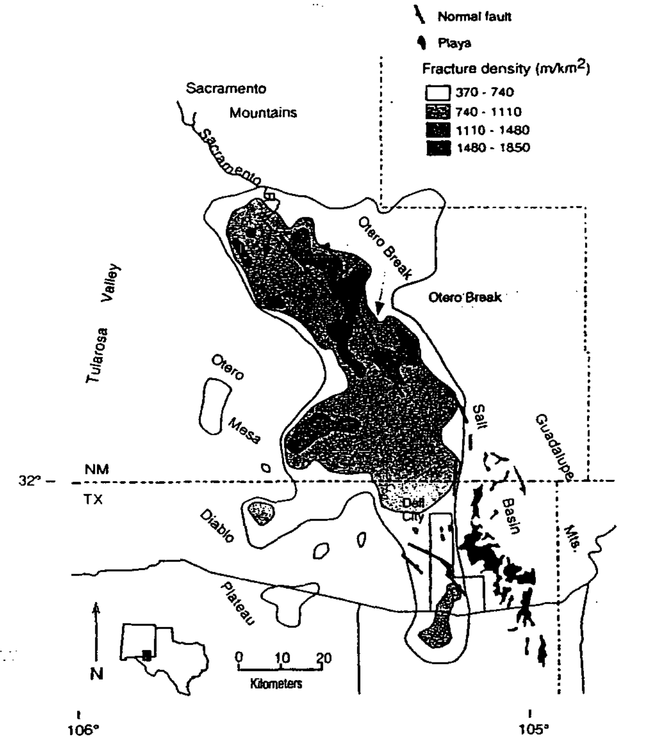

Figure 14. Contour map of fracture density (meters per square kilometer). Note concentration of fractures along Otero Break. Fracture density is least in western Otero Mesa where Yeso Formation crops out. No fractures are mapped in alluvial cover. We hypothesize that fracture distribution is major control of regional ground-water flow.

FINITE-ELEMENT FLOW MODELING

We use a two-dimensional, steady-state finite-element model to test potential configurations of regional transmissivity. The finite-element approach is well suited to analyze the anisotropy and heterogeneity inherent in fractured systems, especially in nonrectangular domains. A Geographic Information System (GIS) interface was used to create the finite-element mesh, discretize input parameters, and display model output. The programs and governing equations were given in their entirety in Mayer (1995). The theory is described in many sources and is not repeated here.

MODEL DEVELOPMENT

The model tests the hypothesis that regional fracture systems control regional ground-water flow by increasing aquifer permeability and creating preferred flow paths. Hence, transmissivity is estimated according to measured fracture properties.

We use an equivalent porous medium/equivalent parallel plate approach (Sharp, 1993). The fractures are assumed to be numerous enough and distributed evenly enough for the effects of individual fractures to be ignored. Thus, transmissivity is modeled as a bulk property of the aquifer; no direct consideration is taken of individual fracture contributions or fracture properties such as aperture, roughness, or length. Implicit in this approach is the un-

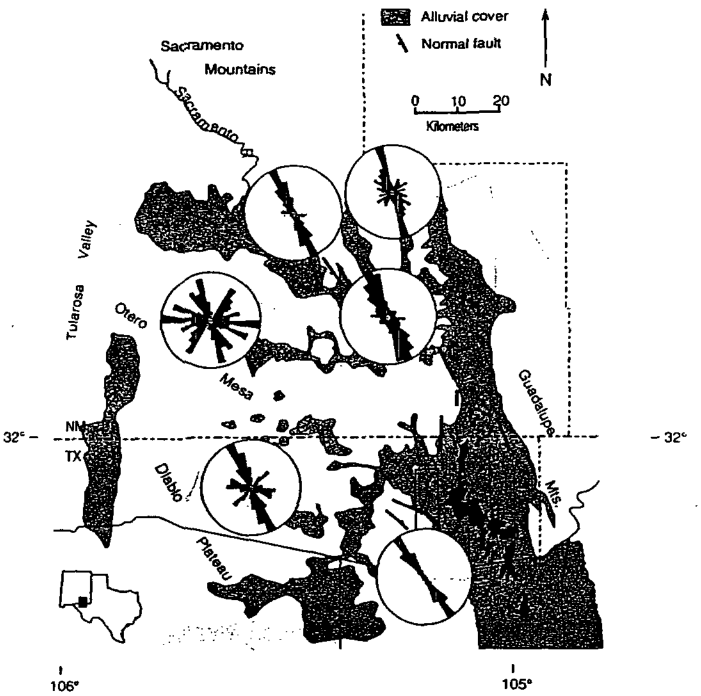

Figure 15. Rose diagrams of fracture orientations. There is a prominent northwest-southeast preferred orientation of fractures across most of region. In Otero Mesa there is no single preferred orientation. Fracture orientation appears to be much less important in regional flow than fracture density.

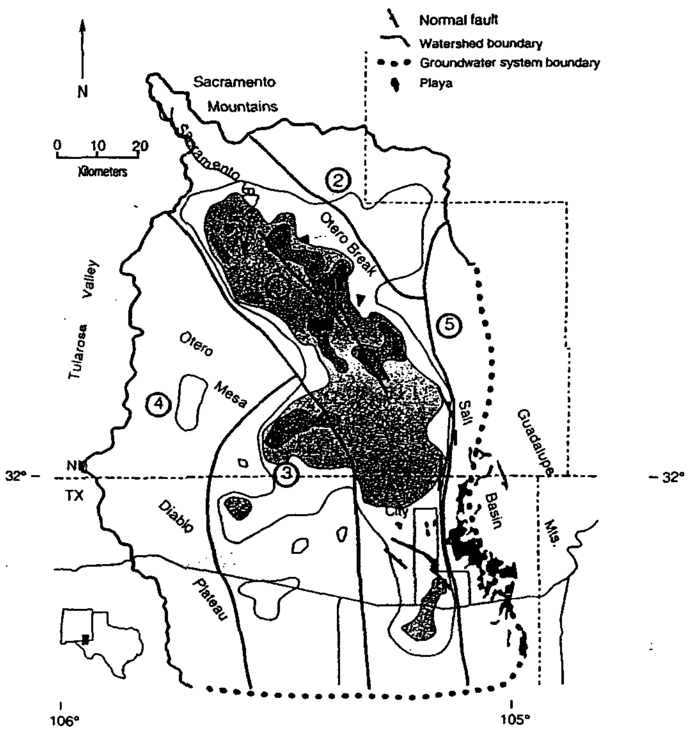

Figure 16. Transmissivity domains defined based on fracture density and orientation. Domain 1 has highest transmissivity; domain 4 has the lowest.

derlying assumption that transmissivity of individual elements in the finite element model can be adequately represented as a symmetric tensor. Given the large study area and the numerous, widely distributed fractures, this may be a reasonable assumption (Long et al., 1982). However, the applicability of porous medium approaches to fractured aquifers is a topic of current debate (e.g., LaPointe et al., 1996).

Mesh Generation

The model boundary was digitized with Arcinfo; the finite-element mesh was generated with Grid Builder 3.0 (McLaren, 1992). The mesh consists of 1134 nodes and 2126 elements; the average element size is 4.5 km^2.

Boundaries

The model is bounded by both constant head and no-flow boundaries (Fig. 17). The western and northern boundaries are the surface-water (and presumed ground-water) divides that delineate the Salt Basin watershed. Coincidence of surface-water and ground-water divides is almost certainly the case on the west because the Otero Mesa and Diablo Plateau drop precipitously into the Tularosa Valley along major normal faults that truncate the aquifer. However, where the ground-water divide separates the Salt Basin from the Rio Penasco watershed (the northern hydraulic boundary) is less certain because in carbonate aquifers of arid regions, ground-water and surface-water divides are less likely to coincide than in more humid climates or in less-permeable aquifers (Maxey and Mifflin, 1966). Because interbasin flow, calculated from water balances, is minimal, we assume that coincidence of ground-water and surface-water divides is reasonable for this boundary.

The eastern no-flow boundary is a symmetry boundary where westward flow from the Guadalupe Mountains and eastward flow from the Otero Mesa converge. The southern no-flow boundary is a symmetry boundary where regional flow is to the east, parallel with the boundary, on the basis of regional potentiometric data (Kreitler et al., 1987). The eastern constant-head boundary corresponds to the water table, which occurs at an elevation of 1095 m (Boyd, 1982), in Salt Basin playas. It is located along the central axis of the Salt Basin.

Transmissivity Domains

Five constant transmissivity domains (Fig. 16) are defined on the basis of fracture domains. Heavily fractured domains are assigned higher transmissivities than less-fractured domains. Transmissivities used in the model are within the range of transmissivities reported for carbonate aquifers (Table 1). Because there are no transmissivity measurements available for most of the study area, transmissivity is estimated by comparing model output to the measured potentiometric surface. However, transmissivity domains are defined, and relative values of transmissivity between zones are predicted, on the basis of mapped fracture domains. Domain 1, the most heavily fractured area, is assigned a transmissivity of 10^{-2} m^2/s, which is in the high transmissivity range of Table 1, but more than an order of magnitude less than the highest values. The other less-fractured domains and domain 5, Salt Basin alluvium, were assigned lower transmissivities.

Recharge and Discharge

Several recharge and discharge processes (summarized in Table 2) operate in the Otero-Diablo region. Recharge from precipitation is distributed over all but the lowest elevations of the study area, and there is significant irrigation return flow in Dell Valley. Discharge occurs by transpiration and evaporation from Salt Basin playas, and since the early 1950s by irrigation

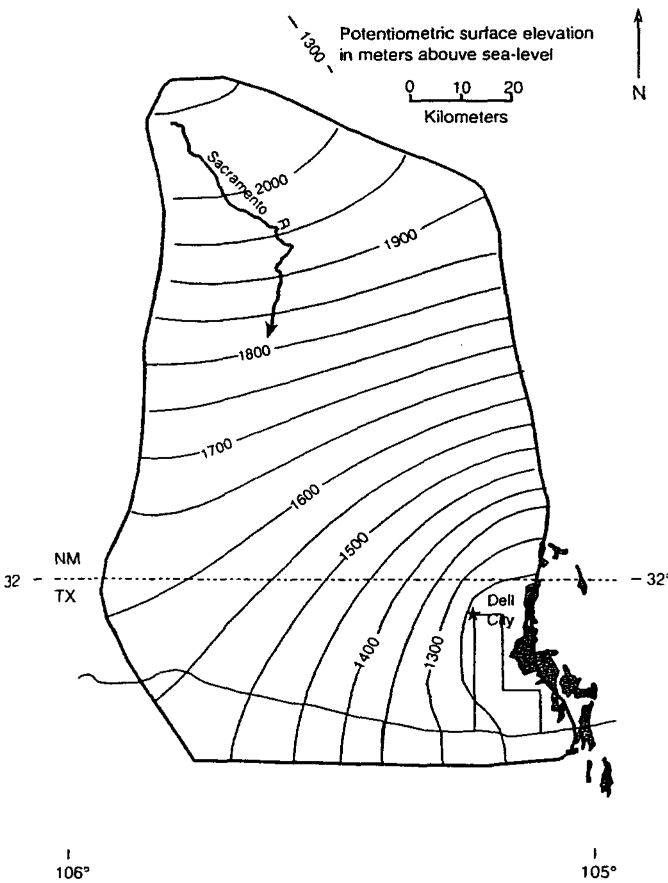

Figure 17. Model-generated potentiometric surface for homogeneous, isotropic transmissivity. By comparison with Figure 9 it is apparent that homogeneous transmissivity is not consistent with the observed hydraulic head distribution, given estimated recharge.

pumping. It is also possible that a small, undetermined amount could discharge through interbasin flow (Davis and Leggat, 1965).

Recharge is strongly elevation dependent; it is estimated by a combination of methods. At relatively low elevations in the central and southern portions of the study area, recharge estimates are based on soil-chloride profiles from the Diablo Plateau. At higher elevations, recharge is based on water-balance studies from similar areas of the Basin and Range province.

In the Salt Basin below an elevation of 1160 m, recharge from direct precipitation is assumed to be negligible. Here, potential evaporation is an order of magnitude greater than precipitation (Boyd, 1982), and soils consist mainly of low-permeability, fine-grained, clay-rich basin-fill deposits (Barnes, 1975). Chapman and Kreitler (1990) reported upward gradients in the unsaturated zone even shortly after significant precipitation events.

Tritium levels and ^{14}C ages of Diablo Plateau ground waters indicate that most wells contain recent, local recharge (Kreitler et al., 1987). Soil chloride profiles from the Diablo Plateau suggest that the main recharge mechanism there is infiltration through fractures in creek beds and closed depressions during occasional flash floods. On the basis of soil chloride profiles, calculated recharge for creek beds and depressions ranges from 0.028 to 0.457 cm/yr, whereas calculated recharge for areas outside creek beds is much less, ranging from 0.005 to 0.020 cm/yr.

The total area of creek beds and closed depressions was calculated on the basis of digitized topography and stream courses, assuming a stream-bed width of 10 m. This gives a total creek bed–depression area of 128 km^2 and an interfluve area of 4713 km^2. Assuming 0.242 cm/yr recharge within creek beds and depressions and 0.0125 cm/yr for the rest of the plateau, the midpoints of the ranges reported by Kreitler et al. (1987), the composite recharge rate for the Otero Mesa–Diablo Plateau is 0.018 cm/yr. This may be lower than the actual recharge for some parts of the Otero Mesa–Diablo Plateau because these data were from a field site at an elevation of approximately 1260 m. Because much of the study region lies at a higher elevation, recharge may be greater.

In the Sacramento Mountains and adjacent high-relief terrain above an elevation of approximately 1675 m, recharge was estimated using techniques established by Maxey and Eakin (1949) for a similar carbonate-dominated regional flow system in the Basin and Range. This technique,

TABLE 1. TRANSMISSIVITY VALUES FOR TEXAS CARBONATE AQUIFERS

Aquifer	Method	Data points	Low	Transmissivity [m^2/s] high	Median	References
Otero-Diablo	Pump tests	4	3.44E–07	2.47E–04	1.24E–04	Kreitler et al., 1987
	Pump tests	2	5.14E–02	5.59E–02	5.37E–02	Logan, 1984
Edwards	Model calibration	21	2.15E–01	2.15E+00	1.18E+00	Maclay and Small, 1980
	Recession curves	6	1.00E–01	4.00E–01	2.50E–01	Senger and Kreitler, 1984
	Specific capacities	525	1.00E–07	1.00E–01	5.57E–03*	Hovorka et al., 1995

*Median value for the Hovorka et al. (1995) study represents a geometric mean of the data.

TABLE 2. RECHARGE AND DISCHARGE MECHANISMS IN THE OTERO-DIABLO REGION

Recharge		[m^3/yr]	
Distributed (Kreitler et al., 1987)		7.20E+07	21,870 AFY
Irrigation return flow (Logan, 1984)		3.7–5.2E+07	
	Total:	1.1–1.2E+08	
Discharge			
Irrigation pumpage (Ashworth, 1995)		1.00E+08	81,000 AFY
Playa evaporation (Almendinger and Titus, 1973)		2.70E+07	21,870 AFY
	Total:	1.27E+08	

which agrees favorably with recharge determined by more rigorous means (Maxey and Robinson, 1947), calculates annual recharge as a percentage of total annual precipitation. Calculated recharge for the Sacramento Mountains is elevation dependent and ranges from 2.1-6.9 cm/yr.

In summary, distributed recharge is assumed to occur over most of the area. It ranges from 0.018 cm in the Diablo Plateau/Otero Mesa to 6.9 cm in the highest parts of the Sacramento Mountains. The Sacramento Mountains receive by far the most intense recharge.

Continuous water-level records (Ashworth, 1995) show that when annual pumpage exceeds approximately 1.24×10^8 m^3 (100 000 acre ft), water levels in the Dell City irrigation district decline. At lower pumping rates, water levels remain constant or increase. The average steady-state flux for the aquifer is 1.24×10^8 m^3 per year.

MODEL RESULTS

Flow simulations tested three main configurations of transmissivity: homogeneous and isotropic; heterogeneous and isotropic; and heterogeneous and anisotropic.

Homogeneous, Isotropic Case

Figure 17 is the output of a homogeneous, isotropic flow system with a transmissivity of $10^{-2.5}$ m^2/s. This is within the range of observed data (Table 1) and was selected by trial and error comparison of model output with the observed potentiometric surface. Although this case presents a theoretically plausible configuration of hydraulic head, there are fundamental discrepancies between observed data and model output. In the central southeastern portions of the study area there is a very low hydraulic gradient of approximately 1 m/km (Fig. 9), whereas this model has a much larger gradient of approximately 5 m/km. This model produces a slight ridge in the potentiometric surface extending from Dell City northwestward, but Figure 9 shows a pronounced trough in the same location. Increasing or decreasing the transmissivity has little effect on the overall configuration of the output; the main effect is to raise or lower the potentiometric surface.

Heterogeneous, Isotropic Case

In simulations 2 and 3 the region is subdivided into transmissivity domains developed according to fracture density (Figs. 15 and 16). More densely fractured areas are assigned higher transmissivities. Transmissivity domain 1 was the highest fracture density of the study area and is assigned a transmissivity of 10^{-2} m^2/s. Domains 2 and 3 (less intensely fractured rock) were assigned a transmissivity of 10^{-3} m^2/s. Domain 4, delineated on the basis of its low fracture density and relatively large variation of fracture orientation, was assigned a transmissivity of 10^{-4} m^2/s. Domain 5 consists of Salt Basin alluvium, and its western boundary coincides with the western bounding fault of the Salt Basin graben. Domain 5 transmissivity is 10^{-4} m^2/s.

Output from the heterogeneous, isotropic case (simulation 2) is shown in Figure 18. This configuration of transmissivity produces a much better match to the observed potentiometric surface than the homogeneous transmissivity case. Note the low hydraulic gradient in the central part of the region, and the potentiometric trough extending from Dell City northwestward—features that are not present in the homogeneous model.

Heterogeneous, Anisotropic Case

In configuration 3 (Fig. 19), domains 1 and 2 are assigned a 10:1 anisotropy ratio, the large value of transmissivity being parallel to the mean fracture direction. This ratio is similar to that used to model the Edwards

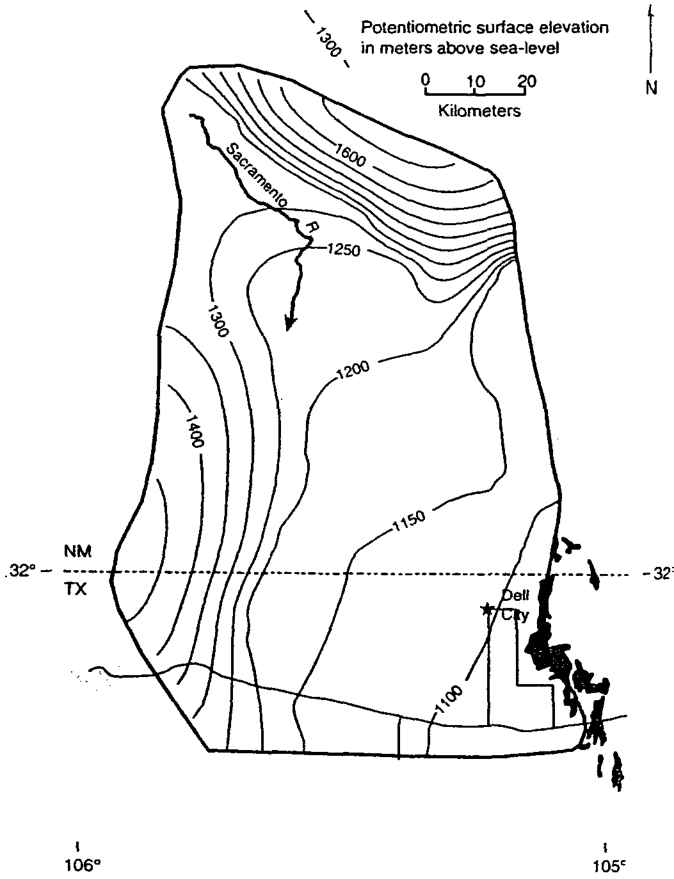

Figure 18. Model-generated potentiometric surface assuming heterogeneous, isotropic transmissivity distribution defined on the basis of fracture density. This transmissivity distribution produces a hydraulic head distribution similar to the observed potentiometric surface. Thus regional potentiometric trends are consistent with a high-transmissivity zone coincident with fracturing along the Otero Break.

aquifer (Uliana and Sharp, 1996) and may represent a reasonable estimate of anisotropy in a fractured carbonate aquifer.

Adding anisotropy does not significantly change the model output from configuration 2. This is because the hydraulic gradient is nearly parallel to the direction of maximum transmissivity. The hydraulic gradient and the preferred fracture direction are aligned parallel to the Otero Break. Hence ground-water flow direction is not strongly affected by anisotropy.

Sensitivity Analysis

The sensitivity analysis evaluates changes in recharge and transmissivity. One parameter was varied in increments of 10% from −30% to +30% while all other model parameters were held constant (Fig. 20). Model error is measured as root-mean-square (RMS) error. Because there is a high concentration of data points in the Dell City area and there are relatively few data elsewhere, calibration points were selected to provide a more even distribution of measured heads throughout the modeled region for the calculation of RMS error. On a percentage change basis, the model is more sensitive to changes in recharge. However, aquifer transmissivity varies over a

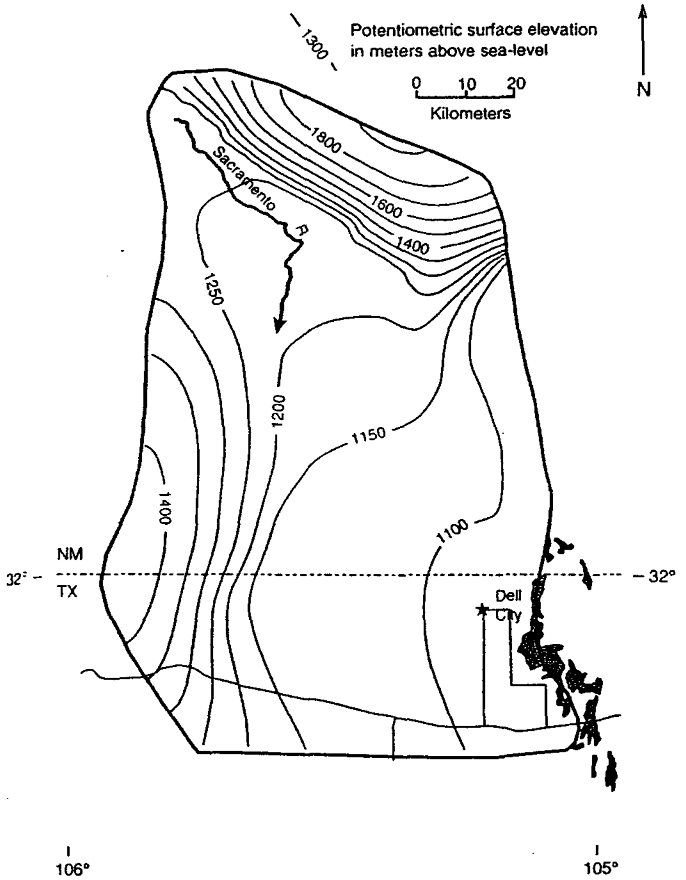

Figure 19. Model-generated potentiometric surface assuming a heterogeneous, anisotropic transmissivity distribution. Domains 1 and 2 are assigned a 10:1 anisotropy ratio, with large value of transmissivity parallel to mean fracture direction. This scenario produces a slightly better match with the observed potentiometric surface; however, the effects are minimal. This suggests that, at least in the Otero-Diablo region, anisotropy is not nearly as important as fracture density in controlling regional ground-water flow in fractured aquifers.

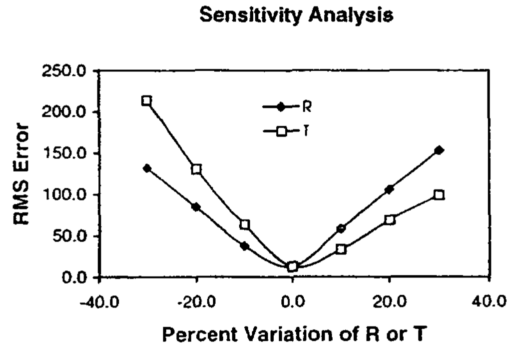

Figure 20. Graph of sensitivity of model to changes in recharge (R) and transmissivity (T). R and T varied in increments of 10% from −30% to +30%, while other model parameters held constant. Error is measured as root mean square (RMS). On a percentage change basis, the model is more sensitive to changes in recharge. However, because the range of variation of transmissivity of geologic materials is much greater than the range of variation of recharge, transmissivity is probably the most critical parameter.

much wider range than recharge; therefore, transmissivity is probably the most important model parameter. Note that we do not evaluate the effects of changing transmissivity domain boundaries, or changing relative transmissivity values between domains. The RMS error could probably be reduced slightly by such an approach.

Integration of Water-Chemistry Results

Numerical flow model results are consistent with a high-transmissivity zone along the Otero Break, extending from the Sacramento Mountains to the Dell City area. This highly fractured zone acts as a drain to the flow system and links the area of most intense recharge (Sacramento Mountains) to the natural discharge areas (Salt Basin playas). This is corroborated by the water-chemistry data including salinity trends, which likewise suggest a conduit along the Otero Break. The low-salinity plume delineated in Figure 10 follows the highly fractured Otero Break. Low salinities extend from the Sacramento Mountains along the length of the Otero Break to Dell City and the Salt Basin. This is consistent with the funneling of relatively fresh Sacramento Mountains recharge along faults and fractures of the Otero Break, ultimately to Dell City and the Salt Basin—a distance of 80 km. Mixing trends also support the existence of high transmissivities along the Otero Break. For example, some Dell City area waters appear to be mixtures of Otero Break and Otero Mesa waters, and in some cases are more similar to distant Otero Break waters than to nearby Diablo Plateau waters (Mayer, 1995, p. 72–75).

DISCUSSION

This study uses readily available geologic data to constrain spatially distributed, two-dimensional transmissivities in a regional carbonate aquifer. Results indicate that a priori analysis of regional fracture systems can significantly improve models of regional ground-water flow, especially in aquifers where fractures are not uniformly distributed. This is significant because geologic controls in regional flow models are normally considered post priori when needed to calibrate the model. Although fracture data are commonly used in reservoir-scale flow characterization, they are rarely used in regional-scale problems.

To incorporate fracture data into regional flow models, we used a finite-element flow model that estimated transmissivity as a function of fracture properties. Transmissivity domains were defined a priori by fracture-density and fracture-orientation trends. Fracture properties were determined from field-checked air-photo analysis and geologic field mapping. The model was calibrated on a 9000 km^2 fractured carbonate aquifer system in northern Hudspeth County, Texas, and southern Otero County, New Mexico. Although fractures are used to estimate transmissivity, the model employs a porous medium approach to flow simulation.

Modeling supports the hypothesis that in the Otero-Diablo region, fractures are the primary factor controlling transmissivity and regional ground-water flow patterns. There is a high correlation between fracture density and modeled transmissivity. When model transmissivity is based upon fracture density, superior simulations result. Preferred flow paths along fractured, high-transmissivity trends also affect ground-water chemistry. In the Otero-Diablo region, this is manifest as a 80 km "plume" of relatively fresh water extending from recharge areas in the Sacramento Mountains to discharge areas in the Salt Basin and the Dell City irrigation district. This prominent zone of distinct water influences regional water chemistry by delivering relatively fresh water to discharge areas and by providing a "drain" along which adjacent waters converge and mix.

Fractures also determine major aspects of regional flow-system geometry. In the Otero-Diablo region, the heavily fractured Otero Break connects the area of most intense recharge (the Sacramento Mountains) to the natural discharge point of the system (Salt Basin playas). We infer that fracturing has created a large-scale conduit that channels Sacramento Mountains recharge to the southeast along a narrow zone where it eventually emerges in the Salt Basin. Were it not for the fractures of the Otero Break, discharge might be more diffuse (spread over larger areas of the Salt Basin), farther north in the Salt Basin, or even directed to the Tularosa basin, which is closer to areas of concentrated recharge.

The Dell City irrigation district, although 80 km from the Sacramento Mountains, receives a large portion of Sacramento Mountains recharge. If there were no fracture zone linking these areas, Dell City ground water would probably be derived from more brackish, less abundant local sources. In the Otero-Diablo region, hydrologic data are sparse, but geologic data can be used to prepare superior numerical models of this complex system.

CONCLUSIONS

This study demonstrates through several lines of evidence a particular example of fracture-controlled regional ground-water flow. Important points are (1) a priori analysis of regional fracture systems can significantly improve models of regional ground-water flow; (2) fracturing is in some cases the major factor controlling regional transmissivity variations, and thus regional ground-water flow; (3) fracturing can define the overall geometry of regional flow systems by creating large-scale flow conduits that strongly influence the locations of discharge areas; and (4) fracturing can strongly influence regional ground-water chemistry variations. Although fracture data are commonly used in flow calculations at the single-well or reservoir scale, fracture data have been underutilized at the regional scale. This study highlights how the timing and nature of tectonic events may play important roles in subsurface fluid flow, including processes such as diagenesis, hydrothermal mineralization, and petroleum migration.

Further studies of the Otero-Diablo region should include analyses of hydrogen and oxygen stable isotopes, tritium, and ^{14}C. An important question in arid-climate ground-water systems in general, and in the Otero-Diablo region in particular, is how much of the water is recent recharge and how much was recharged during wetter times in the Pleistocene. Because the ground water commonly is a mixture of waters of varying ages, it is difficult to estimate a reliable age. However, by combining isotopic analyses it may be possible to eliminate much of the uncertainty involved with any single method. Ground-water age is fundamentally important for ground-water resource evaluation because if a significant portion of the ground water in the system was recharged in Pleistocene time, under present climate conditions this ground water may be a less-renewable resource, and steady-state models of flow and transport may not be appropriate.

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Appendix C.

Selected Parts of the Regional and State Water Plans

Introduction

Water is the common denominator of New Mexico's future and the indispensable element of quality of life for the state's residents. New Mexico must take control of this vital resource at a time when nature is pinching supplies through a drought, and man-made issues – from endangered species matters to interstate water conflicts – are further threatening or squeezing those already dwindling supplies.

This State Water Plan, prepared at the direction of Governor Bill Richardson in response to a mandate from the 2003 Legislature, is a blueprint to move the State forward into the 21st century with 21st century techniques and technology applied to conserve and to increase the supply of water.

Under the leadership of the State Engineer, who is also Secretary to the Interstate Stream Commission (ISC) and Chairman of the Water Trust Board, a draft plan was presented to the public in a joint meeting of the ISC and Water Trust Board on October 22, 2003 in Santa Fe. After review of that draft document by the public, other State agencies, Tribal governments, other interested stakeholders, and the Governor's Blue Ribbon Task Force on Water, the lead collaborators revised the draft.

This 2003 State Water Plan is therefore the outcome of months of intensive work by the three named agencies, with input from a broad spectrum of New Mexico's citizens and institutions, to develop a vision for strategic management of New Mexico's water resources in the future, in keeping with Section B of the State Water Plan Act. Section B directs that:

The State Water Plan shall be a strategic management tool for the purposes of:

(1) promoting stewardship of the State's water resources;

(2) protecting and maintaining water rights and their priority status;

(3) protecting the diverse customs, culture, environment and economic stability of the State;

(4) protecting both the water supply and water quality;

(5) promoting cooperative strategies, based on concern for meeting the basic needs of all New Mexicans;

(6) meeting the State's interstate compact obligations;

(7) providing a basis for prioritizing infrastructure investment; and

(8) providing statewide continuity of policy and management relative to our water resources.

The State must move aggressively to accomplish these goals. To supply water to grow the New Mexico economy while meeting existing needs, the State must move to expand supplies through desalination, efficiency improvements, and recycling. This State must become a world center in research, development and application of technologies to reclaim and recycle water, both ground water and surface water.

This generation must build a State with rich opportunities for the generations yet to come. As New Mexico moves aggressively forward to build a 21st century economy, the State must move aggressively to put in place the legal and physical structures to provide the water to serve this progress. Growth in population and in industry must be managed for the State's general welfare.

The New Mexico Constitution protects the users of water, with the most senior being first in line. For the 21st century, the State must develop water market and water banking mechanisms that will facilitate the voluntary movement of water from old uses to new, with the marketplace supplying the appropriate rewards and the State providing the necessary safeguards.

The water rights of Indian Pueblos and Tribes will be protected, as will the water rights of members of acequias – community irrigation ditch systems – which rights generally predate the Treaty of Guadalupe Hidalgo which brought American sovereignty to what is now New Mexico. Nothing in the State Water Plan will impair or limit the claims that these senior water rights holders assert.

The role of agriculture in New Mexico's future is recognized, and the water necessary to serve that role must be supplied.

The imperative of securing sufficient water to serve the needs of New Mexico's dynamic urban and industrial areas must remain an objective of water planning. The obligation to restore the ecological balance of our surface watercourses must be recognized and met in the implementation of State water policy. Water quality issues must have equal standing with water quantity issues.

The State will plan and prioritize major water infrastructure improvements to get supplies to where they will serve the greatest good in facilitating economic development and in serving existing and future populations.

The State Engineer will initiate an active management program to assert and maintain administrative authority over the allocation of water. Adjudication of water rights in all basins will be expedited.

New Mexico must establish the physical and legal tools to protect the State's water supplies and maintain administrative authority over the State's water resources. Threats to the State's administrative authority over its water may arise from failure to comply with Interstate Compacts, from failure to protect senior rights, or from failure to provide means for the federal government to meet its Endangered Species Act obligations within the framework of State water law. Cooperation and collaboration in meeting endangered species requirements will be a priority, but the State will go to court where necessary to protect the State's administrative authority over its water.

The State Water Plan will lay the foundation and provide guidance for the State's effort to maintain administrative authority over its water resources. It will be a living document, gaining detail and new emphasis as new technologies and new water needs enter the picture. Its primary objective will always be to protect current water users while allowing continued development of the resource to meet the needs of the future.

The State Water Plan does not attempt to identify and resolve region-specific water management issues, because resolution of those issues must include local decision-makers. Still, the sheer number and variety of issues discussed within the State Water Plan demonstrate the complexity of New Mexico's water situation. What at first glance may appear to be a single issue often reveals a web of interrelated matters, which are in turn part of or affected by other issues.

Without an understanding of the complexity of New Mexico's water situation, developing strong, clear policy statements and implementation strategies for statewide common priorities can be difficult. This State Water Plan articulates the policies that will guide the State's management of its water resources into the future, and presents implementation strategies for doing so.

This 2003 State Water Plan is organized following the provisions contained in Sections C through F of the Act. Each Section includes policy statements and implementation strategies, followed by a brief background discussion and a summary of public opinion expressed during the public involvement process.

Specifics and detail on how the State intends to accomplish these aims is contained in the pages that follow.

- *Completing water rights adjudications.*

The following subsections provide a brief background on each of these fundamental common priorities.

Ensuring that water is available for the continued and future economic vitality of the State

The availability of water has always been and will continue to be inextricably linked to the economic vitality of New Mexico's diverse communities. Early in the State's history, water primarily supported local, subsistence-based economies including hunting and gathering societies as well as subsistence-based agriculture and extractive industries where communal production or barter for the products was the norm. Today, its role has evolved to supporting activities which allow our participation in a global economy characterized by diverse endeavors that span that entire spectrum of economic activity. Our citizens still hunt and gather nature's abundance; they still engage in subsistence agriculture, as well as large-scale commercial agriculture for local, regional and global markets; they produce all manner of products and services; they depend on water to support recreational economies such as fishing, boating, golfing, rafting, skiing and tourism; they play an important role in contributing to the national security of the United States; and they produce high technology products which are used worldwide. All of these activities are directly dependent on the availability of sufficient water of the quality needed for the specific uses.

In addition to being diverse, the State's economy is highly decentralized. People throughout the State contribute to the overall economic picture, with people in rural areas producing agricultural, mineral and other naturally occurring products, and those in urban areas providing goods and services as well as industrial and technological products. The continued viability of the diverse entities that supply water for these economic activities is of vital importance to the State. These include municipal suppliers; community water systems including mutual domestic water consumer associations, water cooperative associations, water and sanitation districts, and privately owned public utilities; acequias; irrigation districts; and conservancy districts.

New Mexico's continued economic vitality is also crucially dependent on its ability to preserve its pristine environment, including its spectacularly scenic wild rivers and wilderness watersheds. Both employers and workers are drawn to live and remain in the State by these environmental features and a comprehensive State Water Plan must recognize the importance of preserving and enhancing New Mexico's rivers and watersheds.

Ensuring a safe and adequate drinking water supply for all New Mexicans

The availability of safe and adequate drinking water supplies for all New Mexicans is of paramount importance to the health and safety of the State's citizens. The provision of adequate safe drinking water supplies for their citizens is primarily the responsibility of local agencies and entities, while the State's role is to support local agencies through the combined efforts of the Environment Department, OSE/ISC, and the Water Trust Board. In addition, a significant number of New Mexicans obtain their drinking water from domestic wells. The State needs to strengthen the institutional protections it provides for these users.

Developing water resources to expand the available supply

New Mexico's surface waters in many parts of the State have been fully appropriated since the early to middle 1900s. Most of the municipal and community water supplies developed since then have relied on the State's substantial potable ground water reserves. However, much of that ground water is in storage in aquifers that are hydrologically connected to the State's rivers and is not available for use because the pumping of that ground water would reduce river flows and impair senior surface rights. Therefore, development of these ground water resources has required the identification, purchase and retirement of surface rights. Continued development of potable water supplies will necessitate further development of both surface and ground water resources. Some alternatives that have been identified include:

- Developing the State's limited remaining unappropriated surface water in those basins where it is practical to do so.

- Developing potable ground water in basins where ground water is not closely connected to river flow.

- Characterizing the State's brackish and saline ground water resources to determine where their development is economically feasible.

- Removing accumulated sediment to increase storage capacity in reservoirs with low evaporation losses.

- Constructing new water storage facilities in areas with low evaporation losses where economically and environmentally feasible.

- Implementing Aquifer Storage and Recovery projects where hydrologically and economically feasible

In some areas of the state surface water is potentially available for appropriation but both the timing of the availability of that water and the need to protect senior rights makes development of these resources difficult. In other areas potable ground water occurs in basins that are not hydrologically connected to a stream system, but these resources are often far removed from areas of potential use and would require expensive pipelines to deliver the water.

Large areas of brackish or saline ground water exist that may provide water to meet some New Mexico demands. In these cases, water treatment plants, sludge disposal plants, and pipelines would likely be needed to make the water available for use. Detailed variation and longevity for specific water purveyors. To plan for a dependable water supply, smaller-scale local analyses are required that take into consideration localized aquifer properties and infrastructure constraints specific to each water purveyor.

Water Quality

The New Mexico Environment Department (NMED) maintains a number of sources of water quality data for both ground and surface water. The U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS) also maintain long-term databases of water quality measurements. Pursuant to Section 305(b) of the federal Clean Water Act, New Mexico, through the NMED and the Water Quality Control Commission, prepares and submits to Congress biennial Water Quality and Pollution Control in New Mexico reports that summarize where designated uses of water are being attained and provide a comprehensive overview of the quality of the State's waters.

