United States Department of the Interior

BUREAU OF LAND MANAGEMENT
73544 Highway 64
Meeker, Colorado 81641

IN REPLY REFER TO:
CO110 (1610)

August 15, 2006

Dear Reader:

Enclosed for review is the Environmental Assessment (EA) for the Shell Oil Shale Research, Development and Demonstration (RD&D) Proposal tract. The Shell EA (CO-110-2006-117-EA) will be available on the internet at: http://www.co.blm.gov/wrra/nepa.htm.

Comments on the EA may be submitted in writing to:

Bureau of Land Management
White River Field Office
73544 Highway 64
Meeker, CO 81506
Attn: Jane Peterson

Comments may also be submitted online at Colorado_OSRDDEA@blm.gov. Receipt and consideration of comments by other means cannot be guaranteed by the BLM. Comments mailed to other BLM e-mail accounts may be automatically rejected due to memory limitations or for security purposes. Submission by mail is recommended to ensure your public comments are received. The comment period closes on September 18, 2006. To maximize the efficacy of your comments to the BLM, please be as specific as possible, citing suggested changes, sources, or methodologies.

Written comments on the EA must be postmarked or otherwise delivered by 4:30 p.m. on September 18, 2006 to the address listed above.

Freedom of Information Act Considerations: If you wish to withhold your name or address from public review or from disclosure under the Freedom of Information Act, you must state this prominently at the beginning of your comments. Such requests will be honored to the extent allowed by law. All submissions from organizations or businesses, and from individuals or officials representing organizations or businesses, will be made available for public inspection in their entirety upon completion of comment analysis.

Sincerely,

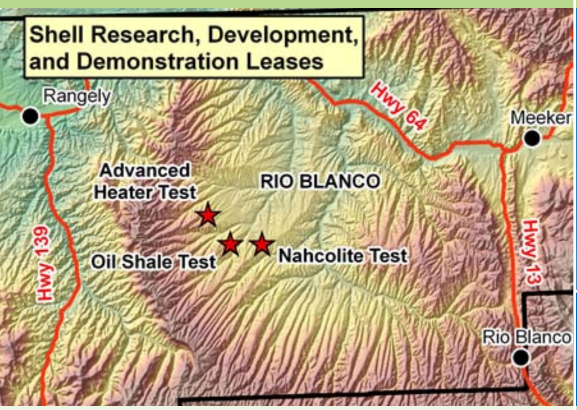
Kent E. Walter

Kent E. Walter
Field Manager

Enclosure

Bureau of Land Management
White River Field Office
Meeker, Colorado

Environmental Assessment



Shell Oil Shale Research, Development, and Demonstration Projects

Rio Blanco County, Colorado

August 2006

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LIST OF ACRONYMS

μeq/l	microequivalents per liter
$\mu g/m^3$	micrograms per cubic meter
ACEC	Area of Critical Environmental Concern
AO	Authorized Officer
APCD	Air Pollution Control Division
AQRV	Air Quality Related Values
AUM	animal unit month
BA	Biological Assessment
BACT	Best Available Control Technology
dB	decibels
dBA	A-weighting (decibels)
BCC	Birds of Conservation Concern
BLM	Bureau of Land Management
BMP	Best Management Practices
CAA	Clean Air Act
CAAQS	Colorado Ambient Air Quality Standards
CCD	Census County Division
CDLE	Colorado Department of Labor and Employment
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response Compensation Liability Act
CDOLA	Colorado Department of Local Affairs
CDOT	Colorado Department of Transportation
CFR	Code of Federal Regulations
cfs	cubic feet per second
CO	carbon monoxide
CO_2	carbon dioxide
COE	U.S. Army Corps of Engineers
COGCC	Colorado Oil and Gas Conservation Commission
CPDES	Colorado Pollutant Discharge Elimination System
CPR	cardiopulmonary resuscitation
CR #	County Road #

CSU	Colorado State University
EA	Environmental Assessment
E-ICP	Electric In-situ Conversion Process
EIS	Environmental Impact Statement
EMT	emergency medical technician
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ERMA	Extensive Recreation Management Area
ERP	Emergency Response Plan
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FLAG	Federal Land Managers' AQRV Work Group
FLPMA	Federal Land Policy Management Act
FR	Federal Register
gpm	gallons per minute
HEL	Highly Erodible Land
HMA	Herd Management Area
ICP	In-situ Conversion Process
kg/ha-yr	kilograms per hectare per year
MBTA	Migratory Bird Treaty Act
mg/l	milligrams per liter
ml	milliliters
mph	miles per hour
NAAQS	National Ambient Air Quality Standards
NDIS	Natural Diversity Information Source
NEPA	National Environmental Policy Act
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
ºF	degrees Fahrenheit
OHV	off-highway vehicle
PEIS	Programmatic Environmental Impact Statement

PIF	Partners in Flight
PM_{10}	particulate matter less than 10 microns in effective diameter
$PM_{2.5}$	particulate matter less than 2.5 microns in effective diameter
PSD	Prevention of Significant Deterioration
R&PP	Recreation and Public Purposes
RCRA	Resource Conservation and Recovery Act
RD&D	research, demonstration, and development
RMP	Resource Management Plan
ROD	Record of Decision
ROS	Recreation Opportunity Spectrum
ROW	right-of-way
RV	recreational vehicle
RVA	remnant vegetative association
Secretary	Secretary of the Interior
Shell	Shell Frontier Oil and Gas Inc.
SO_2	sulfur dioxide
SPCC	Spill Prevention Control and Countermeasure
SWMP	Stormwater Management Plan
TDS	total dissolved solids
TMDL	total maximum daily loads
UIC	Underground Injection Control
USC	U.S. Code
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	volatile organic compound
VRM	visual resource management
WRCC	Western Regional Climate Center
WRFO	White River Field Office, Bureau of Land Management
WRRA	White River Resource Area

U.S. Department of the Interior
Bureau of Land Management
White River Field Office
73544 Hwy 64
Meeker, CO 81641

ENVIRONMENTAL ASSESSMENT

NUMBER: CO-110-2006-117-EA

CASEFILE/PROJECT NUMBER (optional): Oil Shale Research, Development, and Demonstration Pilot

Site 1 COC-69167

Site 2 COC-69166

Site 3 COC-69194

PROJECT NAME: Shell Frontier Oil and Gas
Oil Shale Research, Development, and Demonstration Pilot Project

LEGAL DESCRIPTION: **Site 1 – Oil Shale Test Site**
Sixth Principal Meridian,
T. 2 S., R. 99 W.,
sec. 1, SW¼ of lot 2, S½ of lot 3, S½S½ of lot 4,
W½NW¼SW¼NE¼, S½NW, W½NE¼NE¼SW¼,
N½NW¼SW¼, NW¼NE¼SW¼.

Site 2 – Nahcolite Test Site
Sixth Principal Meridian,
T. 2 S., R. 98 W.,
sec. 4, lots 9, 10, 15, 16.

Site 3 – Advanced Heater Test Site
Sixth Principal Meridian,
T. 1 S., R. 99 W.,
sec. 22, SW¼.

APPLICANT: Shell Frontier Oil and Gas Inc.
4582 S. Ulster Parkway
Denver, Colorado 80237

BACKGROUND

Shell Frontier Oil and Gas, Inc. (Shell) is proposing to develop three oil shale research, development, and demonstration (RD&D) pilot projects on Bureau of Land Management (BLM) property in northwestern Colorado in accordance with BLM's Oil Shale RD&D Program announced in the Federal Register (FR, June 9, 2005, Vol. 70, No. 110).

Pursuant to Section 21 of the Minerals Leasing Act (1920, as amended, 30 U.S. Code [USC] 241), the BLM solicited RD&D proposals to demonstrate technologies for unlocking deposits of energy now trapped in oil shale deposits including, the nomination of lands to be leased for the RD&D project. In response to its FR announcement, BLM received 20 nominations for parcels of public land to be leased in Colorado, Utah, and Wyoming. The initiative was subsequently endorsed by Congress in the Energy Policy Act of 2005, Public Law 109-58 (H.R. 6).

An interdisciplinary team, consisting of representatives from the three states (Colorado, Utah, and Wyoming), the Department of Energy, the Department of Defense, and BLM staff members from the affected states, considered the potential of each nomination based on the following criteria prior to recommending proposals for eligibility in the oil shale recovery RD&D program:

- The nomination's potential to advance oil shale technology
- The nomination's economic viability
- The nomination's potential environmental effects
- Ultimately, of the 20 nominations received, 6 were accepted and 14 were rejected. Five potential RD&D projects and the corresponding leases are located in Colorado (including Shell's proposals) and one in Utah.

Each of the three RD&D sites proposed by Shell encompasses a 160-acre tract and associated preference rights to a contiguous area of 5,120 acres for each site. This amount includes the 160-acre RD&D tract for each site. These larger areas may be converted to commercial leases at a future time after additional BLM review, environmental impact analysis, and approval. Upon a company's successful demonstration of an environmentally sound and economically viable shale oil recovery technology, BLM will non-competitively convert the preference right acreage into commercial oil shale leases for fair market value. Separate National Environmental Policy Act (NEPA) analysis of the larger preference right acreages would occur at that time as the terms and conditions of the RD&D lease do not guarantee the issuance of the additional acreage as described above, or the conditions under which such lands would be leased. Leases will be issued with sufficient terms and conditions to allow BLM to monitor for and prevent unnecessary and undue degradation to public lands. This Environmental Assessment (EA) addresses only the three 160-acre nominated lease sites and the plan of development for RD&D projects proposed by Shell and does not analyze additional impacts or development potential associated with the preference right acreage.

In accordance with NEPA, the Shell proposal (Proposed Action) will be thoroughly analyzed in this EA. Based upon the results, BLM will decide whether three 160-acre leases will be issued to Shell for RD&D of oil shale recovery technology, and whether to authorize activities. If BLM exercises its discretion to issue an oil shale RD&D lease, the lease will be conditioned with sufficient terms to allow BLM to monitor for, and prevent unnecessary and undue degradation to public lands.

The Energy Policy Act of 2005, Public Law 109-58 (H.R. 6), enacted August 8, 2005, also directs the Secretary of the Interior (the Secretary) to complete a programmatic environmental impact statement (PEIS) for a commercial leasing program for oil shale and tar sands resources on public lands with an emphasis on the most geologically prospective lands within each of the states of Colorado, Utah, and Wyoming. This program is being pursued by BLM in addition to the RD&D program. The scope of the PEIS will include an assessment of environmental, social, and economic impacts of leasing oil shale and tar sands resources, including foreseeable commercial development activities on BLM-administered lands located in Colorado, Utah, and Wyoming; discussion of relevant mitigation measures to address these impacts; and identification of appropriate programmatic policies and best management practices (BMPs) to be included in BLM land use plans. The PEIS will address land use plan amendments in the affected resource areas to consider designating lands as available for oil shale and tar sands leasing and subsequent development activities.

PURPOSE AND NEED

The Piceance Basin of northwestern Colorado contains substantial oil shale resources on Public Lands. The Department of Interior identified that more intensive research and development of technology is needed on a pilot-scale to test the technical, economic, and environmental feasibility of technologies to extract liquid fuels from oil shale resources on Public Lands. The purpose of the Proposed Action is to lease three 160-acre parcels of public land for RD&D projects that will inform and advance knowledge of commercially viable production, development and recovery technologies consistent with sound environmental management.

Shell has proposed three RD&D technology test sites to evaluate the feasibility and commercial viability of developing oil shale resources in-situ. The purpose of each of these proposals is to achieve a "proof of concept." That is, while laboratory experiments and theoretical calculations indicate that various in-situ methodologies are viable commercial options, none have been thoroughly field tested to evaluate the practical application. These proposed RD&D projects provide the opportunity to practically apply those technologies under actual conditions. The project results will advance knowledge of these methodologies regardless of whether or not they prove commercial.

Shell research will gather additional operating data for three variations to in-situ hydrocarbon recovery from oil shale for use in commercial operations. At the Shell Oil Shale Test (OST) site (Site 1), testing of in-situ extraction process components and systems will demonstrate the commercial feasibility of extracting hydrocarbons from oil shale. The Second Generation In-situ Conversion Process (ICP) test at Site 2 will determine the practicability of combining already developed nahcolite extraction methods with in-situ hydrocarbon extraction technology. The electric-ICP (E-ICP) or advanced heater technology test at Site 3 will assess an innovative concept for in-situ heating. The sites identified by Shell overlie high grade oil shale yielding more than 25 gallons per ton of shale and a valuable nahcolite resource. BLM has concluded that initiating an analysis of Shell's proposed sequential recovery processes on the specified sites is warranted and may significantly advance knowledge regarding the commercial viability of innovative technologies for both oil shale and nahcolite recovery.

DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

BLM proposes leasing three 160-acre tracts located approximately 20 miles west-northwest of Rio Blanco, Colorado and authorizing associated Plans Of Operation for an oil shale RD&D project that consists of three oil shale extractive technologies. The RD&D project will be phased to ensure that the current oil shale extractive technologies are fine-tuned to operate at economic and environmentally acceptable levels before conversion to commercial operations will be authorized on public lands.

Shell's proposals (the Proposed Action) is consistent with FR Notice published June 9, 2005. Leases will be issued with sufficient measures to allow BLM to monitor for and prevent unnecessary and undue degradation to public lands. To achieve the goals of the RD&D program to advance knowledge of effective technology, economic viability, and sound environmental management, the FR contained specific requirements for a complete application, including:

- Description of the lands, not to exceed 160 acres together with any rights-of-way (ROWs) required to support the development of the oil shale RD&D lease;
- Narrative description of the proposed methodology for recovering oil from oil shale, including a description of all equipment and facilities needed to support the proposed technology;
- Narrative description of the results of laboratory and/or field tests of the proposed technology;
- Schedule of operations for the life of the project and proposed plan for processing, marketing and the delivery of the shale oil to the market (BLM has determined the RD&D leases will be issued for an initial term of 10 years with an option to extend for up to 5 years upon demonstration that a process leading to commercial production is being diligently pursued);
- Map of existing land use authorizations on the nominated acreage;
- Estimated oil and/or oil shale resources within the nominated acreage boundary;
- Method of oil storage and/or spent oil shale disposal;
- Description of any interim environmental mitigation and reclamation;
- Method of final reclamation and abandonment and associated projected costs; and
- Proof of investment capacity, and a statement from a surety qualified to furnish bonds to the U.S. government for the amount the applicant qualifies for under the surety's underwriting criteria.

Since there are no final regulations for commercial oil shale development, the concepts of the federal oil shale RD&D program will be reflected throughout the terms of the lease form. The lease will be the governing document for the oil shale RD&D project until the project succeeds and converts to a commercial lease, fails to meet the goals of the program, or the lease terms expire. BLM will incorporate lease terms addressing incentives for development, conditions for environmental protection, appropriate bonding, and a provision to convert a successful RD&D project into a commercial lease. The RD&D lease will be issued for 10 years with the option to extend for up to 5 years if diligence is demonstrated. Rental fees will be waived for 5 years and royalties will be waived as long as the project is in a RD&D status.

The proposed site locations were chosen to maximize the potential to demonstrate proof of the concept and produce oil in an economically viable and environmentally sound manner. Based on these factors, Shell identified three test sites with physical and environmental attributes favoring in-situ extraction, including but not limited to:

Geology – The Green River Formation contains the oil-shale rich zones including the Mahogany and R-6 zones. Existing data (e.g., data extrapolated from Fischer Assay data obtained from existing coreholes) support the estimates of oil potential to provide the opportunity to successfully demonstrate the technology.

Topography – Level surfaces reduce environmental impacts and enhance access, construction of roads, well pads, ponds, facilities, etc.

Hydrologic Characteristics – Minimize impacts to groundwater.

In accordance with NEPA, the Proposed Action will be thoroughly analyzed against alternative actions. Based upon the results, BLM will decide whether the three 160-acre leases will be issued to Shell for RD&D of oil shale recovery technology, and whether to authorize activities.

PROPOSED ACTION

Shell would conduct RD&D projects on three separate sites. Shell has developed Plans of Operation for three 160-acre parcels on land managed by BLM to demonstrate three different technologies to develop oil shale. These Plans of Operation are available under separate cover, and in summary as Appendices A, B, and C of this document.

The project area boundaries and the locations of the 160-acre parcels are shown in Figure 1. These sites lie within the Piceance Basin, which is bounded on the north by the White River, on the east by the Grand Hogback, on the south by the headwaters of the Roan and Parachute creeks in the Roan Plateau, and on the west by the Cathedral Bluffs. The sites will be used to test different methods of shale oil extraction that may prove more or less economically or environmentally feasible.

All three RD&D projects at the sites would utilize Shell's proprietary ICP to recover kerogen, the technical name for the petroleum contained in the oil shale. Three variations of the ICP process are proposed, one for each of the three land parcels:

- ICP – implemented by recovering hydrocarbons from kerogen using self-contained heaters that heat the rock. This process would be demonstrated at the Oil Shale Test site (Site 1).
- Two-Step ICP – implemented by initially extracting nahcolite by injecting hot water into the shale and then recovering hydrocarbons through ICP once the nahcolite is removed. This process would be demonstrated at the Nahcolite Test site (Site 2).
- E-ICP – implemented by recovering hydrocarbons from kerogen using bare wire heaters to heat the rock; some of the heating is created by the flow of electricity through the shale formation. This process would be demonstrated at the Advanced Heater Test site (Site 3).

SITE 1 – OIL SHALE TEST SITE (ICP)

The following section contains a brief description of the Proposed Action for Site 1. Appendix A contains selections from the Plan of Operation for the site which provides greater detail on the Proposed Action.

Oil shale deposits are one of the largest unconventional hydrocarbon resources in the world. Although oil has been produced from oil shale for a long time, earlier technologies to produce oil from shale using large scale mining and retorting were expensive and had adverse environmental impacts. Shell has worked for over 20 years on an in-situ technique for developing oil shale deposits that could significantly improve the product quality, recovery efficiency, and energy balance while reducing the adverse impacts of oil shale development.

The Shell Oil Shale Test site (Figure 2) is located on 160 acres in the northern part of the Piceance Basin in Section 1, Township 2 South, Range 99 West, Rio Blanco County, Colorado. The site elevation ranges between 6,720 and 6,920 feet. BLM has previously permitted Shell test wells of this property that can be seen on Figure 2. Figure 3 shows the overall operation plan layout for Site 1. The entire 160 acres will be impacted through ground disturbance and the construction of buildings and associated infrastructure.

ICP uses subsurface heating to convert kerogen contained in oil shale into ultra-clean petroleum liquids and gas that require less processing to become finished transportation fuels (e.g., gasoline, jet and diesel fuels). ICP recovers the resource without conventional mining, uses less water, and does not generate large tailing piles. ICP has the potential to make deeper, thicker, and richer resources available for development without the complications of surface or subsurface mining.

ICP's suitability for use in a particular oil shale resource is dependent on natural geologic conditions such as depth, thickness, and the presence of groundwater. Figure 4 shows a highly simplified diagram describing what ICP is, how it works, possible hydrocarbon resource targets, and principal products.

A freeze wall would be installed to prevent groundwater from flowing into areas where ICP is being used, as shown on Figure 5. A series of 150 holes approximately 8 feet apart would be drilled where the freeze wall would be created. The freeze holes would be drilled to a depth of approximately 1,850 feet. A chilled fluid (-45 degrees Fahrenheit [ºF]) would be circulated inside a closed-loop piping system and into the holes. The cold fluid freezes the nearby rock and groundwater and in 6 to12 months creates a wall of frozen ground. The freeze wall would be maintained during both the production and reclamation phases of the ICP project.

After the freeze wall is established, ten producer holes would be drilled inside the freeze wall and used to remove the groundwater trapped inside the wall. These holes would later be converted to producer holes that would remove the hydrocarbon products. The producer holes are completed to a depth of approximately 1,675 feet. Pumps would be installed in each hole to bring the product to the surface.

Approximately 30 heater holes would be drilled in the interior of the containment zones, spaced 25 feet apart, and electric heaters would be installed to uniformly heat the otherwise undisturbed hydrocarbon-bearing shale to between 550 and 750 ºF for a period of several years.

Oil and gas production is expected to be approximately 600 barrels of oil or 1,000 barrels of oil equivalent (oil and gas) per day at full production for the Oil Shale Test site.

Additional holes would be used to monitor subsurface conditions (e.g., temperatures, pressures, and water levels). The monitoring holes would be placed inside and outside the freeze wall. Oil and gas coming to the surface via the previously installed producer holes would be collected for further processing using traditional processing techniques.

After ICP treatment, pumping water into the heated zone would allow recovery of the remaining hydrocarbons. This process followed by a pump-and-treat process with water, and possibly bioremediation, would reduce the amount of hydrocarbons in the heated shale to acceptable levels. Then the freeze wall would be allowed to thaw. Groundwater monitoring would be conducted to assure compliance with groundwater regulations during and after the project.

SITE 2 – NAHCOLITE TEST SITE (TWO- STEP ICP)

The following section contains a brief description of the Proposed Action for Site 2. Appendix B contains selections from the Plan of Operation for the site which provides greater detail on the Proposed Action.

The Shell Nahcolite Test site (Figure 6) is located on 160 acres in the northern part of the Piceance Basin in Section 4, Township 2 South, Range 98 West, Rio Blanco County, Colorado. The site elevation ranges from 6,580 to 6,700 feet. The majority of 160 acres would be impacted through ground disturbance and the construction of buildings and associated infrastructure, except for the Colorado State University (CSU) revegetation test plot (approximately 50 acres) that would remain fenced and undisturbed. An agreement has been reached between CSU and Shell to plan and design oil shale activities with respect to the existing CSU study plots. A copy of the agreement letter, dated June 5, 2006, is included at the end of this EA. An operations layout plan for this site showing the locations of facilities and ponds, is still under development by Shell.

Although significant areas of the Piceance Basin are amenable to ICP technology, the presence of excessive amounts of nahcolite limit the applicability of ICP in portions of the Piceance Basin. Nahcolite, also known as baking soda or sodium bicarbonate, occurs naturally within shale. The process used at this test site would be nearly the same as the process used in Site 1, with the exception of the extraction of nahcolite, prior to removal of hydrocarbon material. The drilling for the freeze walls, heater holes, and extraction would be the same. Appendix B provides selections from the Plan of Operation for Site 2. Removal of the nahcolite prior to implementation of ICP is required for efficient recovery of both the nahcolite and the petroleum products in the kerogen. Shell has demonstrated that nahcolite can be solution mined by circulating hot water through the shale. The nahcolite is dissolved into the hot water and recovered from the hot water after it is pumped back to the surface. Nahcolite, also termed baking soda, is a product of this process. Solution mining removes the nahcolite, increases the permeability and porosity of the remaining rock matrix, and significantly improves the thermal efficiency for recovery of petroleum from the oil shale using the ICP process. Nahcolite has commercial applications and would be sold or otherwise used in a beneficial fashion. There is a multi-use pond shown as an evaporation pond in the Plan of Operations; however, it would not be used for evaporation during the nahcolite production phase. It could be used occasionally as an evaporation pond during the oil shale production phase.

There are a number of energy-saving benefits in this Two-Step ICP technology. The hot water used for nahcolite decomposition may be heated using waste heat from previous areas where ICP has been implemented. Solution mining would preheat the oil shale in the mined zone to at least 250 ºF using otherwise wasted heat. The water used for cooling the ICP-treated oil shale would pass through a surface heat exchanger to heat the water used for nahcolite solution mining, providing additional energy savings.

Removing the nahcolite and then dewatering reduces the mass within the formation that must be heated to ICP temperatures, ultimately reducing the ICP energy requirements. Solution mining the nahcolite would increase the speed at which a heat front moves within the formation, thus reducing the time and energy requirements to produce oil and complete the project.

A freeze wall would be created before initiating solution mining and maintained through implementation of ICP to contain groundwater. Following the solution mining of the nahcolite, electric heaters would be installed to heat the shale to ICP temperatures and the solution mining holes would be converted to hydrocarbon production wells. The boundary between the solution-mined nahcolite-ICP region and the remaining nahcolite-bearing strata would provide an impermeable wall, in addition to the freeze wall, to prevent hydrocarbons from migrating out of, and water coming into the heated area.

Full oil and gas production for the Nahcolite Test site will be approximately 1,500 barrels per day of oil untreated synthetic condensate.

After ICP treatment, pumping water into the heated zone would allow recovery of the remaining hydrocarbons. This process followed by a pump-and-treat process with water, and possibly bioremediation, would reduce the amount of hydrocarbons in the heated shale to acceptable levels. Then the freeze wall would be allowed to thaw. Groundwater monitoring would be conducted to assure compliance with groundwater regulations during and after the project.

SITE 3 – ADVANCED HEATER TEST SITE (E-ICP)

The following section contains a brief description of the Proposed Action for Site 3. Appendix C contains selections from the Plan of Operation for the site which provides greater detail on the Proposed Action.

The Shell Advanced Heater Test site (Figure 7) is located on 160 acres in the northern part of the Piceance Basin in Section 22, Township 1 South, Range 99 West, Rio Blanco County, Colorado. The elevation of Site 3 ranges from 6,840 to 7,060 feet. Figure 8 shows the overall operation plan layout for Site 3. The entire 160 acres would be impacted through ground disturbance and the construction of buildings and associated infrastructure.

The process used at Site 3 would be nearly the same as the process used for Site 1 in terms of the amount and type of drilling and the extraction process. However, the technology for heating is different.

The economics of the ICP process could be improved dramatically if bare electrode heaters were installed that combined both thermal conduction and some heating generated by electricity flow through the shale formation. The bare electrode process is called E-ICP and is a patented in-situ heating technology. The project would include about 70 to 100 vertical heaters spaced 20 to 40 feet apart. The bare electrode heaters are about 1,950 feet long and are designed to concentrate most of their heat output in the bottom 1,000 feet.

Lowering the heater well capital costs with resultant energy savings, E-ICP may increase the oil shale target resource by making much more of the Piceance Basin commercially attractive. Other than the difference in heater technology, the remainder of this process is comparable to the Oil Shale Test (Site 1).

Oil and gas production is expected to be approximately 600 barrels of oil or 1,000 barrels of oil equivalent (oil and gas) per day at full production at the Advanced Heater Test site.

WATER MANAGEMENT

Water requirements would vary throughout the life of each project. Water would be trucked to the sites for initial construction and drilling activities. Potable water would be trucked to the sites throughout the life of the facilities.

Once a freeze wall is formed, the water inside the wall would be removed by pumping prior to heating. The groundwater pumped from inside the freeze wall would be injected into wells located outside the freeze wall. The injection wells would be permitted per the requirements of the U.S. Environmental Protection Agency (EPA) Underground Injection Control (UIC) Program.

During heating, water removed from within the freeze wall along with the hydrocarbon products would be treated in the processing facilities and recycled or discharged. Water used to recover nahcolite would be recycled into the process**.** Figure 9 provides a general schematic of the process water management. Water that cannot be recycled or otherwise used would be treated to appropriate discharge standards in a process water treatment plant and released to a surface drainage consistent with requirements of a Colorado Department of Public Health and Environment (CDPHE) Discharge Permit.

Groundwater would be used only after receiving state approvals. Water wells would be drilled to provide additional water required by the operations, especially during reclamation following completion of hydrocarbon recovery. Reclamation would include flushing and cooling of the shale inside the freeze wall.

SUBALTERNATIVE TO THE PROPOSED ACTION

In addition to the Proposed Action, BLM has analyzed the environmental impacts of the Proposed Action with appropriate mitigation measures applied to the project design. The subalternative mitigation actions are described and analyzed in context of the Proposed Action in the 'Affected Environment and Environmental Consequences' section. The analysis assesses the environmental consequences of the Proposed Action, enumerates alternative mitigation actions, and evaluates the consequences of the mitigation. The alternatives mitigation measures, in addition to the project design features described above are intended to reduce impacts to health and the human environment and minimize surface use conflicts. Where no alternatives are necessary to reduce or minimize impacts (i.e., no impacts are anticipated), this section has been excluded from the analysis.

NO ACTION ALTERNATIVE

Under the No Action Alternative, the application for lease of BLM-administered lands and approval of the proposed oil shale RD&D project would be denied. Shell would not move forward with its research and development proposal at this time on the proposed location, and construction would not occur on BLM-administered lands. The research into improving technology to develop this strategic domestic energy resource would be delayed.

Implementation of the No Action Alternative would prevent or postpone the surface and subsurface environmental impacts associated with Shell's construction and operation of oil shale RD&D facilities on the three 160-acre test sites. None of the impacts associated with the Proposed Action would immediately occur under the No Action Alternative.

All other valid uses of Public Lands would continue under existing authorization or would be considered for approval under the existing White River Resource Management Plan (RMP). The Energy Policy Act of 2005, Public Law 109-58 (H.R. 6), enacted August 8, 2005, directs the Secretary to complete a PEIS for a commercial leasing program for oil shale and tar sands resources on public lands with an emphasis on the most geologically prospective lands within each of the states of Colorado, Utah, and Wyoming. Development of the PEIS is occurring simultaneously to this EA and is common for all alternatives. The scope of the PEIS will include an assessment of environmental, social, and economic impacts of commercially leasing oil shale and tar sands resources, including foreseeable commercial development activities on BLM-administered lands located in Colorado, Utah, and Wyoming; discussion of relevant mitigation measures to address these impacts; and identification of appropriate programmatic policies and BMPs to be included in BLM land use plans. The PEIS will address land use plan amendments in the affected resource areas to consider designating lands as available for commercial oil shale and tar sands leasing and subsequent development activities. The technology described in the Proposed Action and detailed in Appendices A, B, and C of this EA would not be field tested and refined for commercial application unless and until the PEIS is complete and Shell is successful in securing a commercial lease.

ALTERNATIVES CONSIDERED BUT NOT ANALYZED IN DETAIL

BLM considered, but did not analyze in detail, the following alternatives with regard to the location and technology described in the proposed action:

A. Relocating the 160-acre RD&D Lease to another site within the Preference Lease Area:

The preference lease area consists of the contiguous 4,960 acres adjacent to the proposed 160-acre tract. This alternative was not carried forward for detailed analysis. The basis of the proposed action is to provide the opportunity to prove the concept that a specific new and untested extraction technology will demonstrate an economic, technically feasible and environmentally acceptable means of recovering potential oil shale energy fuel resources. Oil shale resources in the Piceance Basin are non-uniform in nature. The applicant chose the site and concluded it was the best location to demonstrate proof of concept for their project based on many factors, including: resource potential, technological and environmental factors. Alternatives that would result in modifications to site location may diminish BLM's ability to advance knowledge of viable recovery technologies, and are unnecessary since no undue environmental degradation will occur. Site relocation within the preference area would have substantially similar effects to the analyzed alternatives and incorporated mitigation, and has been eliminated as a viable proof of concept because the analysis would be redundant.

B. Modified technologies or methodologies:

Alternatives using modified technologies were considered but not carried forward for detailed analysis. The basis for the RD&D project is to provide individual companies the opportunity to prove the concept through a pilot scale demonstration that their specific lab-tested extraction technology will advance our knowledge of economically recovering potential oil shale energy fuel resources. It is the applicant's responsibility to propose the best methodology to demonstrate the proof of concept for their specific technology for advancing knowledge for recovering potential oil shale energy fuel resources. Alternatives that would result in modifications to the technology or methodology could introduce unknown factors that may affect the RD&D outcome and diminish BLM's capacity to meet the purpose of testing this technology. Moreover, given the low level of impacts identified, there is no reason to believe that a substitute technology or methodology would reduce the impacts of the action. Accordingly, BLM can analyze a reasonable range of alternatives without analyzing in detail other methodologies or technologies.

PLAN CONFORMANCE REVIEW

The proposed RD&D projects are subject to and have been reviewed for conformance with the following plan (43 Code of Federal Regulations [CFR] 1610.5, BLM 1617.3):

Name of Plan: White River Record of Decision and Approved Resource Management Plan (ROD/RMP)

Date Approved: July 1, 1997

Decision Number/Page: 2-6

Decision Language: "…At the discretion of the Secretary of the Interior, research scale lease tracts will be considered within lands available for oil shale leasing. Approval of research tracts will be based on the merits of the technology proposed."

and

Name of Plan: White River Record of Decision and Approved Resource Management Plan (ROD/RMP)

Date Approved: July 1, 1997

Decision Number/Page: 2-7

Decision Language: "…Facilitate the orderly and environmentally sound development of sodium resources on public lands…the multimineral zone will be reserved for multimineral leasing."

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

No floodplains, prime and unique farmlands, or Wild and Scenic Rivers exist within the area affected by the Proposed Action. Therefore, there are no impacts associated with these resources and they are not considered in the following detailed resource analyses.

STANDARDS FOR PUBLIC LAND HEALTH

In February 1997, the Colorado Standards for Public Land Health became effective for all public lands in Colorado. These standards apply to five categories of resource values: (1) upland soils, (2) riparian systems, (3) plant and animal communities, (4) threatened and endangered species including BLM sensitive species, and (5) water quality. Standards describe conditions needed to sustain public land health and relate to all uses of the public lands. These findings are located in specific elements listed below.

CRITICAL ELEMENTS

AIR QUALITY

Affected Environment – Sites 1, 2, and 3

The air quality of any region is controlled primarily by the magnitude and distribution of pollutant emissions and the regional climate. The transport of pollutants from specific source areas is strongly affected by local topography. In the mountainous western United States, topography is particularly important in channeling pollutants along valleys, creating upslope and downslope circulation that entrain airborne pollutants, and blocking the flow of pollutants toward certain areas. In general, local effects are superimposed on the general synoptic weather regime and are most important when the large-scale wind flow is weak.

Topography

The project area is located in the northern portion of the Piceance Basin, primarily within Rio Blanco County in northwestern Colorado. The Piceance Basin is bounded by the Cathedral Bluffs to the west, the Grand Hogback to the east, and the Roan Cliffs/Colorado River to the south. Further east is the large elevated and flattened dome plateau (ranging from nearly 9,000 to over 12,000 feet established as the mandatory federal Prevention of Significant Deterioration (PSD) Class I Flat Tops Wilderness Area. The topography of the Piceance Basin varies from moderately steep mountains, canyons, and mesas in the north-central and south-central portions, to rolling hills and gently sloping river valleys in the eastern and western regions. Elevations range from about 6,000 to nearly 9,000 feet.

Climate and Meteorology

The project area is primarily pinyon-juniper woodland at elevations from 6,000 to 7,200 feet with average annual precipitation between 13 to 17 inches, and pinyon-juniper/mountain browse at elevations from 6,100 to nearly 9,000 feet with average annual precipitation 14 to 20 inches.

Temperature and precipitation data obtained from the Western Regional Climate Center (WRCC 2006) for Meeker, Rangely, and Glenwood Springs, Colorado, are considered to be representative of climatic conditions within the project area. However, because elevation, slope, and aspect affect precipitation and temperatures, the complex terrain results in considerable climatic variability. Precipitation is typically well-distributed throughout the year at nearly 1 inch per month, with mid-winter receiving the lowest average amounts (nearly 1 inch) and fall the highest levels (just under 2 inches). Average temperature and annual precipitation measurements are provided below.

Climate Data

Location	Average Temperature Range (°F) January	Average Temperature Range (°F) July	Annual Average Precipitation (inches)
Meeker, CO	7 to 37	47 to 86	16
Rangely, CO	4 to 32	56 to 92	10
Glenwood Springs, CO	12 to 37	51 to 89	17

°F = degrees Fahrenheit

Representative wind measurements are limited within the analysis area. Meteorological data collected during 2004, adequate to represent local air pollutant dispersion and transport, were obtained from the Shell Bar D monitoring site. These data (combined with upper air measurements from the Grand Junction Airport) were used to predict potential air quality impacts using the EPA preferred AERMOD atmospheric dispersion model.

Existing Air Quality

Although specific air quality monitoring is not conducted throughout most of the analysis area, air quality conditions are likely to be very good, as characterized by few air pollution emission sources (limited industrial facilities and few residential emissions, primarily from smaller communities and isolated ranches), good atmospheric dispersion conditions, as well as limited air pollutant transport into the project area, resulting in relatively low local air pollutant concentrations.

Known contributors to existing air pollutant concentrations include the following:

- Exhaust emissions (primarily carbon monoxide [CO] and oxides of nitrogen [NO_x]) from existing natural gas fired compressors, plus gasoline and diesel vehicle tailpipe air pollutants (CO, NO_x, particulate matter less than 2.5 microns in effective diameter [$PM_{2.5}$], particulate matter less than 10 microns in effective diameter [PM_{10}], sulfur dioxide [SO_2], and volatile organic compounds [VOCs]).
- Dust (particulate matter) generated by vehicle travel on unpaved roads, windblown dust from disturbed lands, and very limited road sanding during the winter months.

- Limited transport of air pollutants from emission sources located outside the project area.

The most complete air quality monitoring data are presented in the following table and are considered to be the best available representation of background air pollutant concentrations throughout the analysis area. These data (reported in micrograms per cubic meter [μg/m^3]) were used to define background conditions (presented below), and include impacts from existing sources both inside and outside the project area. The maximum pollutant concentrations are well below applicable Colorado and National Ambient Air Quality Standards (CAAQS and NAAQS, respectively) for most pollutants, although maximum concentrations of ozone approaching the federal standard have been observed. Given the episodic nature of observed high ozone levels, their cause is uncertain, although regional transport or subsidence of stratospheric ozone is possible.

Assumed Background Concentrations of Regulated Air Pollutants

Pollutant	Averaging Time[1]	Background Concentration (μg/m^3)	NAAQS (μg/m^3)	CAAQS (μg/m^3)	PSD Class I Increments (μg/m^3)	PSD Class II Increments (μg/m^3)
Carbon monoxide[2]	1-hour	1,145	40,000	40,000	NA	NA
	8-hour	1,145	10,000	10,000	NA	NA
Nitrogen dioxide[3]	Annual	9	100	100	2.5	25
Ozone	1-hour [4]	173	235	235	NA	NA
	8-hour [5]	145	157	157	NA	NA
$PM_{2.5}$[6]	24-hour	18	65	65	NA	NA
	Annual	8	15	15	NA	NA
PM_{10}[2]	24-hour	41	150	150	8	30
	Annual	11	50	50	4	17
Sulfur dioxide[7]	3-hour	24	1,300	700	25	512
	24-hour	13	365	365	5	91
	Annual	5	80	80	2	20

Source: CDPHE-ACPD 2006
[1] Annual standards are not to be exceeded; short-term standards are not to be exceeded more than once per year.
[2] Data collected by American Soda, Piceance Basin, 2003-2004.
[3] Based on data collected by Southern Ute Indian Tribe at Ignacio, CO.
[4] Data collected by the-National Park Service at Mesa Verde, 2003.
[5] Based on data collected by the CASTNET Network at Gothic and Mesa Verde, CO, and Canyonlands, UT.
[6] Data collected in Grand Junction, CO (515 Patterson).
[7] Data collected by Unocal, Piceance Basin, 1983-1984.
CAAQS = Colorado Ambient Air Quality Standards
NA = not applicable
NAAQS = National Ambient Air Quality Standards
PM_{10} = particulate matter less than 10 microns in effective diameter
$PM_{2.5}$ = particulate matter less than 2.5 microns in effective diameter
μg/m^3 = micrograms per cubic meter

Regulatory Framework

The EPA establishes and revises the NAAQS as necessary to protect public health and welfare, setting the absolute upper limits for specific air pollutant concentrations at all locations where the public has access. Although the EPA recently revised both the ozone and $PM_{2.5}$ NAAQS, these revised limits will not be implemented by the CDPHE-Air Pollution Control Division (CDPHE-

APCD) until the Colorado State Implementation Plan is formally approved by EPA; until then, EPA is responsible for implementing these revised standards.

Potential development impacts must demonstrate compliance with all applicable local, state, tribal, and federal air quality regulations, standards, and implementation plans established under the Clean Air Act (CAA) and administered by the CDPHE-APCD (with EPA oversight). Air quality regulations require proposed new, or modified existing air pollutant emission sources (including the proposed project) undergo a permitting review before their construction can begin. Therefore, the CDPHE-APCD has the primary authority and responsibility to review permit applications and to require emission permits, fees, and control devices, prior to construction and/or operation.

Additionally, the U.S. Congress (through the CAA Section 116) authorized local, state, and tribal air quality regulatory agencies to establish air pollution control requirements more (but not less) stringent than federal requirements (such as Colorado's 3-hour SO_2 ambient air quality standard). Additional site-specific air quality analysis would be performed, and additional emission control measures (including emissions control technology analysis and determination) may be required by the applicable air quality regulatory agencies to ensure protection of air quality resources. Additionally, under the federal CAA and the Federal Land Policy Management Act (FLPMA), BLM cannot authorize any activity which does not conform to all applicable local, state, tribal, and federal air quality laws, statues, regulations, standards, and implementation plans.

The existing air quality of the project area is in attainment with all ambient air quality standards, as demonstrated by the relatively low concentration levels presented above. Given the project area's current attainment status, future development projects which have the potential to emit more than 250 tons per year (or certain listed sources that have the potential to emit more than 100 tons per year) of any criteria pollutant would be required to submit a pre-construction PSD Permit Application, including a regulatory PSD Increment Consumption Analysis under the federal New Source Review and permitting regulations. Development projects subject to the PSD regulations must also demonstrate the use of "Best Available Control Technology" (BACT) and show that the combined impacts of all applicable sources will not exceed the PSD increments for nitrogen dioxide (NO_2), PM_{10}, or SO_2. The permit applicant must also demonstrate that cumulative impacts from all existing and proposed sources would comply with the applicable ambient air quality standards throughout the operational lifetime of the permit applicant's project.

Additionally, a regulatory PSD Increment Consumption Analysis may be conducted at any time by the CDPHE-APCD or EPA, in order to demonstrate that the applicable PSD increment has not been exceeded by all applicable major or minor increment consuming emission sources. The determination of PSD increment consumption is a legal responsibility of the applicable air quality regulatory agency (with EPA oversight).

Mandatory federal Class I areas were designated by the U.S. Congress on August 7, 1977, including those existing wilderness areas greater than 5,000 acres in size and national parks greater than 6,000 acres in size. All other locations in the country where ambient air quality is within the NAAQS (including attainment and unclassified areas) were designated as PSD Class II areas with less stringent requirements. Also, the CDPHE-APCD has designated Dinosaur National Monument as a State Category 1 Area, with the same SO_2 increments as a federal PSD Class I area. Additionally, sources subject to the PSD permit review procedures are required to demonstrate that impacts to Air Quality Related Values (AQRV) will be below Federal Land Managers' AQRV Work Group (FLAG) "Limits of Acceptable Change" (FLAG 2000). The AQRVs to be evaluated include degradation of visibility, deposition of acidic compounds in mountain lakes, and effects on sensitive flora and fauna within the PSD Class I areas. For example, the U.S. Forest Service (USFS) White River National Forest Supervisor and Rocky Mountain Regional Forester are the Federal Land Managers directly responsible for the lands within the PSD Class I Flat Tops Wilderness Area. Under the CAA, they are charged with "… an affirmative responsibility to protect the air quality related values (including visibility) of any such lands within a Class I area…"

Therefore, most of the analysis area is currently designated as PSD Class II; Dinosaur National Monument is a State Category 1 Area, and the Flat Tops Wilderness Area is protected by more stringent NO_2, PM_{10}, and SO_2 PSD Class I increment thresholds, as shown above.

Additionally, the CDPHE-APCD also requires various different pre-construction and operation permits, including: 1) any emission source with the potential to emit air pollutants in excess of 2 tons per year must submit an Air Pollution Emission Notice to CDPHE-APCD; 2) all emission sources with the potential to emit NO_x or CO in excess of 10 tons per year, or 5 tons per year of PM_{10}, are required to obtain a permit before construction can begin; 3) sources with potential emissions in excess of 100 tons per year of CO, 40 tons per year of NO_x, or 15 tons per year of PM_{10}, must also include a new source modeling analysis in their permit application; CDPHE-APCD modeling guidelines specify the requirements for conducting modeling, including cumulative analyses; 4) all sources with the potential to emit any "criteria" air pollutant in excess of 50 tons per year must also provide the opportunity for the public to comment on the permit application; and 5) a Title V (or part 70) operating permit is required for all sources with the potential to emit air pollutants in excess of 100 tons per year. Since these pre-construction and operating permit programs are part of the Colorado State Implementation Plan, they have been approved (and are therefore enforceable) by EPA.

This NEPA analysis compares potential air quality impacts from the proposed project to applicable ambient air quality standards, PSD increments, and AQRV impact threshold levels, but it does not represent a regulatory air quality permit analysis. Comparisons to the PSD Class I and II increments are intended to evaluate a "threshold of concern" for potentially significant adverse impacts, but do <u>not</u> represent a regulatory PSD Increment Consumption Analysis.

Conformance to Existing Plans and Policies

Both the CAA and FLPMA require all federal activities (whether conducted directly, or approved through use authorizations) to comply with all applicable local, state, tribal, and federal air quality law, statutes, regulations, standards, and implementation plans. Potential development would conform to these requirements, consistent with existing land use plans.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Potential impacts to air quality were analyzed as described below.

Impact Types and Criteria

Potential air quality impacts from the proposed development of the three test sites were analyzed and reported solely under the requirements of NEPA, in order to assess and disclose reasonably foreseeable impacts to both the public and federal decision makers. Due to the preliminary nature of this NEPA analysis, it should be considered a reasonable, but conservative upper estimate of predicted impacts. Actual impacts at the time of development (subject to air pollutant emission source permitting by CDPHE-APCD) are likely to be less. Atmospheric dispersion modeling files used to prepare this analysis are available upon request for review.

The air quality impact assessment was based on the best available engineering data and assumptions, meteorological data, and EPA dispersion modeling procedures, as well as professional engineering and scientific judgment. However, where specific data or procedures were not available, reasonable but conservative assumptions were incorporated. For example, the air quality impact assessment assumed that project activities would operate at full production levels continuously (no "down time"). Therefore, this NEPA analysis assumes a development scenario which is not likely to actually occur.

The air pollutant dispersion modeling was based on 1 year of on-site meteorological data collected within the Piceance Basin (Bar D station), as well as regional upper atmosphere data collected at Grand Junction. The EPA preferred AERMOD atmospheric dispersion model was used to predict maximum potential near-field ambient air pollutant concentrations (in the vicinity of proposed project) for comparison with applicable air quality standards and PSD Class II increments. Additionally, similar model analyses for other oil shale RD&D projects, as well as current ExxonMobil Piceance Development Project activities, were combined to determine maximum far-field ambient air pollutant concentrations, atmospheric deposition (acid rain), and visibility impacts at the Flat Tops Wilderness Area. These impacts are analyzed in the Cumulative Impacts section.

The criteria for determining the significance of potential air quality impacts include state, tribal, and federally enforced legal requirements to ensure air pollutant concentrations will remain within specific allowable levels. These requirements include the NAAQS and CAAQS which set maximum limits for several air pollutant concentrations, and PSD increments which limit the incremental increase of specific air pollutants (including NO_2, PM_{10}, and SO_2) above legally defined baseline concentration levels. Where legal limits have not been established, significance thresholds have been identified for potential atmospheric deposition impacts to sensitive lake water chemistry and terrestrial ecosystems, and a "just noticeable change" in potential visibility impacts.

It is important to note that before actual development could occur, the applicable air quality regulatory agencies (including CDPHE-APCD and EPA) would review specific air pollutant emissions preconstruction permit applications which examine potential project-wide air quality impacts. As part of these permits (depending on source size), the air quality regulatory agencies could require additional air quality impacts analyses or mitigation measures. Thus, before development occurs, additional site-specific air quality analyses based on actual facility engineering data would be performed to ensure protection of air quality.

Potential Direct Impacts from the Proposed Action

Significant air quality impacts would not occur due to the proposed Shell RD&D project. No violations of applicable state, tribal, or federal air quality regulations or standards are expected to occur as a result of direct or indirect air pollutant emissions (including construction and operation). The visibility "Limit of Acceptable Change" of more than a single day above a "just noticeable change" (FLAG 2000) from Sites 1, 2, and 3 emission sources could be exceeded between 8 to 14 days per year at the mandatory federal PSD Class I Flat Tops Wilderness Area. However, as discussed below, perceptible visibility impacts are not likely to actually occur from direct air pollutant emissions alone.

<u>Construction Direct Impacts</u>

Air quality impacts would occur during construction (due to surface disturbance by earth-moving equipment, vehicle traffic fugitive dust, drilling rigs, facility construction, and vehicle engine exhaust) and production (including water and product pumping, processing, and engine exhausts). The maximum predicted "near-field" air pollutant concentrations occur close to and between the three test sites; so close to each other that cumulative impacts from other facilities would not significantly increase the maximum predicted "near-field" concentration.

Air pollutant dispersion modeling was performed to quantify potential reasonable, but conservative, PM_{10} and SO_2 impacts during construction based on the individual pollutant's period of maximum potential emissions. The model conservatively assumed that all three test sites would be constructed concurrently. Short-term impacts are reported as maximum high-second-high values. Maximum potential near-field particulate matter emissions from traffic on unpaved roads and during construction were used to predict the maximum 24-hour and annual average PM_{10} concentrations. Maximum air pollutant emissions would be temporary (i.e., occurring only during construction period). The amount of particulate matter emissions during construction would be controlled by watering or applying chemical surfactants to disturbed soils, and by air pollutant emission limits imposed by applicable air quality regulatory agencies. No additional dust control efficiency for use of suppressants was assumed for purposes of estimating the dust emissions from these activities. Actual air quality impacts depend on the amount, duration, location, and characteristics of potential emissions sources, as well as meteorological conditions (wind speed and direction, precipitation, relative humidity, etc.).

The maximum potential high-second-high 24-hour $PM_{2.5}$ and PM_{10} concentrations are primarily from material disturbance and handling sources (including a representative background value of 18 and 41 $\mu g/m^3$, respectively), and would be nearly 57 and 115 $\mu g/m^3$, respectively. These values would be below the applicable NAAQS of 65 $\mu g/m^3$ and 150 $\mu g/m^3$, respectively. Maximum predicted particulate concentrations occur along the facility fenceline and decrease rapidly away from the emission source. Since these PM_{10} construction emissions are temporary, PSD increments are not applicable.

The maximum high-second-high short-term SO_2 emissions would be generated by diesel engines used during construction (sulfur is a trace element in diesel fuel). The maximum modeled concentrations, including representative background values of 24 and 13 $\mu g/m^3$ (3-hour and 24-hour, respectively), would be nearly 55 and 28 $\mu g/m^3$ (3-hour and 24-hour, respectively). These values would be well below the restrictive 3-hour Colorado SO_2 Ambient Air Quality Standard

(700 μg/m^3), the 3-hour SO_2 NAAQS (1,300 μg/m^3), and the 24-hour standards (365 μg/m^3). Since these SO_2 construction emissions are temporary, PSD increments are not applicable.

The maximum predicted long-term (annual) NO_2, PM_{10}, $PM_{2.5}$, and SO_2 impacts (including representative background concentrations) were all predicted during construction to be less than the applicable ambient air quality standards. The maximum predicted annual NO_2 concentration of 71 μg/m^3 (including a representative background value of 9 μg/m^3) would be less than the CAAQS/NAAQS of 100 μg/m^3. The maximum predicted annual $PM_{2.5}$ and PM_{10} concentrations would be 14.9 and 22.8 μg/m^3 (including representative background values of 8 and 11 μg/m^3, respectively) would be less than the CAAQS/NAAQS of 15 and 50 μg/m^3, respectively. The maximum predicted annual SO_2 concentration of 7 μg/m^3 (including a representative background value of 5 μg/m^3) would be less than the CAAQS/NAAQS of 80 μg/m^3.

RD&D Operation Direct Impacts

Air pollutant dispersion modeling was also performed to quantify potential reasonable but conservative NO_2, PM_{10}, $PM_{2.5}$, and SO_2 impacts during operation, based on the period of maximum potential emissions. Short-term impacts are reported as maximum high-second-high values. Operation emissions would occur due to water and product pumping, processing, and engine exhausts. The existing power supplies would meet the needs of the Proposed Action.

As demonstrated below, all other air pollutants and averaging times are also predicted to be well below applicable ambient air quality standards and PSD Class II increments. As stated previously, all NEPA analysis comparisons to the PSD Class II increments are intended to evaluate a threshold of concern, and do not represent a regulatory PSD Increment Consumption Analysis.

Predicted Maximum Direct Air Quality Impacts During Operations

Pollutant	Averaging Time	Direct Concentration (μg/m^3)	Background Concentration (μg/m^3)	Total Concentration (μg/m^3)
Nitrogen dioxide	Annual	0.6	9	9.6
$PM_{2.5}$	24-hour	0.6	18	18.6
	Annual	0.1	8	8.1
PM_{10}	24-hour	0.6	41	41.6
	Annual	0.1	11	11.1
Sulfur dioxide	3-hour	99	24	123
	24-hour	14	13	27
	Annual	1.2	5	6.2

PM_{10} = particulate matter less than 10 microns in effective diameter
$PM_{2.5}$ = particulate matter less than 2.5 microns in effective diameter
μg/m^3 = micrograms per cubic meter

Unavoidable Adverse Effects

Some decrease in air quality would occur through implementation of the proposed project; however, based on the reasonable, but conservative modeling assumptions, these direct impacts are predicted to be below applicable significance thresholds. Potential impacts to air quality were analyzed as described below.

Irreversible and Irretrievable Effects

Once disturbed lands are revegetated, potential air quality impacts from the proposed project would cease after the life of the project. Therefore, there would be no irreversible or irretrievable effects on air quality.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Under this alternative, in addition to the Proposed Action, BLM would require roads and well locations constructed on soils susceptible to wind erosion to be appropriately surfaced to reduce the amount of fugitive dust generated by traffic or other activities. Dust inhibitors (surfacing materials, non-saline dust suppressants, water, etc.) would be used as necessary on unpaved collector, local, and resource roads to prevent fugitive dust problems. To further reduce fugitive dust, Shell would establish and enforce speed limits (15 to 30 miles per hour [mph]) on all project-required roads in and adjacent to the project area.

Monitoring

BLM would require Shell to continue to cooperate with existing atmospheric deposition and visibility impact monitoring programs. The need for, and the design of, additional monitoring could include the involvement of the EPA Region 8 Federal Leadership Forum (EPA 2001) and applicable air quality regulatory agencies. Based upon future recommendations, operators could be required to cooperate in the implementation of a coordinated air quality monitoring program.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Potential impacts to air quality would be reduced as a result of decreased fugitive dust during construction and from traffic during construction and operations. With mitigation, the project’s contribution of fugitive dust would be reduced, resulting in better regional visibility.

Unavoidable Adverse Effects

Some decrease in air quality would occur to a lesser degree than would be expected from implementation of the proposed project; however, based on the reasonable, but conservative modeling assumptions, these direct impacts are predicted to be below applicable significance thresholds.

Irreversible and Irretrievable Effects

Once disturbed lands are revegetated, potential air quality impacts from the alternative to implement the Proposed Action with mitigation cease after the life of the project. Therefore, there would be no irreversible or irretrievable effects on air quality.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur. No violations of applicable state, tribal, or federal air quality regulations or standards are expected to occur as a result of direct or indirect air pollutant emissions (including construction and operation).

AREAS OF CRITICAL ENVIRONMENTAL CONCERN

Affected Environment – Sites 1, 2, and 3

An Area of Critical Environmental Concern (ACEC) is an area established through the planning process provided in the FLPMA where special management attention is required (when such areas are developed or used or where no development is required) to protect and prevent irreparable damage to important historic, cultural, or scenic values; or to fish and wildlife resources or other natural systems or processes; or to protect life and afford safety from natural hazards.

Seventeen ACECs have been designated in the White River Resource Area (WRRA) as indicated in the White River RMP (BLM 1997). There are five ACECs in proximity to the three RD&D sites, but there is no overlap between any of the test sites and the ACECs. The five ACECs surrounding the tests sites are Duck Creek, Ryan Gulch, Dudley Bluffs, South Cathedral Bluffs, and Coal Draw. These five ACECs were designated for protection of sensitive plant species. Ryan Gulch, Dudley Bluffs, and South Cathedral Bluffs are also designated and recognized by the State of Colorado Department of Natural Resources as Natural Areas.

Environmental Consequences of the Proposed Action

The locations of the three test sites in relationship to the nearest ACECs are described below.

Site 1 – Oil Shale Test Site

The Oil Shale Test site is approximately 6 miles north of South Cathedral Bluffs ACEC and 6 miles east of the Coal Draw ACEC. The South Cathedral Bluffs ACEC was designated an ACEC due to the sensitive plants and remnant vegetative association (RVA) present in this area. The Coal Draw ACEC was designated an ACEC due to paleontological resources present in this area. The 160-acre Oil Shale Test site does not overlap any ACECs and there would be no direct environmental consequences to any ACECs associated with the Proposed Action at Site 1.

Site 2 – Nahcolite Test Site

The Nahcolite Test site is approximately 2 miles west of the Ryan Gulch and Dudley Bluffs ACECS. The Ryan Gulch ACEC was designated an ACEC due to threatened and endangered plants present in the area. The Dudley Bluffs ACEC was designated an ACEC due to threatened and endangered plants, sensitive plants, and RVAs present in the area. The 160-acre Nahcolite Test site does not overlap any ACECs and there would be no direct environmental consequences to any ACECs associated with the Proposed Action at Site 2.

Site 3 – Advanced Heater Test Site

The Advanced Heater Test site is approximately 2 miles south of the Duck Creek ACEC. The Duck Creek ACEC was designated an ACEC due to threatened and endangered plants and cultural resources present in the area. The 160-acre Advanced Heater Test site does not overlap any ACECs and there would be no direct environmental consequences to any ACECs associated with the Proposed Action at Site 3.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

No mitigation measures are proposed or necessary to reduce impacts to ACECs from the proposed action.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

CULTURAL RESOURCES

Affected Environment

For federally funded or licensed projects, cultural resource studies are done to meet requirements of NEPA (42 USC 4321), Executive Order (EO) 11593 (36 FR 8921); FLPMA (43 USC 1701); the National Historic Preservation Act of 1966 (as amended); the Archaeological Resources Protection Act of 1979 as amended: and Article 80.1, Colorado Revised Statutes. These laws are concerned with the identification, evaluation, and protection of fragile, non-renewable evidences of human activity, occupation, and endeavor reflected in districts, sites, structures, artifacts, objects, ruins, works of art, architecture, and natural features that were of importance in human events. Such resources tend to be localized and highly sensitive to disturbance.

Site 1 – Oil Shale Test Site

The proposed Oil Shale Test site was covered by two cultural resources surveys performed by the Grand River Institute (Conner et al. 2004, 2005). These surveys included a total of 1,368 acres and documented a total of seven prehistoric sites, one historic site, and 10 prehistoric isolated finds. None of these sites or isolated finds is located within the area of the proposed Oil Shale Test site.

Site 2 – Nahcolite Test Site

The proposed Nahcolite Test site was covered by one cultural resources survey performed by the Grand River Institute (Darnell 2006). This survey included a total of 160 acres and did not locate any cultural resources within the area of the proposed Nahcolite Test site.

Site 3 – Advanced Heater Test

The proposed Advanced Heater Test site was covered by a cultural resources survey performed by the Grand River Institute for a proposed land exchange (Conner and Davenport 2001). This survey included a total of 3,507 acres and documented a total of nine prehistoric sites, seven historic sites, and 23 prehistoric isolated finds. One of the prehistoric sites (5RB4296) and none of the isolated finds are located within the area of the proposed Advanced Heater Test site. Site 5RB4296 is a prehistoric open camp that has been determined to need data (i.e., archaeological testing) in order to establish its eligibility for the National Register of Historic Places (NRHP). Until such testing concludes otherwise, it will be considered eligible for the National Register.

Environmental Consequences of the Proposed Action

The environmental consequences of the Proposed Action at the three test sites are described below.

Site 1 – Oil Shale Test Site

No cultural resources were found on Site 1; therefore, there would be no environmental impacts from the Proposed Action at the site on cultural resources.

Site 2 – Nahcolite Test Site

No cultural resources were found on Site 2; therefore, there would be no environmental impacts from the Proposed Action at the site on cultural resources.

Site 3- Advanced Heater Test

The development of Site 3 will excavate all surface materials for the construction of the oil shale building complex area. During the survey of this site one cultural site was discovered. This cultural site is in an area that would be excavated for RD&D operations and would likely be damaged unless avoided.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

No cultural resources were found on Sites 1 and 2. It is possible that important cultural resources not visible on the surface could be encountered during the construction of the project facilities. To mitigate potential impacts to such resources, the following measures would be implemented to modify the Proposed Action:

Inform all persons associated with the project that they would be subject to prosecution for knowingly disturbing historic or archeological sites or for collecting artifacts.

If site avoidance is not feasible, then a data recovery or testing plan would be developed and implemented prior to disturbance of the site area.

The operator is responsible for informing all persons who are associated with the project operations that they will be subject to prosecution for knowingly disturbing historic or archaeological sites, or for collecting artifacts. If historic or archaeological materials are uncovered during any project or construction activities, the operator is to immediately stop activities in the immediate area of the find that might further disturb such materials, and immediately contact the authorized officer (AO). Within five working days the AO will inform the operator as to:

- whether the materials appear eligible for the NRHP,
- the mitigation measures the operator will likely have to undertake before the site can be used (assuming in situ preservation is not necessary),
- a timeframe for the AO to complete an expedited review under 36 CFR 800.11 to confirm, through the State Historic Preservation Officer, that the findings of the AO are correct and that mitigation is appropriate.

If the operator wishes, at any time, to relocate activities to avoid the expense of mitigation and/or the delays associated with this process, the AO will assume responsibility for whatever recordation and stabilization of the exposed materials may be required. Otherwise, the operator will be responsible for mitigation cost. The AO will provide technical and procedural guidelines for the conduct of mitigation. Upon verification from the AO that the required mitigation has been completed, the operator will then be allowed to resume construction.

Pursuant to 43 CFR 10.4(g) the holder of this authorization must notify the AO, by telephone, with written confirmation, immediately upon the discovery of human remains, funerary items, sacred objects, or objects of cultural patrimony. Further, pursuant to 43 CFR 10.4(c) and (d), all activities in the vicinity of the discovery must stop and the resource must be protected for 30 days or until notified to proceed by the AO.

During the survey of Site 3 one cultural site was discovered. This cultural site is in an area that would be excavated for RD&D operations and would likely be damaged unless the following mitigation is implemented. The mitigation for undiscovered cultural resources stated above apply to Site 3 in addition to:

- Avoiding known cultural resource sites by not utilizing the entire construction workspace.
- At Site 3, Shell will fence-off the site during construction and will completely avoid the site throughout the life of the project. All erosion control associated with the project should keep water and erosion to the north of the road thus not impacting the site.
- At Site 3, conditions of approval will be added to the lease to ensure that the NRHP eligibility of the site is determined prior to any impacts and that site integrity must be safeguarded until eligibility is adequately determined.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

No significant cultural resources would be impacted by the alternative mitigation. However, it is possible that important cultural resources not visible on the surface could be encountered during the construction of the project facilities. As a result of the alternative mitigation, potential impacts will be identified as soon as possible and the impacting action will be appropriately modified to avoid unnecessary or under degradation. Any potential impacts or unforeseen impacts to cultural resources would be avoided, reduced, and minimized.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

NATIVE AMERICAN CONCERNS

Affected Environment – Sites 1, 2, and 3

The American Indian Religious Freedom Act, established in 1978, and the Native American Graves Protection and Repatriation Act, established in 1990, protect and allow access by Native Americans to sites that Native Americans deem sacred or of traditional cultural use and require consultation with Native American groups concerning activities that may affect archaeological resources of importance to the Native American groups.

No traditional cultural properties, sacred sites, or traditional use areas are known in the proposed project area. Letters informing Native American groups of the project were sent out by the BLM White River Field Office (WRFO) on March 16, 2006. The WRFO received a reply to the letter, dated May 6, 2006, declining participation in the EA process. Another letter informing Native American groups of the survey findings will be compiled and sent to representative Native American groups by the BLM WRFO (Selle pers. comm. 2006).

Environmental Consequences of the Proposed Action- Sites 1, 2 and 3

There would be no impact unless previously unknown sites are identified by the Native American groups.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

If traditional use areas or sacred sites are identified, mitigation measures would be determined in consultation with the appropriate tribe/tribes to ensure protection of any sacred sites.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

There would be no impact unless previously unknown sites are identified by the Native American groups. However, the implementation of appropriate mitigation measures negotiated with the appropriate tribe(s) will reduce or minimize impacts to previously unknown sites.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

INVASIVE, NON-NATIVE SPECIES

Affected Environment

Noxious weeds are a concern to BLM, the State of Colorado, and Rio Blanco County.

BLM maintains an active noxious weed management program in cooperation with Rio Blanco County, private landowners, and BLM land users.

A list of noxious weeds was compiled from State of Colorado, Rio Blanco County, and BLM WRFO weed lists. The noxious weeds species listed under Rio Blanco County are identified on the State of Colorado's noxious weed list; however, their designations are different.