According to the latest report, almost 3,080 miles, or 52% of New Mexico's more than 5,875 perennial stream miles, have some level of impairment with respect to designated or attainable uses, and 124,140 out of a total of 148,883 lake acres, or 83%, do not fully support designated uses. Information provided in the report regarding ground water quality indicated that at least 1,200 cases of ground water contamination have been identified in New Mexico since 1927, with 188 public and nearly 2,000 private water supply wells impacted.

The quality of the State's ground water resources has been inventoried in the New Mexico Environment Department's *Ground Water Quality Atlas*, available online at http://www.nmenv.state.nm.us/gwb/GWQ%20Atlas/GWQ_Atlas.html. Ground water quality data in the atlas is listed by county and, where available, by public water supply system within the county. Public drinking water quality reports are already available online in the atlas for 23 municipal and public water supply systems in New Mexico's 33 counties.

About 90 percent of New Mexico's population depends on ground water for drinking, and it is the only source of potable water in many areas of the state. Therefore, protection of ground water is important for public health and welfare. The quality of ground water in New Mexico varies widely. Mountain aquifers, recharged by recent rain and snow melt, often yield high quality water. A tremendous amount of fresh water occurs in the basin-fill aquifers along the Rio Grande, stretching from Colorado to Texas. But ground water in New Mexico often contains naturally occurring minerals that dissolve from the soil and rock that it has flowed through. Some ground water in the southern part of the state is too salty to be used for drinking. High levels of natural uranium, fluoride, and arsenic occur in various areas around the state. Because all water eventually moves through the entire water cycle, pollutants in the air, on land, or in surface water can reach any other part of the cycle, including ground water. The shallow sand-and-gravel aquifers of the river valleys are most vulnerable to contamination. Currently a major source of contamination in these aquifers is septic tanks.

imposed by State administrative constraints to protect existing rights and economic limitations on its recovery and/or treatment.

Table 6. Total ground water in storage and estimated recoverable ground water, by water quality category, for Tularosa basin

Aquifer Category	Water in Storage (ac/ft) by TDS Concentration (mg/L) Range				
	<1,000	1,000-5,000	5,000-10,000	≥10,000	Total
Basin fill, total	32,500,000	232,000,000	238,000,000	26,800,000	529,300,000
Bedrock, total	19,100,000	56,300,000	161,000	0	75,561,000
Basin fill, recoverable	8,120,000	48,000,000	43,700,000	4,700,000	104,520,000
Bedrock, recoverable	9,570,000	28,200,000	81,000	0	37,851,000

The total ground water withdrawn in the Tularosa basin in 1995 was an estimated 47,140 ac-ft. Public water supplies are obtained from both surface water and ground water, while irrigation tends to rely primarily on ground water supplies. Of the surface water withdrawn for public supplies, some is imported from Bonito Lake, in the Rio Hondo watershed of the Lower Pecos basin. Water piped from Bonito Lake provides water to the communities of Nogal, Carrizozo, Alamogordo and Holloman Air Force Base. Combined, these users have rights to a little more than 3,000 ac-ft/yr from Bonito Lake in Lincoln County.

The City of Alamogordo has been very progressive in managing available water resources. An aquifer storage and recovery project is being developed to store the excess winter surface water in the aquifer by well injection and to pump it back during high summer demand. The costs are small (estimated at about $0.15 per ac-ft) because the injection will operate by gravity. Alamogordo has also filed water rights applications to extract saline water and is planning a desalination plant to remove dissolved minerals from ground water. Preliminary cost estimates for a desalination plant in Alamogordo, which could treat 8 million gallons per day, are $15 to $20 million.

Salt Basin

Major Issues

On September 13, 2000, the New Mexico State Engineer declared the Salt UWB to be under his administrative review (ISC/OSE, 2002, Atlas Plate 2). Until the basin was declared, water resource issues were not regulated or monitored. Development pressure within the New Mexico side of the basin has been very modest, less than in Texas. Major issues include:

- Little development of the Salt Basin has occurred in New Mexico, but pressure to develop this resource is growing. Ground water depletions must be managed to prevent mining of the basin's aquifers.

- The Salt basin is being considered by some entities as a water source to augment supplies in southwest Texas. Steps must be taken to ensure that water from the basin is preserved to meet growing demands in southern New Mexico.

Surface Water Hydrology

The Sacramento River, Shiloh Draw and Piñon Creek are the major streams in the Salt basin; all but the Sacramento River are intermittent. There are no surface water reservoirs, other than stock ponds, in the basin. The Sacramento River was gaged from 1985 to 1988, during which time annual flow ranged from about 1,800 to 5,500 ac-ft. Some water from the Sacramento River is diverted for irrigation.

Areal recharge from the Sacramento River and the smaller watersheds around the basin (a total of 358 square miles) is estimated at 35,000 ac-ft/yr.

Ground Water Hydrology

The Salt basin is a complex down-faulted basin, filled with unconsolidated and consolidated sediments. The thickness of Santa Fe Group basin-fill sediments has been reported to be as much as 500 feet, but in most places it is between 25 and 300 feet, and ground water saturation is much less. Bedrock limestone aquifers in the basin are productive where fractured and where solution of minerals has enhanced permeability.

The basin-fill aquifer provides water in the southern Crow Flats, while the bedrock aquifers comprise the main aquifer in the Crow Flats area and other parts of the basin. There are few wells and pumping tests to assess the ground water beneath much of the basin.

Well yields depend on location, depth, and the degree of fracturing in the bedrock aquifer. Reported yields in a few wells reach 6,000 gpm, and irrigation wells can generally produce more than 1,000 gpm. Where bedrock units are less fractured, well yields are generally less than 50 gpm.

Most of the stored and recoverable ground water is in bedrock aquifers (Table 7). The hydrology of the basin is poorly understood, and the estimates in Table 7 are provided for comparison purposes only. The estimates do not reflect legal and State administrative constraints on ground water pumping for protection of existing rights, nor the economic limits to accessing the ground water. Additionally, much of the total ground water is in aquifers that would not support well yields sufficient for economic irrigation. Thorough evaluation of the basin would require many new wells and pumping tests.

Depth to water in the central part of the Salt basin is usually around 200 feet, but is about 400 feet in upland areas surrounding the central basin and about 1,000 feet east of Piñon. Between 1950 and 1995, ground water declines of up to 30 feet have been recorded in the Crow Flats area.

Charlene Anderson
Edward Mosimann

308 Highway 170
Farmington, NM 87401
505-326-9139 phone

6/8/04

Ms. Florene Davidson
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505
Or fax to (505) 476-3462

Dear Ms. Davidson,

We are writing to support stricter rules for pits and drilling in Otero Mesa and the Chihauhuan Desert Area. Our primary hope is that there would be no drilling there at all, but second to that we must protect soil and groundwater from pit leakages. And we must require high standards of operation to protect this fragile area. We live in the San Juan Basin outside Farmington, New Mexico, and have seen the leakages from pits and gas well sites that could have been prevented.

If drilling does proceed, then we should apply the best technology available to prevent pollution (air, soil and water pollution). Protective measures could include banning pits, requiring closed loop drilling systems, prohibiting injection wells, prohibiting on-site disposal, and requiring emission controls; this will help balance between protection and development. The industry *can* afford to spend a little more on better practices. And if the rules are strict and apply to *everyone*, then it is fair business practices.

We need thorough rules to ensure that any future oil and gas development minimizes the size of the well pads, limits the number of roads and traffic to protect wildlife, and protects the solitary and pristine nature of Otero Mesa. We also need the highest standards of restoration of well sites (without industry employing the excuse "If it's a dry year we can't restore it." If areas cannot be restored, then they should not be drilled.

Sincerely,

Charlene Anderson and Edward Mosimann

June 8, 2004

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JUN 17 2004

OIL CONSERVATION DIVISION

Ms. Florene Davidson
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Re: Proposed Amendment to 19.15.1 NMAC

Dear Ms. Davidson,

Please accept this letter as my comments regarding the proposed amendment to 19.15.1 NMAC.

As a rancher in Northern Lea County, New Mexico since the early nineteen sixties, I have seen first hand the damage and destruction that the oil and gas industry has caused to our environment. Much of the damage and destruction that has been caused is the result of the prevalent use of oilfield pits, including pits associated with tank batteries, pipelines and drilling operations. In addition, countless acre feet of water has been contaminated through the use of disposal wells used to re-inject produced water.

I am in full support of the Governor's Executive Order No.2004-05, directing the Oil Conservation Division to adopt a moratorium prohibiting the use of pits and to propose regulations to implement produced water re-injection standards and controls. The oil and gas industry has the technology to allow it to conduct its operations without causing such widespread destruction of our natural resources. It would be unwise for the State of New Mexico not to demand this technology be implemented for the protection of the health and well being of the State and its citizens alike.

Thank you for the opportunity to submit comments on this very important issue. In addition, please be advised that I intend to introduce testimony regarding the matters set forth herein at the public hearing on proposed amendment 19.15.1 NMAC scheduled for June 17, 2004.

If you have any questions, please call me at (505) 398-6547.

Sincerely,

Carl L. Johnson

cc: Governor Bill Richardson

hinklelawfirm.com

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ATTORNEYS AT LAW
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WRITER:
Gregory J. Nibert
GNibert@hinklelawfirm.com

RECEIVED
JUN 14 2004
OIL CONSERVATION DIVISION

June 8, 2004

Mr. Mark E. Fesmire, P.E., Director
New Mexico Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, New Mexico 87505

Re: Comments on Otero Mesa
Proposed Rule Changes 19.15.1.21

Via fax: 505-476-3471

Dear Mr. Fesmire:

The New Mexico Oil Conservation Division (OCD) should continue its traditional rule making path by including the oil and gas industry in developing its rules and regulations. With respect to Rule 19.15.1.21, the OCD has taken the path of arbitrarily establishing a rule without industry involvement. In past rule makings such as the Pit Rule or H_2S Rule, industry representatives worked with the OCD staff and other governmental agencies to establish reasonable rules to address the agency's concern. Failure to include the oil and gas industry in this rule making sets a dangerous precedent and disregards the historical practices that have served the State of New Mexico well in the development of oil and gas within the state over the past 75 years.

Groundwater protection was referenced as the primary concern supporting the need for a new rule. Undisputed testimony during the hearing on the Pit Rule established there is no problem in New Mexico from pits utilized in drilling operations. Testimony for the Pit Rule was based upon a review of OCD files on specific examples of groundwater impact cases related to pits and below-grade tanks. Based upon that extensive review, there was no evidence that any pits from drilling or work over operations were associated with any groundwater contamination cases. The problems, if any, identified during the review appear to be related to very old unlined production pits, spills, and releases. In addition, there was no evidence in the files that contamination of groundwater was caused by an injection well failure or leak.

A recent National Petroleum Council study predicted an impending shortfall in the production of domestic oil and gas. Recent attention has been given to world wide shortfalls in production and declining reserves. New Mexico producers play a critical role in this nation's effort to maximize the production of domestic oil and gas. New Mexico producers have found and produced oil and gas in this state for over 80 years without any serious or lasting damage to the environment. The Otero Mesa rule is unreasonable and is not necessary to provide protection of the environment. In reality the proposed rule is to "deny access" to development of oil and gas resources.

The following comments address specific sections of the Otero Mesa rule:

1. The rule name should be changed from "SPECIAL PROVISIONS FOR THE CHIHUAHUAN DESERT AREA" to "SPECIAL PROVISIONS FOR OTERO AND SIERRA COUNTIES". [19.15.1.21,Section A]

   The rule applies to special areas of Otero and Sierra counties and not the entire Chihuahuan desert.

2. Pits are allowed in Otero Mesa under the current pit rule [19.15.1.21, Section B]

   The current Pit Rule provides adequate measures to protect ground water and surface water and there is no need to ban pits on Otero Mesa.

   Drilling on Otero Mesa will typically be done with either air or fresh water based muds. Air drilling cannot be done with closed loop systems because of the danger associated with venting gases and solids into a closed chamber. Water based drilling mud is benign and the cuttings are not toxic. Both drilling practices are prevalent in other areas of the state, even in sensitive areas. There are benefits to the use of pits over closed loop drilling. First, the extra volume of water inherent in earthen pits is essential for well control to prevent blow outs. Second, truck traffic is minimized by the use of pits over closed loop systems since the solids and cuttings are benign and will be buried in place and versus having to be hauled off for disposal. A recent BLM Resource Management Plan concluded that 45,000 wells have been drilled in the Southeastern New Mexico with no evidence, in the OCD records, of contamination of surface or ground water from temporary drilling and work over pits. Following completion or plugging and abandonment of the well, the pits are restored and over the years, the disturbed area eventually returns to its native state. There is no valid reason or justification to prohibit the use of pits in the Otero Mesa area.

3. Injection wells permits should not deviate from the current, federally approved, practice of Notice and an Administrative Application where there is no valid complaint or objection. [19.15.1.21, Section C.1]

The requirement for additional notice and hearing on all injection well permits adds a burden to industry and the OCD with no tangible benefit. A hearing is provided under current rules upon an objection or protest.

4. Ground water resource data is the pervue of the State Engineer. [19.15.1.21, Section C.3.]

   It is not possible to log and identify fresh ground water using conventional drilling methods for oil and gas. Only wells that are drilled specifically for ground water are capable of providing this information. This section should be removed. Oil and gas companies may be willing to provide electric logs, if run, in the well bore.

5. The three degrees of protection provided by current UIC rules (i.e., dual casing consisting of surface casing cemented to surface and intermediate casing cemented at base, injection tubing, and a packer) provide sufficient protection to ground water without an additional cement. [19.15.1.21, Section C.4.]

   There is no justification for requiring an additional string of cemented casing beyond the protection that is already provided by current UIC requirements. To our knowledge, no ground water contamination has resulted in New Mexico from a properly installed and maintained injection well.

6. The existing casing rules are adequate. [19.15.1.21, Section C.5.]

   There is no evidence to justify altering current practices of the cementing and casing requirements. Present industry practices have demonstrated the adequacy of the cementing process in protecting ground water as evidenced by the OCD's records.

7. Current industry practices of installing single walled produced water flow lines is adequate and allow prompt discovery and remediation in the event of a puncture or cut. [19.15.1.21, Section C.6.]

   Flow line failures are relatively rare, accounting for less than 1% of all releases. They are usually discovered in a short time. Unusual events should not drive a new rule. Where such failures have occurred, a single walled pipe is better, as the failure can be discovered and remedied promptly. A double walled pipe would only compound our ability to timely discover a failure and locate the source of the leak to repair the pipe. It is industry practice to inspect all flow lines regularly for leaks. We are not sure double walled tubing made for use in the oil field.

8. The criteria for tank containment should be "sufficient engineering design to prevent releases from reaching surface and ground water." [19.15.1.21, Section C.7.]

There is no justification for a stipulation that the base of tank containment be impermeable and the berm walls be lined. The intent of water protection regulations is to assure that any spills are contained and prevented from reaching surface or ground water in the time frame that it takes to discover and remove the potential contaminate. Industry experience is that the base and walls of tank containment zones need not be absolutely "impermeable" as the term implies but "sufficiently impermeable" to prevent reaching ground and surface water within a reasonable time that one would discover and remedy the spill. In areas where ground and/or surface water are proximate to tank containment facilities, then synthetic liners and other means of protection are commonly employed. The EPA in SPCC rules; that "the proper method of secondary containment is a matter of good engineering practice, so we do not prescribe here any particular method." The "the appropriate method of secondary containment is an engineering question. Earthen or natural structures may be acceptable if they contain and prevent discharges as described in 112.1(b), including containment that prevents discharge of oil to groundwater that is connected to navigable water."

9. The existing criteria for record keeping and Mechanical Integrity Testing UIC rules is sufficient and there is no justification to require additional record keeping or testing [19.15.1.21, Section C.8. and C.9]

The excellent record of protecting ground water under the existing UIC program proves the adequacy of the current Mechanical Integrity Testing and record keeping requirements.

Very truly yours,

HINKLE, HENSLEY, SHANOR & MARTIN, L.L.P.

Gregory J. Nibert

GJN/jw

INDEPENDENT PETROLEUM
ASSOCIATION OF NEW MEXICO

June 8, 2004

To: William Olson
From: Dan Girand
Re: IPANM Comments on Otero Mesa Rules

Comments on Otero Mesa

OCD Proposed Rule Change

Rule 19.15.1.21

The New Mexico Oil Conservation Division ("OCD") should not depart from its traditional rulemaking path by not including the oil and gas industry in developing this rule. Instead, the OCD has taken the path of arbitrarily establishing a rule without industry involvement.

In past rulemaking, the Pit Rule or H_2S Rule, industry representatives have worked with the OCD staff and other governmental agencies to establish reasonable rules to address the issues of concern. We are extremely disappointed that OCD denied industry the opportunity for being involved in this rulemaking process.

Before any rulemaking, there should be an objective, scientifically supportable need established, and then the rulemaking process should focus on addressing that need. No such need has been presented for Otero Mesa.

Groundwater protection was referenced as the primary concern supporting the need for a new rule. Undisputed testimony during the hearing on the Pit Rule established there is no problem in New Mexico from drilling pits. Testimony was based upon a review of OCD files on specific examples of groundwater impact cases related to pit and below-grade tanks to see if any problems really exist. Based upon that extensive review, there was no evidence that any pits from drilling or workovers were associated with any groundwater cases on file.

The problems, if any, identified during a review appear to be related to historic, unlined production pits, spills, and releases. There was no evidence in the files that contamination of groundwater was caused by failure of injection wells. Therefore, what is the need or validity for the various requirements proposed in the Otero mesa rule?

The National Petroleum Council study predicted an impending shortfall in the production of domestic oil and gas. New Mexico producers play a critical role in this nation's effort to maximize the production of domestic oil and gas. New Mexico producers have found and produced oil and gas in this state for over 80 years without any serious or lasting damage to the environment. That rule goes beyond what is reasonable and prudent for protection of the environment. In reality the proposed rule is "denying access" to development of oil and gas resources.

The following comments address the specific section of the Otero Mesa rule:

1) The rule name should be changed from "SPECIAL PROVISIONS FOR THE CHIHUAHUAN DESERT AREA" to "SPECIAL PROVISIONS FOR OTERO AND SIERRA COUNTIES". [19.15.1.21,Section A]

The rule applies to special areas of Otero and Sierra counties and not the entire Chihuahuan desert. It is more appropriate to title the rule appropriately as applying to special areas of Otero and Sierra counties.

2) Pits must be allowed in Otero Mesa under the current pit rule [19.15.1.21, Section B]

There will be no measurable or meaningful improvement in ground water or surface water protection as a result of banning pits in Otero Mesa. New Mexico has had adequate pit rules since the late 1960s.

Drilling in Otero Mesa will typically be done with either air or fresh water based muds. Air drilling cannot be done with closed loop systems because of the danger associated with venting gases and solids into a closed chamber. Water based drilling mud is benign and the cuttings are not considered toxic. Both drilling practices are prevalent in other areas of the state, even in sensitive areas where temporary earthen pits are allowed under current state rules.

There are benefits to the use of pits over closed loop drilling. The extra volume of water inherent in earthen pits is essential to well control when water is required to kill the well. Secondly, truck traffic is minimized for the use of pits over closed loop systems since the solids and cuttings are benign and can be buried in place and versus having to be hauled off for disposal.

A recent BLM RMP found that some 45,000 wells have been drilled in just the southeast part of the state with no evidence, in the OCD records, of contamination of surface or ground water from temporary drilling and workover pits. These pits are restored to near native conditions and over years, the disturbed area eventually returns to its native state. There is no valid reason or justification to prohibit the use of pits in the Otero Mesa area.

3) Injection wells permits should not deviate from the current, federally approved, practice of Notice and an Administrative Application where there is no valid complaint or objection. [19.15.1.21, Section C.1]

The proposed requirement to mandate additional notice and hearing for all injection well permits is unnecessary and adds a burden to industry and the OCD with no benefit. A hearing is provided for under current rules, if there is a valid objection or protest.

4) The current UIC requirements for an Area of Review of ¼ mile or the value derived by the EPA formula for determining the zone of endangering influence sufficiently protects nearby wells. [19.15.1.21 Section C.2.]

There is no legitimate justification to extend the current Area of Review beyond that defined under current federal UIC regulations. There is no evidence of nearby water wells being impacted by a properly installed injection well that has followed the current UIC criteria for Area of Review. More regulation is not necess better.

5) Ground water resource data is the purview of the State Engineer and industry should not and OCD should not do its job. [19.15.1.21, Section C.3.]

It is not possible to log and identify fresh ground water using conventional drilling methods for oil and gas. Only wells that are drilled specifically for ground water are capable of providing the information this section is requiring. OCC should remove it from the Otero Mesa rule. Industry is willing to provide electric logs that are done as a normal part of logging the well bore, but this will not necessarily identify if a water zone is fresh.

6) The three degrees of protection provided by current UIC rules (i.e., dual casing consisting of surface casing cemented to surface and intermediate casing cemented at base, injection tubing, and a packer) provide sufficient protection to usable ground water without an additional cemented casing. [19.15.1.21, Section C.4.]

There is no justification for requiring an additional string of cemented casing beyond the protection that is already provided by current UIC requirements.

To our knowledge, there is no evidence of any ground water contamination that has resulted in the state from a properly installed and maintained injection well. There is no justification for this requirement, which unnecessarily adds complexity and cost.

7) The existing cemented casing practices are adequate and there is no need to add additional protection. [19.15.1.21, Section C.5.]

There is no evidence to justify altering current practices of cementing casing. Present industry practices have demonstrated the adequacy of the cementing process in protecting ground water zones as evidenced by the review of OCD records.

8) Current industry practices of installing single walled, produced water flow lines is adequate to prevent spills and releases. or if spill or release occurs, to discover and remediate the spill in a timely manner. [19.15.1.21, Section C.6.]

Flow line failures are relatively rare, accounting for less than one percent of all releases. They are usually discovered in a short time. The atypical examples should not drive a new rule.

Where such failures have occurred, a single walled pipe is better, as the failure can be discovered and remedied promptly. A double walled pipe would only compound our ability to discover a failure and repair the pipe.

It is industry practice to inspect all flow lines periodically for leaks. The extremely minimal release frequency of flow lines does not require double walled tubing. We are not sure this type of tubing is made to work in the oil field.

9) The criteria for tank containment should be "sufficient engineering design to prevent releases from reaching surface and ground water." [19.15.1.21, Section C.7.]

There is no justification for stipulating that the base of tank containment be impermeable and the berm walls be lined.

The intent of water protection regulations is to assure that any spills are contained and prevented from reaching surface or ground water in the time frame that it takes to discover and remove such spills. Industry experience is that the base and walls of tank containment zones need not be absolutely "impermeable" as the term implies but "sufficiently impermeable" to prevent reaching ground and surface water.

In areas where ground and/or surface water are proximate to tank containment facilities, then synthetic liners and other means of protection are commonly employed.

The US EPA in SPCC rules that "the proper method of secondary containment is a matter of good engineering practice, so we do not prescribe here any particular method." "The appropriate method of secondary containment is an engineering question. Earthen or natural structures may be acceptable if they contain and prevent discharges as described in 112.1(b), including containment that prevents discharge of oil to groundwater that is connected to navigable water."

10) The existing criteria for record keeping and Mechanical Integrity Testing UIC rules is sufficient and there is no justification to require additional record keeping or testing [19.15.1.21, Section C.8. and C.9]

The excellent industry history of protecting ground water under the existing UIC program has shown the adequacy of the current Mechanical Integrity Testing and record keeping requirements.

HOLLAND & HART LLP

William F. Carr
wcarr@hollandhart.com

June 8, 2004

VIA HAND DELIVERY

RECEIVED

JUN - 8 2004

Oil Conservation Division
1220 S. St. Francis Drive
Santa Fe, NM 87505

Mark E. Fesmire, P. E.
Director
Oil Conservation Division
New Mexico Department of Energy,
Minerals and Natural Resources
1220 South Saint Francis Drive
Santa Fe, New Mexico 87505

Re: Proposed Rule 19.15.1.21 (Otero Mesa)

Dear Mr. Fesmire:

Enclosed for your consideration are the comments of Marbob Energy Corporation on the proposed rules for Otero Mesa. Your consideration of these comments is appreciated.

Very truly yours,

William F. Carr
Holland & Hart LLP
Attorneys for Marbob Energy Corporation

Enclosures

cc: Gail MacQuesten, Esq., Oil Conservation Division
Carol Leach, Esq., Department of Energy, Minerals and Natural Resources
Raye Miller, Marbob Energy Corporation
Brian Collins, Marbob Energy Corporation

marbob
energy corporation

June 1, 2004

Oil Conservation Commission
1220 South Saint Francis Drive
Santa Fe, New Mexico 87504

RE: Proposed Rule 19.15.1.21

Commissioners:

While technical comments have been provided by our company, I feel it is also important that you analyze some of the practical aspects of your proposed rule making.

By not allowing pits you put an operator in a position of removing the drill cuttings to a disposal site. The greatest disturbance related to a drilling operation is the dust generated by truck traffic into and out of a location. The requirement of no pits adds to that same problem. Local ranchers would prefer to minimize traffic at these locations and the proper use of drilling pits does that. The principal ingredient in a drill pit is rocks (drill cuttings), the next largest component is cement (excess cement from casing cement jobs is placed in pits), and lastly is mud. Burying this material on location is not only most practical but also most environmentally sound. It reduces pollution and reduces risk to public safety. Please consider the environmental downsides to your proposed new pit rule.

By increasing the regulations on produced water disposal wells and lines you in effect provide industry with the economic incentive to transport disposal waters by truck to out-of-state facilities. This action results in increased traffic, dust pollution, more road maintenance (county, state, and private), and more public risks due to trucks on the roads. Deep downhole disposal wells near or adjacent to producing fields provide for the safest, most environmentally sound disposal that can be done. Current rules and reviews provide excellent protection for ground water and the environment and the commission should reject these rules that try and pose a road block to the best environmental solution. The commission should ask the Governor to consider legislation which

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would provide tax benefits for undertaking deep onsite disposal of produced waters to encourage industry to use that practice.

Other items, while not a part of your rule making, should possibly be considered by you because of their negative environmental impacts. The restriction on drilling water wells for use for drilling is bad environmental policy. If wells are drilled near drilling operations they provide information regarding shallow ground water, they reduce the tremendous truck traffic involved in hauling in drilling fluids which thereby reduces the dust pollution. These source wells can later be used by the state or local ranchers for information or economic benefit. The largest complaint by the Shaffer family over the recent wells drilled in Southern Otero County (Crow Flats) was the truck traffic. It is the greatest source of pollution and public safety risk.

I ask you to do more analyzing to the rule-making you are considering because impediments to development as proposed here result in greater environmental loss and certainly economic loss to the citizens of this state. Ignore the emotionalism and sensationalism and work with the facts when making your decision.

Sincerely,

Raye Miller

Raye Miller
Land Department

RM/mm

marbob
energy corporation

3 June 2004

New Mexico Oil Conservation Commission
1220 South Saint Francis Drive
Santa Fe, New Mexico 87504

RE: COMMENTS ON PROPOSED NMOCD CODIFICATION OF OTERO MESA RULES
PROPOSED RULE 19.15.1.21

Dear Oil Conservation Commissioners:

Please see below my comments as a petroleum engineer on behalf of my employer, Marbob Energy Corporation, concerning the proposed rule 19.15.1.21 covering Otero Mesa oil and gas operations. The proposed rules are unnecessary because the current NMOCD rules adequately address fresh water aquifer protection and underground injection control. The proposed rules are confusing, don't make technical sense, don't add any protection to fresh water resources, and will have a significant negative impact on the economics of drilling and operating wells in the Otero Mesa area. It is disturbing that the NMOCD has reached the rule making stage without the participation of the oil industry affected by the proposed rules.

B. PITS

It is likely that most wells in the Otero Mesa area would be drilled with fresh water mud. How is there a pollution concern when using fresh water mud? Even if salt mud were used, pit lining will protect any fresh water aquifers.

There will be a significant increase in heavy truck traffic on dirt access roads and public highways because cuttings and raw mud will have to be hauled away during and after drilling operations. If we have to haul fresh water from outside the Otero Mesa area, there will be an enormous amount of truck traffic for this too. If weed washing is required for vehicles entering the basin, an enormous amount of water will be used when washing all these trucks.

Some limitations of closed loop systems follow.

a. Lost circulation. One can quickly lose the entire closed system pit volume if severe lost circulation is encountered, especially if one is not allowed to use a nearby fresh water source well. A conventional reserve pit buys time and fluid volume to get lost circulation material into

P.O. Box 227 • Artesia, New Mexico 88211-0227 • (505) 748-3303 • Fax (505) 746-2523

the mud and attempt to stop the lost circulation. This can be especially critical if a hydrocarbon-bearing zone is present because the loss of the limited volume of drilling fluid in the closed loop system will allow the hydrocarbon-bearing zone to flow into the well bore and result in a potentially serious well control situation.

b. Well control operations (handling an influx of oil and/or gas while drilling). Gas kicks tend to foam up the mud and cause closed loop systems to overflow. The expansion of the gas influx as it is circulated to surface can also cause a pit overflow in a closed loop system. If circulating an oil kick to surface, it is very dangerous to allow oil to be circulated into the steel pits of the closed loop system due to their proximity to the drilling rig if they catch on fire. It is safer to circulate oil to the reserve pit because it is further away from the rig in case of fire (oil can be skimmed out of the reserve pit after well control operations are finished). It is not uncommon to lose circulation during well control operations and this problem is made worse by the small volume of a closed loop system.

c. Water flows. If an artesian water flow is encountered, or large volumes of water are produced while air drilling, a closed loop system will be overwhelmed and will likely overflow.

d. Flowing back fracture treatments. Fracture treatments often utilize large volumes of water that must be flowed back as quickly as possible to minimize formation damage from too much exposure time to the frac fluid. Gas is present in the frac fluid that is flowed back and it presents a significant risk of explosion when flowed into a tank or steel pit. It is normal practice to flow back into the reserve pit and flare the gas produced during clean up operations for safety reasons. Also, frac sand flow back could cause the walls of the steel tank or pit to erode enough to cause a hole and subsequent fluid leakage onto the ground.

C (1) SWD:

Current rules allow the OCD to set SWD applications for hearing.

C (2) AOR/Radius of Endangering Influence (ROEI):

The Theiss formula referenced in 40 CFR Part 146 is set up for groundwater hydrologists to use and is not described in terms suitable for oilfield use. Regardless of format, a large amount of accurate input data will be required to yield anything close to an accurate ROEI. This data likely will not be available and will likely be difficult if not impossible to obtain.

The ROEI is defined as the lateral distance in which pressure in an injection zone may cause the migration of the injection or formation fluid into an underground source of drinking water. Current rules require us to keep injection confined into the injection zone or to model fracture dimensions if applying to inject above fracture pressure. In most cases the vertical distance between the injection zone and aquifer is so great that it is impossible to fracture into the aquifer. The ROEI definition refers to lateral distance, not vertical distance, which makes one think it was targeting injection into the same strata as the fresh water aquifer. Is this formula really applicable to oilfield water injection operations in which produced waters are injected into strata that are not fresh water aquifers?

C (3) Log/Test Vertical Extent of Aquifer:

How does one log or test for the presence and vertical extent of a fresh water aquifer when rotary drilling with fresh water?

How does one test for this data in an existing well? Are we expected to perforate the casing and compromise the casing integrity to gather this data? What if there are multiple casing strings across a suspected aquifer?

Would this data really be necessary on every well if multiple wells were drilled in the same area?

How could this data be gathered without jeopardizing the well if lost circulation problems or well bore stability problems (caving, sloughing, swelling) are occurring?

If this data is needed this badly, the OCD/State Engineer Office should pay the cost to gather this data (including liability for the well if the well bore is lost while trying to gather this data).

The drilling of fresh water source wells for drilling operations would be an excellent way to gather data on fresh water resources and water quality.

C (4) Casing/Cement:

In requiring two cemented casing strings across a fresh water aquifer, is it intended that we set concentric casings at the same depth? This doesn't make sense.

What about a well requiring only two strings of casing (surface and long string) to reach the desired geological target? There is a contradiction between (4)(a) and (4)(b) in this two string scenario. If a well is drilled for water disposal service, the long string cement only has to overlap 100' into the surface casing. If using an existing well, the long string has to be cemented to surface. Why the difference? Does this override the requirement to have two cemented casing strings across an aquifer?

Why does the long string on an existing well have to be cemented to surface while the long string on a well drilled for water disposal have to overlap cement 100' into the previous casing string, regardless of the number of strings run into a well?

What about a case in which terrible lost circulation is encountered in an aquifer and it is only possible to get adequate cement above and below, but not across, the lost circulation interval? This is a common occurrence.

The OCD needs to keep in mind that the observation/recording of pressure data and the periodic mechanical integrity testing as required in the existing rules works well for detecting potential problems before any potential injection into an aquifer could occur.

C (5) Cement Bond Logs (CBL):

Why run CBL's after cementing each casing string? Isn't circulating cement to the surface adequate evidence of cement placement? If cement is not circulated, why not run a temperature survey or calculate the top of cement from the net lift pressure achieved while cementing?

Whose and what type of bond log will be required? Is a basic CBL acceptable or will a more sophisticated cement evaluation log with its associated computer processing and interpretation be required?

Who will be the judge of adequate and competent cementing?

What happens if there is a section of log having questionable cement coverage/quality? Will the OCD condemn the entire well? Will the OCD require the operator to perforate the casing and attempt to "fix" the questionable portion of the cement and hurt the casing integrity in the process?

What happens when the bond log is misleading and the questionable cement is actually adequate cement not needing repair? Most operators are hesitant to attempt to fix a "poor" cement job identified by a bond log because in most cases experience has shown that the cement was OK and couldn't be "fixed". In the process they shot holes in the casing and needlessly compromised the casing integrity.

There are situations (severe lost circulation zones, zones with active water movement, cavernous zones, zones with well bore instability) where it can be difficult, if not impossible, to get a good cement job across the problem zone. Will the OCD exercise reason, common sense and flexibility when dealing with cementing under adverse geologic and operational situations?

C (6) Double Walled Pipe:

What is meant by double walled pipe? Double wall thickness? One pipe inside another (concentric)?

A thicker pipe wall only delays, not prevents, failure if active corrosion is occurring on bare steel pipe.

Concentric lines would be very expensive and difficult to install, especially when installing lines many miles long. It is quite possible that an inner line leak might not be detected until the outer line failed. If the inner line leaks it will be very difficult to pinpoint the exact location of the inner line leak with an outer line in place. Repairing leaks in the inner line will be very difficult. How do you "double wall" a water line at the intake and discharge points?

The OCD approach completely ignores current corrosion control technology for water lines, which is to prevent corrosion by placing a protective coating or lining between the steel and the water or to use a corrosion resistant material for the line itself.

Pipe made of polyethylene, PVC, fiberglass, other corrosion resistant material, or combinations of materials is commonly used to transport produced water. Steel pipe with internal coatings or linings made of polyethylene, polyolefin, PVC, cement, fiberglass, other corrosion resistant material, or combinations of materials is commonly used to transport produced water. This technology is in widespread use, is available, is relatively inexpensive and, most importantly, is far more effective at preventing leaks than "double walled" lines are.

C (7) Impermeable Barrier:

What is the definition of impermeable? What constitutes an impermeable barrier? Is the plastic sheeting used to line reserve pits considered an impermeable pad? If so, what minimum thickness is acceptable?

C (8) Data Recording:

Daily recording is overkill.

C (9) MIT:

An annual MIT is overkill, especially on a well injecting with measurable tubing pressure where the annulus is monitored and would show a pressure increase if there was a packer or tubing failure.

As stated in the beginning of this letter, the proposed rules for Otero Mesa are not needed. If governmental politics dictate the promulgation of additional rules for Otero Mesa, please solicit oil industry participation in the creation of these rules so that the final product makes technical sense, has clarity and is something that the industry can live with.

Sincerely,

Brian Collins, PE
Petroleum Engineer

Davidson, Florene

From: T. Greg Merrion [tgreg@merrion.bz]

Sent: Tuesday, June 08, 2004 4:32 PM

To: nmocd@state.nm.us

Subject: Chihuahuan Desert Rule Comments

Dear Secretary Prukop and Director Fesmire:

Merrion Oil & Gas feels strongly that the subject rule goes beyond what is reasonable and prudent for protection of the environment, and will result in preventing the development of much-needed oil and gas resources.

Please ensure that any final rule is based on sound science and a legitimate need.

Thank you for considering our comments.

Sincerely,

T. Greg Merrion
President, Merrion Oil & Gas

New Mexico Cattle Growers' Association
P.O. BOX 7517 • ALBUQUERQUE, NM 87194
TELEPHONE (505) 247-0584 • FAX (505) 842-1766
E-MAIL: nmcga@nmagriculture.org
WEB SITE: www.nmagriculture.org
Package only (no mail delivery): 2231 Rio Grande Blvd. NW, Albuquerque, NM 87104

June 8, 2004

New Mexico Oil Conservation Commission
Attention: Florene Davidson
1220 S. St. Francis Dr.
Santa Fe, New Mexico 87606

Fax: 505.476.3462

Email: fldavidson@state.nm.us

Re: APPLICATION OF THE NEW MEXICO OIL CONSERVATION DIVISION, THROUGH THE ENVIRONMENTAL BUREAU CHIEF, FOR ADOPTION OF AN AMENDMENT TO 19.15.1 NMAC ADDING NEW MATERIAL TO BE CODIFIED AT 19.15.1.21 NMAC. *Non-Technical Testimony from New Mexico Cattle Growers' Association*

Gentlemen:

Thank you for the opportunity to comment on the above referenced amendment. The New Mexico Cattle Growers' Association (NMCGA) has long been in favor of pit guidelines that conserve and protect the environment.

Excerpts from the proposed amendment states that the Division "*proposes rules to prohibit pits associated with any oil and gas drilling at Otero Mesa…to protect the groundwater resources of Otero Mesa and the public health and environment,*" and "*propose regulations to implement produced water re-injection standards and controls to assure full protection of the groundwater resources of Otero Mesa. The proposed rule imposes additional location, construction, operation and testing requirements on injection wells and related facilities used to dispose of produced water in the Chihuahuan desert area. These requirements strengthen existing rules to provide additional protection from surface contamination and groundwater contamination caused by leaks and spills.*"

NMCGA supports the proposed amendment, however, the Association wonders why are these proposed requirements limited to Otero Mesa? The justifications for the proposed amendment reinforce NMCGA's position that these requirements should be applied statewide for all oil and gas drilling in New Mexico.

Protecting **all** areas from the lasting damage caused from pit contamination and water re-injection needs to be a priority of the Oil Conservation Commission and the Oil Conservation Division of the state of New Mexico.

Thank you again, for the opportunity to comment.