State of Colorado List A species are designated by the Commissioner for eradication, List B species have (or will have) a state noxious weed management plan developed to stop their spread, and management of List C species is the choice of local jurisdictions (Colorado Department of Agriculture 2005). The noxious weed species in this list are acknowledged to be the most widespread and causing the greatest economic impact in the State of Colorado at this time.

For Rio Blanco County, nine noxious weeds species are identified on List B and are prioritized for eradication. Rio Blanco County List A noxious weeds are considered by the Rio Blanco County Weed Advisory Board to be undesirable and are all included on the State of Colorado's "B" noxious weed list. Rio Blanco County has not determined List C species at this time (Rio Blanco County no date).

BLM has designated major portions of the WRRA as "weed free zones," and the White River RMP states that "a key management element" will include the preventative measures of designating weed-free zones (BLM 1997). The following table lists the noxious weeds that are listed in BLM WRFO and Rio Blanco County that may be present in the project sites.

Noxious Weed Species that may be Present in the Test Sites

Common Name	Scientific Name	State of Colorado	Rio Blanco County	BLM WRFO
Black henbane	*Hyoscyamus niger*	B	A	X
Black knapweed	*Centaurea nigra*	B	A	--
Bluebur stickseed	*Lappula redowski*	--	--	X
Bull thistle	*Cirsium vulgare*	--	--	X
Canada thistle	*Cirsium arvense*	A	B	X
Common burdock	*Arctium minus*	C		X
Common mullein	*Verbascum thapsus*	C		X
Dalmatian toadflax	*Linaria dalmatica*	B	A	--
Diffuse knapweed	*Centaurea diffusa*	A	B	X
Field bindweed	*Convolvulus arvensis*	C		X
Halogeton	*Halogeton glomeratus*	C		X
Hoary cress/whitetop	*Cardaria draba*	A	B	X
Houndstongue	*Cynoglossum officinale*	B	A	X
Leafy spurge	*Euphorbia esula*	A	B	X
Musk thistle	*Carduus nutans*	A	B	X
Perennial pepperweed	*Lepidium latifolium*	B	A	X

Noxious Weed Species that may be Present in the Test Sites

Common Name	Scientific Name	State of Colorado	Rio Blanco County	BLM WRFO
Plumeless thistle	*Carduus acanthoides*	B	A	--
Russian knapweed	*Centaurea repens*	A	B	X
Russian olive	*Eleagnus angustifolia*	--		X
Scotch thistle	*Onopordum acanthium* and *O. tauricum*	B	A	--
Spotted knapweed	*Centaurea maculosa*	A	B	X
Tamarisk/salt cedar	*Tamarix parviflora* and *T. ramosissima*	--		X
Yellow starthistle	*Centaurea solstitalis*	--		X
Yellow toadflax	*Linaria vulgaris*	A	B	X

Source: CO Department of Agriculture 2005, Rio Blanco County no date, BLM 1997.
BLM = Bureau of Land Management
WRFO = White River Field Office, Bureau of Land Management

Two noxious weeds were observed during November 2005 surveys along the stream channels of Box Elder Gulch and Corral Gulch: houndstongue and Canada thistle (Roberts 2005a). Cheat grass, though not on the noxious weed list, is a predominate non-native species that occurs throughout the area, including the test sites.

Site 1 – Oil Shale Test Site

Two noxious weeds, houndstongue and Canada thistle, were observed during November 2005 surveys along the stream channels of Box Elder Gulch and Corral Gulch, which are located approximately 1 mile northwest of Site 1 (Roberts 2005a). No noxious weed problems are currently known on Site 1; however, no noxious weed surveys were completed at the site or along the proposed access road (Fowler pers. comm. 2006).

Site 2 – Nahcolite Test Site

Houndstongue was observed in the vicinity of Site 2 (BLM 2005). No noxious weed surveys were completed at this site or along the proposed access road. Currently, BLM is treating spotted knapweed outbreaks on the Yellow Creek Jeep Trail (County Road [CR] 83), adjacent to the site on the east and part of the proposed access into the test site. Rio Blanco County found yellow star thistle by the Yellow Creek Jeep Trail (east of the site), but none has been located in the past 5 years. Hoary cress/whitetop has also been identified in Ryan Gulch, south of the site (Fowler pers. comm. 2006).

Site 3 – Advanced Heater Test Site

No noxious weed surveys were completed at Site 3. Most of the area is within the BLM WRRA RMP designated “weed-free zone.” Yellow toadflax occurs along CR 24X approximately 1.5 miles east of the site. Russian knapweed has been treated on CR 80, approximately 0.75 miles from the site. North of the site at Duck Creek along CR 20A, hoary cress/white top is present (Fowler pers. comm. 2006). Russian knapweed was found along CR 80 and was eradicated (NorWest 2003). Two noxious weeds, houndstongue and Canada thistle, were observed during November 2005 surveys along the stream channels of Box Elder Gulch and Corral Gulch, approximately 1.5 miles south of Site 3 (Roberts 2005a).

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Soil disturbance and removal of vegetation during construction provide suitable conditions for invasive species and noxious weeds to establish at the test sites. Weed seeds and propagules can be carried to the site from construction vehicles and equipment. Establishment of weed species would reduce the quality of habitat through competition with and possibly eventual replacement of native plant species by non-natives. Replacement of native species can have various environmental effects including a change in fire regimes, increasing the frequency and severity of fires, a change in the nutrient regime in soils, and increased soil erosion. Additionally, noxious weeds also can negatively impact community structure by creating, changing the density, or elimination of vegetation layers or canopy cover. The invasion of noxious weeds and invasive species has the potential to impact native flora and fauna through loss of biodiversity and the loss of habitat and forage quality for wildlife. These consequences in turn affect recreational opportunities on BLM lands.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Adverse impacts from noxious weeds would be mitigated through implementation of measures to prevent the introduction of noxious weed infestations during construction and operation, treat existing infestations, and to monitor sites and treat infestations during and after reclamation. Shell would implement the following mitigation actions:

- Conduct pre-construction surveys for noxious weed infestations within the site boundaries and along access roads. Surveys should be conducted in spring.
- Consult with BLM and Rio Blanco County Cooperative Extension to determine treatment for noxious weeds, if identified.
- Construction vehicles and equipment will be cleaned, power-washed, and free of soil and vegetation debris prior to entry and use on access roads and test sites to prevent transporting weed seeds onto sites.
- All seed planted or sowed will be certified. Any other reclamation material brought onto sites will be certified as noxious weed free.
- Revegetated areas will be monitored for at least 3 years following seeding to evaluate the need for supplemental seeding and noxious weed control. Noxious weed control will occur through the use of BLM recommended procedures based on the amount and type of noxious weed present.
- Erosion control materials such as hay, straw, mulch, or other vegetation material used will be certified weed free. Current state standards will be applicable.
- All contractors and land-use operators using surface disturbing equipment in the BLM designated weed free zones must clean their equipment prior to use on BLM lands.
- Monitor the access road ROW and project sites for noxious weed infestations. Control or eradicate new or expanding populations for the duration of the construction, operation,

and reclamation phases using materials and methods approved in advance by the BLM Field Manager.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

The removal of vegetation and the disturbance of soils during construction would create optimal conditions for the establishment of invasive, non-native species that may continue for many years after the initial disturbance. Construction equipment traveling from weed-infested areas to weed-free areas could also facilitate the dispersal of invasive, non-native seeds and propagules and could result in the establishment of invasive, non-native plants in previously weed-free areas. The establishment of invasive, non-native plants could result in the reduction in the overall visual character of the area, competition with or elimination of native plants, reduction of wildlife habitats, increased soil erosion, and loss of forage for livestock and wildlife. Impacts would be minimized by implementing preventative and remedial noxious weed management and revegetation measures.

Impacts from invasive and non-native species from construction and operation of the Proposed Action would be minimized by implementing measures to treat existing infestations, prevent introduction/expansion of infestations during construction, and monitor and treat infestations after construction is complete. Successful implementation of this mitigation would help to ensure that native plant species continue to thrive, benefiting the foraging habitat of native wildlife species and domestic animals.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

MIGRATORY BIRDS

Affected Environment – Sites 1, 2, and 3

The Migratory Bird Treaty Act (MBTA) prohibits disturbance or destruction to an active nest, nesting birds, or their eggs or young. This applies to all birds (including raptors), except non-native species including house sparrow, European starling, rock dove, and upland game birds.

EO 13186 sets forth the responsibilities of federal agencies to implement further the provisions of the MBTA by integrating bird conservation principles and practices into agency activities and by ensuring that federal actions evaluate the effects of actions and agency plans on migratory birds.

U.S. Fish and Wildlife Service (USFWS) compiled a list of Birds of Conservation Concern (BCC) to identify migratory and non-migratory bird species (not including those already designated as federally threatened or endangered) that without conservation actions may become candidates for listing under the Endangered Species Act (ESA) (USFWS 2002). Additionally, Partners in Flight (PIF) North American Landbird Conservation Plan (Rich et al. 2004) addresses bird species not protected by other existing conservation programs.

The BCC and PIF species that are likely present within suitable habitat in the test sites are listed in the following table. Due to the proximity of the sites to each other and the similarity of habitats, species listed in this table could occur at any of the test sites in suitable habitat. Descriptions of vegetation communities at each site are included in the Vegetation section.

BCC and PIF Bird Species with Potential to Occur in the Test Sites

Common Name	Scientific Name	Status	Pinyon-Juniper	Sagebrush Shrubland
Black-throated gray warbler	*Dendroica nigrescens*	BCC	X	
Black-chinned hummingbird	*Archilochus alexandri*	PIF	X	
Golden eagle	*Aquila chrysaetos*	BCC	X	X
Greater sage grouse	*Centrocercus urophasianus*	PIF		X
Gray flycatcher	*Empidonax wrightii*	PIF	X	
Juniper titmouse	*Baeolophus ridgwayi*	PIF	X	
Northern harrier	*Circus cyaneus*	BCC		X
Pinyon jay	*Gymnorhinus cyanocephalus*	BCC, PIF	X	
Prairie falcon	*Falco mexicanus*	BCC	X	X
Sage sparrow	*Amphispiza belli*	BCC, PIF		X
Virginia's warbler	*Vermivora virginiae*	BCC, PIF		X
Williamson's sapsucker	*Sphyrapicus thyroideus*	BCC	X	

Source: Rich et al. 2004, USFWS 2002.
BCC = Birds of Conservation Concern
PIF = Partners in Flight

The Terrestrial Wildlife Avian Species section lists species observed or likely to occur on the test sites that are not included on the BCC or PIF lists but are protected under the MBTA. Migratory birds may nest from April through July within the vegetative communities that occur in the project areas. Raptors that are known to nest in the area, such as red-tailed hawk, Cooper's hawk, and great horned owl, initiate nesting activity as early as February with young fledging up to mid August. Golden eagles are known to nest in Ryan Gulch, which is located approximately 1 mile south of Site 2.

Environmental Consequences of the Proposed Action

Impacts to migratory birds would result from project construction and operation and would be short-term and long-term, as well as direct and indirect. Short-term impacts include disturbance to nesting individuals as a result of heavy equipment operation, which may result in nest abandonment or nest destruction. Long-term effects would result from habitat loss and fragmentation, and noise from the construction and operations over the duration of the testing phase.

The degree of impact is dependent on the vegetation community present and the success in revegetation following reclamation. Herbaceous vegetation would likely reestablish within 1 to 2 years. Big sagebrush would require at least 20 to 75 years to reestablish, and pinyon-juniper woodland from 100 to 300 years to return to pre-disturbance conditions. Revegetation success would affect the degree of long-term impact to migratory birds. Impacts to migratory bird habitat at each test site are discussed below.

Impacts to migratory birds from contamination in process or evaporative ponds could result from the operation and reclamation of the project. The water quality in the ponds may be poor due to water evaporation and concentration of dissolved constituents, thus impacting birds landing in or drinking from the water.

The proposed reserve pits in the project area are expected to attract waterfowl and other migratory birds for purposes of resting, foraging, or as a source of free water. It has recently been brought to the WRFO's attention that migratory waterfowl, including teal and gadwall, have contacted oil-based drilling fluids stored in reserve pits during or after completion operations resulting in mortality to these individuals which is in violation of the MBTA. The extent and nature of the problem is not well defined, but is being actively investigated by BLM and the companies pursuing RD&D leases. Until the specific cause of mortality is better understood, management measures must be conservative and aimed at prevention of bird contact with produced water and drilling and completion fluids that may be harmful to birds (e.g., through acute or chronic toxicity or loss of insulation).

The only "reserve" drilling pit for the area is the single pit known as the "cuttings pit," and it will be a dry pond. All pits that will contain produced water will require mitigation to exclude migratory birds from the pits.

Site 1 – Oil Shale Test Site

The pinyon-juniper woodland located southeast of the existing two-track road on the southeast-facing slope would only be lightly disturbed (Shell 2006a). Vegetation would be removed from the rest of the site. Total acreage at the site includes approximately 96 acres of pinyon-juniper woodland, 2 acres of bottomland sagebrush shrubland, and 49 acres of upland sagebrush shrubland. Approximately 13 acres of Site 1 has been recently disturbed from the development of seven well pads and associated access roads on Wolf Ridge and the northwest slope adjacent to the drainage. Project duration from construction through reclamation would be 20 years or longer (Shell 2006a).

Some of the long-term impacts may be minimized following site reclamation; however, because of the extended period of time that habitat would be occupied by facilities and, therefore, unavailable for wildlife use, impacts to migratory birds and their habitats are considered to be permanent. Construction and operation would displace migratory birds from the project site and immediate vicinity, as well as along the access road. The estimated 300 to 650 vehicles per day during construction at the site would initially cause disturbance to birds present along the access road and site boundaries, creating an edge effect that fragments habitat. In subsequent years, some species of migratory birds that are more sensitive to disturbance would be displaced to other areas of suitable habitat to avoid vehicle noise. However, the cumulative loss of habitat from development would reduce local migratory bird populations due to competition for resources.

Access to the Site 1 would be provided by construction of an access road connecting the site to existing county roads. Initial construction activities include development of the site access road and fencing of the permit area. Present access to Site 1 is from CR 5 to CR 24 to CR 91 to an existing two-track road. This two-track road was originally constructed to access several groundwater hydrology monitoring well sites. The access road would be extended to Site 1 and expanded to a running width of approximately 24 feet to allow heavy equipment travel in two directions. The access road would be paved with asphalt for the 24-foot width and include appropriate ditches and culverts to maintain drainage control. An estimated 300 to 650 vehicles per day would access the site during construction. Construction, operation, and road traffic could displace migratory birds from the project site and immediate vicinity, as well as along the access road.

Loss of habitat would have long-term and indirect adverse impacts to populations that are dependent on sagebrush or pinyon-juniper habitats.

Site 2 – Nahcolite Test Site

Approximately 50 acres of Site 2 was disturbed previously by research conducted by CSU. Additionally, a gas pipeline cuts through the southern portion of the site. However, a small area of pinyon-juniper woodland remains in the southwestern quadrant, south of the existing pipeline. The project facilities would require removal of most of the vegetation on the site, with the exception of the approximately 50 acres currently under lease to CSU and 5 acres along the pipeline.

The two proposed options for the access road include asphalting and widening an existing two-tract road along the pipeline ROW and the second option would require construction of approximately 350 feet of new road entering the site from the east from CR 24. Impacts to migratory birds from road construction and operation, as well as traffic density, would be similar as described for Site 1. Project duration, from construction to reclamation, would be approximately 20 years; long-term impacts to migratory birds are similar to those described for Site 1.

Site 3 – Advanced Heater Test Site

Approximately 75 percent of the site vegetation will be cleared for construction at Site 3. Most of the vegetation that would be removed is upland sagebrush shrubland. The other 25 percent of the site, comprised of areas in the northwestern and southeastern corners of the site, which is currently primarily pinyon-juniper woodland with a small area of upland sagebrush shrubland would have only light disturbance (Shell 2006b). Site 3 includes approximately 103 acres of upland sagebrush shrubland, 9 acres of bottomland sagebrush, and 48 acres of pinyon-juniper woodland. Removal of vegetation would be a long-term, direct impact to migratory birds as the project is expected to occupy the site for approximately 17 years.

Currently access to Site 3 is from CR 5 to CR 24 to CR 24X. Three access roads are currently proposed for Site 3: from CR 24X along CR 80 for approximately 2 miles to the northwest corner of the site, an approximately 2-mile long new road from CR 24X along an unnamed drainage with the proposed powerline, and the third from south of the site along an existing road for approximately 1 mile (Shell 2006b). In general, the access road would measure 24 feet wide (to accommodate heavy equipment use) and be paved with ditches and culverts. Traffic density and impacts from vehicles on the access road would be the same as described for Site 1. Impacts to migratory birds would be similar as described for Site 1 due to disturbance and displacement of migratory birds, as well as long-term or permanent displacement.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Under this alternative, in addition to the Proposed Action, BLM would require the following mitigation to ensure impacts to migratory birds would be minimized by implementation:

- Conduct pre-construction migratory bird surveys in the nesting season to locate active nests within the test sites.
- If the project initiation and construction is delayed until February 1, 2007, then a new survey for nesting raptors will be required prior to project initiation. Shell would be responsible for a qualified biologist to conduct migratory bird surveys. BLM does not specify survey protocol, but at a minimum, surveys would provide estimates of migratory bird species abundance and density.
- No surface occupancy will be allowed within 1/2 mile of active nests of threatened, endangered, or BLM sensitive species of migratory birds, including raptors, from February 1 through August 15 (1/8 mile for all non-listed migratory bird species). The BLM will be contacted and USFWS will be consulted if any special status species nests are discovered on or adjacent to the project area.
- Timing Limitation stipulations would be applied to active, non-Special Status raptor nests (i.e., those species not classified as listed, proposed, or candidate species for listing under the ESA and non-BLM sensitive species). No development or construction-related activities would be allowed within 1/4 mile of identified nest(s) from February 1 through August 15.
- Migratory bird access to, or contact with, reserve pit contents that possess toxic properties from ingestion or exposure or have the potential to compromise the water-repellent properties of birds' plumage will be effectively precluded. Exclusion methods may include netting, the use of "bird-balls," or other alternative methods that effectively eliminate migratory bird contact with pit contents and meet BLM's approval. Shell will notify BLM of the method that will be used to eliminate migratory bird use two weeks prior to initiation of drilling activities. The BLM-approved method will be applied within 24 hours after drilling activities have begun. All lethal and non-lethal events that adversely affect migratory birds will be reported to a WRFO Petroleum Engineer Technician immediately.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

A total of up to 430 acres could be disturbed during construction and operation of the three Shell RD&D project sites for up to 20 years. Construction, operation, and road traffic could displace migratory birds from the project site and immediate vicinity, as well as along the access road. Overall the loss of 430 acres of habitat could have direct, localized impacts on migratory bird habitat and would result in impacts to 0.18 percent the 2.6 million aces in the WRRA.

Surveying for raptors and nests prior to construction and the prohibition of vegetation clearing during breeding or nesting season would reduce localized impacts to nesting sites due to vegetation clearing.

Mitigation measures described above will reduce potential impacts to nesting migratory birds, but may not limit impacts to unknown nest locations. If potential impacts to previously unknown nests are identified, additional mitigation measures may be required to avoid adverse impacts to threatened, endangered or BLM sensitive species. Benefits of these mitigation measures would be less of a reduction of the migratory bird population and a faster return of many species upon completion of operations. This is important for the total health of the ecosystem.

Adverse effects to birds resulting from accidental interaction with reserve pits will be reduced by measures employed to eliminate bird use in these areas. This will lessen the mortality rate of migratory waterfowl which will help to maintain the health and diversity of the species.

Site 1 – Oil Shale Test Site

Vegetation would be removed from the site, except the pinyon-juniper woodland on the southeast-facing slope. Total acreage at the site includes approximately 96 acres of pinyon-juniper woodland, 2 acres of bottomland sagebrush shrubland, and 49 acres of upland sagebrush shrubland. Surveying for raptors and nests prior to construction and prohibiting vegetation clearing during breeding or nesting season would eliminate or reduce impacts to nesting sites due to vegetation clearing. Preventing access to reserve pits will virtually eliminate bird mortality resulting from contact with reserve pits.

Site 2 – Nahcolite Test Site

The project facilities would require removal of most of the vegetation on the site, with the exception of the approximately 50 acres currently under lease to CSU and 5 acres along the existing pipeline. Surveying for raptors and nests prior to construction and prohibiting vegetation clearing during breeding or nesting season would eliminate or reduce impacts to nesting sites due to vegetation clearing. Preventing access to reserve pits will virtually eliminate bird mortality resulting from contact with reserve pits.

Site 3 – Advanced Heater Test Site

Approximately 75 percent of the site vegetation will be cleared for construction at Site 3. Most of the vegetation that would be removed is upland sagebrush shrubland. The other 25 percent of the site would have only light disturbance (Shell 2006b). Surveying for raptors and nests prior to construction and prohibiting vegetation clearing during breeding or nesting season would eliminate or reduce impacts to nesting sites due to vegetation clearing. Preventing access to reserve pits will virtually eliminate bird mortality resulting from contact with reserve pits.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

THREATENED, ENDANGERED, AND SENSITIVE ANIMAL SPECIES

Affected Environment

This section presents federal- and state-listed threatened, endangered, and candidate species, state of Colorado Species of Special Concern, and BLM sensitive species. The special status wildlife species known to occur in Rio Blanco County are listed in the following table.

Special Status Wildlife Species Known to Occur in Rio Blanco County

Common Name	Scientific Name	Status	Habitat	Potential to Occur at Test Sites		
				Site 1	Site 2	Site 3
Mammals						
Black-footed ferret	*Mustela nigripes*	FE, SE	Semi-arid grasslands and mountain basins. Inhabits large prairie dog towns.	Not present.	Not present.	Not present.
Canada lynx	*Lynx canadensis*	FT, SE, BLM	Douglas fir, spruce fir, and subalpine forests above 7,800 feet in elevation.	Not present.	Not present.	Not present.
Fringed myotis	*Myotis thysanodes*	BLM	Coniferous forest and shrubland; forages near water, roosts in rock crevices and cliff walls.	Potentially present; may occur during foraging.	Potentially present; may occur during foraging.	Potentially present; may occur during foraging.
Townsend's big-eared bat	*Corynorhinus townsendii*	SC, BLM	Semidesert shrubland, pinyon-juniper woodland, and open montane forests. Roosts in abandoned mines and caves.	Potentially present; may occur during foraging.	Potentially present; may occur during foraging.	Potentially present; may occur during foraging.
Yuma myotis	*Myotis yumanensis*	BLM	Low elevation semi-arid canyonlands and mesas; forages in riparian zones, roosts in rock crevices, buildings, caves, mines, and swallow nests.	Potentially present; may occur during foraging.	Potentially present; may occur during foraging.	Potentially present; may occur during foraging.
Birds						
American peregrine falcon	*Falco peregrinus anatum*	SC	Nests on cliffs, often near water, forages over adjacent habitats.	May occur during foraging.	May occur during foraging.	May occur during foraging.
Bald eagle	*Haliaeetus leucocephalus*	FT, ST	Nest and roost near open water in areas with adequate prey and perches.	May occur during foraging.	May occur during foraging.	May occur during foraging.
Barrow's goldeneye	*Bucephala islandica*	BLM	Nests in tree cavities at small, isolated ponds. Winters on rivers, lakes, and ponds.	Not present; no suitable habitat.	Not present; no suitable habitat.	Not present; no suitable habitat.
Black tern	*Chlidonias niger*	BLM	Open water habitats.	Not present; no suitable habitat.	Not present; no suitable habitat.	Not present; no suitable habitat.

Special Status Wildlife Species Known to Occur in Rio Blanco County

Common Name	Scientific Name	Status	Habitat	Potential to Occur at Test Sites		
				Site 1	Site 2	Site 3
Burrowing owl	*Athene cunicularia*	ST	Grasslands; usually in or near prairie dog colonies.	Unlikely; no suitable habitat.	Unlikely; no suitable habitat.	Unlikely; no suitable habitat.
Columbian sharp-tailed grouse	*Tympanuchus phasianellus columbianus*	SC, BLM	Gambel oak and serviceberry shrublands, often interspersed with sagebrush shrublands, aspen forests, wheatfields, and irrigated meadows and alfalfa fields. Display grounds are on knolls or ridges.	Unlikely; no suitable habitat.	Unlikely; marginally suitable habitat.	Unlikely.
Ferruginous hawk	*Buteo regalis*	SC, BLM	Open grasslands and semidesert shrublands.	Unlikely; no suitable habitat.	Unlikely; no suitable habitat.	Unlikely; no suitable habitat.
Greater sage-grouse	*Centrocercus urophasianus*	SC, BLM	Inhabits upland sagebrush shrubland in rolling hills and benches; nests and broods young in meadows near water. Winters in sagebrush shrubland in submontane habitats.	Potentially present; within the overall range and nesting/brood-rearing habitat present.	Unlikely; not known to occur in site vicinity.	Unlikely; not known to occur in site vicinity.
Long-billed curlew	*Numenius americanus*	SC, BLM	During migration, rests and forages on shorelines, mudflats, and irrigated hayfields. Nests in grasslands and short sagebrush shrublands.	Unlikely; may occur during migration in late March through mid-May.	Unlikely; may occur during migration in late March through mid-May.	Unlikely; may occur during migration in late March through mid-May.
Mountain plover	*Charadrius montanus*	SC, BLM	Flat desert grasslands in association with prairie dogs.	Not present; no suitable habitat.	Not present; no suitable habitat.	Not present; no suitable habitat.
Northern goshawk	*Accipiter gentilis*	BLM	Nests in mature, old-growth aspen, conifer, and aspen/conifer and pinyon-juniper forests at 7,000 to 10,000 feet; forages in mountain shrub and open areas.	Potentially present; suitable nesting and winter foraging habitat	Potentially present; suitable winter foraging habitat	Present; active nest found 600 feet north of site in 2006.
Yellow-billed cuckoo	*Coccyzus americanus*	FC, SC	Large stands of deciduous woodland (cottonwood/willow) associated with riparian habitats.	Not present; no suitable habitat.	Not present; no suitable habitat.	Not present; no suitable habitat.
White-faced ibis	*Plegadis chihi*	BLM	In migration, shorelines of reservoirs, wet meadows, and irrigated fields. Spring migrants may stopover in low-elevation valleys	Unlikely, no suitable habitat on site or access road.	Unlikely, no suitable habitat on site or access road.	Unlikely, no suitable habitat on site or access road.

Special Status Wildlife Species Known to Occur in Rio Blanco County

Common Name	Scientific Name	Status	Habitat	Potential to Occur at Test Sites		
				Site 1	Site 2	Site 3
			between March and May.			
Amphibians and Reptiles						
Boreal toad	*Bufo boreas boreas*	SE	Marshes, wet meadows, streams, and lakes interspersed in subalpine forest.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Great Basin spadefoot	*Spea intermontanus*	BLM	Pinyon-juniper woodlands, sagebrush and semidesert shrublands at elevations below 7,000 feet.	May occur; suitable habitat.	May occur; suitable habitat.	May occur; suitable habitat.
Midget faded rattlesnake	*Crotalus viridis concolor*	SC, BLM	Desert shrub, mountain shrub, and coniferous forests in rock outcrops, talus slopes, and rocky streambeds.	May occur; suitable habitat.	May occur; suitable habitat.	May occur; suitable habitat.
Northern leopard frog	*Rana pipiens*	SC, BLM	Permanent water and associated moist upland vegetation.	Potential to occur at intersection of proposed access road and CR 91 over Stakes Springs Draw.	Potential to occur where proposed access road is near or crosses drainages.	Potential to occur where proposed access road is near or crosses drainages.
Fish						
Bluehead sucker	*Catostomus discobolus*	BLM	In Colorado, the species is limited to western slope and occurs in the Colorado River Basin.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Bonytail	*Gila elegans*	FE, SE	Main channels of large rivers with swift currents; endemic to Colorado River Basin.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Colorado pikeminnow	*Ptychocheilus lucius*	FE, ST	Main channels of large rivers with swift currents; endemic to Colorado River Basin.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Colorado River cutthroat trout	*Oncorhynchus clarki pleuriticus*	SC, BLM	Found in the Colorado River drainage; the current distribution is limited to a few, small headwater streams and lakes in northwest Colorado.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Flannelmouth sucker	*Catostomas latipinnis*	BLM	In Colorado, the species is limited to western slope and occurs in the Colorado River Basin.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.

Special Status Wildlife Species Known to Occur in Rio Blanco County

Common Name	Scientific Name	Status	Habitat	Potential to Occur at Test Sites		
				Site 1	Site 2	Site 3
Humpback chub	*Gila cypha*	FE, ST	Main channels of large, deep rivers with swift currents in shady canyons; endemic to Colorado River Basin.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Mountain sucker	*Catostomus platyrhynchus*	SC, BLM	In Colorado, the flannelmouth is found only in large rivers in the Colorado River drainage on the western slope.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Plains topminnow	*Fundulus sciadicus*	BLM	Present in the White River in small isolated populations.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Razorback sucker	*Xyrauchen texanus*	FE, SE	Main channels of large; endemic to Colorado River Basin.	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.
Roundtail chub	*Gila robusta*	SC, BLM	Occurs in the Colorado River mainstem and larger tributaries (e.g., White, Yampa, Dolores, San Juan, and Gunnison rivers).	Not present; no habitat.	Not present; no habitat.	Not present; no habitat.

Source: BLM 2000, USFWS 2006, CDOW 2006.
Federal Status: FE = endangered species, FT = threatened species, FC = candidate species for listing, FP = proposed threatened species.
State Status: SE = endangered species, ST = threatened, SC = species of concern
BLM Status: BLM = sensitive species, species which could become endangered.

Federally-listed Species

Of the eight species that are federally listed or a candidate for listing, the bald eagle is the only species with the potential to occur on any of the proposed test sites based on habitats present and previous records of occurrence. Four federally listed fish species that inhabit large rivers in the Colorado River Basin may be affected by the project. These species are discussed below.

<u>Bald Eagle</u>

Bald eagles occur primarily as winter residents and migrants, but a few nesting pairs remain in the summer. Nesting is initiated in early February, with young fledged by mid-July (BLM 1994). Bald eagles generally nest and roost near large water bodies or perennial streams and rivers; populations are concentrated at the White River and Piceance Creek in the area. In most years, approximately 100 bald eagles winter along the White River from mid-November through February (Righter et al. 2004). During winter and migration, bald eagles forage in areas way from water to hunt and scavenge; prairie dogs make up a large portion of their winter diet in some areas.

Site 1 – Oil Shale Test Site

No large open water or perennial streams are present at Site 1. The nearest known nest is more than 5 miles from Site 1 (NDIS 2006). Additionally, the Natural Diversity Information Source

(NDIS) does not recognize the site as a winter or summer foraging area for bald eagles. Bald eagles may occasionally forage over the site, but are unlikely to occur on a regular basis because no prairie dogs or open water habitats are present. Therefore, bald eagles may occasionally occur at the site during foraging, but no nesting or roosting habitat is present at Site 1.

Site 2 – Nahcolite Test Site

Similar to Site 1, bald eagles are known to forage at Ryan Gulch and, therefore, may occasionally forage over the site, but are not expected to frequent Site 2 because no prairie dogs or open water habitats are present.

Site 3 – Advanced Heater Test Site

Similar to Site 1, bald eagles may occasionally occur at the site during foraging, but no nesting or roosting habitat is present at Site 3.

<u>Endangered Colorado River Fish: Colorado Pikeminnow, Humpback Chub, Razorback Sucker, and Bonytail Chub</u>

These four fish species do not occur in Rio Blanco County and no perennial water occurs on the any of the test sites. However, these species occur downstream of the project area. Colorado pikeminnow are present in the White River. The White River downstream from Rio Blanco Lake, including the confluence with Piceance and Douglas creeks, is critical habitat for all four species. Critical habitat for Colorado pikeminnow and razorback sucker is located in the Colorado River from the town of Rifle, downstream. Critical habitat for humpback chub and bonytail chub occurs near the Colorado-Utah border in the Black Rocks area. As part of the Upper Colorado River Fish Recovery Plan, USFWS has determined that any water depletions would adversely affect these fish species in the Colorado River and its major tributaries.

Colorado Special Concern and BLM Sensitive Species

<u>American Peregrine Falcon</u>

No peregrine falcon nesting habitat is present within the project sites. However, because peregrine falcons forage over large areas and many habitats, individuals may occasionally hunt or fly over any of the test sites.

<u>Burrowing Owl</u>

Burrowing owls are uncommon in western Colorado; only one record of breeding is known, in the extreme northwestern corner of Rio Blanco County (Kingery 1998). Burrowing owls nest in burrows, primarily in association with prairie dog colonies in Colorado. No prairie dogs are present in the project area and no suitable open grassland habitats occur; therefore, burrowing owls are not likely to occur at any of the test sites.

<u>Ferruginous Hawk</u>

Ferruginous hawks nest in vast expanses of ungrazed grasslands and shrubland with varied topography, including hills, ridges, and valleys and rarely in pinyon-juniper woodlands (Kingery 1998, NDIS 2006). Ferruginous hawks are unlikely to nest within any of the test sites.

However, the species may be present at any of the test sites during migration or foraging in winter.

Fringed Myotis

Records from western Colorado of fringed myotis are from 5,000 to 8,000 feet in ponderosa pine and pinyon-juniper woodlands (Adams 2003). This bat roosts in caves, mines, and buildings and is fairly susceptible to human disturbance, especially near maternity colonies (Adams 2003). Fringed myotis may roost in live and dead trees, often under loose, exfoliating bark; in cavities; or vertical cracks. Information on hibernation and winter roost is lacking, as is seasonal use of habitats by fringed myotis (Ellison et al. 2003). Foraging habitat is present in the project area in the pinyon-juniper habitat; however, roosting is unlikely.

Great Basin Spadefoot

Records of Great Basin spadefoot toad (*Spea intermontanus*) in Rio Blanco County indicate that the species may occur in pinyon-juniper and sagebrush shrubland habitats (Hammerson 1999). Great Basin spadefoots are nocturnal, and burrow in soil during periods of inactivity. However, the species may be above-ground during daytime in periods of heavy precipitation as they are adapted to breed in ephemeral rain puddles and temporary pools (Hammerson 1999).

Site 1 – Oil Shale Test Site

Suitable habitat is present for Great Basin spadefoots in Site 1 and along the proposed access road. None were observed during 2004 and 2005 surveys; however, the weather conditions were dry during survey periods (SWCA 2005a). Based on the presence of suitable habitat and records from Rio Blanco County, the species may be present at Site 1.

Site 2 – Nahcolite Test Site

Great Basin spadefoots may occur along the proposed access road and along the existing CR 24; however, no spadefoots have been observed.

Site 3 – Advanced Heater Test Site

Great Basin spadefoot toads have been documented near Site 3 (Two Ravens Inc. 2002), though no water sources are present. The two proposed access roads approaching the site from the east run parallel to drainages. Great Basin spadefoots may occur at Site 3 or along any of the three proposed access roads.

Greater Sage Grouse

Greater sage grouse are obligates to sagebrush shrublands. In summer, the species inhabits native or cultivated meadows, grasslands, aspen, and willow thickets adjacent to or interspersed with sagebrush. Site 1 is within the overall range of greater sage grouse and contains winter range, brooding, and production areas (NDIS 2006).

Many of the areas that were formerly suitable greater sage grouse habitat are now dominated by tall, mature sagebrush and pinyon-juniper (SWCA 2005a). A small traditional courtship display area or lek (1-2 males) was active until the mid 1980s on 84 Mesa, approximately 2 miles east of

Site 3. However, during 2001 surveys, no leks were found, and no sage grouse or grouse sign was observed on or near the vicinity of Site 3 (Two Ravens Inc. 2001).

Midget Faded Rattlesnake

Midget faded rattlesnakes (*Crotalus viridis concolor*) are a subspecies of the western rattlesnake (*Crotalus viridus*) with records from the vicinity of the project area. Rio Blanco County is within the intergradation between two rattlesnake subspecies, *C. v. concolor* and *C. v. viridis*, although the two subspecies are genetically and morphologically different (Hammerson 1999). The subspecies is present in many habitats including pinyon-juniper woodland, montane woodland, riparian zones, mountain shrubland, and semidesert shrubland (Hammerson 1999).

Each of the three test sites is within the potential range of the midget faded rattlesnake and suitable habitat is available at Sites 1, 2, and 3. However, precise distribution and occurrence data for this reptile is not available (Hammerson 1999).

Northern Leopard Frog

Northern leopard frogs inhabit wet meadows and the banks and shallows of marshes, ponds, lakes, reservoirs, streams, and irrigation ditches.

Site 1 – Oil Shale Test Site

No wetlands are present in the Site 1 boundary or within the proposed access route into the site (Shell 2006a), therefore northern leopard frogs are not expected to occur at Site 1. Northern leopard frogs may occur where the proposed access road intersects CR 91 over Stake Springs Draw.

Site 2 – Nahcolite Test Site

An intermittent drainage is present in the northwestern corner of Site 2 (NWI 2006). However, no permanent standing water is present and, therefore, northern leopard frogs are not expected to occur at Site 2. The proposed access road where it would be extended from CR 24 does not cross any wetlands or drainages; however, CR 24 crosses several unnamed intermittent drainages near Stake Springs Draw, north of Site 2. These intermittent drainages may support northern leopard frogs due to their proximity to Stake Springs Draw.

Site 3 – Advanced Heater Test Site

Site 3 does not have suitable habitat for northern leopard frogs due to the lack of wetlands and intermittent or perennial water. The proposed access roads approaching the site from the east run parallel to drainages that may support northern leopard frogs, but due to the intermittent nature of these drainages, northern leopard frogs are unlikely to occur in these drainages.

Northern Goshawk

Northern goshawks inhabit large, contiguous stand of forest with some large, mature trees and open areas for foraging and generally prefer ponderosa pine and aspen, but also use spruce fir forest and mature pinyon-juniper woodlands in the Piceance Basin (Smithers pers. comm. 2006, Righter et al. 2004). In winter, goshawks also occur in pinyon-juniper for foraging activities and all three test sites are considered winter foraging habitat (Righter et al. 2004). Breeding range is located to the east, south, and west of the test sites and goshawks have nested in the Piceance Basin (Righter et al. 2004, SWCA 2005). Goshawks initiate nesting in April and incubate eggs in late April through mid-June. Spring migrants occur from late March through early May; fall migrants from early September through late October. Northern goshawks are most likely to occur in the test sites during winter, though Sites 1 and 3 include suitable nesting habitat.

Site 1 – Oil Shale Test Site

Suitable habitat for northern goshawks is present at Site 1, though none were observed in 2004, 2005, or 2006 (Greystone 2006).

Site 2 – Nahcolite Test Site

Site 2 was previously disturbed and only one patch of pinyon-juniper woodland is present in the southwestern portion of the site. Additionally, a gas pipeline is located on the southern boundary of the site. No suitable nesting habitat is present at Site 2 for northern goshawk. The area was surveyed in May 2006 by Greystone Environmental Consultants (2006).

Site 3 – Advanced Heater Test Site

No goshawks were observed on or near the Site 3 during studies in 2001, and no goshawk nests were found during raptor nest searches on localized drilling sites in pinyon-juniper habitat (Two Ravens Inc. 2001). Broadcast surveys for Northern goshawks were not conducted during the 2001 survey.

However, in May 2006, an active goshawk nest was detected approximately 600 feet to the north of the northern boundary, outside of the 160-acre parcel. The nest was detected in a mature stand of pinyon-juniper with an understory of sagebrush (Greystone 2006).

<u>Townsend's Big-eared Bat</u>

In Colorado, Townsend's big-eared bats primarily roost in abandoned mines and inhabit sagebrush and pinyon-juniper woodlands among other habitats, up to 9,500 feet in elevation (Adams 2003). Hibernaculae have been documented in Rio Blanco County. The species may forage over 10 miles in a single evening while foraging, which occurs along streams, adjacent to and within a variety of wooded habitats (Ellison et al. 2003). Townsend's big-eared bats may occur in the test sites during foraging, and may rest in old tree snags. Suitable foraging habitat is present in all three of the test sites. Townsend's big-eared bats may occasionally forage within the three test sites, but no caves, mines, or old buildings are present to support hibernation or maternity roosts.

<u>Yuma Myotis</u>

Yuma myotis occurs in areas near open water; their diet is predominately aquatic invertebrates. In Colorado, this species is associated with riparian woodland, semidesert shrubland, and pinyon-juniper woodland. In Utah, Yuma myotis also occur in sagebrush/pinyon-juniper and mountain brush/pinyon-juniper habitats (Adams 2003). Yuma myotis roost in rock crevices, buildings, caves, and mines. The lack of water and riparian habitat in the test sites makes the presence of Yuma myotis unlikely. However, Yuma myotis may fly over during foraging in the project area.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Impacts to federal, state, and BLM sensitive species would result from direct and indirect loss and degradation of habitat, displacement, and/or direct mortality. Species with potential to incur adverse impacts from the project are discussed below.

Federally-listed Species

Of the 10 federally-listed species presented in the Special Status Wildlife Species Known to Occur in Project Sites table above, only bald eagle and the endangered Colorado River fishes would have the potential to incur impacts from project construction, operation, or reclamation.

Bald Eagle

Impacts to bald eagle would result from loss of foraging habitat. However, the test sites are only occasionally visited by bald eagles and a broader landscape of suitable foraging habitat is available for use. Therefore, the propose action is not likely to adversely affect bald eagles.

Colorado River Fishes: Colorado Pikeminnow, Humpback Chub, Razorback Sucker, and Bonytail Chub

Major threats to federally endangered fish are addressed in the Recovery Plan for the Upper Colorado River Basin. These threats include loss and modification of habitat due to dam development, flow reductions, water contamination, and exotic fishes in the rivers. The White River, including the 100-year floodplain from Rio Blanco Lake to Utah, is designated by USFWS as “critical habitat” for all the federally-listed Colorado River fishes.

USFWS has determined that any federally authorized depletion from the Upper Colorado River Basin has an adverse affect on listed Colorado River fishes. Section 7 consultation with USFWS is required prior to authorizing any federal action that may adversely modify critical habitat, which includes land uses that may alter flow volume or timing (i.e., depletion) or result in contamination. The cumulative effect of minor flow depletions is the most common impact associated with BLM management and involves mineral operations (oil and gas development, extractive mining), major pipeline construction (pressure testing), livestock and wildlife water development, and soil and watershed improvement practices.

Depletions adversely influence listed fish populations by reducing peak spring and base flows that limits access to and the extent of off-channel waters (e.g., backwaters, eddies, oxbows) as habitats necessary for larval and young-of-year rearing areas (i.e., downstream). Attendant reductions in flow velocity and depth deteriorate riverine conditions necessary for spawning and over-winter survival of adult fish. Introduced fish populations, many of which are strongly competitive with or predatory on endemic fish, are also favored under moderated flow regimes.

Project operations would not directly modify habitat for these fish, but would have indirect effects from pumping of groundwater during quenching and reclamation phases following heating of the kerogen and recovery of the oil. These potential depletions would occur late in the project. However, they would be partially offset over the life of the project by augmentation from the initial dewatering of the process area prior to heating. Groundwater would be extracted from one or more wells completed within the Upper Parachute Creek Unit located outside of the freeze wall area. The maximum extraction rate during the reclamation phase would be

300 gallons per minute (gpm), and would be ongoing for up to 18 months. Pumping of groundwater would affect the upper water-bearing unit (Uinta Unit), which would in turn reduce groundwater discharge to Yellow Creek and potentially other creeks in the area. Initial modeling of the regional effects of this groundwater pumping results in a preliminary estimate of a maximum of 19 acre-feet per year (0.026 cfs) of depletion to surface flows in Yellow Creek which is within the Upper Colorado River Basin. A typical flow rate for Yellow Creek where it enters the White River is approximately 3 cfs. The preliminary estimate for the maximum annual depletion in Piceance Creek associated with reclamation phase groundwater extractions would be 6 acre-feet or 0.0085 cfs. This would represent less than one-tenth of 1 percent of the average stream flow of 59 cfs. This preliminary estimate is based on modeling performed for Site 1, which would have the largest volume of reclamation water needed of the three test sites. The test sites would be developed sequentially so the impact of all three running simultaneously was not modeled.

Prior to the heating phase, groundwater would be extracted from within the hydraulic confines of the freeze wall. The extraction wells would be completed within the Upper and Lower Parachute Creek units. This groundwater would be reinjected outside of the freeze wall perimeter into the Lower Parachute Creek Unit. The dewatering that occurs inside the freeze wall area would not cause any surface water depletions. Reinjection of this groundwater would eventually increase groundwater discharges to the White River by a similar amount, which constitutes augmentation of the stream flow. In summary, the initial dewatering of the freeze wall interior area would not cause any significant surface flow depletions.

BLM Sensitive Species

Construction and operation of the test facilities would result in short-term and long-term direct and indirect impacts to BLM Sensitive species. Direct and long-term impacts from habitat loss would result from removal of vegetation removing foraging habitat for northern goshawk, as well as foraging habitat in pinyon-juniper for fringed myotis, Yuma myotis, and Townsend's big-eared bat. Northern leopard frog may be impacted in areas where the hydrology is affected by the Proposed Action.

Other possible effects to northern goshawk include displacement due to disturbance or removal of nesting habitat, changes in winter foraging distribution, as well as indirect impacts from activities associated with construction and operation of test sites and access roads. Habitat loss would be a long-term impact and would include the duration of the project, through reclamation, until the pinyon-juniper woodland and/or sagebrush shrubland would re-establish at the sites 50 to 300 years, depending on revegetation success.

Additionally, direct impacts would occur to small-sized terrestrial or fossorial animals, such as midget-faded rattlesnake and Great Basin spadefoot, from overall habitat loss and mortality by crushing or burial by construction equipment. Construction noise may displace more mobile wildlife from the vicinity of the sites to adjacent areas of suitable habitat during construction and possibly operation. However, as discussed under the Migratory Birds section, cumulative effects to these species from increased oil and gas development in the region would have permanent consequences for wildlife from habitat loss and fragmentation.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

In addition to the Proposed Action, impacts to special status species would be minimized by implementing the following mitigation measures:

- Conduct follow-up raptor surveys if construction activities do not begin prior to the 2007 raptor nesting season.
- Conduct surveys prior to construction activities to determine which species will require clearance surveys in the project area if construction occurs in spring of 2007.
- Enforce limitations on activities within a one-half mile radius of active nests of raptors that are threatened, endangered, or BLM sensitive between February 1 and August 15 (1/4 mile for other raptors) and consulting with USFWS if any special status species nests are discovered on or adjacent to the project area.
- Prevent vegetation clearing while migratory birds are nesting (February 1 through August 15).
- Ensure that reserve pits are lined, fenced on all four sides with net-wire and covered with plastic barrier to exclude both large and small animals and netted to prevent birds from accessing these pits, and reclaiming the pits as soon as possible after use.

Federally-listed Species

Mitigation for endangered and sensitive Colorado River fishes would be determined by USFWS to address proposed water depletions that would adversely affect Colorado River fishes. Because the estimated depletion for each test site is less than 100 acre-feet per year, it is likely that there would be no cost to the water user. Section 7 consultation would apply.

USFWS Migratory Bird Office would be consulted if any nests of threatened and endangered species or raptors occur in the project site, access road, or adjacent to the facilities.

BLM Sensitive Species

<u>Northern Goshawk</u>

Annual pre-construction surveys would be conducted for the duration of construction, between February 1 and August 15, to locate active goshawk nests in or adjacent to each site and access road by a BLM approved biologist using BLM survey protocol.

At Site 3, a goshawk nest has been seen approximately 600 feet north of the northern boundary. Prior to development of Site 3, this location should be observed again. If the nest is active, construction and operation activities would not occur within 1/2-mile of the active goshawk nest between February 1 and August 15 or until young have fledged. Additionally, no surface occupancy (NSO) would occur within 1/4-mile of an active northern goshawk nest between February 1 and August 15. However, due to the steep topography of the northwest portion of Site 3, Shell would not be using the northwest corner of the 160-acre test site. Therefore, the closest operations would be an estimated 1/2-mile from the nest site. A BLM biologist would assess the goshawk nest prior to operations on Site 3.

BLM would be contacted and USFWS Migratory Bird Office would be consulted if any nests of threatened and endangered species of raptors occur in the test sites, access roads, or areas adjacent to the facilities.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Impacts to threatened and endangered species would be minimized by following mitigation measures described above. Benefits of these measures include reducing the loss of individuals and maintaining the breeding population. This contributes to the overall health of the ecosystem.

There will still be a loss of habitat for some species, but adherence to NSO requirements and restrictions on breeding times and construction will greatly reduce the impact. If the restrictions on construction timing are followed, animals and birds will have a greater chance at successful breeding and raising of their young. Covering the reserve pits will ensure that birds do not land in or drink contaminated water.

Any water depletions that are hydraulically connected to the Colorado River Basin are considered to adversely affect the four endangered Colorado River fish species. The project would adhere to the requirements of the streamlined Biological Opinion and USFWS Colorado River Fish Species recovery program (see discussion of ESA Section 7 Consultation below). Benefits of complying with these requirements include a reduced loss of endangered Colorado River fish species; contributing to the overall health of the ecosystem.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Endangered Species Act Section 7 Consultation

A Biological Assessment (BA) was prepared in compliance with Section 7(c) of the ESA and submitted to the USFWS. The USFWS will review the BA to assess the potential impacts of the Proposed Action with Mitigation on federally-listed endangered, threatened, proposed for listing, and candidate species. The analysis, results, and conclusions presented in the BA are based on surveys and research conducted by biologists and botanists contracted by the preparer and the BLM. Based on the analyzed impacts of the subalternative (the Proposed Action with Mitigation) BLM concluded there will be "no effect" on all but five federally-listed endangered, threatened, proposed for listing, and candidate species. For the bald eagle, the BA described that increased activity from implementation of the Proposed Action with Mitigation may increase the incidence of vehicle accidents or disrupted feeding, resulting in a conclusion of "may affect, not likely to adversely affect".

For the four endangered Colorado River fish species, water depletions of up to 19 acre-feet per year for all three sites in total may adversely affect endangered Colorado River fish species. The water depletions constituting the 19 acre-feet per year are to be used during drilling and construction and from boiler makeup water during project operation.

New projects involving a depletion of less than 125 acre-feet per year are required to pay a one-time fee to cover the annual depletion. The estimated depletion for each site is significantly less than 125 acre-feet per year, and depletions are offset in part by augmentation to Yellow Creek during initial dewatering of the process area and reinjection outside of the process area. The project would result in estimated maximum water depletions of 19 acre-feet per year at each test site. Water would be used in drilling, operational, and reclamation phases of the project.

Based on the determination that implementing the subalternative (the Proposed Action with Mitigation) is likely to adversely affect endangered Colorado River fish species, consultation between the BLM and USFWS would occur as agreed under the minor water depletions Programmatic Biological Opinion, which addresses water depletions less than 125 acre-feet per year.

Finding on the Public Land Health Standard for Threatened and Endangered Species

The Proposed Action would have no adverse effect on any federally listed species and would not jeopardize the viability of any animal population. The project would not adversely affect habitat condition, utility, or function, nor have any discernible effect on species abundance or distribution at any landscape scale. The public land health standard would continue to be met.

THREATENED, ENDANGERED, AND SENSITIVE PLANT SPECIES

Affected Environment

This section presents federally-listed threatened, endangered, and candidate plant species and species listed as "sensitive" by BLM. Threatened, endangered, and BLM Sensitive plant species known to occur in northwest Colorado are listed in the following table (BLM 2000). All of these species are considered rare by the Colorado Natural Heritage Program. The majority of species on this list are associated with the Green River Formation. Others are known from the area but may not have such specific habitat requirements. A pedestrian survey was conducted in March 2006 by WestWater Engineering to verify presence or absence of federally listed plant species.

Threatened, Endangered, and Sensitive Species Known to Occur in Northwest Colorado

Common Name	Scientific Name	Potential to Occur	Status
Dudley Bluffs bladderpod	*Lesquerella congesta*	Unlikely	FT
Dudley Bluffs twinpod	*Physaria obcordata*	Unlikely	FT
Ute Ladies'-tresses orchid	*Spiranthes diluvialis*	Very unlikely	FT
Parachute penstemon	*Penstemon debilis*	Unlikely	FC, BLM
Graham beardtongue	*Penstemon grahamii*	Unlikely	FP, BLM
White River penstemon	*Penstemon scariosus var. alvifluvis*	Unlikely	FC, BLM
Park rockcress	*Arabis fernaldiana var. fernaldiana*	Unlikely	BLM
Debris milkvetch	*Astragalus detritalis*	Unlikely	BLM
Ephedra buckwheat	*Eriogonum ephedroides*	Unlikely	BLM

Threatened, Endangered, and Sensitive Species Known to Occur in Northwest Colorado

Common Name	Scientific Name	Potential to Occur	Status
Utah gentian	*Gentianella tortuosa*	Unlikely	BLM
Narrow-stem gilia	*Gilia stenothyrsa*	Unlikely	BLM
Piceance bladderpod	*Lesqerella parviflora*	Unlikely	BLM
Narrow-leaf evening primrose	*Oenothera acutissima*	Unlikely	BLM
Rollins cryptanth	*Oreocarya rollinsii*	Unlikely	BLM

Federal Status: FT=threatened species, FC=candidate species for listing, FP=proposed threatened species
BLM Status: BLM = sensitive species, species which could become endangered.

The rare plants known to occur within the Piceance Basin most commonly occur upon relatively barren outcrops of the Green River Formation. These shale barrens appear from a distance to be devoid of vegetation; however, they support a very specific array of plants that are adapted to this habitat. The shale barrens in this area are usually found along valley slopes (Roberts 2005b). The Thirteen Mile Creek Tongue of the Green River Formation is especially important. This white shale/marlstone exposure occurs in a thin band no wider than 1,000 feet and parallels the valley slopes of Yellow Creek and Piceance Creek and their tributaries.

Descriptions of known occurrences, habitat, and life history of species that have potential to occur in the project study area are provided below for each federally listed and BLM Sensitive species. Of these species, only two federally-threatened plants, Dudley Bluffs bladderpod and Dudley Bluff twinpod, have potential to occur in the test sites. Both of these species are associated with barren shale outcrops of the Green River Formation.

The three test sites are located in an area where the Green River Formation is inter-tongued with several units of the Uinta Formation. The Green River is easily distinguished from the Uinta by its light gray (almost white) color, finer-textured shale fragments, and finer-textured soil particles. The Uinta is light brown to buff in color with coarse-textured rock fragments and soil particles. No special status plants within the Piceance Basin have been documented on soils derived from the Uinta Formation.

Federally-listed Species

Dudley Bluffs bladderpod flowers in late April with blooming peaks in May; fruit are mature in late May and June. It is endemic in the Piceance Basin. The plant forms small cushions of growth on barren, white shale outcrops of the Thirteen Mile Tongue of the Green River Formation at elevations from 6,000 to 7,000 feet. Documented occurrences of Dudley Bluffs bladderpod are located in Yellow Creek above its confluence with Duck Creek as well as in lower Ryan Gulch, approximately 4 to 5 miles from the test sites (Roberts 2005a).

Dudley Bluffs twinpod is also endemic to the Piceance Basin. It flowers in May and June and fruits in July and it is characterized by heart-shaped fruits, attached at the pointed end. The species occurs on barren white shale outcrops and steep colluvial slopes derived from the Thirteen Mile Tongue and the Parachute Creek member of the Green River Formation at an elevation of 5,900 to 7,500 feet. This plant has been documented in the Dudley Bluffs, Ryan Gulch, and Yank's Gulch (WestWater 2006).

Ute ladies'-tresses is an orchid that grows in wet meadows, streamsides, and riverbanks in scattered populations throughout the west. The orchid has white flowers, grows to 16 inches, and blooms in July. No populations of Ute ladies'-tresses have been reported in the Piceance Basin (WestWater 2006). No suitable habitat is located on the test sites; the drainage corridors on the sites are dominated by big sagebrush with deep soils.

Parachute penstemon is only known from five occurrences in Garfield County. It grows on sparsely vegetated, south-facing, steep, white shale talus in the Mahogany Zone of the Parachute Creek Member of the Green River Formation between 7,800 and 9,000 feet. No populations of parachute penstemon are known in the test sites or Rio Blanco County.

Graham's beardtongue is restricted to eastern Utah and one population on Raven Ridge, west of the town of Rangely, Colorado. The species grows on talus slopes and knolls of the Green River Formation at elevations between 5,800 and 6,000 feet. Graham's beardtongue blooms in May. There are no known occurrences of this plant within the Piceance Basin.

White River penstemon occurs on barren shale outcrops of the Green River Formation along the White River in eastern Utah at elevations between 5,000 and 7,200 feet. Like Graham's beardtongue, this species is also known from Raven Ridge, west of the town of Rangely, Colorado, but there are no known occurrences within the Piceance Basin.

BLM Sensitive Plant Species

Park rockcress occurs on Weber sandstone and limestone outcrops in Uintah County, Utah, as well as western Moffat County, Colorado in and near Dinosaur National Monument. This species typically occurs between 5,800 and 6,000 feet in elevation. There are no known occurrences of Park rockcress within the Piceance Basin.

Debris milkvetch is known from populations near the town of Meeker, Colorado into northeastern Utah. It is not associated with a geological substrate; it grows on rocky or sandy soils with cobbles on alluvial terraces. Debris milkvetch blooms in May. The species grows at elevations between 5,400 and 7,200 feet. There are no known occurrences of this species within the Piceance Basin.

Ephedra buckwheat is a small sized species that is known in Colorado from populations on the Green River Formation on Raven Ridge, west of Rangely, but the species has not been documented in the Piceance Basin. It grows at elevations between 5,800 and 6,000 feet and flowers in May.

Utah gentian is known from the crest of the Cathedral Bluffs and grows on barren shale outcrops of the Green River Formation between 8,500 and 10,800 feet in elevation. Several other populations occur in Utah and Nevada. The species blooms in July or August.

Narrow-stem gilia populations have been documented in Mesa and Rio Blanco counties and in the Uinta Basin in Utah. The only known occurrence of the species in the Piceance Basin is within the Lower Greasewood ACEC (WestWater 2006). The species occurs on silty or gravelly loam soils derived from the Green River or Uinta formations. It occurs between 5,000 and 6,000 feet in elevation and blooms in late May into June.

Piceance bladderpod is known to occur in Rio Blanco, Garfield, and Mesa counties in Colorado. The nearest outcropping of the Green River Formation occurs along Calamity Ridge and on the

Cathedral Bluffs. The nearest known population of this species is south of the project area on Cathedral Bluffs. The species grows on shale outcrops of the Green River Formation between 6,200 and 8,600 feet in elevation and flowers from May through July (Roberts 2005b).

Narrow-leaf primrose is known to occur in Daggett and Uintah counties in Utah, and Moffat County, Colorado. Populations grow in sandy, gravelly, or rocky soils in seasonally moist areas at elevations from 5,300 to 8,500 feet. The species flowers in May and June. No populations have been recorded as far south as the Piceance Basin.

Rollins cryptanth occurs on white shale barren slopes of the Green River Formation in western Rio Blanco and Moffat counties at 5,300 to 5,800 feet in elevation. A population is present on Raven Ridge, west of the town of Rangely, Colorado. The species flowers in May.

Specific information for each test sites is provided below.

<u>Site 1 – Oil Shale Test Site</u>

Site 1 is located entirely on Unit 5 of the Uinta Formation at 6,750 to 6,950 feet in elevation. This site does not have light colored barren areas of the Green River Formation, potential habitat for listed species. During a 2004 survey of approximately 1,900 acres on Wolf Ridge, which encompassed Site 1, no special status species were documented (Roberts 2004). Due to the lack of suitable habitat and of documented occurrences of special status plants within 3 miles of Site 1, no special status plant species are expected occur at the site or along the proposed access road (WestWater 2006).

Several very small (less than 200 square meters each) Green River Formation outcrops, considered equivalent to the Thirteen Mile Creek Tongue, occur approximately 0.5 to 1 mile south of the Site 1. While these outcrops visually appear similar to the Thirteen Mile Creek Tongue, they support a different array of plant species (WestWater 2006). No special status species were located in these outcrops during 2004 surveys. Additionally, an exposure of the Black Sulphur Tongue of the Green River Formation crosses the ridge from Stake Springs Draw on Corral Gulch about 1 mile farther up the ridge southwest of Site 1; no listed plants were documented on this exposure (WestWater 2006).

The nearest special status plant populations to Site 1 are Dudley Bluffs bladderpod located within the Duck Creek ACEC, approximately 4.6 miles north of the site along the lower valley slopes of Duck Creek on the Thirteen Mile Creek Tongue of the Green River Formation between 6,360 and 6,480 feet in elevation (WestWater 2006). The nearest population of the Dudley Bluffs twinpod occurs about 7 miles east of Site 1 on the Thirteen Mile Creek tongue within the Ryan Gulch ACEC on the lower slopes of Ryan Gulch between 6,200 to 6,500 feet in elevation. The nearest population of the Dudley Bluffs twinpod within the Yellow Creek drainage occurs approximately 11 miles northeast of this site on the lower slopes of Yellow Creek on an exposure of the Thirteen Mile Creek tongue between 6,200 and 6,300 feet in elevation (WestWater 2006).

<u>Site 2 – Nahcolite Test Site</u>

Site 2 is also located on Unit 5 of the Uinta Formation at 6,570 to 6,690 feet in elevation. No light-colored barren areas of the Green River Formation are present within this site. Additionally, the elevation of the site is well above that of the nearest known special status plant populations. Based upon the uniform vegetative cover, the lack of any potential habitat detected, and the lack of any documented occurrences of special status plants closer than 4.5 miles of the site, none of the special status plants would occur at Site 2 or along the proposed access road (WestWater 2006). Additionally, an exposure of the Black Sulphur Tongue of the Green River Formation crosses the ridge from Ryan Gulch to Stake Springs Draw about 1 mile up the ridge to the southwest of the site. No special status plants were documented on this exposure (WestWater 2006).

The nearest population of the Dudley Bluffs bladderpod to Site 2, as described for Site 1, is located approximately 4 miles north of Site 2. Large populations of Dudley Bluffs bladderpod are documented farther downstream of Yellow Creek, within the Duck Creek ACEC between 6,200 to 6,400 feet in elevation, about 4.5 miles north of Site 2.

The nearest populations of both the Dudley Bluffs twinpod, also a known occurrence of the Dudley Bluffs bladderpod, is located approximately 4.7 miles east of Site 2 on the Thirteen Mile Creek tongue, on the lower slopes of Ryan Gulch between 6,200 and 6,500 feet in elevation. The nearest population of the Dudley Bluffs twinpod within the Yellow Creek drainage occurs almost 10 miles northeast on the lower slopes of Yellow Creek on an exposure of the Thirteen Mile Creek tongue between 6,200 and 6,300 feet in elevation.

<u>Site 3 – Advanced Heater Test Site</u>

Site 3 is located entirely on Unit 5 of the Uinta Formation at an elevation between 6,950 to 7,030 feet with soils derived from the Uinta Formation, which is not potential habitat for any special status plants listed in the Threatened, Endangered, and Sensitive Species Known to Occur in the Project Area Sites table above. The pinyon-juniper woodland stand in the northwest corner of Site 3 appears to have suitable habitat in several barren areas with very little soil cover. However, the soil and rocky surface of this area is characteristic of the Uinta Formation. The remainder of Site 3 exhibits fairly uniform vegetative cover that is not suitable for supporting any of the special status plant species. Additionally, the elevation of Site 3 is well above that of the nearest known population of special status plant, Dudley Bluffs bladderpod. This population occurs approximately 3 miles northeast of the site along the lower valley slopes of Duck Creek on the Thirteen Mile Creek Tongue of the Green River Formation at 6,400 to 6,460 feet in elevation. The nearest population of the Dudley Bluffs twinpod within the Yellow Creek drainage occurs 10.5 miles northeast of this site on the lower slopes of Yellow Creek on an exposure of the Thirteen Mile Creek tongue between 6,200 and 6,300 feet in elevation.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Construction of any of the three test sites and associated access roads is not expected to adversely affect any of the special status plants listed in the Threatened, Endangered, and Sensitive Species Known to Occur in the Project Area Sites table above. Based on surveys conducted in March 2006, no suitable habitat is present on any of the test sites or associated access roads for these species (WestWater 2006).

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

If threatened, endangered, or BLM sensitive plant species are identified on-site during future field surveys, impacts to those species will be minimized or avoided. Measures will be species-specific and will be applied on a site-by-site basis, depending on the results of field surveys. Shell will coordinate with BLM to determine conservation measures and the need for USFWS consultation for threatened, endangered, candidate, and BLM sensitive plant species and will consult with USFWS to determine measures for federal listed threatened, endangered, or candidate species. Shell will:

- Install erosion control measures, as discussed in the Soils section, to control erosion and transport of sediment.
- Return unused disturbed areas to pre-construction status as soon as possible to avoid the infestation of noxious weeds.
- Seed disturbed areas with BLM-approved seed mixes.