Sincerely,

[signature]

Caren Cowan
Executive Director

MARTIN YATES, III
1912 - 1985
FRANK W. YATES
1936 - 1986

YATES PETROLEUM CORPORATION

105 SOUTH FOURTH STREET
ARTESIA, NEW MEXICO 88210-2118
TELEPHONE (505) 748-1471

S. P. YATES
CHAIRMAN OF THE BOARD
JOHN A. YATES
PRESIDENT
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EXECUTIVE VICE PRESIDENT
RANDY G. PATTERSON
SECRETARY
DENNIS G. KINSEY
TREASURER

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JUN 1 0 2004

OIL CONSERVATION DIVISION

June 8, 2004

VIA FACSIMILE 505-476-3462

New Mexico Oil Conservation Commission
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Attention: Director Mark Fesmire, PE

Re: Proposed Rule Otero & Sierra Counties
Proposed New Rule 21 (19.15.1.21 NMAC)

Gentlemen:

Yates Petroleum Corporation has reviewed the proposed rule and believes the proposed rule needs substantial consideration before finalization. While we acknowledge the extreme political pressure being applied to the Oil Conservation Division (OCD) and the Oil Conservation Commission (OCC) for a special rule, we believe both the OCD and the OCC have statutory duties to evaluate and develop rules that are directed at the conservation of oil and gas. We strongly urge the OCC to use its expertise and knowledge of oil and gas operations in evaluating all information and develop a rule, **if a rule is necessary**, that industry can understand and comply with in the development of the oil and gas resources of New Mexico.

Specific Comments

1) Rule title. The rule is titled "Special Provisions for the Chihuahua Desert Area." This is confusing because Chihuanuan Desert Area is not readily identifiable area on any maps commonly used by the industry or the general public. We are not aware of any other rule in the Oil Conservation Division rule book whose title refers to a generic nondescript area.

RECOMMENDATION: The rule should be titled Special Rules for Sierra and Otero Counties.

2) 19.15.1.21 B. Complete prohibition of pits as proposed by PR21 is not acceptable and Yates Petroleum Corporation objects to this provision of the rule. This is an area the Commission must use its expertise and knowledge of oil and gas operations to avoid the political pressure being applied and draft a rule that is workable and meets the statutory duties to prevent waste of oil and gas and protect the environment. Waste can occur through making the drilling requirements so strict that wells will not be drilled. Recently created Rule 19.15.2.50 NMAC is a comprehensive rule regarding pits for oil and gas wells and is creating great turmoil in the industry. We strongly question why the Commission feels its own newly created rule is inadequate to protect Sierra and Otero Counties. This provision appears to be an arbitrary decision based on political pressure. **RECOMMENDATION**: Remove this provision from the draft rule and rely on existing rules for the development of oil and gas.

3) 19.15.1.21 B. Complete prohibition of pits as proposed by this section creates potential safety hazards. Pits are an integral part of the drilling of an oil and gas wells in New Mexico because of the depths of the wells, the characteristics of the producing formation and necessary completion techniques of the wells. While we acknowledge that closed loop systems exist, they are not practicable for exploration and completion in New Mexico because they cannot be designed economically to accommodate the large volumes of drilling mud needed to drill and complete oil and gas wells. Control in the drilling of a well is provided by having the ability to use pumps to move drilling fluids from the pits quickly into the wellbore to maintain control. Use of steel tanks creates an unnecessary impediment to the ability to move large volumes of drilling fluids as required by the conditions encountered in the drilling operation. Likewise, in the completion phase of a well, the pit becomes a receptacle to flow large volumes of fluids in a controlled manner. Restricting the fluid flow back at completion stage may damage the reservoir and waste natural resources. **RECOMMENDATION**: Remove this provision from the rule.

4) 19.15.1.21 B. Complete prohibition of pits as proposed by this section is not environmentally friendly. Taking away the containment mechanism from drilling operations increases the chances of a spill because of the necessity to handle the drill cuttings and drilling fluids multiple times. Numerous handlings will occur when transfers are required to keep the steel tanks empty of the cuttings. Further, you are creating constant stream of traffic from the drill site increasing the chances of unintentional mishaps and air pollution through the dust. **RECOMMENDATION**: Remove this provision from the rule and allow pits under the current rules.

5) 19.15.1.21 C. The need for this provision is questionable at best because it does nothing to protect the environment and prevent the waste of oil and gas. On the other hand, it creates additional bureaucracy aimed at stopping exploration and development of oil and gas reserves in direct violation of the statutory mandate. Again the Commission needs to use its expertise to see through the emotional and political arguments and draft a rule that meets the mandates of preventing waste of oil and gas. **RECOMMENDATION**: Identify the particular perceived problem and how it is not addressed by 19.15.9.701 NMAC. Alternatively, remove this provision from the rule.

6) 19.15.1.21 C. (1). Currently, an injection well can be administratively handled through notice without the need for a hearing as provided by existing rule. Hearings are already available to address specific problems. They are not necessary when there is no objection. The requirement to have a hearing is needless bureaucracy and does nothing to prevent waste. **RECOMMENDATION**: The current OCD rules already address the issue of the need for a hearing. Refer to 19.15.9.701 NMAC and remove this provision.

7) 19.15.1.21 C. (2). This section does not appear to be relevant for the disposal of produced water. Current OCD rules already meet and establish the requirements for the disposal of produced water through injection. Additionally, we are not currently aware of any case where the OCD permitted injection of produced water into ground water. **RECOMMENDATION**: Identify the specific concern and determine why current rules do not provide the protection sought.

8) 19.15.1.21 C. (3) This provision is confusing in that it is unclear what the rule is attempting to accomplish, other than the identification of the water table(s). What type of log is being requested from the operator, a mechanical log or written log? Mechanical logs are used to measure resistivity and not the salinity of the water formation thus failing to identify fresh water. Likewise the drilling process uses fresh water and will not identify fresh water through a written log. Further, Yates has objections to the rule that operators must file logs or test demonstrating the vertical extent of fresh water aquifers. This new rule will require considerable additional time be spent during the drilling operations to try to determine where the fresh water sands are located then the sands will have to be either logged or tested to determine the vertical extent of the sands. This will needlessly drive the cost of drilling the wells up with little or no benefit to the protection of the environment. **RECOMMENDATION**: Revise this section to identify and clearly state the problem sought to be corrected.

9) 19.15.1.21 C. (4) Special rules for injection wells are only necessary to address specific problems and current rules already protect ground water. There is nothing special about ground water in Sierra and Otero Counties

when compared to ground water of the other counties of the State of New Mexico. This is another area where the Commission must use its expertise to avoid emotional and political pressures behind this rule. **RECOMMENDATION**: Use the current rules and do not adopt needless special rules.

10) 19.15.1.21 C. (5) Yates has objections to the rule that operators must run cement bond logs on each casing string after it has been cemented because a problem with how cementing is presently run has not been identified. This new rule will require considerable additional time be spent during the drilling operations to run bond logs on the surface and intermediate casing strings. After these casing strings have been cemented, the cement will have to set up for a minimum of 24 to 72 hours to let the compressive strength of the cement develop so that a bond log could determine where the top of the high strength cement was especially for the surface and the intermediate casing strings. This will make the time to drill the wells considerably longer needlessly driving the cost of drilling the wells up with little or no benefit to the protection of the environment that is not being done with the present rules on cementing casing strings. The majority of the production casing strings have bond logs ran by the operators during the completion operations after the drilling rig have been moved off of the well & the cement has had sufficient time to set and develop it's compressive strength. **RECOMMENDATION**: Remove this provision from the rule for the failure of the requirement to provide any environmental protection.

11) 19.15.1.21 C. (6) Yates objects to the rule that produced water transportation lines be constructed of double walled pipe to protect against leaks. Almost all water transportation lines carry a small percentage of hydrocarbons with the water to the disposal site. If the double wall pipe is used and a leak is created in the inner wall of the pipe, a dangerous situation could be created by the small amount of hydrocarbon in the water leaking and collecting in the annulus space between the inner and outer wall of the pipe. Double walled pipe is only a feel good measure that creates more problems than it solves. **RECOMMENDATION**: Remove this provision.

12) 19.15.1.21 C. (7) The term "impermeable" is a generic feel good word that does nothing more than provide an emotional answer to a technical problem. Unfortunately, it makes for a poorly written rule. Primary containment is provided by the tank battery, which in and of itself is impermeable. Secondary containment is provided by dirt berms, that for a time period are an impermeable layer and provide the opportunity for cleanup. Unfortunately, PR21 goes a step further and provides a third level of protection by requiring and impermeable pad that does nothing to address the problem of containment of any accident or spill. Basically, this provision of the rule is an example of "more is better philosophy" and not sound technical analysis. **RECOMMENDATION**: Remove this provision from the rule.

13) 19.15.1.21 C. (8) We ask the Commission to determine how this rule is any different than existing rules and what it intends to accomplish with this part of PR21. **RECOMMENDATION**: Determine if this provision is really needed.

14) 19.15.1.21 C. (9) It is our understanding that this rule varies from existing rules only in the time period for conducting of mechanical integrity testing. Emotional rhetoric and political pressure are the only justification we can think of for a special rule for this area. Current OCD rule 19.15.9.704 NMAC TESTING, MONITORING, STEP-RATE TESTS provides adequate protection and in the event of a problem the ability of the OCD to require more frequent monitoring. **RECOMMENDATION**: Remove this provision from the rule because current rules already provide this protection.

Yates Petroleum Corporation respectfully submits these comments and reserves the write to supplement and expand on these comments with oral testimony at the hearing.

Very truly yours,

YATES PETROELUM CORPORATION

Chuck Moran
Landman

CC: Bill Carr, Holland & Hart
Independent Petroleum Association of New Mexico
New Mexico Oil & Gas Association

Marathon Oil Company

5555 San Felipe Road
Houston, TX 77056-2723
Telephone: (713) 629-6600
FAX: (713) 296-2952 (MOC)
FAX: (713) 296-4494 (MAP)

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JUN 17 2004
OIL CONSERVATION DIVISION

June 9, 2004

New Mexico Energy, Minerals and Natural Resources Department
Oil Conservation Division
Attn: Mr. Mark E. Fesmire, Director
1220 South St. Francis DriveSanta Fe, New Mexico 87505

RE: Proposed new rules to govern operations in the Chihuahuan Desert Area of Otero and Sierra Counties, New Mexico

Dear Mr. Fesmire:

Marathon Oil Company appreciates the opportunity to comment on the above referenced proposed rule. Marathon is very concerned and disappointed that OCD has departed from its traditional rulemaking path by not involving all parties, including the oil and gas industry, in developing this proposed rule. We hope this precedent does not become the "course of business" that OCD will use for establishing proposed rules in the future. We strongly believe that effective and efficient rulemaking can be achieved if all parties have input in the initial development of proposed rules rather than OCD developing rules without input from stakeholders and then asking for comments.

Marathon is a member of NMOGA, and we fully endorse and support both the general and specific comments submitted by NMOGA on this proposed rule.

Again, we appreciate the opportunity to comment on this proposed rule. However, we truly hope that OCD will return to their previous way of establishing proposed rules by including industry and other parties in the initial rulemaking process.

Sincerely,

GB Dykes

G. B. Dykes
Southern Business Unit Leader
Marathon Oil Company

BURLINGTON RESOURCES

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JUN 1 4 2004

OIL CONSERVATION DIVISION

June 10, 2004

Mark E. Fesmire, P.E.
New Mexico Energy, Mineral & Natural Resources Dept.
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Re: Proposed Rule Change, 19.15.1.21 NMAC
Otero & Sierra Counties, NM

Dear Mr. Fesmire:

Burlington Resources Oil and Gas Company LP (BR) appreciates the opportunity to comment on the above referenced proposed rule change that will affect oil and gas operations in Otero and Sierra Counties, New Mexico.

BR is one of the largest independent (non-integrated) oil and gas companies in the United States in terms of total domestic proved equivalent reserves. We are the lessee of approximately ten percent of the federal leases held by production and operate approximately ten percent of all wells located on federal oil and gas leases. BR currently has working interest in the Bennett Ranch Unit, located in Otero County, and therefore is extremely interested in how oil and gas activity will be affected by the OCD's proposal.

We are an active member of New Mexico Oil and Gas Association (NMOGA) and actively participated on the (NMOGA) committee that prepared comments in response to the proposed rules. BR hereby endorses NMOGA's comments and reiterates some crucial points:

- Such restrictive measures are unwarranted given that past performance does not provide valid justification. There has been very little past oil and gas activity in the area as it is still in the very early stages of exploration. The BLM's Supplement to Proposed Resource Management Plan Amendment and Final Environmental Impact Statement for Federal Fluid Minerals Leasing and Development in Sierra and Otero Counties thoroughly analyzed (and included over 5 years of extensive public involvement) the region and removes a significant amount of land from oil and gas leasing and/or applies a myriad of restrictive, protective stipulations to the area. The OCD's current regulations along with the BLM's proposals are more than adequate to protect all resources in these two counties. Specifically, we ask that the OCD provide examples, at the June 17 public hearing, of how existing regulations have proven ineffective in the protection of groundwater as well as other resources in this area.

3300 N. "A" St., Bldg. 6, 79705-5406, P. O. Box 51810, Midland, Texas 79710-1810, Telephone 432-688-6800

- The proposed special provisions are not consistent with our National Energy Policy in that they go beyond what is determined to be reasonable and necessary for the protection of resources. The imposition of such rules clearly have the potential to deter further exploration and certainly set precedence for imposing similar unnecessary rules in other areas that may be important for the development of our nation's energy.

BR urges the OCD to consider our comments before needlessly implementing the proposed rules.

Please contact me at (432) 688-9042 or Bruce Gantner at (505) 326-9842 should you have any questions or would like to further discuss our comments.

Sincerely,

Eileen Danni Dey
Regulatory Compliance Supervisor

xc: John Zent/BR San Juan Division
Bruce Gantner/BR San Juan Division
Perry Pearce/Houston Corp.

Chihuahuan Desert Conservation Alliance
Earthjustice
National Wildlife Federation
Natural Resources Defense Council
New Mexico Wilderness Alliance
New Mexico Wildlife Federation
Sierra Club, Rio Grande Chapter
Southwest Consolidated Sportsmen
Southwest Environmental Center
The Wilderness Society

June 10, 2004

Via Facsimile (505) 476-3462 and U.S. Mail

Florene Davidson, Division Administrator
Oil Conservation Division
New Mexico Energy, Minerals And Natural Resources Department
1220 South St. Francis Drive
Santa Fe, NM 87505

Re: Comments on Proposed Section 19.15.1.21 NMAC
New rules to govern operations in the Chihuahuan Desert Area of Otero and Sierra Counties, New Mexico
Notice of Technical Testimony

Dear Ms. Davidson:

Please accept this notice of intention to offer technical testimony on behalf of the organizations identified above. In accordance with our written comments sent this day, the organizations listed above will present the technical testimony of Steven T. Finch, Jr., Vice President and Senior Hydrogeologist-Geochemist with John Shomaker & Associates, Inc. We anticipate that Mr. Finch's direct testimony will require approximately twenty (20) minutes.

Sincerely,

Pamela Pride Eaton
Deputy Vice President, Intermountain West BLM Campaign
The Wilderness Society
1660 Wynkoop Street, Suite 850
Denver, CO 80202
(303) 650-5818

Chihuahuan Desert Conservation Alliance
Earthjustice
National Wildlife Federation
Natural Resources Defense Council
New Mexico Wilderness Alliance
New Mexico Wildlife Federation
Sierra Club, Rio Grande Chapter
Southwest Consolidated Sportsmen
Southwest Environmental Center
The Wilderness Society

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JUN 14 2004

OIL CONSERVATION DIVISION

June 10, 2004

Via Overnight Mail

Florene Davidson, Division Administrator
Oil Conservation Division
New Mexico Energy, Minerals And Natural Resources Department
1220 South St. Francis Drive
Santa Fe, NM 87505

Re: Comments on Proposed Section 19.15.1.21 NMAC
New rules to govern operations in the Chihuahuan Desert Area of Otero and Sierra Counties, New Mexico

Dear Ms. Davidson:

On behalf of the undersigned, we are providing written comments on the new rules proposed by the Oil Conservation Division (OCD) to govern operation in an area in Otero and Sierra Counties known as the "Chihuahuan Desert Area." Please accept these comments for consideration as part of the record for the rulemaking.

We support OCD's efforts to protect the Chihuahuan Desert Area and agree with the portion of the proposed rules prohibiting the use of pits. However, we also believe that protection of the fragile and unique resources of the Chihuahuan Desert Area necessitates that the rules be revised to prohibit the use of injection wells and to implement additional protective measures.

The Fragile Chihuahuan Desert Area.

As the OCD recognizes in its application for rule amendment, the Chihuahuan Desert Area is a sensitive ecoregion, which includes the Otero Mesa and Nutt desert grasslands. The Chihuahuan desert grassland is one of the most biologically diverse and endangered arid ecosystems on earth, supporting a diversity of grasses, yuccas, agaves and cacti, while providing habitat for the endangered northern Aplomado falcon, the black-tailed prairie dog, mule deer, pronghorn and other species. The area designated by the OCD is one of the largest contiguous grasslands left in the region.

However, the desert grassland and the species it supports are also extremely vulnerable to damage from oil and gas development. Once destroyed, desert grasslands are rarely, if ever, capable of being fully restored. Oil and gas operations result in loss of vegetation and destruction of habitat for the dependent animal species, including extensive fragmentation of existing habitat. A general discussion of the resources contained in this area and the risk posed to them posed by oil and gas development is found in the 'Review of "Proposed Resource Management Plan Amendment and Final Environmental Impact Statement for Federal Fluid Minerals Leasing and Development in Sierra and Otero Counties," prepared by Walter G. Whitford, Ph.D. and attached as Exhibit 1 to these comments.

Water is an especially vital and vulnerable resource in the Chihuahuan Desert Area. Within the area covered by this rule are the Tularosa Basin, the Salt Basin and Jornado del Muerto basins. Much of the groundwater in these basins is shallow and closely connected to surface water recharge. Surface water is primarily contained in the closed basins and readily recharges the groundwater basins. As a result contaminants in surface water are readily delivered into the groundwater and portions of the aquifers are considered "highly vulnerable to contamination from surface water discharges." [1]

Deeper aquifers are also vulnerable. In its report on groundwater contamination and remediation, the New Mexico Environment Department concludes that "aquifer recharge in areas of deep ground water may be occurring more rapidly, and at greater magnitude, than is widely believed. Areas of shallow ground water are clearly vulnerable to contamination. Deeper ground waters, however, are not as well protected as many believe them to be."[2] This report indicates that delivery of contaminants is "efficient" for shallow and deeper areas of groundwater.

John Shomaker & Associates, Inc. (Shomaker) assisted the State of New Mexico in preparing the Tularosa Basin and Salt Basin Regional Water Plan, with other hydrogeologic evaluation of the Salt Basin for the Interstate Stream Commission, and in supporting preparation of the State Water Plan. Shomaker relied on this experience to further evaluate the vulnerability of the Salt Basin to contamination and the risks posed by oil and gas operations in the area. The comments of Shomaker on the OCD's proposed rules, and on the vulnerability of the Salt Basin to contamination and

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[1] *See, e.g.,* Bureau of Land Management, Proposed Resource Management Plan Amendment/Final Environmental Impact Statement for Federal Fluid Minerals Leasing and Development in Sierra and Otero Counties, released January, 2004, pp. 3-12 - 3-13.

[2] Ground-water Contamination and Remediation in New Mexico: 1997-2000, New Mexico Environment Department, Ground Water Quality Bureau, July, 2000, p. 7.

destruction from discharges related to oil and gas operations, are attached as Exhibit 2 and incorporated by reference. As discussed by Shomaker:

- The majority of the basin, considered a regional aquifer, is underlain by limestone (carbonate) rock that is fractured and also permeable – such that contaminants can move throughout the system.
- The fractures in the basin occur densely and are exposed at the land surface, providing numerous and ready pathways for travel of contaminants into the regional aquifer.
- Recharge of the groundwater occurs from melting snowpack and flash flooding, which infiltrates the system. Recharge occurs in an alluvial aquifer, where depth to water is shallow, making it susceptible to contamination from surface activities.
- Depth to water in the central part of the Salt Basin is approximately 200 feet, but many of the existing wells that produce from shallow perched groundwater may have depth to water of less than 100 feet.
- The direction of regional groundwater flow is from the northern Salt Basin, Otero Mesa and Diablo Plateau toward the Salt Flats near Dell City, Texas. Groundwater flow from Otero Mesa and the Sacramento watershed is toward a highly fractured region known as Otero Break. The high density of fractures and the nature of the rocks provide for transfer of water and contaminants in the water.
- Otero Break's hydraulic connectivity (general flow rate) and hydraulic gradient (slope of groundwater flow) can be used to calculate an average flow rate for water (tracer velocity). The average tracer velocity calculated is high (20 feet per day), but within a fracture can be several orders of magnitude greater (1000 feet per day), showing how "efficiently" contaminants can travel through this groundwater.
- Overall, more information about the location and condition of groundwater is needed to perform sufficient analysis and avoid endangering the vital water resources beneath the Chihuahuan Desert Area.

Restrictions on oil and gas operations in the Chihuahuan Desert Area are needed to protect public health and safety and the environment, and especially our limited water resources. A 2002 report prepared for the State of New Mexico[3] concluded that the basin beneath Otero Mesa, the Salt Basin, contains approximately 15 million acre-feet of recoverable potable water in storage. Taking into account all recoverable water that meets the definition of "fresh water" used by the New Mexico State Engineer[4], this

[3]Tularosa Basin and Salt Basin Regional Water Plan, May 2002, prepared by Livingston Associates, P.C. in association with John Shomaker & Associates, Inc.
[4] Waters containing 10,000 milligrams per liter or less of total dissolved solids.

volume increases to approximately 30 million acre-feet, which would provide water for 1 million New Mexicans for close to 13 years.[5]

Oil and gas operations can pose a substantial risk to groundwater. For example, residents of Silt, Colorado are now forced to rely on bottled water due to a gas seep into shallow groundwater first discovered in March and attributed to a nearby gas operation, which has led to dangerous levels of benzene in drinking water (*See*, Grand Junction Sentinel article, May 29, 2004, attached as Exhibit 3). Rules prohibiting use of pits and injection wells, as well as requiring other protective measures, are justified to prevent these documented risks and fulfill the policy directives set out in the Governor's Executive Order 2004-005 to protect New Mexico's resources.

Proposed Rules.

The proposed rules regulate the use of pits (generally used for disposal or storage of fluids generated in drilling and other wastes) and injection wells (generally used for disposal of produced water generated during production) in oil and gas operations in the Chihuahuan Desert Area.

The proposed rules prohibit the issuance of permits for pits. Injection wells may be permitted, but only after notice and hearing, and with the following additional requirements:

- Identify greater "area of review" to evaluate nearby wells for potential routes for migration of fluid from the injection areas
- Record vertical extent of fresh water aquifers to allow better protection
- Additional casing requirements to protect aquifers from contamination by produced water
- Use double-walled pipes or lay pipe by roads so leaks are easier to detect
- Tanks will be on pads and surrounded by lined berms or other secondary containment
- Record injection pressures and volumes daily
- Perform annual tests of mechanical integrity

While we support the prohibition of pits and recognize the increased regulation of injection wells, we believe that injection wells should not be permitted in the Chihuahuan Desert Area and that further safeguards are needed.

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[5] Based on USGS daily consumption estimates for New Mexico for all uses (household, agricultural, industrial, etc.).

Pits Should Be Prohibited throughout the Chihuahuan Desert Area.

The use of pits can lead to contamination of both soils and water, which is potentially harmful to the public, as well as to the plant and animal species of the Chihuahuan Desert Area. Leaking or overflow from pits can result in the release of contaminants from oil and gas operations (such as volatile organic compounds, hydrocarbons and heavy metals found in produced water, production fluids and other associated wastes). Liquids in pits pose a fatal risk to both wildlife and livestock. These risks are present even for pits used on a temporary basis. In addition, wastes stored in improperly closed pits can migrate through the vadose zone (the unsaturated zone between the ground surface and the top of the groundwater) and kill vegetation.

As discussed above and in more detail in the comments provided by Shomaker (Attachment 1), the hydrology of this area makes contamination of surface or groundwater especially likely to spread and increase the damaging effects. Given the hydrology of this area, even a surface spill of relatively short duration can result in groundwater contamination. Further, the plant and animal species found in the Chihuahuan Desert Area are likely to be significantly harmed by such contamination.

We support the prohibition of pits associated with oil and gas operations in the Chihuahuan Desert Area as a reasonable and enforceable manner of protecting ground and surface water, habitat and wildlife resources.

Injection Wells Should Be Prohibited throughout the Chihuahuan Desert Area.

The use of injection wells has a great potential to contaminate groundwater aquifers and surface soils. Due to hydrologic conditions, such as fractures and faults, produced water injected into underlying formations has a high potential to contaminate protectable groundwater ($\leq$ 10,000 milligrams per liter total dissolved solids) aquifers. Produced water injected into underground formations may travel through the subsurface, coming into contact with groundwater. Produced water usually contains high concentrations of toxic volatile organic compounds, other heavier hydrocarbons, heavy metals and other minerals that will contaminate fresh groundwater aquifers in the area. Surface spills of produced water may also sterilize soil and kill vegetation due to excessive salt content. The risk of contamination is heightened where the subsurface is fractured and not all fractures are fully mapped. As discussed in the Shomaker comments (Attachment 1), the majority of the regional aquifer underlying Otero Mesa is underlain by porous limestone rock that is highly fractured (with numerous routes for contaminants). The basins have not been adequately mapped and tested to define the extent of fracturing and hydraulic connectivity. Further, once contaminants enter the groundwater, they can be transported into surface water and soils based on their closed nature and hydraulic conductivity.

Although the additional requirements for permitting, investigation, construction, maintenance and monitoring of injection wells are preferable to current requirements, they are not sufficient to protect the important groundwater resources in this area.

Therefore, the proposed rules should be revised to prohibit permitting of injection wells and to require use of closed loop systems. The most reasonable way to protect the vulnerable water resources is to prohibit the use of injection wells in the Chihuahuan Desert Area.

Additional Protections Needed.

In addition to the prohibition on the use of pits and injection wells, protection of the public health and safety and the environment, including the water, plants and animals in the Chihuahuan Desert Area, necessitates further restrictions on oil and gas operations. The OCD should add the following requirements as part of its new rules:

- Open tanks must have mesh covers and be surrounded by appropriate netting and fencing to create barriers between stock or wildlife and dangerous toxic liquids.
- All tanks must be surrounded by berms sufficient to contain the volume of the tank and lined with an appropriate synthetic liner of sufficient thickness and strength to prevent any leakage of spills or overflows.
- All tanks (above or below grade) must be equipped with float valves, to prevent the overflow of a tank. Float valves must be connected to production to ensure that operations cannot continue if there is insufficient capacity in the tank. It is unacceptable for tank capacity to be determined based on overflow.
- Reporting and remediation (clean up) for spills and leaks (Section 116) needs to be revised. For example the current level of reporting minor spills and leaks is 5 to 25 barrels (42gallons per barrel) without specifying any time interval and no requirements for immediate actions to remediate the spill or leak for minor or large incidences. The reporting and remediation requirements for minor spills needs to be revised to: a) one to five (1 to 5) barrels per 24 hours for produced water and b) 5 to 42 gallons per 24 hours for condensate, oil, fuel, glycol, and other additives. Major spill reporting should be revised to 5 barrels or greater for produced water and one (1) barrel or greater for condensate, oil, fuel, glycol, and other additives. Appropriate remediation and response time frames should be required in Section 116. This section is not adequate to protect groundwater and substantial damage to the fragile resources in the Chihuahuan Desert Area.
- Open sumps and on-site disposal of waste are prohibited. The vulnerability of the water resources, plants and animals in the Chihuahuan Desert Area cannot be subjected to the associated risks of contamination.
- Restoration of sites must be accomplished by returning the site to its original condition, in terms of terrain, original species composition for vegetation and successful growth of mature plans, in accordance with a restoration plan to be reviewed and approved by the OCD with input from the Environment Department, Game and Fish Department and the State Engineer and with an opportunity for public comment.
- Restoration should commence immediately for all unused areas of a site.

- Penalties for violations of these new rules are heightened and not subject to waiver or modification.
- Exploration and production operations must be conducted to minimize the construction of roads and pipelines and the area of drilling pads, which will reduce fragmentation of habitat and the spread of non-native species.
- OCD needs to have administrative fine capability incorporated into all aspects of regulation and enforcement. Due to OCD's limited staff and enforcement capability, industry has less incentive for compliance with the regulations, protecting the environment and ensuring that public health and safety are paramount.

By protecting the water resources, as well as livestock and wildlife in the Chihuahuan Desert Area, the OCD can best fulfill its mission to protect public health and the environment, while conserving natural resources. The proposed rules, including the additional changes proposed, are within OCD's authority under the Oil and Gas Act (*See, e.g.*, §§ 70-2-12(B)(2), (B)(3), (B)(13), (B)(15), (B)(21), (B)(22) NMSA 1978), consistent with the policy of the State of New Mexico to "provide support for the utmost protection of these grasslands" (*See*, Executive Order 2004-05) and necessary to allow oil and gas exploration and development activities to take place without excessive risk of damage to other valuable resources.

We appreciate the opportunity to comment on the proposed rules and urge the OCD to safeguard the Chihuahuan Desert Area through responsible rulemaking.

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EXHIBIT 1

Review of "Proposed Resource Management Plan amendment and Final Environmental Impact Statement for Federal Fluid Minerals Leasing and Development in Sierra and Otero Counties"

Walter G. Whitford, Ph.D.

Review of "Proposed Resource Management Plan Amendment and Final Environmental Impact Statement for Federal Fluid Minerals Leasing and Development in Sierra and Otero Counties" USDI- Bureau of Land Management, Las Cruces Field Office. December 2003. by Walter G. Whitford, Ph.D.

The following are answers to the questions listed in the Letter of Agreement between The Wilderness Society and the author. (1) Is the description of the affected environment (baseline) conditions adequate to determine what effect oil and gas development will have on the region? The description of the affected environment is inadequate with respect to vegetation composition of the Otero Mesa grasslands, soil depth, wintering avifauna, and interdependence of animal species that use environments modified by species that serve as ecosystem engineers or as niche constructors. Details of these are provided in the comments below.

(2) Does the Otero final EIS meet conditions of NEPA. The final EIS meets the conditions of NEPA with the exceptions of overgeneralizations listed in the detailed comments. Specifically they fail to identify the methodologies to be used in restoration and/or monitoring the success of restoration. This is discussed below.

(3) The EIS does omit some important science that is relevant to understanding the environmental impacts of the proposed oil and gas development especially with respect to the resilience of Chihuahuan Desert grasslands and recovery from disturbance by oil and gas development.

(4) Are conclusions relative to environmental effects supported by accurate and correct scientific opinion and methods? Most of what is provided in the EIS is supported by accurate and correct scientific opinion with respect to environmental impacts. What is not adequately supported are mitigations and restoration management plans. Specifics are provided below.

(5) The Otero Final EIS does not discuss appropriate monitoring and mitigation measures. The statements about surface occupancy being restricted to 0.25 miles of critical habitat as a mitigation measure appears to be an arbitrary measure and is not supported by any research citations.

(6) Incomplete or unavailable scientific information haunts every proposed project EIS and Management Plan. For example, there are no specific studies on the ecological effects of bladed roads in rangeland environments. However the Otero EIS does not cite an important review on ecological effects of roads (Forman and Alexander, 1998) and a review of that document could have modified the agencies conclusions regarding impacts of oil and gas development.

(7) Final EIS consider and discuss alternative approaches that could be implemented to reduce or eliminate environmental effects? The Final EIS presents a management plan that does not involve alternative approaches.

(8 & 9) Unsupported assumptions and conclusions and failure to quantify cumulative impacts are discussed in detail in the following section.

(10) Alternatives that could minimize or eliminate some of the identified impacts include: not permitting well-pads and buried pipelines on hillslopes in the undulating terrain of the Otero Mesa grasslands, keeping all surface occupancy at least 1 mile from prairie dog colonies, not permitting excavation into the indurated calcrete to avoid colonization of excavated areas by mesquite and other deep rooted shrubs. However the

best alternative would be not to allow surface occupancy (no well pads, new roads, new power line corridors, and/or pipelines) in that portion of Otero Mesa that is Chihuahuan Desert grassland (the *Yucca elata* – grama grass dominated grassland). That alternative was considered and rejected by the BLM.

(11) Specific mitigation measures I would include to minimize or eliminate the identified impacts? Other than measures presented above with regard to avoiding impacts on keystone species such as prairie dogs the only other way to minimize identified impacts would be to require restoration of the grassland ecosystem on the disturbed areas. The only way that this can be accomplished is to remove the vegetation and soil in a way that keeps the root-soil environment intact and keep that pedon in a greenhouse or agronomic environment until such time as the well pad, road etc. is abandoned and needs to be reclaimed. That would insure that the same plant ecotypes and soil biota would be returned to the environment and the rangeland would be restored as a functional ecosystem.

Omission of Critical Information or Provision of Insufficient Information: Chapter 4, page 3. The details of area disturbed and type of disturbance does not provide any information on the depth of soil to be moved in the construction of well pads for production wells nor depth of buried pipelines. Given the shallow soil depths of less than 2 feet over much of the Otero Mesa grasslands (W. G. Whitford, unpublished data) and the underlying cemented/indurated calcrete, it is essential to know the depth of well pads and pipelines. If pipelines are to be protected by burial at depths greater than 3 feet, the integrity of the calcrete will be fragmented and when pipeline trenches are backfilled the porous nature of the backfill material will allow deep-rooted shrubs such as mesquite to establish in the pipeline corridor. The virtual absence of mesquite in Otero Mesa grasslands is due in large part because of the shallow soils. Mesquite establishment requires at least 3 feet of soil or fragmented calcrete that allows the deep roots of mesquite to exploit the deep soil environment (Whitford, unpublished data). Because soil depth was not considered and pipeline trench depth was not reported, it is not possible to assess the risk that pipeline corridors may become linear habitats for mesquite and/or other deep-rooted shrubs. If the pipeline corridors become shrub habitat, the pipeline corridors will subdivide the grassland into small patches.

Chapter 4, page 6. The discussion of access roads states that the impacts are limited to increased fragmentation of habitat and removal of vegetation. Newly bladed roads impact the hydrological relationships of the ecosystems on the catenas that are traversed by the roads. Roads disrupt overland flow and frequently result in de-watering of areas down-slope from the road. Recent studies on the Jornada Experimental Range in the Jornada Basin of southern New Mexico have documented loss of plant cover, loss of aggregate stability and reduced infiltration of areas immediately down-slope of roads. The impact of roads is therefore much larger than fragmentation of habitat and removal of vegetation from the road-bed.

Chapter 4, page 19. The presentation of direct impacts on surface water quality claims that clearing well pads will affect surface water in the immediate vicinity and that road, power line or pipeline construction will produce localized and short-term impacts on water quality. As long as these structures are in use there will be potential for sediment discharge from the structures. There is always a risk of spills of fuels, lubricants, etc. during the operations. The EIS states that "bermed ponds which are often lined are used to contain these fluids....... There is no statement about requirements for pond construction or soil clean up following spills. The impacts will certainly not be "short-term" if the well field is in operation for a decade or more. The risk of significant contamination increases exponentially with time of operation.

Chapter 4, pages 22-27. This whole section of the EIS deals with compliance with EPA standards for emissions. There is no consideration of the impacts of dust on the physiological vigor of the vegetation in the deposition area around roads and well pads. Dust that is deposited on leaf surfaces reduces rates of photosynthesis and over time reduces the vigor of plants that are so affected (Sharafi et al. 1997). While this may not be a significant problem during years with adequate or average rainfall during the growing season, it has the potential to hasten the death of grasses that have dust deposited on the leaves during drought growing seasons such as experienced in summer 2003.

Chapter 4, page 31. *Abandonment Phase* "Grasslands generally recuperate relatively quickly while other vegetation types (e.g. pinon-juniper) grow more slowly. This a completely unsubstantiated claim. Chihuahuan Desert grasslands have not recuperated from the combined effects of grazing and drought even with re-seeding and removal of invasive shrubs (Whitford 2000). Virtually all efforts to restore or recuperate Chihuahuan Desert grasslands have failed. This statement in the EIS infers that the Otero Mesa grasslands will recuperate quickly and easily when the liquid minerals extraction is terminated. While it may be possible to get some species of grasses to establish quickly during periods of favorable rainfall, it is extremely unlikely that the original species composition will be restored. Without restoration of the original species composition, the resilience of the plant community following drought will be severely limited and plant cover is likely to be sufficiently reduced to allow wind/water erosion of exposed soils (Whitford et al. 1999).

Chapter 4. page 31. This section presents the management plan for mitigating impacts on riparian/wetland areas. In arid landscapes, areas that accumulate run-off and retain flood-waters for an unspecified period of time are termed playas. The management plan calls for no surface occupancy within 0.25 miles of riparian/other wetland/playa vegetation. This management plan will not mitigate the potential impacts on riparian/wetlands of Otero Mesa or other regions covered by this EIS for the following reasons.

The specific plant assemblages that are considered to identify playas are not described. Landscape depressions that serve as drainage basins that are ephemeral aquatic environments are regular features of the Otero Mesa landscape. Ephemeral waters of flooded playas support a diverse flora and fauna that may be very susceptible to pollutants (Whitford, 2000). The undulating topography of Otero Mesa will allow surface occupancy including well pads, pipeline corridors, powerline corridors, and roads at distances greater than 0.25 miles from playas. In the Chihuahuan Desert ephemeral lakes fill with run-off water during large, intense rain-storms that generate overland flow. Overland flow moving across well pads etc. on sloping terrain will transport soils contaminated by fuel spills and other materials used in the drilling process into the lake waters. If a storm is sufficiently intense of sufficient duration, sump pits can fill to overflowing and materials stored in sump pits transported by overland flow into the lake waters. In desert environments, storms that generate large volumes of overland flow are infrequent, upredictable events (Whitford, 2000) but must be considered as an increasing risk with increased length of time that surface occupancy associated with oil and gas development remain on sloping terrain in the Chihuahuan Desert.

Chapter 4 pages 33-34. The EIS provides a reasonable summary of the effects of habitat fragmentation on grassland biota and acknowledge that the Otero Mesa and to a lesser extent, the Nutt grasslands are among the last remnants of high-quality, unfragmented yucca desert grassland habitat. The EIS states "significant adverse impact if these cumulative effects occurred in the remnant desert grasslands". To protect the remaining desert grassland from degradation the BLM stipulation limits industry disturbance to no more than 5% of the leasehold at any one time. Five percent of the total grassland area disturbed by new roads, well pads, and pipeline corridors will result in fragmentation of thousands of acres of the Otero Mesa and/or Nutt grasslands. Since the restoration procedures required by the BLM's management plan will not result in restoration of the area to contiguous, functioning grassland ecosystems with the same plant species composition and cover as currently exists, the fragmentation will probably result in long-term adverse effects on the fauna

Chapter 4, pages 35 –42 This section discusses the impacts of fluid minerals extraction on wildlife. The final EIS and Management Plan document is very general and references the draft EIS for detailed information on the environments and biotic resources. The BLM document fails to consider the Otero Mesa grasslands as connected ecosystems that make up the Chihuahuan Desert landscapes of Otero Mesa. The BLM approach focuses on soils, climate, vegetation and fauna as separate entities and not integrated into the unique structural and functional units that constitute the Otero Mesa ecosystems. By failing to adopt the ecosystem approach, the BLM document fails to consider many of the interactions among the biotic components and abiotic components of the Otero Mesa landscapes that are critical to evaluating the impacts of oil and gas development and in designing and conducting satisfactory restoration of impacted areas.