Shell will also implement the following BLM mitigation measures in the event sensitive plant species are identified:

- Avoid plants that occur outside the project area and install exclusion fencing to prevent disturbance from construction activities.
- Conduct source population surveys during flowering in areas where plants cannot be avoided to determine the magnitude of impact on the entire population.
- Consider the effectiveness of collecting seed from mature plants to be replanted following construction activities.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

The proposed mitigation alternative would ensure that any potential impacts to special status plant species are avoided, reduced, or minimized. Although there is little potential for special status species to be present on any of the Shell tracts, the proposed mitigation alternatives would ensure impacts to special status plant species are avoided by identifying individual plants prior to construction activities. Site design modification will help ensure impacts to individual plants are minimized or avoided. Avoiding special status plant species will ensure that the plant species continue to thrive.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Finding on the Public Land Health Standard for Threatened and Endangered Plants

The proposed and alternative actions would not jeopardize the viability of any plant population. With implementation of mitigation measures, the project would have no discernible consequence on habitat condition, utility, or function, nor have any discernible effect on species abundance or distribution at any landscape scale. The public land health standard would continue to be met.

WASTES, HAZARDOUS OR SOLID

Affected Environment – Sites 1, 2, and 3

Hazardous materials are defined by BLM as any substance, pollutant, or contaminant that is listed as hazardous under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. The term does not include petroleum products or natural gas.

The affected environment for hazardous materials includes air, water, soil, and biological resources that may potentially be affected by an accidental release of hazardous materials at any of the three test sites or during transport to the test sites. Sensitive areas for hazardous materials release include areas adjacent to water bodies and areas where humans or animals reside.

None of the three test sites contain hazardous or solid waste sites, and no hazardous substances are known to have been stored or disposed of within the project area.

A variety of materials including lubricants, treatment chemicals, paints and solvents, explosives, gasoline, diesel fuel, and hydraulic fluid may be used to construct and operate the facilities at each test site. Potential hazardous materials would likely be kept in minimal quantities at the test sites for short periods.

Most waste generated would be exempt from hazardous waste regulations under the exploration and production exemption of the Resource Conservation and Recovery Act (RCRA). Examples of exempt wastes include process water and hydrocarbon impacted soils.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

During the course of construction and operation, a variety of by-products and waste materials would be generated. They include construction waste, drill hole cuttings, garbage, and miscellaneous solid and sanitary wastes. With the proper procedures in place, it is not anticipated that waste would present any environmental consequences.

Surface construction operations would result in a variety of small waste products that could include paper, wood, scrap metal, refuse, garbage, etc. These materials would be collected in appropriate containers and recycled or disposed off site in accordance with applicable regulations.

Approximately 200,000 cubic feet of earth and rock materials would be generated at each test site during drilling operations for the project. Drill cuttings removed from the drilled holes would be dewatered so the water can be recycled back to the drill rigs. The dewatered cuttings would be placed into a cutting pit. These non-toxic, non-acid forming drill cuttings would be separated from free water and would be buried below grade. Burial depth and soil coverage would be sufficient such that the materials would not impede revegetation.

During operation, garbage from the site would be collected in appropriate containers and disposed off site. Waste oils, reagents, and lab chemicals that are not collected in sumps and treated at the water treatment plants would be recycled or disposed off site in accordance with applicable regulations.

The process of producing hydrocarbons from the oil shale would require processing and treatment of multiple materials. The production complex would include a refrigeration facility, a nahcolite recovery process (at Site 2), groundwater reclamation facility, and a hydrocarbon processing facility. Spill Prevention, Control and Countermeasure (SPCC) Plans and BMPs would need to be implemented for each stage of production and all processing facilities to ensure that no materials are inadvertently released to the outside environment. Additionally, all waste byproducts from the site would need to be properly transported and disposed of according to all rules and regulations regarding the specific waste byproduct. These waste byproducts would include, but would not be limited to, Bio-Solids Effluent and Reverse Osmosis Reject Effluent.

Product Processing System

The recovered product would include a mixture of liquid hydrocarbons, gas, and water that would be processed further to remove impurities and ready the products for transport off site or reuse in the recovery process. The recovery process is a typical process used in the oil and gas industry.

The initial processing would separate the recovered product into three streams: liquid hydrocarbons, sour gas, and sour water. The term sour refers to the presence of sulfur compounds and carbon dioxide (CO_2). Once the three streams have been separated, each stream would be further processed to remove impurities. Except as noted in the following discussions, the waste streams generated during much of the processing would be recycled back into the processing for further treatment.

Sanitary Waste

A combination of sanitary waste handling methods would be employed. Some sanitary waste, such as that collected in temporary toilet facilities, may be shipped to an approved facility for off-site treating and disposal. Any gray water or black water disposed of onsite would be treated in an appropriate sewage processing unit or disposed according to standards via an approved septic system with clarifier and drain field.

Nahcolite Recovery (Site 2 – Nahcolite Test Site, Only)

The nahcolite mining solution would be pumped to a processing building where the mineral would be removed. Detailed engineering has not been completed, but the process would remove the mineral from the water in a series of steps; dried, stored, and loaded for market. Hot solution would be cooled; the mineral is less soluble and crystallizes. Centrifuges would drive off water to concentrate the crystallized material. The water would be reheated and recycled as barren solution. CO_2 would be used to make a final product (sodium bicarbonate).

Detailed design of the processing facility has not been completed. It is anticipated that the nahcolite recovery system would be constructed, operated, and decommissioned prior to beginning of groundwater reclamation. To minimize disturbance, construction of the groundwater reclamation facilities would be intended to be at the same location as the nahcolite processing facility. Additional engineering evaluations would optimize the site arrangements for these facilities.

Refrigeration System

Appropriate procedures for storage, handling, and emergency response for ammonia chemicals used in the refrigeration system would be included in the Process Safety Management Manual to be developed in accordance with Occupational Safety and Health Administration regulations prior to operation. Emergency response procedures including procedures for clean-up of spills and notification requirements would be included in the Emergency Response Plan (ERP) to be developed prior to operations.

The byproducts from production at the test sites would be identified and the appropriate procedures provide for safe removal from the test sites. No environmental consequences from waste production would occur due to the activities at the three test sites because the waste products being developed do not present any problems for the safe collection and transport off site for proper disposal.

Accidental spills or leaks associated with equipment failures, refueling and maintenance of equipment and storage of fuel, oil, or other fluids could cause soil, surface water, and or groundwater contamination during construction and operation of the facilities. The project would increase contributions to solid waste landfills. Solid waste construction impacts would be temporary. The severity of potential impacts from an accidental hazardous material spill would depend upon the chemical released, the quantity released, and the proximity of the release to a water body.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Under this alternative, BLM would require the following mitigation in addition to the actions described in the Proposed Action, to ensure impacts from hazardous or solid wastes would be minimized by implementation:

- Watch for signs of hazardous or solid wastes as Shell excavates operational and infrastructure sites, and if found taking appropriate reporting and mitigative measures to protect the public and workers;
- Maintain the project area in a sanitary condition at all times;
- Provide an adequate number of trash containers on-site;
- Dispose of trash and nonflammable wastes at an appropriate waste disposal site;
- Provide portable toilets on-site, removing and disposing of contents in accordance with applicable laws and regulations;
- Use, store, transport, and/or dispose of hazardous materials in accordance with applicable federal and state laws; and
- Implement spill prevention measures, inspection and training requirements, and spill response and notification procedures to minimize the potential for accidental spills or leak.

BMPs would be required to ensure that wastes will not be released to the outside environment. The appropriate SPCC Plans would be designed so that each facility has the appropriate containment and countermeasures in place. Solid or hazardous waste would be removed from the test sites according to the necessary procedures associated with the type of waste. Any unforeseen waste exposure to the outside environment would need to be addressed and proper mitigation will be implemented, but at this time no waste exposures are anticipated.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Mitigation measures will reduce potential impacts from hazardous or solid wastes by implementing BMPs to ensure all wastes are properly handled and measures are in place to manage accidental releases. The project would increase contributions to solid waste landfills. However, solid waste construction impacts would be temporary, while plant operation impacts would occur for the life of the project. Accidental spills or leaks associated with equipment failures, refueling, or maintenance of equipment, and storage of product, fuel, oil, or other fluids during construction and operation of the Shell facilities may occur. However, the severity of potential impacts from an accidental hazardous material spill would depend upon the chemical released, the quantity released, and the proximity of the release to a waterbody or aquifer. A BLM-approved SPCC plan would reduce impacts to soils from accidental releases.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur. No hazardous or solid wastes would be generated or managed in the No Action Alternative.

WATER QUALITY, SURFACE WATER AND GROUNDWATER

Affected Environment – Sites 1, 2, and 3

Surface Water

The three test sites are all located within the Yellow Creek catchment area which is tributary to the White River in the Green River Basin of the Lower Colorado River Basin. Surface water originates chiefly as snowmelt runoff in the spring (April to June). High stream flows are caused by snowmelt and summer (chiefly August) thunderstorms. Peak flooding events are caused by snowmelt and extreme summer thunderstorms. Baseflow is provided by spring discharges and groundwater inflow to the alluvial valleys.

The Yellow Creek catchment area covers approximately 262 square miles and is part of the White River watershed. The catchment area ranges in elevation from 8,288 feet to the west on Calamity Ridge to 5,535 feet at the confluence of Yellow Creek with the White River. From the headwaters, ancillary creeks flow in an easterly direction from the headwaters along Cathedral Bluffs and Calamity Ridge. Yellow Creek then flows northeasterly from 84 Ranch, located at the confluence of Corral Gulch and Stake Springs Draw, before turning north, and then northwesterly above its confluence with the White River approximately 25 miles east of Rangely, Colorado. The catchment area is characterized by steep-sided, rugged terrain with intersecting gulches incised into plateau areas. Streamflow data have been recorded by the U.S. Geological Survey (USGS) at several gauging stations along the creek or feeder creeks since the early 1970s. The average recorded streamflows are presented in the following table (USGS 2006). The gauging station locations are shown on Figure 10.

Average Recorded Streamflow

USGS Gauging Station	Elevation (feet NGVD29)	Drainage Area (square miles)	Mean Daily Discharge (cfs)	Period of Record
Corral Gulch Near Rangely, CO 09306242	6,580	31.6	1.9	1974-2005
Corral Gulch at 84 Ranch 09306244	6,366	37.8	0.106	1975-1977
Stake Springs Draw near Rangely, CO 09306230	6,365	26.1	0.015	1974-1977
Yellow Creek near White River 09306255	5,535	262	3.07	1972-2005

cfs = cubic feet per second
NGVD29 = National Geodetic Vertical Datum of 1929
USGS = U.S. Geological Survey

Based upon the average discharge data for the two Corral Gulch stations, the segment between the two gages (segment above 84 Ranch) is a losing stream. However, the data for one of the stations only represent about 3 years of streamflow measurements. A hydrograph from the Corral Gulch station (09306242) and Yellow Creek at White River (09306255) is shown as Figure 11. Mean daily streamflow is higher in Yellow Creek near the confluence with the White River than on Corral Gulch above 84 Ranch. Mean daily streamflow in Stake Springs Draw above 84 Ranch is very low, and may represent a losing stream system in this drainage segment.

The “Status of Water Quality in Colorado –2006” (CDPHE 2006b) and Regulation No. 37 Classifications and Numeric Standards for Lower Colorado River Basin (CDPHE 2006c) were reviewed for information relating to drainages within the project area. Stream segment 13b of the White River Basin is defined as the mainstem of Yellow Creek including all tributaries, from the source to the confluence with the White River. The State has classified stream segment 13b of the White River Basin as “Use Protected” and further designated as beneficial for the following uses: Warm Aquatic Life 2, Recreation 2, and Agriculture. The antidegradation review requirements in the Antidegradation Rule are not applicable to waters designated use-protected. For those waters, only the protection specified in each reach will apply. For this reach, minimum standards for three parameters have been listed. These parameters are: dissolved oxygen = 5.0 milligrams per liter (mg/l), pH = 6.5 - 9.0, and Fecal Coliform = 2,000/100 milliliters (ml) and 630/100 ml E. coli. Numeric standards for inorganic compounds and metals can be found within Regulation No. 37 Classifications and Numeric Standards for Lower Colorado River Basin (CDPHE 2006c). Stream segment 13b is subject to temporary modification for all numeric standards to reflect “current conditions.” The temporary modifications reflect uncertainty regarding the numeric standards necessary to protect aquatic life and agricultural uses in Yellow Creek. Shell would work in coordination with the Water Quality Control Division to resolve the uncertainty before the temporary modification expires on February 28, 2009.

Newly promulgated Colorado Regulations Nos. 93 and 94 (CDPHE 2006c and 2006d, respectively) were reviewed for information related to the proposed project area drainages. Regulation No. 93 is the State's Section 303(d) list of water-quality-limited segments requiring Total Maximum Daily Loads (TMDLs). The 2006 303(d) list of segments needing development of TMDLs includes two segments within the White River - segment 9b, White River tributaries North and South Forks to Piceance Creek, specifically the Flag Creek portion (for impairment from selenium with a low priority for TMDL development) and segment 22, tributaries to the White River, Douglas Creek to the Colorado/Utah boarder, specifically West Evacuation Wash, and Douglas Creek (sediment impairments). Regulation 94 is the State's list of water bodies identified for monitoring and evaluation, to assess water quality and determine if a need for TMDLs exists. The list includes two White River segments that are potentially impaired – 9 and 22. Segment 13b was not listed.

The following table summarizes water quality data for several USGS surface water monitoring stations in the area of Corral Gulch and Stake Springs Draw. Locations where water quality data have been generated are shown on Figure 10; however, data are only available for a few of the sites shown on this figure.

Stream and Spring Water Quality Data from the Corral Gulch Area (Average values from the range of record dates shown)

Location*	TDS (Residue) (mg/l)	pH	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Bicarbonate (mg/l)	Sulfate (mg/l)	Chloride (mg/l)
Stream Data								
Corral Gulch at 84 Ranch 09306244 (1975-1978)	1311	8.1	109	106	184	608	554	18
Corral Gulch near Rangely 09306242 (1974-2004)	892	7.9	87	70	132	511	345	12
Yellow Creek at White River 09306255 (1965-2004)	2343	8.5	42	129	669	1433	691	109
Spring Data								
395559108260500 (Corral Gulch, 1975-1980)	1266	7.5	108	97	182	626	512	18
395325108271501 (Stake Springs 1975-1980)	1079	7.6	100	85	135	510	463	13

mg/l = milligrams per liter
TDS = total dissolved solids
From USGS NCIS website (http://co.water.usgs.gov/Website/projects/viewer.htm)
* The date range generally varies for each parameter, but the range shown is the maximum range a given location.

Water quality generally becomes poorer downstream, although water quality at all three stream gauging and two spring stations exceeds the EPA secondary drinking water standard of 500 mg/l.

Surface water quality in Yellow Creek at the White River location has the highest total dissolved solids (TDS), sodium, sulfate, and chloride concentrations.

Surface water quality near the project area is typically characterized by sodium sulfate and bicarbonate, with moderate salinity levels (TDS concentrations between 500 and 1,500 mg/l) and high to very hard hardness (i.e., hardness as calcium carbonate greater than 121).

Groundwater

Groundwater in the Yellow Creek catchment area occurs in both alluvial and bedrock systems. In the project area, alluvium consists of silty Quaternary deposits with low permeability, formed by wasting of Uinta siltstone, up to 120 feet thick in Yellow Creek. The alluvium is typically incised by recent ravines in which ephemeral or small perennial streams flow. In lower reaches of major drainages groundwater discharges to the alluvium, while in upper reaches alluvium-colluvium recharge bedrock. The principal source of recharge is spring snowmelt, with snowpack increasing toward higher elevations. Each of the three test sites are located on ridges, and not within the larger alluvial valleys in the region. Groundwater in the Piceance Creek and Yellow Creek drainages occurs in both alluvial and bedrock systems. Discharge of groundwater to streams occurs principally in the lower reaches of Piceance Creek, and to a lesser extent the lower reaches of Yellow Creek (Coffin et al. 1971). Spring discharge areas in the lower reaches of both Piceance Creek and Yellow Creek appear to be controlled by major fracture systems that allow hydraulic communication with deeper, more saline groundwater (Robson and Saulnier 1981). Groundwater discharge in the upper drainages occurs primarily from shallower bedrock (Uinta and Upper Parachute Creek).

Based upon studies completed largely in the eastern portion of the basin, bedrock water systems of the Green River and Uinta were described in terms of two hydrologic bedrock units, "Upper" and "Lower," as proposed by Coffin and others (1971), who defined the confining unit between them as the Mahogany Zone or R7. It should be noted the terms "Upper" and "Lower" aquifers come from original USGS terminology and are not currently used to describe local conditions at the three test sites, except for direct reference to historic USGS reports. The three test sites are located in the western portion of the Piceance Basin. Based upon review of potentiometric elevations at a number of well clusters recently installed by Shell in the area of the test sites, the Mahogany Zone does not serve as a confining unit. Instead, the deeper R5 interval acts as a confining unit. These well cluster locations are shown on Figure 12. The number in parentheses following the well number indicates the number of individual wells at the location. Each well is screened in a different stratigraphic interval. Figures 13 and 14 show the geologic stratigraphic naming convention for the Parachute Creek Member, and the corresponding hydrostratigraphic units. The hydrostratigraphic intervals are based on water level and water quality data from monitoring wells recently installed by Shell, as described below.

The new hydrogeologic conceptual model is based on water level measurements with clusters of individual wells screened in different hydrostratigraphic intervals (i.e., L7, L6, L5, L4, and L3, where present). Data from these wells show that in the test site areas on the western side of the basin, the water levels in the L7, L6, and L5 intervals are similar, and the water levels in the L4 and L3 intervals are similar to each other, but distinctly different than wells completed in overlying intervals. Therefore, an upper and lower "aquifer" do exist; however, the R5 unit serves as the confining unit between the two, and not the R7 or Mahogany Zone. The "upper" and “lower” zones of Robson and Saulnier (1981) follow the USGS convention, and refer to the A Groove (L7) and B Groove (L6) intervals, respectively. However, these two intervals are both contained within the Upper Parachute Creek Unit hydrostratigraphic unit shown on Figure 14. This unit is approximately 500 feet thick at Site 1, and extends from a depth of 800 to 1,300 feet below ground surface. The Lower Parachute Creek Unit on Figure 14 is separated from the Upper unit by the R5 interval. The Lower unit at Site 1 is about 600 feet thick, and is located between depths of 1,300 and 1,900 feet below ground surface. Figure 15 is a regional schematic hydrogeologic cross-section that shows the R5 interval as the dominant confining unit. The L3 and L4 intervals were not deposited at the western edge of the basin; however, nahcolite deposits occupy the majority of these intervals in the basin center, to the east.

Based on current water level data made available by Shell for review as part of this EA, the R5 hydrostratigraphic interval serves as a confining unit at all 16 well cluster locations. The difference in potentiometric elevation between wells screened in the L5 and the underlying L4 units ranged from 6 to 400 feet, across an area measuring 4 miles by 12 miles on Figure 12. The average water level difference was 137 feet. Only one of the well clusters (#8-3 on Figure 12) showed a significant difference in water levels between the A Groove and B Groove intervals (90-foot difference across the Mahogany Zone), and there was still a 60-foot water level difference across the R5 interval at this location.

A downward vertical hydraulic gradient was observed at 15 of the 16 well cluster locations. Only well cluster #4-1 (Site 1) showed an upward hydraulic gradient from the L3/L4 up to the L5. A slight but consistent downward vertical hydraulic gradient was observed within the Uinta Transition and Upper Parachute Creek Group down to the top of the R5 interval in 14 of the 16 well clusters.

Packer testing conducted by Shell at well locations at the Freeze Wall Test site and Site 1 indicate that there are also differences in hydraulic conductivity values between the different hydrostratigraphic units. Although these results are preliminary, the tentative results show that the horizontal hydraulic conductivity in feet per day is approximately 3 feet per day in the L7 unit, 1.5 feet per day in the L6 unit, 0.75 feet per day in the L5 unit, 0.08 feet per day in the L4 unit, and 37 feet per day in the basal L3 unit.

Potentiometric data for the individual lean intervals do retain the strong east-northeast gradient that is shown on the regional potentiometric surface maps for upper and lower systems developed by Robson and Saulnier (1981), which are reproduced in Figures 16 and 17, respectively. The similarities are striking for both the potentiometric surface maps and TDS concentrations shown for the upper and lower aquifers (USGS terminology corresponding to the L7 and L6 intervals of this report) in the northern Piceance Creek basin in the Groundwater Atlas of Colorado (CGS 2003). This is in agreement with the recent Shell findings, and suggests that a significant confining layer does not exist between the two “aquifers” in this area.

Discharge of groundwater is primarily in the form of springs, baseflow to streams, alluvial underflow, and evapotranspiration. There has been some groundwater pumping in the northern Piceance Basin that was conducted for nahcolite extraction activities. The lower reaches of Piceance Creek, and to a much lesser extent the lower reaches of Yellow Creek, are the major groundwater discharge areas (Weeks et al. 1974).

Discharge in the upper reaches of the Piceance Creek and Yellow Creek drainages is generally in the form of a limited number of discrete springs. Discharge from springs in the creek channels of upper tributaries is observed to re-infiltrate into the alluvium and may provide some of the recharge for other springs further downstream. A large proportion of these tributary spring flows is consumed by stream channel vegetation before reaching the lower reaches of Piceance and Yellow creeks. Groundwater has been observed to discharge from the uppermost intervals of the Parachute Creek Member of the Green River Formation in the lower-elevation drainages some distance up-drainage of the Site 1. Springs that discharge directly from the lower Parachute Creek or underlying unnamed members of the Green River Formation have not been reported or identified near Site 1 (Shell 2006a).

A review of the water well permits approved by the State Engineers Office (SEO 2006) in the area of the test sites suggests there is little local use of groundwater. There are far more "monitoring wells" registered with the SEO than any other type of well use in this area. Several water wells are permitted to the BLM and listed as "stock" wells. One shallow (26 feet deep) well near 84 Ranch on Corral Gulch is permitted to the Colorado Department of Game and Fish as a "domestic" well. American Soda, Inc. has been denied some well permits near Site 2. There are very few wells permitted within 1/2 mile of Site 3 (Permit numbers 40985 and 220068) and the water wells permitted near Site 1 are monitoring wells permitted by Shell. Several of the permitted wells are shown as "confidential." The permitted water wells and permitted gas wells, are shown on Figure 18.

Groundwater is dominantly a sodium-rich bicarbonate type where increases in TDS are the result of increases in sodium and bicarbonate. The principal variants are substitution of calcium for sodium and substitution of chloride for bicarbonate. These substitutions occur within zones and seemingly increase with increasingly deeper hydrostratigraphic zones.

In general, the regional groundwater quality of the Uinta Formation, Parachute Creek Member, and Garden Gulch Member of the Green River Formation is of moderately poor quality, using "common" water quality parameters such as TDS. The data show the presence of a number of "more common" water quality parameters in concentrations that exceed numeric criteria used to assess the appropriateness for use of the water. These parameters are boron, iron, fluoride, sodium, and sulfate. These parameters do not necessarily exceed criteria in each and every stratum. (TDS does exceed the guideline value of 500 mg/l for domestic water supplies in every case.) At Site 2, salinity is so elevated in the area around this planned facility, that Shell will mine the salt nahcolite prior to production. Concentrations of some water quality parameters are shown in the following table.

Concentrations of Some Water Quality Parameters at Nearby USGS Well Locations

Well ID	Latitude	Longitude	Sample Date	Sodium filtered, mg/l	Sulfate filtered, mg/l	Fluoride filtered, mg/l	Boron filtered, µg/l	Iron filtered, µg/l
395451108301501	39°54'51"	108°30'15"	10/25/1984	600	580	0.5	190	170
			5/13/1985	630	540	0.4	140	50
			9/4/1985	220	990	0.3	150	50
			5/30/1986	300	1,100	0.5	150	40
			8/14/1986	180	1,200	2.2	600	8,200
			9/12/1989	180	1,100	3.3	930	60
		Average		352	918	1	360	1428

Concentrations of Some Water Quality Parameters at Nearby USGS Well Locations

Well ID	Latitude	Longitude	Sample Date	Sodium filtered, mg/l	Sulfate filtered, mg/l	Fluoride filtered, mg/l	Boron filtered, µg/l	Iron filtered, µg/l
		Maximum		630	1,200	3	930	8,200
		Minimum		180	540	0	140	40
395452108301502	39°54'52"	108°30'15"	9/13/1989	150	690	0.7	290	700
395452108301501	39°54'52"	108°30'15"	7/19/1978	180	230	1.6	160	320
395452108301401	39°54'52"	108°30'14"	9/13/1989	130	570	0.5	140	820
395451108301504	39°54'51"	108°30'15"	10/25/1984	620	3,200	3	2,300	90
			5/13/1985	640	2,700	2.8	2,200	60
			9/4/1985	250	1,400	2.3	810	50
			5/30/1986	220	1,500	3.2	1,200	40
			8/14/1986	160	860	4.4	780	19
			9/12/1989	180	980	4	1100	70
		Average		345	1773	3	1398	55
		Maximum		640	3200	4	2300	90
		Minimum		160	860	2	780	19
395451108301502	39°54'51"	108°30'15"	10/25/1984	760	3500	2.1	2100	70
			5/13/1985	650	3100	1.8	1800	40
			9/4/1985	230	1300	3.8	960	80
			5/30/1986	230	1600	2.8	1200	50
			8/14/1986	180	830	2.6	640	32
			9/12/1989	200	1100	3.3	1100	30
		Average		375	1905	3	1300	50
		Maximum		760	3500	4	2100	80
		Minimum		180	830	2	640	30
395450108301502	39°54'50"	108°30'15"	9/12/1989	200	1200	0.9	220	5500
395451108301503	39°54'51",	108°30'15"	10/25/1984	690	3500	1.8	2000	70
			5/13/1985	600	3200	2	2100	60
			9/4/1985	230	1400	2.5	830	50
			5/30/1986	220	1500	2.1	1000	< 3
			8/14/1986	160	910	3.6	680	16
			9/12/1989	180	1100	3.3	1100	40
		Average		347	1935	3	1285	47
		Maximum		690	3500	4	2100	70
		Minimum		160	910	2	680	16
395425108300001	39°54'25"	108°30'00"	4/10/1975	260	230	11	560	
395712108243403	39°57'12"	108°24'34"	8/22/1975	250	140	12	180	20
			8/26/1975	260	8.8	19	410	60
		Average		255	74	16	295	40

Concentrations of Some Water Quality Parameters at Nearby USGS Well Locations

Well ID	Latitude	Longitude	Sample Date	Sodium filtered, mg/l	Sulfate filtered, mg/l	Fluoride filtered, mg/l	Boron filtered, µg/l	Iron filtered, µg/l
		Maximum		260	140	19	410	60
		Minimum		250	9	12	180	20
395712108243402	39°57'12"	108°24'34"	7/23/1975	250	120	13	150	20
395439108223302	39°54'39"	108°22'33"	7/1/1975	320	130	14	330	180
			7/12/1975	550	6.5	18	500	20
			8/27/1979	410	5.4	9.1	810	11000
			8/30/1983	380	13	21	660	10
		Average		415	39	16	575	2803
		Maximum		550	130	21	810	11000
		Minimum		320	5	9	330	10
395439108223301	39°54'39"	108°22'33"	8/23/1979	260	190	6.6	180	60
			8/26/1983	270	180	5.6	180	70
		Average		265	185	6	180	65
		Maximum		270	190	7	180	70
		Minimum		260	180	6	180	60

From USGS NCIS Website.

Seasonal variations were not expected and were not found in these confined water-bearing units. The variability of the groundwater quality is high. In other words, concentrations vary widely from location to location, both horizontally (within a permeable stratum) and vertically (from one more permeable stratum to another). Examination of the data suggest no discernable horizontal trends; rather a high degree of variation due to the heterogeneous mineral composition of the Uinta, Parachute Creek, and Garden Gulch members of the Green River Formation. The water quality assessment to date does confirm a vertical variation that is quasi-predictable; that of increasing TDS with depth of the permeable strata.

At Site 2 the variability of the groundwater quality is high. The preliminary data supplied by Shell show that water entering the various more permeable strata in areas of recharge appears to gain a “signature” chemical pattern that remains with that water as it flows from “west to east” along an individual horizon, unless the water encounters a variation in the mineralogy of the particular horizon. Certain other parameters mimic this increase (e.g., fluoride and boron), while a few change with depth, but decrease in concentration.

The high degree of variability in concentration with no horizontal trend allows combination of data from various longitude-latitude locations by individual, more permeable stratum. This heterogeneity facilitates grouping groundwater quality parameters by zone, which also corresponds to the zonation based upon the distribution of hydraulic head elevations in well clusters. Then, the distinct changes in water quality with depth as function of the hydrostratigraphy allow additional grouping of strata into four water-quality-distinct groups: (1) UT (Uinta Transition), (2) L7-L5 (Upper Parachute Creek Unit), (3) L5-L2 (Lower Parachute Creek Unit), and (4) L1 (Garden Gulch Unit). Although no specific data from the recently installed Shell monitoring well clusters were available for inclusion in this EA, the TDS values at

Site 2 for the Upper Parachute Creek Group are in the range of 1,600 mg/l, and are higher (near 4,000 mg/l) for the Lower Parachute Creek Group.

Shell is testing multiple zone completions for some wells interior to the freeze wall containment at the Freeze Wall Test site (not part of this Proposed Action). Multiple completion wells are equipped with isolation packers to prevent cross-flow between zones. Sample ports in the tubing string will allow for collection of pressure data and water samples. Should the information gained from the multiple zone completion wells demonstrate this type of completion is appropriate for groundwater quality monitoring, then multiple zone completions could be proposed for groundwater monitoring at a later date, subject to BLM approval.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Surface Water

Surface water quality could be impacted as a result of discharges of process or other waters with high salinity or other contaminants resulting from leaks, spills, or storm events. Storm events could also increase sediment loads to nearby drainages. The magnitude and duration of associated runoff events could also be impacted due to runoff from paved surfaces.

Leakage from the process water pond used to store, contain, or treat liquids could potentially impact the groundwater near the pond, as well as surface water situated down gradient of the pond vicinity. Overflowing of ponds due to operator errors or storm events could result in discharges to nearby surface water features. This is especially relevant for the high salinity waters resulting from nahcolite solution mining.

Groundwater

Dewatering operations conducted within the heated zone prior to heating would likely alter the naturally occurring hydraulic pressure gradients within the production zones. This could cause movement and mixing of groundwater between hydrostratigraphic zones, and potentially between the Upper and Lower Parachute Creek units, across the R5 confining unit. Potential consequences of this mixing could be an increase in TDS concentrations within the upper water-bearing unit, and subsequent degradation of water quality in this unit in the area immediately downgradient of the production zone. Existing water quality within the overlying Uinta Unit and underlying Garden Gulch Unit should not be impacted because dewatering activities would not occur in these water-bearing units that are located above or below the production zone at each of the three test sites.

During dewatering operations, water from the dewatered zone would be reinjected into the same zone or potentially a different zone at another location on the property (Figure 19). If there is mixing of water from the lower zone (poorer water quality) into the upper zone, and the upper zone is dewatered, there would be a potential for groundwater from a zone of poorer water quality to be extracted and then reinjected into a zone of better water quality. This would negatively impact water quality in the upper zone.

Groundwater extraction from outside the heated zone and subsequent reinjection during reclamation at each test site has the potential to lower the groundwater table within water-bearing units that discharge or supply water to surrounding surface water bodies (i.e., Yellow and/or

Piceance creeks). Shell has completed a preliminary regional groundwater flow model for Site 1 to evaluate the potential drawdown in the Upper Parachute Creek and Uinta Units from dewatering during reclamation and estimate any potential stream depletions. The preliminary model results indicate that 1 foot of drawdown could extend up to 2 miles from the dewatering well location, and that discharge to Yellow Creek could decrease a maximum of 0.026 cfs as a result of groundwater extraction. The depletion would be partially offset over the life of the project by augmentation during initial dewatering of the heated zone and treatment and reinjection of this groundwater outside the production area.

Removal of lighter oils from the kerogen-rich stratigraphic intervals during the heating or pyrolysis phase of the project could alter the natural permeability or hydraulic conductivity of the confining units. If sufficient head difference exists between the more permeable units located above and below the confining unit, a larger volume of groundwater could flow between the permeable intervals. In areas where there is a vertical upward gradient, deeper, poorer quality groundwater could potentially mix with shallower and fresher groundwater, deteriorating water quality in this unit. At the majority of the monitoring well clusters drilled to date by Shell, a downward hydraulic gradient has been observed, suggesting that groundwater in the deeper unit would become less saline if this mixing were to occur.

The pyrolysis process occurring within the approximately 130-foot by 100-foot test area would likely increase the porosity of the oil shale intervals due to removal of kerogen, resulting in an increase in horizontal hydraulic conductivity. Shell's testing to date, using their heating process on oil shale materials, suggest that the porosity of the rock will increase about 30 percent as a result of pyrolysis of kerogen and removal of oil. There will likely be a minimal increase in the vertical hydraulic conductivity associated with the heating effect on the rock mass. The removal of kerogen is not anticipated to affect the aperture widths of pre-existing joints or fractures.

Heating of the oil shale during the pyrolysis phase could increase the vertical permeability of the confining units (R5 at the three test sites), by enlarging pre-existing joints or fractures. The potential consequence of the increased fracture apertures is that groundwater could flow more easily between the Upper and Lower Parachute Creek units. In areas with vertical upward hydraulic gradients (well cluster #4-1 at Site 1), poorer quality groundwater present in the lower unit could flow upward into the upper unit and degrade water quality in the upper unit downgradient of the test site. During the reclamation and post-reclamation phases, the rate at which groundwater in the upper and lower saturated zones can potentially mix as a result of the heating process is dependent on the hydraulic conductivities and hydraulic gradients in the L4, R5, and L5 units. The two primary constraints on groundwater flow between these units are the low permeabilities of the native L4 and R5 units. Given the downward vertical hydraulic gradient existing at the majority of well clusters at this time (except at well cluster #4-1 at Site 1), the flow of water would be downward from the low TDS upper unit into the higher TDS (i.e., poorer water quality) lower unit.

Following reclamation and thawing of the freeze wall, there would be a large number of wells located in the reclamation area. The wellbores could serve as vertical conduits for water movement between saturated units if not properly plugged and abandoned.

Based on the current hydrogeologic model, and the small scale of the test sites, there appears to be low likelihood of significant long-term impacts to surface water or groundwater at any of the test sites. However, additional newly collected information regarding hydrogeologic conditions must be reviewed to verify the hydrogeologic model and proposed mitigation measures.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

The Proposed Action identifies potential impacts to surface and groundwater resources. In order to mitigate potential impacts, BLM would require alternative mitigation measures. Mitigation measures may be modified as additional geologic, hydrologic, and geochemical data obtained by the operator from on-going studies are analyzed. Additional geologic, hydrologic, and geochemical data obtained by Shell would be submitted to the BLM for analysis. All three companies with RD&D leases would work together and with the BLM in development of surface water and groundwater monitoring plans. Development of these monitoring plans could also be coordinated with and receive input from personnel at the Colorado Division of Mines and Geology and the USGS. The water quality parameters and analytes to be monitored and the frequency and locations of monitoring would be developed within this group. Additional mitigation includes:

Dewatering of the freeze wall interior area prior to heating would occur in both the Upper and Lower Parachute Creek units, which would minimize the hydraulic gradient between the two units during the dewatering phase. The recovered groundwater would be a mixture of water quality for the Upper and Lower Parachute Creek units, and would be reinjected downgradient of the freeze wall using wells completed in the deeper L3 interval (Lower Parachute Creek) that has a high transmissivity. The injection wells would be permitted with the EPA UIC program for Class V injection wells authorized by rule. Water of appropriate quality would be injected into appropriate zones so that beneficial use classifications are maintained. The water quality of the injected water would be of better quality than the native water in the injection zone (L3).

Any groundwater that enters the production zone during the heating and kerogen recovery phase would be recovered with the hydrocarbons, pumped to the surface, and separated in the process area. During production, recovered groundwater would be treated prior to reinjection.

The installation of extraction wells completed in the L4 interval at locations upgradient of the heated area may be required following the recovery of kerogen to control the vertical hydraulic gradient in this area. The extracted water would likely be reinjected in wells located downgradient or cross-gradient locations. Shell may choose to alter their resource recovery interval at Site 1 if additional hydrologic work at this site indicate that the upward gradient from the Lower Parachute Creek Unit will be a long term issue. Given the finite lateral size of the heated zone, it may be possible to inject a low permeability material above the R5 interval during plugging and abandonment of wells in the heated zone.

Once the flushing is completed and the freeze wall is allowed to thaw, drill holes associated with each test site would be plugged and abandoned. Plugging and abandonment would occur over a period of time, as certain holes would continue to be used for monitoring of the freeze hole thawing and related water quality monitoring internal to the freeze wall containment area.

All borings would be plugged and abandoned consistent with applicable state rules and regulations. A Plugging and Abandonment Plan would be developed with BLM, the three RD&D lease companies, and the Colorado Division of Mines and Geology. Most of the holes would have surface casing cemented through the alluvial zone. This casing would be left in place, but would be cut off 5 feet below final grade. The uppermost 5 feet of the hole would be filled with a material less permeable than the surrounding soils and would be adequately compacted to prevent settling and a cap would be welded at the top of the hole with proper identification information. Cement plugs would also be placed where the surface casing is cut off, 5 feet below the surface and where required to isolate individual water-bearing zones. Coated bentonite pellets, cement grout, abandonment fluid, or comparable alternative will be used as fill between required cement plugs.

Waters discharged into surface waters would be treated to meet specifications of permits. Shell is responsible for complying with all local, state, and federal water quality regulations (e.g., Storm Water Permits, Industrial Wastewater/Produced Water Permits, and Section 404 permits). Shell would also be required to provide the BLM with documentation that all required permits were obtained. Additionally, a Stormwater Management Plan (SWMP) would be developed showing how BMPs are to be used to control runoff and sediment transport. The applicant is required to have a copy of the SWMP on file with the Meeker Field Office and to implement the BMPs in that plan as on-site conditions warrant.

A BLM approved surface water monitoring plan would be implemented to verify environmental protection measures are being met.

A surface water drainage collection and conveyance system would be established to manage drainage throughout each test site. The surface drainage control system along with the site grading would route storm water flows from the disturbed areas into a storm water pond prior to discharge to the existing surface drainage system. The surface drainage system would consist of ditches, storm sewers, culverts, curbs, and paving. Ditches would be lined with riprap or other material where necessary to assure stability. A storm water pond would be designed to retain the runoff and sediment from a 50-year, 24-hour storm event (2.5 inches

Construction storm water drainage would be managed through a construction SWMP and the use of accepted BMPs, in accordance with a construction storm water permit. During construction and operations, areas of light disturbance that do not drain to the storm water pond would be managed using BMPs. Erosion control measures would include stabilization of exposed soils and protection of steep slopes. Exposed soils would be stabilized by a combination of mulching, seeding, soil roughening, or chemical stabilization. Steep slopes would be protected by use of geotextiles, temporary slope drains, mulch, or seeding. Selection of appropriate geotextiles would also consider potential small animal and wildlife issues. Sediment controls may include sediment basins, rock dams, sediment filters such as filter cloth, hay bales, erosion blankets, and/or temporary seeding.

The process water pond would be used to increase storage capacity for stripped sour water from the sour water stripper. This pond would be used to provide extra storage at each test site and in the event that the dissolved air floatation, membrane bio-reactor, or the reverse osmosis units are off-line for maintenance or repair or during periods when additional storage is needed. The stripped sour water could be diverted and stored in the process water pond until the water treatment units are functional again. Pond sizing and design for each test site would be defined by further engineering studies and must be approved by the AO.

Shell would develop a spill containment plan for each pond at each test site. To verify the proposed ponds (process and evaporation) have no negative effects on groundwater, a surface water leak detection system, and a pond monitoring and response plan should be submitted and approved by the AO prior to implementation of pond use.

Any water not needed for the project would be discharged to the Yellow Creek drainage following treatment to the applicable standards. A common surface/groundwater monitoring plan for all companies would be developed in conjunction with BLM, Colorado Division of Mines and Geology, EPA, and USGS. Monitoring parameters, locations, and frequencies would be addressed in that plan.

Groundwater monitoring would verify environmental protection measures are effective. Groundwater monitoring would be conducted immediately outside of the freeze wall barrier to monitor groundwater quality before and during operation as well as after reclamation. Groundwater monitoring would consist of monitoring of the water bearing units including the Uinta Unit, A and B Groove (L7 and L6 intervals), L5, L4, and L3. Depending upon local hydrologic and geochemical conditions, some of these intervals may be combined for monitoring purposes. Compliance monitoring of these zones would occur using dedicated single completions in each significant zone.

During dewatering, the water being re-injected would be monitored periodically (i.e., monthly) for relevant water quality parameters and constituents (as agreed upon between Shell and BLM) prior to re-injection to ensure that the water is being re-injected into the appropriate strata and that existing classified beneficial uses are not diminished. Dewatering and re-injection flow rates would also be monitored to allow calculation of the amount of water taken from the containment zone and associated rate of re-injection.

The freeze wall containment area would be maintained until it can be demonstrated that the containment system is sufficiently rinsed and collected rinse water meets appropriate water quality criteria so that the water quality of the re-injected water would meet or exceed water quality in the target formation outside the freeze wall.

There would be downgradient early warning well(s) and at least one compliance well downgradient. These would be operated following post-pyrolysis and post-thawing for as long as necessary to be able to assure compliance with established groundwater numeric protection levels. All the early-warning and compliance wells must be located inside the property boundary, downgradient from the potential contaminant source (i.e., inside the 160-acre test site

The number of years that the early warning and compliance wells would be open will depend on the travel time from source to wells. The Colorado State Division of Mining and Geology permit could not be closed out until compliance with groundwater protection levels is assured. Shell would install compliance wells sufficiently close to the source to assure that a plume would reach those wells in a reasonable amount of time. Shell would also install early warning wells sufficiently upgradient of the compliance wells and sufficiently near the source in order to respond to any potential release from the source in a reasonable amount of time. Travel times of months to a year are typical for early warning wells, and travel times of 1 to 2 years are typical for compliance wells.

To verify the effects of the Proposed Action on groundwater and surface water, a water monitoring and response plan would be submitted and approved by the AO prior to implementation of the project. Locations of proposed groundwater monitoring wells would be shown in the plan.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Potential impacts to surface and groundwater quality in the project area could result from surface disturbance on the Shell test sites, from spills onto the surface of the tract, and from changes to the flow regime and water quality in the upper aquifer. A variety of measures proposed in the subalternative would reduce or minimize these impacts to surface and groundwater resources resulting from the Proposed Action. All the mitigative actions are taken to preserve the existing water quality (both surface and ground) and minimize further deterioration.

Potential impact to water quality in the Uinta Unit would be minimized as the freeze wall would extend down from the water table in the Uinta Unit, and the Uinta Unit will not be dewatered at any of the three test sites. The overlying seal above the heated zone is the R8 interval, which underlies the Uinta Unit. This interval would not be heated and will have a pressure head exerted on it from the overlying Uinta Formation and Uinta Unit.

Groundwater quality could be impacted but would be monitored during all phases of the operation to ensure that existing classified beneficial uses are not diminished. Compliance monitoring wells would be established to ensure that the quality of the groundwater outside the test units remained the same after the freeze walls are thawed. These wells would be placed close enough to the test unit to assure that a plume would reach those wells in a reasonable amount of time.

The surface water could be impacted due runoff and leaks from detention ponds. These impacts will be minimized with the implementation of the SWMP and the BMPs, use of leak detection systems, compliance with the terms of the Colorado Discharge Permit System, and construction of a surface water drainage collection and conveyance system.

To verify the effects of the Proposed Action on groundwater and surface water, Shell will comply with an approved water monitoring and response plan.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Finding on the Public Land Health Standard for Water Quality

The Public Land Health Standard for Water Quality standard (Standard 5) is currently being met at the three test sites. However, many of the upper tributaries, which are ephemeral in nature, are not meeting standards during periods of peak flows. Given the small footprint of the area at each site affected by the Proposed Action, combined with successful implementation of all suggested mitigation measures, Colorado State Water Quality standards should continue to be met. Advanced understanding of localized surface/groundwater characteristics and interaction will be essential to ensure additional mitigation measures are developed during the life of the project to protect water quality. The surface water and groundwater monitoring plans will be utilized to show compliance with these water quality standards.

Implementation of the Proposed Action with mitigation measures and monitoring would lessen the potential for impacts to the public land health standard for water quality for groundwater.

Implementing the Proposed Action with mitigation and achieving successful reclamation would also prevent exceeding the public land health standard for riparian systems.

WETLANDS AND RIPARIAN ZONES

Affected Environment

Wetlands are important biological resources that perform many functions, including groundwater recharge, flood flow attenuation, erosion control, and water quality improvement. They also provide habitat for many plants and animals, including threatened and endangered species.

Riparian vegetation in the area is associated with small, perennial streams, reservoirs, and stock ponds with year-round water, and springs. Riparian plant communities are typically narrow bands along stream channels. Riparian communities generally support a greater diversity and abundance of plants and animals than other rangeland vegetation types.

Stake Springs Draw is an intermittent stream with very low flows and a 30 square mile watershed. Flows immediately upstream of the confluence of the unnamed tributary of Stake Springs Draw and Stake Springs Gulch had no flow during site visits conducted in 2001 and 2002 (Chadwick 2002). Stake Springs Draw has sections supporting primarily herbaceous riparian vegetation including several species of sedges and rushes. Corral Gulch and Stake Springs Draw watersheds are moderately-sized and generate little runoff due to the arid climate of the region and well-drained soils. No crop irrigation occurs in the project area.

Site 1 – Oil Shale Test Site

No wetlands or riparian zones are present in Site 1 or along the majority of the proposed access route into the site (Wright Water Engineers 2005). The proposed access road would intersect CR 91 at the confluence of Stake Springs Draw and an unnamed ditch in the vicinity of Corral Gulch. The bottom of the valley contains an upland vegetated swale dominated by big sagebrush and upland grasses. No ordinary high water mark or evidence of recent flow exists in this swale. No culvert exists where Stake Springs crosses CR 91.

Site 1 is located in the Corral Gulch watershed in the headwaters of the White River Watershed, a tributary of the lower Colorado River. Stake Springs Draw is southeast of Site 1 and Corral Gulch is to the north. Both are predominately intermittent tributaries of Yellow Creek, a perennial stream with areas of interrupted flow that flows north into the White River. Stake Springs Draw and Corral Gulch have short reaches of perennial flow in association with springs and seeps (Shell 2006a). There is also an intermittent tributary of Corral Gulch located in the northwest corner of this site.

Site 2 – Nahcolite Test Site

No wetlands or riparian zones are present in Site 2 or along the access roads, but intermittent stream channels protected as “waters of the U.S.” under the Clean Water Act are located on the site (Wright Water Engineers 2006). About 2,000 feet of intermittent stream channel that have a defined bed and bank are located in the extreme northwestern and part of the southwestern portions of the site. These are tributaries of Stake Springs Draw. The proposed access road extending from CR 24 does not cross any drainages.

Site 3 – Advanced Heater Test Site

No wetlands or riparian zones are present in Site 3 or along the access roads, but one intermittent stream channel that is protected under the Clean Water Act is present on-site. This drainage, a tributary of Big Duck Creek, crosses the northwestern corner of the site for about 2,100 feet. The proposed access roads do not cross drainages; however, the two proposed roads approaching the site from the east parallel intermittent drainages. Permanent stream flow and valley bottom geomorphology and soils needed to provide moisture retention and supply to support distinct riparian vegetation is mostly absent in these drainages.

Environmental Consequences of the Proposed Action

Impacts to wetlands and riparian habitats from the Proposed Action are described by site below.

Site 1 – Oil Shale Test Site

Construction and operation at Site 1 and associated access road would not disturb any wetland or riparian vegetation or other waters of the U.S. No impacts are expected on Site 1.

Site 2 – Nahcolite Test Site

Construction and operation activities at Site 2 would not affect any wetlands or riparian vegetation. However, about 2,000 feet of intermittent stream channel located on the northern boundary of Site 2 could be affected. This channel is protected as a Water of the U.S. under the Clean Water Act; removal, relocation, or modification of this drainage would require a nationwide or individual Section 404 permit from the U.S. Army Corps of Engineers (COE). Nationwide Permit No. 39 allows for loss of up to 300 linear feet of stream bed, but also specifies that greater losses may be allowed for intermittent stream beds when the project otherwise complies with the terms and conditions of the nationwide permit and impacts to the aquatic environment are minor. Impacts to waters of the U.S. could be reduced during project permitting and final design.

Site 3 – Advanced Heater Test Site

Construction and operation activities at Site 3 would not affect any wetlands or riparian vegetation. However, about 2,100 feet of intermittent stream channel that is protected as waters of the U.S. under the Clean Water Act could be affected. Based on the preliminary plot plan, about 1,200 feet of channel would be located in an area that would be occupied by major facilities in the northern portion of the site, and, therefore, may be removed, relocated, or modified in other ways, and the other 900 feet would be outside of the facility area and may be less affected by construction. As with Site 2, removal, relocation, or modification of the intermittent drainage would require a nationwide or individual Section 404 permit from the COE. Impacts to Waters of the U.S. could be reduced during project permitting and final design.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

The Proposed Action identifies potential impacts to wetlands and riparian areas. In order to mitigate potential impacts, BLM would require alternative mitigation measures. Downstream wetland areas may be impacted because of sedimentation. Nearby wetlands may be affected through dewatering. Impacts to wetlands and riparian areas will be minimized by the following mitigations:

- To minimize potential impacts from the Proposed Action, BLM would require Shell to install monitoring wells on the tracts and collect surface water data from Corral Gulch and Stake Springs Draw to determine if there would be any hydrologic interactions between groundwater withdrawn and reinjected on the Shell test sites and any wetlands or riparian areas associated with those creeks (see Water Quality, Surface and Ground).
- Obtain a Section 404 permit from the COE for impacts to waters of the U.S. from removal or modification of intermittent stream channels. For approval of the project, the project will need to avoid and minimize impacts to waters of the U.S. to the extent practicable, and compensatory mitigation may be required for unavoidable impacts.
- Install and maintain erosion control structures to minimize potential for sediment runoff into surface waters or drainages.
- Prohibit storage of hazardous materials, chemicals, fuels, lubricating oils, concrete coating, and refueling activities within 200 feet of wetland or riparian areas.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

No wetlands would be permanently filled or drained as a result of the Proposed Action. Riparian areas and wetlands could be indirectly impacted if groundwater fluctuations or surface water recharge were affected. The alternative mitigation, if implemented, would reduce or minimize impacts resulting from hydrologic interactions between groundwater and any wetland or riparian areas. Monitoring data will help Shell determine if there would be any hydrologic interactions.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Finding on the Public Land Health Standard for Riparian Systems

The Proposed Action may adversely impact the public land health standard to protect riparian areas and wetlands in the proposed Shell test sites, but area-wide would not have a large effect. Implementing the alternative mitigation and achieving successful reclamation would not affect the public land health standard for riparian systems.

CRITICAL ELEMENTS NOT PRESENT OR NOT AFFECTED

No floodplains, prime and unique farmlands, or wild and scenic rivers exist within the area affected by the Proposed Action.

NON-CRITICAL ELEMENTS

The following elements are addressed due to the Involvement of Standards for Public Land Health: Soils, Vegetation, Aquatic Wildlife, and Terrestrial Wildlife. Additional Non-Critical elements addressed in this EA include: Access and Transportation, Fire Management, Forest Management, Geology and Minerals, Hydrology and Water Rights, Paleontology, Rangeland Management, Realty Authorizations, Recreation, Visual Resources, and Wild Horses.

SOILS

Affected Environment – Sites 1, 2, and 3

The predominant soils in the project area are the Redcreek-Rentsac complex, the Rentsac channery loam, and the Rentsac-Piceance complex. These soil types support livestock grazing, wildlife habitat, and woodlands. These soils are primarily well drained with moderately rapid permeability with a very low available water capacity. Soils in the project area are derived primarily from the Uinta Formation, with exposures of the Green River Formation along valley slopes.

The elevation range of Sites 1, 2, and 3 is between 6,460 to 7,100 feet. The test sites are dominated by pinyon-juniper woodlands along the ridge tops with a few intermingled Wyoming sagebrush/grass parks. The bottoms of larger upland drainages generally have shallower soils supporting pinyon and juniper. Lower slopes of these upland drainages usually have deeper soils that generally support Wyoming sagebrush/grass plant communities.

The test sites affect seven soil map units, which are described below:

- **Forelle loam, 3-8 percent slopes, rolling loam (33):** deep, well-drained soil on terraces and uplands; formed in eolian and alluvial material derived predominantly from sedimentary rock; surface texture is loam and subsurface textures are clay loam and loam.
- **Piceance Fine Sandy Loam, 5 to 15 percent slopes (64):** moderately deep, well drained soil on uplands and broad ridgetops; formed in eolian and colluvial material derived dominantly from sandstone; surface texture is fine sandy loam and subsurface textures are channery loam; depth to hard sandstone ranges from 20 to 40 inches.
- **Redcreek-Rentsac complex, 5 to 15 percent slopes (70):** shallow, well-drained soils on mountainsides and ridges. Redcreek soils are formed in residual and eolian material derived dominantly from sandstone; surface texture is sandy loam and subsurface textures are calcareous sandy loam and calcareous loam; depth to hard sandstone or hard shale ranges from 10 to 20 inches. Rentsac soils are formed in residuum derived dominantly from sandstone; surface texture is channery loam and subsurface textures are very channery loam and extremely flaggy loam; depth to hard sandstone or hard shale ranges from 10 to 20 inches.
- **Rentsac channery loam, 5 to 50 percent slopes (73):** shallow, well-drained soils on ridges, foothills, and side slopes; formed in residuum derived dominantly from calcareous sandstone; surface texture is channery loam and subsurface textures are channery loam and extremely flaggy light loam; depth to sandstone ranges from 10 to 20 inches.

- **Rentsac-Piceance complex, 2 to 30 percent slopes (75)**: shallow and moderately deep, well-drained soils on uplands, broad ridges, and foothills. Rentsac soils are formed in residuum derived dominantly from calcareous sandstone; surface texture is channery loam and subsurface textures are strongly calcareous very channery loam and extremely flaggy light loam; depth to sandstone ranges from 10 to 20 inches. Piceance soils are formed in eolian material and colluvium derived dominantly from sandstone; surface texture is fine sandy loam and subsurface textures are loam and channery loam; depth to sandstone or hard shale ranges from 20 to 40 inches.
- **Torriorthents-Rock outcrop complex, 15 to 90 percent slopes (91):** very shallow to moderately deep, well-drained to excessively drained soil on extremely rough and eroded areas on mountains, hills, ridges, and canyon sides; formed in residuum and colluvium derived dominantly from sandstone, shale, limestone, and siltstone; surface texture is loam, and subsurface textures vary from channery loam, very channery loam, and fine sandy loam; depth to shale or sandstone is 16 inches. Rock outcrops consist of barren escarpments, ridge caps, and points of sandstone, shale, limestone, or siltstone.
- **Yamac loam, 2 to 15 percent slopes (104):** deep, well-drained soils on rolling uplands, terraces and fans; formed in eolian and alluvial material; surface and subsurface textures are loam.

For each soil map unit, permeability, available water capacity, surface runoff potential, erosion hazard, and ecological site type are provided in the following table. Piceance Fine Sandy Loam (64) and Rentsac channery loam (73) are classified by the Natural Resources Conservation Service (NRCS) as meeting the Highly Erodible Land (HEL) criteria for severe wind and water erosion.

Soil Map Unit Characteristics in the Project Area

Soil Map Unit	Slope (percent)	Permeabilit y	Available Water Capacity	Surface Runoff	Erosion Hazard	Range/ Woodlan d Site	Applicabl e Site
Forelle loam (33)	3 to 8	Moderate	High	Medium	Moderate to high	Rolling loam	2
Piceance Fine Sandy Loam (64)	5 to 15	Moderate	Moderatel y Low	Slow to medium	Moderate to high (HEL)*	Rolling Loam	2
Redcreek-Rentsac complex (70)	5 to 30	Moderately rapid	Very low	Medium	Moderate to high	Pinyon-juniper	1
Rentsac channery loam (73)	5 to 50	Moderately rapid	Very low	Rapid	Moderate to very high (HEL)*	Pinyon-juniper	1, 2, 3

Soil Map Unit Characteristics in the Project Area

Soil Map Unit	Slope (percent)	Permeability	Available Water Capacity	Surface Runoff	Erosion Hazard	Range/ Woodland Site	Applicable Site
Rentsac-Piceance complex (75)	2 to 30	*Rentsac*: moderately rapid *Piceance:* moderate	*Rentsac*: very low *Piceance:* low	*Rentsac*: medium *Piceance:* slow to medium	*Rentsac*: moderate to high *Piceance:* slight to moderate	*Rentsac*: pinyon-juniper *Piceance:* rolling loam	1,3
Torriorthents-Rock outcrop complex (91)	15 to 90	Moderate	Very low	Very rapid	Very high	Stony foothills	3
Yamac loam (104)	2 to 15	Moderate	Moderate	Medium	Slight	Rolling loam	2

* Classified as Highly Erodible Land (HEL) by the Natural Resources Conservation Service.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Construction activities could affect soils in several ways including increased erosion, compaction, reduced fertility, and poor vegetation reestablishment. Clearing, grading, and movement of construction equipment and vehicles would remove vegetative cover and expose soils to the effects of wind, rain, and runoff. The effects could accelerate the erosion process and result in discharges of sediment to waterbodies and wetlands that could subsequently adversely affect water quality. Additionally, clearing of existing vegetation could provide an opportunity for noxious weeds to invade the construction areas and road ROWs.

Spills of petroleum products, fuels, lubricants, and other chemicals used in facility construction, operation, and maintenance could reduce the productivity of soils and inhibit the germination and growth of plants.

Grading and backfilling could result in mixing of soil horizons, which may reduce soil fertility and revegetation potential. Movement and operation of construction equipment may compact soil and result in increased erosion hazards and reduced revegetation potential. Construction equipment could leak or spill petroleum products or coolants into soil, causing contamination. Impacts to soil would be short- to long-term; impacts are dependent on site stabilization and success of reclamation.

The following table presents the total acres of impact to each soil type by construction, operation, and reclamation at each test site.

Acres of Impacts to Soil at Test Sites

Soil Map Unit	Range/Woodland Site	Site 1		Site 2		Site 3		Total (acres)
		Acres of Impact	Percent of Site	Acres of Impact	Percent of Site	Acres of Impact	Percent of Site	
Forelle loam (33)	Rolling loam	--	--	9.85	8.9	--	--	**9.85**
Piceance Fine Sandy Loam (64)	Rolling Loam	--	--	40.05	36.4	--	--	**40.05**
Redcreek-Rentsac complex (70)	Pinyon-juniper	43.71	27.32	--	--	1.59	1	**45.30**
Rentsac channery loam (73)	Pinyon-juniper	48.07	30.04	31.43	28.57	37.78	23.62	**117.28**
Rentsac-Piceance complex (75)	*Rentsac*: pinyon-juniper *Piceance:* rolling loam	68.22	42.64	--	--	120.60	75.38	**188.82**
Torriorthents-Rock outcrop complex (91)	Stony foothills	--	--	--	--	0.02	0.01	**.02**
104 Yamac loam	Rolling loam	--	--	13.84	12.58	--	--	**13.84**
Disturbed Land	--	--	--	14.83	13.48	--	--	**14.83**
Total		**160.00**	**100**	**110.00**	**100**	**160.00**	**100**	**429.99**

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Construction impacts to soil resources will be minimized by implementing measures for handling topsoil and subsoil, erosion control, compaction, and reclamation. These measures include:

- Topsoil will be stripped to a depth of 6 to 12 inches, depending on its depth. Any subsoil stripped during grading will be stored separately from topsoil to prevent mixing. Soil stockpiles will be seeded and covered with geotextile fabrics. During reclamation, soils will be returned to their pre-construction locations.
- Temporary erosion and sediment controls, including silt fences, straw bales, geotextile fabrics, and sedimentation basins (if needed), will be installed immediately following clearing and grading of the site to control erosion. These structures will be maintained and will be removed during reclamation, as appropriate.
- During site reclamation, compacted soils will be loosened using a tractor-pulled ripper or similar device. The site will be returned to its pre-construction contours. All disturbed areas will be seeded with BLM-recommended seed mixes. Permanent erosion control measures, such as mulch and geotextile fabrics will be installed where needed.
- Shell will also prepare and implement an SPCC plan for BLM approval aimed at reducing the potential for adverse impacts associated with spills and leaks.

Environmental Consequences of the Subalternative Mitigation – Sites 1, 2, and 3

Implementing the Proposed Action with additional mitigation would increase the potential for successful reclamation and decrease adverse, long-term impacts to soils at the project by ensuring that soils do not erode and do become contaminated.

Erosion control measures implemented until reclamation is initiated would minimize the amount of soils migrating off-site and potentially becoming sediment in surface water streams. Proper handling and storage of topsoil would increase the success of reclamation and seeding. All surface-disturbing activities would strictly adhere to BLM Gold Book (BLM and USFS 2006) surface operating standards for oil and gas exploration and development ensuring proper road design to minimize soil erosion. A BLM-approved SPCC plan would reduce impacts to soils from accidental releases.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Finding on the Public Land Health Standard for Upland Soils

Soils at the Shell test sites predominantly meet the public land health standard. The Proposed Action may adversely impact the public land health standard to protect upland soils in the proposed Shell test sites, but area-wide would not have a large effect. Implementing the alternative mitigation would maximize successful topsoil handling procedures, erosion control methods, and restoration measures during construction and reclamation, and the proposed project would continue to meet the standard.

VEGETATION

Affected Environment

The vegetation communities present in the test sites include pinyon-juniper woodland, upland sagebrush shrubland, bottomland sagebrush shrubland, and disturbed habitats. Wetlands and riparian areas are discussed in the Wetlands and Riparian Zones section. Disturbed areas consist of previously developed and reclaimed areas, areas with current facilities present, and access roads. The following table lists the acreages of vegetation communities present in the test sites and the percentage of the each site the vegetation represents.

Acreage and Percentage of Vegetation Community at Proposed Test Sites

Vegetation Community	Site 1		Site 2		Site 3		Total Acres
	Acres	Percent	Acres	Percent	Acres	Percent	
Pinyon-juniper woodland	96	60	6	4	48	30	150
Upland sagebrush shrubland	49	31	84	52	103	64	236
Bottomland sagebrush shrubland	2	1	--	--	9	6	11
Disturbed/Developed	13	8	70	44	--	--	83
Total	**160**	**100**	**160**	**100**	**160**	**100**	**480**

Pinyon-juniper woodland habitats grow on ridgetops and among rock outcrops with scattered sagebrush and grass at mid-elevations (between 6,500 and 7,000 feet). The dominant species associated with this community are pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*); Rocky Mountain juniper (*Juniperus scopulorum*) may also occur. Within the pinyon-juniper community, stand composition, site characteristics, and productivity are highly variable and depend on moisture. On drier sites (lower precipitation and/or elevation or south and west aspects), Utah juniper is dominant, but as elevation increases or on north and east aspects where more moisture is available, pinyon pine is more dominant, and at upper elevations, stands tend to be pure pinyon pine (BLM 1994).

The understory in the pinyon-juniper woodland is approximately 60 to 70 percent bare ground. Common understory species in the pinyon-juniper habitat include Indian ricegrass (*Achnatherum hymenoides*), mutton grass (*Poa fendleriana*), and western wheatgrass (*Agropyron smithii*). Mutton grass is nutritious forage that emerges in early spring (ESCO 2001). The pinyon-juniper provides vertical structure and value to wildlife, and mosaic patches of tall deciduous shrubs are present on northwest-facing slopes in drainages (ESCO 2002).

Upland sagebrush shrubland habitat is characterized by Wyoming big sagebrush (*Artemisia tridentate* spp. *wyomngensis*) and mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) on convex uplands at middle elevations. Upland sagebrush shrubland occurs primarily on the gentle slopes and adjacent to drainages. Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), western wheatgrass, muttongrass, various sedges, needle-and-thread (*Stipa comata*), Junegrass (*Koeleria cristata)*, scarlet globemallow (*Sphaeralcea coccinea*), cicada milkvetch (*Astragalus chamaeleuce*), and holly-leaf clover (*Trifolium gymnocarpon*) are common associates of upland sagebrush habitat. Vegetation cover is generally greater than 60 percent (ESCO 2001). Upland sagebrush shrubland occurs on upland sites where the soils are relatively deep and loamy.

Bottomland sagebrush shrubland occurs on stream terraces and other low-slope alluvial deposits at mid-elevations. The dominant vegetation includes basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) and black greasewood (*Sarcobatus vermiculatus*), that can reach 6 to 8 feet in height (SWCA 2005). Rubber rabbitbrush (*Chrysothamnus nauseosus*) is present in disturbed areas. Herbaceous species present in the understory include western wheatgrass in less disturbed areas and weedy species such as cheatgrass (*Anisantha tectorum*), perfoliate pepperweed (*Lepidium perfoliatum*), and goosefoot (*Chenopodium* spp.) in areas of more disturbance (ESCO 2001, SWCA 2005).

Vegetation specific to each test site is discussed below.

Site 1 – Oil Shale Test Site

Site 1 is located on Wolf Ridge between Stake Springs Draw to the east and Corral Gulch to the west. This site includes sagebrush parks and pinyon-juniper woodlands, as well as disturbed areas where seven well pads were recently constructed (Figure 21). The vegetation cover is fairly uniform across most of the site and is primarily pinyon-juniper woodland fragmented by well pads. While the pinyon-juniper woodland on the north-facing slope has been thinned, a mature stand of pinyon-juniper is present on the broad ridge top of Wolf Ridge (SWCA 2005). This stand consists of squatty, short-stature pinyon and juniper trees, which indicate very shallow, unproductive soils on the ridge. The estimated average number of trees on the ridgetop is 241 trees per acre, of which 123 are pinyon pine and 118 are juniper (Shell 2006a). The canopy closure is 75 to 80 percent; therefore, the understory is primarily bare ground with scattered antelope bitterbrush (*Purshia tridentada*) and Indian ricegrass (Roberts 2004). There are many areas where pinyon and juniper have invaded the sagebrush community from adjacent woodlands within the site (WestWater 2006).

The intermittent drainage bottom in the northwestern corner of the site is bottomland sagebrush shrubland with upland sagebrush shrubland adjacent to the drainage. The bottomland sagebrush has an understory of native herbaceous plants including Indian ricegrass, mutton grass, squirrel tail (*Sitanion hystrix*), beardless bluebunch wheatgrass (*Agropyron spicatum* var. *inerme*), elk sedge (*Carex geyeri*), Hood’s phlox (*Phlox hoodii*), prickly pear (*Opuntia polyacantha*), rushy milkvetch (*Astragalus lonchocarpus),* and mustard (Roberts 2005a). Antelope bitterbrush and Wyoming big sagebrush are the dominant shrubs in the sagebrush parks (Roberts 2005a).

The proposed access road follows Wolf Ridge on an upland, ridgeline route. No wetlands or other waters of the U.S. occur along the proposed access road route. The lower portion of the proposed route (parallel to CR 91) is an upland sagebrush community; the upper portion of the road route is pinyon-juniper woodland. A two-track road was recently constructed over the first mile or so of the proposed route (WWE 2005).

The understory along the proposed access road is sparsely vegetated. Dominant species are Indian rice grass, needle and thread grass, snakeweed (*Gutierrezia sarothrae*), fringed sage (*Artemesia frigida*), and slender wheatgrass (*Agropyron trachycaulum*) (WWE 2005).

Site 2 – Nahcolite Test Site

This tract is located on Bar D Mesa a broad ridge top between Ryan Gulch to the south, Stake Springs Draw to the west and Yellow Creek to the north. The site is located from 6,500 to 6,700 feet in elevation. This parcel is located on the upper end of the sagebrush expanse which covers much of the mesa. A majority of the parcel is located within the upland sagebrush shrubland community with fingers of pinyon-juniper woodlands extending from the south onto the parcel on shallower soils.

The proposed access road would approach Site 2 from CR 91 in the southeastern portion of the site. The 260 foot proposed access road transects the upland sagebrush community and terminates in a pinyon-juniper woodland adjacent to an existing pipeline ROW.

Approximately 50 acres of Site 2 has previously been disturbed from research activities within the CSU research site or from pipeline and road construction. Most of the disturbed areas have been reclaimed and have a cover of mostly perennial grasses. The remainder of the Site 2 is primarily undisturbed upland sagebrush shrubland with a perennial grass understory and several small pinyon-juniper patches along the southern edge (Roberts 2006). Vegetation communities for Site 2 are shown in Figure 22.

The approximately 50 acre CSU research site lies entirely within the boundary of Site 2 and is fenced from the adjoining rangelands. The research plots have been recolonized by grass, forb, and/or shrub species.

Additionally, a pipeline ROW corridor crosses the southern edge of Site 2. The ROW has been reclaimed with primarily introduced grass species with some minor recruitment of sagebrush and rabbitbrush onto the corridor.

Site 3 – Advanced Heater Test Site

Site 3 is located in an area of intermingled sagebrush parks and pinyon-juniper woodlands at an elevation of 6,800 to 7,000 feet. The upland sagebrush shrubland is fairly uniform across most of the site and occurs primarily on gentle slopes and adjacent to drainages. Scattered pinyon pine and juniper are invading the upland sagebrush community. A narrow string of trees occurs in the southeast portion of the parcel and appears to have a fairly open canopy with an understory of sagebrush and other upland shrubs (WestWater 2006). The proposed access road vegetation is primarily comprised of pinyon-juniper woodland with areas of upland sagebrush (Shell 2006b).

The drainages trend southwest to northeast in Site 3; drainage bottoms are dominated by bottomland sagebrush. Several areas where sagebrush and young pinyon-juniper are mixed have soils that are intermediate in depth (ESCO 2001).

BLM Ecological Sites

The test sites are within three BLM ecological sites. Specific environmental factors characterize an ecological site, such as soils, hydrology (particularly runoff and infiltration), and plant communities. Each characteristic is influenced by the others and influences the development of the others. The plant community on an ecological site is typified by a species association that differs from other ecological sites in the diversity and/or proportion of species or in total production (NRCS 2003). BLM ecological site descriptions for the test sites are provided in the following table.

Descriptions of BLM Ecological Sites at the Test Sites

BLM Ecological Site Name	Plant Species Association	Site
Pinyon-juniper woodland	Pinyon pine, Utah juniper, mountain mahogany, bitterbrush, Utah serviceberry, Wyoming big sagebrush, beardless bluebunch wheatgrass, western wheatgrass, junegrass, Indian ricegrass, mutton grass	1, 2, 3
Rolling Loam	Wyoming big sagebrush, winterfat, low rabbitbrush, spineless horsebrush, bitterbrush, western wheatgrass, Indian ricegrass, needle-and-thread grass, junegrass, Nevada bluegrass, mutton grass	1, 2, 3
Stony Foothills	Beardless bluebunch wheatgrass, western wheatgrass, needle-and-thread grass, junegrass, Indian ricegrass, fringed sage, Wyoming big sagebrush, black sagebrush, serviceberry, pinyon pine, Utah juniper.	3

Environmental Consequences of the Proposed Action

Construction of the test sites would result in removal of the majority of the existing vegetation within each of the 160-acre test sites, except at Site 2 where a maximum of 110 acres would be disturbed. Vegetation not cleared would be minimally disturbed. Potential negative impacts from vegetation removal include increased soil erosion, potential noxious weed and non-native plant invasions, as well as loss of wildlife habitat, fugitive dust, and loss of livestock forage.

Impacts from vegetation removal would be long-term and direct, and would vary in degree by the vegetation community, the ecological site type, and success of reclamation. Project duration from construction through reclamation would be 20 years or longer (Shell 2006b). Revegetation success would have an affect on soils, surface water quality, wildlife, and aesthetic value. Following soil disturbance, impacts to native vegetation from noxious weed infestations could increase. Herbaceous vegetation would likely reestablish within 1 to 2 years. After reclamation with successful reseeding, big sagebrush would require at least 20 to 75 years to reestablish, and pinyon-juniper woodland from 100 to 300 years to return to pre-disturbance conditions.

The following table lists the acreages of vegetation communities present in the test sites and the percentage of the each site the vegetation represents.

Acreage of Impact to Vegetation Communities at Proposed Test Sites

Vegetation Community	Site 1		Site 2		Site 3		Total Acres
	Acres	Percent	Acres	Percent	Acres	Percent	
Pinyon-juniper woodland	96	60	6	5	48	30	**150**
Upland sagebrush shrubland	49	31	84	76	103	64	**236**
Bottomland sagebrush shrubland	2	1	--	--	9	6	**11**
Disturbed/Developed	13	8	20	18	--	--	**33**
Total	**160**	**100**	**110**	**100**	**160**	**100**	**430**

Site 1 – Oil Shale Test Site

The pinyon-juniper woodland located southeast of the existing pipeline ROW on the southeast-facing slope would only be lightly disturbed (Shell 2006a). Site 1 has been recently disturbed from the development of seven well pads and associated access roads on Wolf Ridge and the northwest slope adjacent to the drainage (see the Acreage of Impact to Vegetation Communities at Proposed Test Sites table above). Removal of vegetation would be a long-term, direct impact to vegetation through the duration of the project. Some of the long-term impacts could be minimized following site reclamation.

An existing two-track road would be used as the site access road; the road would be asphalted and widened to 24 feet to allow heavy equipment. This would remove vegetation within the ROW in the area of widening and would remain asphalted until reclamation.

Site 2 – Nahcolite Test Site

The CSU research site occupies approximately 50 acres of Site 2 and is considered a previously disturbed vegetation community. The CSU research site would not be used by the RD&D project. The project facilities would occupy the remainder of the site which consist primarily of upland sagebrush shrubland with a small stand of pinyon-juniper woodland in the southwestern quadrant, south of the existing transmission line (Figure 22) (see the Acreage of Impact to Vegetation Communities at Proposed Test Sites table above).

The two proposed options for the access road include asphalting and widening an existing two-tract road along the pipeline ROW and the second option would require construction of approximately 350 feet of new road entering the site from the east from CR 24. Project duration, from construction to reclamation, would be approximately 20 years; long-term impacts to vegetation are similar to those described for Site 1.

Site 3 – Advanced Heater Test Site

The primarily vegetation community that would be removed from Site 3 is upland sagebrush shrubland (see the Acreage of Impact to Vegetation Communities at Proposed Test Sites table above). Pinyon-juniper woodland, which primarily is present in the northwestern and southeaster corners of Site 3, would be only lightly disturbed (Shell 2006b; see Figure 23). Project duration, from construction to reclamation, would be approximately 20 years; long-term impacts to vegetation are similar to those described for Site 1.

BLM Ecological Sites

The following table lists the acreages of impacts to BLM ecological sites from construction, operation, and reclamation.

Acreage of Impact to BLM Ecological Sites at Proposed Test Sites

BLM Ecological Site Name	Approximate Impacts (acres)			Total
	Site 1	Site 2	Site 3	
Pinyon-juniper	92	2	39	**133**
Pinyon-juniper/ Rolling loam	68	85	120	**273**
Rolling Loam	--	23	--	**23**
Stony Foothills	--	--	<1	**<1**
Total	**160**	**110**	**160**	**430**

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Potential impacts of the Proposed Action from disturbances to vegetation could include soil erosion, increased potential for invasive non-native species, and indirect impacts to wildlife resulting from reduction of habitat. To minimize these effects the BLM would require Shell to implement the following measures:

- Minimize vegetation removal to the extent necessary to allow for safe and efficient construction activities.
- Cut trees with a chain saw and/or mechanical shears and cutting brush with a hydro-axe or similar equipment as close to the ground as possible.
- Leave stumps and root balls in place except in areas requiring topsoiling, or as necessary to create a safe and level workspace.
- Shred or chip brush and salvage with topsoil.
- Salvage and replace topsoil, to preserve and replace existing seed banks and return organic matter needed for seed establishment to the soil.
- Restore pre-construction contours, drainage patterns, and topsoil.
- Prepare a seedbed (scarifying, tilling, harrowing, or roughening) prior to seeding where needed to improve revegetation potential.

- Install and maintain erosion control measures until vegetation becomes established.
- Control noxious weeds.
- Seeding methods should be drill or broadcast to ensure proper seed placement. Drill seeding is preferred and will be used wherever soil characteristics and slope allow effective operation of a rangeland seed drill. Drill seed perpendicular to the slope. Place seed in direct contact with the soil at an average depth of 0.5 inch, cover with soil, and firm to eliminate air pockets around the seeds. Employ broadcast seeding only in areas where drill seeding is unsafe or physically impossible. Apply seed uniformly over disturbed areas with manually operated cyclone-bucket spreaders, mechanical spreaders, or blowers. Broadcast application rates should be twice that of drill rates. The seed would be uniformly raked, chained, dragged, or cultipacked to incorporate seed to a sufficient seeding depth.
- Complete drill and/or broadcast seeding prior to redistribution of woody material.

The goal for rehabilitation of the sites is for the permanent restoration of original site conditions and productive capability. Disturbed areas will be restored as nearly as possible to their original contours. Additionally, appropriate seed mixtures will be used for revegetation, including pinyon-juniper mixture on ridgelines, a more mesic mix with scattered pinyon-juniper for mid-slope of regarded topography, and another mix for upland drainages (Shell 2006a). The following table lists the appropriate BLM seed mixes.

BLM Seed Mixes

Standard WRFO Seed Mix (Native Seed Mix #2)	Rates* (lbs PLS/a)
Western wheatgrass (Rosanna)	2.0
Indian ricegrass (Rimrock)	1.0
Bluebunch wheatgrass (Whitmar)	2.0
Thickspike wheatgrass (Critana)	2.0
Globemallow	0.5
Fourwing saltbush (Wytana)	1.0
Total	**8.5**

*All seeding rates are pounds (lbs) Pure Live Seed (PLS) per acre (a).
WFRO = White River Field Office, Bureau of Land Management

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

The mitigation measures identified would serve to minimize areas where soil is disturbed, and enhance soil stabilization with replacement of topsoil and revegetation. Up to 430 acres of vegetation will be lost in total on the three sites. Long-term impacts to wildlife habitat would proportionally decrease as reclamation success increases. The use of native seed mixes and implementing the mitigation measures enhancing seeding would stabilize the soil, control erosion and increase the chances for successful reclamation of vegetation.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Finding on the Public Land Health Standard for Plant and Animal Communities

The Shell test sites predominantly meet the public land health standard. The Proposed Action may adversely impact the public land health standard to protect plant and animal communities in the proposed Shell test sites, but area-wide would not have a large effect.

Implementing the alternative mitigation would maximize reclamation of native vegetation, enhance erosion control methods during construction and reclamation, and the proposed project would not change this status. Vegetation communities within the test sites have an appropriate age structure and diversity of species that meet the public land health standard. With successful reclamation, the project would not change this status.

WILDLIFE, AQUATIC

Affected Environment

Perennial creeks and streams are absent from the test sites. Drainages on the test sites are intermittent and do not support typical riparian vegetation. Several drainages occur in the vicinity of each test site and were sampled for aquatic resources in 2001 and 2002. Information on aquatic resources at each test site are provided below. Information on endangered Colorado River fishes are provided in the Threatened, Endangered, and Sensitive Animal Species section.

Site 1 – Oil Shale Test Site

Site 1 is located on a ridge between Stake Springs Draw (to the south) and Corral Gulch (to the north) both are intermittent, with only short reaches of perennial flow in association with springs and seeps (Shell 2006a) (see Figure 1). Both of these streams flow northeast into Yellow Creek. An unnamed intermittent tributary of Corral Gulch is present on the northwest corner of Site 1. Sampling of springs indicated reduced dissolved oxygen levels that would preclude the presence of aquatic wildlife (Shell 2006a). However, the mainstem of Yellow Creek and all of its tributaries from the source to the confluence with the White River have stream standards classified for Class 2 aquatic life warm.

The sampling site north of Site 1 is located on Corral Gulch, 30 feet downstream of the confluence with Box Elder Gulch. The site had good flow and very dense aquatic vegetation during 2002 site visits. A sampling site downstream of Site 1 at the confluence of Stake Springs Draw to Yellow Creek had good flow but little aquatic vegetation (Chadwick 2002).

Sampling on Duck Creek approximately 1.8 miles upstream of the confluence with Yellow Creek had good flow, but was a very narrow channel with limited aquatic vegetation (Chadwick 2002). Additionally, a fish sampling survey was conducted on Corral Gulch, to the north of Site 1.

Site 2 – Nahcolite Test Site

The northwest corner of Site 2 supports an unnamed intermittent tributary of Stake Springs Draw (see Figure 1).

Site 3 – Advanced Heater Test Site

No perennial surface water resources are present at Site 3. An unnamed intermittent tributary of Big Duck Creek, located about 1.5 miles to the northwest, flows through the northwest corner of Site 3 (see Figure 1). Corral Gulch, a perennial stream, is located approximately 1.5 miles south of Site 3; both Big Duck Creek and Corral Gulch flow into Yellow Creek.

General

Regional studies have been completed in association with the proposed project of tributaries to Yellow Creek and Piceance Creek, the two streams that flow into the White River. The White River is a tributary of the Green River, which flows to the Lower Colorado River (Shell 2006a). Prior to closure of the Taylor Draw Dam in 1984, native fish populations dominated 98 percent of the White River drainage in Colorado. Since then, exotic red shiner, fathead minnow and, to a lesser extent, common carp and predatory sportfish have increased in the lower White River, and even accounted for 36 percent of the sample population 1 year after dam closure (BLM 1994).

According to the Shell Plan of Operations for each proposed test site, operations may involve discharges of treated wastewater to local drainages under a Colorado Pollutant Discharge Elimination System (CPDES) permit. However, amounts of discharge are not known at this time (Shell 2006a). Subsequently, information on Yellow Creek and Big Duck Creek are provided in this section.

The results of fish sampling on Yellow Creek indicated that fish have a very limited distribution in the Yellow Creek drainage (Chadwick 2002). According to surveys conducted in 2001 and 2002, fish populations in Yellow Creek are limited to stream reaches downstream of the waterfall (fish barrier) located upstream of the confluence of Barcus Creek to Yellow Creek. This area is upstream of the confluence of Yellow Creek to White River, which is north of the project site boundaries. Species included mountain sucker (*Catostomus platyrhynchus*), speckled dace (*Rhinichthys osculus*), fathead minnow (*Pimephales promelas*), brown trout (*Salmo trutta*), and one brook trout (*Salvelinus fontinalis*) (Chadwick 2002). There does not appear to be a brook trout population in Yellow Creek, but a few individuals were present from stocking or washed out of a pond in the area. Speckled dace were the most abundant species; only four mountain suckers were collected in 2002, down 93 percent from Fall 2001 collections (Chadwick 2002).

Macroinvertebrate communities are present in the Yellow Creek basin; communities appear to be relatively healthy in Yellow Creek and its tributaries in areas that have perennial flow. Macroinvertebrate communities in the area are dominated by taxa that are adaptable and tolerant to adverse conditions such as sedimentation, unstable fine substrates, very low flows, and elevated TDS concentrations. Zooplankton are dominated by rotifers and mayfly (*B. longirostris*) and densities are considered low due to the lack of lentic habitats and are dominated by taxa that are common to most freshwater communities (Chadwick 2003). No toxicity was apparent in the upper Yellow Creek drainage (Chadwick 2002).

Fall 2001 and Spring 2002 macroinvertebrate sampling in the vicinity of the test sites included:

- Yellow Creek at the confluence with Duck Creek;
- Yellow Creek (below the waterfall);
- Duck Creek near the confluence to Yellow Creek;
- Stake Springs Draw, southwest of Site 1;
- Corral Gulch, south of Site 3; and
- Confluence of Box Elder Gulch to Corral Gulch.

The tributaries of Yellow Creek are characterized by shallow depths and narrow, wetted stream widths. Yellow Creek at its confluence with Duck Creek had no noticeable flow, a very wide, wetted channel, and is relatively deep compared to other areas sampled along Yellow Creek and its tributaries. The average flow of Yellow Creek is estimated to be 3 cfs. The aquatic community endures in harsh conditions as the water depths are generally shallow, but terraced cut-banks suggest streams are subject to periodic high-flow events (Chadwick 2002). December 2005 field visits concluded that stream flow and aquatic habitat conditions on Corral Gulch and Yellow Creek had not changed since 2001 and 2002 studies (Chadwick 2005).

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Project construction and operations would not directly modify aquatic habitats but would result in increased flow during construction of wells, as well as reduced flow from groundwater pumping during reinjection of water into the wells. Water depletion activities would occur during quenching and resaturation phases that are expected to occur for 18 months when groundwater extraction rates could reach 300 gpm. Anticipated normal process operations at each site would use approximately 10 to 20 gpm of water. However, initial dewatering activities inside the freeze wall would increase stream flows by a similar amount.

The Proposed Action would result in short-term water depletions of an estimated 0.026 cfs in Yellow Creek at Site 1. An extrapolated annual water depletion for all three test sites is estimated to be a maximum of 0.078 cfs per year. This assumes that reclamation activities at all three test sites would require the anticipated volume of reclamation water estimated for the initial development site (Site 1), that the reclamation activities would occur at the same time, and that subsurface hydrogeologic conditions would be similar between the three test sites. Water would be used in drilling, operational, and reclamation phases of the project.

Indirect impacts to nearby wetlands from construction and dewatering could occur, but impacts to aquatic wildlife would be considered negligible.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Aquatic wildlife in down-gradient perennial stream sections may be impacted because of dewatering. Impacts of the Proposed Action would be mitigated by maintaining water quality through the use of conveyance and containment structures to detain water until it is clean enough for release (Shell 2006a). Additionally, impacts to aquatic wildlife would be minimized by obtaining and complying with the COE Nationwide Permit 12 conditions.

To mitigate potential impacts to aquatic wildlife, BLM would require Shell to:

- Conduct a comprehensive groundwater monitoring program to evaluate the extent of any hydraulic connection between affected groundwater and surface water.
- Monitor stream flow and water quality in nearby streams and springs.
- Install erosion and sediment control measures, to prevent the flow of spoil into any water bodies.
- Maintain erosion and sediment control measures at the project sites.
- Prohibit storage of hazardous materials, chemicals, fuels and lubricating oils, and prohibit concrete coating and refueling activities within 200 feet of any waterbody or wetland.
- Minimize erosion from upland areas by restoring and seeding disturbed areas.
- Install temporary equipment bridges across flowing waterbodies.
- Place topsoil and spoil at least 10 feet from waters edge.
- Cross streams during periods of low flow and complete the crossing within 24 hours, as feasible.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Potential impacts to aquatic wildlife in the project area could result from surface disturbance on the Shell test sites, from spills onto the surface of the test sites, and from changes to the flow regime and water quality in the upper aquifer. The alternative mitigation would reduce or minimize impacts to surface and groundwater resources by maintaining water quality through the use of conveyance and containment structures to detain water until it is clean enough for release. The alternative mitigation would improve soil stability, minimize erosion potential, and minimize potential for accidental spills, all of which will help to ensure that off-site water quality will not harm aquatic wildlife.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Finding on the Public Land Health Standard for Plant and Animal Communities

The Proposed Action would not jeopardize the viability of any aquatic animal population, and would have no significant consequence on aquatic habitat condition, utility, or function. The Proposed Action would not have any discernible effect on aquatic animal abundance or distribution at any landscape scale. The public land health standard would remain unchanged.

WILDLIFE, TERRESTRIAL

Affected Environment

Information for this section was obtained from BLM and Colorado Division of Wildlife (CDOW) records, as well as environmental impact statements (EISs) and baseline reports for nearby developments. Those sources furnished primarily regional background data and historical information. Recent site-specific data were obtained from wildlife studies conducted on and near the test sites. Discussion regarding seasonal faunal ranges is based on electronic versions of CDOW range maps accessed from NDIS.

Habitat

As described in the Vegetation section, four vegetation communities are present in the test sites: pinyon-juniper woodland, upland sagebrush shrubland, bottomland sagebrush shrubland, and disturbed habitats. These vegetative communities provide cover and shelter, as well as nesting and foraging habitat for a variety of mammal, bird, and herptile species. Special status species are discussed in the Threatened, Endangered, and Sensitive Species section. Detailed descriptions of wildlife habitats at each site are provided in the Vegetation section.

Site 1 – Oil Shale Test Site

Site 1 is primarily pinyon-juniper woodland habitat with upland sagebrush shrubland. The pinyon-juniper cover is fairly uniform but due to recent construction is fragmented by seven well pads. Currently, the pinyon-juniper woodland comprises approximately 70 percent of the site vegetation.

Site 2 – Nahcolite Test Site

Approximately 50 acres of Site 2 has been used by CSU for research. The native vegetation has been removed within the research site, as well as in the southern portion of the site for pipeline and road construction. Much of the disturbed areas have been reclaimed and are now vegetated with mostly perennial grasses. The rest of Site 2 is still primarily undisturbed upland sagebrush shrubland with a perennial grass understory (WestWater 2006). The southeast corner of the site is characterized by an interface between mature pinyon-juniper woodland and upland sagebrush shrubland (Roberts 2006).

Site 3 – Advanced Heater Test Site

The dominant habitat at Site 3 is pinyon-juniper woodland. Most of the pinyon-juniper woodland is composed of mature, large-diameter trees with minimal understory vegetation. Upland sagebrush shrubland is the second most dominant habitat at Site 3. Bottomland sagebrush shrubland occurs in narrow bands along the intermittent drainages. The channels are dry in the absence of snowmelt or significant precipitation, and in most areas are moderately to severely downcut from the adjacent terrace. Very minor rock outcrops are also present on the site.

Avian Species

Game Birds

Two species have range within the project area. Mourning doves are common in most habitats in the summer in the Piceance Basin and nest in the area. Greater sage grouse historically occurred in the area, but no leks have been located since the mid 1980s; greater sage grouse are discussed in the Threatened, Endangered, and Sensitive Species section. No greater sage grouse were located during 2003 surveys (Two Ravens Inc. 2003).

Raptors

Various raptors inhabit the region and some are present year round. The stands of pinyon-juniper woodland provide nesting habitat for raptors. Raptors generally initiate nesting in mid-February to late April and lay eggs during March and April; young fledge between June and mid-August. Species known or likely to nest in the project area include:

- Cooper's hawks (*Accipiter cooperi*) nest in pinyons and junipers. Nests were observed during nest surveys.
- Sharp-shinned hawks (*Accipiter striatus*) nest primarily in coniferous forest; forage in pinyon-juniper (Righter et al. 2004).
- Northern harriers (*Circus cyaneus*) may nest in sagebrush and montane shrub habitats in western Colorado (Righter et al. 2004).
- Red-tailed hawks (*Buteo jamaicensis*) nest in tall trees in a variety of habitats. Nests observed in test sites.
- American kestrels (*Falco sparverius*) nest in tree cavities or woodpecker holes in pinyon-juniper and other habitats.
- Great horned owls (*Bubo virginianus*) are known to occur in the pinyon-juniper woodland.
- Long-eared owls (*Asio otus*) were observed at Site 1; the species may occur as year-round residents or migrants in the area. Wintering individuals and roosting groups of up to 12 may occur, but numbers and areas occupied vary with prey density. Therefore, patches of preferred habitat occupied in some years may not be in other years (Righter et al. 2004).
- Northern saw-whet owls (*Aegolius acadicus*) nest in pinyon-juniper and other forests (Righter et al. 2004).

Additionally, several special status raptor species are known to be present or may occur, and are discussed under Threatened, Endangered, and Sensitive Animal Species. These include bald eagle, ferruginous hawk, and northern goshawk.

Due to the absence of cliffs and rock outcrops at the test sites, there is no suitable nesting habitat for golden eagles (*Aquila chrysaetos*), peregrine falcon (*Falco peregrinus*), prairie falcons (*Falco mexicanus*), or turkey vultures. However, these species are known to nest in the region; golden eagles and peregrine falcons are known to nest in the vicinity in Ryan Gulch; therefore, they likely forage at the test sites (SWCA 2005a). The number of golden eagles in the area increases in winter when birds migrate from northern areas (Righter et al. 2004). Rough-legged hawks may occur at the test sites during winter or migration.

Between May 16 and 19, 2006, Cooper's hawk nest surveys were conducted by Greystone Environmental biologists using the Southwestern Region Goshawk Inventory Protocol, which involved playing recorded calls of raptor species at regularly spaced calling stations along parallel transects in contiguous patches of suitable habitat. Approximately 1,440 acres were surveyed at each test site (the 160-acre test site plus a 1/2-mile buffer).

Site 1 – Oil Shale Test Site

Transect surveys were conducted in July 2004 (West 2005) and in June 2005 of a 2,225-acre site which includes the boundaries of Site 1 (SWCA 2005a). July 2004 and June 2005 surveys were conducted by pedestrian transects spaced 75 to 100 meters apart. Survey methods for the July 2005 raptor surveys were 300-meter transects using broadcast tapes of Northern goshawk calls (West 2005). An active Cooper's hawk nest was found at the site on Wolf Ridge in the pinyon-juniper woodland (West 2005, SWCA 2005a). An inactive red-tailed hawk nest was found just northwest of the site in 2003 (Two Ravens Inc. 2003); the nest was dilapidated when found in 2003 and was still inactive in 2004 and 2005 (SWCA 2005a). Additionally, an unknown raptor nest was also located on Wolf Ridge in the site (Two Ravens Inc. 2003).

In 2004, seven long-eared owls were found roosting in an area of dense pinyon-juniper woodlands, indicating that a nest was likely located nearby, though no nest was found at the site. In 2005 surveys, no long-eared owls were detected (SWCA 2005a). No raptors or raptor nests were observed during surveys in the spring of 2006 (Greystone 2006).

Site 2 – Nahcolite Test Site

Cooper's and red-tailed hawk nests were observed on Site 2 (or in the vicinity), and golden eagles have been documented to nest in vicinity of Ryan Gulch, south of the site (Two Ravens Inc. 2003).

Additionally, in May 2006, an adult Cooper's hawk was observed flying within the 1/2 mile buffer surveyed around Site 2 (Greystone 2006). A brief nest search at that time did not locate an active nest. No other raptors or raptor nests were observed at this site in 2006 (Greystone 2006).

During a 2005 survey of proposed well hole locations and associated access roads, an unknown accipiter nest was observed approximately 100 feet southeast of the western terminus of the southern access road proposed for Site 2. The nest is located in a pinyon tree adjacent to the pipeline, approximately 40 feet high. Evidence of recent tending of this nest was observed, such as sticks at the base of the tree beneath the nest. The nest appeared to be in good condition but was not occupied at the time of the survey (SWCA 2005b).

Site 3 – Advanced Heater Test Site

Red-tailed hawk nests were observed in 2003 drilling site surveys in the current location of Site 3 (Two Ravens Inc. 2001). During 2006 surveys, an active northern goshawk nest was observed about 600 feet north of the site boundary; no other raptor nests were found (Greystone 2006).

Other Birds

Avian surveys were conducted on a 3,800-acre parcel in 2001, which included the boundaries of Site 3. Results of this survey found the avian community to be moderately abundant and diverse (Two Ravens Inc. 2001). The most common species were those which typically inhabit pinyon-juniper and sagebrush habitats as these are the most abundant habitat type. The pinyon-juniper woodland at Site 1 (on Wolf Ridge) and Site 3 have mature trees, snags, and cavities that support a variety of nesting birds. However, because of the varying density and composition of pinyon-juniper woodlands, birds are not uniformly distributed in this habitat.

During 2004 and 2005 transect surveys of a 2,225-acre area that included Site 1, 36 species were observed, including birds that nest in the area in the pinyon-juniper and sagebrush communities. The following table lists birds observed on site or with potential to occur and their relevant habitat association. Birds that were observed in the area but are unlikely to nest include turkey vulture (*Cathartes aura*), Townsend's solitaire (*Myadestes townsendi*), red crossbill (*Loxia curvirostra*), and pine siskin (*Carduelis pinus*).

Birds Known or with Potential to Occur at Test Sites

Common Name	Scientific Name	Relevant Habitat	Occurrence	Site
Mourning dove	*Zenaida macroura*	All	Present	All
Common nighthawk	*Chordeiles minor*	All	Present	All
Common poorwill	*Phalaenoptilus nuttallii*	Pinyon-juniper, sagebrush	Present	All
Merriam's turkey	*Meleagris gallopavo*	Pinyon-juniper	Potentially present	1, 3
Black-chinned hummingbird	*Archilochus alexandri*	Pinyon-juniper	Potentially present	1, 3
Broad-tailed hummingbird	*Selasphorus platycercus*	Pinyon-juniper	Likely present	All
Hairy woodpecker	*Picoides villosus*	Pinyon-juniper	Likely present	1, 3
Northern flicker	*Colaptes auratus*	Pinyon-juniper or banks of arroyos in sagebrush shrub	Present	1, 3
Western wood-peewee	*Contopus sordidulus*	Pinyon-juniper	Potentially present	1, 3
Ash-throated flycatcher	*Myiarchus cinerascens*	Pinyon-juniper especially with mature Utah juniper	Likely present	1, 3
Gray flycatcher	*Empidonax wrightii*	Pinyon-juniper, especially where interspersed with sagebrush	Present	All
Loggerhead shrike	*Lanius ludovicianus*	Open country with scattered trees and shrubs; pinyon-juniper and sagebrush and greasewood	Potentially present	2, 3
Northern shrike	*Lanius excubitor*	Sagebrush shrubland at low elevation	Potentially present	2, 3

Birds Known or with Potential to Occur at Test Sites

Common Name	Scientific Name	Relevant Habitat	Occurrence	Site
Plumbeous vireo	*Vireo plumbeus*	Pinyon-juniper at higher elevations in tall, dense stands	Potentially present	1
Western scrubjay	*Aphelocoma californica*	Pinyon juniper	Present	All
Pinyon jay	*Gymnorhinus cyanocephalus*	Pinyon-juniper	Present	All
Clark's nutcracker	*Nucifraga Columbiana*	Pinyon-juniper	Likely present	1, 3
Black-billed magpie	*Pica hudsonia*	All	Present	All
Common raven	*Corvus corax*	All	Present	All
Mountain chickadee	*Poecile gambeli*	Pinyon-juniper	Present	1, 3
Juniper titmouse	*Baeolophus ridgewayi*	Pinyon-juniper	Present	1, 3
Bushtit	*Psaltriparus minimus*	Pinyon-juniper	Present	1, 3
White-breasted nuthatch	*Sitta carolinensis*	Pinyon-juniper	Present	1, 3
Rock wren	*Salpinctes obsoletus*	Rocky outcrops and slopes in open areas	Potentially present	1, 2
Bewick's wren	*Thryomanes bewickii*	Pinyon-juniper, juniper-sagebrush	Present	1, 3
House wren	*Troglodytes aedon*	Pinyon-juniper	Potentially present	1, 3
Blue-gray gnatcatcher	*Polioptila caerulea*	Pinyon-juniper	Likely present	1, 3
Mountain bluebird	*Sialia currucoides*	Ecotone between pinyon-juniper and sagebrush shrubland	Present	All
Townsend's solitaire	*Myadestes townsendi*	Pinyon-juniper	Present in winter	1, 3
American robin	*Turdus migratorius*	All	Likely present	All
Sage thrasher	*Oreoscoptes montanus*	Sagebrush shrubland	Likely present	All
Virginia's warbler	*Vermivora virginiae*	Pinyon-juniper interspersed with montane shrub	Potentially present	1, 3
Black-throated gray warbler	*Dendroica nigrescens*	Pinyon-juniper	Present	1, 3
Western tanager	*Piranga ludoviciana*	Pinyon-juniper	Likely present	1, 3
Green-tailed towhee	*Piplio chlorurus*	Montane and sagebrush shrubland	Likely present	1, 2
Spotted towhee	*Piplio maculatus*	Pinyon-juniper and sagebrush shrubland	Present	All

Birds Known or with Potential to Occur at Test Sites

Common Name	Scientific Name	Relevant Habitat	Occurrence	Site
Chipping sparrow	*Spizella passerine*	Pinyon-juniper	Present	1, 3
Brewer's sparrow	*Spizella breweri*	Sagebrush shrubland	Likely present	1, 2
Vesper sparrow	*Pooecetes gramineus*	Grasslands with scattered shrubs, sagebrush shrubland, also pinyon-juniper	Likely present	All
Lark sparrow	*Chondestes grammacus*	Grassland with scattered juniper, greasewood, or sagebrush	Potentially present	2, 3
Sage sparrow	*Amphispiza belli*	Upland sagebrush shrubland 1 to 3 feet high	Potentially present	2, 3
Dark-eyed junco	*Junco hyemalis*	Pinyon-juniper	Potentially present	1
Black-headed grosbeak	*Pheucticus melanocephalus*	Pinyon-juniper	Likely present	1, 3
Western meadowlark	*Sturnella neglecta*	Open grassland and low density shrubland	Likely present	2, 3
Red crossbill	*Loxia curvirostra*	Pinyon-juniper	Present occasionally and in migration	1, 3
Pine siskin	*Carduelis pinus*	Pinyon-juniper	Potentially present	1, 3

Source: SWCA 2005b, Righter et al. 2004

Mammalian Species

Big Game

Mule Deer

Mule deer (*Odocoileus hemionus*) are the most common big game species that likely occur at each of the test sites. Currently the mule deer population in the Piceance Basin is below historic levels in the 1950s and 1960s. Due to the high number of mule deer and large amount of public land, deer provide a significant level of recreation in the forms of hunting and wildlife viewing. Mule deer migration routes are located northwest and northeast of the project sites (NDIS 2006).

Site 1 is within mule deer winter range; migration routes are northwest and northeast of the site (NDIS 2006).

Site 2 is year round range and severe winter range for mule deer (NDIS 2006).

Site 3 is mule deer summer range and winter range; no severe winter range or critical range for deer is on the site, but exists northeast of the site in the Duck Creek and Yellow Creek valleys (NDIS 2006). Deer were only occasionally observed during on-site studies in 2001 in bottomland habitats; few observations occurred in pinyon-juniper woodland (Two Ravens Inc. 2002). This may be due to the lower visibility in wooded areas or possibly that the large amount of bare ground in the pinyon-juniper woodland limited browsing opportunity. The site is considered good habitat value for mule deer due to the elevation and habitats, especially for winter range.

Elk

Elk (*Cervus elaphus*) inhabit pinyon-juniper and upland sagebrush shrubland habitats. Elk use the woodland habitat for cover, but also occur in open areas. The test sites are in elk summer and winter range; winter concentration areas are located northeast of the test sites (NDIS 2006). The summer range, which includes the three test sites, is considered critical habitat because of the limited availability of summer range for elk that inhabit the Piceance and Douglas creek basins (BLM 1994). Requirements of summer range are a mixture of open shrubland and grassland, water source, and areas of forest for cover. In winter, elk migrate to winter ranges where cover and forage are available.

Elk are less abundant than mule deer in the Piceance Basin, but the elk herds have been increasing. During 2001 studies, no elk were observed and elk sign was uncommon (Two Ravens Inc. 2001). This may be due to the commercial traffic on CR 24X and recreational traffic on CR 80.

Mountain Lion

Mountain lions (*Felis concolor*) usually den in rock outcrops or cliffs, but in the absence of these characteristics, will use brushy thickets or deadfalls (Chapman and Feldhammer 1982). Deadfalls are present in the three test sites and the surrounding area and could be used by denning lions. While no evidence of mountain lions was observed during field surveys conducted at the three test sites in previous years, they are likely to occur as the sites are suitable habitat and support mule deer (their primary prey). Furthermore, mountain lions have large home ranges (from 73 to 282 square miles) (Anderson et al. 1992). The test sites are only a small area of the large home range potentially used by mountain lions.

Black Bear

Black bears have large ranges, from 2 to over 70 square miles in western Colorado (Fitzgerald et al. 1994). The overall range of black bears (*Ursus americanus*) includes the three test sites. The nearest black bear summer concentration is located south of the town of Meeker, east of Highway 13; while the nearest fall concentration area is nearly 15 miles southwest of the test sites (NDIS 2006). As discussed for mountain lions, the test sites are only a small portion of the overall range of black bears. Black bears are opportunistic eaters and will prey on small mammals, carrion, and young ungulates, as well as fruits of serviceberry, oak, and juniper (Two Ravens Inc. 2002).

Other Mammals

Many other small and medium-sized mammals would be expected to occur at the test sites. The availability of tree cavities, snags, and deadfall creates plentiful refuges, den sites, and habitat for roosting bats. Pinyon nuts provide an abundant forage resource in years of good production for small mammals.

Species observed during previous field surveys include mountain cottontail (*Sylvilagus nuttallii*), badger (*Taxidea taxus*), coyote (*Canis latrans*), fox (*Vulpes vulpes*), porcupine, golden-mantled ground squirrel (*Spermophilus lateralis*), least chipmunk (*Tamias minimum*), and bushy-tailed woodrat (*Neotoma cinerea)* (Two Ravens Inc. 2002). Other species not observed, but expected based on range and habitat, include: bobcats (*Felis rufus*), ringtail (*Bassariscus astutus*), long-tailed weasels (*Mustela frenata*), fringed myotis, and a variety of small rodents such as mice and voles.

Amphibians and Reptiles

Amphibians

Amphibians are generally associated with ponds and streams and, therefore, would be absent from the site boundaries due to the lack of permanent water. However, where access roads would cross riparian zones amphibians may be present. Western chorus frog (*Pseudacris triseriata*) and Great Basin spadefoot have been recorded in the vicinity (NorWest 2003), but would only be able to successfully breed in years of adequate precipitation or snowmelt in order to create and maintain puddles to support metamorphosing tadpoles.

Reptiles

A number of reptile species are commonly associated with rocky outcrops and deadfalls.

Site 3 provides limited areas of exposed rock, but deadfalls are relatively common in mature stands of pinyon-juniper. Sagebrush lizards (*Sceloporus graciosus*) and short-horned lizard (*Phrynosoma hernandesi*) were observed during 2001 surveys at Site 3 and in 2004/2005 surveys at Site 1 in the mature pinyon-juniper habitat (Two Ravens Inc. 2001; Shell 2006a).

While no snakes were observed during 2001 field surveys of Site 3, western terrestrial garter snake (*Thamnophis elegans*), western rattlesnake, midget faded rattlesnake, milk snake (*Lampropeltis triangulum*), and gopher snake (*Pituophis catenifir*) may occur (Two Ravens Inc. 2002) at any of the test sites.

Environmental Consequences of the Proposed Action

Impacts from construction and operation of the test sites would be direct and indirect, long-term and short-term, as well as temporary and permanent. Since project duration is planned for approximately 20 years at each test site, wildlife impacts would be long-term.

Raptors

Impacts to raptors would be short-term and long-term, direct and indirect. Short-term impacts would occur during construction if initiated in the breeding season. Long-term and possibly permanent impacts to raptors would result from loss of foraging and nesting habitat and disturbance to nesting birds and young during breeding season.

Some species more tolerant of noise and disturbance, such as great-horned owls and American kestrels, may continue to nest in the vicinity of the test sites; however, other species such as northern goshawk, that are not tolerant of human disturbance and habitat fragmentation would have permanently lost habitat due to these factors. Noise disturbances could result in nest destruction or abandonment. These impacts are likely to be short-term as some species may choose to nest near the site when operations have been ongoing.

Site 1 – Oil Shale Test Site

The Cooper's hawk nest on Wolf Ridge would be permanently removed from the site during vegetation clearing as well as any other nests present in the pinyon-juniper woodland on Site 1. A red-tailed hawk nest, located outside of and just northwest of Site 1 in 2003 may not be used in the future due to disturbance from site operations. Construction of the facilities would remove known roosting and possibly nesting habitat for long-eared owls that were observed on the site in 2004.

Site 2 – Nahcolite Test Site

Clearing of vegetation would remove habitat for nesting and foraging raptors. Cooper's hawks and red-tailed hawks have nested on the site in the past and, if present, would be displaced from the vicinity.

Site 3 – Advanced Heater Test Site

Similar to Site 1, Site 3 has suitable habitat for nesting raptors; removal of this vegetation would result in direct and indirect, long-term impacts to raptors from habitat loss and disturbance. Red-tailed hawk nests have been identified on the site during previous years.

Other Birds

Impacts to passerines and other birds would be similar to impacts described in the Migratory Birds section. Construction of storm water, evaporative, and process ponds at each test site may have an adverse impact on waterfowl if water is of poor water quality. These ponds would be fenced to keep medium and large-sized terrestrial mammals out of the site, but may be an attractive open water habitat for waterfowl.

Big Game

Impacts to big game species including mule deer, elk, mountain lion, and black bear include loss of habitat.

Site 1 – Oil Shale Test Site

Construction and operation of Site 1 would result in short-term and long-term, direct and indirect adverse impacts on mule deer though the loss and fragmentation of 160 acres of winter range and on elk summer and winter range. Long-term disturbance from site operations would produce noise and activity that deer and elk would avoid. Animals would avoid the test site area up to 1/4-mile (Lyon and Ward 1982). Additionally, construction and operation of the test site would increase human activity through traffic noise and vehicle travel on roads, which could result in increased mortality to deer and elk due to avoidance, vehicle collisions, or poaching. While the access roads would be gated to prevent recreational traffic from entering sites, the estimated 300 to 650 vehicles per day traveling to and from the site would be a long-term, direct impact to big game.

Short-term impacts resulting from construction would force mule deer and elk to find other areas of habitat, which may or may not be suitable. Elk tend to avoid areas with disturbance, such as heavily trafficked roads and, therefore, the project site and proposed access roads would result in a direct and indirect loss and fragmentation of habitat. Similarly, due to fragmentation and habitat loss, mountain lions and black bears would be negatively affected.

<u>Site 2 – Nahcolite Test Site</u>

Site 2 is year round range and severe winter range for mule deer and summer and winter range for elk. Impacts to these species would be similar as described above, though to a greater extent at Site 2, as it is mule deer severe winter range. Impacts to mountain lion and black bear would be as described in Site 1.

<u>Site 3 – Advanced Heater Test Site</u>

Impacts to big game would be similar to those described for Site 1 as the site is year round range for both mule deer and elk. Impacts to mountain lion and black bear would be as described in Site 1, though to a potentially greater extent as the proposed access road may be constructed in a previously undisturbed area, depending on which access road option is chosen.

Other Wildlife

Impacts to other wildlife would be similar to impacts described for big game. However, due to the lower mobility of small mammals and herptiles, direct impacts would include mortality from crushing or burial during earth moving activities during construction. Additionally, construction noise from heavy equipment and the facility operation disturbs wildlife and could result in avoidance of the area or disruption of normal behavior. As discussed in the Migratory Birds Mitigation section, the degree of impact to wildlife in the long-term is dependent on the habitat removed and the success of reclamation. Herbaceous vegetation would reestablish within a couple of years, while pinyon-juniper requires from 100 to 300 years to reestablish.

Loss of wildlife habitat would displace wildlife species to other areas of suitable habitat due to the decreased carrying capacity of the land. While suitable habitat may be available in adjacent areas, loss and fragmentation of habitat would increase intra-and inter-specific competition among species depending on the same resources, such as carnivores and large bodied mammals, especially if alternative areas of habitat are at carrying capacity or are unusable for habitation. Large and medium sized mammal populations would decrease as a result of the increased resource competition and mortality from stress, and could have reduced reproductive success and health from the increased energy expenditures required to deal with disturbance.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

The Proposed Action identifies potential impacts to terrestrial wildlife, such as loss of habitat and disturbance during breeding season. In order to mitigate potential impacts, BLM would require alternative mitigation measures. Wildlife impacts will be minimized through mitigation as described below.

- Prohibit construction activities in severe/critical mule deer and elk winter range between December 1 and April 30.
- Redistribute large, woody material salvaged during clearing operations so as not to exceed 3 to 5 tons per acre, and mulch excess woody materials.

- Limit fencing on the tract to facilities that otherwise would present a hazard to humans and/or wildlife.
- Seed disturbed areas according to BLM recommendations.
- Support carpooling and establish a policy of reduced vehicular speed, especially at night.
- Ensure that reserve pits are lined, fenced on all four sides with net-wire and covered with plastic barrier to exclude both large and small animals and netted to prevent birds from accessing these pits, and reclaiming the pits as soon as possible after use.

Raptors

If the project initiation and construction is delayed until February 1, 2007, then a new survey for nesting raptors will be required prior to project initiation. Shell would be responsible for a qualified biologist to conduct migratory bird surveys. BLM does not specify survey protocol, but at a minimum, surveys would provide estimates of migratory bird species abundance and density.

No surface occupancy will be allowed within 1/2 mile of active nests of threatened, endangered, or BLM sensitive species of migratory birds, including raptors, from February 1 through August 15 (1/8 mile for all non-listed migratory bird species). The BLM will be contacted and USFWS will be consulted if any special status species nests are discovered on or adjacent to the project area.

Timing limitation stipulations would be applied to active, non-Special Status raptor nests (i.e., those species not classified as listed, proposed, or candidate species for listing under the ESA and non-BLM sensitive species). No development or construction-related activities would be allowed within 1/4 mile of identified nest(s) from February 1 through August 15.

No facilities may be constructed within 1/8 mile of an active raptor nest (BLM 1997).

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Construction activities could affect wildlife through disturbance, displacement, and mortality. Implementing seasonal restrictions would minimize these impacts during the time it is likely the largest populations would be present in the area. Impacts to wildlife from loss of cover, nesting, and forage habitat would be decreased with successful reclamation efforts. Herbaceous vegetation would be likely to reestablish within 1 to 2 years, and big sagebrush dominated communities would likely return to their pre-construction aspect within 20 to 75 years. Pinyon-juniper woodlands would take up from 100 to 300 years to return to pre-construction conditions.

Limiting fencing would assist in limiting displacement of wildlife from areas in and adjacent to the Shell test sites. Displaced animals may relocate into similar habitats nearby; however, the lack of adequate territorial space could increase intra- and inter-specific competition and could lower reproductive success and survival. Displacement would likely be a temporary impact and animals would likely return to the disturbance area after construction activities are complete.

Efforts to minimize increased interaction near humans and motor vehicles could result in less mortality from collisions with motor vehicles or poaching. Such impacts would exist for the life of the project due to increased traffic along highways from Meeker and Rifle, along Piceance

Creek Road, and on county roads leading to the site would result from construction and operation of the proposed project.

It has been agreed upon by the BLM, WRFO and the CDOW, Meeker Service Center that the extent, dispersion, and relatively short duration of big game impacts attributable to the proposed action would, at the present time, not radically alter the distribution or abundance of local big game populations. However, the agencies expect that the cumulative effects of commercial oil shale development simultaneous with anticipated natural gas development in Piceance Basin would warrant a coordinated, comprehensive wildlife mitigation strategy based on a newly developed RFD for natural gas and refined plans for commercial shale oil development when available.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

Finding on the Public Land Health Standard for Plant and Animal Communities

The Proposed Action would not jeopardize the viability of any animal population. Because of the small scale of the operations within the larger game management unit, only minor impacts on terrestrial habitat condition, utility, or function would be foreseen, with no discernible effect on animal abundance or distribution at any landscape scale. Neither the Proposed Action nor the mitigation alternative would affect the achievement of the public land health standard. The proposed mitigation measures would further decrease the potential for adverse impact to the standard.

OTHER NON-CRITICAL ELEMENTS

For the following elements, only those brought forward for analysis will be addressed further.

Non-Critical Element	Not Applicable or Not Present	Applicable or Present, No Impact	Applicable and Present and Brought Forward for Analysis
Access and Transportation			X
Cadastral Survey	X		
Fire Management			X
Forest Management			X
Geology and Minerals			X
Hydrology/Water Rights			X
Law Enforcement		X	
Noise			X
Paleontology			X
Rangeland Management			X
Realty Authorizations			X
Recreation			X

Non-Critical Element	Not Applicable or Not Present	Applicable or Present, No Impact	Applicable and Present and Brought Forward for Analysis
Socioeconomics			X
Visual Resources			X
Wild Horses			X

ACCESS AND TRANSPORTATION

Affected Environment – Sites 1, 2, and 3

The three test sites all have access from existing Rio Blanco county roads. The roads to access the test sites are CR 5, CR 24, CR 68, CR 91, and CR 24X. CR 5 is the primary access road to the east of all three test sites and is paved. CR 24 connects with CR 5 and generally runs north/south through the test site area. CR 68 connects with CR 24 near Site 2 and runs east/west. CR 91 connects with CR 24 north of Site 2 and will be used to access Site 1. CR 91 runs diagonally southwest/northeast. CR 24X is an offshoot of CR 24. It takes off from CR 24 to the north and then begins to head west and will be used to access Site 3. All five of these county roads are two-lane gravel roads. Figure 20 shows the road locations and names.

Average daily traffic numbers compiled from the Colorado Department of Transportation (CDOT) and the Garfield and Rio Blanco counties Road and Bridge Departments for major roads that would access the test sites are presented in the table below.

Average Daily Traffic

Road	Baseline Average Daily Traffic
Colorado Highway 13 between Rifle and Junction with South End of Rio Blanco CR 5 (Piceance Creek Road)	2,300[1]
Colorado Highway 13 Between South End of CR 5 and Colorado Highway 64 Near Meeker	2,300[1]
Colorado Highway 64 between Meeker and North End of CR 5	830[1]
Colorado Highway 64 between north end of CR 5 and Colorado Highway 139	1,700[1]
CR 5 (Piceance Creek Road)	562-1,076[2]
CR 24	584[3]

[1]Colorado Department of Transportation.
http://www.dot.staet.co.us/App_DTD_DataAccess/Downloads/TrafficVolumeMaps/TVMap1.pdf
[2]Rio Blanco Country Road and Bridge Department, 2005. Lower traffic range measured in May, high traffic range measured in late October/early November, coinciding with big game hunting season.
[3]Rio Blanco County Road and Bridge Department, 2005. This was measured in early November 2005 as an average over a 10-day period.
CR = County Road #

Site 1 – Oil Shale Test Site

Access to the Site 1 would be provided by construction of an access road connecting the site to existing county roads. Initial construction activities include development of the site access road and fencing of the permit area. Present access to Site 1 is from CR 5 to CR 24 to CR 91 to an existing two-track road. This two-track road was originally constructed to access several groundwater hydrology monitoring well sites. The access road would be extended to Site 1 and expanded to a running width of approximately 24 feet to allow heavy equipment travel in two directions. The access road would be paved with asphalt for the 24-foot width and include appropriate ditches and culverts to maintain drainage control. Access to the site from the road would be restricted through an entry gate. An estimated 300 to 650 vehicles per day would access the site during construction.

Site 2 – Nahcolite Test Site

Access to Site 2 would be provided by construction of an access road connecting the site to existing county roads. Initial construction activities include development of the site access road and fencing of the permit area. There are two proposed options for access roads into Site 2. One access is from CR 5 to CR 24 which would enter the site from the northeast. The other option is from CR 5 to CR 24 to CR 68 which would enter the site on the southeast pipeline along an existing access road. The access road would be expanded to a running width of approximately 24 feet to allow heavy equipment travel in two directions. The access road would be paved with asphalt for the 24-foot width and include appropriate ditches and culverts to maintain drainage control. Access to Site 2 from the road would be restricted through an entry gate. An estimated 300 to 650 vehicles per day would access the site during construction.

Site 3 – Advanced Heater Test Site

Access to Site 3 would be provided by construction of an access road connecting the site to existing county roads. Initial construction activities include development of the site access road and fencing of the permit area. Currently access to Site 3 is from CR 5 to CR 24 to CR 24X. Three access roads are currently proposed for Site 3: from CR 24X along CR 80 for approximately 2 miles to the northwest corner of the site; an approximately 2-mile long new road from CR 24X along an unnamed drainage with the proposed powerline; or from south of the site along an existing road for approximately 1 mile (Shell 2006b).

One of these roads would be extended to the site and expanded to a running width of approximately 24 feet to allow heavy equipment travel in two directions. The access road would be paved with asphalt for the 24-foot width and include appropriate ditches and culverts to maintain drainage control. Access to Site 3 from the road would be restricted through an entry gate. An estimated 300 to 650 vehicles per day would access the site during construction.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

There are potential environmental consequences from the construction of the access roads from county roads to the test sites; however, the majority of these would be limited to short-term construction impacts and can be controlled with BMPs. Long-term impacts include increased runoff due to the conversion of gravel road to pavement, loss of habitat due to creation of new roads or increased road widths, and an increased number of wildlife fatalities from vehicular collisions.

Additionally, there would be increased traffic on existing roadways as described for each site. Workers and contractors would commute to and from the job site as no employee housing or man-camp accommodation at the test sites is anticipated. The traffic volume would vary with the phasing and actions of the RD&D operations. However, because the three test sites would not be developed at the same time, the total traffic volumes would not be cumulative. Long-term impacts to traditional use of the roads could occur if recreationists, such as hunters, are dispersed from the area due to the construction and operation of the sites.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

The Proposed Action identifies potential impacts to terrestrial wildlife such as increased numbers of wildlife fatalities. In order to mitigate potential impacts, BLM would require alternative mitigation measures. Wildlife impacts will be minimized through mitigation as described below.

- Prohibit construction activities in severe/critical mule deer and elk winter range between December 1 and April 30.
- Redistribute large, woody material salvaged during clearing operations so as not to exceed 3 to 5 tons per acre, and mulch excess woody materials.
- Seed disturbed areas according to BLM recommendations.
- Control dust along unsurfaced access roads and minimize tracking of soil onto paved roads.
- Comply with county weight and load restrictions.
- Maintain unsurfaced roads during construction and operations of the project.
- Support carpooling and establish a policy of reduced vehicular speed, especially at night.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Most impacts from the Proposed Action would be the result of increased traffic during construction and operation. Implementing the proposed mitigation would work to decrease the number of vehicles expected and decrease wear and tear on the roads and fugitive dust emissions from traffic.

An estimated 300 to 650 vehicles per day would be accessing each of the three test sites. However, due to the phasing of these projects, all three sites would not likely be operated at one time; therefore it is difficult to quantify the total estimated number of vehicles. Carpooling would reduce the number of light vehicles on the local roads and potentially decrease local traffic congestion.

Impacts to roads would be minimized by limiting vehicles to State and County standard weight, size, and axle arrangements.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

FIRE MANAGEMENT

Affected Environment – Sites 1, 2, and 3

According to the White River ROD/RMP, the objective of fire management in the area is to protect public health, safety, and property as well as allow fire to carry out important ecological functions. Prescribed fire, which includes both management and natural ignition sources, may be used to achieve land or resource management objectives. Prescribed fires will be conducted by qualified personnel and with a pre-approved prescribed fire plan. Approximately 639,573 acres have been identified as prescribed natural fire area within the WRRA. None of the three test sites are located within the prescribed natural fire area.

The actions proposed for Sites 1 and 3 all occur within B6 Yellow Creek fire management unit, an area where wildland fire is not desired and fire suppression is aggressive. The actions proposed for Site 2 occur in the C6 Lower Piceance Basin fire management unit, an area where wildland fire is desired, but there are constraints that must be considered to achieve public land health objectives and perform its natural function within an ecosystem. Nearly all the plant communities in the general vicinity of the project area are mature with moderate to considerable fuel loads. Most of these communities are rejuvenated by fire to maintain healthy, diverse plant communities.

The mature plant communities and relatively dry climate of the Piceance Basin make this area prone to fire, especially in the heat of summer when rains are infrequent and dry thunderstorms are common. Human activities, such as construction and welding, can pose an extreme fire hazard during this time as well. Fires in this area are likely to move swiftly as they gain momentum from the considerable fuel loads associated with pinyon-juniper communities on either side of ridges and cross the prominent ridge top primarily vegetated with a mix of mature sagebrush and pinion-juniper vegetation.

The Proposed Action would clear approximately 160 acres of sagebrush and pinyon-juniper vegetation on Sites 1 and 3 and 110 acres on Site 2. Vegetation along the proposed ROWs for power, communications, and natural gas pipeline installation would also be cleared.

The BLM WRFO has the primary fire response and suppression responsibility for the northern end of the Piceance Basin. In the vicinity of the Proposed Action the Meeker Volunteer Fire Department provides mutual aid as requested.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Construction of facilities on the three 160-acre test sites would restrict the ability of natural fire to spread, since measures will be taken to protect facilities from fire. Alternatively, fires started accidentally during construction or operations could adversely affect land or resource management objectives for the vegetation communities in and around the test sites.

Development of oil shale RD&D facilities along with the prevalent oil and gas operations located on the area would restrict BLM's ability to use wildland fire to achieve public land health objectives for the plant communities in the general vicinity of Site 2 for approximately 2 miles around the test site. Wildland fire occurrence within a 2-mile buffer around Sites 1 and 3 would be suppressed aggressively. This would likely be a long-term impact to fire management objectives as the RD&D lease term is proposed for up to 10 years, and oil and gas activities in the vicinity may continue for a considerable time. Any naturally occurring fires in this area would likely be put out while they are small. Large areas of mature vegetation without periodic fires would continue a downward decline in diversity of plant species, especially herbaceous species. Higher costs per acre for fire management would be incurred by BLM for full suppression versus wildland fire use, also considerably higher costs can be expected for vegetation management by mechanical or prescribed fire means. These practices must be continued since BLM is mandated to manage for public land health and declining vegetation communities commonly result in declines in overall land health standards. At the same time, fires started accidentally during construction could adversely affect land or resource management objectives for the vegetation communities in and around the project area.

Vegetation removal and soil disturbance could provide an opportunity for noxious weeds and cheatgrass to invade the site and related ROWs, which could result in a shift from the natural fire regime to an unnatural, more frequent, fire regime which could result in the loss of key ecosystem components. The cleared vegetation would be windrowed if reclamation were to occur immediately after construction, or chipped and scattered for long-term disturbances. This would represent a light dead fuel load as the quantities would be relatively small.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

BLM would require standards and practices that would minimize the risk of fire danger and, in case of fire, provide for immediate suppression if possible. Prior to beginning construction activities, Shell would be responsible for developing a fire management plan as an integral part of the overall safety plan that would include evacuation procedures and designate escape routes. This plan would be consistent with the WRFO fire management plan in relation to suppression tactics and accepted practices.

Specifically, Shell would ensure that fire management objectives are achieved by:

- Coordinate with the BLM and Rio Blanco County Emergency Response teams in developing fire suppression priorities, identifying management restrictions, and determining appropriate fire suppression strategies.
- Equip construction equipment operating with internal combustion engines with approved spark arresters.
- Carry fire-fighting equipment (long-handled, round-point shovel and dry chemical fire extinguisher) on motor vehicles and equipment.
- Take immediate action to suppress accidental fires.
- Consistent with BLM guidelines, a fire break will be constructed around each of the test sites.
- Site personnel will be reminded of fire prevention practices concerning smoking materials, welding, etc. and will have hand tools available for fire control, including shovels and fire extinguishers.
- An emergency evacuation plan will be followed in the event of a fire.
- All motor vehicles and equipment will carry fire fighting equipment.

- Fire fighting equipment and water tanks on site will be staged in readily accessible areas.
- All welding will be done in areas where vegetation and other flammable materials have been removed.
- The power line will be constructed with defensible space.
- Large wood material salvaged during clearing operations will be redistributed. Materials will be disposed over the portion of the ROW from which the trees and brush were originally removed to meet fire management objectives and to provide wildlife habitat, seedling protection, and deter vehicular traffic.
- Should a wild fire occur within or adjacent to any of the test sites, Shell will notify the appropriate agencies and will provide assistance, where feasible, for containing and extinguishing the fire.
- Notify BLM, and the affected landowners, of any fires during construction, maintenance, or operation of the test sites.
- Control noxious weeds and cheatgrass as discussed in the Invasive, Non-Native Species section.
- Seed disturbed areas as discussed in the Vegetation and Soils sections should these practices not be successful, continued efforts would be made to establish desired vegetation within disturbed areas.
- Construct the combined power, communications, and pipeline ROW with defensible space. Defensible space would be achieved through an ecologically and aesthetically pleasing manner with thinning and mulching of trees and brush instead of removing all vegetation.
- Redistribute large, woody material salvaged during clearing operations on BLM WRFO-administered lands. Disperse materials over the portion of the ROW from which the trees and brush were originally removed to meet fire management objectives (not to exceed 5 tons per acre of evenly distributed material) and to provide wildlife habitat, seedling protection, and deter vehicular traffic.
- Provide all employees on site, as well as county and BLM officials, with a developed evacuation plan.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Development of oil shale RD&D facilities would restrict BLM's ability to use wildland fire to achieve public land health objectives and could be a long-term impact to fire management objectives. Large areas of mature vegetation would continue a downward decline in diversity of plant species, especially herbaceous species at the project locations. Higher costs per acre for fire management would be incurred by BLM for full suppression versus wildland fire use. Also, considerably higher costs can be expected for vegetation management by mechanical or prescribed fire means as is required by the BLM to meet public land health standards and fire management objectives. Implementing the proposed mitigation measures would decrease the potential for fire ignition, increase the ability for rapid response in the case of an accidental or natural ignition, and provide a framework fire management that would increase public safety in the event of a fire in the location of the Proposed Action.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

FORESTRY MANAGEMENT

Affected Environment – Sites 1, 2, and 3

Within the WRRA, the forest management program has been divided into two sections, Timberland Management and Woodland Management (BLM 1997). Timberlands consist of those lands that support stands of trees predominated by Douglas-fir, spruce/fir, lodgepole pine, and aspen. Woodlands consist of those lands that support stands of trees predominated by pinyon-juniper and Gambel oak. There are approximately 24,125 acres of timberlands and approximately 622,590 acres of woodlands in the WRRA (BLM 1997). The objective of the BLM for forestry is to manage the timberlands to maintain productivity, extent, forest structure, and enhancement of other resources.

The pinyon-juniper vegetation type is a broad classification covering several associations of pinyon pine (*Pinus edulis*) and various western junipers. The primary juniper species found in the resource area is Utah juniper (*Juniperus utahensis*). The type characteristically occurs on xeric ridgetops with shallow soils. It apparently has a competitive advantage over other vegetation types and is the climax association on these sites.