There are important ecosystem level interactions between one the important game species, the pronghorn antelope and a species of concern, the black-tailed prairie dog. Pronghorn antelope select prairie dog colonies as preferred feeding areas. Prairie dogs modify the vegetation within their colonies and that vegetation is preferred forage for antelope (Kruger 1986). This relationship is especially important during droughts such as has been experienced in 2003. During field surveys in November 2003, we recorded large groups of pronghorn antelope on prairie dog colonies and the prairie dog colony areas supported the only green vegetation on the mesa at that time. Prairie dog colonies provide the only habitat for another species of concern, the western burrowing owl. Roads, well pads and or pipeline corridors that are located near prairie dog colonies will adversely impact not only the prairie dogs but will adversely affect the pronghorn antelope and burrowing owls. Roads that provide access to prairie dog colonies will also increase the risk that recreational "shooters" will use prairie dogs as targets. That increases the risk that antelope and burrowing owls will be reduced in numbers because of the reduction or loss of the "keystone species", black tailed prairie dogs.

The EIS fails to mention the importance of the Otero Mesa and Nutt grasslands as winter habitat for grassland bird species. Habitat fragmentation adversely impacts wintering birds as well as breeding birds. Spatially extensive grasslands are very important to avian species experiencing declines in North America. The effects of habitat fragmentation in grasslands is greatest when disturbance results in a mosaic of suitable and unsuitable habitat patches derived from what was previously a homogeneous landscape (Knick and Rotenberry, 2002). Ferruginous Hawk, Horned Lark, Sprague's Pipit, Eastern and Western Meadowlark, and Grasshopper Sparrow are grassland species that exhibited population declines between 1966 and 1996 (Peterjohn and Sauer, 1999) and have been reported to use the Otero Mesa grasslands as winter habitat (Meents, 1979). Ferruginous Hawk, Burrowing Owl, Loggerhead Shrike, Grasshopper Sparrow, Baird's Sparrow and Western Meadowlark have formal conservation status in the U. S and/or Canada (Manzano-Fischer et al. 1999) and these species use Otero Mesa grasslands as winter habitat. Oil and gas development on Otero Mesa is likely to limit or eliminate the area as suitable winter habitat for these species.

Appendix B page 10. States that reclamation will be considered successful when ground cover with desired species showing signs of stable establishment. Establishment indicated by the existence of healthy, mature, annuals and perennials in the correct density and composition, as compared to the seed mixture established by the Authorized Officer.

By these statements the BLM clearly indicates that there is to be no attempt to restore the disturbed areas to pre-disturbance ecosystem status. The plant species composition is to be compared to a seed mixture, not to the pre-disturbance plant community composition. The authorized officer is not identified nor is the criteria by which the authorized officer will determine the seed mixture.

Restoration should require that the disturbed areas be returned to as close to the pre-disturbance ecosystem structure as possible. Restoration of Otero Mesa grasslands should include dominant cover by the drought resistant grama grasses with the more readily established bunch grasses as a minor component. Restoration should also include restoration of the soil biota and evidence that the soil biota – plant association is functioning in a sustainable manner (Whitford, 1988; Whitford, 1996).

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Sigma Xi Local Chapter President, 1981-1982.
Phi Kappa Phi - Local Chapter President, 1973.
Distinguished Visiting Lecturer in Entomology, Texas A&M University, March, 1982.
Westhafer Award for Excellence in Research, 1984.
Exchange Professor, University of Rhode Island, 1992
Distinguished Alumni in Science, University of Rhode Island, 1993
U. S. Environmental Protection Agency - Outstanding Contributions in Ecological Science - 1994.

Professional Societies:

Australian Ecological Society., American Institute of Biological Sciences., American Association for the Advancement of Sciences (Fellow)., American Society of Mammalogists, Entomological Society of America, International Union for the Study of Social Insects., Herpetologists League (Fellow)., Ecological Society of America., British Ecological Society., Southwestern Association of Naturalists., International Society for Ecosystem Health and Medicine (member editorial board)

Professional Service:

1994-present- Executive Editor – Journal of Arid Environments
1986 -1990 Long Term Ecological Research Program Coordinating Committee.
1984 -1992 Founding Co -editor of Biology and Fertility of Soils published by Springer Verlag.
Aug. 1982 NSF Advisory Review Panel.
1982 - 1986 NSF Ecosystems Panel, Biotic Systems and Resources.
1969 - 1978 Served as a site coordinator (Jornada Site) and member of the Executive committee of the U.S. International Eological Program: Desert Biome Project.
1975 - 1981 Ecology Editorial Board Member.
Mercer Award Committee of Ecological Society - 1979
1989 Member of executive committee Southwestern and Rocky Mt. division of AAAS.
1983 President Southwestern and Rocky Mountain Division of AAAS (SWARM).
Coordinator and Principal Investigator, Jornada Long Term Ecological Research Project (LTER).
1982 present Editorial Board, Journal of Arid Environments.
1980 - 1989 Member of Committee on Arid Zones Research of the SWARM
1983 Symposium Organizer IUSSI International Congress
1987 - 1989 Member National Academy of Science Climate Change Committee
1989 Reviewed Karoo Desert Biome Program for Foundation for Research Development, Republic of South Africa
NSF Young Investigators Awards Panel
External Thesis Examiner : University of Sydney, La Trobe University (Australia), University of New England (Australia), University of Western Australia, Murdoch University (Australia), University of Port Elizabeth, (South Africa) University of Capetown (South Africa)

Graduate Students: (Master of Science Degrees) Mark Conley, Charles Alexander, Andrew Preito, Charles Drieling, Douglas Schaefer, David Shaffer, Kenneth Meltzer, James Edwards, Elliot Jacobson, Walter Smith, Tim Schowalter, Robert Repass, Gary Wright, Richard Walker, K. Bruce Jones, Wendy Wisdom, Jack DeAngelis, Kenneth Stinnett, Carla Alford, Buddy Hartwick, David Peterson, Vicki

Medland, Thomas Boswell, Gerado DeLira, Gustavo Martinez-Turanzas, Stanley Carlson, Eric Jackson, Sonya Krogh, Rudolfo DiMarco

Ph.D. Students: Jeff Delson, Kenneth Hoover, Carol Kay, Fenton Kay, Brian Locke, Perseu F. Santos, Jorge Cepeda, Julio Gutierrez, Ned Elkins, Richard Mishaga, Marsha Conley, Kevin Zimmer, Norman Dronen, Ahmed El Shahaby, David Lightfoot, Solange Silva, Marlen Eve, Gregory Forbes

Postdoctoral Fellows Advised: Dr. Lawrence Parker, Dr. Yosef Steinberger (Israel), Dr. John Zak , Dr. Hyeong Tae Mun (Korea), Dr. William MacKay, Dr. Craig James (Australia), Dr. Frederick Fisher , Dr. Timm Hoffman (South Africa) Dr. Darrell Moorhead Dr. Mohamed Ali Beder (Egypt), Dr. Steve Loring, Dr. Graham Kerley (South Africa), Dr. Ron Nielson, Dr. Amrita DeSoyza

Courses Taught: Principles of Ecology (juniors and seniors), Desert Ecology
Desert Ecosystems (senior - graduate), Global Environment (Honors students, juniors and seniors), Human Ecology (upper division/graduate) Introductory Biology, Human Anatomy, Human Physiology, General Physiology, Cell Physiology, Insect Ecology, Zoogeography, Soil Ecology, Physiological Ecology, Seminar in Restoration Ecology, General Zoology

Research Grants: International Arid Lands Consortium - Effects of desertification on biopedturbation. NOAA Grant: Physiological Control of Evapotranspiration by Vegetation: Patterns in Plant Communities and Role in Atmospheric Coupling of Regional ET. NSF: Shrub Resource Islands in the Chihuahuan Desert (1991-1994) Water Resources Research Institute (tolerance limits of fish; productivity of desert and montane ponds); NASA estivation in desert amphibia); NSF US/IBP Desert biome Program (wood boring insects of mesquite, ecology of harvester ants, role of seed consumers); U. S. Air Force (thermal stress physiology of primates); U. S. Forest Service (arthropods in mine spoil reclamation); N. M. Energy Institute (minespoil reclamation); Sandia Corporation DOE (arthropods at the WIIP proposed nuclear waste disposal site); NSF (the role of arthropods in decomposition processes in desert ecosystems); NSF (decomposition and nutrient cycling processes in desert ecosystems); U. S. Forest Service (the effect of organic amendments on soil biota of degraded arid rangeland; Westinghouse corp. (decomposition and arthropod populations at the WIIP site). NSF Root symbionts and plant productivity in warm desert ecosystems.
NSF, Primary productivity, decomposition and nitrogen cycling in a desert ecosystem: a modelling synthesis. NSF: Time and space variation in a desert ecosystem U.S. Long Term Ecological Research Program (Principal Investigator); U.S. Israel Binational Science Foundation Decomposition and nutrient processing in deserts.

Invited Seminars: Visiting ecologist, Idaho State University, University of New Mexico (3 times); University of Oklahoma; Northern Arizona University; University of Arizona; University of Georgia, University of California, Riverside;University of California, Los Angeles; North Carolina State University; Georgia Southern University; University of Miami; Texas Technological University (3 times); University of Texas at El Paso; Arizona State University; Westfield College University of London; Tel Aviv University,Israel; Desert Research Institute, Sde Boker, Israel; Distinguished Visiting Lecturer in Entomology, Texas A&M University; Utah State University; Southwest Texas State Univ., University of Rhode Island; Duke University; University of Texas, San Antonio; McQuarie University, Sidney Australia; Monash University, Melbourne, CSIRO, Soils Division, Adelaide. San Diego State University, University of New South Wales, Sydney University, National Herbarium of Australia, CSIRO Ecology Division Darwin, Alice Springs, Canberra, Deniliquin, Idaho State University, University of Connecticut, University of Capetown, Worcester State University, Botanical Institute - Capetown, SA.

Professional Consulting:
Have served or currently serving as a consultant for the following Corporations or Agencies: U. S. Forest Service, Bureau of Land Management, Westinghouse Corp., Public Service Co. of N. M., Sandia Corp., Union Oil of California, El Paso Natural Gas, Molycorp, Stone and Webster Engineering, HDR Ecosciences, NM Department of Agriculture, Bureau of Reclamation, Environmental Protection Agency, Escuela Superior de Agricultura "Hermanos Escabar" Juarez, Mexico; Desert Research Institute, Sde Boker, Israel; Denny, Cross and Associates, ICI- America Div., Benham Corporation; EDAW Inc.; Sunbelt Mining Co.; CSIRO Soils Division, Adelaide, Australia, CSIRO Ecology and Wildlife Division, Bechtel Corporation, CSIR- South Africa, El Paso Independent School District, Idaho Board of Education, Wilderness Alliance, Rhino Waste Management.

PEER REVIEWED PUBLICATIONS: Note peer reviewed book chapters marked with asterisk

Whitford, W. G. & V. H. Hutchison (1963). Cutaneous and pulmonary gas exchange in the spotted salamander Ambystoma maculatum. Biological Bulletin 124: 344 -354.

Whitford, W. G. & V. H. Hutchison (1965). Effect of photoperiod on pulmonary and cutaneous respiration in the spotted salamander, Ambystoma maculatum. Copeia (1965): 53-58.

3. 1965. W.G. Whitford and V.H. Hutchison. Gas exchange in salamanders. Physiol. Zool. (3):228 -242.

1966. W.G. Whitford and A. Vinegar. Homing survivorship and overwintering of larvae in spotted salamanders, Ambystoma maculatum. Copeia (3):515 - 519.

5. 1966. Cutaneous and pulmonary gas exchange in ambystomid salamanders. Copeia (3):573 -577. W.G. Whitford and V.H. Hutchison.

6. 1966. Survival and under water buccal movements in submerged anurans. Herpetolgica 22(2):122 - 127. (with V.H. Hutchison).

1967. Body size and metabolic rate in salamanders. Physiol. Zool. 40(2):127 - 133. W.G. Whitford and V.H. Hutchison.

1967. Observations on territoriality and aggressive behavior in the western spade foot toad, Schaphiopus hammondii. Herpetologica 23(4):318. W.G. Whitford.

9. 1968. Energy requirements of Uta stansburiana. Copeia 4:678 - 683. C.E. Alexander and W.G. Whitford.

10. 1968. Relation of body size and surface area to gas exchange in anurans. Physiol. Zool. 41(1):65 - 85. (with V.H. Hutchison and M. Kohl).

11. 1968. Aerial and aquatic respiration in axolotl and transformed Ambystoma tigrinum. Herpetologica 24(3):233 - 237. W.G. Whitford and Robert E. Sherman.

12. 1968. Physiological responses to temperature and dessication in the endemic New Mexico plethodontids, Plenthodon neomexicanus and Aneides hardii. Copeia 2:247 251. W.G. Whitford.

13.* 1969. Heart rate and changes in body fluids in aestivation toads from xeric habitats. IN: Hoff, C.C. and M.L. Reidesel ed. Physiological Systems in Semi - Arid Environments. University of New Mexico Press, Albuquerque. 125 - 133. W.G. Whitford.

14. 1970. The effect of acclamation on physiological responses to temperature in the snakes, Thamnophis proximus and Natrix rhombifera. Comp. Biochem. Physiol. 35:439 -449. E.R. Jacobson and W.G. Whitford.

15. 1970. Responses of a population of Ambystoma triginum to thermal and oxygen gradients. Herpetologica 26(3):372 - 376. W.G. Whitford and M. Massey.

16. 1970. Soil water absorption capabilities in selected species of anurans. Herpetologica 26(4):411- 418. R.F. Walker and W.G. Whitford.

17. 1971. Physiological responses to temperature in the patch nosed snake Salvadora hexalepis. Herpetologica 27(3):289 - 295. E.R. Jacobson and W.G. Whitford.

18. 1971. Physiological responses to temperature in the horned lizards, Phrynosoma cornutum and Phrynosoma douglassii. Copeia (3):489 -504. A.A. Prieto, Jr. and W.G. Whitford.

19. 1971. Oxygen consumption and water metabolism in a carnivorous mouse. Comp. Biochem. Physiol. 40A:797 - 803. W.G. Whitford and M.I Conley.

20. 1973. Adaptation of the tiger salamander Ambystoma tigrinum, to arid habitats. Comp. Biochem. Physiol. 46A:631- 638. J. Delson and W.G. Whitford.

21. 1973. Critical thermal maxima in several life histroy stages in desert and montane populations of Ambystoma tigrinum. Herpetologica 29(4):352 - 355. J. Delson and W.G. Whitford.

22. 1973. Oxygen consumption of two species of Pogonomyrmex harvester ants (Hymenoptera:Formicidae). Comp. Biochem. Physiol. 46A:605 - 611. W. G. Whitford & G. Ettershank.

23. 1973. The effects of temperature on respiration in the amphibia. Amer. Zool. 13:505 - 512. W.G. Whitford.

24. 1973. Combat in the horned lizard, Phrynosoma cornutum. Herpetologica 29(2):191 - 92. W.B. Whitford and W.G. Whitford.

25. 1974. The foraging ecology of two species of Chihuahuan desert ants: Formica perpilosa and Trachymyrmex smithi neomexicanus (Hymenoptera:Formicidae). Insectes Sociaux 21:317 - 330. A. Schumacher and W.G. Whitford.

26. 1975. Foraging ecology and relative importance of subterranean termites in Chihuahuan desert ecosystems. Environ. Entomol. 41(1):66 - 70. K.A. Johnson and W.G. Whitford.

27. 1975. Influences of temperature and humidity on oxygen consumption of five Chihuahuan desert ants. Comp. Biochem. Physiol. 52A:281 - 286. Whitford, W. G. & C.A. Kay
28. 1975. Water loss in Chihuahuan desert ants. Physiol. Zool. 48(4):390 - 397. W.G. Whitford, C.A. Kay and A.M. Schumacher.
29. 1975. Factors affecting foraging activity in Chihuahuan desert harvester ants. Environ. Entomol. 4(5):689 - 696. W.G. Whitford and G. Ettershank.
30. 1976. Sweating responses in the Chimpanzee Pan troglodytes. Comp. Biochem. Physiol. 53:333 - 336. W.G. Whitford.
31. 1976. Sweating responses in the rhesus monkey, Macaca mulatta. Comp. Biochem. Physiol. 53:337 - 341. W.G. Whitford and R.E. Sherman.
32. 1976. Changes in O2 consumption body water and lipid in burrowed desert juvenile anurans. Herpetologica 32(1):23 - 25. W.G. Whitford and K.H. Meltzer.
33. 1976. Ecological relationships in a desert anuran community. Herpetologica 32:7 - 18. F.M. Creusere and W.G. Whitford.
34. 1976. Comparative ecology of the harvester ants, Pogonomyrmex barbatus (F. Smith) and Pogonomyrmex rugosus (Emery). Insecters Sociaux 23:117 - 132. W.G. Whitford, P. Johnson and J. Ramirez.
35. 1976. Foraging behavior of Chihuahuan desert harvester ants. Amer. Midl. Natural. 95:455 - 458. W.G. Whitford.
36. 1976. Temporal fluctuations in density and diversity of desert rodent populations. J. Mammal. 57(2):351 - 369. W.G. Whitford.
37. 1976. Seasonal activity and water loss in four species of Eleodes Coleoptera:Tenebrionidae). Southwest Entomol. 1(4):161 - 163. W.E. Smith and W.G. Whitford.
38. 1976. Spatial and temporal variations in Chihuahuan desert ant faunas. Southwest Natural. 21(1):1-8. A. Schumacher and W.G. Whitford.
39. 1976. Growth characteristics of the range caterpillar, Hemileuca oliviae (Ckll.), on an artificial diet. The Southwestern Entomologist 1(4):164 - 167. T.D. Schowalter, W.G. Whitford and R. Turner.
40. 1977. Factors influencing the distributions of two species of Perognathus. Ecology 58:877 - 884. (with K.D. Hoover and P.Flavill).
41. 1977. Seasonal and yearly fluctuations in Chihuahuan desert lizard communities. Herpetologica 33:54 - 65. W.G. Whitford and F.M. Creusere.
42. 1977. An evaluation of transmission line construction in pinon-juniper woodland and grassland communities in New Mexico. J. Eviron. Manage. 5:127-137. (with J.A. Ludwig, A. Rodney and R. Grieve).

43. 1977. Bioenergetics of the range caterpillar, Hemileuca oliviae (Ckll.). Oecologia 28:153-161. T.D. Schowalter, W.G. Whitford and R.E. Turner.
45. 1978. Burrow environment of the banner-tailed kangaroo rat, Dipodomys spectabilis, in south central New Mexico. Amer. Midl. Natural. 99(2):270-279. F.R. Kay and W.G. Whitford.
46. 1978. Structure and seasonal activity of Chihuahuan desert ant communities. Insectes Sociaux 25(1):79-88. W.G. Whitford.
47. 1978. Critical thermal limits of desert honey ants: possible ecological implications. Physiol. Zool. 51:206-213. C.A. Kay and W.G. Whitford.
48. 1978. Effects of nitrogen fertilization on primary production in a Chihuahuan desert ecosytem. J. Arid Environ. 1:135-139. G. Ettershank, J. Ettershank and M. Bryant and W.G. Whitford.
49. 1978. Spatial distribution of litter and microarthropods in a Chihuahuan desert ecosystem. J. Arid Environ. 1:41-18. P.F. Santos, E. DePree and W.G. Whitford.
50. 1978. Factors affecting the nesting success of the large Carpenter Bee, Xylocopa californica arizonensis. Environ. Entomol. 7:614-616. W.E. Smith and W.G. Whitford.
51*. 1978. Foraging by seed harvesting ants. Pages 107-110. IN: Brian, M.V. ed. Production Ecology of Ants and Termites. Cambridge Univ. Press. 409 pp.
52. 1978. Effects of shrub defoliation on grass cover and rodent species in a Chihuahuan desert ecosystem. J. Arid Environ. 1:237-242. W.G. Whitford, S. Dick Peddie, D. Walter and J. A. Ludwig.
53. 1978. Foraging in seed harvester ants Pogonomyrmex spp. Ecology. 59:185-189. W.G. Whitford.
54. 1978. The use of termites and other soil fauna to develop soils on strip mine spoils. USDA Forest

Service Research Note RM 361. 4pp. G. Ettershank, N.Z. Elkins, P.F. Santos, W.G. Whitford and E.F.Aldon.
55. 1978. The effects of twig girdlers (Cerambycidae) and node borers (Bostrichidae) on primary production in mesquite (Prosopis glandulosa). J. Arid Environ. 1:345-350. W.G. Whitford, D.J. DePree and R.K. Johnson, Jr..
56. 1979. Behavior of a predator and its prey: the horned lizard, Phrynosoma cornutum and harvester ants (Pogonomyrmex spp.). Ecology 60:686-694. W.G. Whitford and M. Bryant.
57. 1979. Territorial behavior of Bootetix argentatus Bruner (Orthroptera: Arcrididae). Amer. Midl. Nat. 102:182-184. T.D. Schowalter and W.G. Whitford.
58. 1980. Foraging ecology of two Chihuahuan desert ant species: Novomessor cockerelli and Novomessor albisetosis. Insectes Sociaux. 27:148- 156. W.G. Whitford, E. DePree and P. Johnson.
59. 1980. Termites, microarthropods and the decomposition of senescent and fresh creosotebush (Larrea tridentata) leaf litter. J. Arid Environ. 3:63-68. H.G. Fowler and W.G. Whitford.
60. 1980. Arthropods and detritus decomposition in desert ecosystems. VII Intern. Soil Zool. Coll., Syracuse 1979. 879 pp. W.G. Whitford and P.F. Santos.
61. 1980. Location of food sources by subterranean termites. Environ. Entomol. 9:645-648. G. Ettershank, J.A. Ettershank and W.G. Whitford.
62. 1980. Surface litter breakdown in a Chihuahuan desert ecosystem. Pedobiologia. 4:243-245. W.G. Whitford, M. Bryant, G. Ettershank, J. Ettershank and P. F. Santos).
63. 1981. Behavioral responses of a predator, the round-tailed horned lizard, Phrynosoma modestum and its prey, honey pot ants, Myrmecocystus spp. Amer. Midl. Nat. 105:209-216. D. Schaffer and W.G. Whitford.
64.* 1981. Short-term water and energy flow in arid ecosystems. IN: Goodall & Perry. Arid Land Ecosystems: Structure Function and Management. Vol. 2 IBP 17. Cambridge Univ. Press. 217-199. J.A. Ludwig and W.G. Whitford.
65. 1981. Ant communities of southeastern longleaf pine plantations. Environ. Entomol. 10:183-185. W.G. Whitford and J.B. Gentry.
66. 1981. Foraging ecology of seed-harvesting ants, Pheidole spp. in a Chihuahuan Desert ecosystem. Amer. Midl. Nat. 105(1):159-216. W.G. Whitford, D.J. DePree, P. Hamilton and G. Ettershank.
67. 1981. The effects of microarthropods on litter decomposition in a Chihuahuan Desert ecosystem. Ecology 62(3):654-663. P.F. Santos & W.G. Whitford.
68. 1981. Mating behavior of Polyphylla diffracta (Coleoptera: Scarabaeidae). The Southwestern Naturalist 26(2):215-216. H.G.Fowler and W.G. Whitford.
69. 1981. The effects of microarthropods on litter decomposition in a Chihuahuan desert ecosystem. Ecology 62:654-663. P.F. Santos and W.G. Whitford.
70. 1981. The role of mites and nematodes in early stages of buried litter decomposition in a desert. Ecology 62:667-669. P.F. Santos, J. Phillips and W.G. Whitford.
71. 1981. Diurnal migration and responses to simulated rainfall in desert soil microarthropods and nematodes. Soil Biology and Biochem. 13:417-425. W.G. Whitford, D.W. Freckman, N. Elkins, L. Parker, R. Parmalee, J. Phillips and S. Tucker.
72. 1981. Nutrient cycling by the subterranean termite, Gnathamitermes tubiformans in a Chihuahuan desert ecosystem. Oecologia 48:277-83. D. Schaefer and W.G. Whitford.
73. 1981. Exceptions to the AET model: deserts and clear-cut forests. Ecology 62:275 277. W.G. Whitford, V. Meentemeyer, T. Seastedt, K. Cromack, Jr., D. A. Crossley, Jr., P. F. Santos,R. L. Todd and J. B. Waide.
74. 1981. Effects of vegetation change on ant communities of arid rangelands. Environ. Entomol. 10:893-897. W. Wisdom and W.G. Whitford.
75. 1981. Litter decomposition in the desert. BioScience 145-146. P.F. Santos and W.G. Whitford.
76*. 1982. The role of nematodes in decomposition in desert ecosystems. IN: Freckman, D. W. (ed.) Nematodes in Ecosystems, University of Texas Press. pp. 98-117. W.G. Whitford, D. Freckman, P. F. Santos, N.Elkins and L. Parker).
77. 1982. Factors affecting the applicability of the AET model for decomposition in arid environments. Ecology 63:579-580. N.Z.Elkins and Y. Steinberger and W.G. Whitford.
78*. 1982. Temporal and spatial resource partitioning in a Chihuahuan desert lizard community. pp.121-127. IN: Herpetological Communities: a Symposium of the Society for the Study of Amphibians and Reptiles and the Herpetologists' League.(N.J.Scott, Jr., ed.). U.S. Fish and Wildlife Reserve Report 13.

239 pp. F. Michael Creusere and W.G. Whitford.
1982. Effects of initial litter accumulation and climate on litter disappearance in a desert ecosystem. The American Midland Naturalist 108:105-110. W.G. Whitford, R. Repass, L.W. Parkerand N.Z. Elkins.

80. 1982. The role of microarthropods and nematodes in decomposition in a semi arid ecosystem. Oecologia 55:303-310. N.Z. Elkins and W.G. Whitford.
81. 1982. Contributions of subterranean termites to the "economy" of Chihuahuan desert ecosystems. Oecologia 55:298-302. W.G. Whitford, Y. Steinberger and G. Ettershank.
82. 1982. The contribution of shrub pruning by jackrabbits to litter input in a Chihuahuan desert ecosystem. J. Arid Environ. 6:183-187. Y. Steinberger and W.G. Whitford.
83. 1982. The contribution of rodents to decomposition processes in a desert ecosystem. J. Arid Environ. 6:177-181. Y. Steinberger and W.G. Whitford.
84. 1982. The relationship between wood litter infall and relative abundance and feeding activity of subterranean termite Reticulitermes spp. in three southeastern coastal plain habitats. Oecologia 54:63-67.J.B. Gentry and W.G. Whitford.
85. 1982. Floral visitation by Chihuahuan desert ants. J. Natural History 16:879-881. H.G. Fowler and W.G. Whitford.
86*. 1983. The contributions of soil fauna to nutrient cycles in desert systems. In: (Lebrun, Ph., H.M. Andre, A. de Medts, C. Gregoire-Wibo and G. Wauthy (eds.) New Trends in Soil Biology.Proceedings of the VIII Intl. Colloquium of Soil Zoology.Louvain Neuve (Belgium). August 30 September 2, 1982.Inprimeur Dieu Brichart, Louvain Neuve.
87. 1983. Soil respiration in a Chihuahuan Desert rangeland. Soil Biol. Biochem. 15:303 309. L.W. Parker, J. Miller, Y. Steinberger and W.G. Whitford.
88. 1983. Decomposition rates of various quantities of buried litter in a desert. Southwestern Naturalist 28:111-112. Sandra Urbaniak and W.G. Whitford
89. 1983. The effects of subterranean termite removal on desert soil nitrogen and ephemeral flora. J. Arid Environ. 5:53-59.L.W.Parker, H.G. Fowler, G. Ettershank and W.G. Whitford.
90. 1983. Seasonal and spatial variation in the soil microarthropod fauna of the White Sands National Monument. Southwestern Naturalist 28(4):417-421. Perseu Santos and W.G. Whitford.
91. 1983. The influence of soil biota on decomposition of plant material in a gypsum sand dune habitat. Southwestern Naturalist 28(4): 423-427. Perseu Santos and W.G. Whitford.
92. 1983. Predispersal seed feeding insects of a desert legume, Astragalus nutallianus. The Southwestern Naturalist 28(4):466-469. H.G.Fowler and W.G. Whitford.
93. 1983. Temperature regulation and metabolism in developing white-necked ravens. Comp. Biochem. Physiology 74A(3):605 -613. R. Mishaga and W.G. Whitford.
94. 1983. Structure and organization of awinter community of cavity inhabiting, web building spiders (Pholocidae and Theridiidae) in a Chihuahuan desert habitat. J. Arid Environ. 8:57 - 65. H.G. Fowler and W.G. Whitford.
95. 1984. Coordinated prey capture by Novomessor cockerelli (Hymenoptera: Formicidae). J. New York Entomol. Soc. 91(4):328 - 332. H.G.Fowler and W.G. Whitford.
96. 1984. Spatial and temporal relationships of soil microarthropods on a desert watershed. Pedobiologia 26:275 - 284. Y. Steinberger and W.G. Whitford.
97. 1984. Carbon and nitrogen dynamics during the decomposition of litter and roots of a Chihuahuan desert annual. Ecological Monographs 4(3):339 - 360. L.W. Parker, P.F. Santos, J.Phillips and W.G. Whitford.
98. 1984. A comparison of surface and buried Larrea tridenta leaf litter decomposition in North American hot deserts. Ecology 65(1):278 - 284. P.F. Santos, N.Z. Elkins, Y. Steinberger and W.G. Whitford.
99. 1984. Responses of soil biota to organic amendments in stripmine spoils in northwestern New Mexico. Journal of Environmental Quality 13(2):215-219. N.Z. Elkins, L.W. Parker, E. Aldon and W.G. Whitford.
1984. Life styles of desert soil microarthropods: a reappraisal based on the reproductive behaviour of Cryptostigmatid mites. South African Journal of Science 80:163-169. J.A. Wallwork, B.W. Kamill, and W.G. Whitford.

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microarthropods. Pedobiologia 26:267-274. Y. Steinberger, D.W. Freckman, L.W. Parker and W.G. Whitford.
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103. 1984. The effects of high salt concentration on desert soil microarthropod density and diversity. Southwestern Naturalist 29(2):239 - 241. N.Z. Elkins and W.G. Whitford.
104. 1985. Distribution and diversity patterns of soil mites and other microarthropods in a Chihuahuan desert site. J. Arid Environ. 9:215 - 231. J.A. Wallwork, B.W. Kamill and W.G. Whitford.
105. 1985. The failure of nitrogen and lignin control of decomposition in a North American desert. Oecologia 65:382 - 386. D. Schaefer, Y. Steinberger and W.G. Whitford.
106. 1985. Soil microarthropods from the Chihauhuan desert of New Mexico. Journal of Zoology (London) 205:273 -286. Bernadette W. Kamill, Y. Steinberger and W.G. Whitford.
107. 1985. Microarthropods of a desert tabosa grass (Hilaria mutica) swale. Amer. Midl. Nat. 114:225 - 234. Y. Steinberger and W.G. Whitford.
108. 1985. An analysis of above ground gallery construction by the subterranean termite Gnathamitermes tubiformans (Isoptera: Termitidae). Environmental Entomology 14:420
474. W.P. MacKay, J.H. Blizzard, J.J. Miller and W.G. Whitford.
109. 1985. The relative contributions of termites and microarthropods to fluff grass litter disappearance in the Chihuahuan Desert. Oecologia 67:31 - 34. S.I. Silva, W.P. MacKay and W.G. Whitford.
110. 1985. The effects of oxamyl and chlordane on the activities of non target soil organisms. Biol. Fert. of Soils 1:141 - 148. L.W. Parker, J. Ryder White, S. Thomas and W.G. Whitford.
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112. 1985. Structure and organization of a winter communityof cavity inhabiting, web-building spiders (Pholocidae and Theridiidae) in a Chihuahuan desert habitat. J. AridEnviron. 8:57 - 65. H. G. Fowler and W. G. Whitford.
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<u>EXHIBIT 2</u>

Comments on the Proposed Amendment to the New Mexico Oil Conservation Division Rule Book titled *19.15.1.21 Special provisions for the Chihuahuan Desert area*

John Shomaker & Associates, Inc.

JOHN SHOMAKER & ASSOCIATES, INC.
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(505) 345-3407, FAX (505) 345-9920

June 7, 2004

Ms. Davidson
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Written comments on the proposed amendment to the New Mexico Oil Conservation Division Rule Book titled *19.15.1.21 Special provisions for the Chihuahuan Desert area*

Dear Ms. Davidson:

John Shomaker & Associates, Inc. (JSAI) was contracted by The Wilderness Society to evaluate the proposed BLM Resource Management Plan (RMP) for the Otero Mesa and Salt Basin areas in New Mexico, and to provide comments on the proposed amendment to the New Mexico Oil Conservation Division Rule Book.

The focus of our evaluation of the BLM RMP was to determine if the water resources beneath Otero Mesa had been adequately described and if proper consideration had been made to protect the water resources. In our February 5th, 2004 report titled *Evaluation of potential water-resources impacts from BLM proposed resource management plan amendment from federal fluid minerals leasing and development in the Salt Basin, New Mexico*, (copy of report is enclosed) we concluded the following:

1. The proposed plan leaves approximately 70 percent of the public land open with standard lease terms and conditions, and no special provisions for protection of ground-water resources (public water supply). Proposed activities may include oil and gas exploration and development, with the potential for injection wells to dispose waste. Proposed activities and protection of identified water resources (public water reserves) would be regulated under standard lease terms and conditions (BLM, 2003).
2. Depth to water in the central part of the basin is around 200 ft, and many of the wells that produce from shallow perched ground water may have depth to water less than 100 ft (see well data in Appendix A). The BLM RMP and Environmental Impact Statement (EIS) do not include the shallow depth to water data in the analysis of water-resource impacts.
3. The majority of the Salt Basin is underlain by limestone (carbonate) rock that is fractured, and considered as a regional aquifer (Mayer, 1995; Mayer and Sharp, 1998).

4. The regional aquifer is similar to the Edwards Aquifer in Texas, where the recharge zone is sensitive to contamination and requires controlled surface use for protection. Oil and gas exploration and development activities should not be allowed in these areas where the aquifer is highly susceptible to contamination.
5. The Silurian-age Fusselman Dolomite has been reported by the oil and gas exploration industry as having "fresh" water in the Otero Mesa and Diablo Plateau areas. The Fusselman Dolomite is generally found at depths greater than 2,000 ft below land surface (Pearson, 1980; Harder, 1982).
6. The possibility of injection wells should be omitted from the RMP given the widespread distribution of fresh "public ground water beneath the Salt Basin, and the fractured nature of the aquifer(s)."

Proposed Amendment

The proposed amendment to the New Mexico Oil Conservation Division Rule Book titled *19.15.1.21 Special provisions for the Chihuahuan Desert area* covers the entire Otero Mesa area (19.15.1.21.A). The proposed amendment (19.15.1.21.B) does not allow for pits associated with oil and gas drilling, as described in 19.15.2.50 NMAC and 19.15.9.711 NMAC, although it is unclear if above-ground self-contained pits will be allowed or if there are exemptions to the proposed amendment. Special provisions have been proposed for produced water injection wells under amendment 19.15.1.21.C. The provisions are designed in good faith to protect fresh-water resources by requiring tests to identify fresh-water aquifers, and to isolate fresh-water aquifers from the injection well and associated facilities.

The proposed amendment does not prohibit the installation and use of injection wells and associated facilities in areas where fresh-water aquifers are highly sensitive to contamination via surface spills or factures and preferential pathways.

The main concern regarding the proposed amendment is that is does not include provisions to protect fresh-water recharge areas by completely omitting the potential of contamination from pits (above or below ground), injection wells, and associated facilities. As a result, JSAI was requested to address additional questions regarding details about the migration of potential contaminants from oil and gas development on Otero Mesa, New Mexico, such as:

A. How vulnerable are existing and proposed water supply wells to potential contamination from Oil and Gas development activities on Otero Mesa?

B. What hydrogeologic issues are there in relation to oil and gas production activities? (i.e., impacts to aquifer)

Provided below is a discussion on vulnerability of the fresh-water resources in the Otero Mesa area.

Vulnerability of Water Supply Beneath Otero Mesa

The vulnerability of the aquifer beneath the Otero Mesa can be inferred from fracture mapping performed by Mayer (1995), the direction of ground-water flow, and the proximity of water-supply wells to the BLM land proposed for oil and gas development (shown on the attached map). In many areas there are existing or proposed water-supply wells in the same area as BLM land proposed for oil and gas development.

The areas of highest vulnerability for contamination of the regional aquifer beneath Otero Mesa are in the areas where the fracture density is highest in the central part of the Salt Basin (shown on the attached map).

Potential for Contaminant Migration in Salt Basin

The aquifer beneath Otero Mesa (Salt Basin) is composed of carbonate rocks of the Permian-age Bone Springs Victorio Peak Formation. This rock unit has been tectonically altered by the Otero Break; a region of numerous faults and fractures. These faults and fractures relay ground water recharge from the Sacramento Mountains to the Dell City area, where extensive ground water development has occurred.

In addition to being fractured by the Otero Break, the Bone Springs Victorio Peak aquifer has been characterized as a "karst" aquifer containing solution-cavities and caverns. There are two flow regimes that occur in karst settings, which are as follows:

1. Pipe Flow – fluids completely fill the solution cavities and channels, and the fluid movement may be described as non-turbulent pipe flow.
2. Open-Channel Flow – fluid movement occurs as subterranean streams through modest to large solution cavities and caverns (Gorelick and Others, 1993)

Either flow regime results in a tracer velocity greater than that observed in porous media such as sand and gravel.

There are no known case studies of contaminant migration for the Bones Springs Victorio Peak aquifer, although case studies and other information on the comparable Edwards Aquifer in central Texas may suggest possible examples of contaminant migration beneath Otero Mesa. Tracer velocities of 30 ft/day have been calculated for the Edwards Aquifer by Maclay and Small (1986), but the actual tracer velocity in the Bone Springs Victorio Peak aquifer would depend on the quantity of recharge and discharge driving the flow.

In summary, water supply beneath Otero Mesa is highly vulnerable to contamination by proposed oil and gas development because of the proximity of existing water supply wells and the porous nature of the regional aquifer. Due to the potential for rapid migration of contaminants, remediation would be very difficult, and permanent degradation of water quality would be likely. There is also a lack of data on the fresh-water resources for making long-term decisions about oil and gas development and associated activities. For these reasons, oil and gas exploration and development activities should be omitted from the Otero Mesa area where fractured carbonate rocks at the surface and at depth are highly susceptible to potential spills and leaks of contaminated fluids from pits and injection wells. In addition, permitting of pits and injection wells in other parts of the Chihuahuan Desert area should require detailed hydrogeologic analysis of the proposed facility and demonstrate contamination will not occur.

Based on the findings from our analysis of the hydrogeologic setting beneath Otero Mesa, we recommend prohibiting pits, injection wells, and the facilities associated with oil and gas exploration and development in the Otero Mesa area, particularly the area of high fracture density shown on the attached map. This is particularly appropriate at this time, given the lack of detailed hydrogeologic analysis and demonstration that contamination will not occur.

Sincerely,

JOHN SHOMAKER & ASSOCIATES, INC.