The pinyon-juniper association varies from an open to closed overstory of woodland conifers supporting highly variable understory shrub and grass-forb production. Understory production generally varies inversely with overstory closure. The type exists on a wide range of soils, elevations and exposures and is limited primarily by semiarid or cool-mesic climatic conditions and saline-alkaline soils. The type is found from about 5,200 to 8,000 feet corresponding to a general precipitation range of 10 to 20 inches per year. Approximately 150 acres total on all three Shell test sites are comprised of pinyon-juniper woodland.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

There are no timberlands located on or adjacent to these sites. Approximately 150 acres of pinyon-juniper woodlands could be removed in total from all three Shell test sites. The loss of pinyon-juniper woodland would adversely affect wildlife and nesting habitat. Impacts would be long-term until woodlands revegetate successfully. Pinyon-juniper woodlands would require 100 to 300 years to return to preconstruction conditions.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

In order to mitigate potential indirect impacts that could affect vegetation, forage, and nesting habitat, BLM would require alternative mitigation measures:

- Cut trees with a maximum stump height of 6 inches and dispose of the trees by one of the following methods: cutting the trees into 4-foot length, down to 4 inches in diameter, and placing the trees along the edge of the disturbance; removing the trees from federal land for resale or private use; or chipping and scattering the trees.
- Seed disturbed areas.
- Control noxious weeds.
- Acquire a fuel woods permit and compensate the BLM for trees.

Environmental Consequences of the Subalternative

Alternative mitigation would not decrease the potential loss of approximately 150 acres of pinyon-juniper woodland, but would decrease indirect impacts to soils and invasive species, and would enhance reclamation success.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

GEOLOGY AND MINERALS

Affected Environment – Sites 1, 2, and 3

The test sites are located within the northern portion of the Piceance Creek Basin which contains thick sequences of Eocene-age sedimentary bedrock. The Piceance Creek Basin is located within the Colorado Plateau physiographic province, which is characterized by dissected plateaus with strong relief (Fenneman 1931). The Piceance Creek Basin is a broad, asymmetric, southeast-northwest trending structural and topographic basin located in northwest Colorado. It is bordered by the White River Uplift to the east, the West Elk Mountains to the southeast and south, the Uncompahgre Uplift to the southwest, the Douglas Creek Arch to the west, and the Axial Basin Anticline to the north (Newman 1980). Deposition of sediments into this region began with downwarping of the basin floor in the Cretaceous and continued through Eocene time. Low stream gradients and moderate uplift of the marginal mountains prevented significant erosion of the basin's perimeter. This sequence of events resulted in the creation of the Wasatch Green River and Uinta formations in and around a series of landlocked lakes (Bradley 1964, Tweto 1980).

Stratigraphy

The Piceance Creek Basin contains stratified sediments ranging in age from Cambrian through middle Tertiary. Stratigraphically there are approximately 28,000 feet of rock units between the highest point on the White River Uplift to the east and the lowest depth of the basin, the Precambrian crystalline basement. The Precambrian crystalline basement rock is estimated to be 24,000 feet below ground surface in the central portion of the northern Piceance Creek Basin (Murray and Haun 1974).

In general, a thin veneer or unconsolidated Quaternary alluvium, valley fill, and terrace deposits occupies low-lying areas. Below these unconsolidated sediments lie approximately 8,000 feet of Tertiary sedimentary deposits.

The Tertiary section consists of three major formations: the Uinta (Eocene), Green River, and Wasatch (Paleocene-Eocene) formations. These sediments grade into the unconformable top of the Cretaceous Mesaverde Group. The stratigraphic sequence of interest at the nominated tracts is the Tertiary-age rocks of the Parachute Creek member of the Green River Formation.

At the nominated tracts, a thin veneer of unconsolidated surficial deposits (including residual, eolian, and alluvial deposits) overlie Uinta Formation bedrock. Below the Uinta Formation is the Green River Formation which includes the oil shale beds targeted by the project (Cashion 1973).

The Uinta Formation outcrops throughout most of the Piceance Creek Basin and is situated below the unconsolidated Quaternary sediments. The Uinta Formation consists of sandstones with interlayered sequences of siltstones and marly siltstones. Marlstone is more abundant in the lower portion of the formation. It also includes conglomerates and tuff. The Uinta Formation was formed mainly from clastic fluvial-deltaic sediments prograding southward, inter-tonguing with the lacustrine Green River Formation. The thickness of this formation varies among the nominated tracts.

The lower contact of the Uinta Formation with the Green River Formation is marked by an abrupt transition from gray siltstone to dark brown, moderately rich oil shale. Below this contact, siltstone, and other detrital rocks are rare.

The Tertiary Green River Formation in the Piceance Creek Basin is divided into four members: the Parachute Creek (upper member), Garden Gulch (intermediate member), Douglas Creek (lowest member), and Anvil Points (lateral correlative of the Douglas Creek and Garden Gulch Members, and part of the lower Parachute Creek Member). At the top of the Parachute Creek Member, tongues of the Green River Formation are interfingered with the lower part of the Uinta Formation. The Green River Formation rests conformably on top of the Wasatch Formation.

<u>Tongues of the Green River Formation</u>

Five major tongues of the Green River Formation composed of marlstone, silty marlstone, and lean oil shale are interstratified with the sandstones and siltstones of the Uinta Formation. These tongues, which are associated with lacustrine deposition, include (in stratigraphically descending order) the Coughs Creek, Black Sulfur (Black Sulphur), Thirteenmile Creek, Dry Fork, and Yellow Creek tongues (Duncan et al. 1974, O'Sullivan 1975).

<u>Parachute Creek Member</u>

The Parachute Creek Member is the uppermost unit of the Green River Formation. The Parachute Creek Member contains virtually all of the oil shale, nahcolite, and dawsonite resources in the Piceance Creek Basin. The Parachute Creek Member exceeds 2,000 feet in thickness in the depositional center of the basin. The upper part of the Parachute Creek Member is transitional with the Uinta Formation.

The Parachute Creek Member is composed of marlstone and lean to rich oil shale, some of which contains nahcolite, halite, and nahcolitic halite. These sedimentary rocks were predominantly chemically precipitated, which resulted in indistinct boundaries between the different rock types.

The mineral composition of the Parachute Creek oil shale and marlstones is similar, except that oil shale has a higher kerogen (organic matter) content. The general composition of these two rock types includes quartz, calcite, dolomite, analcime, potassium feldspar, albite, and minor concentrations of illite. Dawsonite may be disseminated throughout certain stratigraphic horizons.

The Parachute Creek Member is generally considered to comprise three distinct zones referred to (in stratigraphically descending order) as the Mahogany, Leached, and Saline zones.

Mahogany Zone - The Mahogany Zone is a rich oil shale interval that behaves as a leaky semi-confining layer. The Mahogany Zone is about 180 feet thick and is located between two thin layers of lean oil shale known as the A-Groove (above) and the B-Groove (below).

Leached Zone - The stratigraphic interval between the Mahogany Zone and the Saline Zone is referred to as the Leached Zone. Some documents refer to this interval as “the upper leached portion of the saline facies of the Saline Zone of the Parachute Creek Member.” The Leached Zone is usually discussed separately because all soluble saline minerals such as halite and nahcolite have been removed by the percolation of groundwater through this zone. The leached shale is badly fractured and contains numerous interstratified horizons of breccia, rubble, vugs, collapse intervals, and cavities.

Saline Zone - The Saline Zone has significant concentrations of nahcolite, dawsonite, and halite. The Saline Zone is separated from the Leached Zone by a well-defined contact known as the Dissolution Surface.

Stratigraphic analyses of the Saline Zone have shown that various oil shale zones, along with nahcolite, dawsonite, and halite horizons, are laterally continuous over long distances. One of the most widespread beds of microcrystalline nahcolite is the Love Bed, which underlies a minimum area of 60 square miles and ranges in thickness from 6.2 to 11.8 feet. Nahcolite in this layer averages about 60 percent by weight.

Garden Gulch Member, Douglas Creek Member, and Anvil Points Member

The Douglas Creek and Garden Gulch members contain sandstone, siltstone, marlstone, algal limestone, and some lean, clay-rich oil shale. Clay-rich oil shale is abundant in the Garden Gulch Member. The Douglas Creek Member is approximately 800 feet thick, and the Garden Gulch Member is about 700 feet thick (Bradley 1931). The Anvil Points Member is similar in composition and is actually a lateral correlative of the Douglas Creek and Garden Gulch members, as well as being part of the lower Parachute Creek Member.

Wasatch and Lower Tertiary Formations

The Wasatch Formation may reach a maximum thickness of 5,500 feet, making this stratigraphic sequence the thickest Tertiary unit in the Piceance Creek Basin. In the southern and eastern portion of the basin, the Wasatch Formation has been subdivided into the Shire, Molina, and Atwell Gulch members. The Shire Member has variegated siltstone, claystone, and sandstones. The Molina Member is dominated by massive, cross-stratified sandstone. The basal Atwell Gulch Member is composed of variegated siltstone and claystone (Donnell 1961). The Wasatch Formation is undivided in the northern part of the basin.

The base of the Tertiary section is composed of a conglomerate formerly called the Ohio Creek Formation, which overlies Cretaceous rocks of the Mesaverde Group (Hunter Canyon or Williams Fork Formation).

Geologic Hazards

The test sites lie within Seismic Risk Zone 1 (on a scale of 0 to 3, with Zone 3 having the highest risk) (Algermissen 1969). Within Zone 1, minor damage to structures from distant earthquakes may be expected. The National Earthquake Information Center data base (2006) was searched for the area within approximately 100 miles of the nominated tracts. Since 1950, the largest seismic event within the search area was magnitude 5.7 (Modified Mercalli Intensity VII) and was centered at approximately 39º 47'N, 108º 22'W which is 9 miles south of Site 2.

Significant faults are located subparallel to the anticline crest with fault tips at Black Sulphur Creek showing vertical stratigraphic separation of several feet. They are not known to be active.

Mineral Resource

Oil Shale and Marlstone

High grade oil shale yielding more than 25 gallons of oil per ton of shale is present beneath the project sites (Bunger et al. 2004, Cashion 1973). The oil shale beds are found within the Parachute Creek Member of the Green River Formation. The richest oil shale bed is the Mahogany Zone with total thickness of up to 200 feet and an average content of 26 gallons of oil per ton. Below the Mahogany Zone (separated by Groove B) lies the R-6 zone which is approximately 240 feet thick with an average richness of 25 gallons per ton (based on extrapolation from Sinclair Oil and Gas corehole 1, located in the center of Section 20 Township 1 North Range 99 West).

The Eocene Green River Formation conformably overlies the Wasatch Formation and it conformably underlies the Uinta Formation in the Piceance Basin (see Figure 13). The Parachute Creek Member of the Green River Formation contains most of the oil shale resources in the basin. The lithology of the Parachute Creek Member consists ubiquitously of interbedded oil shale and marlstone with minor thin beds of siltstone, and volcanic tuff. An oil shale contains greater than 10 gallons per ton oil yield from Fischer Assay analysis whereas a marlstone contains less than 10 gallons per ton. The two lithologies form an alternating stratigraphic succession of stacked organic-rich zones (R zones) composed primarily of oil shale and organic-lean zones (L zones) composed predominantly of marlstone. The organic-rich and organic-lean zones are laterally continuous and can be correlated across the Piceance Basin. The Parachute Creek Member contains the interval ranging from the R-2 zone through the R-8 zone.

Sodium-bearing Minerals

The Piceance Creek Basin contains the world’s largest and most economically significant nahcolite resource (naturally occurring sodium bicarbonate). The nahcolite-bearing intervals are typically interbedded with the oil shale in the Parachute Creek Member of the Green River Formation. The Parachute Creek Member thickens toward the basin-center, ranging from 650 feet on the basin margins to 1,750 feet in the north-central part of the basin. This thickening is largely attributed to increased deposition and preservation of marlstone, oil shale, and sodium-bearing minerals including nahcolite, dawsonite, and minor halite. The sodium-bearing minerals are interbedded, nodular, or disseminated within the oil shale and marlstone. The concentration and stratigraphic distribution of sodium-bearing minerals decreases rapidly toward the basin margins as a result of depositional facies and/or dissolution by circulating groundwater.

Nahcolite was deposited in varying amounts across the R-2 through R-8 interval during Eocene time. Nahcolite has undergone extensive groundwater leaching in the basin. Nahcolite occurs in the lower part of the Parachute Creek Member, ranging from the R-2 through L-5 interval in the depositional center of the Piceance Basin. This interval is commonly referred to as the Saline Zone. Lying above the Saline Zone is the Leached Zone where circulating groundwater has leached away the nahcolite and halite. Basinward of the Saline Zone limit the nahcolite-bearing rocks increase in thickness and nahcolite concentration. The top of the Saline Zone, also known as the dissolution surface, rises stratigraphically toward the depositional center of the basin. The dissolution surface ranges from the R-2 zone on the west and climbs stratigraphically to the L-5 zone in the center of the basin. It represents the lowest stratigraphic level where groundwater has leached the nahcolite in the Parachute Creek Member.

All three of the test sites are located to the west-southwest of the limit of the Saline Zone. At Sites 1 and 3, much of the originally deposited nahcolite has been leached away by circulating groundwater beneath the tract and are located in an area identified in the BLM ROD/RMP (BLM 1997) as available for sodium and oil shale leasing. The nahcolite-leached rocks form stratified layers with varying degrees of vugular porosity, fracture porosity, and permeability. These rocks contain substantial volumes of groundwater in the pore space and can display high transmissivities. Geo-hydrologic models will be developed for Sites 1 and 3 during the delineation phase on the test sites.

At Site 2, the dissolution surface beneath the site occurs near the L-4 zone. The nahcolite-leached rocks above the dissolution surface, also referred to as the Leached Zone, form stratified layers with varying degrees of vugular porosity and permeability. They can hold substantial volumes of groundwater, and can be strong potential flow intervals. Below the dissolution surface the nahcolite-bearing interval (Saline Zone) has not been leached by circulating groundwater. The Saline Zone ranges stratigraphically from near the L-4 zone at the top of the zone down to the R-2 at the base. Site 2 is located in an area identified in the BLM ROD/RMP as available for multi-mineral leasing and is encumbered by federal sodium lease COC-0120057.

Dawsonite, a mineral consisting of sodium-aluminum carbonate, occurs as small, disseminated crystals within the marlstone and oil shale. It occurs primarily within the R-2 through R-5 interval of the Parachute Creek Member. Dawsonite is not a soluble mineral in groundwater and as a result it has not been leached. The x-ray diffraction data from the Stake Springs Draw #1 core hole, located one mile southeast of Site 2, indicate dawsonite concentrations up to 15 percent by weight in some samples. The average dawsonite concentration is estimated to be 5 percent by weight across the R-2 through R-5 interval. Beneath Site 3, the average dawsonite concentration is estimated to be 4 percent by weight in the R-7 through R-3 interval.

Coal, Metallic Minerals, and Natural Gas

Coal deposits beneath the nominated tract are at depths greater than 3,000 feet and are not considered recoverable using current technologies. There are no coal mines in the immediate area (Kirschbaum and Biewick 2003). The formations do not contain locatable mineral deposits in significant concentrations. The test sites are not located near any active sand and gravel quarry operations (Schwochow 1981).

The test sites are located in an area underlain by several natural gas reservoirs. Based on review of the most recent Colorado Oil and Gas Conservation Commission (COGCC) data available, within a 5-mile radius of the three test sites, there are approximately 31 producing gas wells, 6 shut-in wells, 3 temporarily abandoned wells, 30 dry and abandoned or plugged and abandoned wells, 1 injection well, 1 well waiting on completion, 22 abandoned locations that were likely never drilled, and 24 permitted locations waiting to be drilled (Figure 18). Most of the wells are completed at depths of 9,000 to 12,000 feet below ground surface, which is well below the strata containing the oil shale. Some condensate is produced along with the gas, but there is little oil produced from existing wells within this area. The COGCC show three gas fields in the area: Corral Creek (producing from the Mancos, Dakota, and Morrison formations), Sage Brush Hills II (producing from the Mancos and Mesaverde formations), and the Sulphur Creek field (producing from the Wasatch, Mesaverde, Williams Fork, and Mancos formations). Sites 1, 2, and 3 are located within the Left Fork and Ryan Gulch federal oil and gas exploratory units. They are encumbered by the following federal oil and gas leases:

- COC-64204 and 60754 located at Site 1
- COC-60737 located at Site 2
- COC-60753 located at Site 3

Only one of the test sites is located in close proximity to gas wells; there is one gas well located about a 1/2-mile north of Site 2. There are also three currently-permitted gas well locations within approximately 1/2-mile of Site 2.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

The potential environmental consequences of the Proposed Action are described below.

Geologic Hazards

There are no significant geological hazards which would have any impact on the Proposed Action. The Proposed Action at the test sites is not expected to create or exacerbate geologic hazards. For the Proposed Action, surface subsidence could be up to 1 inch, with no visible surface cracks, and would occur slowly over a period of about 10 years.

Mineral Resources

The Proposed Action will extract oil shale and nahcolite (Site 2 only) resources at the test sites. This would result in a loss of these resources for future use. At Site 1, the recoverable resource is distributed within the R7 to R4 intervals; however, recovery of kerogen from the R4 interval is considered “technology-driven” at this time. For Site 2, the recoverable resource is located within the R7 to R3 intervals; however, the recovery of kerogen from the R3 and R4 intervals is technology driven. At Site 3, the recoverable resource is within the R7 through R2 intervals, with the recovery of kerogen present in the R2, R3, and R4 intervals considered technology driven.

The volume of potentially extractable resources at each site were estimated based on the assumption that all of the resource just listed was technologically available for extraction, and that oil shale is 35 percent kerogen, assuming 100 percent can be recovered, and that the lean (L) intervals comprise 10 percent of the lithologic material shown in Figure 14 (Stratigraphic Column). The amount of potentially recoverable shale oil at Sites 1, 2, and 3 is 25.5 million, 29 million, and 32 million gallons, respectively.

The volume of nahcolite that could be recovered at Site 2 using solution mining was estimated using several assumptions, including: the saline zone is approximately 400 feet thick, nahcolite comprises 20 percent of the volume of the strata, and the solution mined area is the same size as the proposed heated zone at Site 1. The resulting weight of nahcolite that could be produced is approximately 72,000 tons. The maximum anticipated volume of water that would be required to extract the nahcolite, and that would be removed from the upper Parachute Creek unit during the course of the solution mining is 7.8 million gallons.

Directional drilling to recover the oil and gas resources beneath the developed tract(s) would be required to prevent interference with the RD&D development.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

In order to minimize potential indirect impacts that could affect mineral resources, BLM would require Shell to contact the lease holders of federal oil and gas leases and inform them of their proposed activities.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

The alternative mitigation would not decrease the direct impacts on the mineral resources in the proposed test sites but would lead to the resolution of conflicts over mineral resources.

Environmental Consequences of the No Action Alternative

Under the No Action Alternative, oil shale and nahcolite resources which would have been extracted under the Proposed Action would remain. Site-specific knowledge and information of the targeted resources and proposed technologies would not be obtained.

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

HYDROLOGY AND WATER RIGHTS

Affected Environment

The regional studies completed in the area associated with the Proposed Action assessed tributaries to Yellow Creek and Piceance Creek, which are the two streams flowing within the topographic basin to the White River. The White River is a tributary of the Green River, which is a tributary to the Lower Colorado River. Each of the three test sites is located in different tributary regions of Yellow Creek. Previous investigations of surface water quality have been completed in the vicinity of each of the three test sites. More recent studies of surface water and groundwater hydrology and water quality in the area of the three test sites have been completed by Shell.

Precipitation is about 12 inches annually, occurring throughout the year in winter snow showers and summer thunderstorms. Wettest months are March through May with September through October being fairly dry. Most precipitation is lost to evapotranspiration; an estimated 98% of snowmelt and precipitation is lost to evapotranspiration. The remaining water runs off rapidly and replenishes stream flow or recharges the water-bearing zones (Taylor 1987). Approximately 80% of annual stream flows in Piceance Creek originates as discharge from alluvial and bedrock water-bearing zones (Tobin 1987).

Water is a valuable commodity in the western United States due to limited supply. Colorado water rights (and water rights in the western United States in general) are governed by the doctrine of prior appropriation, which bases enforcement of water rights on priority in time. To obtain a water right a party must make a diversion and beneficial use of water. To perfect that right (i.e., to make it enforceable against others), a party must obtain a judicial decree from the Colorado Water Court system. The date of the decree determines priority in time. A prior right is a senior right. To protect downstream senior rights, junior users may be prevented from exercising their rights. A right to use groundwater additionally requires the approval of an augmentation plan to protect against harming downstream senior users due to the delay in manifestation of harm associated with subsurface waters.

Site 1 – Oil Shale Test Site

Site 1 is located on a ridge between Stake Springs Draw to the south, and Corral Gulch to the north. Both Stake Springs Draw and Corral Gulch are tributaries to Yellow Creek which is an intermittent stream (with perennial reaches) flowing north to the White River. Stake Springs Draw and Corral Gulch are also intermittent, with short reaches of perennial flow in association with springs and seeps.

Springs and seeps near Site 1 (with the possible exceptions of two at Yellow Creek) discharge from alluvial sediments near the floor of the stream channels in the major drainages. The alluvial groundwater systems that support streams and springs in the study area are likely recharged from higher-elevation regions to the west along Cathedral Bluffs, where precipitation and the potential for groundwater recharge is greater. The Uinta Formation generally underlies alluvial groundwater systems present in the major drainages. The Uinta Formation consists of sandstones with interlayered sequences of siltstones and marly- siltstones. Permeability would be variable as sandstones are more permeable than siltstones. Additionally, joints and fractures within the formation greatly increase hydraulic conductivity and are likely sources for groundwater discharge that would be partially responsible for recharging localized alluvial water-bearing units. The alluvial water-bearing units likely act as conveyance mechanisms for water from recharge areas to the west to discharge areas in lower-elevation regions to the northeast. This is further substantiated by the fact that there are no springs or seeps (bedrock or colluvial) that discharge from the hillsides along the margins of the drainages. Similarly, there is no water in the ephemeral surface water drainages in the upland areas between the major drainages. This suggests that discharges from springs in the channel bottoms in the major drainages are likely from alluvial groundwater systems. Surface water hydrology monitoring locations for the test sites are shown on Figure 20.

Proposed Surface Water Monitoring Locations Near Site 1

Location Relative to Test Site	Stream	Location Name
Upstream	Corral Gulch	CR242
Downstream	Corral Gulch	CR408
Upstream	Stake Springs Draw	CR407
Downstream	Stake Springs Draw	CR411
Downstream	Yellow Creek	CR412 and CR255

Site 2 – Nahcolite Test Site

Surface hydrology studies for the Site 2 area to date have been conducted on Stake Springs Draw, which flows to Yellow Creek. Site 2 is located above an unnamed tributary of Stake Springs Draw. Stake Springs Draw has eight sample sites listed on the following tables (two are for streams and six are from springs), and there are four sites on Yellow Creek (one for the stream and three for springs). The stream and spring monitoring sites are listed in the two tables below. The locations of these sites are shown on Figure 10. Water quality and quantity parameters were measured at each of the locations.

Stake Springs Draw is an intermittent stream with exceptionally low flows (see the following table). It has a contributing watershed of 30 square miles. Flows immediately upstream of the confluence of the unnamed tributary of Stake Springs and Stake Springs Gulch (CR411) exhibited no flow in three visits (Shell 2006c). However, seasonal variations in surface water flow regimes may be attributed to this finding because the time of year these observations were made is unknown. Site CR255 on Yellow Creek is near the confluence with the White River, and does exhibit perennial flow, due to the size of the contributing watershed (262 square miles).

Stream Flows (Discharge) Near Site 2 (cfs)

Drainage	New Site Name	Count	Min	Max	Mean	Median
Stake Springs Draw	CR407	6	0.00	0.16	0.04	0.01
Stake Springs Draw	CR411	3	0.00	0.00	0.00	0.00
Yellow Creek	CR255	15	0.64	25.95	3.60	1.78

cfs = cubic feet per second

There are multiple springs in the region (see the following table). Flows for springs in Stake Springs Draw range in flow from 0 to 0.16 cfs or 74 gpm. Flows for springs along Yellow Creek range in flow from 0 to 1.16 cfs or 520 gpm. The largest spring in Yellow Creek is SP129, which exhibited the elevated flows of 520 gpm. It is located 2 miles below the confluence of Big Duck Creek and Yellow Creek in Township 1 North Range 98 West Section 34.

Spring Flows Near Site 2 (cfs)

Drainage	New Site Name	Count	Min	Max	Mean	Median
Stake Springs Draw	SP154	6	0.00	0.164	0.0349	0.00
Stake Springs Draw	SP155	6	0.017	0.056	0.033	0.033
Stake Springs Draw	SP156	6	0.008	0.013	0.011	0.012
Stake Springs Draw	SP156A	5	0.002	0.002	0.002	0.002
Stake Springs Draw	SP156B	5	0.00	0.00	0.00	0.00
Stake Springs Draw	SP157	5	0.00	0.00	0.00	0.00
Yellow Creek	SP129	13	0.00	1.159	0.397	0.348
Yellow Creek	SP130	4	0.002	0.011	0.007	0.007
Yellow Creek	SP162	4	0.00	0.00	0.00	0.00
Yellow Creek	SP163	5	0.00	0.00	0.00	0.00

cfs = cubic feet per second

All of the springs and seeps near the Site 2 area (with the possible exceptions of two at Yellow Creek) are observed in the bottoms of the ravines within the alluvium in the major drainages. There were no springs or seeps (bedrock or colluvial) observed to discharge from the hillsides along the margins of the drainages. Surface water drainages in the upland areas between the major drainages are ephemeral.

Site 3 – Advanced Heater Test Site

Surface hydrology studies for the Site 3 area to date have been conducted on Big Duck Creek and Corral Gulch, which flow to Yellow Creek. Site 3 is located near an unnamed tributary to Big Duck Creek (to the north) and Corral Gulch which bounds the property to the south. Big Duck Creek has two sample sites, Little Duck Creek has one sample site, Corral Gulch has seven sample sites, and there are four sites on Yellow Creek. The locations of these sites are shown on Figure 20. Five of the sites are stream locations and 10 of the sites are springs.

Flows and water quality parameters were measured at each of the locations. Stream flow varied seasonally, and did not exceed 3 cfs during sampling events on Corral Gulch or Big Duck Creek (see the following table). Corral Gulch is intermittent among many of its reaches. Yellow Creek is perennial to the north near site CR255.

Streamflows Near Site 3 (cfs)

Drainage	Site Name	Count	Min	Max	Mean	Median
Big Duck Creek	CR405	7	0.12	0.51	0.23	0.14
Corral Gulch	CR235	13	0.00	0.77	0.16	0.11
Corral Gulch	CR242	16	0.15	3.00	0.48	0.26
Corral Gulch	CR408	6	0.01	0.59	0.16	0.11
Yellow Creek	CR255	15	0.64	25.95	3.60	1.78

cfs = cubic feet per second

Flows have been monitored in 10 springs in Big Duck Creek, Duck Creek, Corral Gulch, and Yellow Creek, and flows are summarized in the following table.

Spring Flows Near Site 3 (cfs)

Drainage	Site Name	Count	Min	Max	Mean	Median
Big Duck Creek	SP118	7	0.025	0.047	0.035	0.033
Little Duck Creek	SP124	10	0.370	0.902	0.650	0.622
Corral Gulch	SP105	9	0.000	0.001	0.000	0.000
Corral Gulch	SP106	9	0.000	0.003	0.001	0.000
Corral Gulch	SP107	9	0.000	0.004	0.002	0.002
Corral Gulch	SP159	5	0.000	0.245	0.093	0.071
Yellow Creek	SP129	13	0.000	1.159	0.397	0.348
Yellow Creek	SP130	4	0.003	0.011	0.007	0.007
Yellow Creek	SP162	4	0.000	0.000	0.000	0.000
Yellow Creek	SP163	5	0.000	0.000	0.000	0.000

cfs = cubic feet per second

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Water requirements vary throughout the project life. Water uses include construction, potable water, dust control, drilling, processing, filling and cooling of the heated interval for reclamation, and rinsing of the zone inside the freeze wall.

Water would be trucked to the site for initial construction and drilling activities. Potable water for personnel consumption would be trucked to the site throughout the life of the facilities.

On-site water will be used for most operational uses and would be supplied from water wells drilled for that purpose. A primary and a backup water supply well are planned for each test site. The well would supply water needed for processing and reclamation. Peak pumping demand (250 to 300 gpm, approximately 400 to 480 acre-feet per year) would occur during the cooling and resaturation phase of the reclamation cycle. If the water well is available during construction and drilling, then this water would supplement or replace construction and drilling water trucked to the site.

Water needs for each phase of the operation are outlined below. The projected water needs are estimates and are subject to change as additional information becomes available and facility designs are finalized. The current estimated water need for process water is 10 gpm. This water would be supplied from groundwater extracted from either the Uinta or Upper Parachute Creek units. Water rights required for the project would be acquired prior to the startup of the operation. The combined annual volume of water required for all three sites is unknown at this time, and would vary based upon when each project is started and progresses. Assuming that all three sites are operating at the same time for at least one year, the combined process water needs would be a minimum of 30 gpm. This flow rate equates to an annual volume of almost 48 acre-feet per year.

Construction water would be trucked to the sites as necessary for use in compaction, dust control, and miscellaneous construction water needs. Potable water needs during construction would be brought to the sites.

Water required for drilling would be trucked to the sites until water from the on-site water supply well is available to supplement or replace trucked water.

Water would be needed for various processing and operating needs. Water removed with the hydrocarbon products would be treated in the processing facilities and recycled or discharged at a permitted discharge point. The locations of discharge points have not been determined. It is currently anticipated that there would be excess water available during the initial processing period as a result of dewatering operations from within the freeze wall containment area and that there would be no need for the water supply well to provide water for processing during this initial period. As processing progresses, there would be a need for additional water in processing.

Water is also needed to conduct reclamation filling and cooling of the heated interval within the freeze wall containment barrier as well as rinsing of the heated interval. This water would be a combination of recycle water and make up water from the water supply well as needed. During reclamation a water supply would be needed for initial stages of flushing and cooling. Two wells would be completed in the upper Parachute Creek Unit to serve as reclamation water supply wells. However, only one well would be used at a time. Anticipated water usage for the Proposed Action is shown in the following table.

Anticipated Water Usage

Water Requirements	Water Source	Estimated Water Usage(1)			Stream Depletion(2)	
		Site 1	Site 2	Site 3	Yellow Creek	Piceance Creek
Potable Water	Trucked In	Unknown	Unknown	Unknown	NA	NA
Drilling	Trucked In or Groundwater	5 gpm (8 a-f/yr)	5 gpm (8 a-f/yr)	5 gpm (8 a-f/yr)	NA	NA
Construction Water	Trucked In	6 gpm (10 a-f/yr)	6 gpm (10 a-f/yr)	6 gpm (10 a-f/yr)	NA	NA
Process Water(3)	Groundwater	10 gpm (16 a-f/yr)	10 gpm (16 a-f/yr)	10 gpm (16 a-f/yr)	No known depletion	No known depletion
Nahcolite Recovery(4)	Groundwater	NA	7.8 million gallons (24 a-f)(5)	NA	No known depletion	No known depletion
Reclamation(6)	Groundwater	300 gpm max (480 a-f/yr)	300 gpm max (480 a-f/yr)	300 gpm max (480 a-f/yr)	19 a-f/yr max each site	6 a-f/yr max each site

1 - Estimated quantities of water usage for Sites 2 and 3 are based on the Plan of Operations for Site 1.
2 - Estimated maximum annual depletion from preliminary groundwater modeling at Site 1. Annual depletion ranges from 0 to 19 a-f/yr (Yellow Creek) or 0 to 6 a-f/yr (Piceance Creek) over the project life.
3 - Groundwater would be obtained initially from extraction wells inside the freeze wall (initial dewatering); subsequent process water would come from water wells completed in the Upper Parachute Creek Unit. Process water is treated and recycled again for process operations.
4 - Groundwater for nahcolite solution mining would largely originate from dewatering of the freeze wall interior area, with additional water from extraction wells in the Upper Parachute Creek Unit located outside of the freeze wall. Water used would be treated and reused.
5 - Volume estimated for nahcolite solution mining a 130 feet by 100 feet pyrolyzed zone footprint. Water would be treated and reused.
6 - Reclamation includes quenching, cooling, and reclamation of the pyrolyzed zone. Groundwater would originate from extraction wells in the Upper Parachute Creek Unit located outside of the freeze wall, and would be treated and reused.
a-f = acre-feet
a-f/yr = acre-feet per year
gpm = gallons per minute
max = maximum anticipated or estimated
NA = Not Applicable

Colorado water rights law applies to all tributary water. All water is presumed to be tributary. A party may rebut this presumption by showing that the diversion would not affect the flow of any stream by 0.1 percent within 100 years. Non-tributary water is deemed to be possessed by the owner of the property on which it is found.

There are several potential environmental consequences of the Proposed Action relative to water quantity issues.

The production of kerogen extraction from oil shale beneath each test site would require significant volumes of groundwater. The volume of process water anticipated to be required at each test site is approximately 10 gpm or 5.25 million gallons per year (16 acre-feet per year). This water would be obtained from extraction of groundwater from the upper Parachute Creek Unit. Water for human consumption would be trucked in to each site as necessary. Perhaps the largest volume of groundwater required will be during the post-heating reclamation phase, to quench (cool), resaturate, and rinse the heated area. Drawdown of water levels in the upper Parachute Creek Unit may impact streamflows in Yellow or Piceance creeks.

Use of groundwater could impact surface water and groundwater available for other water users and various forms of wildlife. Shell must have sufficient senior water rights to supply their anticipated usage at each test site.

Given the relatively small footprint of the heated area (approximately 100 feet by 130 feet wide), natural groundwater flow patterns would likely be modified only slightly, if at all, after production. The structure of the oil shale/marlstone beds would likely remain in place. The porosity of the marlstone would increase approximately 30 percent from the removal of kerogen, increasing the storage capacity of the saturated intervals. The estimated increases in storage volume due to removal of kerogen at Sites 1, 2, and 3 are 25.5 million gallons, 29 million gallons, and 32 million gallons, respectively. The dewatering and heating of the production area would be performed below the Uinta Unit, and is not anticipated to impact long-term surface recharge or flow within the Uinta Unit. Shell is committed to not impacting beneficial users of groundwater and surface water in the area of the test sites.

The estimated groundwater volume for solution mining of nahcolite is 7.8 million gallons (approximately 24 acre-feet). This water would be extracted from the area inside the freeze wall, treated, and returned to the groundwater system through injection wells located downgradient of the freeze wall as part of the dewatering process prior to initiating the heating phase.

Groundwater will be extracted from one or more wells completed within the Upper Parachute Creek Unit located outside of the freeze wall area. The maximum extraction rate during the reclamation phase is 300 gpm, and would be ongoing for up to 18 months. This equates to approximately 725 acre-feet of water over the 18-month period. Extraction of groundwater from the Upper Parachute Creek Unit would affect water levels in the upper saturated interval (Uinta Unit), which would in turn reduce groundwater discharge to Yellow Creek and potentially other creeks in the area. Initial modeling of the regional effects of this groundwater pumping at Site 1, results in a preliminary estimate of the maximum annual depletion of 19 acre-feet per year (0.026 cfs) to surface flows in Yellow Creek, which is within the Upper Colorado River Basin. A typical flow rate for Yellow Creek where it enters the White River is approximately 3 cfs, so the potential depletion represents less than one percent of the total flow. The preliminary estimated maximum annual depletion to Piceance Creek is 0.008 cfs. This represents about one-hundredth of the average stream flow in Piceance Creek of 59 cfs. This preliminary estimate is based on modeling performed for Site 1, which will have the largest volume of reclamation water needed of the three test sites.

Based on the current hydrogeologic model, and the small scale of the test sites, there appears to be low likelihood of significant long-term impacts to surface water or groundwater from the individual test sites. However, additional newly collected information regarding hydrogeologic conditions will be provided to the BLM and reviewed to verify the hydrogeologic model and proposed mitigation measures.

Preliminary groundwater modeling results for the regional area suggest that the radius of influence from the extraction of 300 gpm from the upper Parachute Creek Unit over the course of a year may result in a drawdown cone that extends a distance of approximately 2 miles from the extraction well(s) location.

Shell is in the process of acquiring additional water rights from the YZ Ranch. These rights are senior and include 70 cfs on the White River. Shell has numerous smaller water rights within the Piceance Basin. An augmentation plan will be submitted for use of groundwater. Shell will provide BLM with a list of water rights including beneficial uses, volume decreed, and relative seniority of individual rights.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Prior to the heating phase, groundwater would be extracted from within the hydraulic confines of the freeze wall. The extraction wells would be completed within the Upper and Lower Parachute Creek units. This groundwater would be reinjected outside of the freeze wall perimeter into the Lower Parachute Creek Unit. The dewatering that occurs inside the freeze wall area would not cause any surface water depletions. Reinjection of this groundwater outside of the freeze wall is anticipated to increase groundwater discharges to the White River (augmentation) by a similar amount. As the lead federal agency, the BLM would initiate consultation with USFWS based on the average annual water depletion amount over the life of the project (10 years). If the average annual depletion is less than 100 acre-feet, the project is considered a “small project depletion” and USFWS can issue a 2-page Biological Opinion. If the average annual water depletion exceeds 100 acre-feet, then the consultation is more complicated and would result in a longer Biological Opinion. Currently available information indicates that the three test sites combined would result in stream depletions of less than 100 acre-feet of water annually over the life of the project.

In order to minimize potential indirect impacts that could affect hydrology, BLM would require alternative mitigation measures:

- Up-gradient and down-gradient multi-level monitoring wells will be installed along the edges of the tract to characterize the structure and properties of local aquifers, establish pre-development baseline groundwater conditions, better define the geology of the oil shale resource, and monitor water quality. Additionally, the stream flow in nearby streams and springs will also be monitored. All monitoring data will be submitted to the BLM for further review.
- Design of the de-watering and re-injection program will be submitted to the BLM for review.

- Water that cannot be recycled or otherwise used will be treated to appropriate discharge standards in the process water treatment plant and released to a surface drainage under a Colorado Discharge Permit.

For additional mitigation measures see the Water Quality, Surface Water and Groundwater section.

Environmental Consequences of the Subalternative Mitigation – Sites 1, 2, and 3

The Shell project could alter groundwater between the Mahogany and R-6 zones and adjacent aquifers could be altered and the withdrawal and injection wells could locally alter groundwater hydrology in the upper aquifer. Up-gradient and down-gradient monitoring wells would first establish baseline data to characterize the structure and properties of local aquifers and groundwater conditions and construct a groundwater model. These data would provide critical information on continuing water quality through the life of the Proposed Action, and would be incorporated in the final design of the de-watering and reinjection systems. These measures would limit the potential for impacts to groundwater.

Changes in upper aquifer hydrology could alter interactions between the upper aquifer, alluvial aquifers, and surface waters. Well completion design and cementing surface and intermediate casings would protect shallower waters. Surface water characterization and monitoring in nearby streams and springs would provide early identification of any surface water impacts that could potentially be associated with this project.

The alternative mitigation would reduce or minimize these impacts to surface and groundwater resources resulting from the Proposed Action.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

NOISE

Affected Environment

Noise is defined as unwanted or annoying sound that is typically associated with human activities and that interferes with or disrupts normal activities. Sound and noise are measured as sound pressure levels in units of decibels (dB). Response to noise varies according to its type, its perceived importance, its appropriateness in the setting and time of day, and the sensitivity of the individual receptor. Human hearing is simulated by measurements in the A-weighting (dBA) network, which de-emphasizes lower frequency sounds to simulate the response of the human ear. Some typical sound levels from common noise sources are presented in the following table.

Sound Levels Associated With Noise Environments and Field Operations

Noise Source	Scale of A-weighted Sound Level (dBA)	Human Judgment of Noise Loudness (relative to a reference loudness dB*)
Typical construction site at 50 feet	85	*Approximately 15 times as load
Diesel truck, 40 mph at 50 feet	75	*Approximately 8 times as loud
Light traffic at 50 feet	56	*Approximately 2 times as loud
Rural area daytime	45+	Reference loudness
Rural area at night	35+	Quiet - * 1/2 as loud
Human voice whisper at 5 feet	20	Very quiet

* These values are logarithmic measurements (i.e., Every 10-dBA increase is perceived by the human ear as approximately twice the previous noise level. Therefore, a rural area during the day is about twice as loud to the human ear as a rural area at night). Source: Compiled from EPA 1974.
+ Corrected for high winds.
dB = decibels
dBA = A-weighted decibels
mph = miles per hour

A noise analysis has not been conducted at the three Shell test sites. Due to the extreme rural nature of the project sites, it is assumed existing conditions are very quiet.

Environmental Consequences of the Proposed Action – Sites 1, 2 and 3

Colorado has established a Noise Statute that identifies the maximum permissible noise levels that may radiate from any source or activity. The COGCC has also established noise control regulations applicable to oil and gas facilities, consistent with the Colorado Noise Statute, that identify allowable noise levels. The following table identifies the allowable noise levels for Colorado based on time periods and zones. The Shell test sites are located in a rural/agricultural setting, therefore it is likely that the allowable noise levels from the project will be 50 to 55 dbA.

COGCC Allowable Noise Levels

Zone	7:00 am to 7:00 pm	7:00 pm to 7:00 am
Residential/Agricultural/Rural	55 dbA	50 dbA
Commercial	60 dbA	55 dbA
Light Industrial	70 dbA	65 dbA
Industrial	80 dbA	75 dbA

dBA = A-weighted decibels

There are no potential noise receptors or noise sensitive areas such as homes, schools, hospitals, or churches within one mile of the proposed site.

Noise generated during the testing phase of the project will be from drill rigs installing monitoring wells and the heating/production wells. The noise generated will be typical of other smaller well drilling operations in the area, and no receptors are anticipated to be impacted. Equipment used in the facilities will be designed to meet COGCC noise levels as required. Noise readings will be taken at the site during operations to verify noise levels.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

In order to minimize potential impacts from noise, BLM would require alternative mitigation measures:

- Install and maintain appropriate mufflers and silencers on construction equipment and facility machinery.
- House or cover noise producing sources with appropriate insulated facilities.

Environmental Consequences of the Subalternative Mitigation – Sites 1, 2, and 3

Impacts related to construction activities and operation of the facility would be minimized by complying with the COGCC allowable noise level conditions and by implementing measures to reduce noise levels.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

PALEONTOLOGY

Affected Environment

The Piceance Basin has a structural aerial extent of about 7,225 square miles. Hence, there are large areas of public lands in the Piceance, and other basins, that include exposures of the Uinta and Green River formations. The Green River and Uinta formations are known in many parts of the region to host important paleontological (fossil) resources. While these formations have not been previously investigated in detail in all of the test sites, it is possible that they all contain commonly occurring and scientifically significant paleontological resources.

Paleontological resources are considered scientifically significant based on a number of accepted criteria including:

- All vertebrate fossils.
- Any invertebrate, ichnofossil, or paleo-botanical resource that represents an undescribed taxon or expands the understanding of a known taxon.
- An assemblage of taxa that allows the study of a paleo-environmental grouping.
- Any fossil that may aide in the understanding of the rock unit in which the fossil was deposited. This would include “index fossils” that represent the relative chronology of the rock unit and any fossil that aide in the understanding of the depositional environment.

Scientifically significant paleontological resources have been recorded in the Piceance Creek Basin from various named and unnamed tongues of the Uinta Formation and the Green River Formation and from the underlying Parachute Creek Member of Green River Formation (Robinson 1978, Bilbey and Hall 1999, Johnson 1985). Fossils, particularly fossil plants, fossil insects, and vertebrates (fish and other very rare vertebrates), have been recovered from the Parachute Creek Member of the Green River Formation.

The various tongues of the Uinta and Green River Formation represent a period of regressive and transgressive lake margins within the Piceance Creek Basin. The Uinta Formation is fluvial while the Green River Formation is lacustrine.

Site 1 – Oil Shale Test Site

Site 1 was surveyed for paleontological resources in 2005 (Young 2005). It was determined by this study that the depositional environment in this area was active and did not lend itself to the preservation of fossil remains. Therefore, it was concluded that the chance for discovery of identifiable plant or animal remains in this area is not good.

Site 2 – Nahcolite Test Site

Paleontological investigations have not been conducted in the Site 2 area.

Site 3 – Advanced Heater Test Site

A survey was previously conducted of Site 3 to determine the potential for scientifically significant paleontological resources for a land exchange (Paleontological Investigations 2003).

The site is in an area mapped as "Group C tongues of the Uinta and Green River Formations." Group C includes the Thirteenmile Creek and Black Sulphur Tongues of the Green River Formation and one unnamed tongue of the Uinta Formation. Laterally equivalent Group C exposures are mapped on more than 85 square miles in the surrounding area, much of which is federally managed lands. Therefore, it is possible that any paleontological resources found on Site 3 could also occur on other nearby federal lands.

The unnamed tongue of the Uinta Formation is exposed in incised drainages on the site. A number of paleo-botanical sites were recorded during the survey for the land exchange in adjacent sections but not in the specific test site area. However, the survey methodology did not provide for 100 percent coverage of the site and it is likely that these types of fossils occur there as well. In general, fossil plants from the Uinta Formation in the Piceance Creek Basin have not been studied in any detail. The fossil plants found on Site 3 represent both a chronologically younger assemblage and a depositional change (fluvial rather than lacustrine) than the better-understood Parachute Creek Member of the Green River Formation. Therefore, these sites are significant paleontological scientific resources.

Vertebrate fossils recorded from Uinta tongues in the Piceance Creek Basin have been observed within a basal conglomerate (Robinson 1978, Bilbey and Hall 1999). In support of the investigation of the Site 3, this conglomerate was reexamined at the recorded localities approximately 8 miles east of the site. This particular conglomerate was not observed within the Uinta tongue exposed on the site, nor were any vertebrate fossils observed on the site. Thus, it is deemed unlikely that the Uinta Formation rocks exposed on Site 3 contain vertebrate fossils.

Environmental Consequences of the Proposed Action

The environmental consequences of each site are described below.

Site 1 – Oil Shale Test Site

No paleontological resources were found on Site 1; therefore, there would not be environmental impacts expected from the Proposed Action at the site on paleontological resources. This presumes that it would be unnecessary to excavate into the underlying rock for foundations for any of the facilities. If it is necessary to excavate for foundations for any building or facility, there is a potential to impact fossils. A staff BLM paleontologist would be notified at that time for further evaluation.

Site 2 – Nahcolite Test Site

Paleontological investigations have not been conducted at Site 2; therefore, it is not known if the Proposed Action would impact any significant paleontological resources. If it is necessary to excavate for foundations for any building or facility, there is a potential to impact fossils. A staff BLM paleontologist would be notified at that time for further evaluation.

Site 3 – Advanced Heater Test Site

Scientifically significant plant fossil remains have been identified in the vicinity of Site 3. It is thus probable that the Proposed Action would have an impact on significant paleontological resources.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Impacts to any paleontological resources would be minimized by implementing BLM mitigation measures as follows:

- Avoid known paleontological resource sites by not utilizing the entire construction workspace.
- If site avoidance is not feasible (such as at Site 3), the sites may be quarried prior to construction to recover a sampling of the paleontological resources. These recovered fossils would then be curated in a recognized repository and be available for future study.

The operator is responsible for informing all persons who are associated with the project operations that they would be subject to prosecution for knowingly disturbing paleontological sites, or for collecting fossils. If fossil materials are uncovered during any project or construction activities, the operator would immediately stop activities in the immediate area of the find that might further disturb such materials, and immediately contact the AO. Within five working days the AO would inform the operator as to: whether the materials appear to be of noteworthy scientific interest and the mitigation measures the operator would likely have to undertake before the site could be used (assuming in-situ preservation is not feasible).

If the operator wishes, at any time, to relocate activities to avoid the expense of mitigation and/or the delays associated with this process, the AO would assume responsibility for whatever recordation and stabilization of the exposed materials may be required. Otherwise, the operator would be responsible for mitigation cost. The AO would provide technical and procedural guidelines for the conduct of mitigation. Upon verification from the AO that the required mitigation has been completed, the operator would then be allowed to resume construction.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

A monitor would identify paleontological resources during surface disturbing activity and reduce the potential for irretrievable losses of these resources.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

RANGELAND MANAGEMENT

Affected Environment – Sites 1, 2, and 3

Livestock grazing on rangeland is the predominant land use in the project area. Grazing allotments are areas of land where individuals graze livestock. An allotment generally consists of federal rangelands, but may also include intermingled parcels of fee-lands. The BLM stipulates the number of livestock and season of use for each allotment.

Site 1 – Oil Shale Test Site

Site 1 is within the Square S grazing allotment (#06027). It is also within Pasture C, which is used by two cattle operations in the spring and fall as part of a rotational grazing plan. Total permitted use on the allotment is as follows:

Allotment Permittee	Livestock Number	Period of Use	AUMs
06027 – Square S- Boone Vaughn	500	05/16- 06/10	410
	600	06/11- 07/30	178
	300	10/16-12/15	578
	100	12/16-05/15	477
	110	05/01-12/15	795
06027 – Square S – Mantle Ranch	190	04/15-06/15	256
	46	04/15-07/15	92
	75	05/01-07/15	124
	140	07/16-10/01	237
	250	10/02-10/21	108
	80	11/30-04/30	264

AUM = animal unit month

Construction and operation of the facilities would result in a long-term loss of 160 acres of potential grazing lands from this site.

Site 2 – Nahcolite Test Site

Site 2 is within the Reagles grazing allotment (#06026).

Permitted grazing use is as follows:

- Larry Mautz: Use from 5/1 - 12/15; 343 animal unit months (AUMs)
- Dean Mantle: Use from; 5/1 - 12/15; 610 AUMs

The site is utilized in the spring and late fall, early winter as part of a rotational grazing management plan.

Approximately 50 acres of this site has been fenced off and used as a vegetative test center by CSU since 1974. Therefore, this acreage on Site 2 has been off-limits for grazing animals for many years. The effective additional long-term loss of grazing area would be approximately 110 acres on Site 2.

Site 3 – Advanced Heater Test Site

Site 3 is within the Boxelder pasture of the Yellow Creek allotment (#06030) which is permitted for livestock grazing use as follows:

- Burke Brothers, Cattle, use from 07/01 - 10/15, 451 AUMs

Construction and operation of the facilities would result in a long-term loss of 160 acres of potential grazing lands from this site.

Environmental Consequences of the Proposed Action

Each of the three test sites would take 160 acres out of potential rangeland for free-grazing livestock. Specific grazing allotments for each site have been described above. The Proposed Action could interfere with proper functioning of the range improvements near the test sites. The fences and watering facilities are necessary for control of cattle to achieve grazing objectives on the grazing allotments. Changes made to fences and/or watering facilities could interfere with control of cattle and ultimately the proper utilization of the rangeland resources.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

In order to minimize potential indirect impacts on rangeland, BLM would require alternative mitigation measures:

- Seed disturbed areas as discussed in the Vegetation section and
- Control noxious weeds as discussed in the Invasive, Non-Native Species section.
- Wherever heavy traffic is expected it may be necessary to install cattleguards with adjacent gates. Cattleguards will be installed above the existing grade and all such cattleguard/fence work will conform to BLM specifications.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Alternative mitigation measures would reduce potential impacts to vegetation from the Proposed Action and indirectly reduce impacts to range. Adherence to requirements for cattleguards would maintain integrity of the allotment boundaries. The loss of rangeland is insignificant and does not require additional mitigation.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

REALTY AUTHORIZATIONS

Affected Environment

The test sites are located on or are adjacent to many existing realty authorizations. There are additional authorizations on surrounding sections of land, but those are not listed in this document.

Site 1 – Oil Shale Test Site

The proposed access to Site 1 from CR 91 will be by improving an existing 2-track road. Portions of this route may follow roads authorized to Shell in grant COC68435 for access to hydrological test wells. The grant for well pads and access includes use stipulations, a granted width of 14 feet, and an expiration date of December 31, 2008 which can be renewed at the discretion of the BLM AO.

An existing White River Electric 7.2 kilovolt power line follows CR 91 to the southeast of the tract. White River substations are located approximately 1 and 3 miles from the site. A gas pipeline corridor passes through the parcel which includes three large transmission lines: COC012685 for Questar; COC52705 for Colorado Interstate Gas; and COC67980 and COC69299, a temporary use area, for Encana O&G.

Site 2 – Nahcolite Test Site

There are two alternatives to access Site 2. Alternate A will be from CR 24 from the northeast and Alternate B will be from CR 68 from the southeast. Portions of this route may follow roads authorized to Shell in grant COC68435 to Shell for access to test hydrological wells. The grant includes use stipulations, a granted width of 14 feet, and an expiration date of December 31, 2008, which can be renewed at the discretion of the BLM AO.

A gas pipeline corridor passes through the parcel which includes three large transmission pipelines: COC012685 for Questar; COC52705 for Colorado Interstate Gas; COC67980 and COC69299, a temporary use area, for Encana O&G; and COC67991, a gathering line for Bargath Inc. There are no electrical power lines, substations, or communications lines located on or adjacent to the parcel.

COC34329 is an existing Recreation and Public Purposes (R&PP) lease to CSU for the purpose of disturbed land reclamation studies. The lease is for 49.92 acres in lots 9, 10, and 15-18. Issued May 31, 1989, the lease expires May 30, 2014, and may be renewed at the discretion of the BLM AO.

Site 3 – Advanced Heater Test Site

There is no current developed access to Site 3. Shell has proposed three alternatives. Alternative A would improve the route currently used for access which begins at CR 24X to the east and follows a 2-track cross-country into the east side of the parcel. Alternative B follow CR 80 and then new construction into the west side of the parcel. Alternative C begins at CR 24, follows BLM Road 1109 west, and then new construction into the south side of the parcel.

There are no existing linear ROW located in, or contiguous to, the parcel, including electrical power lines, substations, or communication lines. The parcel is a part of the proposed Shell-BLM exchange proposal.

Environmental Consequences of the Proposed Action

The environmental consequences of each site are described below.

Site 1 – Oil Shale Test Site

Off-lease portions of the access road would involve a separate proposal, analysis, and ROW. The currently proposed access would require an agreement with Rio Blanco County for connecting to CR 91. Any utilities and services brought in from off-lease would require a ROW following a site-specific application and analysis. The appropriate application would be made by the service provider.

Full development of the site could negatively impact any existing surface uses. Construction involving excavation could damage existing underground facilities. Shell would negotiate mutually agreeable solutions to any potential impacts to existing facilities and/or ROWs prior to construction.

Site 2 – Nahcolite Test Site

Off-lease portions of the access road would involve a separate proposal, analysis, and ROW. The currently proposed access routes would require an agreement with Rio Blanco County for connecting to either CR 24 or CR 68. Any utilities and services brought in from off-lease would require a ROW following a site-specific application and analysis. The appropriate application would be made by the service provider.

Full development (complete surface disturbance) of the site would negatively impact existing surface uses. Construction involving excavation could damage existing underground facilities. Shell would negotiate mutually agreeable solutions to any potential impacts to existing facilities and/or ROW prior to construction. The CSU R&PP lease (50 acres) will be fenced and there would be no impacts from the Proposed Action at Site 2.

Site 3 – Advanced Heater Test Site

Off-lease portions of the access road would involve a separate proposal, analysis, and ROW. The currently proposed access routes would require an agreement with Rio Blanco County for connecting to CR 24X, CR 80, or CR 24. Any utilities and services brought in from off-lease would require a ROW following a site-specific application and analysis. The appropriate application would be made by the service provider.

Full development of the site could negatively impact any existing surface uses. Construction involving excavation could damage existing underground facilities. Shell would negotiate mutually agreeable solutions to any potential impacts to existing facilities and/or ROWs prior to construction.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Under this alternative, in addition to the Proposed Action, BLM would require the following:

- The Conditions of Approval for the proposed RD&D sites would be made a part of any ROW grant stipulations, along with compliance with all applicable regulations contained in Title 43 CFR part 2800.
- The Colorado One Call Procedure would be implemented before any excavation. In the event that the Proposed Action would impact, or conflict with, any preexisting uses in the area, the proponent would work with the other operators to resolve any issues in a mutually acceptable manner. Sources and ROW routes must be identified for all off-lease utilities such as electrical line or substations and communication lines. Holder or service providers shall apply for any off-lease ROW at an appropriate interval before needed to allow sufficient time for site-specific analysis.
- The holder would comply with all applicable state and county laws and regulations, and obtain all related applicable permits. This term/condition could be waived by the AO if he/she determines that such state or local law, regulation, or permitting requirement impermissibly conflicts with the achievement of a Congressionally approved use of public lands.
- A mutually acceptable agreement concerning the CSU R&PP lease (COC34329) has been negotiated. Shell is committed to preserving the necessary portions of the reclamation plots and has downsized their project to fit the constraints agreed to by BLM and CSU.
- Necessary revisions to the Proposed Action and to the R&PP lease shall be provided to BLM before the Shell RD&D lease approval.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Potential conflicts with existing, pipelines, proposed pipelines and ROW would be minimized. Any damage to existing utilities will be minimized by implementing the identified mitigation measures. Alternative mitigation measures would reduce or minimize potential impacts by identifying locations prior to construction activities and by maintaining safe distances from utilities and pipelines during construction.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

If the RD&D lease are not granted, conflicts associated with existing pipelines and wells, and proposed pipelines would not occur and ROWs would not be required.

RECREATION

Affected Environment – Sites 1, 2, and 3

Hunting is the most popular and most lucrative recreation activity in northwest Colorado and also in the area of the test sites. Fishing and off-highway vehicle (OHV) use are also popular activities. There are some commercially operated recreational businesses in the area as well.

Tourism accounts for approximately 10 percent of jobs in Rio Blanco County. In 1997 Rio Blanco County had 371 tourism related jobs. Outdoor recreation accounted for 45 percent of these jobs and most of them were related to hunting. In 1996, total direct expenditures on hunting in Rio Blanco County were $15,579,000; secondary expenditures were $19,053,000. Elk hunting is the major source of revenue in Rio Blanco County (NorWest 2001).

The White River ROD/RMP (BLM 1997) indicates that the entire WRRA is to be managed as the White River Extensive Recreation Management Area (ERMA). The White River ERMA would be managed custodially to provide unstructured recreation opportunities. A diversity of outdoor recreation opportunities and activities, with resulting experiences and benefits would be maintained and protected.

On BLM-administered lands, the Recreation Opportunity Spectrum (ROS) is a classification system and a prescriptive tool for recreation planning and management. ROS classes include Primitive, Semi-Primitive Non-Motorized, Roaded Natural, Rural, and Modified Urban. ROS classes within the WRFO ERMA are not specified within the test sites. However, the area most closely resembles a ROS class of Semi-Primitive Non-Motorized. This physical and social setting is typically characterized by a natural appearing environment with few administrative controls and low interaction between users (but evidence of other users may be present). The recreational experience would characterized by a high probability of isolation from the sights and sounds of humans within a setting that offers challenge and risk.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

The public would lose up to 160 acres of dispersed recreation potential at each of the three test sites over the life of the Proposed Action. Increased traffic, noise activity, and dust could affect some user's recreational experiences by increasing the likelihood of human interactions, the sights and sounds associated with the facilities, and a less natural appearing environment.

The public would most likely avoid these areas for recreation and disperse elsewhere. Hunters would be prohibited from the test sites, and it is likely that those hunters would disperse to other public BLM lands.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

No mitigation measures are proposed or necessary to reduce impacts to recreation from the Proposed Action.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

SOCIOECONOMICS

Affected Environment – Sites 1, 2, and 3

The assessment area for the potential effects of oil shale research and development on social and economic conditions is Rio Blanco County, including the towns of Meeker and Rangely, as well as the City of Rifle, located in Garfield County. Based on the standard elements of socioeconomic assessment, conditions inventoried in this section include the following:

- Local Economy
- Employment
- Income and earnings
- Oil and gas activity
- Other important economic activities near the proposed project area (e.g., grazing, hunting, and possible oil shale development)
- Population
- Housing, including temporary and long-term housing resources
- Community facilities and services
- Environmental justice

Socioeconomic statistics are often subject to reporting delays of a year or two after the fact. Consequently, socioeconomic effects of the recent increase in energy development that has occurred in Rio Blanco County and northwestern Colorado are not yet fully reflected in most published statistics. To augment the published data, this section includes information about recent socioeconomic conditions obtained from interviews with local officials and service administrators. *(Unless referenced otherwise, statistical information contained within this section have been derived, in part or in whole, from the ExxonMobil Piceance Development Project Socioeconomic Technical Report and all references therein. The complete report is on file with the BLM WRFO.)*

Local Economic Conditions

Employment, earnings, and income are common indicators of economic conditions. Employment data reported by the Colorado Department of Labor and Employment (CDLE) indicate a dramatic increase in employment associated with oil and gas exploration and development activity in the region. More than 500 energy production jobs were added between 2003 and 2004, with more than 1,500 added between 2004 and the third quarter of 2005 (see the following table). Gains have been registered across the region, with the largest occurring in Garfield and Mesa counties; the latter reflecting a sharp increase in oil and gas field services.

County Employment Data for the Years Listed

County	2000	2001	2002	2003	2004	2005 (Estimated)**	Percent Change
Garfield	224	301	364	402	432	1,498	569
Mesa	345	364	389	453	809	1,152	234
Moffat	521	509	543	518	499	546	5
Rio Blanco	454	504	525	504	608	724	59
Routt	478	504	520	538	573	575	20
Total	2,022	2,182	2,341	2,415	2,921	4,494	122

Source: BLM 2006
** Annual averages for 2005 are not yet available. The estimated employment is the average of the first three quarters.

Unemployment and Labor Force

Rio Blanco County's annual unemployment rate from 2000 through September 2005 indicates that recent local unemployment rates tend to parallel statewide unemployment rates, but with Rio Blanco County unemployment generally 1 to 2 percent lower than the State of Colorado as a whole.

Labor market information is compiled and reported by the CDLE. These data are collected and reported monthly on a place of residence basis. An area's labor force is the number of individuals living in a county who are currently employed or unemployed but actively seeking work. Of an average 2004 Rio Blanco County resident labor force of 3,770, a total of 3,611 persons were employed and an average of only 159 persons (4.2 percent) were unemployed and actively looking for work.

Labor Earnings and Personal Income

Between 2000 and 2002 total and energy industry wages increased from $70 million to $84 million; a 20 percent increase. Modest gains in total earnings were registered in 2003, with substantial growth in 2004 and 2005. Total estimated wages of $109 million paid in 2005 reflects a gain of $24 million or 28 percent over the 2003 total. After discounting the growth for the effects of inflation (13.4 percent), the net change from 2000 to 2005, represents a 38 percent gain in real wages paid in the Rio Blanco County.

Growth in wages paid in the oil and gas industry has accounted for much of the change. Mining (including oil and gas) sector wages increased between 2000 and 2002, from about $21 million to $30 million; an increase of 43 percent. Subsequent increases through 2005 (estimated) raised the total mining sector earnings to $48 million in 2005. Inflation adjusted mining sector earnings rose by 99 percent between 2000 and 2005. As a result of the strong expansion in wages paid in the mining industry, its share of total countywide wages increased from 30 percent in 2000 to 44 percent in 2005.

Per capita personal income in Rio Blanco County increased from $26,605 in 2000 to $27,048 in 2003, about 2 percent over the 4-year period. However, when adjusted for inflation, Rio Blanco County real per capita personal income fell by about 5 percent during this period. Per capita personal income trends in the county generally parallel those of the state as a whole, with Rio Blanco County per capita personal income trailing the statewide averages by 20 to 26 percent.

Other Economic Activities near the Project Area

Other economic activities occurring within the areas adjacent to the Proposed Action include ranching, grazing, dispersed tourism and recreation (primarily big-game hunting), nahcolite mining, and potential oil shale research and development. Other than natural gas exploration and production, cattle grazing is the predominant year-round land use in the vicinity of the three 160-acre test sites.

As discussed in the Recreation section, hunting is traditional for many local residents and tourist alike. The hunting and fishing industry is also a vital part of the economy in northwestern Colorado. According to a recent study prepared by the CDOW, direct sales in Rio Blanco County associated with wildlife-related recreation activities was approximately $16.3 million in 2002. Total economic impact to Rio Blanco County, including secondary spending by people who own or work for businesses related to fish and wildlife activities, was about $28.4 million. Fish and wildlife-related activities were responsible for 360 jobs, mostly in retail trade and services, in Rio Blanco County. Direct sales associated with wildlife-related activities in Garfield County were $30 million in 2002. Secondary spending was estimated near $53.1 million and employment related to wildlife activities was 690 jobs (BBC Research and Consulting 2004).

CDOW collects hunting statistics for the Game Management Units that include the Proposed Action, but there are no estimates of hunting or other recreation use for the 160-acre site specifically. No licensed hunting and outfitting services are provided in the project area.

There are also extensive deposits of nahcolite and oil shale in the area of the test sites. Nahcolite has recently been mined commercially, and the BLM recently approved five applications for oil shale RD&D leases for further consideration.

Population

Like much of northwestern Colorado, Rio Blanco County experienced rapid population growth during the 1970s. The county grew from 4,842 in 1970 to 6,255 in 1980, or 30 percent during the decade. By 1990 total county population had fallen to 6,051 and has remained around 6,000 through 2004.

Population conditions in Rio Blanco County's two population centers, the towns of Meeker and Rangely, have roughly paralleled that of the county. Meeker population grew from 1,597 in 1970 to 2,396 in 1980, a 50 percent increase, then decreased to 2,098 in 1990 and remained between 2,100 and 2,300 through 2004. Rangely population grew from 1,591 in 1970 to 2,278 in 1990, an increase of 41 percent, then peaked in 1996 at 2,361 and has since declined to 2,099 in 2004. In contrast, population for the State of Colorado grew by 110 percent between 1970 and 2004. In 2004, 37.5 percent of total Rio Blanco County population was within the Town of Meeker and 34 percent was within the Town of Rangely; about 28.5 percent lived in unincorporated areas of the county.

Unlike communities in Rio Blanco County, population for the City of Rifle in Garfield County has generally continued to trend upward since 1970, rising from 2,150 in 1970 to 6,784 in 2000, a 216 percent increase over the 3 decades. By 2004, Rifle's population had increased by an additional estimated 976 persons to 7,760, a 14 percent increase in 4 years.

The Colorado State Demography Office prepares population projections for counties within the state. Rio Blanco County population is projected to grow from 6,048 in 2005 to 8,384 in 2030, about 39 percent during the 25 year period. For the same period, the State of Colorado is projected to grow by 55 percent. These projections do not fully reflect the short-term influences that the county is currently experiencing from energy development. Although the State Demography Office does not publish population estimates for municipalities, Rifle city officials anticipate average population growth of 4 percent over the next 20 years (BLM 2006).

Housing

The Colorado State Demography Office estimates that 20 percent of total Rio Blanco housing units were vacant during 2004, with 13 and 17 percent vacant in Meeker and Rangely respectively. Vacancy rates in Rifle were reported at 3.87 percent in 2004. A portion of the vacant units were second and seasonally occupied homes and the largest number of second homes in Rio Blanco County were located within the unincorporated portions of the county, which is consistent with many vacancies being attributable to second homes. In contrast to the 2004 State statistics, local officials reported almost no vacancies in rental housing during the fall of 2005.

Rental housing in and around Meeker and the 81 pads in the town's five mobile home parks were completely occupied during the fall of 2005. Many mobile home spaces were occupied by construction crews, drilling crews, and the long-established seasonal demand from hunters. Two temporary recreational vehicle (RV) parks have been developed near Meeker to house pipeline workers, one with 90 RV pads and one with 25 RV pads. These construction worker RV park facilities are operating under county temporary use permits and not intended for long-term use.

The Town of Meeker has also approved the renting of rooms in private residences, as long as the activity does not impact residential (R1) zones. There has recently been some residential subdivision activity within the town; however, few houses have recently been offered for sale in Meeker and when houses come on the market they are quickly purchased for the full asking price and sometimes more.

There were virtually no vacant rental units in Rangely during the fall of 2005 and many rental properties had waiting lists. There are 200 mobile home/RV spaces within the town and recent occupancy has averaged 30 to 40 percent. Rangely has three motels with a total of about 90 rooms. Recent motel occupancy has averaged an estimated 80 percent.

Rifle had an estimated vacancy rate of about 2 percent across all types of units in the fall of 2005. With the opening of two new motels in 2006, Rifle will have six motels with 387 rooms and two RV parks with 57 RV pads; existing motels were typically full during fall of 2005.

Local Government Facilities and Services

The Proposed Action would be located entirely within unincorporated Rio Blanco County. Although the Proposed Action would affect most county government services to some degree, those likely to be most affected would be law enforcement (Sheriff's Department), emergency management and response (fire suppression and ambulance), and county road maintenance. Some Garfield County services would also be affected, primarily law enforcement and emergency response services along Colorado Highway 13 north from Rifle to the Rio Blanco County line. Municipal services in Meeker, Rangely, and Rifle could also be affected.

Most Rio Blanco County Services are headquartered in Meeker. Some services also maintain satellite offices in Rangely.

Law Enforcement

The Rio Blanco County Sheriff's Office provides law enforcement services to the unincorporated portion of Rio Blanco County. Current demand for law enforcement and emergency response services in the county is high, particularly in the areas adjacent to access from Rio Blanco CR 5. According to the 2005 Rio Blanco County Sheriff's Office Annual Report, traffic on the 42-mile stretch of CR 5 increased more than 1,200 percent and consequently, so did calls for service. The Piceance Creek area of the County incorporates a large land mass intersected by 24 county roads. The incidents and calls for services in this area has risen 220 percent since 2004 and 402 percent since 2003. Incidents in the east end of Rio Blanco County, which includes the Piceance Creek area, have gone up 59 percent, where incidents in the west end of the county only rose by about 2 percent (Woodruff 2005).

About 68 percent of all calls in 2005 were traffic or motor vehicle related. For the period from March 1 to March 31, 2006, nearly 70 percent of all calls were related to traffic incidents (Woodruff 2006). The Sheriff's Office has responded to an increasing number of accidents on the highways that provide access to the Piceance Creek area. Between 2003 and 2005, accident responses increased 142 percent on Colorado Highway 64, and 101 percent on Colorado Highway 13. These figures include property damage accidents resulting from collisions with Deer and other animals. Colorado State Patrol Troopers have recently been reduced from four troopers to one in northwestern Colorado, which has placed additional demands on the Rio Blanco County Sheriff's Office for accident response.

The patrol sergeant and deputies based in Meeker and Rangely provide law enforcement coverage to the areas adjacent Rio Blanco CR 5. Response times to the Piceance Creek area can run 45 minutes to an hour or more because of the distance from these population centers. Annual mileage driven by the Rio Blanco County Sheriff's Office in response to service calls, investigations, detentions, and administration increased by 79 percent from 2004 to 2005. This represents a substantial operational cost increase over the previous year.

The Garfield County Sheriff's Department provides law enforcement on the portion of Colorado Highway 13 from I-70 to the Rio Blanco County line. In the past several years, energy traffic has increased dramatically on the highway, resulting in a corresponding increase in complaints and calls for service. Although the Colorado State Highway Patrol provides patrol services on the rural portion of the highway from Rifle north to the Rio Blanco County line, the Garfield County Sheriff's Department does respond to complaints, incidents, and accidents in that area.

Statistical information for all incidents that occurred on the 24 Rio Blanco county roads within the Piceance Creek area is provided in the following table.

Rio Blanco County Sheriff's Office Piceance Creek Area Statistics

Classification	January 1 to December 31			January 1 to March 31
	2003	2004	2005	2006
Abandoned Vehicles	1	3	3	1
Accidents	4	20	31	
Property Damage Accidents				10
Injury Accidents				2
Animal Calls	13	9	38	4
Arson	1	0	0	0
Assault	0	0	1	0
Assist All Other Agencies	17	22	41	7
Assist Meeker Ambulance				5
Assist State Patrol				11
Auto Theft	0	0	1	0
Burgleries	0	0	1	0
Citizen Assist	3	3	7	1
Civil Situations	4	8	4	3
Criminal Mischief	6	2	3	3
Disturbance - Fight	1	0	1	0
Domestic Violence	0	1	1	0
D.U.I.	0	0	3	2
Fires	4	6	10	1
Fraud/Forgery	7	0	0	0
Harassment	1	4	1	0
Homicide	0	0	1	0
Juvenile Problem	0	1	2	0
Motorist Assist	0	1	12	5
Narcotics Cases	1	0	3	0
911 Hang up calls	5	13	18	9
Property (Lost/Found)	3	1	5	0
Search and Rescue	2	2	2	0
Sexual Assault	0	0	1	0
Suspicious Incident	11	8	22	3
Thefts	2	5	10	0
Traffic Arrests	0	6	9	4
Traffic Complaints	0	10	17	4
Traffic Hazards	0	2	4	4

Rio Blanco County Sheriff's Office Piceance Creek Area Statistics

Classification	January 1 to December 31			January 1 to March 31
	2003	2004	2005	2006
Traffic Contacts	39	70	410	69
Trespass	3	4	7	1
Truancy	0	0	1	0
Unattended Death	0	1	0	0
VIN Inspections	6	5	7	6
Warrant Arrests	1	1	1	3
Weapons Violation	0	1	0	0
Totals	135	209	678	158

Woodruff 2006.

The Rio Blanco County Detention Center was constructed in 1937 and designed to hold 18 prisoners. During the year of 2005, the average daily inmate population for the year was over 18 for the first time in the Center's history. An all-time high record of 31 inmates in detention was reached during the month of July 2005. The average daily inmate population for the month of March 2006 was 21 (Woodruff 2006). In the not too distant past, the jail routinely had excess capacity and the county generated revenue by hosting prisoners from other counties. Over the last several years the situation has reversed, and Rio Blanco County must now often transport inmates and pay other counties to house inmates when the jail is full, resulting in increased costs for the county.

Emergency Management and Response

Emergency response agencies in Rio Blanco County face a variety of issues in providing services, including:

- the large size of the county,
- numerous backcountry roads,
- the large number of recreation visitors,
- the proliferation of energy exploration and development sites,
- extensive communications dead spots, and
- the constraints of mostly volunteer services.

Rio Blanco County does not have a dedicated hazardous materials response team and must rely on agencies in Glenwood Springs, Craig, or Grand Junction for assistance in dealing with accidents involving hazardous materials. Response times for hazardous materials incidents are typically 2.5 hours.

Fire suppression services in the area of the Proposed Action are provided by the Meeker Fire and Rescue District, and it takes an hour or more to assemble volunteers, mobilize equipment, and respond to emergencies and incidents in the Piceance Creek area. Responding to the Piceance Creek area with equipment and volunteers reduces coverage for Meeker and the surrounding population areas for the duration of the response. Range and wildland fire response is provided by the BLM WRFO in Meeker.

Ambulance services for the eastern part of the county are also provided out of Meeker, with two four-wheel drive ambulances and about 15 volunteer emergency medical technicians (EMTs). Air ambulance services are also available when weather conditions allow. Patients are transported to Pioneers Medical Center in Meeker or hospitals in Rifle, Grand Junction, or Denver, depending on the type and severity of the injury and the location of the accident. Emergency management and response services (including fire suppression and ambulance) for the area that includes Colorado Highway 13 in Garfield County are provided by the Rifle Fire Department from their main fire station in Rifle.

Hospital and Medical Services

Hospital and medical services for Meeker and the eastern portion of Rio Blanco County are provided by Pioneers Medical Center, which operates a 15-bed hospital and provides 24-hour emergency medical, pulmonary, laboratory, radiological, surgical, acute care, and rehabilitative services. There are four resident physicians in Meeker who provide services through the Meeker Family Health Center and staff the hospital and emergency room. The physicians also provide medical direction to EMTs who staff the ambulance service and provide training to law enforcement and emergency response personnel in the county.

Environmental Justice

EO 12898, "Federal Action to Address Environmental Justice in Minority Populations and Low-Income Populations" was published in the FR (59 FR 7629) on February 11, 1994. EO 12898 requires federal agencies to identify and address disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations (defined as those living below the poverty level).

The percentage of minorities in Rio Blanco County overall is lower than the state average by 18.1 percentage points. According to the 2000 Census, persons in poverty are 10.7 percent of the Meeker Census County Division (CCD), the eastern half of the county, which includes the Proposed Action. This is 1.4 percentage points higher than the overall rates for Rio Blanco County and the State of Colorado. However, the area which excludes the Town of Meeker is closer to the county-wide average.

Very few people live within the areas surrounding the three test sites. The rural, agricultural nature of the Piceance Creek area and the relatively limited amount of privately owned land within and immediately adjacent to the proposed lease site means that a limited number of residents, regardless of their minority or income status, would be directly affected by health and safety aspects of the Proposed Action.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Shell has committed to good stewardship of the land, and to the health and vitality of the communities in the region. Development would be implemented at a measured pace so as to reduce the risk of making poor decisions with regard to the economic viability of the proposed technology. In the event that any of the RD&D technologies were deemed unsuccessful during the RD&D program, abandonment of the project would include removal of all facilities after which the site would be returned as nearly as possible to pre-construction conditions, and any measures required to alleviate the impacts that such abandonment would have on the local population of the region would be implemented by working closely with local municipalities.

The maximum number of people employed at the site would occur during construction and drilling. An estimated maximum of approximately 720 individuals would be employed at Sites 1 and 3 during the construction and drilling period. At Site 2, an estimated maximum of approximately 700 individuals would be employed during the construction and drilling period. However, because the three test sites would not be developed at the same time, the number of worker employed during construction and drilling would not be cumulative.

Demand for temporary housing would rise, and would increase even more during hunting season in Rio Blanco County. Housing would still be available, but would be more difficult to find and/or more expensive to secure. Construction workers could have to drive longer distances to locate accommodations. Other demands on local agencies would include increased enforcement activities associate with issuing permits for vehicle load and width limits, emergency medical services to treat injuries resulting from construction activities, and law enforcement services to respond to traffic violations and accidents, landowner complaints, and criminal activities. Local businesses, including gas station, laundromats, restaurants, liquor stores, and grocery stores would see an increase in revenue. Cities and counties would see an increase in sales tax revenue due to increased purchases by the construction workforce. The purchases of materials, supplies, goods, and local services would have a positive, short-term impact on communities near the project area. The increase demand for public services could have a negative, short-term impact on communities near the project area.

Once construction is completed, the maximum expected employment would be approximately 155 individuals at Sites 1 and 3 and 150 individuals at Site 2. For Sites 1 and 3, long-term impacts in the communities surrounding the project area could include population growth of approximately 341 people (2.2 times each employee to represent the average family size including spouses and children). For Site 2, population impacts are expected to be approximately 330 people. Increased demand on housing and local services would be similar to above. Operation of the project would have a positive, long-term impact on Rio Blanco County due to the increased property tax revenues.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

The pilot scale and exploratory nature of the proposed RD&D project, along with the staged approach of its implementation, would preclude this action from having the adverse impacts to the socioeconomics of the region as was experienced in the past. No commercial scale oil shale development would take place at this time. It is unlikely that there would be any notable increase in regional activity at this scale for the10-year term of the proposed oil shale leasing program.

The ongoing Colorado Local Government Energy Impact Program would be a source of future mitigation for socioeconomic costs that may be related to the Proposed Action. However, Federal royalties would be waived for the duration of the RD&D program, and rents would be waived for the first 5 years of the 10-year lease term, so the RD&D program would not make any substantial contribution to the distribution of funds associated with energy impacts at this time.

The Colorado Department of Local Affairs (CDOLA), provides direct distributions and grant funds to local governments in areas impacted by energy development, specifically including Mineral Lease activities. These direct distributions and grant funds would be applicable to the local governments in Rio Blanco County to help mitigate the demands that the Proposed Action may place on community resources.

Shell would initiate discussions with local municipalities to determine the appropriate mitigation measures to offset the demands that the Proposed Action may place on community resources beyond the scope of the Colorado Local Government Energy Impact Program.

Measures to offset demands on local law enforcement and emergency response services could include:

- Implement a health and safety program that would include training on-site supervisory personnel in first aid and cardiopulmonary resuscitation (CPR).
- Provide site security for the protection of the public, site personnel, and property.
- Implement a fire prevention and control program as discussed in the Fire Management section.
- Encourage employees and contractors to carpool to and from the site to cut down on traffic on state highways and county roads.

Measures to offset demands on employment and housing could include:

- If possible, new employees would be hired from within the communities of the region.
- Local contractors would be used for the majority of construction and drilling activities.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

No mitigation measures are proposed or necessary to reduce socio-economic impacts from the Proposed Action.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur. Under the No Action Alternative, no exploration and future development of the oil shale resources to supply our future domestic energy needs would take place. No additional local jobs would be provided. Cities and counties would not see an increase in sales tax revenue due to increased purchases by construction and operations workforces, and Rio Blanco County would not see an increase in property tax revenues from construction and operation of the project.

VISUAL RESOURCES

Affected Environment – Sites 1, 2, and 3

The project areas are, according to the White River ROD/RMP, within a Class III visual resource management (VRM) area. The objective of a Class III area is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Visually, all three test sites are characterized by low-growing juniper and pinyon pines intermittently dispersed on relatively flat, dry land. Natural features of the area landscape include rolling hills vegetated with pinyon-juniper and sagebrush vegetation. The area is rural with infrequent energy related facilities, power lines, and radio towers access by a network of unsurfaced roads. Site 1 has numerous well pads already installed and visible. Site 2 includes the CSU vegetative test plot, which is visible and includes fencing. Site 3 currently has not been disturbed.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

The proposed test wells and related facilities, with associated access roads, would alter the landscape character and would create visual changes for the life of the project. The test sites would introduce man-made industrial facilities that could draw attention due to their size, color, and shape. The tallest structure would likely be the drilling rigs. In the vicinity of the project, the landscape would change from undeveloped to that typical of energy development. The texture of the landscape would change from that of vegetation to square buildings, piping, stacks, and fencing.

For all three test sites, the changes to the characteristic landscape would be moderate. The impacts would be in conformance with Class III values.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

In order to minimize potential impacts, BLM would require alternative mitigation measures. Visual contrast impacts would be minimized by implementing the following mitigation measures:

- Per BLM lease stipulations, above ground facilities will be painted Munsell Juniper Green or other appropriate color so as to better blend into the natural landscape.
- Recontour disturbed land to conform to natural contours as closely as possible;
- Reseed disturbed areas using BLM-approved seed mixes as quickly as possible.
- Dust control as needed based on activities and moisture conditions; to reduce fugitive dust, establish and enforce speed limits on gravel roads in and adjacent to the proposed project site.
- Regular monitoring and cleanup of site and surrounding area for litter and other debris.
- Where feasible, site structures off ridge lines.
- Where feasible, use low-profile structures.
- Site slash/debris piles in low visibility areas.
- Feathering and thinning edges of cleared areas outside the site buffer zone, and inside the facility (where applicable and feasible).

- Co-location of utility services in combined ROW.
- Encourage carpooling and other methods to reduce traffic, parking, and damage to roadsides.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

The Shell test sites are in a relative remote location, generally obscured from view from the heaviest traveled roads in the Piceance Creek area. Construction of the proposed facilities would still cause some visual impacts by the removal of existing vegetation and temporarily increasing fugitive dust emissions.

Implementing the alternative mitigation would minimize fugitive dust and the visual impacts associated, both short-term and long-term and would minimize visual impacts to observers from key locations where impacts could be easily noticed.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

WILD HORSES

Affected Environment – Sites 1, 2, and 3

Wild horses on public lands are protected, under the Wild and Free Roaming Horse and Burro Act of 1971 and are managed by the BLM. BLM's White River ROD/RMP (BLM 1997) includes an implementation plan for wild horse management. The wild horses are managed by BLM to provide a healthy, viable breeding population with a diverse age structure.

BLM's Piceance/East Douglas Herd Management Area (HMA) consists of approximately 190,000 acres. Sites 1 and 3 are located in this HMA. Site 2 is located to the east of the HMA. The current configuration of the Piceance/East Douglas HMA provides for high summer range on the Cathedral Bluffs, surrounded by adjacent fall-winter-spring ranges in both the Piceance and Douglas Creek Basins.

The Piceance/East Douglas HMA is especially valuable because of the habitat diversity it contains. Vegetation within the HMA consists of pinyon-juniper woodlands interspersed with sagebrush and greasewood. Wild horses rely on these woodlands during the summer months for shade and protection of newborn foals from predation, and during the winter months for cover during severe winter storms. Over 90 percent of wild horse diet is comprised of grasses with shrubs becoming more important during periods of heavy snowfall when horses can less readily paw through snow cover to the grass below. Water intake is supplied by springs, man-made water developments, stock ponds, and perennial streams.

The population of the Piceance/East Douglas herd, prior to the spring 2005 foal crop, was estimated at 290 individuals. The management range is between 135 and 235 animals. The herd's annual production rate is on the order of 20 percent. The wild horse population is controlled through round-ups and adoptions of surplus animals every third year. Wild horse viewing is a popular form of non-consumptive recreation.

Environmental Consequences of the Proposed Action – Sites 1, 2, and 3

Sites 1 and 3 are located within the HMA. Construction and operation of these sites would result in the removal of 320 acres of land area for the wild horse herd. The primary impact would be removal of existing vegetation and loss of forage and cover. The loss of 320 acres in an area of 190,000 acres would be less than 0.2 percent.

Additionally, horses could be disrupted by noise and fugitive dust associated with construction activities, particularly during foaling season. Impacts would be expected to be temporary and limited to the construction period.

Site 2 is not located in the HMA. There would be no impacts to wild horses as a result of the project at Site 2.

Subalternative - Proposed Action with Mitigation – Sites 1, 2, and 3

Shell would meet with BLM prior to construction of the project to discuss BLM's requests for the protection of the horses. Several techniques may be used to minimize impacts to the wild horses. These include:

- Keep operation equipment and materials within each of the 160-acre test sites using adequate fencing to keep horses out. Appropriate portions of the test sites will be fenced to exclude large game, wild horses, livestock, and the public for safety purposes.
- Maintain and repair fences as necessary.
- Avoid construction during recognized foaling season between March 1 and June 15.
- Replace water sources with equal sources of water in locations determined by BLM specialists.

Environmental Consequences of the Subalternative – Sites 1, 2, and 3

Fencing would preclude harm to wild horses from interaction with facilities associated with the Proposed Action. However, fencing may obstruct movement of individual animals and remove habitat from use by wildlife species.

Environmental Consequences of the No Action Alternative

If the RD&D leases are not approved, no impacts associated with the Proposed Action would occur.

CUMULATIVE IMPACTS

This section provides an analysis of the cumulative impacts of past, present, or reasonably foreseeable future projects on various natural and human resources. Cumulative impacts may result when the environmental impacts associated with a proposed project are added to temporary or permanent impacts associated with past, present, or reasonably foreseeable future projects. Although the individual impact of each separate project might not be significant, the additive impacts of multiple projects could be.

Existing environmental conditions in the project area reflect changes based on past projects and activities. The project area is rural and relatively undeveloped but is experiencing growth related to energy development. A total of five Oil Shale RD&D proposed actions are located in the northern portion of the Piceance Basin, primarily on undeveloped land. The percentage of the five proposed tracts currently developed with pipelines, wells, research tracts, or roads was estimated by each of the consultants preparing the EA using aerial photography and site visits. The percentage ranged from 0 percent on Shell's Site 3 tract to 34 percent on Shell's Site 2 tract. The remaining Shell tract is estimated to be approximately 15.6 percent disturbed currently, with both the EGL and Chevron tracts estimated at less than 5 percent developed.

The primary human influences on the project area are oil and gas development, historic oil shale and nahcolite mining, and livestock grazing. Estimates of the total past, present, and reasonably foreseeable future surface disturbance from oil and gas development and oil shale and nahcolite mining are presented in the table below. Future developments are based on proposed EnCana and Exxon Mobil oil and gas projects and future oil and gas development.

Surface Disturbance Estimate for Past, Present, and Reasonably Foreseeable Future Projects in the WRRA

Activity	Assumptions	Disturbance (acres)
Future Oil Shale Research, Development, and Demonstration Tracts		
Shell Oil Company	Three 160-acre tracts (Shell estimates nearly all the tracts will be disturbed.)	480
Chevron USA, Inc.	One 160-acre tract (Chevron estimates that approximately 100 acres of the 160 acre tract will be disturbed. For purposes of this tabulation, the entire 160 acres is included.)	160
EGL Resources Inc.	One 160-acre tract (EGL estimates that only 36 acres of the 160 acre tract will be disturbed. For purposes of this tabulation, the entire 160 acres is included.)	160
Existing Pipelines – all in reclamation process		
CIG Uintah Basin	84 miles (220 miles total) of 20-inch diameter natural gas pipeline from Uintah County, Utah to Greasewood Hub, Colorado to Sweetwater County, Wyoming.	475
EnCana Eureka and Double Willow Units	Variable length and diameter gathering pipelines in Piceance Basin, Colorado.	175
NGL Pipeline	16.9 miles of 4-inch diameter NGL pipeline from Dragon Trail Plant, Colorado to Dragon, Utah.	85
Kinder Morgan TransColorado	32 miles (300 miles total) of 22-inch diameter natural gas pipeline from Greasewood Hub, Colorado to Farmington, New Mexico.	300
Questar	45 miles (45 miles total) of 14-inch diameter natural gas pipeline from Plateau Creek, Colorado to Greasewood Hub, Colorado to Utah.	260

Surface Disturbance Estimate for Past, Present, and Reasonably Foreseeable Future Projects in the WRRA

Activity	Assumptions	Disturbance (acres)
El Paso	38 miles (143 miles total) of 24-inch diameter natural gas pipeline from Greasewood Hub, Colorado to Wamsutter, Wyoming.	350
Entrega	46 miles (327 miles total) of 36-inch and 42-inch diameter natural gas pipelines from Meeker Hub, Colorado to Cheyenne, Wyoming.	560
Future Pipelines		
EnCana Meeker Project Eureka and Double Willow Units	175 miles (205 miles total) of up to 10-inch, 12-inch, 16-inch, 24-inch, 30-inch, and 36-inch natural gas, NGL and water pipelines from Logan Wash, Colorado to Dragon, Utah. Variable length and diameter gathering pipelines in Piceance Basin, Colorado.	1,222 875
Riata Sagebrush	19 miles of up to 10-inch natural gas gathering line from Black Sulphur to ROC.	100
Northwest/Williams (FERC)	37 miles of 36-inch natural gas pipeline from Parachute to Greasewood Hub.	525
Proposed Gas Plants		
Encana/Enterprise (Meeker Gas Plant)	Natural Gas Plant in T.1S., R.97W., Sections 18 and 19	50
EnCana	Natural Gas Plant near Meeker Hub, Colorado.	80
Riata Energy	Natural Gas Plant near Stake Springs Draw.	10
Existing Oil and Gas Development		
Other Oil and Gas Wells	3,052 wells and ancillary facilities.	8,761
Future Oil and Gas Development		
EnCana Figure Four Unit	327 wells and ancillary facilities.	900
ExxonMobil Piceance Development Project	Central Treatment Facility, ponds and pipeline.	1,600
Other Oil and Gas Wells	15,000 wells and ancillary facilities in 15-20 years. Complete Cumulative Analysis to be completed in WRFO RMPA/EIS to be completed in CY08.	17,000
Existing Nahcolite Mining		
American Soda Natural Soda Inc.	Parachute Pipeline, Mining Production Well Field and Piceance Processing Site. Mining Production Well Field.	80 72
Existing Oil Shale Mining		
Shell Mahogany Project	Experimental Oil Shale Recovery Activities.	150

Surface Disturbance Estimate for Past, Present, and Reasonably Foreseeable Future Projects in the WRRA

Activity	Assumptions	Disturbance (acres)
Future Utilities		
White River Electric	138kV connection lines to substations in Piceance Basin.	184
Future Rio Blanco County Services		
Waste Water Disposal Pond	Sewer, Septic and waste disposal. Wray Gulch, Hwy 64 and County Road 5.	2
Paving and Overlay	County Road 5 Piceance Creek.	0
Meeker Airport Expansion	Runway expansion and/or extension.	TBD
Rangely Airport Upgrade	Update runway, aprons, facilities.	0
Meeker Jail/Justice Center	Pending study results and budget approval.	TBD
Total		34,616

Sources: BLM 2005.
cy = calendar year
FERC = Federal Energy Regulatory Commission
RMPA/EIS = Resource Management Plant Amendment/Environmental Impact Statement
WRFO = White River Field Office, Bureau of Land Management

The study area for cumulative impacts is the WRRA, which is managed by the WRFO ROD/RMP. Of the 2.6 million acres of land within the WRRA, the surface of 1.5 million acres is managed by the BLM (1997). The area of analysis is both the 1.5 million acres of BLM managed lands within the WRRA, and the WRRA itself. The five Proposed RD&D projects occur within the BLM managed lands within the WRRA, and the cumulative effects of nearby projects can be specifically evaluated in relation to the five Proposed RD&D projects. For some resources (e.g., Air Quality and Socioeconomics), the analysis area extends beyond the boundary of the WRRA. To assist in quantifying cumulative impacts, the 800 acres associated with these five Proposed RD&D projects equate to 2.3 percent of all past, present, and reasonably foreseeable future development projects and 0.06 percent of the WRRA managed by BLM. The total amount of disturbed acreage associated with all past, present, and future actions as listed in the table above equate to 2.4 percent of the BLM managed lands within the WRRA.

Direct, indirect, and cumulative effects of reasonably foreseeable oil and gas development were analyzed in the White River ROD/RMP and associated EIS. The RMP/EIS, completed in 1997, addressed all reasonably foreseeable oil and gas development (including roads and pipelines) over a 20-year period. The developments proposed in the three EAs for oil shale RD&D, as well as cumulative impacts to the resource area, are within the scope and analysis of the existing RMP/EIS and are tiered to the White River RMP/EIS. Most of the proposed pipeline routes are ROW corridors designated in the White River ROD/RMP. As such, impacts including, direct, indirect, and cumulative, were addressed in the related EIS.

The Energy Policy Act of 2005, Public Law 109-58 (H.R. 6), enacted August 8, 2005, directs the Secretary to complete a PEIS for a commercial leasing program for oil shale and tar sands resources on public lands with an emphasis on the most geologically prospective lands within each of the states of Colorado, Utah, and Wyoming. The scope of the PEIS will include an assessment of the positive and negative environmental, social, and economic impacts of leasing oil shale and tar sands resources, including foreseeable commercial development activities on BLM-administered lands located in Colorado, Utah, and Wyoming; discussion of relevant mitigation measures to address these impacts; and identification of appropriate programmatic policies and BMPs to be included in BLM land use plans. The PEIS will address land use plan amendments in the affected resource areas to consider designating lands as available for oil shale and tar sands leasing and subsequent development activities.

Although the WRRA is the analysis area, impacts on adjacent areas have not been ignored. Many of the past, present, and future projects traverse the WRRA and cross into other adjacent resource areas. Impacts from reasonably foreseeable oil and gas development activities outside the WRRA have been analyzed in other resource area-specific resource management plans including, but not limited to, the Book Cliffs RMP, the Grand Junction RMP and ROD, and the Colorado Oil and Gas Leasing and Development Final EIS (covering the BLM Glenwood Springs, Kremmling, Little Snake, Northeast, and San Juan/San Miguel Field Offices) (BLM 1991b).

The potential cumulative impacts associated with each critical and non-critical element that must be addressed to meet the Public Land Health Standard are discussed below.

POTENTIAL CUMULATIVE EFFECTS

AIR QUALITY

Construction and operation of the five proposed oil shale RD&D projects would result in temporary impacts to air quality during construction, and longer-term impacts during operation of the RD&D facilities. Construction of the reasonably foreseeable future projects would involve the use of heavy equipment that produces exhaust emissions and fugitive dust. The majority of impacts would be mitigated by the large geographical area in which the projects would occur. Wind dispersion and dilution would reduce the magnitude of emissions and fugitive dust.

Air pollutant dispersion modeling was performed to quantify potential NO_2, PM_{10}, $PM_{2.5}$, and SO_2 impacts during operation, based on the period of maximum potential emissions and other emission sources located within the Piceance Basin (including all five oil shale RD&D projects, plus current ExxonMobil Piceance Development Project activities). Operation emissions would occur due to water and product pumping, processing, and engine exhausts.

Potential maximum cumulative air quality concentrations throughout the Piceance Basin, SO_2 impacts within Dinosaur National Monument (a CDPHE-APCD Category I area), as well as NO_2, PM_{10}, and SO_2, atmospheric deposition (acid rain) and visibility impacts to the Flat Tops Wilderness PSD Class I areas are presented in the following table.

Maximum Potential Cumulative Air Quality Impacts by Impact Region

Location	Parameter	Units	Cumulative Impact	Impact Threshold
Piceance Basin	Nitrogen dioxide	Annual (μg/m^3)	4.3	25
	$PM_{2.5}$	24-hour (μg/m^3)	1.4	65
		Annual (μg/m^3)	0.3	15
	PM_{10}	24-hour (μg/m^3)	5.0	30
		Annual (μg/m^3)	0.6	17
	Sulfur dioxide	3-hour (μg/m^3)	124	512
		24-hour (μg/m^3)	17.1	91
		Annual (μg/m^3)	2.8	20
Dinosaur National Monument	Sulfur dioxide	3-hour (μg/m^3)	10.7	25
		24-hour (μg/m^3)	1.6	5
		Annual (μg/m^3)	0.08	2
Flat Tops Wilderness Area	Nitrogen dioxide	Annual (μg/m^3)	<0.01	2.5
	$PM_{2.5}$	24-hour (μg/m^3)	<0.01	65
		Annual (μg/m^3)	<0.01	15
	PM_{10}	24-hour (μg/m^3)	0.01	8
		Annual (μg/m^3)	<0.01	4
	Sulfur dioxide	3-hour (μg/m^3)	1.8	25
		24-hour (μg/m^3)	0.4	5
		Annual (μg/m^3)	<0.01	2
	Atmospheric Deposition	Maximum Total Nitrogen Deposition (kg/ha-yr)	0.265	3
		Maximum Total Sulfur Deposition (kg/ha-yr)	0.033	3
	Ned Wilson Lake Chemistry (1)	ANC Change (μeq/l)	0.75	1
	Trappers Lake Chemistry	ANC Change (percent)	2.7	10
	Upper Ned Wilson Lake Chemistry (1)	ANC Change (μeq/l)	0.80	1
	Visibility	Greater than 1.0 deciview (days/year)	13 to 20	More than 1 day/year

(1) Because these lakes' lowest (10th percentile) background ANC values are less than 25 μeq/l, the applicable impact threshold is no more than a 1 μeq/l change.
ANC = acid neutralizing capacity
kg/ha-yr = kilograms per hectare per year
NA = Not applicable
PM_{10} = particulate matter less than 10 microns in effective diameter
$PM_{2.5}$ = particulate matter less than 2.5 microns in effective diameter
μeq/l = microequivalents per liter
μg/m^3 = micrograms per cubic meter

Potential direct atmospheric deposition (acid rain) impacts within the Flat Tops Wilderness Area were also calculated. The maximum direct total (wet and dry) nitrogen and sulfur deposition during operation were predicted to be nearly 0.265 and 0.033 kilograms per hectare per year (kg/ha-yr), respectively; well below the 3 kg/ha-year threshold (Fox et al. 1989). Additionally, potential changes in Acid Neutralizing Capacity at three lakes within the Flat Tops Wilderness Area were all predicted to less than their significance thresholds (USFS 2000): a potential 2.7 percent change at Trappers Lake (compared to the 10 percent threshold), and nearly a

0.8 microequivalent per liter (μeq/l) change at the more sensitive Ned Wilson and Upper Ned Wilson lakes (also below a one μeq/l threshold for sensitive lakes).

USFS considers potential visibility impacts within their mandatory federal PSD Class I areas greater than a 1.0 deciview "just noticeable change" from cumulative air pollutant emission sources to be an adverse impact. Potential cumulative visibility impacts were calculated based on observed hourly relative humidity and speciated aerosol concentrations measured between 2001 and 2004, as specified in the FLAG Guidance (FLAG 2000). If the predicted air quality impacts had occurred during the observed visibility measurement period, a 1.0 deciview "just noticeable change" would have been exceeded between 13 and 20 days per year at the Flat Tops Wilderness Area. However, 10 to14 days per year were predicted to occur in the months of November through January, when visitor use in the Flat Tops Wilderness Area is minimal. For the 3 to 6 days per year predicted to have more than a "just noticeable change" in visibility during February through October, 1 to 3 days per year also experienced precipitation events. Given the reasonable, but conservative assumptions incorporated into the cumulative visibility impact analysis (maximum emission rates, duration and timing of the predicted impacts, etc.), and considering the magnitude, frequency, duration, and timing of the predicted impacts, it is unlikely that perceptible visibility impacts would actually occur from the Proposed Action when combined with other activities in the Piceance Basin. The BLM will cooperate with the CDPHE-APCD to achieve the national visibility goal of "no man-made impairment of visibility within mandatory federal PSD Class I areas" by EPA's specified date of 2064 AD. The BLM is also preparing a less conservative cumulative modeling analysis (using the CALPUFF modeling system) in order to better quantify potential cumulative visibility impacts within the Flat Tops Wilderness Area. Finally, the BLM requires the operators to comply with all applicable air quality regulations. As noted in the direct and indirect impacts section, BLM will impose mitigation measures to reduce emissions of particulate matter and other pollutants which could impact visibility. Therefore, no significant adverse air quality impacts are likely to actually occur.

The BLM recognizes that if Oil Shale RD&D Projects can successfully establish that their technologies are adequate to proceed for commercial development, another more detailed and less conservative air quality impact assessment would be prepared using updated air pollutant emissions inventories, meteorological conditions, and dispersion modeling techniques.

AREAS OF CRITICAL ENVIRONMENTAL CONCERN

Construction and operation of the five Proposed RD&D projects would not impact any ACEC in the WRFO. Construction of the reasonably foreseeable future projects would be limited to existing disturbance footprints within any ACEC as managed by the WRFO ROD/RMP. No cumulative impacts would occur.

CULTURAL RESOURCES AND NATIVE AMERICAN RELIGIOUS CONCERNS

Past disturbances to cultural resources in the project area have been related to prior collection, disturbance by OHV users, intentional destruction or vandalism, and construction associated with roads and utilities. Construction of the five Proposed RD&D projects would not affect any known eligible cultural sites. One of the sites requires additional data before eligibility can be determined, and, until such determination is made, the site would be avoided. Another site was listed as requiring additional data, but during the survey for the project, was recommended as not eligible. Each of the five Proposed RD&D projects and reasonably foreseeable future projects would include mitigation measures designed to avoid additional direct impacts to cultural resources. Where direct disturbance cannot be avoided, mitigation (i.e., data recovery) would occur prior to construction. Pressure on nearby sites would likely continue, and would be at least slightly exacerbated by the addition of more cleared ROWs in the same general area, by increased human presence from workers at the sites wandering from the sites during breaks, and by vibration from drilling or heavy equipment. Increased access by ROWs and access roads would increase the potential for trespass or vandalism at previously inaccessible sites in reasonably foreseeable future projects.

SOILS AND FARMLANDS, PRIME AND UNIQUE

Not all of the tract areas will be disturbed during construction. Construction of the five Proposed RD&D projects is estimated to disturb approximately 595 acres of the 800 acres associated with the Proposed RD&D projects. Disturbance would result in short- to long-term impacts on soils depending upon site stabilization and successful reclamation. There are no prime farmland soils impacted by any of the five Proposed RD&D projects. Soil disturbance from the Proposed RD&D projects would result in approximately 1.8 percent of all soils impacted from past, present, and reasonably foreseeable future soil disturbance in the project area, and would disturb soils in 0.04 percent of the entire WRRA. Impacts would be highly localized and limited to the period of construction and reclamation. Cumulative impacts would be minimized by implementing measures for the proper handling of topsoil and spoil, erosion control, and reclamation procedures for each of the reasonably foreseeable future projects.

FLOODPLAINS

None of the five Proposed RD&D projects would be constructed within floodplains. Construction of the five Proposed RD&D projects would have no short- or long-term impacts on floodplains. Cumulative impacts would be minimized by implementing streambank stabilization and restoration measures and engineering practices for reasonably foreseeable future development projects within or impacting floodplains.

WATER RESOURCES, SURFACE WATER AND GROUNDWATER

Construction of the five Proposed RD&D projects would have short-term impacts on surface water and groundwater resources. Cumulative impacts on surface water bodies affected by the Proposed RD&D projects would be limited primarily to water bodies that are affected by other projects within the same watersheds as each of the Proposed RD&D projects. Direct in-stream impacts associated with construction runoff and increased sediment load during initial storm events following construction would have the greatest impacts on water resources. Runoff from construction activities at reasonably foreseeable future projects near water bodies would also contribute to cumulative impacts. Cumulative impacts would be minimized with implementation of erosion control measures, development of SPCC Plans, and BMPs during project operation and reclamation for all reasonably foreseeable future projects.

The large geographical area in which the Proposed RD&D projects would occur would mitigate the conceivable impacts to water quality. Three of the five test sites are located within the Yellow Creek watershed. The volume of groundwater flow moving through a 10-mile long cross-section or vertical slice of the Yellow Creek watershed in the Upper Parachute Creek Unit is over 7,000 gpm. The volume of groundwater flow moving through the combined three test sites in this watershed is approximately 50 gpm, or less than 1 percent of the total groundwater flow in the basin. The potential long-term effects from the two sites in the Piceance Creek watershed are even smaller, considering the much larger size of this watershed and groundwater flow zone. The Proposed RD&D projects would all perform suitable reclamation activities to meet Colorado Groundwater Quality Standards at compliance well locations, resulting in no cumulative downgradient impacts. Groundwater monitoring programs will be established to allow verification of water quality standards. Reasonably foreseeable future projects would also be required to meet or exceed these standards.

VEGETATION AND INVASIVE, NON-NATIVE SPECIES

Construction of the five Proposed RD&D projects would have short- to long-term impacts on vegetation. Removal of vegetation and the disturbance of up to 595 acres of the 800 acres of soils from the five RD&D sites would create optimal conditions for the invasion and establishment of invasive, non-native noxious weed species that could continue for many years after the initial disturbance. The impacts of the Proposed RD&D projects would contribute to a cumulative impact on vegetation and invasive species and are part of the overall impacts of oil and gas vegetative disturbance in the area. These impacts would be greatest where other projects are constructed within the same time period and area as the RD&D sites. Vegetative loss from the Proposed RD&D projects would result in approximately 1.8 percent of all vegetation impacted from past, present, and reasonably foreseeable future soil disturbance in the project area, and would result in a temporary vegetation loss of 0.04 percent of the entire WRRA. Cumulative impacts would be minimized by implementing measures for the proper handling of topsoil and spoil, erosion control, preventative and remedial noxious weed management, and revegetation for each of the reasonably foreseeable future projects.

MIGRATORY BIRDS

Construction of the five Proposed RD&D projects would contribute to cumulative habitat loss and displacement of migratory birds from oil and gas development and other activities. Impacts would result from construction, operation, and reclamation phases of the projects. Over the duration of the projects, loss and fragmentation of habitat would directly affect about 2.2 percent of bird habitat and would indirectly affect a large area due to displacement. Impacts would be long-term and adverse to migratory bird populations that are dependent on sagebrush or pinyon-juniper habitats. Habitat loss from all five Proposed RD&D projects would be approximately 1.8 percent of habitat loss from past, present, and reasonably foreseeable future soil disturbance in the project area, and would result in a temporary habitat loss of approximately 0.04 percent of the entire WRRA.

After 20 years, the oil and gas development in the area could cumulatively result in an overall loss and fragmentation of habitat, resulting in reductions of population of many migratory bird species from reduced carrying capacity and displacement from the area. Cumulative impacts may be minimized by imposing timing limitations and buffer zones around active nests or sensitive areas to preserve habitat for nesting birds and implementing measures for reclamation for each of the reasonably foreseeable future projects. Impacts would be minimized by co-locating reasonably foreseeable future projects in areas of existing development or disturbance, as well as limiting construction of new roads and ROWs.

THREATENED, ENDANGERED, AND SENSITIVE ANIMAL SPECIES

Construction of the five Proposed RD&D projects would not likely jeopardize the viability of any threatened, endangered, or sensitive animal species. Construction of the five Proposed RD&D projects would result in a loss of up to 595 acres within the 800 acres of tracts, which could serve as habitat for threatened and endangered and BLM sensitive species. Impacts include nest abandonment, direct mortality, reproductive failure from stress, and loss and fragmentation of foraging and breeding habitat. The five Proposed RD&D projects would contribute to a cumulative impact on northern goshawk habitat, by temporary loss of approximately 161 acres of pinyon-juniper habitat. Approximately 364 acres of upland sage and bottomland sagebrush habitat would be lost, and approximately 70 acres of grassland habitat. Cumulative impacts would be greatest where other projects are constructed within the same time frame and area.

Within the WRRA, BLM sensitive species may cumulatively be impacted through habitat loss by future oil and gas development. Cumulative impacts would be minimized by implementing measures that prohibit construction during sensitive nesting seasons for each of the reasonable foreseeable future projects.

Reclamation activities would reestablish vegetation and reasonably foreseeable future projects would commit to off-site mitigation as necessary, to compensate for unavoidable disturbances. Construction of the Proposed RD&D projects would not likely jeopardize the viability of any threatened, endangered, or sensitive animal species. Reclamation activities would reestablish vegetation and reasonably foreseeable future projects would commit to off-site mitigation as necessary, to compensate for unavoidable disturbances.

THREATENED, ENDANGERED, AND SENSITIVE PLANT SPECIES

There is no habitat for threatened, endangered, and sensitive plant species on any of the five RD&D tracts. Construction of the Proposed RD&D projects would not jeopardize the viability of any threatened, endangered, or sensitive plant species. Reasonably foreseeable future projects would be subject to pre-construction surveys, avoidance requirements, and mitigation measures if special status species plants could not be avoided. Cumulative impacts are not anticipated.

WASTES, SOLID OR HAZARDOUS

Accidental spills or leaks associated with equipment failures, refueling and maintenance of equipment, and storage of fuel, oil, or other fluids could cause soil, surface water, and/or groundwater contamination during construction of each of the Proposed RD&D projects. The severity of potential impacts from an accidental hazardous material spill would depend upon the chemical released, the quantity released, and the proximity of the release to a waterbody or aquifer. The projects would increase contributions to solid waste landfills during construction, operation and upon closure and would contribute to cumulative impacts on solid waste. Reasonably foreseeable projects would be required to comply with all applicable federal, state, and local regulations. Hazardous waste cumulative impacts are not anticipated.

WETLANDS AND RIPARIAN ZONES

No wetlands or riparian zones would be directly impacted by any of the five RD&D Proposed projects and none of the disturbance areas coincide with identified wetlands or riparian areas. Runoff from sites during construction could result in impacts to wetlands or riparian zones, but would be mitigated through storm water runoff control and BMPs. Nearby wetlands may be affected through dewatering. Reasonably foreseeable future projects would be subject to requirements for protection of wetlands and riparian areas under the Clean Water Act and BLM guidelines, including avoidance and mitigation of impacts, and compensatory mitigation of unavoidable wetland impacts, and cumulative effects are not anticipated.

WILDERNESS

No wilderness areas are impacted by the five proposed RD&D projects. Potential indirect impacts to wilderness areas caused by dust and air emissions from project construction and operation and from reasonably foreseeable future development are described in the air emissions cumulative impact discussion.

WILDLIFE, AQUATIC AND TERRESTRIAL

Construction of the proposed RD&D projects would have some temporary and possibly long-term impacts on wildlife resources. Many woodland accipiters and owls nest extensively in pinyon-juniper woodland with the Proposed Action areas. These raptors can be sensitive to habitat changes caused by development and disturbance from industrial activity. Loss of approximately 161 acres of pinyon-juniper woodland wildlife habitat would displace wildlife species to other areas of suitable habitat due to the decreased carrying capacity of the land. While suitable habitat may be available in adjacent areas, loss of habitat would increase intra- and inter-specific competition. Wildlife populations would decrease as a result of the increased resource competition and mortality from stress, as well the reduction in reproductive success and health from the increased energy expenditures required to deal with disturbance.

Vegetation removal would result in a loss of cover, nesting, and forage habitat. The degree of impact would depend on the type of habitat affected and the rate that vegetation would regenerate after reclamation. Impacts would occur during construction, operation, and reclamation of the sites. Loss of habitat for wildlife, including raptors and big game, would occur on approximately 595 of the 800 acres. Vegetative loss from the proposed RD&D projects would result in approximately 1.8 percent of all vegetation impacted from past, present, and reasonably foreseeable future soil disturbance in the project area, and would result in a temporary vegetation loss of 0.04 percent of the entire WRRA. However, the cumulative effect from all past, present, and reasonably foreseeable projects within the WRRA has contributed and would continue contribute to an overall change of habitat.

Within the WRRA, habitat changes from oil and gas development and the proposed RD&D projects would influence the distribution of big game. The proposed RD&D projects are within important mule deer winter ranges in the WRRA. Local and long-distance migratory patterns could be adversely modified by cumulative effects of reasonably foreseeable future projects, including the RD&D Proposed Action. Increased traffic and oil and gas development would result from changing areas of winter and summer range. The additional traffic and human activity in the region would likely contribute to an increase in poaching and vehicle collisions with wildlife, but would not likely cause a noticeable reduction in populations. Cumulative impacts would be minimized by implementing measures that prohibit construction activities during sensitive wildlife periods.

ACCESS AND TRANSPORTATION

For transportation, the cumulative impact analysis area includes Rio Blanco CR 5 (Piceance Creek) and the associated local road network in the Piceance Creek area. These county roads were originally designed for rural and agricultural uses and were not intended for the repeated heavy loads associated with the current expansion in oil and gas production. The increasing traffic volume, frequency, and vehicle size on these rural roads has contributed to an increase in the costs associated with repair and maintenance of these county roads. Sustained high levels of traffic could have secondary impacts on wildlife, and on the quality of recreation in the region. Collectively, construction and operation of the five proposed RD&D projects would contribute to these traffic effects. Additionally, past, present, and reasonably foreseeable future developments have, and will continue to, create additional access onto BLM lands by constructing new roads into areas that were previously inaccessible by vehicle. The remote and relatively undisturbed nature of these areas are valued by local hunters and recreationists that seek a natural appearing environment with few administrative controls and low interaction between users. The probability of isolation from the sights and sounds of human activity would be diminished over time. Development of the five RD&D sites would not create additional access onto BLM-administered lands, but would contribute to an increase in human activity in the region and would thereby become a factor in the diminished sense of isolation in these remote areas.

FIRE MANAGEMENT

None of the five proposed RD&D projects are located within prescribed natural fire areas defined in the RMP. They are located in areas where fires can be suppressed as wildfires.

The five proposed RD&D projects are estimated to result in removal of approximately 595 acres of pinyon-juniper woodland, sagebrush, and grasslands. This acreage anticipates removal that includes defensible space around project facilities. Of the 595 acres of disturbance, approximately 161 acres is estimated to be of pinyon-juniper woodland, which could create dead fuel load if left unmanaged upon removal. Approximately 364 acres of cleared sagebrush could create a moderate fire load. Utility lines through pinyon-juniper woodlands could create fire hazard potential. Accidental, human caused fires would likely increase in the vicinity of the five Proposed RD&D projects and transportation routes accessing the five tracts due to the increased number of people in the areas where fire fuels are located. Cumulatively, accidental fires would increase due to the increased number of personnel and electrical equipment associated with the five Proposed RD&D projects and reasonably foreseeable future development.

FORESTRY MANAGEMENT

Construction of the five proposed RD&D projects would result in the clearing of 161 acres of pinyon-juniper woodlands and would have short- to long-term impacts on vegetation, terrestrial wildlife, and threatened and endangered species. The current WRFO ROD/RMP EIS anticipated that oil shale and sodium development would occur on 620 of the 632,800 acres of pinyon-juniper woodland on the WRRA (BLM 1997). The RD&D Proposed RD&D projects are within the range of previously-analyzed impacts and less than 0.03 percent of the available resource. Cumulative impacts would be minimized by seeding disturbed areas, controlling noxious weeds, and reclaiming the site at the conclusion of the RD&D programs.

The five proposed RD&D projects are estimated to result in removal of approximately 161 acres of pinyon-juniper woodland. This results in approximately 0.03 percent of the pinyon-juniper woodland within the WRRA that is classified as non-commercial. The woodlands are not within the allowable harvest and are not managed for commercial firewood production. The cleared woodlands will be considered for benefits of other resources and will be appraised by BLM for value. Cumulatively, past, present, and reasonably foreseeable future development projects have resulted in temporary reductions in woodlands. Restoration methods would be applied as appropriate to meet forestry management objectives.

GEOLOGY AND MINERALS

The five proposed RD&D projects would each retort oil shale under a portion of a 160-acre tract. Each Proposed Action would, by virtue of the limited areal extent and thickness of the retorted zone, produce to the surface a small portion of the shale oil resource underlying the tract. The total amount of shale oil that would be produced would be extremely small relative to the 1,200 billion barrels of shale oil estimated to be contained in the Green River formation in the Piceance Basin.

A thick zone of sodium minerals, primarily nahcolite and dawsonite, is intermingled with oil shale in the depositional center of the Piceance Basin. Development of oil shale resources containing substantial deposits of nahcolite and/or dawsonite could preclude future development of the sodium minerals at those locations. The Proposed RD&D projects would avoid such interference either by retorting oil shale zones lacking substantial deposits of sodium minerals, recovering the minerals before recovering the oil resources, or by isolating the formations so as to avoid destruction of the nahcolite and dawsonite.

The RD&D projects would not adversely affect the future recovery of oil shale outside the retorted zones or of other minerals in the project area.

HYDROLOGY AND WATER RIGHTS

Groundwater extraction for on-site use as makeup and process water (1 to 20 gpm) at the Shell test sites would result in minor impacts to groundwater flow in the Upper Parachute Creek member at those sites. However, these impacts would last only through the completion of the oil recovery phase. The largest volume of groundwater would be required during reclamation to resaturate the area where kerogen was heated and the oil was recovered. Resaturation or refilling of the pyrolyzed, or retorted, materials would require from 1 to 3 years using water derived from either natural inflow or extraction and injection wells completed in the Upper Parachute Creek member. There would be potential for minor depletions from Yellow Creek during the reclamation phase at each site, caused by a reduction in groundwater discharge. Given the small size of each site and the relatively slow movement of groundwater in the subsurface, potential depletions would be limited to Shell's estimated maximum of 19 acre-feet per year or 0.026 cfs flow reduction at Yellow Creek. Following the reclamation phase, groundwater flow directions and velocities would likely resemble pre-development patterns. Water rights for any depletions would be secured prior to use. Water depletions are not anticipated for the Chevron and EGL projects. Long-term, basin-wide, cumulative impacts are not anticipated given the scale of the RD&D proposals.

NOISE

The five proposed RD&D tracts are located several miles from each other in a rural setting. There are no noise receptors (homes, schools, businesses) within 0.5 mile of any of the tracts. Noise from each of the operations would not be cumulative due to distance and facilities dispersed in a rural setting. Cumulatively, noise increases are associated with reasonably foreseeable future development. Noise mitigation will be applied as appropriate on a site-specific basis to mitigate impacts to receptors.

PALEONTOLOGY

All of the proposed RD&D projects are on sites underlain by the Uinta Formation. The Uinta Formation is a BLM Class I paleontologic formation, one known to contain vertebrate fossils or noteworthy occurrences of invertebrates or plant fossils. Disturbance of bedrock could damage those fossil resources and contribute to the basin-wide degradation of paleontologic resources caused by construction activities. The Proposed Action tracts have either not been surveyed for fossils or have been surveyed with negative results, although significant plant fossils have been found in the vicinity of Shell Site 3. Cumulative impacts would be mitigated by having paleontologists monitor bedrock-disturbing activities and by training construction and operation personnel not to collect fossils.

RANGELAND MANAGEMENT

Grazing leases exist on all of the five proposed RD&D tracts. Fences erected at the sites to protect health and safety would eliminate grazing on approximately 550 acres. Impacts to the total of 126,490 AUMs within the WRRA would be less than 1 percent.

One watering facility on one of the tracts would need to be relocated. Grazing acreage losses may require the number of livestock to be grazed by permittees to be reduced, or replacement forage may need to be identified. Cumulatively, reasonably foreseeable future projects could result in the reduction of available livestock forage.

REALTY AUTHORIZATIONS

The five RD&D tracts all have existing and proposed projects within or crossing them including wells, water and gas pipelines, utilities, roads, and a vegetation research plot. Some of the existing facilities would need to be moved to accommodate safe construction and operation of the oil shale RD&D facilities. Some of the facilities would need to be moved off of the parcels and require acquisition of additional ROW, and additional disturbance to move existing facilities. Cumulatively, energy development has expanded to result in multiple project requests on parcels. More realty authorizations would be required to accommodate the increase in projects, with appropriate stipulations and increased management of the authorizations.

RECREATION

The five RD&D tracts all occur within the White River ERMA, which BLM has custodial management to provide for unstructured recreation activities. The primary recreational users in the area include hunters and mountain bikers. Development of the five Proposed RD&D projects would result in potential loss of up to 800 acres of recreational lands for hunting and cycling. There are sufficient hunting areas and road systems available that are away from the RD&D tracts that recreationists would likely move onto other lands. Cumulatively, increased development in the WRRA will reduce lands available for recreation, and impact the recreational experience of those desiring an environment free of structures and facilities. Big game habitat will become more dispersed with increased roads and changes in habitat.

SOCIOECONOMICS

The cumulative impact assessment area for socioeconomics includes Rio Blanco, Garfield, and Mesa counties since these counties would provide the workforce and would receive the tax and royalty income generated by other reasonably foreseeable projects within the WRRA. The five proposed oil shale RD&D projects would contribute to the development of mineral resources in the Piceance Basin, and would be a factor in the ongoing socioeconomic change throughout the region.

The five proposed projects along, with present and future oil and gas production activities in the Piceance Basin would contribute to additional employment opportunities throughout the region and would expand the local tax base as workers move into the area and purchase homes, land, goods, and services. Although federal royalties have been waived for the duration of the proposed RD&D program and rents have been waived for 5 years, reasonably foreseeable future oil shale development would ultimately contribute to Colorado Local Government Energy Impact Programs, and increased oil and gas production in the WRRA will continue to contribute federal royalties, bonuses, rents, and severance tax revenues to the local governments impacted by energy development. These impacts would be considered beneficial to local communities in the region.

The social infrastructure of the cities and counties affected have not been able to keep pace with the rapid growth in the oil and gas industry and demands upon law enforcement, emergency response, community services, and road and bridge maintenance have increased substantially. Aging facilities are at, or near, capacity, transportation networks and community services are in need of upgrading and/or repair, and current staffing is not adequate for managing the increased activity. This creates a financial and logistical burden on local governments attempting to maintain the level of service expected within the communities, while at the same time they are under increasing pressure to provide the needed services in more remote locations such as the Piceance Basin. The proposed oil shale RD&D projects would contribute to these demands on local services. The monies received in the form of royalties, taxes, bonuses, and rents from oil and gas production would provide some compensation to offset the effects of development, and would provide a portion of the funding needed to expand the local infrastructure to accommodate industry growth. Direct distributions and grant funds through CDOLA would be applicable to the local governments in Rio Blanco County to help mitigate the demands that the Proposed RD&D projects may place on community resources.

The surface disturbance resulting from construction of the proposed oil shale facilities, along with present and future oil and gas activities, could have an effect on the economic viability of the ranching and recreation industries in Rio Blanco County. The cumulative loss of forage for livestock and big game could result in a reduction in livestock numbers and the dispersement of deer and elk away from traditional hunting grounds in the area. Other recreational activities could be dispersed to more isolated locations as the Piceance Basin becomes more developed. The changes in the natural landscape of the WRRA brought about by development could contribute to a decline in the economic benefits generated by these industries.

Implementing reclamation activities as required to re-establish vegetation in disturbed areas, limiting new road and facility construction to existing corridors, and adhering to VRM stipulations to diminish the sights and sounds of human activities would minimize the cumulative impacts to these industries.

The White River ROD/RMP (BLM 1997) included oil shale research as reasonably foreseeable in its cumulative impact analysis. Current developments in the WRRA, including the actions proposed, have not exceeded the foreseeable development analyzed in the ROD/RMP. However, oil shale development beyond the proposed RD&D program together with sustained oil and gas expansion in the Piceance Basin could result in broad impacts to the communities of northwestern Colorado. Although the BLM has not made the decision to allow oil shale development on a commercial scale, the leasing of oil shale lands for this purpose is a reasonably foreseeable future prospect. Should the proposed RD&D projects prove to be successful in developing efficient methods for shale oil extraction, the processes would likely generate interest from other oil and gas producers and new development could expand quickly on both public and private lands in Colorado, as well as in Utah and Wyoming. Rapid development of oil and gas operations in northwestern Colorado could change the rural/agricultural character of remote energy producing regions into a more industrial environment.

Construction of new roads, pipelines, utility corridors, and production facilities would introduce additional human activity to relatively undisturbed areas, and an increase in local populations would likely result from the promise of high-paying jobs in the energy industry. Traffic on local roads could be expected to grow and facility maintenance and service needs would insure that relatively high levels of traffic are sustained.

The smaller communities in the region would experience the greatest impact resulting from sudden population growth. Meeker, Rangely, Parachute, DeBeque, and Rifle do not presently have sufficient housing, emergency response capabilities, community services, or correctional facilities to accommodate a substantial population increase, and city and county governments in the area are reluctant to increase spending on community services and housing requirements for energy production growth as a result of previous experience with the historic boom and bust nature of the oil and gas industry. Other communities in the region, such as Grand Junction, are capable of meeting the social demands of a large workforce, but would be impacted to some degree by the problems associated with population growth, such as crime and drug use. On the other hand, managed growth is necessary to sustain local economies. Local governments benefit from the increase in tax revenues to support schools, hospitals, and community services. Sustained growth brings with it the addition of new business in the retail, service, and public sectors which provides jobs, lowers unemployment rates, increases productivity, and maintains the health and vitality of a community.

The decision to allow commercial-scale oil shale development is contingent upon the assurance that today's extractive technologies are able to operate economically, and at environmentally acceptable levels, before conversion to commercial operations is considered. The pilot RD&D program would be designed as small-scale, carefully staged, research and development projects that would advance our collective knowledge of the oil shale resource and evaluate its potential as a future domestic energy supply. A Programmatic EIS is currently being prepared by the BLM to address the foreseeable commercial-scale oil shale leasing, and in response to the increase in oil and gas drilling activity, the BLM will prepare an RMP Amendment/EIS beginning later this year. The cumulative impacts of the industry on the social infrastructure in the WRRA, including the Piceance Basin, will be further analyzed in that RMP Amendment/EIS.

VISUAL RESOURCES

All of the five proposed RD&D projects are within VRM Class III and have the objective to partially retain the existing character of the landscape. VRM Class III evaluations for each of the five RD&D projects will result in some change to the landscape from areas within the project area. The Chevron site is the most prominent, atop a ridge adjacent to CR69 which is traveled heavily by hunters and other recreationists. The other tracts are less visible to the majority of workers, recreationists, or casual visitors in the project area. Facilities will be painted colors chosen by BLM to reduce visual impacts. Cumulatively, reasonably foreseeable future development will cause increased disturbance, visible from more locations within the project area.

WILD HORSES

Two of the five proposed RD&D projects are within the Piceance/East Douglas HMA which encompasses 190,000 acres. Approximately 320 acres (0.02 percent) of the HMA would be fenced and no longer available as wild horse habitat. Horses may be disrupted by noise and fugitive dust associated with construction activities, particularly during foaling season. Cumulatively, reasonably foreseeable future development within the Piceance/East Douglas Herd HMA would eliminate wild horse habitat. Prompt reseeding of disturbed areas upon completion would enhance habitat restoration.

PROPOSED ACTION AND SUBALTERNATIVE MITIGATION SUMMARY

Shell would implement design criteria and mitigation activities as identified in the Proposed Action and Plan of Operations. In addition to mitigation and design criteria identified in the Proposed Action, BLM would require Shell to incorporate additional mitigation identified in the Subalternative. The table below summarizes the Shell- and BLM- directed mitigation.

Proposed Action and Subalternative Mitigation Summary

Resource Area	Proposed Action Design Mitigations	Subalternative Proposed Action with Additional Mitigation
	As identified in the Proposed Action and Plan of Operations, Shell Frontier Oil and Gas Inc (Shell) would implement the following design criteria and mitigation:	**In addition to mitigation and design criteria identified in the Proposed Action, the Bureau of Land Management (BLM) would require Shell to:**
Air Quality	• Develop a Fugitive Dust Control Plan. • Control wild fires. • Comply with Colorado Department of Public Health and Environment (CDPHE) Air Pollution Control Division (APCD) construction emissions permits and control measures.	• Surface roads and well locations on soils susceptible to wind erosion to reduce the amount of fugitive dust generated by traffic or other activities. • Use dust inhibitors to prevent fugitive dust problems. • Establish and enforce speed limits (15 to 30 miles per hour [mph]) • Continue to cooperate with existing atmospheric deposition and visibility impact monitoring programs.
Cultural Resources	• Survey for and mitigate any cultural resources prior to construction. • Fence-off the cultural site on Site 3 during construction and completely avoid the cultural site throughout the life of the project. Erosion control should be used to avoid impacting the cultural site. • Add conditions of approval to the Site 3 lease to ensure that National Register of Historic Places (NRHP) eligibility of the site is determined prior to any impacts, and safeguard site integrity until NRHP eligibility is adequately determined.	• Inform personnel that they would be subject to prosecution for knowingly disturbing historic or archaeological sites, or for collecting artifacts. • Stop activity in the area if historic or archaeological materials are uncovered and immediately notify the BLM Authorized Officer (AO). • Notify the BLM AO by telephone and with written confirmation, immediately upon discovery of human remains, funerary items, sacred objects, or objects of cultural patrimony. Stop activities in the immediate area of the find, and protect the discovery for 30 days or until notified to proceed in writing by the BLM AO.
Invasive, Non-native Species	• Reseed exposed areas quickly. • Reseed all areas during reclamation using BLM-certified seed mix, combined with erosion control and fertilizer to restore vegetation.	• Monitor distribution and density of noxious weeds and control and/or eradicate any new or expanded populations. • Keep disturbed areas as free of noxious weeds and undesirable species as practicable. • Conduct pre-construction field surveys each spring to identify existing noxious weed infestations within the project area. • Consult with BLM and local weed agencies to develop treatment strategies for any identified noxious weed infestations. • Require vehicles and equipment to arrive at the site clean, power-washed, and free of soil and vegetative debris capable of transporting weed seeds or other propagules. • Install wash stations at designated infestation areas if any are identified in Spring 2007. Wash water would be contained and grease traps would be added as required. • Seed disturbed areas.