Steven T. Finch, Jr.
V.P. - Senior Geochemist/Hydrogeologist

STF:sf

Encl: Report prepared by JSAI
Map of Otero Mesa

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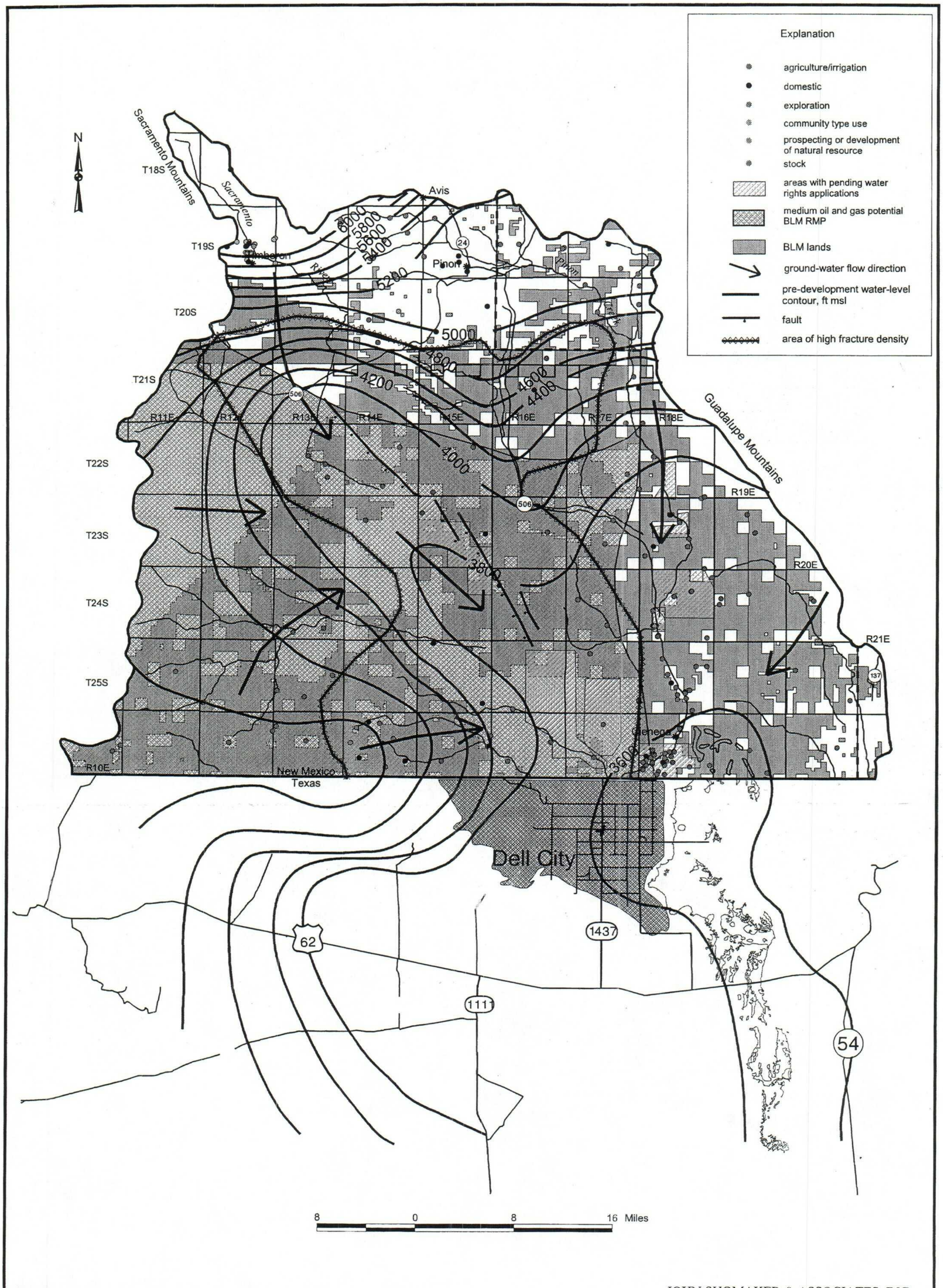

JOHN SHOMAKER & ASSOCIATES, INC.

EVALUATION OF POTENTIAL WATER-RESOURCE IMPACTS FROM BLM PROPOSED RESOURCE MANAGEMENT PLAN AMENDMENT FOR FEDERAL FLUID MINERALS LEASING AND DEVELOPMENT IN THE SALT BASIN, NEW MEXICO

prepared by

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Otero Mesa Coalition

February 6, 2004

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EVALUATION OF POTENTIAL WATER-RESOURCE IMPACTS FROM BLM PROPOSED RESOURCE MANAGEMENT PLAN AMENDMENT FOR FEDERAL FLUID MINERALS LEASING AND DEVELOPMENT IN THE SALT BASIN, NEW MEXICO

1.0 INTRODUCTION

John Shomaker & Associates, Inc. (JSAI) was contracted by the Otero Mesa Coalition to provide a technical opinion on the U.S. Department of Interior Bureau of Land Management (BLM) proposed resource management plan for the Otero Mesa area. The BLM document is titled *Proposed Resource Management Plan Amendment and Final Environmental Impact Statement for Federal Fluid Mineral Leasing and Development in Sierra and Otero Counties* (BLM, 2003).

The primary area of concern and review is the Otero Mesa and surrounding area within the Salt basin, New Mexico (Fig. 1). As stated in the Resource Management Plan (RMP), some of the criteria in developing the plan included (but was not limited to) the following:

1. Provide for the protection of water resources
2. Maintain public health and safety
3. Consider social and economic effects

1.1 BLM Proposed Plan

According to the proposed plan, the majority of public land in the Salt Basin part of Otero County would remain open to fluid mineral leasing. The BLM (public land) in the Salt Basin is shown on Figure 1, and comprises more than 70 percent of the basin (approximately 850,000 acres). The proposed plan leaves approximately 70 percent of the public land open with standard lease terms and conditions and no special provisions for protection of ground-water resources (public water supply). Proposed activities may include oil and gas exploration and development, with the potential for injection wells to dispose waste. Proposed activities and protection of identified water resources (public water reserves) would be regulated under standard lease terms and conditions (BLM, 2003).

1.2 Objective and Purpose

The objective and purpose of this report is to address the following issues:

- Identify water resources underlying Otero Mesa that the BLM has not recognized or adequately addressed
- Identify areas of the aquifer that could potentially be impacted from surface disturbances (i.e., recharge zones)
- Identify activities and methods related to oil and gas exploration and development that could affect the existing aquifer(s)

2.0 DESCRIPTION OF REGIONAL AQUIFER(S)

The Salt basin is a large, internally drained basin covering about 5,900 square miles, of which 4,000 square miles are in Texas and the remaining 1,900 square miles are located just across the state line in New Mexico (Bjorklund, 1957). The water in the Salt Basin originating in New Mexico flows toward Texas. The portion of the Salt Basin in New Mexico includes Crow Flats and Otero Mesa. The Crow Flats portion of the basin drains to a series of alkali flats or playas to the south, just above the state line (Bjorklund, 1957). Irrigation with ground water has occurred in the Salt Basin near the New Mexico-Texas border, an extension of the agricultural area referred to as the Hudspeth County Underground Water District No. 1 (HCUWD#1) in Dell City, Texas.

Major watersheds within the New Mexico portion of the Salt Basin include the Sacramento River, Piñon Creek, and Shiloh Draw (Fig. 1). The Sacramento River drains the southern end of the Sacramento Mountains, where elevations of the upper watershed range from 8,000 ft to 9,500 ft.

Depth to water in the central part of the basin is around 200 ft, and many of the wells have depth to water less than 100 ft (see well data in Appendix A).

2.1 Structure and Framework

The Salt Basin is an extensional basin that widens to the south and is bordered on the east by the Guadalupe and Brokeoff Mountains and on the west by the Hueco Mountains and Otero Mesa. The Salt Basin is a block-faulted graben bounded by faults that extends 260 miles from the Sacramento River south into Texas (Fig. 1). The Crow Flat area is at lower elevation than the surrounding mesas, plateaus, and mountains, and is the site of the salt flats where ground-water discharges and evaporates.

Faults and associated folds on the eastern side of the basin represent the eastern extent of the Rio Grande Rift portion of the Basin and Range physiographic province. A good description of the hydrogeologic setting for the Salt Basin can be referenced from TWDB/NMWRRI (1997).

Ground-water flow in the limestone rocks of the Salt Basin is largely controlled by regional fracture systems (Mayer and Sharp, 1998). The most significant regional fracture system in the Salt Basin area is referred to as the Otero Break, trending from the Sacramento River to Dell City, Texas.

The Otero Break structural feature "graben" formed in late Paleozoic time along a northwest fault zone from right-lateral shear and extensional forces (Mayer, 1995). This fault zone was reactivated during the development of Basin and Range extension (Salt Basin), and extensively fractured the Permian-age carbonate rocks (Yeso Fm., San Andres Fm., etc) that occupy the majority of the Salt Basin and Otero Mesa area (Fig. 2).

2.2 Geologic Units

A summary of the geologic units found in the study area is presented as Table 1, and shown on Figures 2 through 4. Tertiary igneous intrusions of both andesitic and basaltic composition are present in the Cornudas Mountains and Dell City area (Dietrich et al. 1995). Quaternary-age basin fill in the form of alluvium and piedmont deposits, as well Santa Fe Group sediments, can be more than 500 ft thick, but in most places range from 25 to 300 ft thick (Bjorklund, 1957).

The principal bedrock aquifer units in the New Mexico portion of the Salt Basin are the San Andres Limestone, Yeso Formation, and Abo (Hueco) Formation, which together make up the bulk of the water bearing strata. In the Dell City area, the carbonate rock aquifer is referred to as the Victorio Peak-Bone Spring. Older formations (pre-Permian-age rocks), such as the Fusselman Dolomite, are water bearing and may possibly contain a viable public water supply.

Table 1. Summary of geologic units for the Salt Basin

age	symbol	stratigraphic unit	thickness, ft	description
Quaternary	Qal	alluvium	200 - 500	basin fill - unconsolidated clay, silt, sands, and gravels
	Qts	Upper Santa Fe Group	500 - 2000	basin fill - silts, sands, and gravels
Tertiary	Ti	intrusives	10 - 100	igneous intrusives - dikes and sills
Permian	P	Permian undivided	2000 - 5000	shale, limestone, mudstone, gypsum
	Psa/ Pvp	San Andres/ Victorio Peak	200 - 1000	limestone
	Pbs	Bone Spring	900 – 1,700	limestone
	Py	Yeso Formation	1200 - 1800	interbedded limestones and shales
	Pa/ Ph	Abo/ Hueco Formations	200 - 500	mudstones and conglomerates
	Pb	Bursum Formation	400 - 600	interbedded siltstones, sandstones, shales and conglomerates
Pennsylvanian	IPh	Holder Formation	500 - 900	interbedded limestones and conglomerates
		Gobbler Formation	1200 - 1600	sandstones and conglomerates
Mississippian	M	Lake Valley Formation	350 - 450	interbedded limestones and shales
Devonian	D	Percha Shale	40 - 80	black noncalcareous shale
Silurian	Sf	Fusselman Dolomite	20 - 100	massive dolomite with chert
Ordovician	Om	Montoya Formation	190 - 225	massive dolomite
Cambrian	Ce	El Paso Formation	350 - 450	dolomitic sandstone
		Bliss Sandstone	100 - 150	quartz sandstone
Precambrian	pC	granite	--	granites and granodiorites

Figure 2 is a map showing the distribution of major geologic units that make up the aquifer(s) in the study area. On Figure 2, the basin-fill deposits (Qal) refer to alluvium and Upper Santa Fe Group listed in Table 1; other Permian-age rocks are equivalent to Permian undivided. Cretaceous rocks refer to the Cox Sandstone and other overlying and underlying rocks of similar age.

The upper sequence of Permian-age rocks, Yeso, San Andres, Bone Spring, and Victorio Peak Formations, were deposited in a shallow sea environment behind the reef margin of the Delaware Basin. These carbonate rocks typically become more permeable toward the reef margin (Capitan reef in the Guadalupe Mountains), which would suggest increasing permeability to the southeast in the New Mexico portion of the Salt Basin. The lower member of the San Andres Formation grades to the southeast toward the Permian reef facies into the Victorio Peak Formation (Black, 1975). Therefore, the Victorio Peak is equivalent, in time of deposition, to the upper Yeso and lower San Andres. Cross-sections showing the relationship of major geologic units from west to east, across the New Mexico portion of the Salt Basin, are provided as Figures 3 and 4.

The San Andres Limestone and Yeso Formation cover most of the upper portion of the Salt Basin (Fig. 2). The San Andres Formation is composed of limestone, with sandstone at the base of the formation. The Yeso consists of sandstone, limestone, dolomite, siltstone, shale, and evaporites (Pray, 1961). The Yeso Formation is approximately 1,000 ft thick in the southern Sacramento Mountains (Kelly, 1971). Many of the springs in the southern Sacramento Mountains discharge from the contact between the San Andres and Yeso Formations. Most wells that yield water from the Yeso Formation are completed in the upper 500 ft of the formation in fractured limestone and dolomite where the permeability has been enhanced by solution. In the Timberon area, wells drilled into the lower Yeso Formation are typically low yielding (<5 gpm) as compared with wells in the upper Yeso, which produce more than 100 gpm.

The Bone Spring-Victorio Peak aquifer extends from Crow Flat in an arc to the south around the edge of the Permian-age Delaware Basin. The Bone Spring-Victorio Peak aquifer is present under most of the east part of the Diablo Plateau (Fig. 2). High-yield irrigation wells that produce from the Bone Spring-Victorio Peak aquifer commonly intercept fractures that have been opened by the percolation of ground water from overlying alluvium (Scalapino, 1950; Bjorklund, 1957). Scalapino (1950) reported that approximately 50 percent of the wells drilled are high-yield (> 1,000 gpm) and the other half are low-yielding (< 500 gpm).

Rocks older than Permian include (1) Pennsylvanian- and Mississippian-age limestone and shale, (2) shale, dolomite, and sandstone of Devonian-, Silurian-, Ordovician-, and Cambrian-age, and (3) Precambrian-age granite and metamorphic rocks (see Table 1).

Exploration drilling has indicated biogenic gas is associated with the Pennsylvanian- and Mississippian-age organic shale, which is formed by decomposition of organic matter by fresh water microbes.

The Silurian-age Fusselman Dolomite has been reported by the oil and gas exploration industry as having "fresh" water in the Otero Mesa and Diablo Plateau areas. The Fusselman Dolomite is generally found at depths greater than 2,000 ft below land surface (Black, 1975; Pearson, 1980; Harder, 1982).

2.3 Recharge

Due to the absence of perennial streams in the basin center, ground-water recharge is mainly infiltration of precipitation from melting snowpack and during flash flooding of ephemeral channels (Bjorklund, 1957). Most of the water for recharge originates from the higher elevations of the Sacramento River and Piñon Creek watersheds. The total annual average yield of these watersheds is approximately 35,000 ac-ft/yr (Table 2). The area of these watersheds is approximately 20-percent of the total area for the New Mexico portion of the Salt Basin.

Table 2. Watersheds in the Salt Basin, and summary of watershed data and estimated yield

name	mean annual precipitation, in./yr	mean elevation, ft amsl	area, mi^2	estimated watershed yield, ac-ft/yr
Sacramento River	22.8	7,795	135	17,580
Piñon Creek	20.0	7,100	99	8,872
small un-named watersheds and mountain front on Otero Mesa and Cornudas and Brokeoff Mountains	17.2	6,500	124	8,626
Salt Basin total			358	35,078

in./yr inches per year
mi^2 square miles
ft amsl feet above mean sea level
ac-ft/yr acre-feet per year

The watershed yield analysis was performed by evaluating monthly precipitation and potential evaporation data collected from weather stations in the region (Livingston Associates and John Shomaker & Associates, Inc., 2001).

The watershed yield analysis indicates that aerial recharge does not occur below an elevation of 5,860 ft, although below an elevation of 5,860 ft recharge from storm-water runoff occurs along arroyos and highly fractured rock where infiltration rates are high. Total watershed yield calculated for the Salt Basin area is 35,000 ac-ft/yr (Table 2), with approximately one-half originating from the Sacramento River Watershed.

Due to the fractured conditions of the rocks, all of the 35,000 ac-ft/yr plus storm-water runoff infiltrates into the ground-water system and can be considered as recharge.

Mayer (1995) estimated a total average annual rate of recharge at 58,000 ac-ft/yr for the Salt Basin, which included part of the Diablo Plateau in Texas.

2.4 Direction of Ground-Water Flow

Ground-water elevation contour maps for only parts of the study area have been developed by Ashworth (1995), Mayer (1995), and TWDB/NMWRRI (1997). The water-level contour maps from Ashworth (1995) and TWDB/NMWRRI (1997) are limited to the Dell City area and are representative of near present pumping conditions. The water-level contouring by Mayer (1995) was limited to a few data points in New Mexico, and implied a relatively flat hydraulic gradient throughout the study area.

The ground-water elevation contour map shown as Figure 5 was constructed from data from existing reports, the Texas Water Development Board (TWDB) database, and the New Mexico Office of the State Engineer (NMOSE) WATERS database. There are several areas where water-level data are absent, and extrapolation between data points 10 to 20 miles apart was made. Additional data are needed for Otero Mesa, Diablo Plateau, and the northern fringes of Otero Break to have a more accurate ground-water elevation contour map of the study area.

Regional ground-water flow is from the northern Salt Basin, Otero Mesa, and Diablo Plateau toward the Salt Flats near Dell City (Fig. 5). Ground-water elevation contours along the northern watershed boundary of the Salt Basin, between Timberon and Piñon, indicate ground-water flow from the Peñasco Basin to the Salt Basin.

The direction of ground-water flow from Otero Mesa and the Sacramento watershed area is toward the highly fractured region referred to as Otero Break. The fractured rocks of Otero Break have very high permeability and, as a result, effectively transport water to the

Dell City area and Salt Flats. Figure 6 is an aerial photograph of a portion of the Otero Break area (T23S, R16E), showing the visibility and northwest orientation of the regional fracture system.

Ground-water flows radially away from the Cornudas Mountains, presumably as a result of recharge there. Mayer (1995) suggested the water levels in the Cornudas Mountains indicate a perched water table, but data from nearby deep wells still show radial flow from the Cornudas Mountains.

2.5 Current and Historic Use

The primary uses of ground water in the New Mexico portion of the Salt Basin have been for domestic supply, stock watering, and irrigation. Irrigation has primarily been in the Crow Flat area. Bjorklund (1957) reported 3,000 acres of irrigated land from 17 wells in 1956, all in the Crow Flats area with most of it near the New Mexico-Texas state line.

Stock wells are scattered throughout the Salt Basin, and several of them are converted oil and gas exploration wells. A list of well data from the NMOSE WATERS database is provided in Appendix A. Existing wells are shown on the map provided as Figure 7.

Timberon Water & Sanitation District has approximately 1,500 ac-ft/yr of surface-water rights associated with Carriza Spring, tributary to the Sacramento River. Table 3 summarizes the declared water rights in the Salt Basin.

Table 3. Summary of declared water rights in Salt Underground Water Basin, New Mexico

use	declared water rights, ac-ft/yr
domestic	80
stock	566
municipal	1,499
irrigation*	47,595
total	49,740

* Hunt Development Corp. has declared 35,290 ac-ft/yr for irrigation of 3,600 acres
ac-ft/yr acre-feet per year

The majority of pumping from the Salt Basin occurs in the Dell City area, in Texas. Ashworth (1995) and Scalapino (1950) have summarized the acre-feet pumped for the HCUWD#1 (Dell City area), as listed in Table 4. Irrigation in the Dell City area began in 1947, and approximately 26,000 acres are currently irrigated for growing alfalfa, cotton, and chile. The HCUWD#1 claims 36,000 acres can potentially be irrigated, which would require about 180,000 ac-ft/yr of pumping at the current application rate of about 5 acre-feet per acre. Wilson and Lucero (1997) estimated a total pumping for irrigation in the New Mexico side of the Salt Basin at 10,171 ac-ft/yr in 1995.

Table 4. Summary of historic pumping for irrigation in the Dell City area

year	acre-feet pumped
1948[a]	7,500
1949[a]	18,000
1958[b]	67,000
1964[b]	91,500
1974[b]	132,700
1979[b]	144,600
1984[b]	102,000
1989[b]	94,700
1994[c]	100,000
1999[c]	100,000

[a] from Scalapino (1950)
[b] from Ashworth (1995)
[c] from HCUWD#1

2.6 Future Use

Recognizing the importance of the public ground-water reserve, the New Mexico State Engineer declared the Salt Underground Basin in September 13, 2000. After the basin was declared, several applications have been filed to further develop the water resources in Crow Flat and Otero Break (Fig. 7).

The Tularosa-Salt Basin Regional Water Plan was adopted by the New Mexico Interstate Stream Commission in May 2002, which defines the water resources of the Salt Basin and outlines current and future use. Even though the Salt Basin is sparsely populated and remote, the vast water supply in the Salt Basin is an important alternative resource for the future of New Mexico. Alternatives include development and importation to areas of need, as well as, preservation for use beyond the 40-year planning horizon.

The State Water Plan for New Mexico (selected pages in Appendix C) contains the following discussion on the Salt Basin and associated water resources:

- The availability of safe and adequate drinking water supplies for all New Mexicans is of paramount importance to the health and safety of the State's citizens (pg 6).
- Little development of the Salt Basin has occurred in New Mexico, but pressure to develop this resource is growing (appendix A, A-36)
- Steps must be taken to ensure that water from the basin is preserved to meet growing demands in southern New Mexico (appendix A, A-37)

3.0 DEFICIENCIES IN BLM RMP AND EIS

3.1 Identification of Water Resources and Potential Impacts

The BLM RMP and EIS did not review and include key publications on the water resources for the impact assessment (see references Section 5.0, and Appendix B).

- The majority of the Salt Basin is underlain by limestone (carbonate) rock that is fractured, and considered a regional aquifer (Mayer, 1995; Mayer and Sharp, 1998). Detailed description of this regional aquifer can be obtained from the references provided in Appendix B.
- The shallow alluvial aquifer is localized to arroyo and stream channels where recharge occurs. The alluvial aquifer is used for domestic and stock purposes. Depth to water is shallow in the alluvial aquifer rendering it susceptible to contamination from surface disturbances.
- There are potentially significant fresh water resources above and below the target formations for oil and gas development.
- The full extent of the water resources in the Salt Basin has not been defined.

3.2 Characterization of Aquifer(s) and Sensitivity to Management Alternatives

The BLM RMP and EIS did not identify the regional fractured carbonate rock aquifer beneath the Salt Basin and its susceptibility to surface disturbances related to oil and gas development.

- The regional aquifer is similar to the Edwards Aquifer in Texas, where the recharge zone is sensitive to contamination and requires controlled surface use for protection.
- The majority of the Salt Basin has fractured Permian-age carbonate rocks exposed at the surface, which is part of the regional aquifer. The fracture density has been quantified by Mayer and Sharp (1998), in which fracture density can be as high as 15,800 ft per square mile; in some cases fractures are no more than one meter apart (see discussion and photographic documentation by Mayer (1995) in Appendix B). Fractures are exposed at the land surface and potentially provide pathways for contaminant migration to the regional aquifer.
- The hydraulic conductivity for the Otero Break area is estimated to average 100 ft/d, and the hydraulic gradient estimated from Figure 5 is 0.002 ft/ft. Using Darcy's Law to calculate the tracer velocity, an average value of 20 ft/d was calculated for the fractured part of the aquifer at Otero Break (assuming an effective porosity of 0.01). With in a particular facture, the tracer velocity may be several orders of magnitude greater. This indicates how rapid contaminants could travel once introduced into the aquifer.

3.3 Ground-Water Protection Measures

Additional ground-water protection measures need to be implemented to insure protection of water resources in the Salt Basin.

- The possibility of injection wells should be omitted from the RMP given the widespread distribution of fresh "public ground water beneath the Salt Basin, and the fractured nature of the aquifer(s)."
- The fracture density study performed by Mayer (1995) could provide guidance for determining areas of the aquifer susceptible to contamination from surface disturbances. It is likely a more detailed fracture evaluation will need to be undertaken before land management decisions are made.

3.4 Economic and Ranking Evaluation of Resources

The BLM RMP and EIS should review existing water plans for the Salt Basin and incorporate those into resource evaluation and protection of water resources identified for future use. (excerpts from the State Water Plan can be referenced in Appendix C).

- The value of the water resources and fluid mineral resources should be evaluated, and appropriate methods should be used to rank resources based on impacts, value, and sustainability.

4.0 CONCLUSIONS AND FINDINGS

1. The proposed plan leaves approximately 70 percent of the public land open with standard lease terms and conditions and no special provisions for protection of ground-water resources (public water supply). Proposed activities may include oil and gas exploration and development, with the potential for injection wells to dispose waste. Proposed activities and protection of identified water resources (public water reserves) would be regulated under standard lease terms and conditions (BLM, 2003).
2. Depth to water in the central part of the basin is around 200 ft, and many of the wells that produce from shallow perched ground water may have depth to water less than 100 ft (see well data in Appendix A). The BLM RMP and EIS does not include the shallow depth to water data in the analysis of water-resource impacts.
3. The majority of the Salt Basin is underlain by limestone (carbonate) rock that is fractured, and considered as a regional aquifer (Mayer, 1995; Mayer and Sharp, 1998).
4. The regional aquifer is similar to the Edwards Aquifer in Texas, where the recharge zone is sensitive to contamination and requires controlled surface use for protection.

5. The Silurian-age Fusselman Dolomite has been reported by the oil and gas exploration industry as having "fresh" water in the Otero Mesa and Diablo Plateau areas. The Fusselman Dolomite is generally found at depths greater than 2,000 ft below land surface (Black, 1975; Pearson, 1980; Harder, 1982).

6. The possibility of injection wells should be omitted from the RMP given the widespread distribution of fresh "public ground water beneath the Salt Basin, and the fractured nature of the aquifer(s)."

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ILLUSTRATIONS

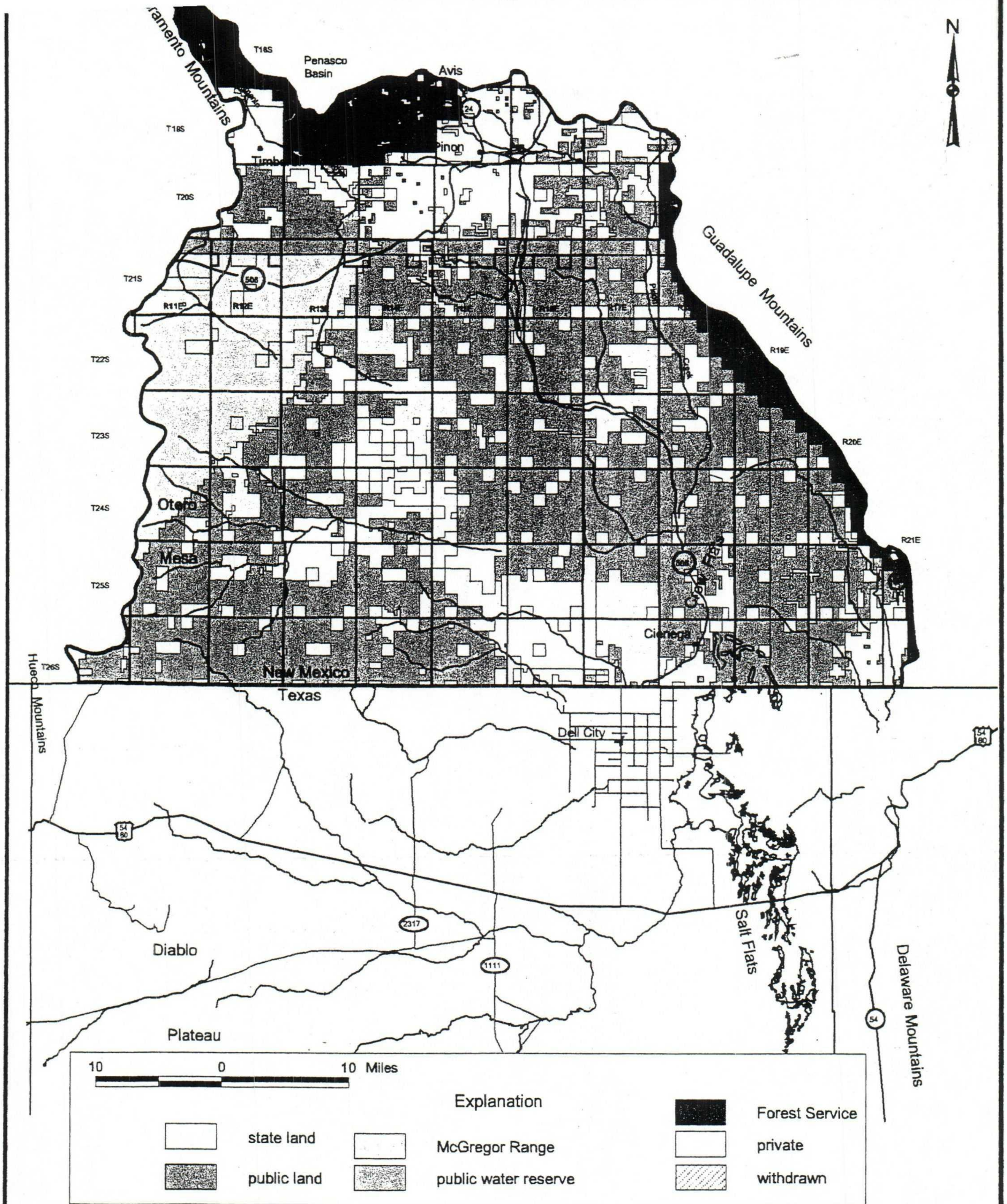

Figure 1. Map showing location of study area, land ownership, and geographic features within the Salt Basin and Diablo Plateau.

JOHN SHOMAKER & ASSOCIATES, INC.

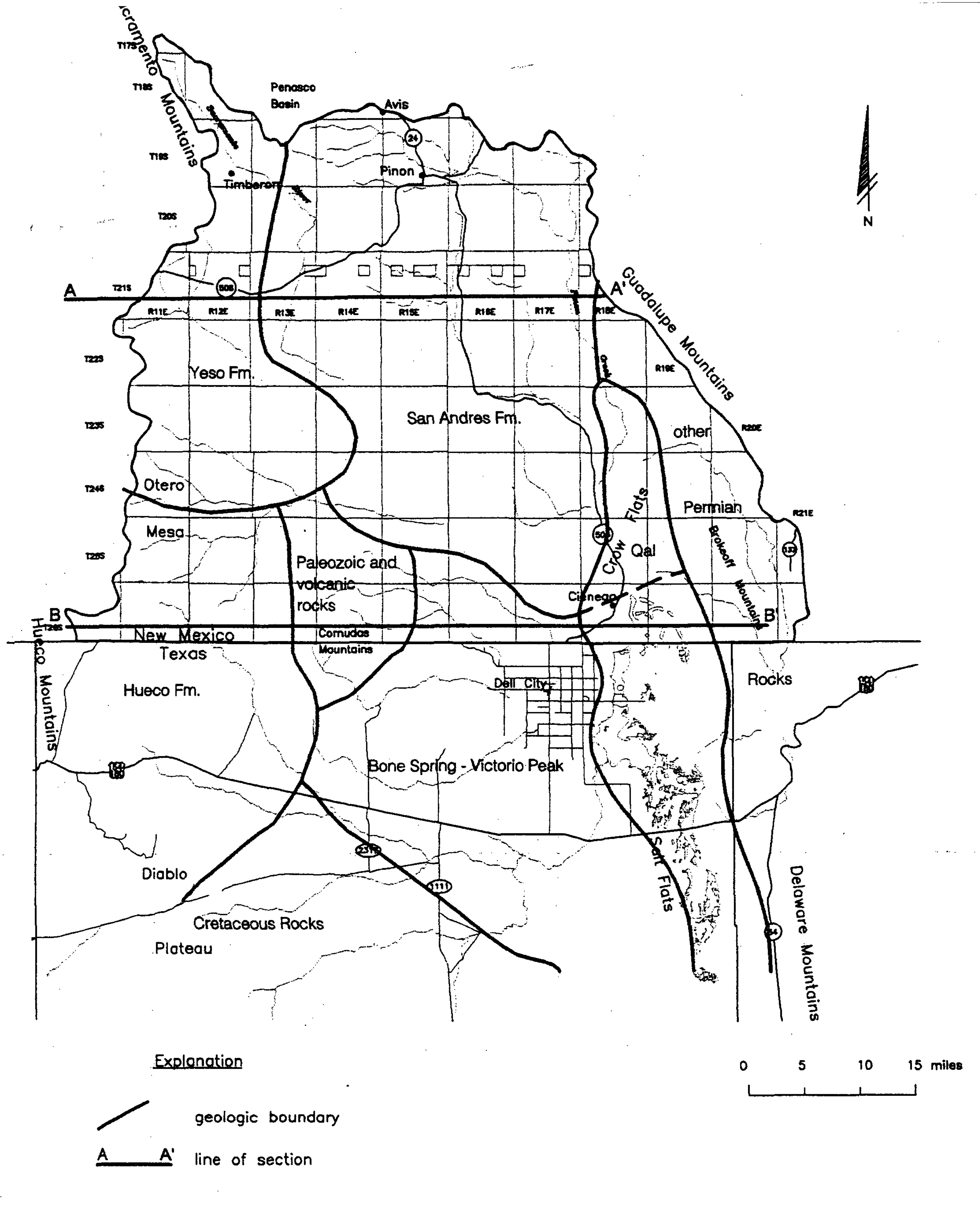

Figure 2. Map showing regional geology of the Northern Salt Basin and Diablo Plateau.

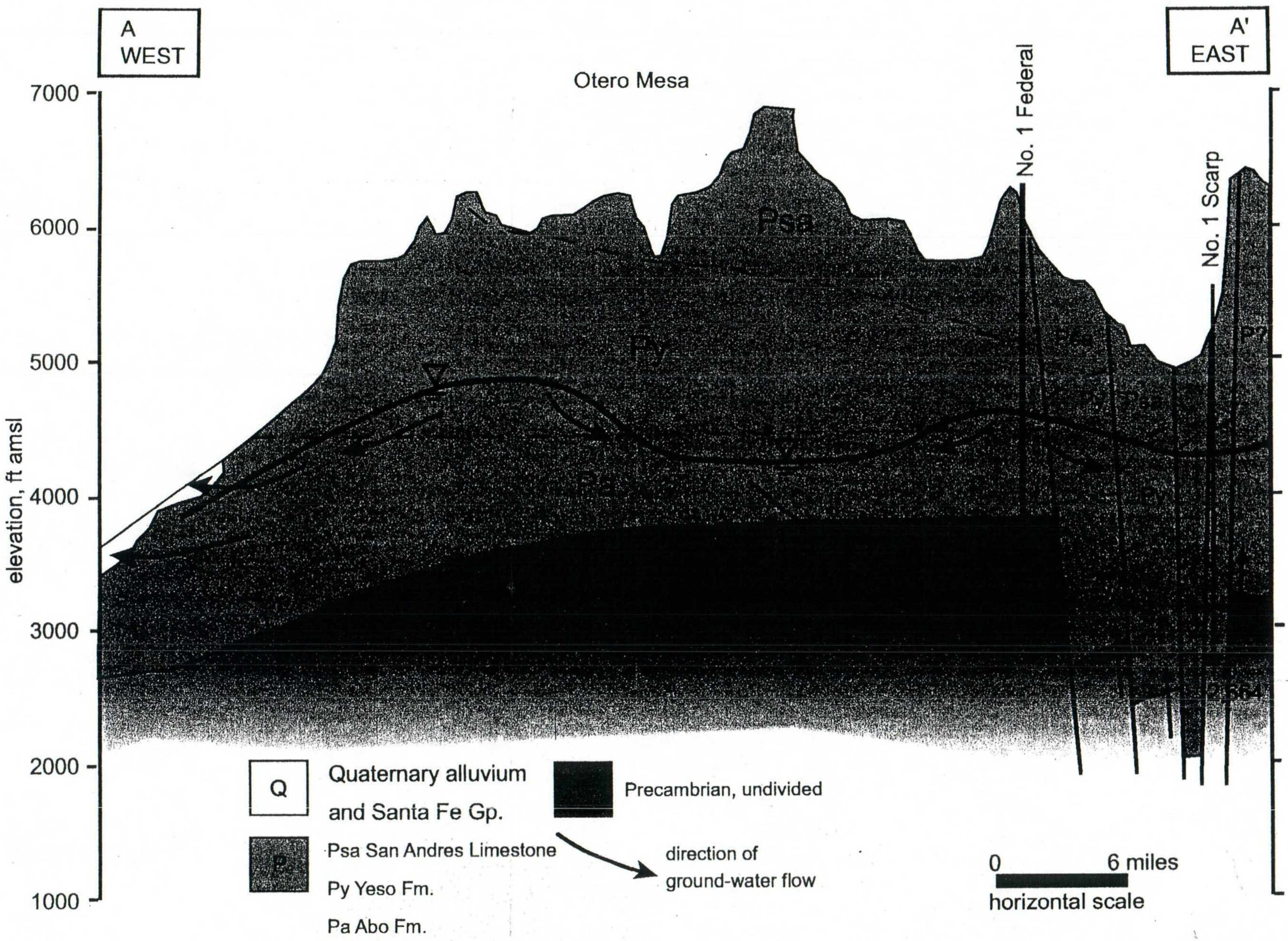

Figure 3. Hydrogeologic cross-section, A-A', Salt Basin.

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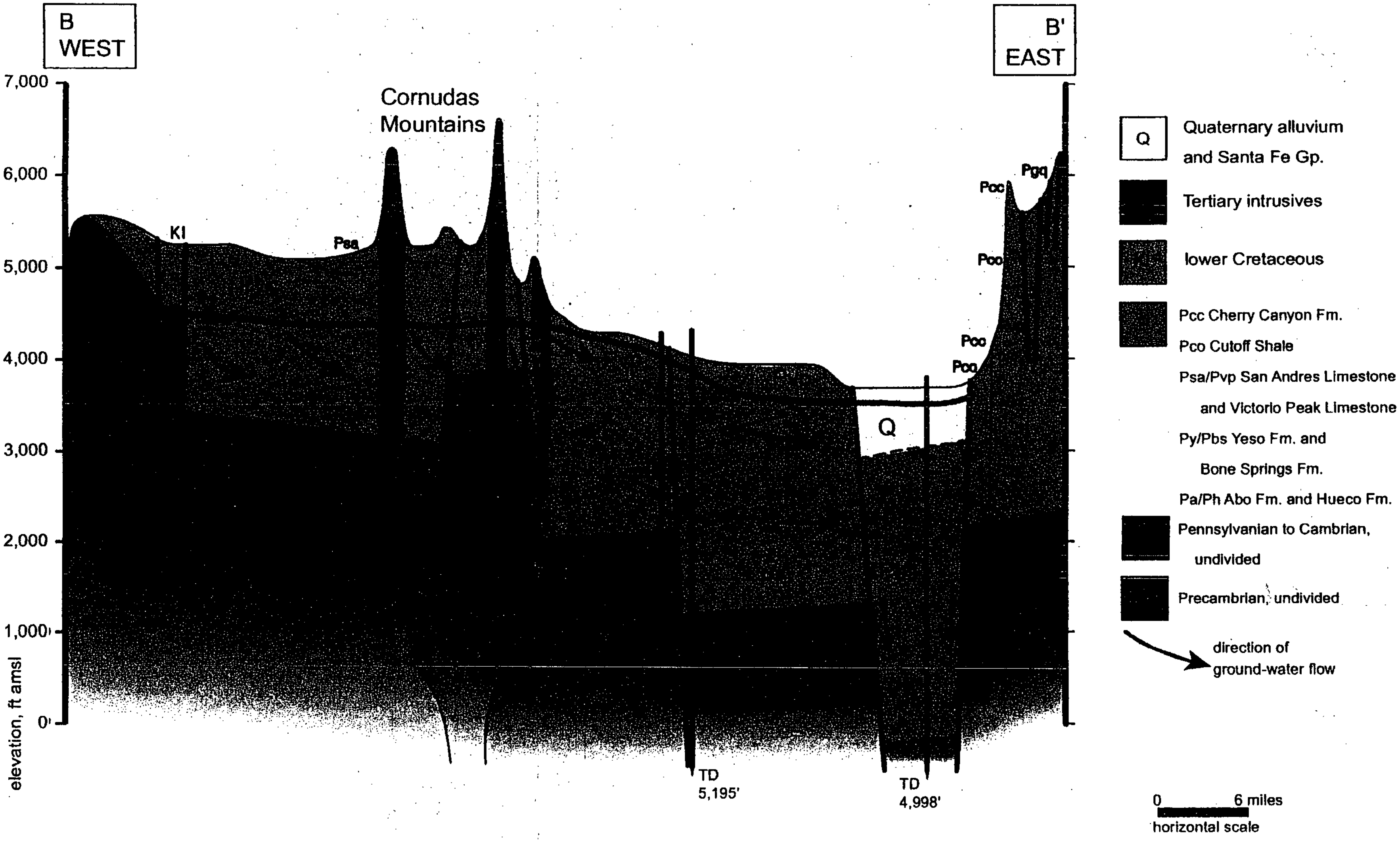

Figure 4. Hydrogeologic cross-section, B-B', Salt Basin.