Proposed Action and Subalternative Mitigation Summary

Resource Area	Proposed Action Design Mitigations	Subalternative Proposed Action with Additional Mitigation
Migratory Birds	• Maintain water in conveyance and containment structures until water quality is acceptable for release. • Reclaim and return the area with natural vegetation.	• Re-survey for nesting migratory birds, including raptors, before project initiation if construction is delayed until February 1, 2007. • No surface occupancy allowed within 1/2 mile of active nests of threatened, endangered, or BLM sensitive species of migratory birds, including raptors, from February 1 through August 15 (1/4 mile for all non-listed migratory bird species). • No vegetation clearing while migratory birds are nesting (February 1 through August 15). • Preclude migratory bird access to, or contact with, reserve pit contents using methods that effectively eliminate migratory bird contact with pit contents and meet BLM's approval. • Notify BLM of the method to be used to eliminate migratory bird use 2 weeks prior to drilling activities and implement within 24 hours after drilling activities begin. • Report lethal and non-lethal events that involve migratory birds to a BLM Petroleum Engineer Technician immediately.
Threatened, Endangered, and Sensitive Animal Species	• Maintain water in conveyance and containment structures until the water quality is acceptable for release. • Reclaim and return the area with natural vegetation. • Fence process water ponds.	• Line reserve pits. Enclose with net-wire fencing covered with plastic barrier to exclude animals and netted to prevent birds from accessing pits. Reclaim pits as soon as possible after use. • Re-survey for raptors if construction is delayed until February 1, 2007. • Conduct pre-construction surveys to determine which species require clearance surveys if construction occurs in spring of 2007. • No surface occupancy allowed within 1/2 mile of active nests of threatened, endangered, or BLM sensitive species of migratory birds, including raptors, from February 1 through August 15 (1/4 mile for all non-listed migratory bird species). • No vegetation clearing while migratory birds are nesting (February 1 through August 15).
Threatened, Endangered, and Sensitive Plant Species	• No specific mitigation plans because no suitable threatened and endangered plant habitat was found at the test sites.	• Avoid plants that occur outside the project area and install exclusion fencing to prevent disturbance from construction activities. • Conduct source population surveys in areas where plants could not be avoided to determine the magnitude of impact on the entire population. • Evaluate the potential for site design modifications in areas where plants occur. • Conduct pre-construction surveys for special status plants during the flowering period.

Proposed Action and Subalternative Mitigation Summary

Resource Area	Proposed Action Design Mitigations	Subalternative Proposed Action with Additional Mitigation
Wastes, Solid or Hazardous	• Develop a Spill Prevention Control and Countermeasures (SPCC) Plan, Risk Management Plan, Process Safety Management, and an Emergency Response Plan. • Report releases of hazardous substances to state and local emergency response coordinators. • Pressure test piping systems prior to use. • Visually monitor sumps within concrete containment areas daily. • Pump sump liquids to the process water treatment plant or send offsite for disposal. • Send surface construction materials offsite in appropriate containers. • Dewater and bury drill cuttings below grade. • Dispose of site garbage, waste oils, reagents, and Lab chemicals offsite. • Ship sanitary waste to an approved offsite facility. • Monitor surface water and groundwater.	• Watch for signs of hazardous or solid wastes during excavation activities; if found, report and mitigate. • Use, store, transport, and/or dispose of hazardous materials in accordance with applicable federal and state laws. • Implement spill prevention measures, inspection and training requirements, and spill response and notification procedures. • Maintain sanitary conditions in the project area at all times. • Provide adequate trash containers on-site, and dispose of trash at an appropriate disposal site. • Provide portable toilets on-site, removing and properly disposing of contents in accordance with applicable laws and regulations.
Water Quality, Surface and Ground	• Protect water quality through plans and design features. • Attempt to extract groundwater prior to the production phase and reinject the groundwater in another area. • Pump groundwater that is recovered during hydrocarbon removal to the surface and treat it prior to reinjection. • Work with BLM on the development of surface and groundwater monitoring plans. • Obtain permits and follow all local, state, and federal water quality regulations.	• Obtain permits and comply with applicable water quality requirements. • Develop a groundwater monitoring and response plan consistent with groundwater monitoring programs undertaken at the other Colorado oil shale RD&D tracts. • Continue groundwater monitoring as long as needed to determine that the site is acceptable for abandonment. • Obtain a stormwater discharge permit and submit its stormwater management plan to the WRFO. • Prepare and implement a SPCC plan for BLM approval. • Adhere to "Gold Book" 4th edition surface operating standards for oil and gas exploration and development for all surface disturbing activities. • Submit a water monitoring and response plan to the AO prior to project implementation.
Wetlands and Riparian Zones	• Obtain 404 permits from the U.S. Army Corps of Engineers (COE) if intermittent stream channels are to be modified.	• Install monitoring wells on the tracts and collect surface water data from Corral Gulch and Stake Springs Draw to determine hydrologic interactions. • Obtain a Section 404 permit from the COE for impacts to waters of the U.S. for removal or modification of intermittent stream channels. • Install and maintain erosion control structures. • Prohibit storage of hazardous materials, chemicals, fuels, lubricating oils,

Proposed Action and Subalternative Mitigation Summary

Resource Area	Proposed Action Design Mitigations	Subalternative Proposed Action with Additional Mitigation
		concrete coating, and refueling activities within 200 feet of wetland or riparian areas.
Soils	• Salvage and stockpile suitable top soils (6 to 12 inches as available). Seed with BLM approved grass seed mix to minimize erosion and associate loss of soil. Protect with erosion control netting. • Reclaim areas with procedures provided in the Plans of Operations. • Recontour soils and redistribute and seed salvaged soils with approved BLM seed mixes during reclamation. • Test soils for petroleum contamination. • Test redistributed soils to determine if amendments are necessary to promote plant establishment. • Use sediment control structures to control erosion and contain runoff. • Reclaim site access roads to dirt roads with asphalt removed and the road regarded. .	• Strip topsoil to a depth of 6 to 12 inches, depending on its depth. Store any subsoil stripped during grading separately from topsoil to prevent mixing. Seed soil stockpiles and cover. During reclamation, return soils to their pre-construction locations. • Install and maintain temporary erosion and sediment controls immediately following clearing and grading of the site to control erosion. Remove during reclamation, as appropriate. • Return the site to pre-construction contours. Seed disturbed areas with BLM-recommended seed mixes. Install permanent erosion control measures where needed. • Prepare and implement a SPCC plan for BLM approval aimed at reducing the potential for adverse impacts associated with spills and leaks.
Vegetation	• Use BLM approved seed mixes. • Install and maintain erosion control measures until vegetation is established. • Restore pre-construction contours, drainage patterns, and topsoil. • Restore wildlife habitat during reclamation by planting grasses, forbs, shrubs, and tress.	• Cut trees with a chain saw and/or mechanical shears and cut brush close to the ground. • Leave stumps and root balls in place (except in areas requiring topsoiling, or as necessary to create a safe and level workspace). • Shred or chip brush and salvage with topsoil. • Salvage and replace topsoil. • Improve re-vegetation potential by preparing a seedbed prior to seeding. • Control noxious weeds. • Use certified weed-free seed purchased from and blended by qualified producers and dealers. • Comply with BLM Instruction Memorandum No. 2006-073 entitled *Weed-Free Seed Use on Lands Administered by the BLM* and as listed in the Table in the Vegetation Section. • Redistribute large, woody material salvaged during clearing operations in order to meet fire management objectives and provide wildlife habitat and seedling protection.

Proposed Action and Subalternative Mitigation Summary

Resource Area	Proposed Action Design Mitigations	Subalternative Proposed Action with Additional Mitigation
Wildlife, Aquatic	• Develop and conduct a comprehensive surface water and groundwater monitoring program. • Monitor stream flow and water quality in nearby streams and springs. • Install and maintain erosion and sediment control measures.	• Conduct a comprehensive groundwater monitoring program to evaluate hydraulic connection. • Monitor stream flow and water quality in nearby streams and springs. • Install and maintain erosion and sediment control measures. • Prohibit storage of hazardous materials, chemicals, fuels and lubricating oils, and prohibit concrete coating and refueling activities within 200 feet of any waterbody or wetland. • Minimize erosion from upland areas by restoring and seeding disturbed areas. • Install temporary equipment bridges across flowing waterbodies. • Place topsoil and spoil at least 10 feet from waters edge. • Cross streams during periods of low flow and complete the crossing within 24 hours, as feasible.
Wildlife, Terrestrial	• Maintain water in conveyance and containment structures until water quality is acceptable for release. • Reclaim and return disturbed areas with natural vegetation. • Fence process water ponds with an 8-foot high chain link fence to prevent wildlife from entering the pond. • Restore wildlife habitat during reclamation by planting grasses, forbs, shrubs, and tress.	• Prohibit construction activities in severe/critical mule deer and elk winter range between December 1 and April 30. • Redistribute large, woody material salvaged during clearing operations so as not to exceed 3 to 5 tons per acre, and mulch excess woody materials. • Limit fencing on the tract to facilities that otherwise would present a hazard to humans and/or wildlife. • Seed disturbed areas according to BLM standard. • Ensure that reserve pits are lined, fenced with net-wire and covered with plastic barrier, and reclaim pits as soon as possible after use. • Support carpooling and establish a policy of reduced vehicular speed, especially at night.
Access and Transportation	• Control dust along unsurfaced access roads and minimize tracking of soil onto paved roads. • Reclaim site access roads to dirt roads with asphalt removed and the road regarded. Replace and revegetate stockpiled soils.	• Encourage carpooling programs to minimize vehicle travel to the site. Maintain site access roads. • Consider providing temporary overnight accommodations at the site to reduce travel. • Control dust along unsurfaced access roads and minimize tracking of soil onto paved roads. • Comply with county weight and load restrictions. • Maintain unsurfaced roads during construction and operations of the project. • Restore unsurfaced roads to equal or better condition than pre-construction condition.
Fire Management	• Control wild fires and contain and extinguish fires.	• Coordinate with BLM and county Emergency Response teams for fire suppression priorities, management restrictions, and fire suppression

Proposed Action and Subalternative Mitigation Summary

Resource Area	Proposed Action Design Mitigations	Subalternative Proposed Action with Additional Mitigation
		strategies. • Equip construction equipment operating with internal combustion engines with approved spark arresters. • Carry fire-fighting equipment on motor vehicles and equipment. • Take immediate action to suppress accidental fires. • Construct a fire break around each test sites. Construct power lines with defensible space. • Comply with BLM fire management requirements in all activities. • Redistributing large, woody material salvaged during clearing operations on WRFO-administered lands. • Implement appropriate mitigation identified in the BLM Fire Management Activity Plan (FMAP). • Develop and provide to all employees on site, county and BLM officials an evacuation plan.

Forestry Management	• Seed disturbed areas.
	• Control noxious weeds.
		• Cut trees with a maximum stump height of 6 inches.
		• Dispose of trees by:
		  • cut into 4-foot length, down to 4 inches in diameter
		  • place trees along the edge of the disturbance
		  • remove trees from federal land for resale or private use; or
		  • chip and scatter.
		• Acquire a fuel woods permit and compensate the BLM for trees.

Noise	• No noise mitigation identified by Shell.	• Install and maintain appropriate mufflers and silencers on construction equipment and facility machinery. • House or cover noise producing sources with appropriate insulated facilities.
Paleontology	• Avoid known paleontological resource sites by not utilizing the entire construction workspace on Site 3.	• Require a paleontologic monitor to be on-site prior to any ground-disturbing activities. • Train personnel that collection of paleontological specimens is not allowed.
Rangeland Management	• Fence off sites for protection of range animals and other wildlife.	• Seed disturbed areas as discussed in the Vegetation section. • Control noxious weeds as discussed in the Invasive, Non-Native Species section. • It may be necessary to install cattleguards where heavy traffic is expected.
Realty Authorizations	• Provide a mutually acceptable agreement concerning the Colorado State University (CSU) Recreation and Public Purposes (R&PP) lease (COC34329).	• Make the Conditions of Approval for the sites a part of any ROW grant stipulations, along with compliance with all applicable regulations contained in Title 43 Code of Federal Regulations (CFR) part 2800.

Proposed Action and Subalternative Mitigation Summary

Resource Area	Proposed Action Design Mitigations	Subalternative Proposed Action with Additional Mitigation
		• Use the "One Call" system to locate and stake the centerline and limits of underground facilities in areas of proposed excavation.. • Comply with all applicable state and county laws and regulations, and obtain all related applicable permits. • Necessary revisions to the Proposed Action and to the R&PP lease shall be provided to BLM before the Shell RD&D lease approval.
Socioeconomics	• Initiate discussions with local municipalities to determine appropriate mitigation measures to offset the demands on local resources.	• Implement a health and safety program. • Provide site security. • Implement a fire prevention and control program as discussed in the Fire Management section. • Encourage employees and contractors to carpool to and from the site. • If possible, new employees would be hired from within the communities of the region. • Use local contractors for the majority of construction and drilling activities.

Visual Resources	• Minimize dust.
	• Seed disturbed areas as soon as possible.
		• Paint above ground facilities in accordance with BLM-recommended color schemes.
		• Recontour disturbed land to conform to natural contours as closely as possible.
		• Reseed disturbed areas using BLM-approved seed mixes as quickly as possible.
		• Reduce fugitive dust. Establish and enforce speed limits on gravel roads in and adjacent to sites.
		• Monitor and cleanup litter and other debris.
		• Where feasible:
		  • site structures off ridge lines,
		  • use low-profile structures,
		  • site slash/debris piles in low visibility areas, and
		  • feather and thin edges of cleared areas outside the site buffer zone, and inside the facility.
		• Co-location of utility services in combined ROW.

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CONSULTATION, PREPARATION, AND REVIEW

The following agencies were consulted, formally and/or informally through personal discussion, during preparation of this document.

AGENCY CONSULTATION

Bureau of Land Management
U.S. Fish and Wildlife Service
Native American Tribal Consultation
Colorado State Historic Preservation Officer
Rio Blanco County Commissioners
Rio Blanco County Planning
Rio Blanco County Road and Bridge Department

PREPARERS

This Environmental Assessment was prepared by URS (a third party contractor) with direction and independent review by BLM resource specialists in the White River Field Office. Oversight was provided by BLM staff at several stages of the project. Two Interdisciplinary Team reviews of the document were conducted with meetings held in the Meeker BLM office to resolve BLM comments and URS responses. Preparers are listed below.

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INTERDISCIPLINARY REVIEW

Project Team		
Name	**Title**	**Area of Responsibility**
BLM Oversight		
Jane Peterson	NEPA Specialist	EA Project Manager
Paul Daggett	Mining Engineer	Geology and Minerals
Brett Smithers	Wildlife Biologist	Migratory Birds; Threatened, Endangered, and Sensitive Animal Species; Wildlife; Wetlands and Riparian Zones
Tamara Meagley	Natural Resource Specialist	Areas of Critical Environmental Concern; Threatened and Endangered Plant Species
Chris Ham	Outdoor Recreation Specialist	Recreation; Wilderness; Access and Transportation
Mark Hafkenschiel	Rangeland Management Specialist	Vegetation; Invasive, Non-Native Species; Rangeland Management
Michael Selle	Archeologist	Cultural and Paleontological Resources
Scott Archer	Air Quality Specialist	Air Quality
Craig Nichols	National Science and Technology Center	Air Quality and Modeling
Nate Dieterich	Hydrologist	Air Quality; Water Quality, Surface and Ground; Hydrology and Water Rights; and Soils
Linda Jones	Realty Specialist	Realty Authorizations
Mary Taylor	Rangeland Management Specialist	Wetlands, Riparian Zones
Ken Hosinger	Natural Resource Specialist	Fire Management
Robert Fowler	Forester	Forest Management
Melissa Kendall	Hazmat Collateral	Wastes, Hazardous or Solid
Chuck Romaniello	State Office Socioeconomist	Socioeconomics Analysis
Carol Dawson	State Office Botanist	Threatened and Endangered Plant Species, Invasive, Non-Native Species
Brian St. George	State NEPA Coordinator	NEPA

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www.warnercnr.colostate.edu

5 June 2006

Kent Walter
White River Field Office
73544 Highway 64
Meeker, Colorado 81641

Dear Kent:

I am writing on behalf of Mark Paschke and myself about our reclamation test plots in the Piceance Basin and the *in situ* oil shale project proposed by Shell Production & Exploration Company. We have met with Mike Long from Shell and discussed the proposed R&D activities on the site that is under long-term lease by CSU. Shell has provided us with the assurance that they will include us in the planning and design of activities that could potentially impact our study site. Our inclusion in this process should help mitigate impacts to our studies and based on our understanding of the proposed activities, we feel that with careful planning these activities could be carried out in such a fashion as to have minimum impact on our research.

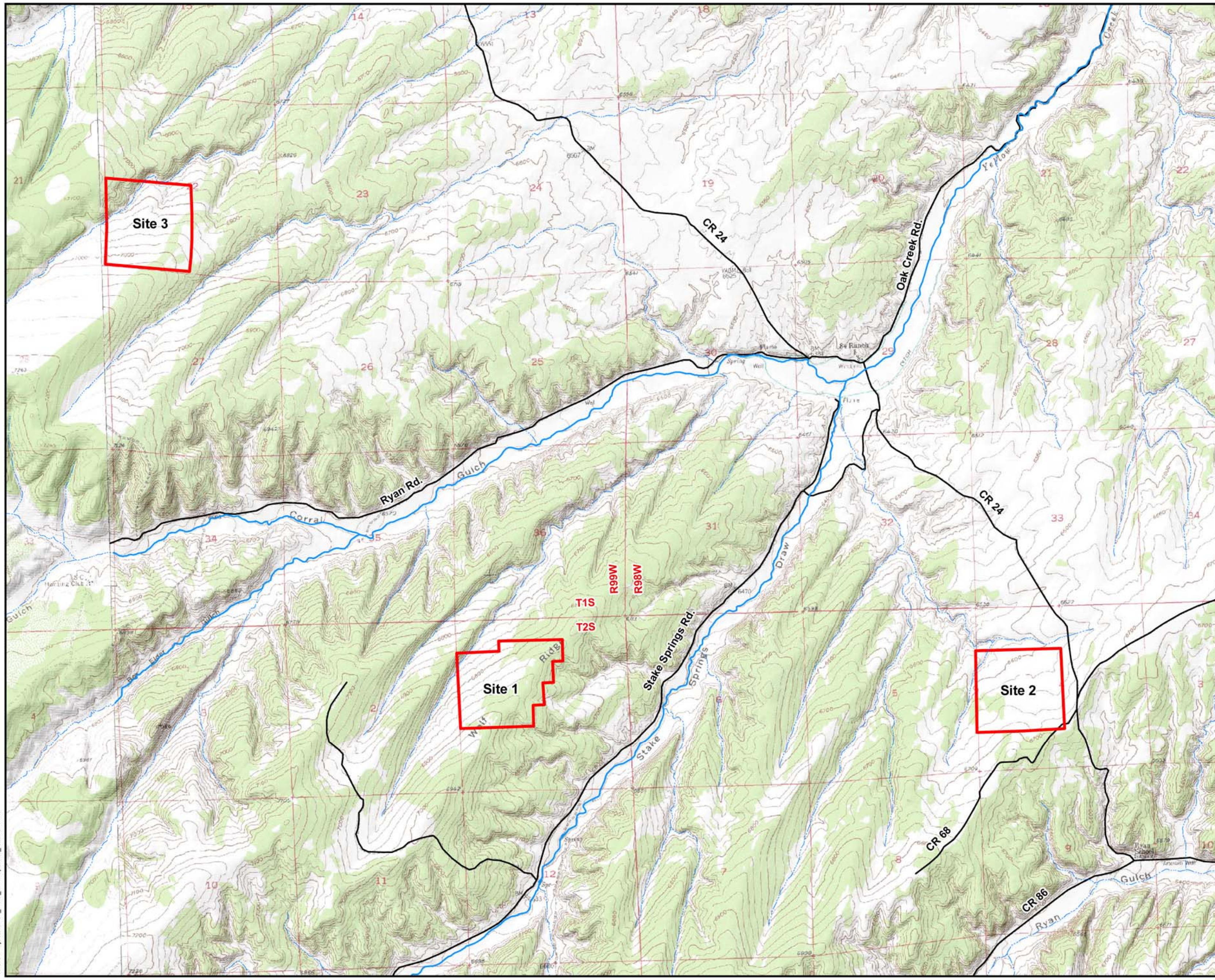
Our main concerns at this point are to minimize dust around our study plots, maintain the fences around our study plots, avoid any intrusions into our study areas, and avoid any unforeseen activities that affect the ecological integrity of our plots. Shell has agreed to do all that they can to address these concerns and we will continue to work together so that everyone's objectives can be met.

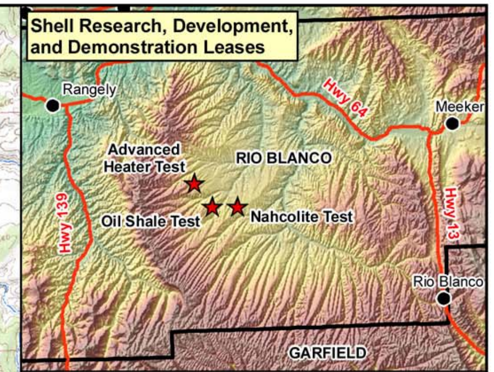
If you have any questions, please contact either Mark or myself.

Sincerely,

Edward F. Redente, Ph.D.
Dean

cc: Mike Long





Legend

Shell Research, Development, and Demonstration Leases

Stream/River: Perennial

Stream/River: Intermittent

Roads

Site 1 - Oil Shale Test Site

Site 2 - Nahcolite Test Site

Site 3 - Advanced Heater Test Site

N
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3,000 0 3,000 Feet

1 inch equals 3,000 feet

Topographic Map Source:
This raster dataset represents a download from the Microsoft TerraServer site. The downloaded data is of type DRG. This dataset was published in 1995. Road locations may be out of date.

Figure 1
Project Area Boundaries

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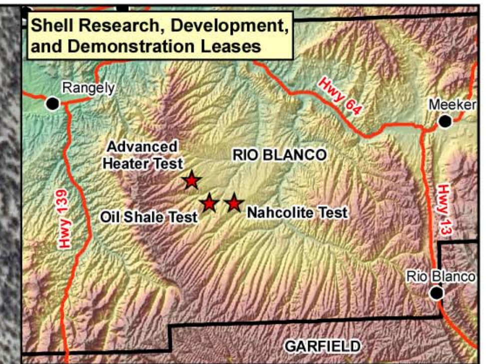

Legend

Shell Research, Development, and Demonstration Leases

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1 inch equals 400 feet

Location: Township T2S, Range R99W, Section 1

Figure 2
Site 1 - Oil Shale Test Site

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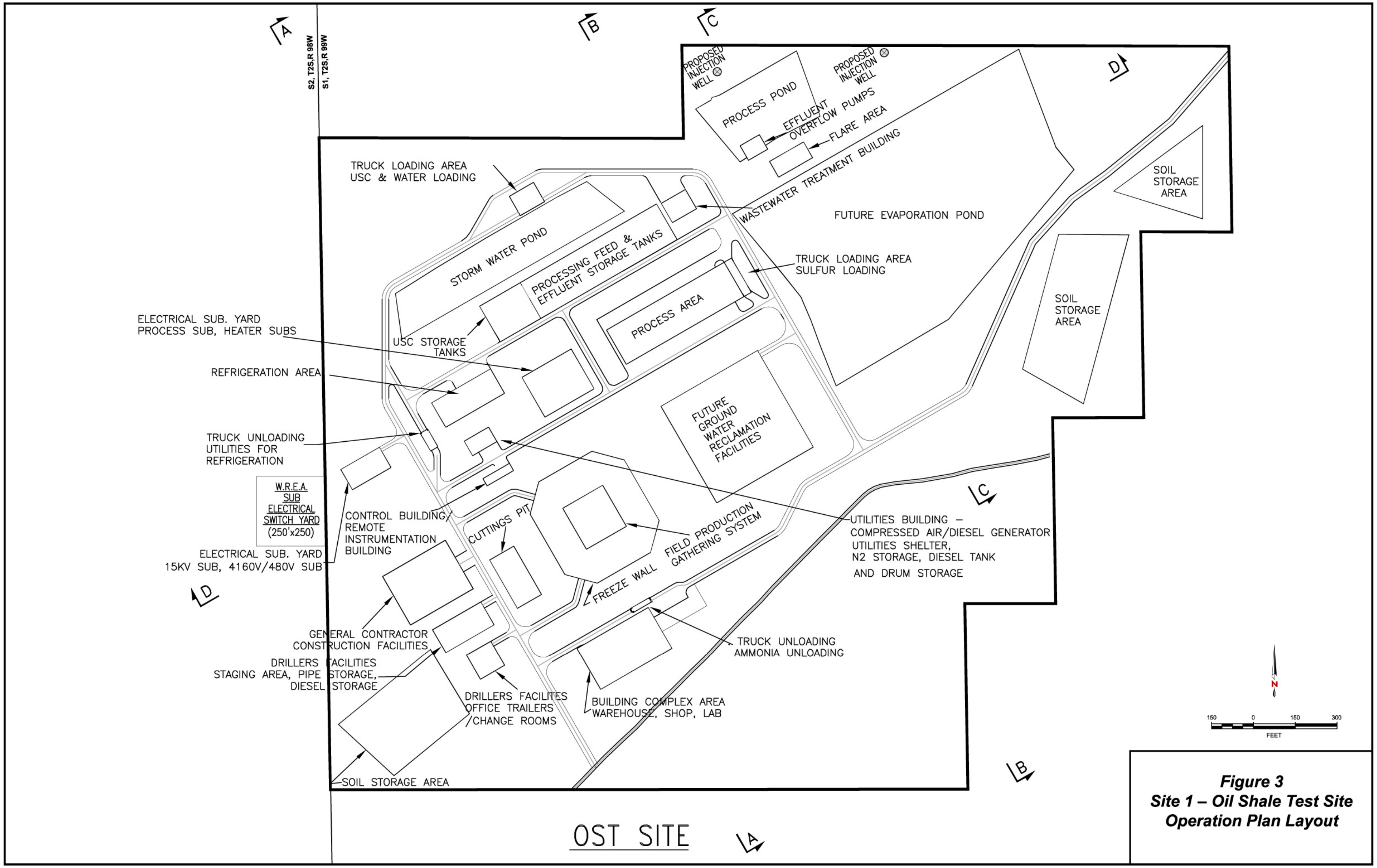


Figure 3
Site 1 – Oil Shale Test Site
Operation Plan Layout

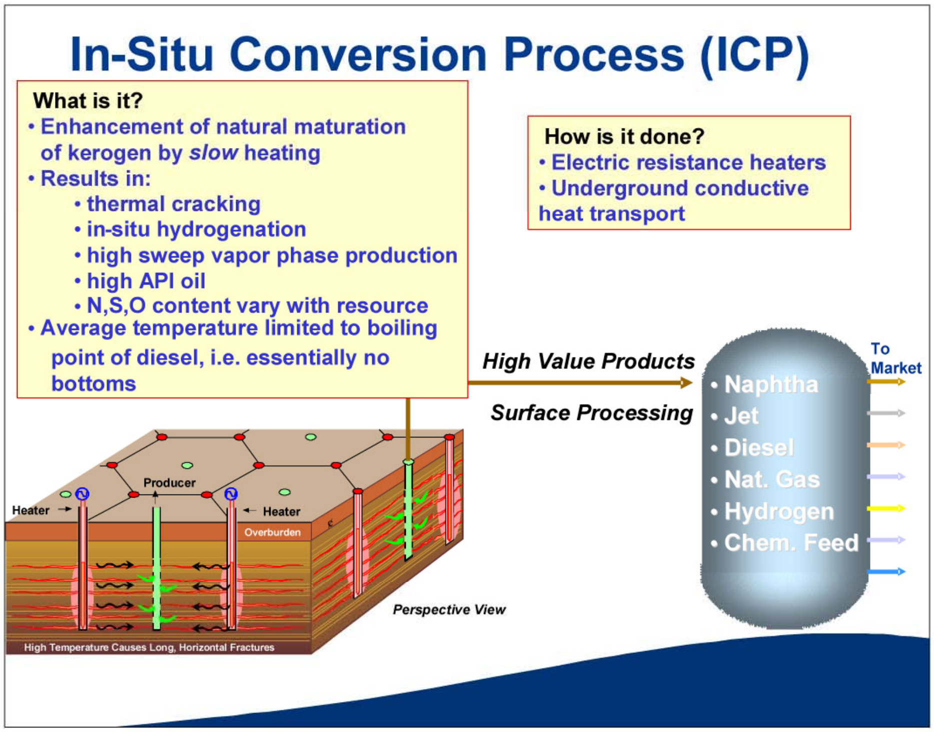


Figure 4. ICP Process

1. **SURFACE FOOTPRINT** – Surface facilities for the freeze wall include access points to the closed-loop pipe system, monitoring wells and groundwater wells, which will pump out the groundwater from inside the contained reservoir once the freeze wall is built.
2. **ICE WALL** – A chilled liquid would be circulated through a closed system of pipes causing the water in the surrounding rock to freeze and eventually form a wall of ice. This freeze wall will serve as a barrier to keep groundwater out of the contained reservoir.
3. **HOLES** – Shell will drill a maximum of 150 holes spaced about 8 feet apart in order to create the closed-loop pipe system.
4. **SHALE BED** – Up to 2,000 feet beneath the surface, the shale layer is a rock formation containing organic matter (kerogen). It is this organic matter trapped in the rock that results in oil and gas when gradually heated. Shell's goal is to find a way to produce this potential energy resource in an economically viable, environmentally responsible and socially sustainable manner.

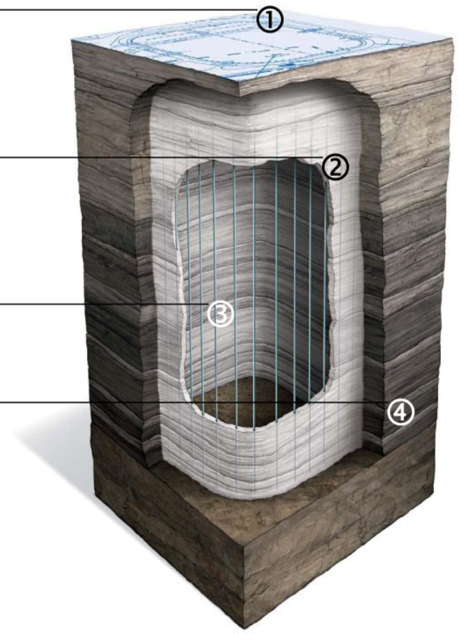
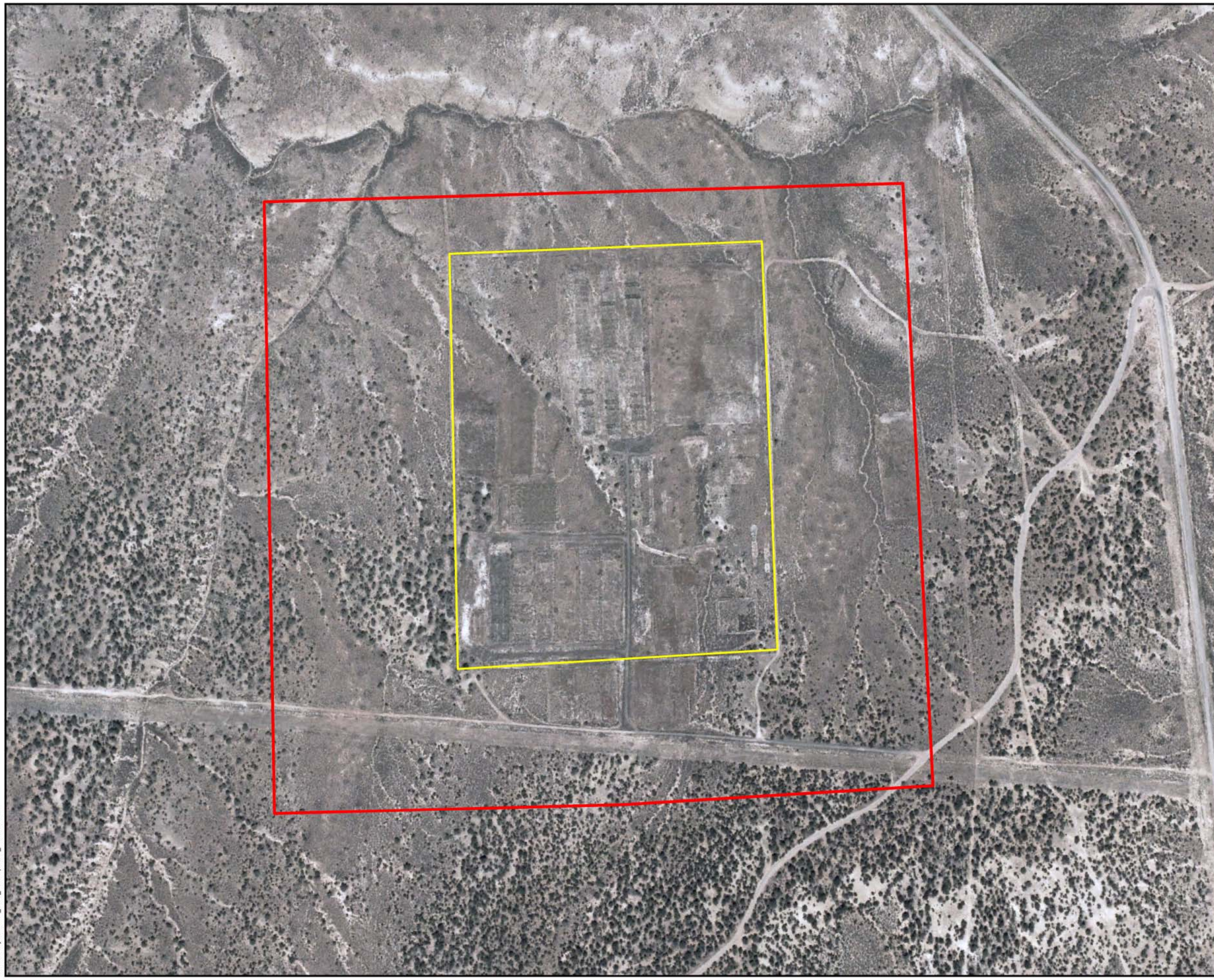
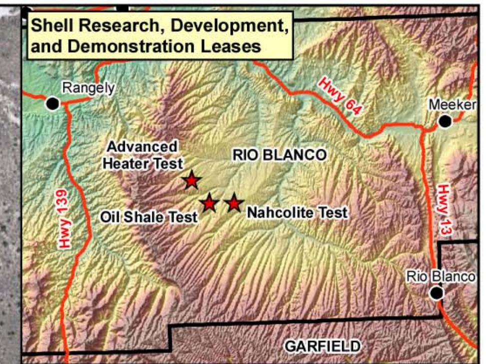


Figure 5. Freeze Wall





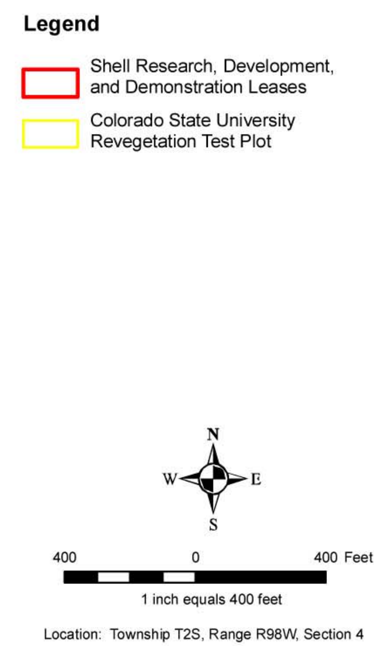


Figure 6
Site 2 - Nahcolite Test Site

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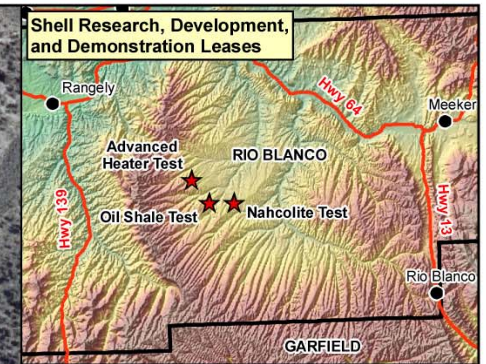

Legend

Shell Research, Development, and Demonstration Leases

N
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400 0 400 Feet

1 inch equals 400 feet

Location: Township T1S, Range R99W, Section 22

Figure 7
Site 3 - Advanced Heater Test Site

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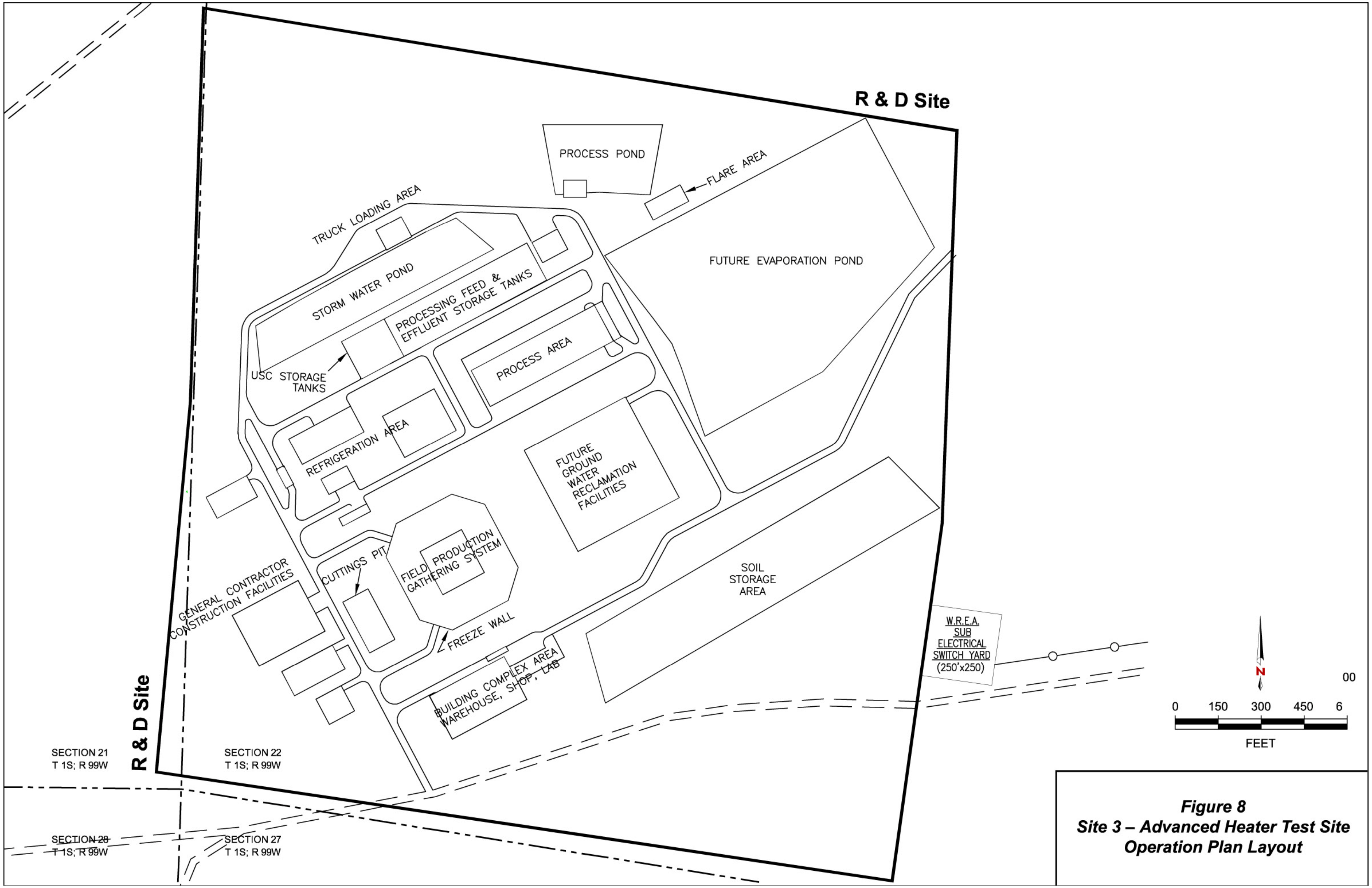


Figure 8
Site 3 – Advanced Heater Test Site
Operation Plan Layout

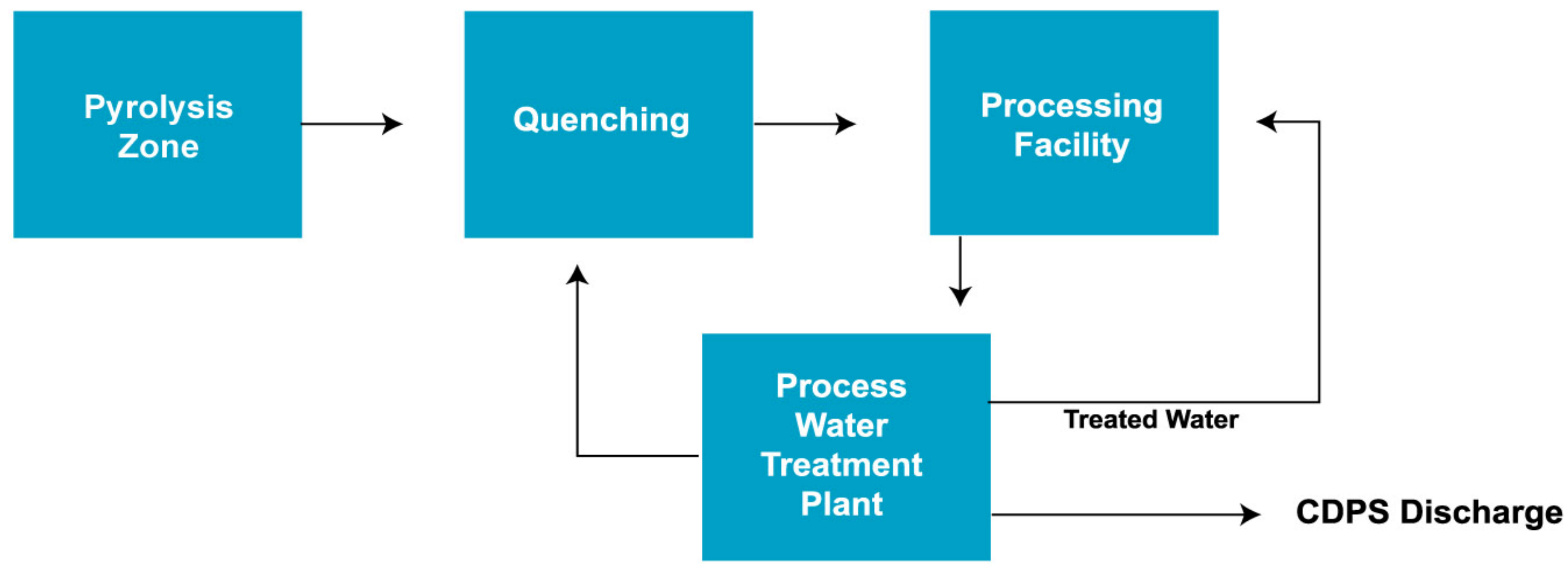


Figure 9
Process Water Management

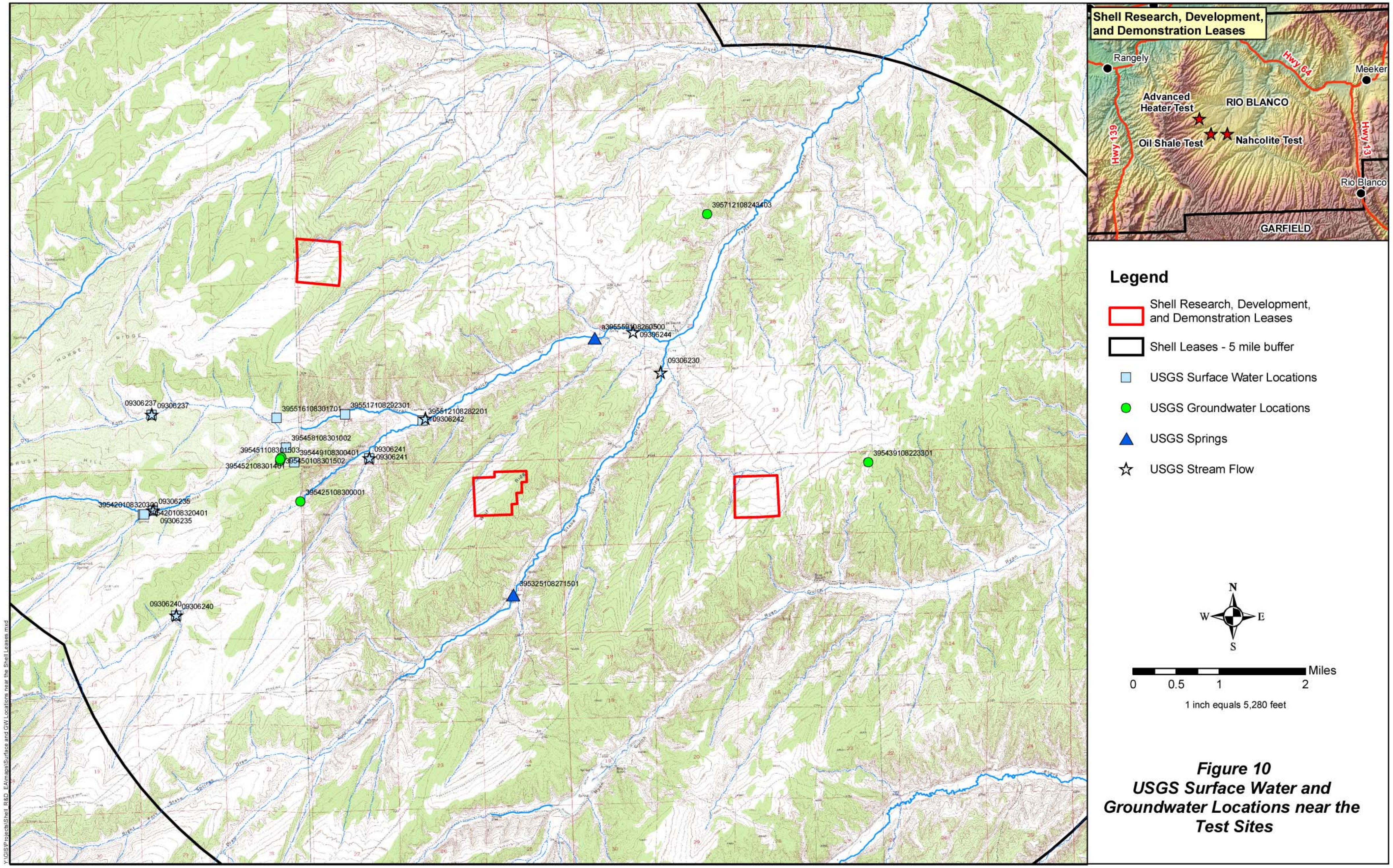
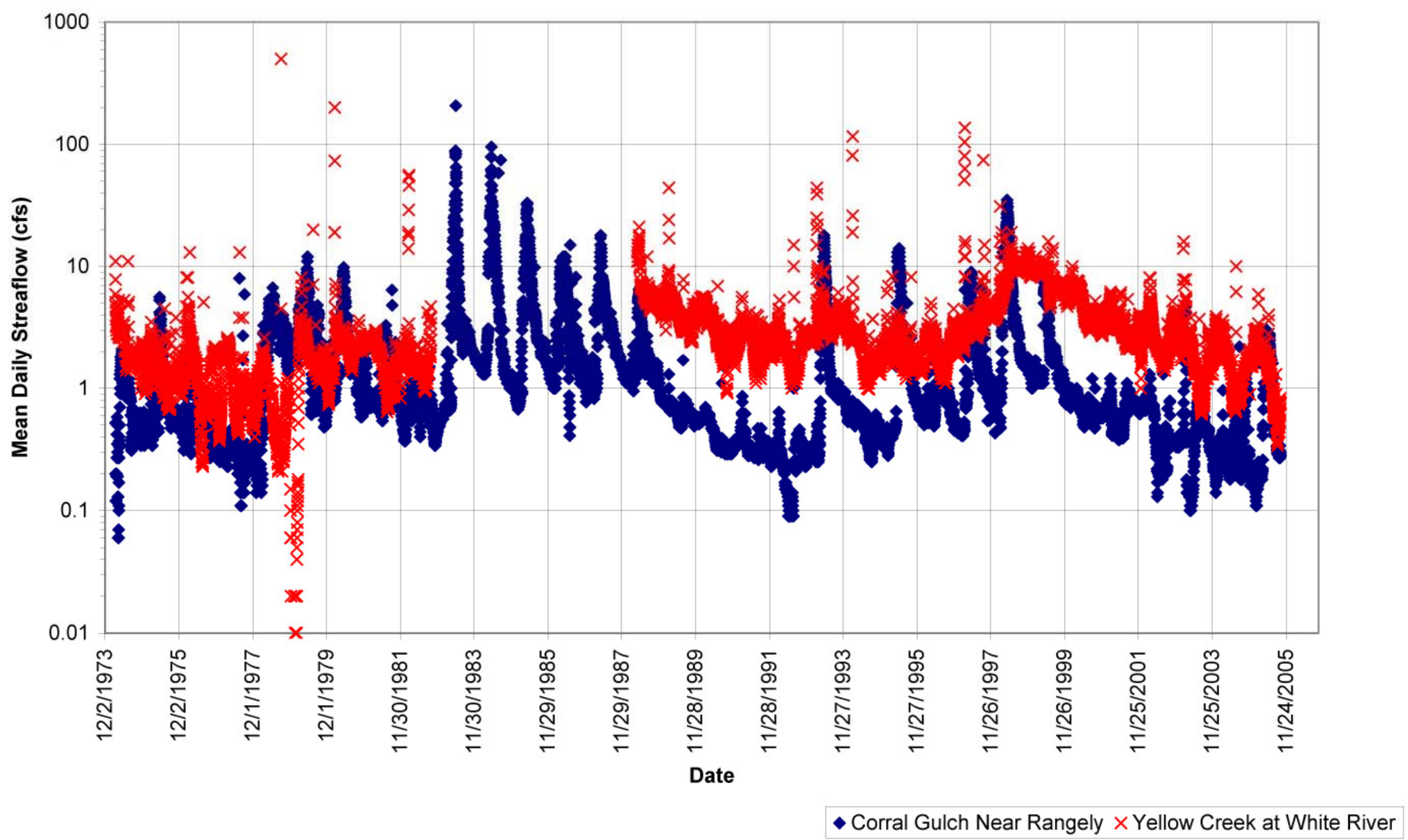


Figure 10
USGS Surface Water and Groundwater Locations near the Test Sites

Figure 11
Daily Streamflow Hydrograph for Corral Gulch and Yellow Creek



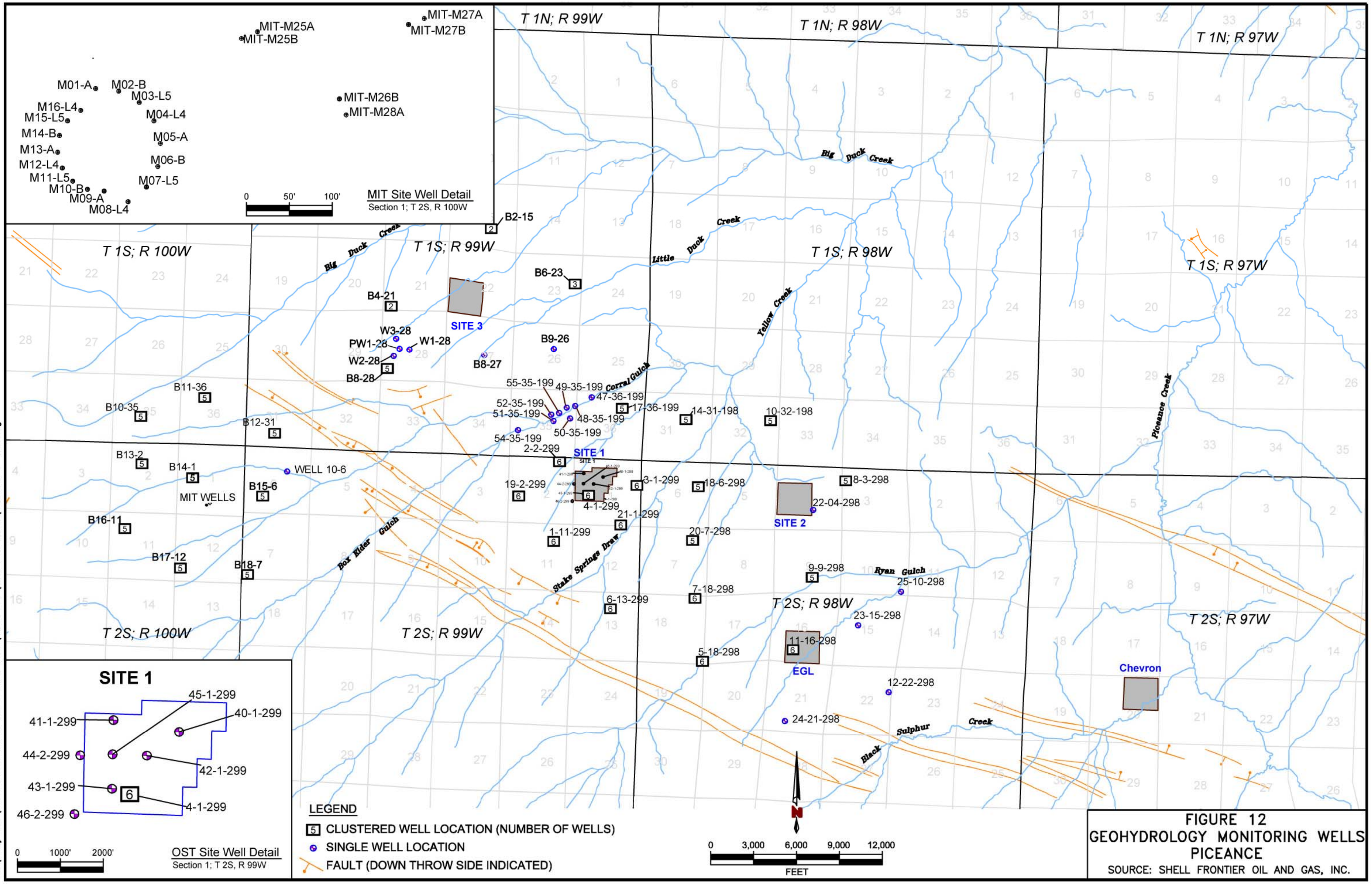


FIGURE 12
GEOHYDROLOGY MONITORING WELLS
PICEANCE

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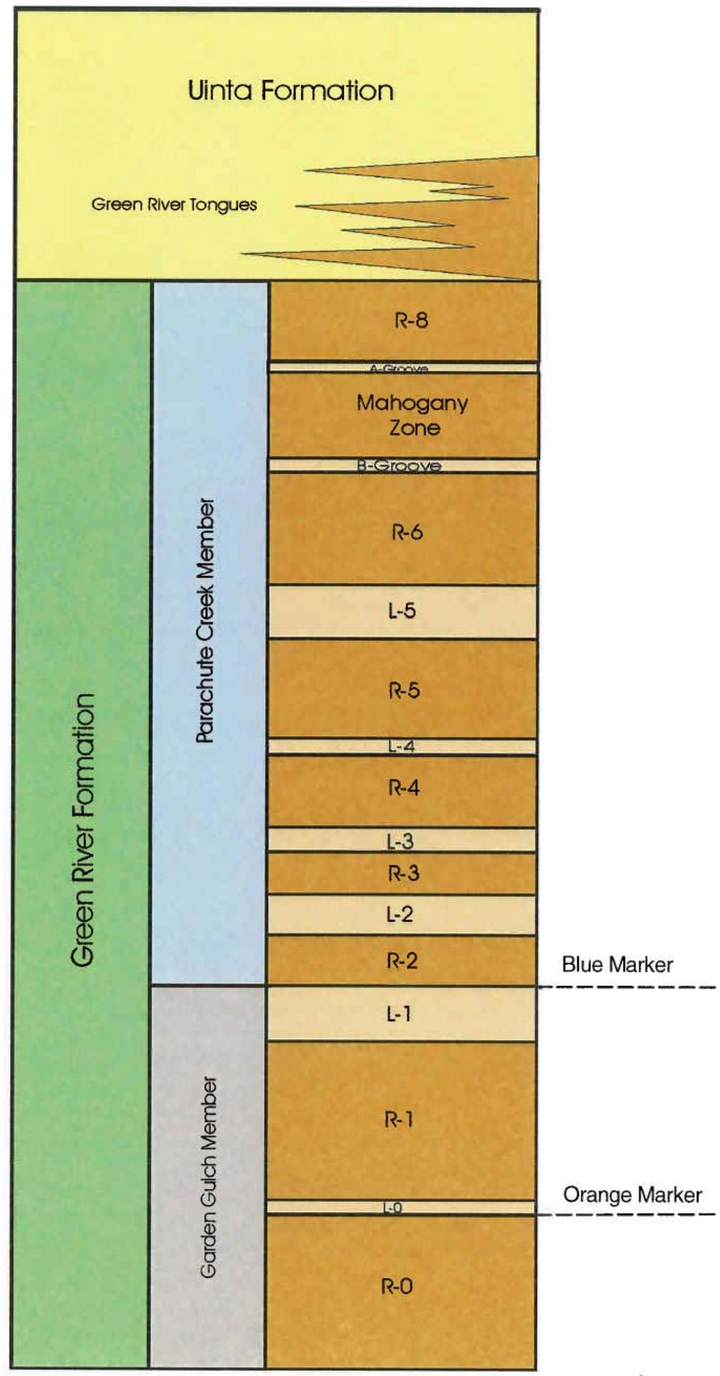


R = organic rich *L = organic lean*	***Figure 13*** ***General Stratigraphic Column for the Three Test Sites*** *Source: Shell Frontier Oil and Gas, Inc.*

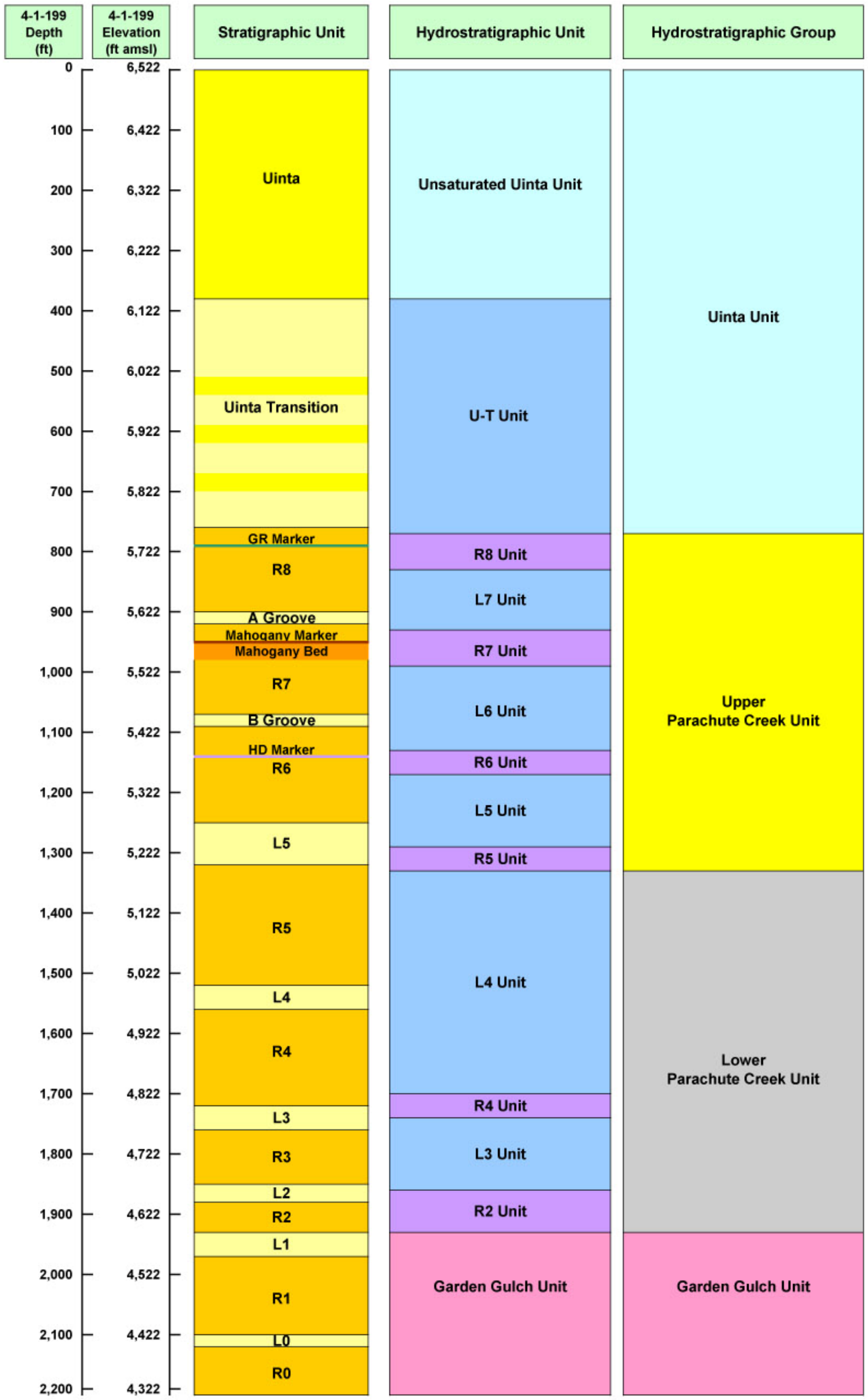


Figure 14
Stratigraphic and Hydrostratigraphic Units and Group
Test Site 1

Source: Shell Frontier Oil and Gas, Inc.