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WATER-RESOURCE AND ENVIRONMENTAL CONSULTANTS

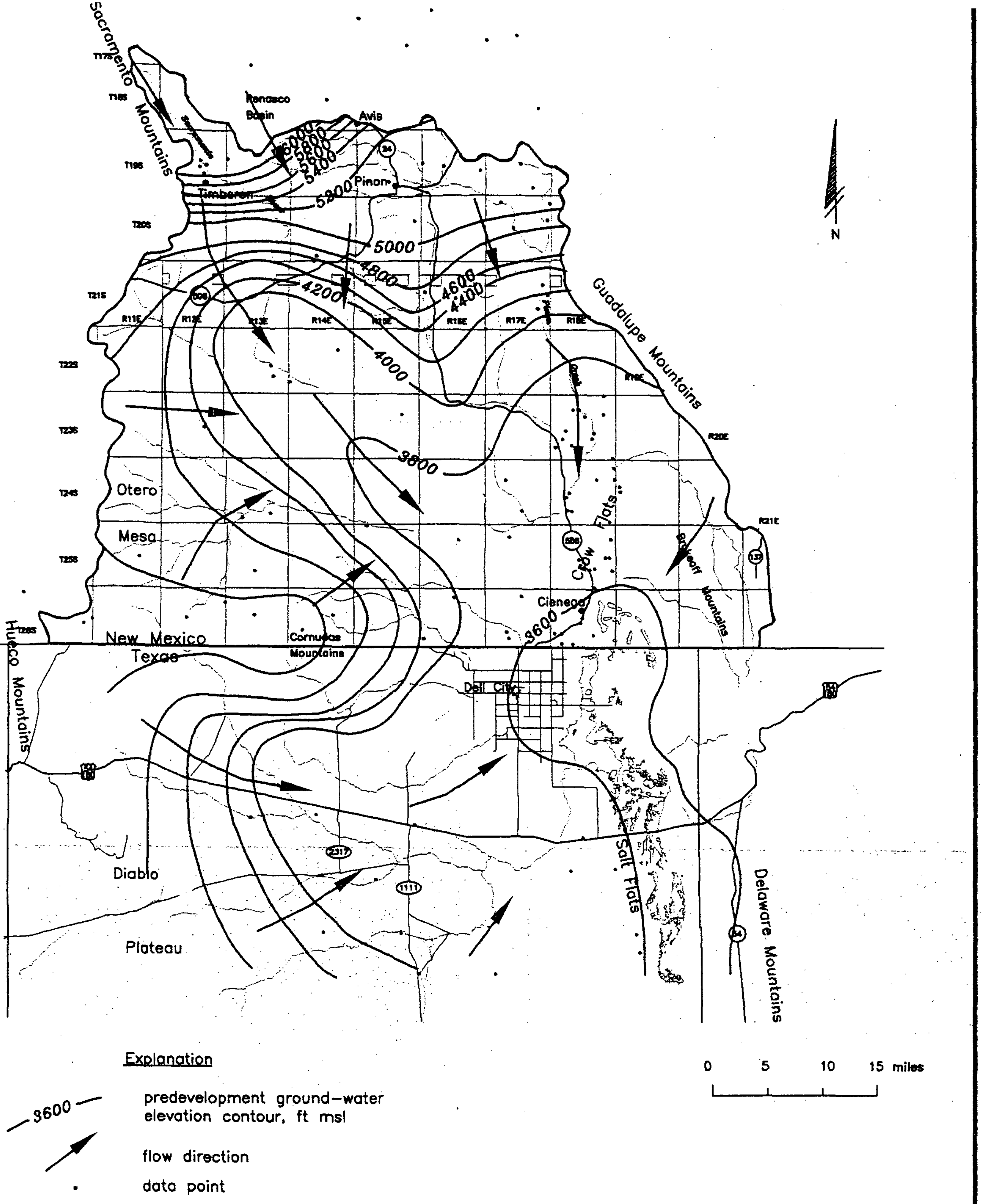

Figure 5. Predevelopment ground-water elevation contours and direction of ground-water flow for the study area.

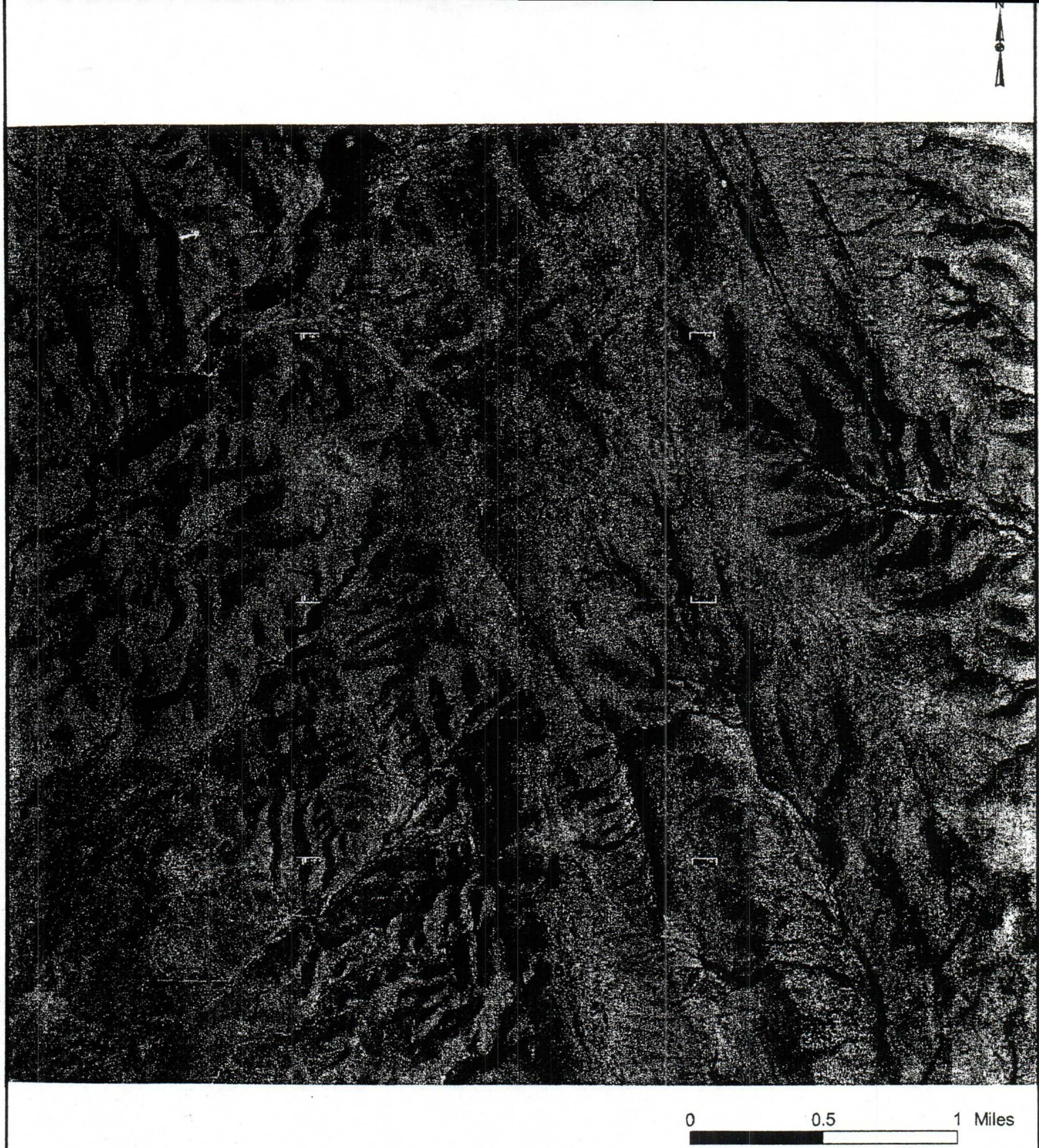

Figure 6. Aerial photograph mosaic from September 21, 1996, of southeastern Otero Mesa, showing system of northwest-trending lineaments.

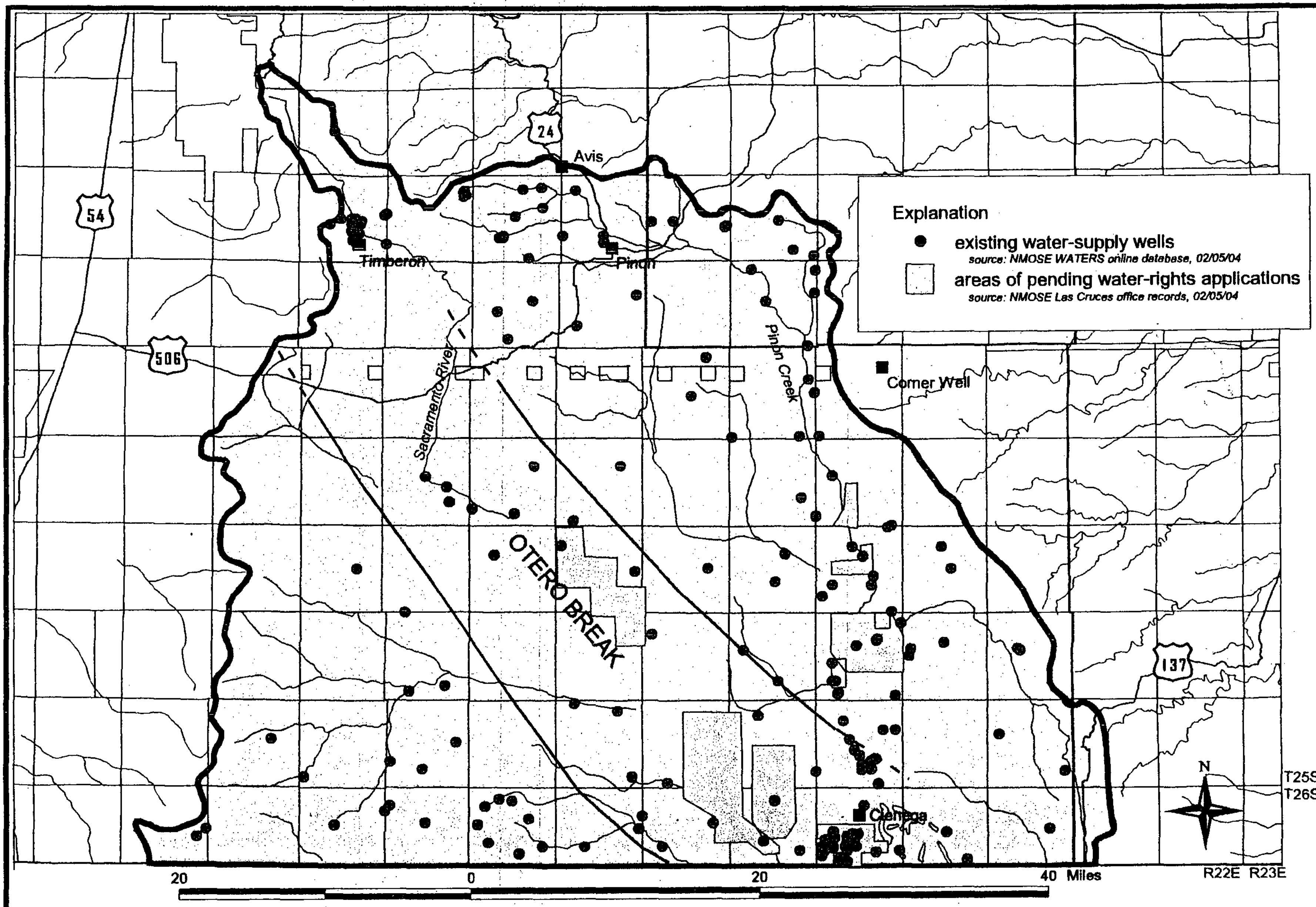

Figure 7. Map of Salt Basin, southern New Mexico, showing existing wells and locations of pending water-right applications.

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WATER-RESOURCE AND ENVIRONMENTAL CONSULTANTS

EXHIBIT 3

Sample finds high levels of carcinogen benzene

Grand Junction Sentinel - May 29, 2004

News

Sample finds high levels of carcinogen benzene

Saturday, May 29, 2004

By MIKE McKIBBIN

The Daily Sentinel

SILT — High levels of a cancer-causing agent were found in a recent water sample taken from the banks of a West Divide Creek natural-gas seep south of Silt, state officials said.

The May 19 sample was taken by Colorado Oil and Gas Conservation Commission Environmental Protection Specialist Bob Chesson at the request of Lisa Bracken, who lives near the seep.

"These .... are the result of the EnCana (Oil and Gas) gas release and indicate an impact to shallow groundwater adjacent to the main seep area," Chesson wrote in a letter to Bracken and adjacent property owner Pepi Langegger.

Bracken said benzene was found at 200 parts per billion, compared to 99 parts per billion a month ago.

"I wonder that if they missed this spot where the benzene was at, how many others have they missed?" she asked.

The commission and EnCana were discussing appropriate response measures, Chesson said. Monitoring wells will be installed and weekly testing done to closely monitor levels of the chemical, a byproduct of the well-drilling process. No immediate health concern exists, Chesson said.

The seep, discovered at the end of March, has decreased by about 90 percent, Chesson said.

Problems with a nearby well EnCana drilled are believed to have caused the gas to bubble up in the creek, and they have raised health concerns among area residents. EnCana was issued a notice of alleged violation of commission rules in connection with the seep.

Deputy Director Brian Macke said the commission could potentially issue EnCana the largest fine in its history. The largest fine was $120,000, he said.

EnCana continues to provide drinking water to about 30 affected residents and has ceased all new drilling within a two-mile radius of the seep, among other steps.

NDCBU 7460
Taos, NM 87571
June 6, 2004

Ms. Florene Davidson
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Dear Ms. Davidson;

In response to an Executive Order issued by Governor Richardson, the New Mexico Oil Conservation Division (OCD) has proposed new, stricter rules that would apply to oil and gas development in the Chihuahuan Desert Area (almost all of Otero and Sierra counties). While we would like to see the Otero Mesa, Nutt Grasslands and other sensitive areas completely protected from oil and gas development, the proposed rules would provide protection for the water, wildlife and habitat where oil and gas exploration and production could ultimately proceed. In general, this new rule prohibits pits and places stricter criteria on injection wells and related facilities used to dispose of produced water in the Chihuahuan Desert Area.

Over all, Otero Mesa is a unique and fragile area that should be protected from oil and gas development. For those limited areas that can safely sustain development, the most protective measures and state of the art technology should be utilized to prevent pollution and protect Otero Mesa's unique qualities such as wildlife, clean groundwater and solitude.

I strongly support the development of protective measures, including banning pits, requiring closed loop systems and prohibiting injection wells, as responsible ways to achieve a balance between development and protection.

I ask the Oil Conservation Commission to prohibit injection wells on Otero Mesa. While the stricter requirements proposed in this rule are an improvement on the current regulation, Otero Mesa's fragile environment and groundwater resources cannot tolerate injection wells at all. I also support the Oil Conservation Division initiating further rulemakings to ensure that any future oil and gas activity minimize impacts to water resources, delicate grasslands, fragmentation of habitat and risks to wildlife.

Additional rulemakings that should be initiated include: prohibiting sumps and on-site disposal of waste; promoting the drilling of multiple wells from one pad; minimizing the size of well pads; limiting roads and imposing limitations on oil-field traffic to protect wildlife and wilderness opportunities; setting specific criteria for netting, fencing and tank coverings; and implementing the highest standards in restoration of well sites.

Thank you for your consideration of these issues.

Truly yours,

Julia Ruth Claus

Julia Ruth Claus

New Mexico Oil & Gas Association

To: Members of the Oil Conservation Commission
Date: June 10, 2004

RE: Comments on OCD Proposed Rule Change for Otero and Sierra Counties – to be codified as Rule 21

The New Mexico Oil and Gas Association (NMOGA) represents over 300 member companies, which includes major and independent oil and gas producers, as well as the transportation, processing and refining of oil and gas in New Mexico. NMOGA promotes the conservation and orderly development of the oil and gas resources and the welfare of the oil and gas industry within the state of New Mexico.

Below are consensus comments amongst the NMOGA membership.

General Comments

NMOGA would first like to comment that we believe the New Mexico Oil Conservation Division (OCD) has erred by departing from its traditional rulemaking path by not in involving all parties, including the oil and gas industry, in developing this rule. Instead, the OCD has taken the path of arbitrarily and unilaterally establishing a rule without stakeholder involvement.

In past rulemaking efforts (Pit Rule, H_2S Rule, Vacuum Rule, etc.), NMOGA representatives have worked with the OCD staff, members of the public and non-governmental organizations (NGOs) to establish pertinent and comprehensive rules to address the issues of concern. Although the process on these other rules was not always smooth and consensus was not reached on every issue, NMOGA believes that it was beneficial to hear the views of all and to work in a cooperative and collaborative manner. We are extremely disappointed that OCD has denied industry and other parties the opportunity for being involved in this rulemaking process.

Secondly, NMOGA membership would like to point out that as with any rulemaking, there first should be a justifiable need established before the OCD embarks on a rulemaking process and then the rulemaking process should focus on addressing that need.

With respect to the proposed Otero Mesa rule, groundwater protection was repeatedly referenced as the primary concern of the OCD in requiring various aspects of the rule. As was provided in testimony on the OCD Pit Rule, NMOGA has reviewed the OCD files for specific examples of groundwater impact cases related to pit and below-grade tanks to see if what problems existed. Based upon that extensive review, there was no evidence apparent to NMOGA representatives that drilling and workover pits were associated with groundwater cases on file.

In fact, the problems identified during our review appear to be related to production pits, spills, and releases, which could be more specifically addressed. Furthermore, there was no evidence in those files that contamination of groundwater appeared to be caused by failure of injection wells. Given these facts in OCD files, we question the need or validity for the various requirements proposed in the Otero Mesa rule.

On what basis is the OCD justifying the added measures to protect groundwater in Otero Mesa when the evidence in OCD files does not indicate groundwater contamination problems from temporary drilling and workover pits or from injection wells?

As a final note, we would remind you that New Mexico plays a critical role in this nation's effort to maximize the production of domestic oil and gas given the impending shortfall that has been predicted for the next decade in the National Petroleum Council study and other comparable studies. We recognize that all development of oil and gas resources in the state needs to be done in a prudent and responsible manner to assure protection of public safety and the environment. However, NMOGA believes that rules that go beyond what is determined to be reasonable and necessary for such protection are in reality "denying access" to development of oil and gas resources and such appears to be the case with OCD's proposed rule for Otero Mesa. The use of rulemaking to create substantial obstacles to exploring and developing energy resources in previously underdeveloped areas such as Otero Mesa deprives our nation of vital, new domestic energy reserves and deprives New Mexico of important new sources of revenue to offset declines in existing production.

Specific Comments

The following comments address the specific sections of the Otero Mesa rule:

1) NMOGA proposes that the rule name be changed from "SPECIAL PROVISIONS FOR THE CHIHUAHUAN DESERT AREA" to "SPECIAL PROVISIONS FOR OTERO AND SIERRA COUNTIES". [19.15.1.21,Section A]

It is NMOGA's position that the rule applies to only to special areas of Otero and Sierra counties and not the entire Chihuahuan desert; it seems more appropriate to title the rule accordingly.

2) NMOGA proposes that pits be allowed in Otero Mesa under the current pit rule [19.15.1.21, Section B]

NMOGA contends that there will be no measurable or meaningful improvement in ground water or surface water protection as a result of banning pits in Otero Mesa.

Based upon current drilling practices in nearby counties, drilling in Otero Mesa will typically be done with either air drilling or water based muds. Air drilling cannot be done with closed loop systems given the danger associated with venting gases and solids into a closed chamber. Water based mud drilling has consistently been shown to be benign and the cuttings are not considered toxic. Both drilling practices are prevalent in other areas of the state, even in riparian and other sensitive areas where temporary earthen pits are allowed under current state rules.

NMOGA would also point out to the OCD that there are benefits to the use of pits over closed loop drilling. The extra volume of water inherent in earthen pits is extremely critical if a well control situation occurs where water is required to kill the well. Secondly, truck traffic is minimized for the use of pits over closed loop systems since the solids and cuttings are benign and can be buried in place versus having to be hauled off for disposal.

As a final point, NMOGA points to the industry record in drilling thousands of wells in the state with no evidence, as shown by NMOGA's inspection of state records, of contamination of surface and ground water from temporary drilling and workover pits. These pits can be restored to near native conditions and over years, the disturbed area eventually returns to its native state. NMOGA can see no valid justification or reason not to allow the use of pits in the Otero Mesa area.

3) NMOGA proposes that injection well permits need not deviate from the current practice of Notice and an Administrative Application where there is no valid complaint or objection. [19.15.1.21, Section C.1]

NMOGA believes that the proposed requirement to require notice and hearing for all injection well permits is unnecessary and adds burden to industry, the agency and the public with no apparent benefit. A hearing is provided for under current practice, if there is a valid objection or protest; but there is no automatic need for a hearing if there are no legitimate objections.

4) NMOGA proposes that the current UIC requirements for an Area of Review, which is ½ mile or the value derived by the EPA formula for determining the zone of endangering influence, is sufficiently protective of nearby wells. [19.15.1.21 Section C.2.]

NMOGA can find no legitimate reason or justification to extend the current Area of Review beyond that defined under current federal UIC regulations. NMOGA is not aware of any instance in the state where nearby water wells have been impacted by a properly installed injection well that has followed the current UIC criteria for Area of Review. NMOGA requests that OCD provide adequate reason and justification for extending this radius.

5) NMOGA believes that if the state needs more ground water resource data, it should pursue that under a separate process rather than require it under this rule. [19.15.1.21, Section C.3.]

NMOGA would like to point out to the OCD that it is not possible to log and identify fresh ground water using conventional drilling methods for oil and gas.

In order to provide meaningful data for fresh water aquifers, wells that are drilled *specifically for ground water* are needed. Hence, OCD should remove it from the Otero Mesa rule and possibly address it through other means. Industry is willing to provide electric logs that are done as a normal part of logging the well bore, but this will not necessarily identify if a water zone is fresh.

6) NMOGA proposes that the three degrees of protection provided by current federal and state UIC rules (i.e., dual casing consisting of surface casing cemented to surface and intermediate casing cemented at base, injection tubing, and a packer) already provide sufficient protection to usable ground water without the need to a second cemented casing. Moreover, it may be impractical to do so in some instances, necessitating a "perf and squeeze" remedial effort, which ultimately compromises the wellbore integrity. [19.15.1.21, Section C.4.]

NMOGA can find no reason or justification for requiring an additional string of cemented casing beyond the degrees of protection that are already provided by current federal and state UIC requirements.

To our knowledge, there is no evidence of any ground water contamination that has resulted in the state of New Mexico from a properly installed and maintained injection well. NMOGA believes that there is no justification for this requirement, which unnecessarily adds complexity and cost.

7) **NMOGA believes that the existing practices concerning the adequacy of cemented casing are sufficient and there is no need to add additional protection. [19.15.1.21, Section C.5.]**

NMOGA finds no justification to alter current practices concerning the adequacy of cemented casing. Present industry practices have demonstrated the adequacy of the cementing process in protecting ground water zones as evidenced by the NMOGA review of OCD records.

8) **NMOGA believes that the current industry practices of installing single walled, produced water flow lines is adequate in preventing spills and releases and where a spill or release occurs, to discover and remediate the spill in a timely manner. [19.15.1.21, Section C.6.]**

NMOGA has reviewed the internal records of a number of its member companies and flow line failures are relatively rare, accounting for less than 1% of all releases.

Where such failures have occurred, it is the experience of NMOGA members' that a single walled pipe is better, as the failure can be discovered and remedied promptly. A double walled pipe would only compound our ability to discover a failure and repair the associated pipe.

NMOGA would also point out that it is currently industry practice to inspect all flow lines routes periodically for leaks, so if any failure has occurred it can be found and promptly remedied.

NMOGA would ask OCD to justify how the extremely minimal release frequency experienced in the state for flow lines and piping would require double walled flow lines and piping?

9) **NMOGA contends that the criteria for tank containment should be "sufficient engineering design to prevent releases from reaching surface and ground water." [19.15.1.21, Section C.7.]**

NMOGA can find no justification for stipulating that the base of tank containment be impermeable and that the berm walls be lined.

The intent of OCD and federal SPCC regulations are that *any spills are properly contained and prevented from reaching surface and ground water in the time frame that it takes to discover and remove such spills and conduct appropriate remediation.* Industry experience is that the base and walls of tank containment zones need not be absolutely "impermeable" as the term implies but "sufficiently impermeable" to prevent reaching ground and surface water.

In areas where ground and/or surface water are proximate to tank containment facilities, then synthetic liners and other means of protection are commonly employed.

NMOGA would suggest to OCD that the agency take a similar tact as the US EPA which stated in the preamble to its SPCC rules; "the proper method of secondary containment is a matter of good engineering practice, so we do not prescribe here any particular method." The US EPA further stated, "the appropriate method of secondary containment is an engineering question. Earthen or natural structures may be acceptable if they contain and prevent discharges as described in 112.1(b), including containment that prevents discharge of oil to groundwater that is connected to navigable water."

10) **NMOGA contends that the existing criteria for recordkeeping and Mechanical Integrity Testing under federal and state UIC rules are sufficient and that there is no justification or need to require additional recordkeeping or testing [19.15.1.21, Section C.8. and C.9]**

NMOGA contends that the excellent history of protecting ground water under the existing UIC program has shown the adequacy of the current Mechanical Integrity Testing and recordkeeping requirements.

Thank you for taking our comments under consideration as you move forward in the rulemaking process.

dugan production corp.

RECEIVED

JUN 1 4 2004

OIL CONSERVATION
DIVISION

June 11, 2004

FAX & MAILED
FAX NO: 505-476-3462

Mr. Mark Fesmire, Director
New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, NM 87505

Re: Industry Comments
Proposed NMOCD Rule 19.15.1.21
Chihuahuan Desert Area (Otero Mesa)

Dear Director Fesmire,

Dugan Production Corp. is an independent oil and gas operator whose primary area of operation is northwest New Mexico. During 2003, we drilled 40 wells, and were ranked No. 28 in the state for volumes of gas produced. We do have some operations in southeast New Mexico, and have some serious concerns about the captioned proposed special rules for the Chihuahuan Desert Area.

Our largest concern is that it appears that the NMOCD's proposed rules are nothing more than a reaction to a directive by the Governor. The proposed rules completely discount the effectiveness of existing statewide NMOCD rules and appear to have no scientific basis. To date, a significant work effort (regulatory and industry) has been expended dealing with issues surrounding the protection of groundwater and surface contamination. It is our opinion that existing statewide rules are sufficient to address the groundwater and surface contamination issues raised by Governor Richardson. To establish special rules for a portion of the state is not necessary and is not warranted. The Chihuahuan Desert Area can be sufficiently protected by the same statewide rules that apply to all other unique parts of New Mexico, many of which are also important flora and fauna habitats. To say that the Chihuahuan Desert Area is so unique that it warrants a higher level of protection than the existing statewide rules currently provide for areas such as the Carson National Forest or Navajo Lake State Park makes no sense.

Dugan Production supports the comments submitted by the New Mexico Oil & Gas Association. In addition, we offer the following comments:

1. 19.15.1.21B. – Rule 19.15.2.50 has recently been revised based upon input from "stake holders" from all areas of concern (environmental, ranching, regulatory and industry), to specifically address groundwater and surface contamination issues on a statewide basis. It is our opinion that this rule more than adequately addresses the environmental concerns expressed in the proposed rule. We are unaware of any information that would support a complete ban of pits in the Chihuahuan Desert Area.

709 E. MURRAY DR. • P. O. BOX 420 • FARMINGTON, N.M. 87499-0420 • PHONE: (505) 325-1821 • FAX# (505) 327-4613

2. 19.15.1.21C.(1) – We object to requiring a formal hearing for all proposed injection projects. To date, this has been an administrative process, unless there was a specific need for a hearing. We are unaware of any reason or information that would necessitate a hearing for all proposed injection projects. To require a hearing for all proposed projects will impose unnecessary burdens upon the NMOCD and industry.

3. 19.15.1.21C.(2) – We are unaware of any information that supports the need for a larger area of review than currently is required. This will add unnecessary administrative efforts and costs.

4. 19.15.1.21C.(3) – We support operators providing all well data collected to the NMOCD, however typically, the hole interval in which fresh water zones may exist is not logged using open hole logs and is cased and cemented as quickly as possible. To require logging and/or testing of these intervals will not only add unnecessary costs to the well, but will extend the time that these intervals are open to drilling operations.

5. 19.15.1.21C.(4) – We object to requiring fresh water zones to be isolated by two strings of cemented casing. This will add unnecessary cementing costs to the well. Typically there will be two strings of casing across the fresh water zones, but to require the inner string to be cemented from top to bottom will serve no benefit and may actually jeopardize the casing integrity if it becomes necessary to perforate the casing in order to raise the cement top. In addition, since injection wells typically require a packer to isolate the tubing-casing annulus, should a leak ever develop in the inner casing, the leak can easily be detected and repaired.

6. 19.15.1.21C.(5) – We object to requiring cement bond logs on all strings of casing. This is an unnecessary cost. For surface casing, cement is typically circulated to the surface and for other strings of casing, the cement top typically can be calculated with reasonable accuracy or if necessary, located using temperature surveys.

7. 19.15.1.21C(6) – We object to requiring that pipelines carrying produced water be constructed using "double-walled" pipe. This will add unnecessary costs and if anything will make the repairs of leaks much more costly and difficult. During the past ±45 years, Dugan Production has never used "double-walled" pipe for flow lines and upon checking with our pipe supplier, we find that a "double-walled" pipe is not readily available. In addition, even if a double-walled pipe were available, or we ran a smaller pipe inside a larger pipe, should a leak ever develop in the inside pipe, it will be almost impossible (and very costly) to locate the leak and repair it. We have had little problem with flow line leaks and should a leak ever occur it is repaired as soon as the leak is detected.

8. 19.15.1.21C(7) – We object to requiring tanks to be placed on impermeable pads and surrounded by lined berms. This issue has been discussed at length and this will not significantly improve the protection from potential contamination but may actually create a potential contamination exposure should the impermeable bermed area become filled with rain water and a leak occur. In addition, operators will incur significant costs keeping any accumulated rain water or snow melt removed from the bermed areas.

9. 19.15.1.21C(9) – We object to requiring annual mechanical integrity tests. This will add administrative costs not only to producers but to the NMOCD. We are unaware of any information that indicates the current five year MIT requirement is not providing sufficient surveillance and groundwater protection.

We respectfully submit these comments and request that the NMOCD seriously reconsider the proposed Rule 19.15.1.21. We do not believe there is any evidence to support the need for special rules in the Chihuahuan Desert Area. We do believe the existing statewide rules will provide the necessary protection for this area, just as they do for all other areas within the State of New Mexico.

Dugan Production Corp. does not plan to appear at the hearing for this matter and requests that these comments be made part of the record in this case.

Should you have questions, please let me know.

Sincerely,

Thomas A. Dugan

Thomas A. Dugan
President

TAD/JDR/tmf

xc: New Mexico Oil & Gas Association

Manzano, LLC
P.O. Box 2107
Roswell, New Mexico 88202-2107 (505) 623-1996

June 11, 2004

RECEIVED

JUN 14 2004

OIL CONSERVATION DIVISION

New Mexico Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

Attention: Florene Davidson

RE: Proposed Rule Change For Otero and Sierra Counties (Rule 21)

Manzano wishes to submit this letter in support of the comments submitted to you by the New Mexico Oil and Gas Association. In addition, we would also like to submit a few comments of our own:

1. In developing "Rule 21", The New Mexico Oil Conservation Division (OCD) has ignored the use of sound science and common sense and has bowed to political pressure from a Governor that is trying to use this issue as a political tool.
2. As members of the OCD are aware, there have thousands of "reserve pits" built that are associated with drilling operations and there has not been a documented case of groundwater contamination from a pit associated with drilling operations. There is no sound basis supporting the proposed pit ban.
3. Virtually every issue addressed in "Rule 21" is already adequately addressed by existing OCD regulations (pits, injection wells, ground water protection, etc.).
4. As we in the industry have seen, once a regulatory agency establishes rules (such as those associated with Rule 21), the rules are then applied to other areas outside of the special case that for which they were developed.

In closing, we would encourage the OCD to use sound information to develop policy and to maintain its' past ability to operate effectively without folding to excessive political pressures from whomever might be the current administration. In the past, the OCD has successfully navigated through the turbulent water associated with the change of administrations. Without a doubt, the issue of drilling on Otero Mesa has very little to do with being able to safely develop whatever resources may underlie this area, but has everything to do with political posturing.

As the OCD is aware, this industry has proven that we can develop oil and gas resources in an environmentally sensitive manner.

Thank you for the opportunity to comment on this issue.

Sincerely

Mike Hanagan, Managing Member

June 11, 2004

Via Overnight Mail

Florene Davidson, Division Administrator
Oil Conservation Division
New Mexico Energy, Minerals And Natural Resources Department
1220 South St. Francis Drive
Santa Fe, NM 87505

Re: Comments on Proposed Section 19.15.1.21 NMAC
New rules to govern operations in the Chihuahuan Desert Area of Otero and Sierra Counties, New Mexico

Dear Ms. Davidson:

On behalf of the Oil & Gas Accountability Project ('OGAP'), I am providing written comments on the new rule proposed by the Oil Conservation Division (OCD) to govern oil and gas operations in an area in Otero and Sierra Counties known as the "Chihuahuan Desert Area." In support of the following written comments, there are a number of attached exhibits, which I request be included in the record being considered by the Oil Conservation Commission.

<u>The prohibition on issuance of pit permits.</u>

OGAP is strongly supportive of section 19.15.1.21.B of the proposed rule, which prohibits issuance of permits for pits located in the Chihuahuan desert area under either 19.15.2.50 NMAC or 19.15.9.711 NMAC. We are supportive of this prohibition for the following reasons.

I. The history of the use of pits in New Mexico shows that, when pits are allowed, soil and water contamination follows.

Until December of 2003, the OCD did not require permits for pits, and therefore, had no reliable records of how many pits existed in the state. However, according to the Well Statistics fact sheet posted on the Oil Conservation Division website (http://www.emnrd.state.nm.us/ocd), there were 40,728 wells producing oil or gas at the end of 2003. (Exhibit 1) If every one of these operations used just one pit, there would be more than 40,000 pits in the state.

In 1999, the OCD estimated that 90% of all drilling muds and cuttings and 50% of all associated wastes (exploration and production wastes other than produced water and drilling muds and cuttings) were disposed in pits. (Exhibit 2, pg. 4) The annual volume of drilling wastes was estimated by OCD to be nearly 90,000 cubic yards (almost 18 million gallons) of drill cuttings and more than 1.1 million barrels (about 47 million gallons) of drilling fluids.

There are a variety of toxic substances utilized and created during the oil and gas extraction process that are, therefore, likely to end up in pits. As shown in the table below, a representative waste characterization of muds, cuttings and associated wastes illustrates the potentially hazardous substances often found in pits that could contaminate groundwater, surface waters and the soil.

Potentially hazardous oil and gas wastes that may be found in pits.

	Benzene (mg/l)	**Arsenic** (mg/l)	**Barium** (mg/l)	**Cadmium** (mg/l)	**Chromium** (mg/l)	**Lead** (mg/l)	**Selenium** (mg/l)
It should be considered a hazardous waste if it is above:	**0.5**	**5**	**100**	**1**	**5**	**5**	**1**
Production pit sludges	24					18.3	1.59
Production sands/solids	2,500	9.9			5.98		4.11
Workover/completion fluids	1,530	Heavy metals were not analyzed					
Produced formation – fresh water	1.3		646				
Produced formation – salt water	543		372	27.8	7.25	14.4	2.83
Oil-based drilling muds/cuttings	293	6.5	101	18.8		12.6	
Water-based drilling muds/cuttings	1,100	Heavy metals were not analyzed					

Source: Subra Company, Inc., New Iberia, Louisiana, 2003

In light of the number of pits in New Mexico, the volumes of waste placed in those pits and the toxic nature of many of the substances contained in those wastes, it is no wonder New Mexico Environmental Bureau Chief, Roger Anderson, listed, as of October, 2003, 6748 cases of pit-caused contamination since the mid-1980's. (Exhibit 3) More than 98% of these pit-caused contaminations resulted from field activity, that is, well-related activity, as opposed to centralized facilities. Mr. Anderson further stated that 557 of these cases resulted in contamination of underlying groundwater.

Based upon the above historical data for New Mexico, it is hard to come to any conclusion other than that the use of pits has inevitably led to contamination of soils, surface waters and groundwater in New Mexico. This Commission has begun to recognize that history. For example, in its December 11th, 2003 Order No. R-12011-B, this Commission noted that, since 1958, the potential of pits to contaminate fresh water resources has led to increasing regulation. Therefore, consistent with that historical reality, OGAP believes that the prohibition on issuance of permits for pits contained in this rule reflects the necessary next step in the evolution of this Commission's regulation of pits.

II. Alternatives to pits are available and feasible.

There are existing alternatives to the use of pits that are available and feasible. Within New Mexico, both the cities of Farmington and Lovington have required the use of closed-loop systems. (Exhibit 4) In 2003, Farmington required MarkWest Resources to use a closed system for produced water. Also in 2003, Lovington passed an ordinance that, in section 8.30.390, requires the use of a closed system and the removal from the site of all cuttings and fluids. Oil and gas companies have continued to do business in both of those communities, despite this requirement.

The OCD itself identifies closed-loop drilling as a best management practice in their Pollution Prevention Best Management Practices for the New Mexico Oil and Gas Industry. (Exhibit 5) New Mexico OCD is not alone in identifying closed-loop drilling systems as a "best practice." In almost any pollution prevention or "Best Management Practices" document for the oil and gas industry, closed-loop drilling systems are mentioned as the most environmentally safe method for reducing the potential impact that drilling operations can have on the environment. (see, e.g., the Illinois Environmental Protection Agency's "Best Management Practices for Oil Exploration and Extraction" (http://www.epa.state.il.us/p2/fact-sheets/bmp-oil-exploration.html) and the Railroad Commission of Texas' "Waste Minimization in Drilling Operations" (http://www.rrc.state.tx.us/divisions/og/key-programs/ogkwodoc.html).

Increasingly, closed loop systems are being used all over the United States, Canada, and the world. In personal conversations with closed-loop drilling system companies, OGAP staff have been informed that one company has performed approximately 900 closed-loop drilling operations in the past 8 years in Colorado, Wyoming, North Dakota, New Mexico and other western states. A representative from another company operating out of Texas, Louisiana and Oklahoma remarked that most of the major companies in the region are using closed-loop drilling systems at the majority of their operations, because they understand the potential future liabilities that may follow them if they use conventional drilling systems that use pits.

This information is corroborated by the Texas Railroad Commission, which stated that "Even though it is not always cost effective, some companies have elected to use only closed loop drilling fluid systems in their operations. . .whenever a closed-loop system is used, the operator reduced his potential liability associated with a conventional earthen pit and waste management and site closure costs." (Railroad Commission of Texas. Oil and Gas Division. Waste Minimization in Drilling Operations. http://www.rrc.state.tx.us/divisions/og/key-programs/ogkwodoc.html)

So, it is an emerging industry standard elsewhere to use closed loop systems. The only reason it has not become the industry standard in New Mexico is that industry has not been paying the full costs associated with pits, leaving the clean-up to be funded by the taxpayers of New Mexico.

In light of the significant increase in prices for oil and gas that companies have been receiving over the past year, they can certainly afford to use closed loop systems. However, even if these companies were not receiving this tremendous 'windfall' of increased revenue, the costs of closed loop systems are relatively low and their use may actually <u>reduce</u> a company's production costs.

For example, one company used the same rig, crew, mud company and bit program to drill two wells, 200 feet apart through the same formations. The only difference was that one used a conventional pit system and the other a closed loop system. (Exhibit 6) The closed loop system resulted in:

-a 43% savings in drilling fluid costs;
-23% fewer rotating hours;
-33% fewer days to drill to a comparable depth;
-a 37% reduction in the number of bits used; and
-up to a 39% improvement in the rater of penetration.

In a second example, another oil and gas production company drilled an exploratory well using a closed loop system, among other pollution prevention measures. (Exhibit 7) The use of a reduced hole size, air drilling and the closed loop system resulted in waste reduction <u>of nearly 1.5 million pounds</u> and material and disposal cost savings of nearly $13,000.

In yet a third example, a direct comparison of the costs of a conventional drilling operation with a standard pit versus a closed loop system showed that the closed loop system cost $1600 <u>less</u> than the pit system. (Exhibit 8) As summarized in that report, use of the closed loop system was "a reliable, cost effective tool for reducing conflicts with surface owners and reducing impact to the environment." (p. 189)

Based upon the above information, OGAP supports the prohibition on pit permits contained in this proposed rule because it will prevent contamination, and it is technically and economically feasible.

<u>The additional requirements for water injection wells.</u>

OGAP believes, based upon current information, that this Commission should prohibit the use of injection wells for produced water in the Chihuahuan desert area. As noted in the OCD's Application for an Amendment in this case, the aquifers in this area are highly vulnerable to contamination from surface discharges, and there is a lack of information with regard to groundwater. (Application, p. 1) In addition, other New Mexico and federal agencies have documented that shallow groundwater in the area is vulnerable to contamination, due, in part, to the fractured nature of the underlying limestone.

Given the documented vulnerability of the area's groundwater to contamination and the lack of information and studies with regard to the safety of injection of produced water into the groundwater in this area, OGAP believes that this Commission should heed the words of the new OCD Director. Earlier this week, Mr. Fesmire stated that "we're going to take very, very good care of our water – both our ground and surface water, which can be effected by oil and gas operations." (Exhibit 9) In this instance, we believe that means exercising caution and prohibiting injection wells in this area.

We appreciate the opportunity to comment on the proposed rules.

Respectfully submitted,

Bruce Baizel
Attorney
Oil & Gas Accountability Project
New Mexico Office
P.O. Box 426
El Prado, NM 87529
970/259-3353

Exhibit 1:

New Mexico Well Statistics

NEW MEXICO WELL STATISTICS
May 17, 2004

Number of Wells

	Approved APDs, Not Plugged, Not Cancelled	*Completed Wells*
Carbon Dioxide	501	456
Gas	25,031	24,184
Injection	4,058	4,045
Misc	127	103
Oil	23,379	21,857
Salt Water Disposal	633	595
Water	65	47
	53,794	51,287

Number of Wells by Land Type

	Approved APDs, Not Plugged, Not Cancelled	*Completed Wells*
Federal	27,307	26,299
All Indian	2,896	2,837
Private	9,565	9,160
State	13,570	12,988
Not Recorded	456	3
	53,794	51,287

Number of Producing Wells

Number of wells that produced oil or gas in 2003: 40,728

Number of wells that had injected volumes reported in 2003: 3,459

Number of Wells Permitted by Year

Calendar Year	*APDs Issued for Wells Now Completed**	*APDs Issued for New Drills*
1996	1,002	1,372
1997	1,056	1,513
1998	1,031	1,465
1999	955	1,196
2000	1,601	2,098
2001	1,427	2,009
2002	1,095	1,493
2003	1,389	2,035
2004	585	810

*Not included if all zones now abandoned

Number of Wells Plugged by Year

Calendar Year	*Wells Plugged and Site Released***
1996	563
1997	624
1998	576
1999	378
2000	636
2001	763
2002	929
2003	569
2004	154

** Sites are generally released up to one year after plugging, so 2003 and 2004 numbers are incomplete.

Exhibit 2:

August, 2001. *State Review of Oil and Natural Gas Environmental Regulations, Inc. New Mexico Follow-up and Supplemental Review.* (www.strongerinc.org/pdf/NMfinal.pdf)

NEW MEXICO

FOLLOW-UP AND SUPPLEMENTAL REVIEW

State Review of Oil and Natural Gas Environmental Regulations, Inc.

August, 2001

PROGRAM OVERVIEW

Oil and Gas Production

Oil and natural gas were first produced in New Mexico in 1921. Since then, virtually all production has been from four counties in the San Juan Basin in the northwest and four counties in the Permian Basin in the southeast. Crude oil produced from Permian and older sediments is the principal hydrocarbon resource in southeastern New Mexico, while natural gas produced from Cretaceous and Tertiary sands is the principal resource in the northwestern part of the state.

Oil production in the state peaked in 1969 at 129.2 million barrels. In 1999, New Mexico produced about 65.4 million barrels of oil from 22,451 wells, ranking 5th in the nation. Production on federal lands accounted for 67 percent of total production while state lands, private lands and Indian lands accounted for 39 percent, 20 percent, and about 1 percent, respectively. Oil reserves were estimated at 718 million barrels -- fourth highest in the nation. Oil production has decreased gradually over the past 25 years and is expected to continue to decrease, barring a major discovery.

Unlike crude oil, production of natural gas has increased, fueled primarily by development of coal-bed methane resources in the San Juan Basin in the past 10 years. New Mexico produced 1.66 trillion cubic feet of natural gas in 1999 from 20,849 wells and ranked third nationally. Production on federal lands accounted for 67 percent of total production, while production from state lands, private lands and Indian lands accounted for 17 percent, 13 percent and 3 percent respectively. Natural gas reserves of 15.5 trillion cubic feet ranked second nationally.

Land Status and Environmental Setting

New Mexico is the fifth largest state in the nation. Its 77,866,240 acres (121,666 square miles) include 147,187 acres under water in lakes, rivers and wetlands. Land ownership is characterized by a large percentage of publicly held lands; 34 percent of the land is owned by the federal government and 12 percent is owned by the state of New Mexico. Indian lands account for 9 percent of the total and privately owned lands account for the remaining 44 percent.

New Mexico is an arid to semiarid state where the landscape ranges from Upper Sonoran desert life zones in the southwest to alpine life zones in the south-central and north-central mountains. Annual rainfall averages from less than 7 inches in the deserts to more than 30 inches in the mountains. Groundwater provides about 90 percent of drinking water used in the state. Surface water is used principally for irrigation of crops.

Waste Management Issues

Regulation of exploration and production wastes historically has focused on management of the large volumes of produced water generated annually in New Mexico. About 593 million barrels were produced in 1999; 92 percent of that volume was generated in two southeastern counties (Lea and Eddy) alone. The water-to-oil ratio now stands at 6.5 barrels of water to every 1 barrel of oil produced. Since 1982, produced water volumes have increased nearly 80 percent as recoverable crude has decreased.

About 90 percent of all produced water is re-injected, either for enhanced oil recovery (EOR) or for disposal. EOR operations (4,467 wells) accounted for about 58 percent of injection in 1999. About 42 percent of all injected produced water was disposed in 628 Class II disposal wells. About 59 million barrels of produced water were disposed in on-site pits and in commercial and centralized surface impoundments. Surface discharge of produced water to waters of the U.S. is not currently done in New Mexico.

OCD estimates that 90 percent of all drilling muds and cuttings are disposed in pits and the rest are landfarmed. Estimates for the volume of drilling wastes generated from the 1,450 wells drilled in New Mexico in 1999 are 89,650 yd^3 of drill cuttings and 1,134,400 bbls of drilling fluids. OCD also estimates that about half of all associated wastes (E&P wastes other than produced water and drilling muds and cuttings) is disposed in pits, about 45 percent is diverted to oil reclaimers, and the remainder is buried on-site. No estimates are available for the volume of associated wastes generated annually in the state.

E&P wastes not managed on-site in pits and tanks are treated or disposed at a wide range of off-site facilities. As of the time of this review, OCD has approved 26 commercial surface disposal facilities, including three that manage produced water exclusively, 13 that are exclusively landfarms, and three that accept multiple waste streams; OCD has also approved 18 centralized surface disposal facilities. OCD has approved 16 crude oil and tank bottom reclamation operations, which in New Mexico are known as waste oil processing companies or waste oil treating plants. Nine of those 16 are co-located with commercial surface disposal facilities.

From data acquired from the pit inventory required in 1997, there are an estimated 11,600 on-site pits in the state. Approximately 5800 pits have been closed in the last seven years. Although unlined production pits were prohibited by OCD in the four southeastern counties in 1967, low-volume production pits, tank-drain pits, and basic sediment and water (BS&W) pits are allowed.

Of the eight refineries in New Mexico, four were operating at the end of 1999. The state hosts 37 operating gas-processing plants, at least 5000 natural gas pipeline compressor stations, 700 oil-field service company facilities, and 17 operating brine manufacturing wells. In all, OCO has issued permits for more than 402 major, off-site facilities associated with the refining, processing, and transporting of crude oil and natural gas and the management of E&P wastes.

OCD and industry are addressing both area-wide and site-specific contamination problems in both producing regions. As of January 1, 2001, OCD had addressed or was continuing to investigate 734 cases of soil or groundwater contamination statewide. Remediation had been completed at 220 of those sites. Of the 734 cases, 444 were at field production locations.

Exhibit 3:

October 23, 2003 letter from Roger Anderson, NMEB, to Jennifer Goldman, OGAP

NEW MEXICO ENERGY, MINERALS and NATURAL RESOURCES DEPARTMENT

BILL RICHARDSON
Governor
Joanna Prukop
Cabinet Secretary

Lori Wrotenbery
Director
Oil Conservation Division

October 23, 2003

Ms. Jennifer Goldman
Oil & Gas Accountability Project
P.O. Box 426
El Prado, New Mexico 87529

RE: INFORMATION ON PITS IN NEW MEXICO

Dear Ms. Goldman:

The New Mexico Oil Conservation Division (OCD) is in receipt of the Oil & Gas Accountability Project's (OGAP) September 19, 2003 correspondence titled "INFORMATION ON PITS IN NEW MEXICO". This document asks several questions related to postponement of the Oil Conservation Commission (OCC) hearing on new pit rules from September 11, 2003 to November 13-14, 2003, and requests information on specific items related oilfield pits in New Mexico.

The September 11, 2003 OCC pit rule hearing was postponed since legal notice advertisements in newspapers did not appear at least 20 days before the hearing as required by 19.15.14.1201(B)(1) NMAC. Enclosed is a copy of the OCD's October 16, 2003 memorandum that was sent last week to parties interested in the hearing.

In regards to information requests, the OCD does not have a database on pit closures. As will be presented at the upcoming hearing, in reviewing the OCD case files, the Santa Fe Office has records of 6748 total cases of pit-caused contamination since formation of the Environmental Bureau in the mid 1980's, 557 of these cases have resulted in contamination of underlying ground water. Of the total pit-caused contaminations, 132 occurred at facilities such as refineries, natural gas processing plants, compressor stations, brine stations and service companies, 72 of these 132 resulted in contamination of underlying ground water.

There is currently no OCD rule that requires registration or permitting of existing pits, but the OCD has proposed for this to be included as part of the new rule. The best available data on the number of pits that will be subject to the proposed rule comes from an OCD Memorandum To Operators on July 14, 1997 requesting information on lined and unlined pits. Based upon responses from operators, there are at least 5609 lined and 7639 unlined pits that would be subject to the proposed rule. The OCD has no information on how many of these existing pits have associated contamination.

If you require more specific information on individual cases, please contact us to make an appointment to review the OCD case files.

If you have any questions, please call me at (505) 476-3490.

Sincerely,

Roger C. Anderson
Environmental Bureau Chief

Enclosure

Exhibit 4:

February 2, 2003 Farmington Daily Times, "Planning panel Oks residential gas wells", Laura Banish;

December 16, 2003 Hobbs News-Sun, "Water field ordinance approved", Richard Trout.

2/1/03

Planning panel OKs residential gas wells

By Laura Banish/Staff writer

FARMINGTON — Five oil and gas well special use permits were recommended for approval by the Municipal Planning and Zoning Commission Thursday.

The gas well permits, which were requested by MarkWest Resources, were tabled at the last Planning and Zoning meeting two weeks ago. The commission's cause of concern was in regard to the construction and impact of the gas wells on residential neighborhoods.

"Concerns centered around appearance issues, screening, water hauling, and emissions," city long range planner Mike Sullivan said.

Sullivan added that the city as well as other local municipalities have entered an Early Action clean air agreement with the Environmental Protection Agency. It is to help municipalities address issues with air quality. Because of this recent agreement, Sullivan suggested the commission not get "too wrapped up in emissions."

Discussion at the Jan. 16 meeting also generated concerns about increased water truck traffic surrounding well sites because of a new city regulation no longer allowing the disposal of produced water in the city's sewer system. The rules were changed because of water quality issues. As a result of the new regulation, water will have to be stored on site and trucked out for disposal.

Representatives from OMI Inc. and the city of Farmington Wastewater Utilities Division appeared at the meeting Thursday to explain the policy change.

OMI's Britt Chesnut explained that salts contained in the produced water were well above the EPA's standards.

"In a two-year span, 80-percent of the time we are out of compliance," Chesnut said.

A selenium study was done to monitor ways in which salts could be reduced. In an attempt to reduce the high salt levels, OMI concluded that prohibiting new gas wells from dumping waste water into the city sewer system will significantly reduce the salt levels.

Using figures provided by waste water representatives, the commission determined that wells producing the most water will only require one truck once a day for water removal.

Currently there are 34 gas wells in the city of Farmington which are emptying their produced water into the city sewer system. The rest are trucking the water to injection wells.

With that, the commission voted 5-to-1 to recommend approval of the five gas well petitions.

MarkWest Resources have proposed to build a Fulcher Pictured Cliffs well and Basin Dakota well on the same pad on a tract of land near Placitas Trail. The area is zoned suburban residential and is currently surrounded by vacant properties.

MarkWest Resources also plans to build two of the same gas wells approximately 550 feet northwest of the intersection of Lion's Trail and Anasazi Trail. The area is also zoned suburban residential and is currently surrounded by vacant lots.

The last well proposed by MarkWest Resources is a Fruitland Coal gas well to be situated north of the intersection of Hood Mesa Trail and Anasazi Trail.

The commission recommended approval subject to several conditions, including landscaping, protective fencing, hours of operation, construction hours, adherence to fire codes, maintenance and sound abatement measures. It was also suggested that the condensate tanks — which hold oil produced from the well — be buried or left above ground depending on agreement with the Farmington fire marshal. If buried, it was recommended the tanks are buried with leak protection, such as double walls.

In addition to the conditions of approval indicated by city staff development services, recommendations made by the Oil and Gas Commission were added as they apply to the permit requests as well.

The Oil and Gas Commission asked that drilling operations be limited to the hours of 7 a.m. and 7 p.m., unless an emergency of critical operation warrants otherwise. Also, there must be an experienced, knowledgeable industry person on site at all times once drilling has begun. Furthermore, only new casing, well head equipment and ancillary valves may be installed on new wells, and there must be the two joints or 50 feet, whichever is greater, of surface casing set into bedrock.

The petitions will be forwarded to the agenda of the next City Council meeting which is scheduled for 7:30 p.m. Feb. 11 at Farmington City Hall.

Laura Banish: laurab@daily-times.com

Land Commissioner appoints three to advisory board

By Darren Marcy/Outdoor editor

SANTA FE — Commission of Public Lands Patrick Lyons filled three spots on the state Land Trust Advisory Board with a broad sweep of the political brush Tuesday.

Lyons appointed people representing the Republican, Democrat and Green parties.

"The Land Trust Advisory Board should be politically diverse because the environment is a bipartisan issue," Lyons said.

He appointed Republican Tom Tinnin, former New Mexico state fair executive director; Democrat Paula Garcia, executive director of the New Mexico Acequia Association in Santa Fe; and 2002 Green Party gubernatorial candidate David Bacon.

"David, Paula and Tom bring a wealth of knowledge, experience and commitment to the table," Lyons said.

The Land Trust Advisory Board assists the commissioner with policies and programs, and are assigned to represent public interests, the agricultural community, the extractive industries, or conservation efforts.

The three appointees must be confirmed by the state senate and will then serve six-year terms.

They will join current board members Kris Havstad of Las Cruces, Joseph Kelly of Roswell, and Felicia Thal of Buena Vista. All have four years remaining on their terms.

"The state Land Office earns hundreds of millions of dollars for education by doing business with the oil and gas industry, developers and the agricultural community," Lyons said. "We must also provide our children with a healthy environment in which to live and these appointees are the right people to help me get the job done."

Information: nmstatelands.org, or (505) 827-5760.

Darren Marcy: darrenm@daily-times.com

News-Sun

JAL EUNICE HOBBS LOVINGTON TATUM SEMINOLE DENVER CITY

December 16, 2003

■ LOVINGTON

Water field ordinance approved

RICHARD TROUT
NEWS-SUN

LOVINGTON — Tatum and Crossroads rancher Carl Johnson proudly got to his feet after Lovington mayor Troy Harris asked if there was any public comment regarding ordinance No. 449.

On Monday the Lovington City Commission adopted the ordinance protecting the city's water field.

No one was sure if Johnson was about to cry foul or blast the Lovington commission for starting a bureaucratic boondoggle.

He did neither, choosing to praise the commission instead.

"We, personally, from Jal to Crossroads and east and west, know of many, many, many, many water wells that are already polluted by the oil and gas business, and we think this is one of the best moves by any entity in Lea County that's been made in my lifetime," Johnson said.

"I think this is the start of trying to get the oil industry to do us right, and not harm other people by doing their business. And we appreciate your taking the lead on this thing."

Ordinance No. 449 was designed by the Lovington commission to prevent the city's water field from being contaminated by oil leaks or spills. After becoming frustrated with the Oil Conservation Division's slow response time to oil spills near the city's water supply, city manager Pat Wise and the commission felt it was necessary to draft its own regulations.

There are about 1,900 acres south of Lovington with 17 water wells that provide 100 percent of the city's water supply.

The meeting was quite unlike the commission's Sept. 14 gathering, when the oil industry showed up en masse to stall the progress of the water field ordinance.

At the September meeting, about six representatives from the oil and gas industry told the commission the new ordinance would only complicate matters, as the industry is already regulated by the OCD and Bureau of Land Management.

Three months later, the only public comment was uttered by one grateful rancher surrounded by several other ranchers who appeared equally pleased.

According to the ordinance, it is now unlawful for any person to begin a drilling operation or re-entry within the confines of the city's water field without having been issued a permit from the city. If a leak or spill does occur on the water field, the operator must report it to the city engineer within 15 days.

Lovington attorney Lewis Cox explained the changes to the ordinance on Monday.

In the section called "permit required," a line was added stating the application for a permit shall be filed with the Lovington city engineer, and should include such items as the type of activity for which the permit is sought and the site of the proposed activity.

In another section called "reporting requirements," Cox said a list of minimal information regarding a leak or spill was added to the ordinance. This information includes items such as the name of the operator, the date and time of the leak or spill and identification of the spilled material.

The commission also adopted a new section in the ordinance called "leakage surveys." "At least once each calendar year, any operator of a well on the Lovington water field must conduct a leakage survey for that well and file the results with the city engineer. It is unlawful to fail to provide the annual survey report to the city engineer within 30 days after it was performed, or should have been performed," the section states.

Each day of failure after the first offense will be considered a separate offense, with the offender subject to a maximum fine of $500 per day that the report remains unfiled.

A final addition to the ordinance was a section banning the drilling of disposal wells, or the conversion of existing wells into disposal wells.

Exhibit 5:

Pollution Prevention Best Management Practices: Case History 1 Drilling Operations, OCD website:
(http://www.emnrd.state.nm.us/ocd/publications/Pollution%20Prevention%20Manual/Best%20Practices%20Manual.htm)

CASE HISTORY 1

DRILLING OPERATIONS

USE OF "CLOSED DRILLING PIT SYSTEM" TO REDUCE DRILLING WASTE

(submitted by Langham Petroleum Exploration Corp.)
cited in the Railroad Commission of Texas, 1994

CHALLENGE — Challenges associated with conventional reserve pits include volume of drilling wastes; drill site installation and restoration costs; pollution of land and/or surface water due to failure of pits and/or containment system and associated cleanup costs; and potential for subsurface pollution due to downward migration from pits and/or surface soil permeability.

SOLUTION — Use closed-drilling pit system to reduce volume of drilling waste, as follows:

Conventional reserve pit (235' x 77' x 5'), cuttings pit (20' x 10' x 5'), and water pit (40' x 10' x 5'):

TOTAL DRILLING MUD AND WASTES IN PITS	16,625 BBL

With closed-loop drilling fluid system (eliminated reserve pit), cuttings pit, and water pit:

TOTAL DRILLING MUD & WASTES IN PITS	1,100 BBL
TOTAL REDUCTION IN DRILLING MUD AND WASTES IN PITS	15,625 BBL

CASE HISTORY 1

The drilling contractor maintained "safe pit levels" and recycled drilling fluid to minimize pit volumes and disposal requirements. Waste management costs due to procedures other than those specified were also the responsibility of the drilling contractor. Cost savings provided the incentive to implement and maintain proper procedures to minimize waste generation in the closed-loop system.

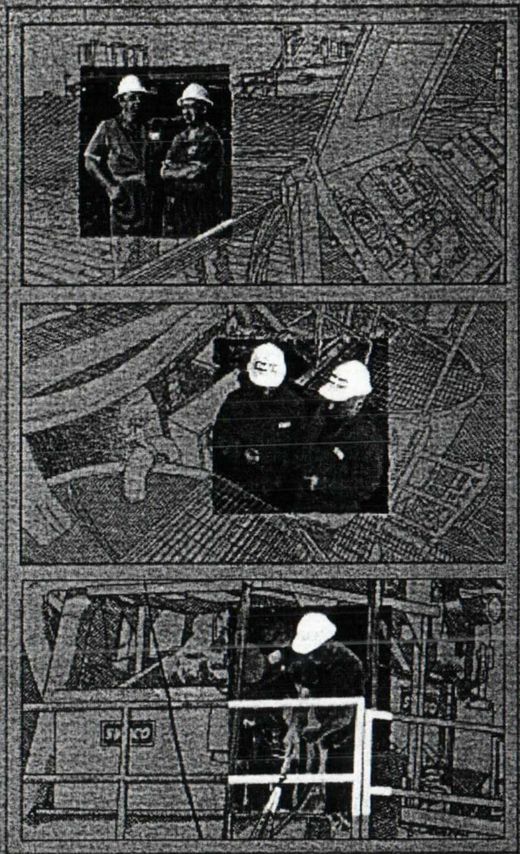
(*Note: Optimum use is for on-shore, normal pressure, relatively shallow drilling operations.*)

BENEFITS — The following benefits were realized:

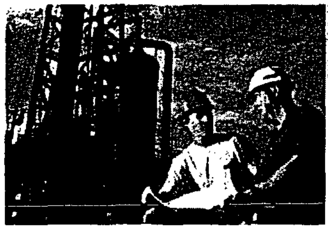
- TOTAL ESTIMATED COST SAVINGS (considering reduced costs for drill site installation, fluid hauling and disposal, dirt work, and surface damage payment): $11,000.00
- Reduced potential for environmental impact to surface and groundwater

Exhibit 6:
SWACO Website:
http://www.miswaco.com/More_Info/About_Us/98131.pdf

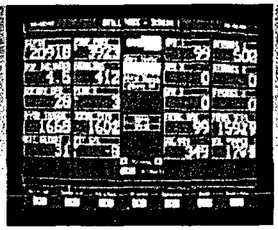
This is Swaco



SWACO



Swaco operations and technical support personnel are specialists at working with you to find the right combination of equipment and services to meet your drilling and environmental objectives.



Swaco's fast, accurate and reliable SG-Smart and Geo-Smart data acquisition systems provide real-time monitoring of a wide variety of critical drilling variables.

Swaco gives you control over more of the things that affect your total well costs.

Just as drilling and completion fluids have undergone radical shifts in how they are thought about and applied, so too has the practice of solids control and many of the disciplines related to it. Not too long ago, controlling solids simply meant removing large cuttings from the mud. And while that was the state of the art, Swaco® offered the best in solids-control equipment.

Today however, Swaco has redefined "solids control" to be much broader and more technical in nature. The time frame now extends from the planning stages of your well beyond the end of the drilling activities. The factors that affect the interaction between the fluid system, the drilled solids and your well's economics now require a broader suite of disciplines. That's why Swaco provides services, equipment and engineering for solids control, pressure control, rig instrumentation and waste management.

While a basic concern may still be the removal of drilled solids from the fluid system, the technologies used to achieve it and the environmental aspects of handling and disposing of cuttings and used fluids are changing every day. With Swaco on your well, you'll have access to the latest developments in these increasingly important areas. These innovations will help you attain compliance with stringent environmental regulations and achieve economies that were out of reach only a few years ago.

The comprehensive services that make good sense and good economics.

With a history of serving the oilfield since 1940, Swaco is in the business of helping customers achieve their drilling goals through a variety of disciplines and technologies. The services we now offer from 38 locations in 13 countries can be divided into four principal areas of expertise:

Pressure-control equipment. Chokes and operating consoles, degassers and mud gas separators give drillers the ability to drill safely and economically in sour-gas and high-pressure zones. Technology such as the Super Mud/Gas Separator™ (SMGS™) is helping operators drill for extended intervals in underbalanced conditions.

Solids control. Swaco manufactures, sells and rents a complete line of linear shakers, desanders, desilters, hydrocyclones, mud cleaners and centrifuges.

Rig instrumentation. The SG-Smart® Level I, Level II Data Acquisition Systems and the Virtual Geolograph Gas Detector™ use state-of-the-art, electronic technology to provide drillers with vital, fluid-related parameters on a real-time basis. The Geo-Smart™ system takes data acquisition to a new level, providing the ability to track lithology data inputs. This enhanced capability furnishes the information needed for improved decision making, both on the rig and as real-time data transmitted to customer offices.

Treatment services. This category covers a range of activities, including site assessment, cuttings injection, stabilization, landfarming, location construction, water treatment, soil washing, pit closure and remediation, bioremediation, dewatering, and thermal processing.

As with any of our services, we provide more than just basic capabilities. Our engineers are also specialists at finding the right combination of equipment and services to help you meet your drilling and environmental objectives. You get equipment, engineering expertise, service and responsiveness — all geared to making you more efficient and cost-effective in the shortest amount of time.

The Swaco 518 Variable Speed Centrifuge provides superior performance over a wide range of operating parameters.

Controlling your costs before there's a well.

In the planning stages of your well, Swaco's engineers review the fluid program, the planned well profile and the environmental aspects of the project. They work with the mud engineers and members of your staff to lay out a plan that optimizes the drilling profile. They also run through "What-if?" scenarios to anticipate reasonable contingencies. The end result of this team effort is an engineered grouping of products and ongoing support that meet your well's requirements.

To keep you running at peak efficiency throughout the drilling operation, we routinely monitor and measure the performance of our equipment, conducting a preventive maintenance program throughout the drilling program. On critical wells, where technical challenges heighten safety and environmental considerations, we assign a project engineer to ensure 'round-the-clock, onsite fine-tuning and maintenance of our equipment.

When the drilling's finished, we can work with your people to perform an end-of-well recap, reviewing how the whole operation went and how Swaco performed. If you wish, you get an exact accounting of waste volumes and project documentation that serves as a basis for tackling new challenges on future wells.

Going beyond the well.

If there is one factor that has single-handedly changed drilling practices more than any other, it is the growing, worldwide concern for our environment. And while more efficient shakers, centrifuges, mud gas separators and instrumentation represent a good start in protecting the environment, Swaco has gone further.

Our customers look to us to provide a variety of waste-treatment services and technologies that reduce total drilling costs and ensure environmental compliance. These can include:

- Site assessment
- Pit closure and remediation
- Bioremediation
- Cuttings containment/re-injection
- Sludge/mud dewatering
- Landfarming
- Stabilization
- Thermal processing
- Water treatment
- Soil washing

Our specialists will make recommendations and develop a treatment and/or remediation strategy that includes the most effective methods for your application. As drilling progresses, our field engineers take soil samples and perform onsite analytical work to ensure that the drilling procedures are meeting local environmental regulations. For special situations, Swaco engineers have at their disposal the experience and capabilities of M-I's environmental experts in Colombia, Norway, the United Kingdom, the United States, Venezuela and Indonesia.

A history of service to the industry.

1940
Salt Water Control Inc. is founded.

1967
Dresser Magcobar acquires Salt Water Control and changes the name to Swaco.

1976
Swaco is spun off as a separate division of Dresser Industries.

1987
Swaco merges with Geolograph Pioneer.

1990
Dresser Industries adds Swaco to the M-I Drilling Fluids joint venture.

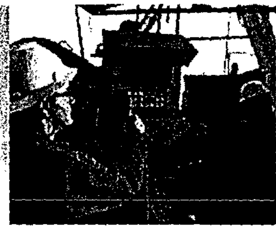
1995
Swaco acquires Baker-Hughes Treatment Services.

1997
Swaco acquires Branath Oilfield Services.

1997
Swaco acquires DSR Companies.

1998
Swaco acquires Mantovani & Vicentini.
Swaco acquires Safeguard Disposal Systems, Inc.

Swaco's 414 and 518 centrifuges are manufactured with stainless steel bowls, scrolls, compartments and covers. The result, corrosion resistance and longer insert life.



Swaco's trained field service personnel routinely monitor and measure the performance of our equipment throughout the course of your drilling program.

Turning good ideas into best practices.

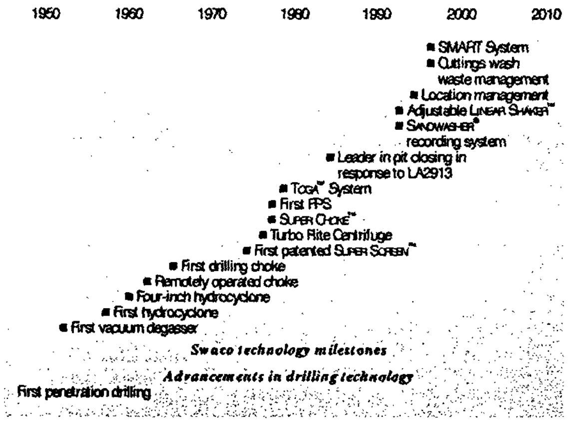
There's a very good reason Swaco products have become industry standards. We know how to move quickly and surely from engineering concept to rig-floor reality.

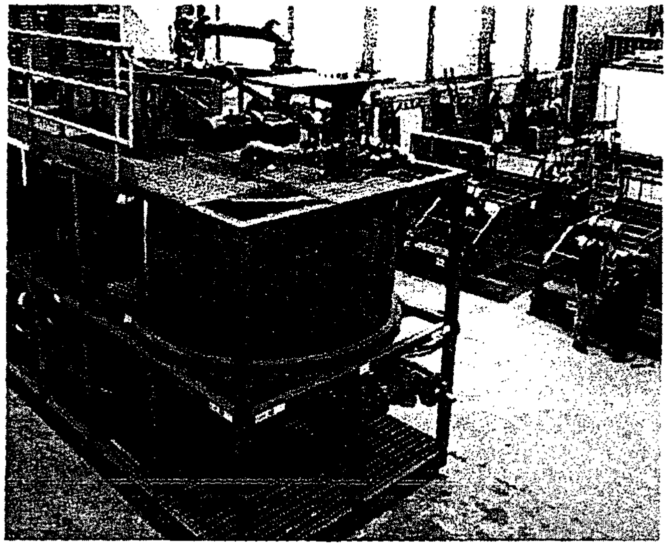
Everything we need to implement a change, whether it starts with Swaco engineers or a customer, is located at our Oklahoma City facility — engineering, manufacturing, quality assurance, production control and testing laboratories. Our ISO 9001 certification attests to our attention to detail in design, manufacturing and delivery. And our expertise allows us to customize products to meet our customers' special needs, creating the best solution for the job at hand. Within these capabilities we have processes in place for constantly examining and responding to: ideas for new products and services, ways to improve existing ones, current industry trends and future possibilities.

Two of the tools currently in use at Swaco are Pro/Engineer* and Pro/Mechanica.* These powerful software packages are capable of state-of-the-art solid modeling and highly advanced engineering diagnostics. In the hands of Swaco designers and engineers, they result in specific advancements that help accomplish Swaco's four major overall goals: satisfy customer needs, improve safety, protect the environment and reduce overall costs.

Outside the company, we are always looking for better ways to improve communication among our customers, our suppliers and Swaco people. To that end, we are increasing the use of alliances, so there is a reliable and constant flow of information that saves time and money for everyone involved in developing your well.

A record of significant contributions to solids-control technology.





Swaco provided one of the first cuttings classification and re-injection systems for North Sea platforms.

Building a reputation, one person at a time.

When you're in a business that puts a premium on technologically sophisticated equipment, it's very easy to overlook the real power behind the machinery — the people. To make sure our emphasis is always on excellent people, Swaco trains its employees throughout their careers with the company.

When an individual joins Swaco, there is initial training that gives the person basic skills in his or her chosen field. Like our technologies, Swaco training programs are also constantly evolving to keep our people the most knowledgeable in the field. For example, courses include a thorough explanation of fluids processes and their impact upon every phase of drilling and completion.

In the next phase of training, the employee receives on-the-job experience and schooling by actually performing the assigned duties under the watchful eye of an experienced supervisor who is responsible for evaluating performance and making recommendations.

When Swaco people show exceptional talent for a particular portion of their responsibilities, they receive advanced training to keep them current with the evolving technologies we provide our customers. In this way, excellence in technologies, practices and people unite to give Swaco customers a level of service they won't find anywhere else.

Swaco closed-loop systems: A tale of two wells.

The Swaco closed-loop system is probably the surest way to ensure the best solids-control value for your dollar. Basically, it is a suite of solids-control equipment custom-matched to your well and drilling objectives in order to minimize drilling fluid dilution and provide the most economic handling of the drilling waste. The result is that no mud is discarded from the rig, reserve pits are eliminated and used fluids are recycled.

Two wells, drilled only 200 ft apart in Matagorda County, Texas, provided a unique opportunity to compare the cost savings difference between conventional solids-control equipment and a Swaco closed-loop system. Both wells drilled through the same formations, using the same rig, crew, mud company and bit program. Improved solids control resulted in some significant savings:

- A 43% savings in drilling fluid costs
- 23% fewer rotating hours
- 33% fewer days to drill to a comparable depth
- A 37% reduction in the number of bits used
- Up to a 39% improvement in the rate of penetration

Typically, the system includes a series of linear-motion shakers, mud cleaners and centrifuges followed by an optional dewatering system. The dewatering system adds flocculants to the feed of a high-speed centrifuge to coagulate ultra-fine particles that can then be discarded. This combination of equipment typically results in a "dry" location where a reserve pit is not required, and solid waste can be landfarmed, hauled off or injected downhole.

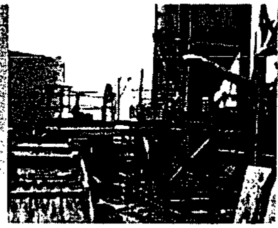
Swaco takes the pressure off underbalanced drilling.

The drilling of deeper, hotter, higher-pressure underbalanced horizontal wells presents unique challenges in terms of both safety and potential formation damage. Unpredictable surges or kicks of high volumes of liquid and gas are the main sources for these hazards.

To meet the challenges of underbalanced drilling, Swaco's engineers have developed the Super Mud/Gas Separator (SMGS) as part of the complete Underbalanced Drilling System (UDS™). The UDS gives Swaco customers much greater gas handling capabilities at the surface — where the dangers manifest themselves — than has been previously available. In addition to improved safety, the UDS also delivers cost efficiency by furnishing gas handling capabilities as well.

In summary, the Swaco Underbalanced Drilling System provides these main benefits:

- Improves rig safety by acting as a "shock absorber" against well surges or kicks
- Monitors and display of all critical well data
- Handles large volumes of liquids or gas without costly add-on equipment
- Facilitates the drilling of deeper and larger-diameter holes at higher circulation rates
- Eliminates the cost of a skimming system for gas
- Permits the immediate sale of gas during drilling operations



Customers worldwide trust Swaco to provide essential waste treatment services and technologies that reduce drilling costs and ensure environmental compliance.

Worldwide locations

Global Sales and
Technical Support
P.O. Box 42842
Houston, Texas 77242-2842
Tel: 713-308-9455
Fax 713-308-9463

Direct Sales Worldwide
Quotation/Orders of Parts and Equipment
P.O. Box 25246
Oklahoma City, Oklahoma 73125
Tel: 405-752-6911
Fax 405-751-1649

Swaco/DSR — Anchorage, Alaska
Tel: 907-274-5533
Fax 907-284-5535

Ventura, California
Tel: 805-644-8445
Fax 805-644-8868

Denver, Colorado
Tel: 303-623-0911
Fax 303-629-0909

Harvey, Louisiana (Service)
Tel: 504-349-8004
Fax 504-349-8090

Lafayette, Louisiana (Sales)
Tel: 318-261-8127
Fax 318-261-8133

Lafayette, Louisiana (Service)
Tel: 318-234-6395
Fax 318-234-6399

Safeguard/Swaco
Lafayette, Louisiana
Tel: 318-235-8483
Fax 318-237-8110

New Orleans, Louisiana
Tel: 504-527-6490
Fax 504-561-6393

Laurel, Mississippi
Tel: 601-649-8874
Fax 601-649-8879

Williston, North Dakota
Tel: 701-572-7731
Fax 701-572-7419

Chickasha, Oklahoma
Tel: 405-224-4170
Fax 405-224-1429

Oklahoma City, Oklahoma
Tel: 405-752-6986
Fax 405-751-3775

Corpus Christi, Texas
Tel: 512-289-2200
Fax 512-289-2303

Liberty, Texas
Tel: 409-336-5672
Fax 409-336-2441

Odessa, Texas
Tel: 915-550-2944
Fax 915-362-2101

Tyler, Texas
Tel: 903-593-9491
Fax 903-593-5953

Casper, Wyoming
Tel: 307-472-7257
Fax 307-473-8776

Airdrie, Alberta, Canada (Service)
Tel: 403-948-4400
Fax 403-948-4664

Calgary, Alberta, Canada
Tel: 403-290-5320
Fax 403-290-5315

Nisku, Alberta, Canada
Tel: 403-955-3310
Fax 403-955-8899

Dartmouth, Nova Scotia, Canada
Tel: 902-463-8015
Fax 902-468-5103

Neuquen, Argentina
Tel: 54-99-440930
Fax 54-99-440933

Bogota, Colombia
Tel: 571-636-0066
Fax 573-618-2800

Quito, Ecuador
Tel: 593-2-266-224
Fax 593-2-266-227

Cairo, Egypt
Tel: 20-2-3500194
Fax 20-2-3511042

Celle, Germany
Tel: 49-5141-84061
Fax 49-5141-84064

Balikpapan, Indonesia
Tel: 62-542-72901
Fax 62-542-72903

Swaco/MV — Italy
Tel: 39-532-831010
Fax 39-532-831650

Villahermosa, Mexico
Tel: 52-93-163374
Fax 52-93-164736

Netherlands
Tel: 31-524-533334
Fax 31-524-533422

Stavanger, Norway
Tel: 47-51-571055
Fax 47-51-571303

Bucuresti, Romania
Tel: 40-1-210-6850
Fax 40-1-210-6886

Moscow, Russia
Tel: 7-095-785-1021
Fax 7-095-262-1146

Aberdeen, Scotland
Tel: 44-1224-703771
Fax 44-1224-824909

Singapore
Tel: 65-542-4488
Fax 65-542-2986

Dubai, U.A.E.
Tel: 971-4-837247
Fax 971-4-837140

Anaco, Venezuela
Tel: 58-82-241711
Fax 58-82-240076

Exhibit 7:

Oklahoma Department of Environmental Quality website: Case Studies

http://www.deq.state.ok.us/CSDnew/P2/Casestudy/oxyusa%7E1.htm

Pollution Prevention | Case Studies

There are currently ten case studies on file of organizations who have implemented pollution prevention strategies and the savings/benefits they have gained.

1. Amoco Production Company
2. Dayton Tire
3. Empire Castings
4. Greenleaf Nursery
5. The City of Guymon
6. Oxy USA, Inc.
7. Tinker Air Force Base (TAFB)
8. VAC Corporation
9. Vance Air Force Base (VAFB)
10. Webco Industries

Click on any of the case studies to find out more about what improvements they made.

OXY USA, Inc. is a large oil and gas production company, a subsidiary of Occidental Oil and Gas Corporation and Occidental Petroleum Corporation. The proposed well site was located on lands which were directly adjacent to the Tishomingo Wildlife Refuge.

Improvements

The pollution prevention project centered around an exploration well in Johnston County, Oklahoma, drilled on land owned by the U.S. Army Corps of Engineers. Some of the P2 measures instituted in the drilling of the well were:

- drill site entirely enclosed with a berm capable of holding several times the volume of liquids stored on location plus any anticipated precipitation
- location pad and berm were built with an impermeable clay base. The area under the drilling rig itself was protected by a 30 mil plastic liner a smaller casing was selected which allowed for the use of a 25% smaller hole and generated lesser amounts of cuttings and used smaller amounts of drilling fluids
- a closed-loop mud system was instituted which allowed for reuse of drilling fluids and use of smaller quantities of water for dilution of the mud to control viscosity and density
- compressed air was used as the drilling fluid where possible. This allowed for the use of smaller quantities of water and drilling fluid in the drilling fluid system.

Savings and Benefits

The pollution prevention measures listed above are responsible for the following benefits and financial savings:

- the hole size reduction, use of air drilling, and closed-loop system resulted in waste reduction of nearly 1.5 million pounds. A material and disposal cost savings of $12,700 was also realized
- low-toxicity additives allowed for the land application of the used drilling fluids and cuttings
- reduced hole size resulted in fewer environmental impacts, as did the use of air drilling
- building the location with the capability of containing all liquids reduces the potential for pollution

OXY USA, Inc.
Box 300
Tulsa, OK 74102

Waste stream: used drilling fluid, drilled cuttings

Exhibit 8:

John Longwell and Glenn Hertzler, Closed-Loop System as a Cost Effective Alternative to Reserve Pits, paper presented at the "Advances in Drilling Technologies for the North American Rockies", Denver, Colorado, 1997

Consortium for Emerging Gas Resources in the Greater Green River Basin

"Advances in Drilling Technologies for the North American Rockies"

Monday April 28, 1997
Mount Elbert Room
Hyatt Regency Downtown
Denver, Colorado

Sponsored by

Gas Research Institute

U.S. Department of Energy

Independent Petroleum Association of Mountain States

CLOSED-LOOP SYSTEM AS A COST EFFECTIVE ALTERNATIVE TO RESERVE PITS

JOHN LONGWELL
PRIMA ENERGY CORP

GLENN HERTZLER
NABORS DRILLING USA, INC.

PRIMA ENERGY CORP.

NABORS

Introduction

Prima Energy Corp. and Nabors Drilling USA, Inc. have teamed up to drill over 50 wells utilizing a highly automated closed loop system in lieu of traditional earthen reserve pits. Environmental and economic damage caused by drill site construction and reclamation has been greatly reduced with no increase in total well cost. Drilled solids are stripped from the mud while drilling, and are put to beneficial use. Remaining fluid is transported to the next drill site and used on the subsequent well, thus virtually eliminating drilling waste, reducing water consumption, and improving surface owner relations.

Background

Operators have drilled over 7000 wells in the Wattenberg Field of Colorado over the past 15 years. Due to the large increase in population and environmental sensitivity in the front range area, it has become desirable to minimize the surface disturbance and truck traffic associated with our drilling operations. Heavy drilling activity during and immediately following the 1990 - 1992 tax credit qualification period caused public concern and numerous Colorado Oil & Gas Conservation Commission rule changes. Prima has drilled over 400 wells in the Wattenberg Field and continues to pursue methods to reduce impact associated with drilling and production operations, and improve the public perception of our industry.

New Technology

Nabors Drilling USA, Inc., Environmental Equipment Corp., and Prima Energy Corp. embarked on a program to develop a closed loop drilling system in 1993. The system uses a high speed linear motion shale shaker to remove the bulk of the cuttings, which are moved by a loader to a storage pile. Remaining mud is then pumped from the drilling rig's 400 bbl steel tank to a highly automated chemical addition trailer which adjusts PH, automatically mixes, hydrates, meters, and injects a polymer flocculent into the mud stream. The coagulated mud is then pumped into a standard centrifuge, which removes all remaining solids. The remaining water, which is remarkably clear, is then returned to the circulating mud system to be re-used as drilling water.

Field Results

Prima has drilled roughly 50 wells with the automated system, and have seen the following benefits from the use of this system:

1. Eliminates excavation expense and risk of damaging underground pipelines and utilities.
2. Reduces surface disturbances and surface damage payments.
3. Eliminates the most unsightly part of our industry-PITS.
4. Reduces time and manpower requirements to build and reclaim pits and locations.
5. Reduces truck traffic associated with drilling operations by up to 75%.
6. Eliminates soil segregation and wind erosion problems.
7. Reduces pad size and cuts in sensitive and hilly areas.

8. Greatly reduces waste tracking and need for land farming operations.

Field Results (cont.)

9. Eliminates the need to fence reserve pits in certain areas.
10. Allows drilling in areas with a high ground water table.
11. Eliminates risk of waterfowl mortality in pits.
12. Provides finely ground clay for berm construction around tank batteries.
13. Reduces water consumption by up to 80%.

Waste Elimination

Frequently, drilling is conducted on level farm fields, where no site preparation or reclamation is required other than ripping to relieve compaction. The only remaining waste at the conclusion of drilling operations is a pile of finely ground cuttings, mostly comprised of clay, stacked on the location. These cuttings have proven to be very useful for berm construction around production facilities, as the clay provides a very effective barrier should a spill occur. Many local feedlots and other agriculture interests have found this product to be an inexpensive material to line waste ponds, corrals, and feedlots to prevent animal waste from fouling the shallow ground water found in the alluvial soils in eastern Colorado.

Economics

The following table was prepared to show the cost comparison of conventional rotary drilling using reserve pits versus the current closed loop drilling system utilizing mud motors and diamond bits.

	Conventional drill Standard Pit	Mud motor 7 7/8" bit Closed loop system
Water	6400 bbls-$4720	1200bbls-$1350
Location	300'x300'-$3000	200'x300'-$900
Mud	$2000	$1700
Damages	$3500	$2500
Berm	$1000	$0
Mud Haul	$2800	$900
Dewatering Unit	$0	$8250
Total Cost	**$17,020**	**$15,600**

Summary

The closed loop drilling system developed has proven to be a reliable, cost effective tool for reducing conflicts with surface owners and reducing impact to the environment. Field results have shown no net increase in total well cost to utilize the system. Applying this system on wells drilled on valuable vegetable crop land can result in significant savings by reductions in normally high surface damage payments, eliminating the cost of laser leveling, and all but eliminating future economic liability for crop failures. This system, when integrated with a drilling rig such as the package Nabors Drilling USA, Inc. offers, provides a trouble free solution to the problems many operators encounter when trying to develop gas and oil reserves in populated areas.

Exhibit 9:

June 8, 2004, Farmington Daily Times, "New director seeks balance in oil, environment", Walter Reubel

Headlines

New director seeks balance in oil, environment
By Walter Rubel/Santa Fe Bureau Chief
Farmington Daily Times
Jun 8, 2004, 11:44 pm
http://www.daily-times.com/artman/publish/tuesday/article_11699.shtml

SANTA FE — Mark Fesmire refers to the oil and gas industry in New Mexico as "the goose that laid the golden egg."

But, as is the case with all waterfowl, not all that is left behind is golden. Fesmire, who was recently named director of the state's Oil Conservation Division, said his job is to find the right balance — protecting the environment while still allowing oil and gas companies to remain productive.

"We see our position as walking a very, very fine line," he said. "We're not going to strangle that golden goose. We're going to nurture that golden goose. But at the same time, we're going to take very, very good care of our water — both our ground and surface water, which can be effected by oil and gas operations."

In a news release announcing Fesmire's hiring, Energy, Minerals and Natural Resources Secretary Joanna Prukop said the Oil Conservation Division is "taking a new direction for stronger environmental enforcement and compliance." For that to happen, Fesmire said they would focus on increasing inspections and improving education.

But he admits that it will be difficult with existing resources.

"One of the things that we intend to focus on is getting some more inspectors," he said. "There have been some recommendations that we have as many as one inspector for every 500 to 1,000 wells. We've got between 60,000 and 80,000 wells, depending on how you count them, and we've got 12 inspectors statewide."

He said the increase in oil and gas prices has brought new employees and companies into the industry.

"We're going to be faced with people that aren't as experienced as some of the hands we've got now," he said.

"A general concern with the industry in New Mexico is that the industry is maturing, and as it matures you go from very well-financed, large oil companies who are doing the majority of the work, down to smaller independents, down to very upstart companies that purchase these companies as they deplete and have to cut overhead to make these things profitable," he said. "And at some point you reach a point with some leases where the people who operate them would have a tendency to be less than prudent in some of the safety and environmental concerns we have.

"One thing we have to do is make sure that those people understand that we are still going to pay attention to those low-overhead leases."

Fesmire said that even as he works to increase inspections and enforcement, he is aware of the huge impact the oil and gas industry has on the state. The industry pumps more than $1 billion into the state coffers every year, and is the largest civilian employer. Fesmire said the decisions made by the Oil Conservation Division will have a large impact.

"Every regulation that we promulgate, every enforcement action that we do is some part of a well that won't be drilled in New Mexico," he said. "It's some part of an exploratory well that won't get drilled, which means it's some part of a field that won't be discovered, which means it's some part of a series of development wells that won't be drilled.

"It's some job that won't be created; or worse yet, a job that will be eliminated. So we're not going to regulate for the sake of regulating."

He said the industry seems to be receptive to the new emphasis on enforcement and compliance.

"I met with an operator in Farmington (last week) — a large independent up there, and their commitment was palpable," he said. "We agreed on just about everything. I think where we're going to differ is maybe in the degree. But the direction, I think, is pretty universally held in New Mexico as to the things we need to do to protect the environment."

Bob Gallagher, head of the New Mexico Oil and Gas Association, described Fesmire as "open minded" and said his group was pleased with the selection.

"The administration has made it very clear it wants to step up enforcement. We are very supportive of that," Gallagher said. "If one of our companies is not operating within the regulations, they need to be told that and they need to be brought into compliance."

Jennifer Goldman, of the industry watchdog group Oil and Gas Accountability Project, said she had not yet met Fesmire, but applauded the new direction the state appears to be taking.

"I do see a change in leadership as a positive situation, and our group is eager to start anew," she said. "In the past, they've had a poor reputation with land owners."

Fesmire said he didn't see his role as to bring "revolutionary change," but said there would be a new emphasis on protecting surface and ground water.

"I've spent a lot of time in Texas, and I've seen what good regulation can do," he said. "And, I've seen what can happen when people are skirting the regulations. And I'm not going to let that happen in my state."

Walter Rubel: wrubel@lcsun-news.com

Williams

June 11, 2004

RECEIVED

JUN 14 2004

OIL CONSERVATION DIVISION

Mark E. Fesmire, P.E.
Director
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Proposed new rules to govern operations in the CHIHUAHUAN DESERT AREA at Otero and Sierra Counties, New Mexico

Dear Director Fesmire:

The Williams Companies (Williams) is providing this letter to express our concerns with the Oil Conservation Division's (OCD) action to amend §19.15.1 NMAC (General Provisions and Definitions). The OCD has stated that the purpose for adding new provisions is to protect groundwater and minimize surface contamination to the Chihuahuan desert area (Otero and Sierra Counties). As a major producer in New Mexico, Williams is concerned that the proposed provisions could impede production and increase the costs of producing oil and gas in the state.

Pursuant to NMOGA's study, the Williams Companies (Williams) Williams ranks #8 out of the top 50 producers in New Mexico producing 40,839,113 Mcf in 2003. While Williams respects the concerns for protection of groundwater and surface damage, it is uneasy with the precedent that the proposed amendment could set by placing further impediments on the production of domestic oil and natural gas. Of even more concern to Williams is the lack of evidence showing how drilling activities are associated with any of the groundwater problems. Additional requirements will only add more costs to the production of natural gas, while providing little or no additional protection to groundwater zones. Williams believes current business practices and regulations are working to protect the valuable resources in the state.

The New Mexico Oil and Gas Association (NMOGA) has submitted detailed comments and, as a member of NMOGA, Williams whole-heartedly supports those comments. While reviewing NMOGA's comments, as well as, Williams' and other industry comments, Williams would hope that the OCD would consider the importance of the oil and gas production industry to the state of New Mexico and try to strike a balance. Williams would also hope that the OCD would consider the troubled times in which our country now finds itself and set forth guidelines which will allow the country to depend upon its domestic production to fuel the U.S. economy.

Again, Williams appreciates the opportunity to provide comments to you on the Chihuahuan amendment, however, we strongly oppose the amended language to §19.15.1 NMAC. If you have any questions, please contact me at 918-573-4326. Thank you for your consideration.

Sincerely,

Debbie Beaver

Debbie Beaver
Manager, State Government Affairs

RECEIVED

JUN 17 2004

OIL CONSERVATION DIVISION

Trisha London
324 Townsend Terrace
Las Cruces, NM 88005

June 12, 2004

Florence Davidson, Division Administrator
Oil Conservation Division
New Mexico Energy, Minerals And Natural Resources Department
1220 South St. Francis Drive
Santa Fe, NM 87505

Re: Comments on Proposed Section 19.15.1.21 NMAC
New rules to govern operations in the Chihuahuan Desert Area of Otero
And Sierra Counties, New Mexico

Dear Ms. Davidson,

I very much appreciate the OCD's action and response to Governor Richardson's Executive Order, recognizing the importance of New Mexico's Chihuahuan Desert grassland areas. I recognize that our current OCD rules inadequately protect the precious groundwater resources and ecological aspects of these areas. While the heightened requirements regarding injection wells is an improvement over the current rules, they are still insufficient to provide complete protection of this irreplaceable commodity, fresh water and a rare and disappearing habitat. For too long, our public and regulatory agencies have been more promoters of industry instead of protectors of those resources and values that should be perpetuated far into the future. Without sufficiently stringent regulations on the oil and gas industry, the status of our natural resources along with our quality of life will continue to decline.

Pits should be prohibited in the Chihuahuan Desert grasslands. The groundwater here is far too precious a resource to risk potential contamination. The OCD should incorporate the best science available for designing restoration standards that fully acknowledge the fragile and unique character of the Chihuahuan Desert grasslands.

Thank you for considering my comments,

Trisha London
324 Townsend Terrace
Las Cruces, NM 88005
ph. 505-527-9962

BP America Production Company
1660 Lincoln Street, Suite 3000
Denver CO 80264

June 14, 2004

Mr. Mark Fesmire, P.E.
Director
Oil Conservation Division
1220 St. Francis Drive
Santa Fe, New Mexico 87505

RE: Proposed New Rules To Govern Operations in The Chihuahuan Desert Area of Otero and Sierra Counties, New Mexico.

Dear Mr. Fesmire:

BP America Production Company is the third largest natural gas producer in New Mexico and we operate over three thousand wells in the state. We have reviewed the proposed new rules to govern oil and gas operations in the Chihuahuan Desert Area of Otero and Sierra Counties (Otero Mesa). Thank you for the opportunity to comment on the proposed rules.

BP shares the concerns expressed by the New Mexico Oil and Gas Association in their comments. Current industry practice and existing rules governing drilling and production operations, including the use of pits, groundwater protection, and underground injection control have been highly effective in protecting environmental resources throughout the state of New Mexico. Industry and the New Mexico Oil Conservation Division's experience regulating oil and gas operations in other parts of the state should provide assurance that these existing rules will be just as effective in Otero Mesa. Therefore, we urge the Oil Conservation Commission to rely upon existing rules and regulations and avoid adopting rules for Otero Mesa that are unwarranted and unjustifiably burdensome to industry.

Sincerely,

James W. Hawkins
BP San Juan Regulatory Consultant

NEW MEXICO
ENVIRONMENTAL LAW CENTER

June 14, 2004

Ms. Florene Davidson
Oil Conservation Division
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

VIA FACSIMILE: (505) 476-3462

Re: Comments of the New Mexico Environmental Law Center on Proposed Rule Banning Pits on Otero Mesa and the Chihuahuan Desert Area

Dear Ms. Davidson:

The New Mexico Environmental Law Center (NMELC) is dedicated to helping preserve valuable natural resources in the state of New Mexico, such as the Chihuahuan Desert. This desert is not only an exceptionally unique warm-weather desert with vast grasslands and diversified trees and cacti, but it also sits upon large future groundwater resources vital to the southern region of New Mexico. Because the Chihuahaun Desert combines two concerns of the NMELC, an intrinsic natural resource and a fundamentally needed resource, the NMELC submits the following comments on proposed rule 19 NMAC § 15.1.21.

In general, the addition of this rule is a step in the right direction. However, this proposed rule should be strengthened further before it is finalized. Below is a list of comments to be considered while promulgating the final rule.

Comments –

1. Proposed 19 NMAC § 15.1.21(c)(5) indicates that "[o]perators shall run cement bond logs acceptable to the division during new construction." It is not clear what an "acceptable" bond log is. Specific language is needed to indicate what will be considered an "acceptable" bond log.

2. Also, under § 15.1.21(c)(5), more descriptive language than "adequate and competent" is needed to detail what will "satisfy" the division when they review the cementing of casing strings. Possibly a reference to 19 NMAC 15.9.702 – Casing and Cementing of Injection Wells – might be adequate. However, if this proposed subsection is a qualifying statement for proposed

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Phone (505) 989-9022 Fax (505) 989-3769 nmelc@nmelc.org

subsection 19 NMAC 15.1.21 (C)(4)(a), reference to that effect would provide more clarity.

3. The Oil and Gas Conservation Division (Division) should prohibit the use of underground injection wells on Otero Mesa. The Division has the specific power to regulate the disposition of produced water under NMSA § 70-2-12(15). The law sets a minimum standard of "reasonable protection" for fresh water supplies but mandates no maximum limits on how strict the guidelines should be. Thus, it is well within the Division's authority to completely eliminate the use of produced water injection wells. The unique character of the Chihuahuan Desert, and the extreme importance of protecting water resources in a desert climate warrant this prohibition.

4. At a minimum, efforts to protect fresh water aquifers from contamination by produced water injection wells should be furthered by reference to the abatement requirements in 19 NMAC § 15.1.19. The reference is necessary because as the proposed rule indicates, currently only §§ 19.15.9.701-19.15.9.710 will be the supplemental guidelines applicable to the Chihuahuan Desert area.

   Reclamation/abatement plans play an important role in noticing to the oil and gas industry (industry) that pollution of groundwater will not only result in the stoppage of operations, but serious costs and consequences associated with cleaning a groundwater source can be expected. The overall message to oil and gas operators should be clear - cleanliness of groundwater will not be compromised. Regulatory requirement of abatement plans will inspire industry to utilize the best available technology and best management practices to protect groundwater in the first place. It also discourages any acceptance of water contamination as "business as usual."

   Federal Jurisdiction under the Safe Drinking Water Act does not hinder the Division's ability to implement abatement plans. The Safe Drinking Water Act (SDWA) prohibits federal restrictions on oil and gas operations such as restricting injection wells of brine or other fluids. 42 USC § 300(h)(2)(A). However, even with federal application of the SDWA, restrictions considered essential to assure underground sources of drinking water will be enforced. *Id.* Thus, the state's power to regulate oil and gas injection wells will not be hindered if there is a concern about ground water pollution. As regulator of certain injection wells under the Oil and Gas Act, the Division has the authority to require further regulations in order to protect drinking water.

   The Chihuahuan desert has several possible underground water resources for future use. One basin location (the Salt Basin) is estimated to have 2.6 trillion gallons of recoverable groundwater. With a lingering drought and water resources dwindling in public reservoirs, large potential sources of water should be subject to the most protection possible. Denying any injection of possible contamination, including produced water, would be the most beneficial, but a reclamation/abatement requirement would put industry on notice that pollution of groundwater is not an acceptable practice, and the cost to abate should be considered before drilling begins.

5. A review of the Division's mandates provided in NMSA § 70-2-12(21), and other sections implying authority, do not limit how or when to utilize pits. Accordingly, further requirements on industry to use options such as close-loop systems or banning pits all together are appropriate. The need to protect public health and the environment justifies regulatory efforts inhibiting use of pits. Open pits have been the possible culprits of 6,700 cases of soil and water contamination in New Mexico. Further, without proper fencing or netting, wildlife has suffered the effects of mistaking pits for water sources. Water tables in New Mexico have varying degrees of depth, those which have shallow depths will be very prone to contamination by seepage or leeching of spilled or overflowing pits.

6. The radius of the area of review proposed in 19 NMAC § 15.2.21(C)(2)(a) would be more adequate and smoothly integrated with the rule concerning underground injection control fields in New Mexico, 20 NMAC § 6.2.5202(B)(1), if it required a two and one half mile zone extending from the well, or well field. 20 NMAC § 6.2.5202 regulates the area of review for two major classes of underground injection wells in New Mexico. Although authority has been granted to the Division to regulate injection wells associated with oil and gas development, adopting similar requirements between the regulations controlling injection wells would provide more continuity and streamlining of concepts, making application of the regulations easier for industry. Unless there is very convincing evidence to believe that produced water from oil and gas development is less threatening than non-hazardous waste, there is no reason to lower the size of the established area of review from 20 NMAC 6.2.5202 (B)(1) to the first proposed option of area of review under 19.15.1.21 (C)(2)(a).

If you have any questions regarding these comments, please fill free to contact Luke Miller or me at the phone number or address above.

Sincerely,

Roderick Ventura
Staff Attorney

Davidson, Florene

From: Rick_Foppiano@oxy.com
Sent: Monday, June 14, 2004 8:43 AM
To: fldavidson@state.nm.us
Cc: gallagher@nmoga.org; seligman@nmoga.org; Greg_Hardin@oxy.com; Matt_Hyde@oxy.com; Mike_Starrett@oxy.com
Subject: OXY Comments on Case No. 13269, OCD-proposed amendments to 19.15.1.21 NMAC (Otero Mesa Rules)

Florene, for the record in the subject case before the Oil Conservation Commission on June 17th, 2004, following are the comments of Occidental Permian Limited partnership, OXY USA Inc., and OXY USA WTP Limited Partnership (hereafter referred to as "OXY").

OXY is a very active operator in the Permian Basin, which includes Southeast New Mexico. We support the comments filed by the New Mexico Oil and Gas Association ("NMOGA") in this matter. In particular, we believe the concerns that give rise to this proposed regulation could be addressed in a more cooperative manner, starting with identifying the problems that such focused regulation is intended to solve. Experience shows that industry is willing to commit substantial time and effort to these collaborative efforts, as demonstrated by the recent revision of the hydrogen sulfide rules and the push to reduce the number of temporarily-abandoned wells. Absent that, we believe the current statewide rules, practices and policies of the NMOCD are more than adequate to protect fresh water and the surface environment in this area. We urge that this proposed rulemaking be withdrawn, and that a joint effort to commissioned to investigate and identify issues that warrant area-specific solutions.

OXY thanks the Commission and the Oil Conservation Division for the opportunity to comment on this proposed rulemaking.

Rick Foppiano P.E.
Regulatory Team Leader
OXY Permian - Houston, TX
Phone: 713-366-5303*
Fax: 713-985-1550**
E-Mail: Rick_Foppiano@oxy.com
*changed effective 10-13-03
** corrected

Davidson, Florene

From: tom.mullins@synergyoperating.com
Sent: Monday, June 14, 2004 10:02 AM
To: fldavidson@state.nm.us
Cc: gallagher@nmoga.org; Deborah Seligman; ftchavez@state.nm.us
Subject: Rule 21 - Comments Oil and Gas - Otero Mesa

June 14, 2004

New Mexico Oil Conservation Division

Dear Ms. Florene Davidson:

Welcome to the new NMOCD Director Mark Fesmire. Thank you for extending the comment deadline regarding Rules for Oil and Gas Development in Otero and Sierra Counties, New Mexico.

This is referred to as Rule 21.

Synergy Operating, LLC (Synergy) is a small New Mexico Oil and Gas producer located in Farmington, NM. We have participated for many years in NMOCD rule making decisions.

We feel it important to write and offer our support and echo the comments offered by NMOGA and IPANM in this matter. We are a member of both organizations.
We are concerned not only about oil and gas regulations effecting distant NM counties, but most specifically about oil and gas regulations that may be enacted anywhere within the state without adequate consideration for the current successful environmentally responsible oil and gas development practices being utilized. Rule 21 appears to set an unsound precedent of rulemaking without adequate representation. Small business which makes up the majority of all private employers in New Mexico is often a voice not heard in many quarters. I am writing to offer the voice of a small oil and gas business in this important matter.

There appears to be an excessive focus on the emotional environmental aspect of Otero Mesa, with less focus on the science and economicly based environmental protections. New Mexico receives over 25 percent of its annual general fund budget directly from oil and gas production. For FY-2005, this will exceed one billion dollars. New sources of oil and gas must be located to replace this finite resource. New Mexico in collaboration with industry has protected the environment while supplying this needed fuel for our state and nation. By continuing to raise the environmental bar, inappropriately, excessively, and without regard for the economic impacts of these hurdles, hurts every New Mexican through higher gasoline and natural gas fuel prices. Clean burning natural gas development can co-exist with reasonable regulation of industry practices.

Synergy believes that the "Chihuahuan Desert" term be replaced with a more geographically appropriate term. The public hears "Chihuahuan", and often thinks of a small defenseless dog. That is not the case in this matter. The dogs in this fight are by no means "Chihuahuan".

Due to the complexity and natural fragmentation of New Mexico grassland areas, utilizing a more appropriate term such as "Otero and Sierra Counties, NM" would more properly define the area encompassed by this Rule.

Synergy believes that by disallowing pits in the Otero Mesa area, that the unnecessary operational and un-required financial hardships placed upon an operator of gas wells may not be overcome. This rule would effectively prevent oil and gas development on these public lands. Oil and gas operations are present and continue to be developed in areas of special environmental concern. We strongly urge the NMOCD to review the scientific facts and historic information regarding pits and their proper use before banning pits in oil and gas operations throughout the state.

Synergy believes the science reflected in the recently updated Underground Injection Control Manual (UIC) prepared by the NMOCD on February 26, 2004 was not adequately referenced when reviewing the rule-making associated with Rule 21

Synergy believes that groundwater resources have been historically protected through enforcement of existing regulations in all New Mexico oil and gas development areas. We urge continued review and enforcement of regulations rather than creating of additional burdens. Searching for oil and gas is challenging. Typically when hydrocarbons are not found in exploratory wells, water of some type is encountered. This information has historically been supplied to the appropriate regulatory bodies for consideration by technical staff in the determination of water resources.

Synergy believes that current NMOCD rules and regulations are more than adequate to ensure the prevention of waste, protect the environment, while responsibly promoting oil and gas development. Cementing requirements and reporting requirements under existing rules are sufficient. No improved measure of safety or protection is afforded by changing the quantity or frequency of these items.

Synergy concludes our comments by reaffirming our commitment and our industry's commitment to responsibly develop oil and gas resources in New Mexico. Through collaboration, we can jointly protect the environment and develop clean burning fuel for New Mexico.

Thank you for your consideration of these comments.

Best regards,

Tom Mullins

Thomas E. Mullins
Engineering Manager
Synergy Operating, LLC
PO Box 5513
Farmington, NM 87499
tom.mullins@synergyoperating.com
(505) 566-3725 - direct
(505) 320-1751 - cellular
(505) 325-6585 - facsimile

June 16, 2004

Ms. Florence Davidson
1220 South St. Francis Drive
Santa Fe, New Mexico 87505

RE: Public Hearing-Pit Rule for Otero Mesa

Dear Ms. Davidson,

Please allow me to apologize for taking up valuable time. I am aware that the comment period for 19.15.1 NMAC to be amended and codified at 19.15.1.21 NMAC was closed.

However, due to recent events in our area I failed to submit the timely comments. In lieu of that, I wish to supply, for your perusal, a copy of the position of the Otero Mesa and Crow Flat area ranchers.

Please make use of or forward these positions to anyone you feel may be interested. Again, I thank you for your time and trouble.

Sincerely,

Bobby Jones
Otero Mesa rancher
Chairman of Otero County Grazing
Advisory Board

THIS IS THE POSITION PAPER FOR OIL AND GAS EXPLORATION AND DEVELOPMENT ON OTERO MESA AND CROW FLAT BY RANCHERS WHO ARE RESIDENTS OF THE AREA

1. The BLM administratively declare Otero Mesa and Crow Flat a special management area

2. Adopt rigid protection for the invaluable water resources in the Salt Basin and Otero Mesa

3. Adopt the areas designated on the accompanying map to be exempt from drilling. The Cornudas Mountain complex and drainage areas from the rim of the mesa to Crow Flat, including careful protection of the flood plain of Crow Flat.

4. Protection to be upgraded and improved for the Butterfield and Emigrant Trail to California.

5. Protection for the Native American petroglyphs and pictographs located throughout the area plus other cultural remains.

6. On going maintenance while in development for all county and ranch roads using road graders and water trucks.

7. Implementation of similar regulations to those embodied on Vermijo Park.

8. Compensation fro the negative impacts to grazing operations to be set by two (2) Oil and Gas representatives, one (1) BLM representative, two (2) ranch representatives and one (1) county commissioner.

9. On going monitoring of all activity by the same group as listed in No. 8, including one (1) environmental representative.

10. The oil company should designate one (1) individual to be responsible for all problems created the development activity with financial liability.

11. A group should be appointed by the Otero County Commission to work closely with the BLM in reclamation of roads, well sites and other activities and placements of well sites, pipelines and electric lines.

12. The 5% limitation on disturbance during exploration on the grasslands areas should be expanded to cover all federal leases of minerals on Otero Mesa and Crow Flat.

This area is the home of ranch families who have lived here for over 100 years with very little impact on its pristine condition. Please help us protect all those values that have been preserved by these families.

Harvey E. Yates Company Comments on the OCD Proposed Rule
Changes For Otero and Sierra Counties
Rule 19.15.1.21

Harvey E. Yates Company (HEYCO) as an Operator in the Otero Mesa Area of Otero County, New Mexico believes the New Mexico Oil Conservation Division (OCD) has arbitrarily proposed this rule for political reasons and not for specific scientific reasons or based on any scientific data. HEYCO also thinks the stakeholders in the area were intentionally omitted in the writing and preparation of this rule up until this point.

In recent years, the OCD has allowed and encouraged participation from the stakeholders in the process of establishing a new rule. In this type of process, they are representatives of the OCD, various Oil and Gas organizations, the Agriculture community and members of the general public. This group's input was three fold: 1) to establish the need for the rule or the rule change; 2) the concerns of the parties for both the environmental and economic impact; and 3) the safety factors of everyone involved. The process you have chosen to take on the Rule is as if the stakeholders do not matter, but the OCD has or has been given an agenda it wants to invoke. This kind of action is directly opposite the statement made by Joanna Prukop, Secretary, New Mexico Department of Energy, Minerals and Natural Resources, at the Congressional Hearing on the Endangered Species Act (ESA) in Carlsbad New Mexico. She testified she and Governor Richardson have been and still are working with the Oil and Gas Industry in New Mexico for a safe and environmentally-sound method to produce oil and gas in New Mexico. This Rule, as being established here, is not working with the Oil and Gas Industry, nor with any other parties involved in the area. Furthermore, the need for this rule has not been established, as it deals with the protection of underground water in the specific counties named. In my research, I have not found any data to support the need for this rule, as there is not any evidence to indicate the contamination of ground or underground water in the Otero Mesa Area. The wells drilled by Threshold Exploration were not drilled on the Otero Mesa and the contaminated water in that situation was hauled into the location by a truck, and was discovered prior to any use of the water.

To comment on the specific sections of the Rule, please review the following:

1) HEYCO requests the name of the Rule is changed to "SPECIAL PROVISION FOR OTERO AND SIERRA COUNTIES".

It is clear this rule is designed to protect a specific area in Otero and Sierra Counties of New Mexico and is not to cover the entire Chihuahuan Desert Area.

2) HEYCO proposes that properly lined pits be allowed in Otero and Sierra Counties and will operate under the current pit rule (19.15.1.21. Section B).

First reason is, to date, there has not been any scientific evidence to indicate damage to groundwater resources or to impede the public health and environment by the use of surface pits.

Second reason is the drilling in an exploratory situation, as in Otero and Sierra Counties, is normally done with air or a fresh-water mud system. Air drilling is the preferred method, as mud can and will mask indications of gas and/oil by being too heavy to allow the product to be detected. This method (air drilling) cannot be used in a closed system, thereby taking away one of the tools used for the discovery of low-pressure gas and/or low gas drive oil.

Third reason is the industry's record in drilling of wells in the state with no evidence of contamination, and the drilling of HEYCO's two (2) wells in Otero Mesa without contamination of the surface and with restoration of the pit area on the wells.

3) HEYCO proposes that the current federally-approved practice of "Notice" and an "Administrative Application" on injection well permits remain in place and not be changed (19.15.1.21, Section C.1)

HEYCO believes the proposed requirement to require notice and hearing for all injection well permits is unnecessary, it will only add addition burden to the industry without any benefit.

4) HEYCO proposes the current UIC requirements for the Area of Review, or the value derived by the EPA formula for determining the zone of endangering influence is sufficiently protective of any nearby wells (19.15.1.21 Section C.2.)

HEYCO believes there is not any justification for a change in this matter. HEYCO requests the OCD provide scientific reasons for the proposed change.

5) HEYCO does not believe the Oil and Gas Industry should be required to invest additional capital in equipment for the gathering of data for the State of New Mexico concerning the ground water.

Normal costs for drilling operations in the Oil and Gas Industry for the exploration of oil and gas have increased, and the industry does not have a method to log or identify fresh ground water, so this will be another increase on any drilling cost, which may make the drilling of certain wells uneconomical.

6) HEYCO proposes the three degrees of protection provided by current federal and state UIC rules already provide sufficient protection to usable ground water without the need for a second cementing of the casing. (19.15.1.21, Section C.4)

This is another situation where there is not justification for requiring additional strings of cemented casing beyond the protection already provided by current federal and state UIC requirements.

7) HEYCO believes the existing practice of cemented casing is sufficient and there is not any need to add additional protection. (19.15.1.21, Section C.5)

Present Industry practices have demonstrated the adequacy of the cementing process in protecting ground water zones.

8) HEYCO believes the practice of installing single walled, produced water flow lines is adequate to prevent spills and release, and where a spill or release occurs, to discover and remediate the spill in a timely manner. (19.15.1.21, Section C.6

HEYCO has found flow line failures are rare and when they occur, are discovered in a very short time, as is common industry practice. Our people are in the presence of the flow lines on a daily basis. Double walls will compound any problem as the leak in the inner wall may be a great distance from the leak in the outer wall, causing extra time to locate the main leak and the additional clean up on a larger area.

9) HEYCO believes the criteria for tank containment should be "sufficient engineering design to prevent release from reaching surface and ground water". (19.15.1.21, Section C.7)

The intent of water protection regulations is to assure "any spills are contained and prevented from reaching surface or ground water in the time frame that it takes to discover and remove such spills and conduct appropriate remediation". Industry experience is that the base and walls of tank containment zones need not be absolutely "impermeable" as the term implies but "sufficiently impermeable" to prevent reaching surface and ground water.

In certain areas where surface and/or ground water is proximate to tank containment facilities, the industry commonly employs the use of synthetic liners and other means of protection.

HEYCO does suggest guidelines as set by the US EPA in SPCC rules; "the proper method of secondary containment is a matter of good engineering practice, so we do not prescribe here any particular method".... "the appropriate method of secondary containment is an engineering question. Earthen or natural structures may be acceptable if they contain and prevent discharges as described in 112.1(b), including containment that prevents discharge of oil to groundwater that is connected to navigable water."

10) HEYCO believes the existing criteria for record keeping and Mechanical Integrity Testing under the federal and state UIC rules are sufficient and there is not any justification to require additional record keeping or testing

HEYCO, as well as the industry as a whole, has an excellent history of protecting ground water under the existing UIC program. This program has shown to adequately fulfill current Mechanical Integrity Testing and record keeping requirements.