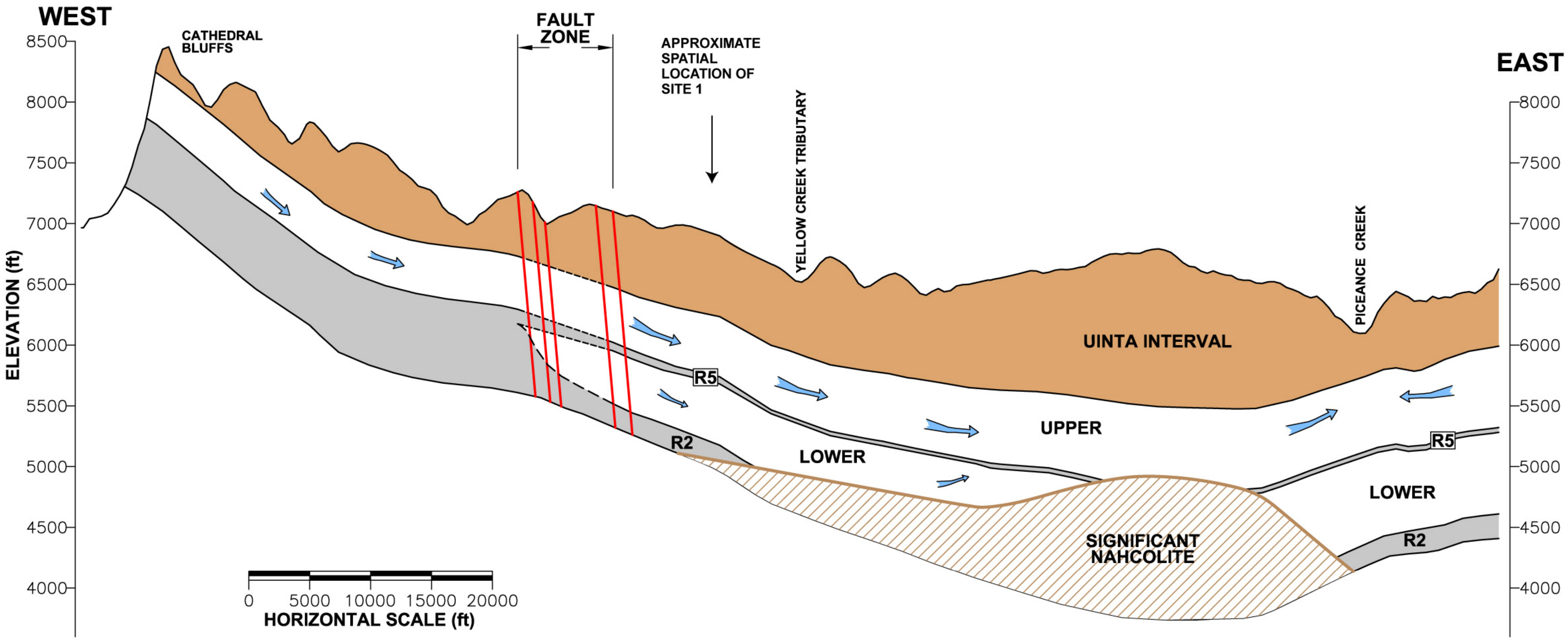
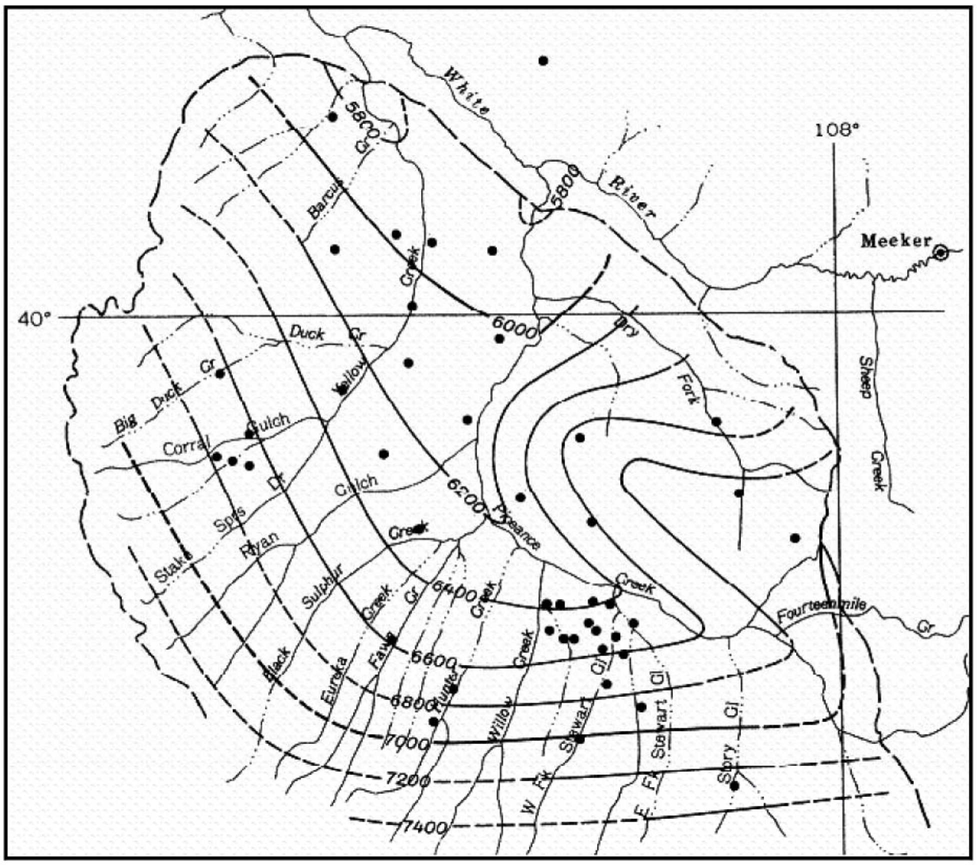


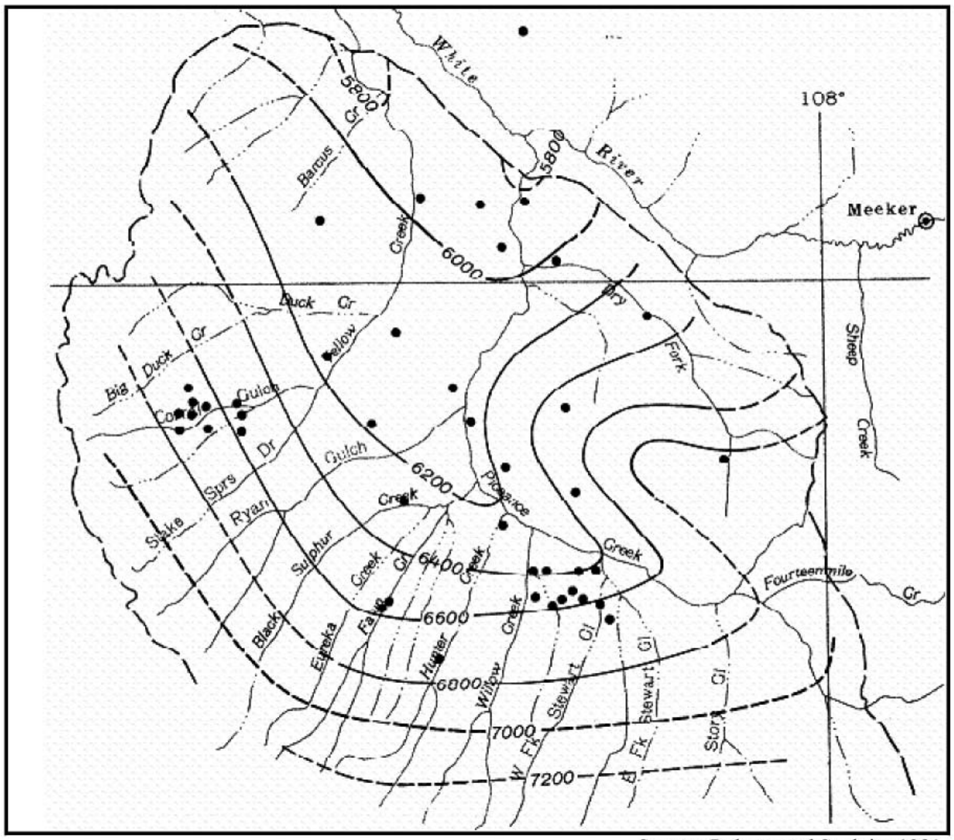
Figure 15
Conceptual Regional Hydrostratigraphic Cross-Section

Source: Shell Frontier Oil and Gas, Inc.



Source: Robson and Saulnier 1981.

Figure 16. Regional Potentiometric Surface for the "Upper Aquifer" of USGS



Source: Robson and Saulnier 1981.

Figures 17. Regional Potentiometric Surface Map for the “Lower Aquifer” of USGS

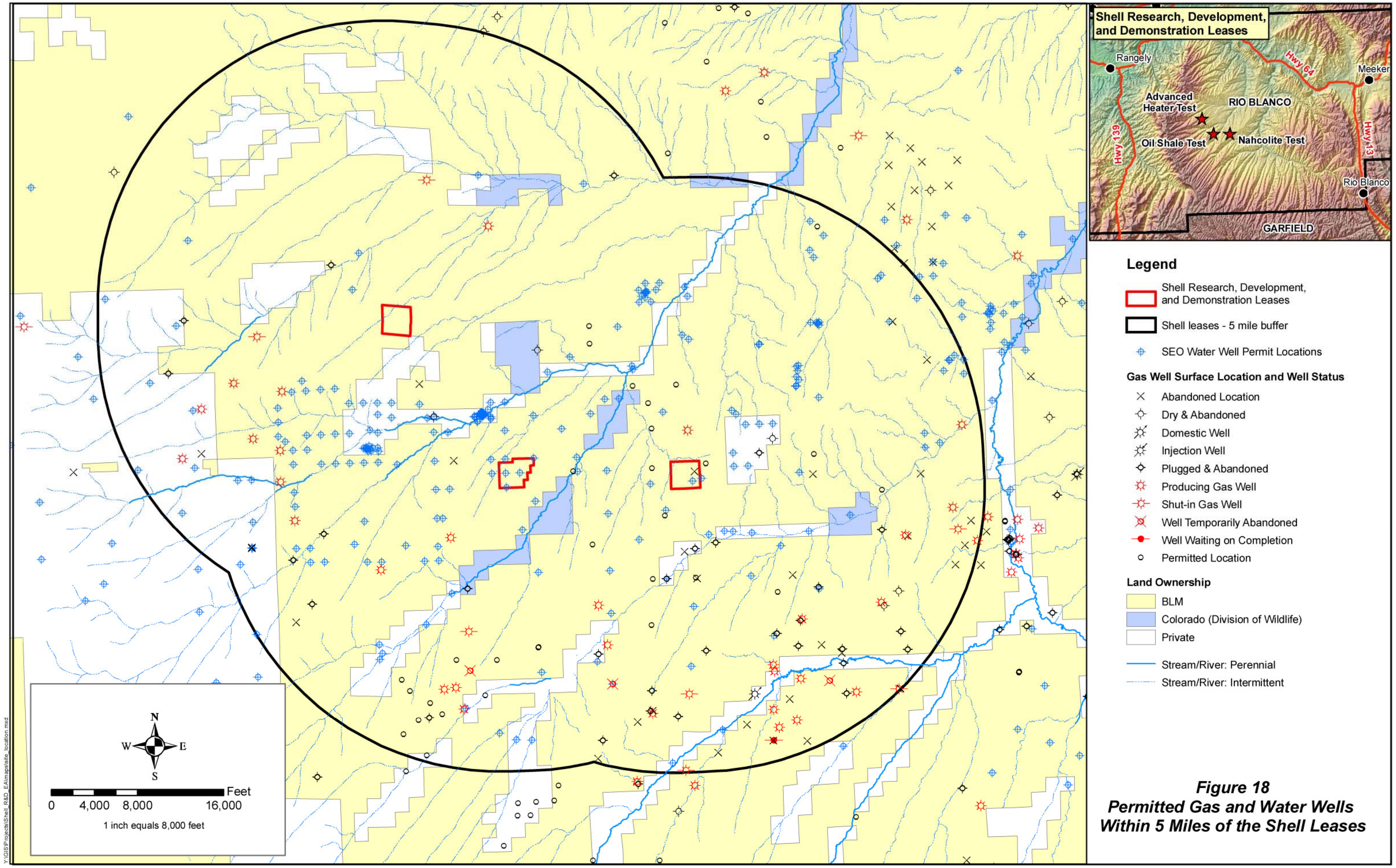


Figure 18
Permitted Gas and Water Wells
Within 5 Miles of the Shell Leases

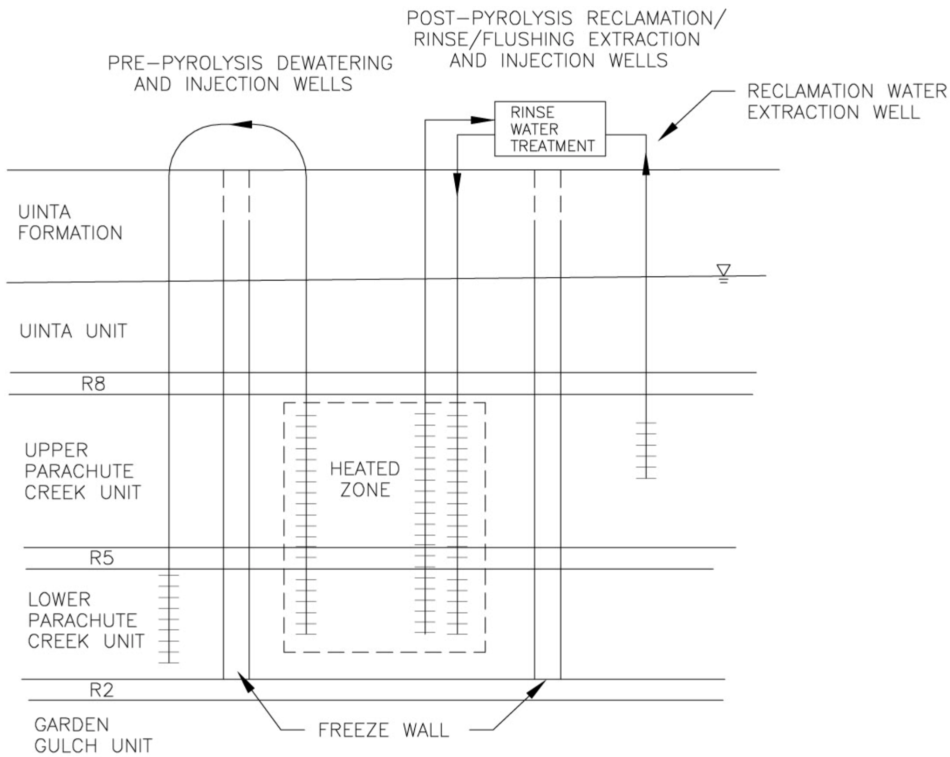


FIGURE 19
CONCEPTUAL DIAGRAM SHOWING
DEWATERING AND RECLAMATION
GROUNDWATER USE
SOURCE: SHELL FRONTIER OIL AND GAS

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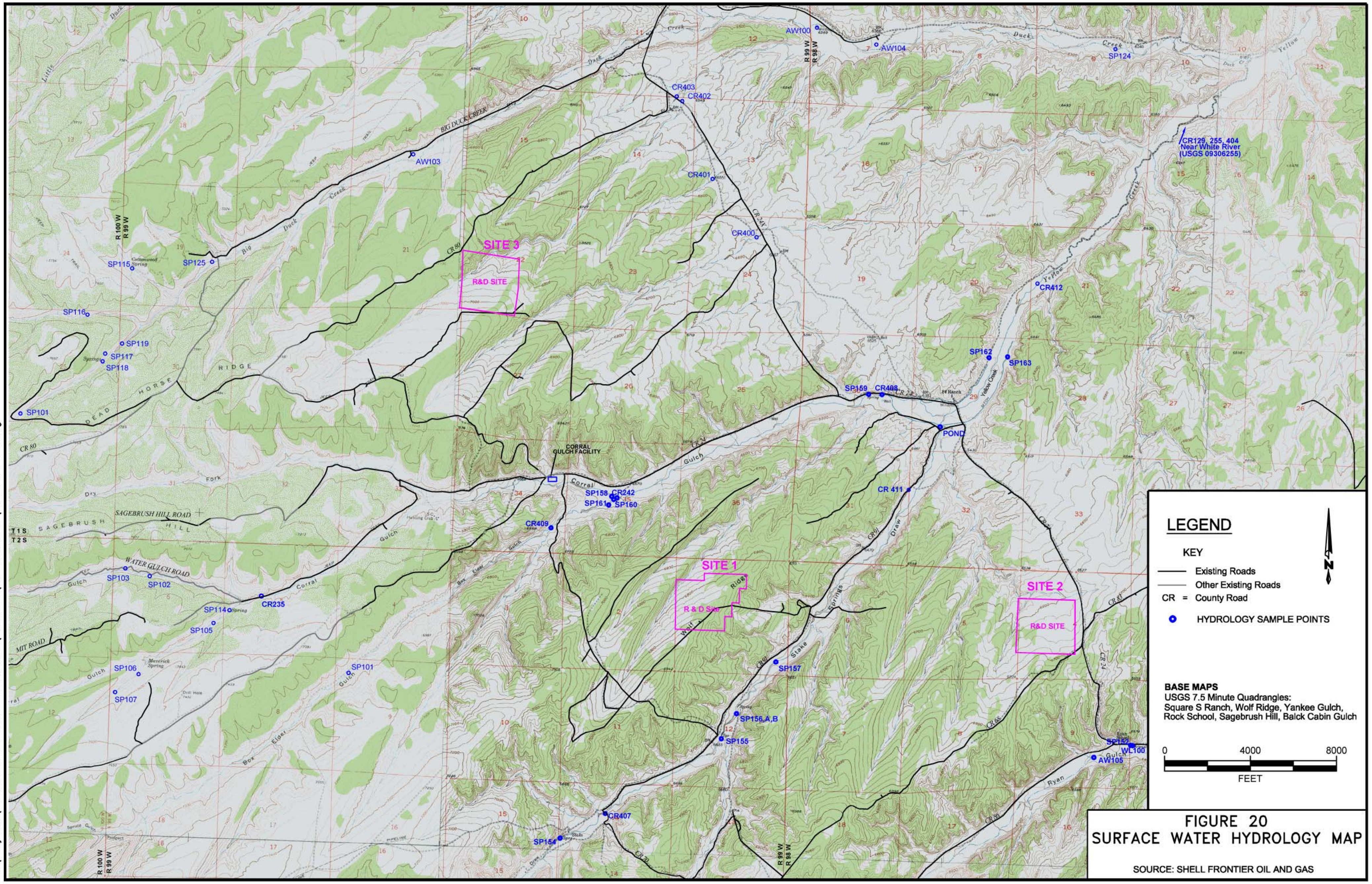

FIGURE 20
SURFACE WATER HYDROLOGY MAP

SOURCE: SHELL FRONTIER OIL AND GAS

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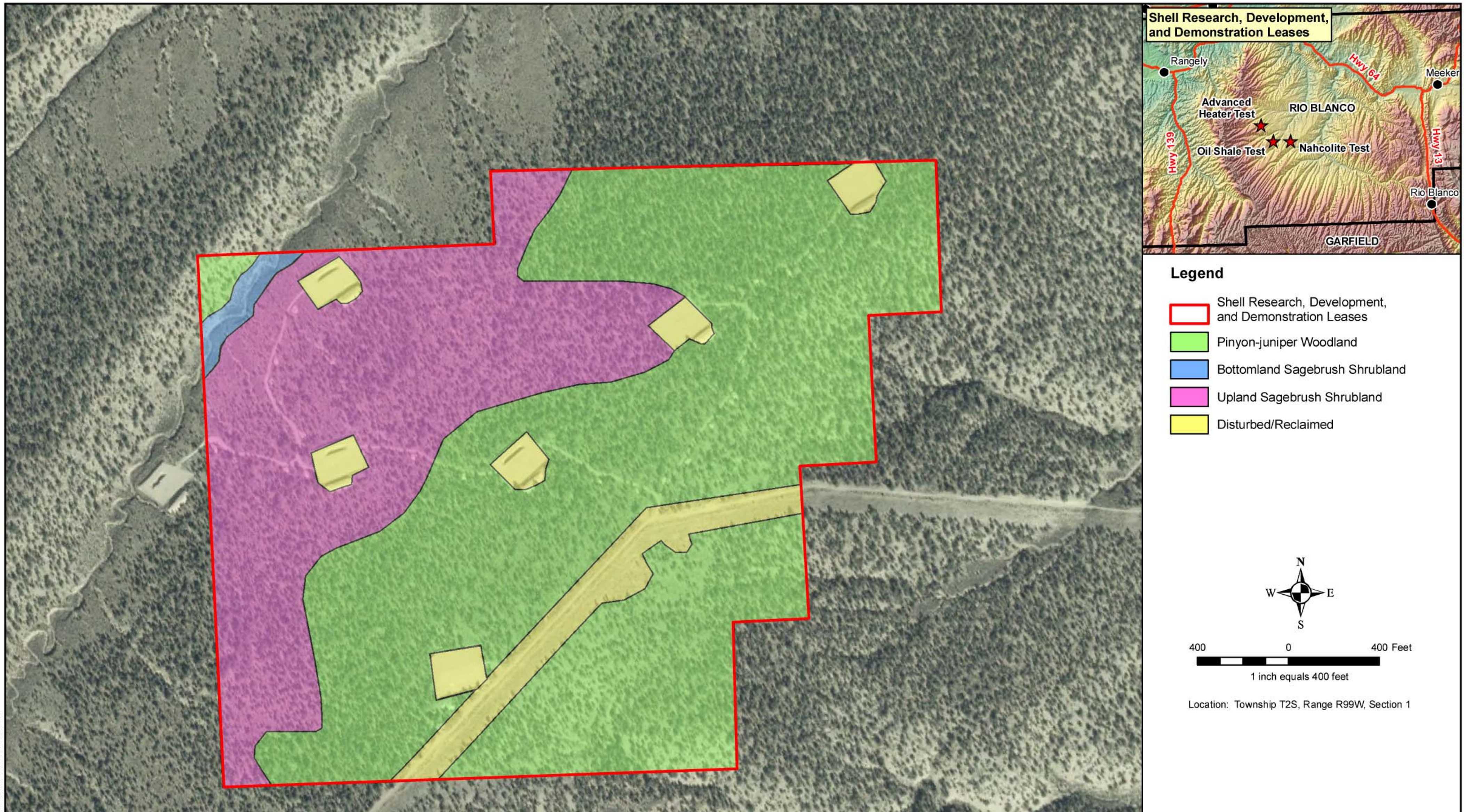


Figure 21
Vegetation Communities and Wildlife Habitats
Site 1 - Oil Shale Test Site

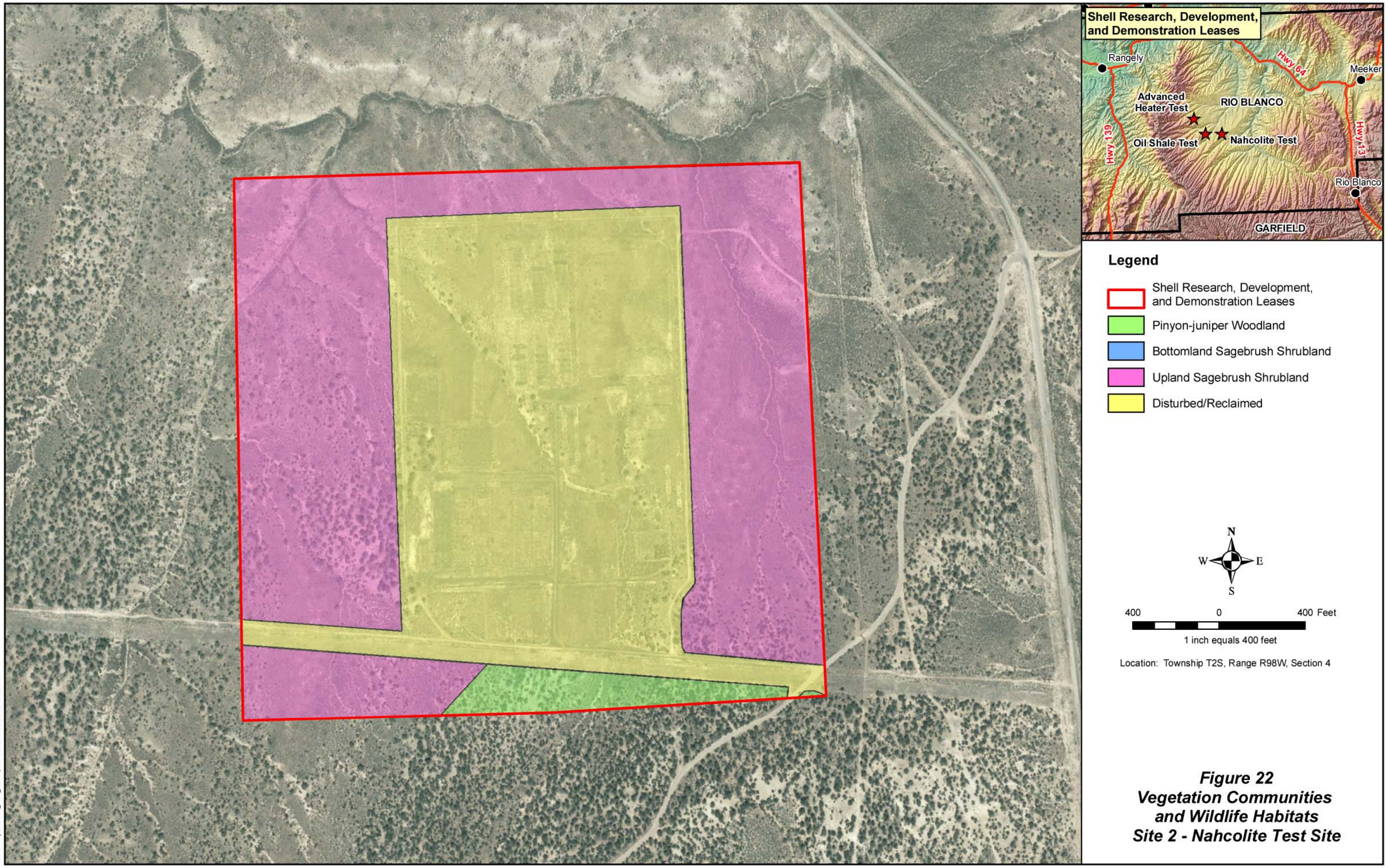


Figure 22
Vegetation Communities and Wildlife Habitats
Site 2 - Nahcolite Test Site

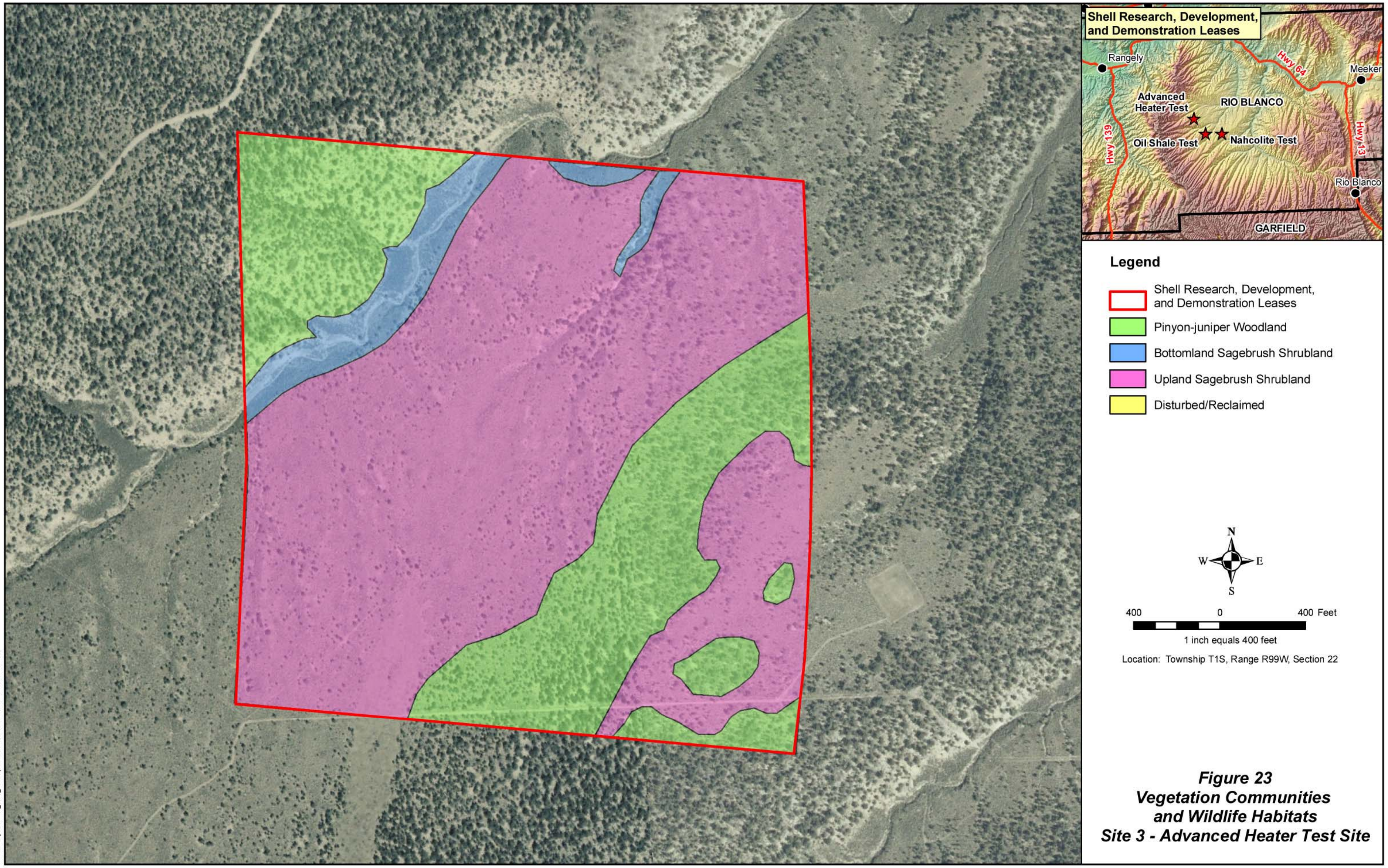


Figure 23
Vegetation Communities and Wildlife Habitats
Site 3 - Advanced Heater Test Site

APPENDIX A

SELECTIONS FROM
PLAN OF OPERATION
OIL SHALE TEST PROJECT

[[SELECTIONS FROM]]

Plan of Operations

Shell Frontier Oil and Gas Inc.

Oil Shale Test Project

Oil Shale Research and Development Project

Prepared for:
Bureau of Land Management

February 15, 2006

4.0 OPERATING PLAN

4.1 General Project Overview and Summary

The Oil Shale Test Project (OST) is a research, development, and demonstration project designed to demonstrate the In Situ Conversion Process (ICP), gather additional operating data and information, and allow testing of components and systems to demonstrate the commercial feasibility of recovering hydrocarbons from oil shale. This plan details the construction, operation, and reclamation of the OST and the supporting facilities.

The ICP is an in situ process using electric heaters to heat the oil shale in place. The heating process pyrolyzes the organic matter in the oil shale and converts this matter into oil and hydrocarbon gas. The oil and gas are then removed from the ground using conventional oil field pumping and extraction technology and processed using conventional oil and gas processing. The recovery is conducted within a contained area to allow recovery of the hydrocarbons while excluding ground water flow through the oil production area. Containment is provided in a freeze wall containment area consisting of a freeze wall system and low permeability barrier above and below the oil shale resource zone. These are described below.

Since the ICP for the OST is planned for use in areas below the ground water table, a freeze wall containment area is created to isolate the ICP from the surrounding ground water. Freezing of the in situ ground water and associated rock matrix creates a containment barrier that prevents migration of fluids into or out of the ICP area. The freeze wall is constructed by drilling closely spaced holes outside the intended oil shale resource target zone and circulating chilled refrigerant through closed loop piping in each freeze wall hole. Through heat exchange with the surrounding rock matrix, the refrigerant returns to the surface warmer than its inflow temperature and the surrounding rock and associated pore and fracture water is cooled and frozen. This frozen barrier is formed along the entire depth of the freeze hole and continues to grow and thicken until the area between freeze holes is frozen, forming a continuous frozen wall-like barrier that extends through the resource zone and into the impermeable layer at the bottom, thus forming a containment area that confines the ICP. The freeze wall containment area is maintained through heating and product recovery as well as during ground water reclamation.

Once the freeze wall is established, a series of dewatering holes are drilled in the interior of the freeze wall containment area to allow recovery of the hydrocarbon products. Initially these ten holes will be used to remove ground water inside the freeze wall containment area prior to heating. The holes will later be converted to producer holes that will remove the hydrocarbon products. Water from dewatering the freeze wall containment area will be re-injected outside the freeze wall into the appropriate water-bearing zones so that existing water quality is not impacted. Dewatering and reinjection flow rates will be monitored to allow calculation of the amount of water taken from the containment area. Removal of the ground water prior to heating will prevent mixing of the hydrocarbons and ground water. Dewatering will not result in removal of all of the ground water within the containment area as some pore water cannot be removed through pumping during dewatering.

A series of heater holes are also drilled within the freeze wall containment area. Heaters are installed in these holes to allow heating of the resource interval. The heater holes are placed such that an unheated zone of approximately 125 feet is maintained between the freeze wall barrier and the heated zone so that the freeze wall is not impacted by heating. The heaters raise the temperature of the oil shale and initiate pyrolysis, releasing hydrocarbon products that are then removed using the production holes.

Products from the pyrolyzed zone are piped to an on-site processing facility, where processing separates the oil, gas, and water. Oil is processed to remove impurities, then shipped off site to existing refineries for refining. Gas from the production holes is also treated and used to supplement energy needs at the site or incinerated as quantities are not sufficient to justify facilities necessary for commercial transportation and sale. Sulfur, produced as a product during processing, is transported off-site as a marketable product. Figure 4.1 shows a simplified diagram describing the steps included in the OST ICP.

After removal of the recoverable product from the oil shale deposit, the area within the freeze wall containment area contains residual pyrolysis products. These are removed through rinsing prior to allowing the freeze wall barrier to thaw. The water used for rinsing is treated in an on-site ground water reclamation treatment plant, then recycled as rinse water. Waste from the ground water reclamation treatment plant is hauled off site. Reject brine solution from the ground water reclamation treatment plant is disposed in the evaporation pond. When the area is sufficiently rinsed and the collected rinse water meets appropriate quality, the freeze wall barrier is then allowed to thaw.

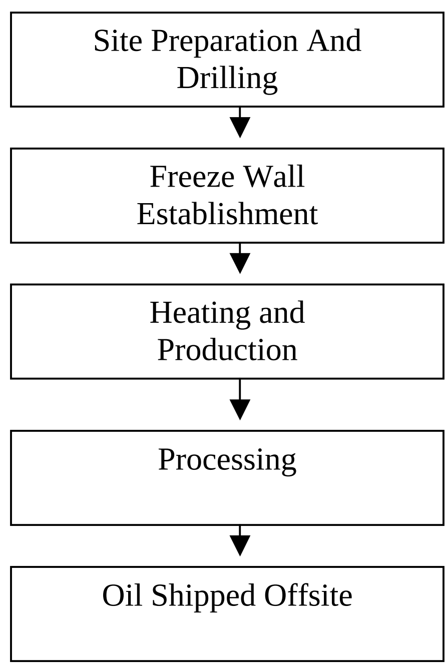


Figure 4.1 Diagram of OST ICP

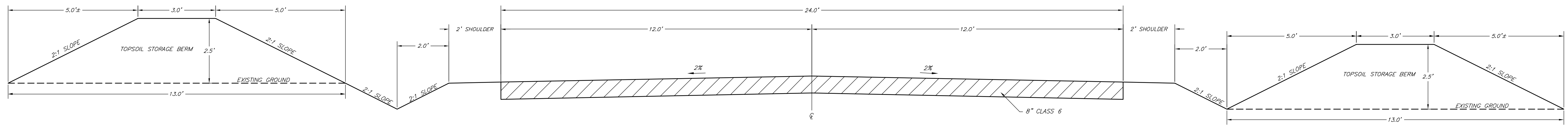
As a part of reclamation, the wells and holes not needed for monitoring are plugged and abandoned in accordance with requirements of the Colorado Office of the State Engineer. Facilities will be demolished and removed and the site will be regraded and revegetated. The paved access road will also be reclaimed, leaving a dirt road access route. The reclamation plan (Section 5) provides details on reclamation of the ICP and of the site disturbance.

Support facilities include a site access road; construction and drilling support consisting of lay down yards, storage units and office trailers; portable pilot test plants, process control building, change house, utilities, warehouse, shop/ maintenance facilities, laboratory, and other facilities necessary to support the OST Project. Potable water will be trucked to the site and stored for use in the on site potable water system. The following sections contain detailed information on the various process components associated with the OST facility.

4.2 General Site Development and Preparation

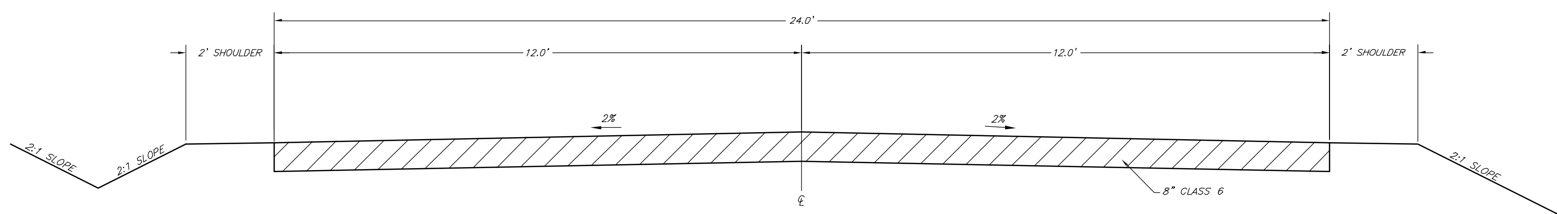
Initial construction activities include development of the site access road and fencing of the permit area. The present access to the OST site is from County Road (CR) 5 to CR 24 to CR 91 to an existing two-track road (see Exhibit C). This two-track road was originally constructed to access several ground water hydrology monitoring well sites. The access road will be extended to the OST site and expanded to a running width of approximately 24 feet to allow heavy equipment travel in two directions. The access road will be paved with asphalt for the 24-foot width and include appropriate ditches and culverts to maintain drainage control. Soils salvaged during the road construction will be stored in berms located on either side of the road. Figure 4.2 provides additional information on the design of the access road. Access to the OST site from the road will be restricted through an entry gate.

The OST project, excluding the access road, will be fenced with a combination barbed/smooth wire fence with the top wire being smooth. A 12-foot wide fire lane will be constructed along the permit boundary fence. Signs reading “Do Not Enter” will be posted at points of logical entrance to the facility, such as roads or trails, to redirect unauthorized personnel. Eight-foot high chain link fencing will be provided around lined ponds (storm water pond, process water pond, and evaporation pond) when these ponds are constructed.



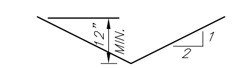
TYPICAL ROAD DETAIL (W/BERMS)

NTS



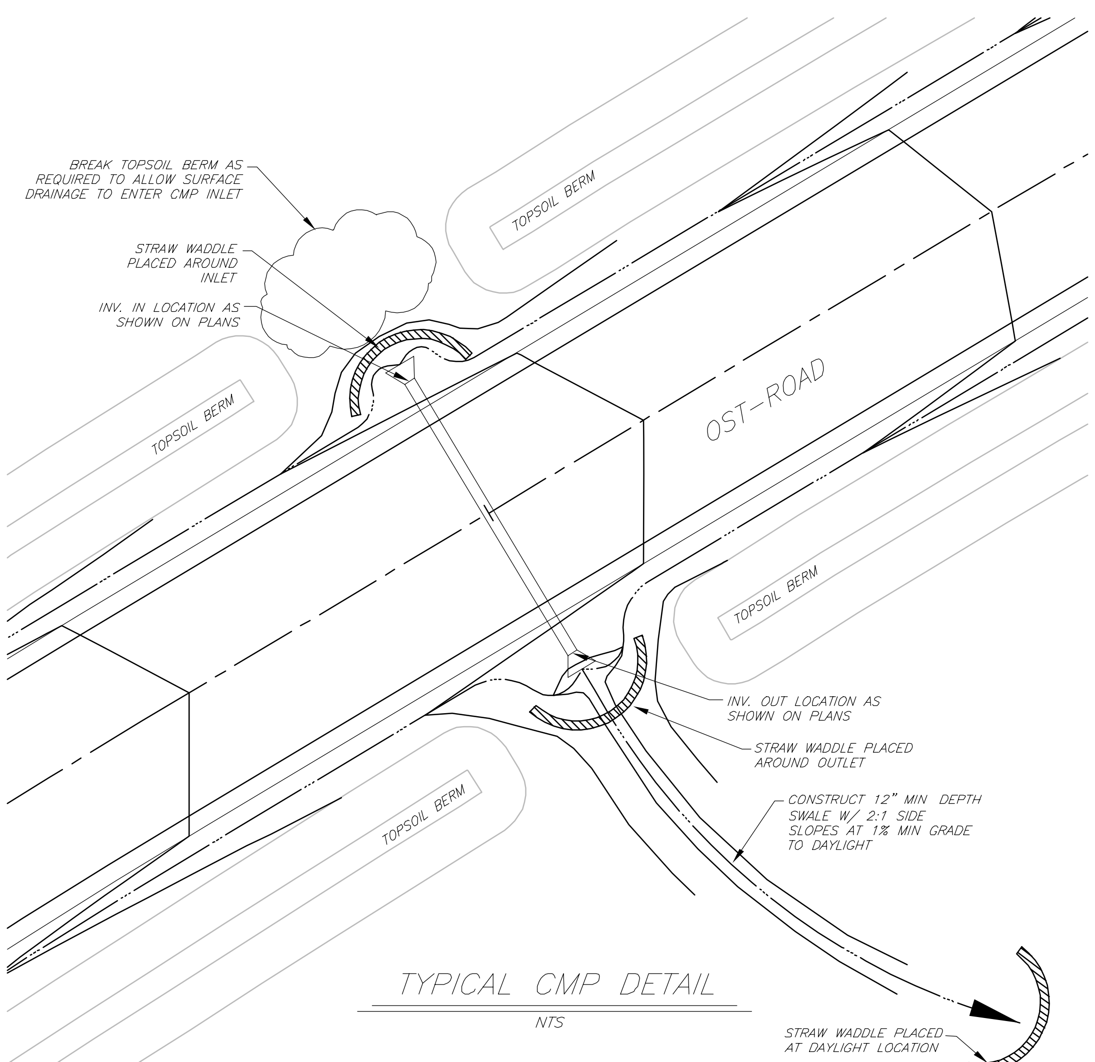
TYPICAL ROAD DETAIL

NTS



TYPICAL DRAINAGE SWALE

NTS



TYPICAL CMP DETAIL

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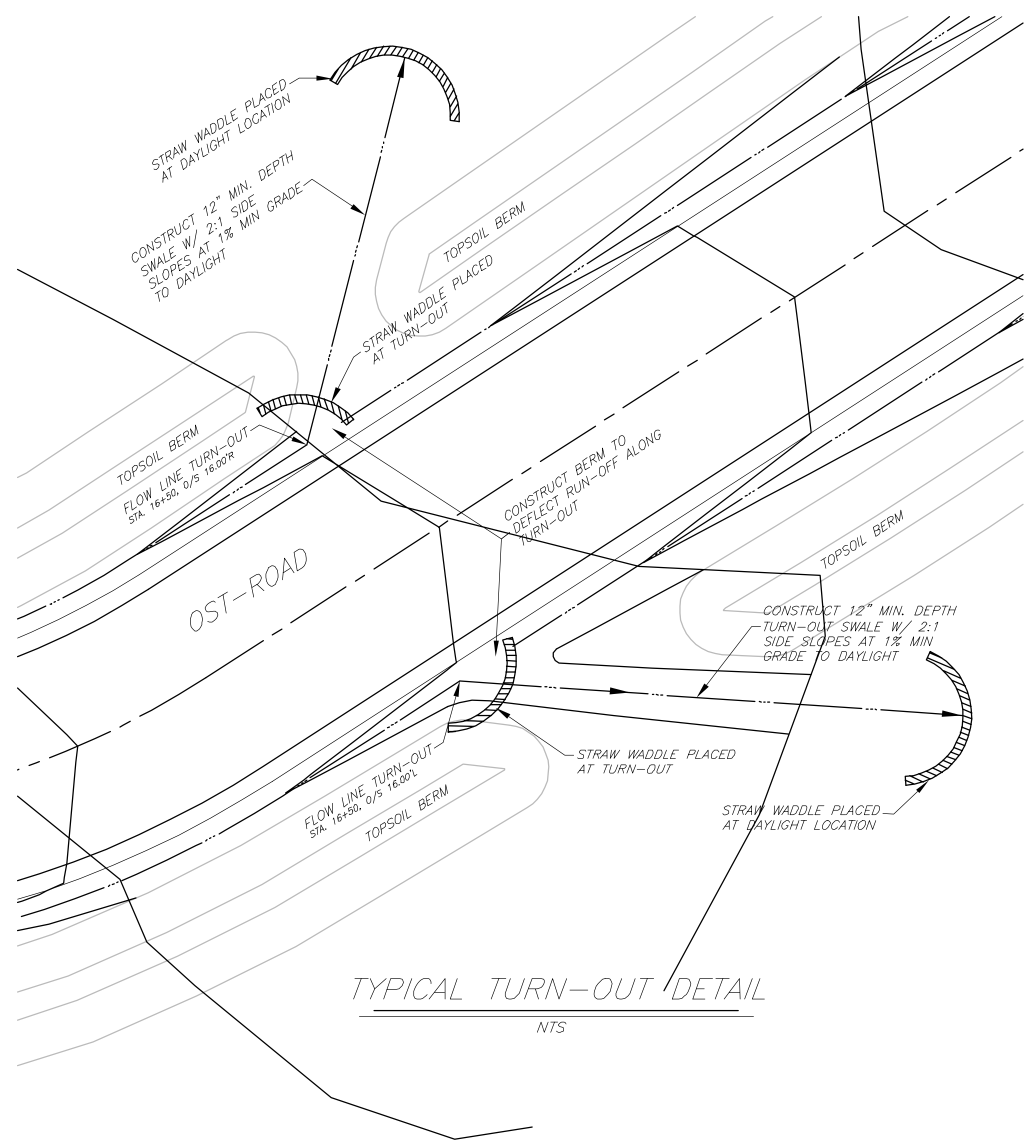
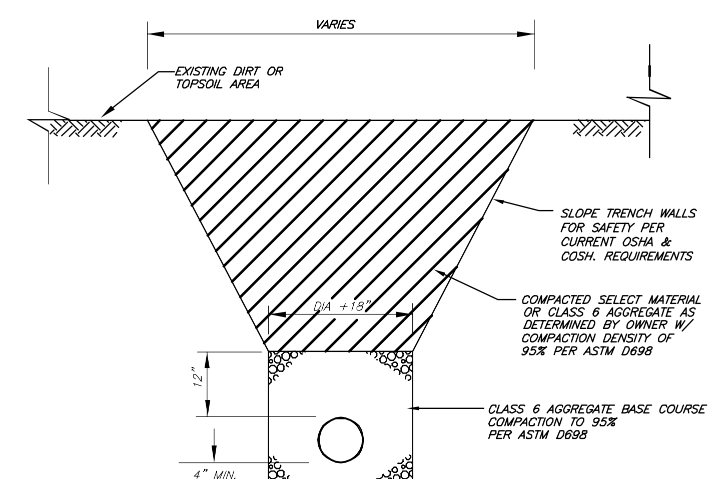


TYPICAL TURN-OUT DETAIL

NTS



1) PAVEMENT REPLACEMENT SHALL MEET EXISTING THICKNESS AND KIND WITH THE FOLLOWING MINIMUMS: ASPHALT SURFACING = 3" MIN., AGGREGATE BASE COURSE = 8" MIN.
2) BASE COURSE REPLACEMENT SHALL MEET EXISTING THICKNESS WITH THE FOLLOWING MINIMUMS: AGGREGATE BASE COURSE = 12" MIN.
3) DIRT / TOPSOIL PLACEMENT SHALL MEEET EXISTING THICKNESS AND KIND WITH THE FOLLOWING MINIMUMS: 4" TOPSOIL.
4) SELECT MATERIAL AS FOLLOWS: 6" MAXIMUM SIZE IN TOP 12" OF BACKFILL
12" MAXIMUM SIZE IN REMAINDER OF BACKFILL

TRENCH CROSS SECTION

NTS

FIGURE 4.2	
TYPICAL ACCESS ROAD DESIGN	
Drawn By: DD	Date: 02/10/06
Approved By:	Date:
FILE: FIG4.2 TYPACCESSROADDESIGN 3235\Task 45\P00 5-2-05\FEB06	SCALE: NTS
SHELL FRONTIER OIL & GAS INC.	

Surface Drainage Controls

A surface water drainage collection and conveyance system will be established to manage drainage throughout the site. The surface drainage control system along with the site grading will route storm water flows from the disturbed areas into a storm water pond prior to discharge to the existing surface drainage system. The surface drainage system consists of ditches, storm sewers, culverts, curbs, and paving. Ditches will be lined with riprap or other material where necessary to assure stability. The storm water pond has been designed with a retention capacity of approximate 15.3 acre-feet and will be constructed near the northwest corner of the property. The pond has been designed to retain the runoff and sediment from a 50-year, 24-hour storm event (2.5 inches). A conservative runoff factor of 0.9 was used, assuming 90 percent of the precipitation is directed into surface water control structures. The storm water pond will be lined with a single synthetic liner. The liner is not needed for storm water control, hence the pond may be constructed without the liner for use in collecting sediment during construction activities and the liner would be installed at a later date. Although not anticipated to be needed, the pond will be lined to provide the potential for additional lined containment should such containment be needed in the future. Exhibit M shows the drainage control plan.

Construction storm water drainage will be managed through a construction Storm Water Management Plan and the use of accepted Best Management Practices (BMP), in accordance with a construction storm water permit. During construction and during operations areas of light disturbance that do not report to the storm water pond will be managed using BMPs. Erosion control measures will include stabilization of exposed soils and protection of steep slopes. Exposed soils will be stabilized by mulching, seeding, soil roughening, or chemical stabilization. Steep slopes will be protected by use of geotextiles, temporary slope drains, mulch, or seeding. Sediment controls may include sediment basins rock dams, sediment filters such as filter cloth, hay bales, erosion blankets, temporary seeding.

Site Preparation

The OST site will be terraced to provide five levels (support facilities, production, processing, storage tanks, and shipping). Exhibit J is a plot plan that shows the locations for all facilities at OST. Exhibit K contains several cross sections through the OST site showing the operating levels and associated facilities.

The support facilities level will contain the warehouse, shop building, laboratory, potable water tank and delivery system, and security. The production level will contain the freeze wall, heaters, production gathering system, and water reclamation facility. The process level will contain the process building, sulfur loading facility, refrigeration unit, refrigerant unloading facility, utility buildings, and electrical substations. The storage tank level contains tank storage and associated containment for the Untreated Synthetic Condensate (USC) and storage for process watertreatment feed and effluent. The shipping level contains the process water treatment plant, product storage, truck loading and storm water pond. The process water pond and evaporation pond will be located northeast of the terraced areas. A partial list of equipment needed for the project is shown on Table 4.1.

Table 4.1 Equipment List

Air Blowers	Granular Activated Carbon Beds	Scrapers
Ammonia Circulation Pumps	H2S Stripper	Separator
Ammonia Stripper Accumulator	H2S Stripper Accumulator	Skimmings Concentrator
Ammonia Stripper Condensers	H2S Stripper Condenser	Slop Oil Equalization Tank and Pumps
Ammonia Strippers	H2S Stripper Inlet Preheat	Slops Pumps
Backhoes	High Pressure Nitrogen Storage Package	Solids Separation Clarifier
Backwash water Pumps	Influent Transfer Pumps	Solvent Stripper
Bio-solids Blower	Instrument Air package	Sour Water Stripper Cooler
Bio-solids Pump	Lean Sulfinol Heaters	Spent Carbon Feed Tanks
Biotreater Feed Cooler	Lo-cat Absorber	SRC Pumps
Biotreater Pumps	Lo-cat Oxidizer Vessel	Stabilizer Reboilers
Boiler Packages	Lo-cat Slurry Centriguge	Stand-by Generator
Bulldozers	Lo-cat solution Recirculation Tank	Stripper Effluent Coolers
Carbon Regeneration Furnace	MDEA Carbon Beds	Stripper Feed Pumps
Clarifier Sludge Transfer Pumps	MDEA Cooler	Sulfinol Pumps
Coalescing Filter	MDEA Exchanges	Sulfinol Reboilers
Combustion Products Accumulator	MDEA Pumps	Sulfur Pit
Combustion Products Condenser	Membrane Bio-reactor Unit	Sulfur Product Tank
Concrete Trucks	Nitrogen Storage and Vaporizer	Sulfur recovery unit Reaction Furnace
Condensate Pots	NO2 Gas Absorber	Sulfur Seal Pots
Condensate Pumps	NO2 Gas Compressor	Sulfur Slurry Pumps
Converter Heaters	NO2 Gas Condenser	Sump Pumps
Converters	NO2 Gas Recycle Pumps	Supply Trucks

Deaerator Packages	Oil/Water Separators	SWS Overhead Accumulator
Deep bed Nutshell Filters	Product Pumps	SWS Pumps
Discharge Coolers	Product Tanks	SWS Reboilers
Dissolved Air Flotation Unit	Quench Tank	SWS Strainers
Drills	Quench Water System	Thickener and Pumps
Equalization Tanks and Pumps	Recirculation Pumps	Utility Vehicles
Filter Press	Refrigeration Units	Vapor Catalytic Combustor
Flare Knock Out Pumps	Regeneration Carbon Storage Tanks	Virgin Carbon Make-up Silo
Flare Packages	Reverse osmosis Unit	Water Heaters
Fuel Trucks	Sanitary Septic System	Water Pumps
Gas Burners	Scot Carbon Filters	Water Storage Tanks
Gas Compressors	Scot Pumps	Water Trucks
Gas Heaters	Scot Reflux Accumulator	Wet Well/Surge Tank
Glycol Chillers	Scot Regenerator	

Prior to site preparation, the boundaries of the 160-acre site lease will be marked. The storm water pond will be constructed, clean water diversion ditches installed, and BMPs will be implemented. Larger trees will be cut and made available for firewood through a commercial operator. Stumps will be disposed of by burning on site (with the appropriate burn permits) or by hauling off site. Stumps may also be buried on site. Remaining vegetation will be cut and chipped with chips left on the ground to be incorporated into the salvaged soil. Approximately 12 inches of soil will be segregated, removed and deposited in three designated soil storage areas (Exhibit J). In areas where 12 inches of soil is not available for salvage, reasonable available soil material will be removed, with a targeted minimum of six inches removed in any location, where available. This material may not all be soil by strict definition, but will support vegetation and hence be suitable for plant growth medium. The soil stockpiles, capable of storing approximately 200,000 cubic yards of material will disturb approximately 10 acres. The piles will be approximately 12 to 15 feet in height. Soil stockpiles will be graded so that outslopes do not exceed 2 Horizontal to 1 Vertical (2H:1V), unless the angle of repose is shallower. The soil stockpiles will be seeded with the BLM approved grass seed mix to minimize erosion and associated loss of soil. Soil stockpiles will also be covered with an erosion control netting to further minimize erosion and promote growth.

4.3 In-situ Conversion Process

Ground freezing as a means of containment was introduced in the 1800s to temporarily strengthen soils and serve as a barrier to ground water flow. Ground freezing continues to be applied in civil and geotechnical engineering to exclude water from areas being excavated; to seal tunnels, mine shafts, or other subsurface structures against flooding from ground water; and to enclose and/or consolidate hazardous or radioactive contaminants during remediation or reclamation operations. The containment system for the OST will consist of a series of drill holes in a close pattern (Exhibit L). Refrigerant will be circulated through the holes in a closed circuit to create a barrier of frozen water in a rock matrix.

The construction of the freeze wall containment area for the OST will allow heating of oil shale to recover products while preventing mixing of products with the ground water system. A freeze wall will be established for the depth of the freeze holes and will encircle the resource target zone creating an enclosed freeze wall containment area. The resource target zone is a carefully selected portion of the oil shale resource. The top and bottom of the resource target zone are low permeability layers that will prevent movement of converted hydrocarbons in a vertical direction. The freeze wall containment area provides lateral containment. The freeze wall will act to prevent liquid movement into or out of the containment area, separating the ground water system from the ICP products. The freeze wall containment area will be maintained and monitored throughout the heating, recovery, and the ground water reclamation phases of the operation. Since the freeze wall will take an extended period of time to thaw, the freeze wall refrigerant circulation may be stopped prior to final flushing if it can be demonstrated that the containment area is sufficiently rinsed and collected rinse water meets appropriate quality.

Freeze Wall Construction

Upon completion of site preparation, approximately 157 drill holes will be drilled approximately 8 feet apart. The freeze holes will be drilled to a depth of approximately 1,850 feet or the depth of the entire target interval. The configuration of a typical freeze hole is shown on Exhibit N. Both air-mist fluid drilling and aerated fluid drilling methods are under consideration at this time. The air-mist method produces greater volumes of water compared to the aerated fluid method. Drilling methods will be selected based on field conditions and technology. Drilling fluids and additives that may be used are shown in Table 4.2

Revised 2/28/06

Table 4.2 Inventory of Drilling Fluid Additives for use by Shell and its Contractors

Coring and Drilling Projects

Foamers
Baroid Quik-Foam
Bachman 485
Weatherford WFT FM A-100
Gels and Polymers
Baroid EZ-Mud - polymer
Halliburton Quik-Gel – bentonite gel
Halliburton Mud-Gel – bentonite gel
Baroid Quik-Trol and Quik-Trol LV - polymer
Benseal– for plugging back holes and hole abandonment
Baroid Holeplug – for plugging back holes and hole abandonment
Thread Compounds
Jet Lube Well Guard
MacDermid – Vinoleo thread compound for fiberglass casing
Best-O-Life Silicone GGT
Best-O-Life 72733 high temperature high pressure thread compound – not used in water wells or monitor holes.
Lub-O-Seal NM-91 anti-seize
Corrosion Inhibitors
Weatherford Corrfoam
Others
Rock Drill Oil R.D.O. ES
Sodium bicarbonate –pH neutralizer
Mazola Corn Oil – to free stuck pipe
Ventura Ultra-Fry (Canola Oil) – to free stuck pipe
Huskey LVI-50 Rod Grease – lubricate drill rods in dry hole

To complete the freeze hole and provide refrigeration for the length of the hole, an interior steel freeze tube will be installed to a depth of approximately 1,850 feet. The bottom of the steel tube will be sealed with an end cap. A smaller diameter high-density polyethylene (HDPE) inner freeze tube will be installed inside of the steel freeze tube. It is expected to take about six months to complete the drilling for the freeze wall pattern.

Once the drilling is completed, a chilled aqua ammonia solution (refrigerant), at an approximate temperature of -45º F is pumped through the holes. The interior HPDE tube will be used to convey the chilled aqua ammonia to the bottom of the hole and the outer steel pipe allows the

Revised 2/28/06

solution to return to the surface for recycling back to the refrigeration system (see Figure 4.3). The aqua ammonia solution will be circulated at approximately 50 gallons per minute (gpm) per hole.

The area immediately surrounding the holes is frozen first. The frozen area continues to expand as refrigerant is re-circulated down each hole. Eventually the frozen "columns" expand to the point where the approximately concentric frozen "columns" are joined and a freeze wall barrier is created as shown in Figure 4.4.

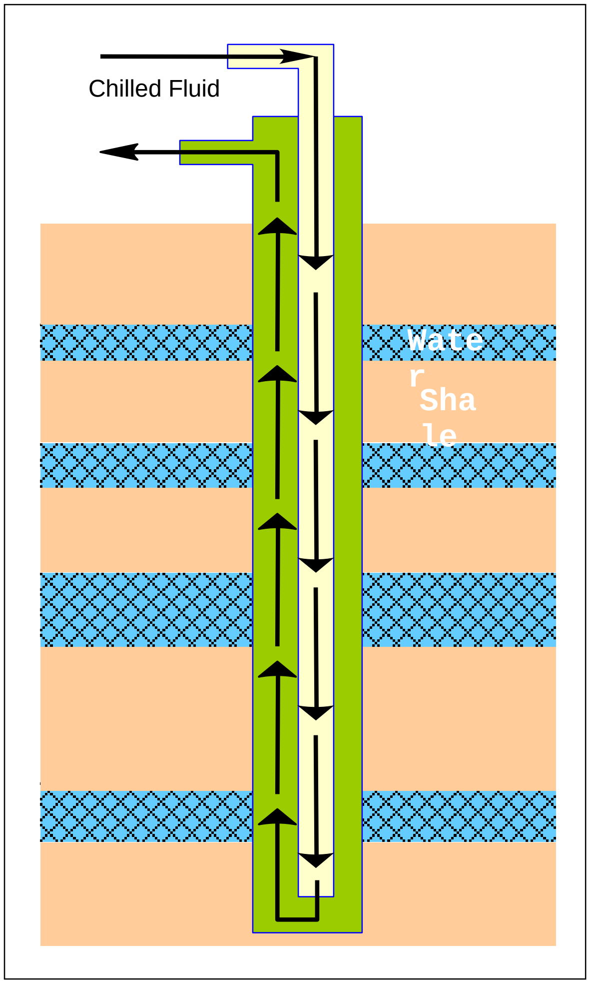


Figure 4.3 Schematic of Refrigerant Flow

It is anticipated to take approximately 18 months to establish a continuous freeze wall barrier.

As the circulation of refrigerant continues, the thickness of the freeze wall will continue to grow, although the rate of growth will slow as the wall thickens. Heating in the interior of the containment zone will inhibit inward growth of the freeze wall barrier.

Once the freeze wall is in place, there will be little change in the temperature of the wall throughout the thickness because of the insulating capacity of the rock matrix. In addition, the system can withstand power outages without damaging the integrity of the freeze wall due to the temperature and thickness.

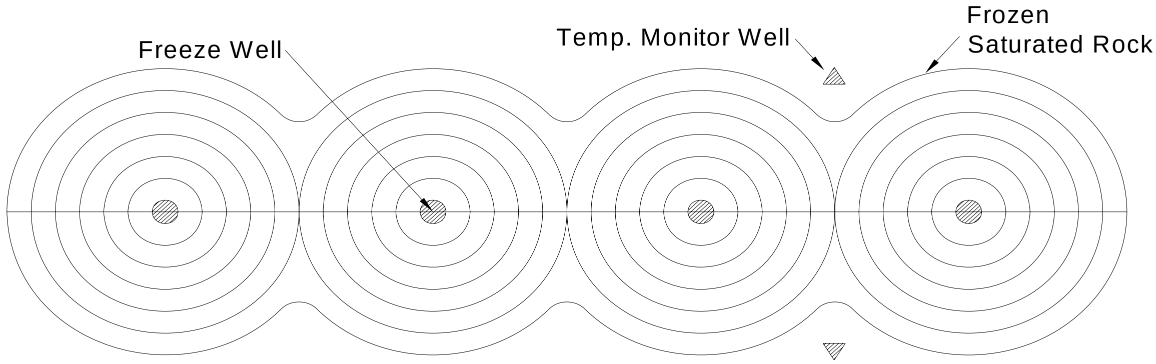


Figure 4.4 Freeze Well

The freeze wall containment area will be maintained until it can be demonstrated that the containment system is sufficiently rinsed and collected rinse water meets appropriate quality. The period of time for operation of the freeze wall containment area is currently estimated to be approximately ten to eleven years.

If piping in the freeze hole or above ground develops a leak, it would be detected by pressure and temperature sensors in the closed loop system. Shutoff valves are available at each hole to stop circulation of fluid in the hole. Shutoff valves are also available within the surface system to stop surface flows should a leak be detected. Any aqua ammonia in the down hole piping can be purged using high-pressure nitrogen. Leaks or spills would be piped back into the refrigeration system or hauled off-site. A Process Safety Management Manual for ammonia handling will be developed in accordance with Occupational Safety and Health Administration regulations prior to operation.

Refrigeration System

As the freeze holes are being drilled and completed, the refrigeration system will be constructed. The refrigeration system will be installed before other process equipment due to the length of time required to establish the freeze wall containment barrier. The refrigeration system will be located on the processing level along with the processing facilities as shown on Exhibit J. The plant will contain three (3) refrigeration units, which can each be operated separately. Initial charging of the refrigeration system with anhydrous ammonia and carbon dioxide will occur using the truck loading area closest to the refrigeration system, also on the processing level southwest of the refrigeration units.

The refrigeration units will be constructed on a concrete foundation that is curbed and graded to drain to a series of collection points that convey any spilled materials to a concrete sump. The sump will collect spills which will then be pumped to a truck for transport and disposal off-site. This containment includes operating areas and truck loading and unloading facilities. An expansion tank, an approximately 25,000-gallon tank, will contain aqua ammonia solution during initial cooling and in the event of an extended shutdown in the system. The expansion tank will be located adjacent to the production area.

Appropriate procedures for storage, handling and emergency response for ammonia chemicals used in the refrigeration system will be included in the Process Safety Management Manual to be developed in accordance with Occupational Safety and Health Administration regulations prior to operation. Emergency response procedures including procedures for clean-up of spills and notification requirements will be included in the Emergency Response Plan (ERP) to be developed prior to operations.

Because the refrigeration system is a closed loop system, the system will be designed with temperature and pressure monitors throughout to identify changes that will indicate a potential leak within the system as well as shutoff valves to stop the flow of refrigerant when a problem is detected. The monitoring will include alarms to alert of potential problems. Provisions are made to isolate portions of the system when a problem is detected. Because there are three separate refrigeration units within the refrigeration system, individual units can be isolated and shut down without impacting the entire system.

Dewatering Within the Freeze Wall Containment Area

Once the freeze wall has been established, drilling will occur inside the freeze wall containment area for both producer wells and heater holes. The functions and operations of these are discussed in later sections of this Project Description. Some of the producer holes will initially serve as ground water dewatering holes and their function as dewatering holes is discussed in this section.

There will be approximately ten dewatering holes drilled inside the freeze wall containment area. The dewatering holes will be completed to the total depth of approximately 1,880 feet as shown on Exhibit N. The upper portion of the hole will be cased with and cemented in place. Slotted liner will be placed from just below the bottom of the casing to the bottom of the hole and electrical submersible pumps will be installed.

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Ground water removed from inside the freeze wall containment area prior to heating will be injected into wells located down gradient, and outside the freeze wall. This will be accomplished through an above ground piping network that allows this water to be directed from dewatering holes to injection wells.

Two to four injection wells will be installed outside of the freeze wall as shown on Exhibit J; one upper strata and one lower strata. The dewatering phase is expected to last approximately 4 months, but actual time will be determined by dewatering efficiency. Dewatering pumping rates will be adjusted to match with injection rates.

Once the ability to pump water slows to the point that dewatering is no longer economical or feasible, dewatering operations will cease. During dewatering, the water being re-injected will be monitored periodically for water quality prior to re-injection to ensure that the water is being re-injected into the appropriate strata and that existing water quality is not impacted. Dewatering and re-injection flow rates will also be monitored to allow calculation of the amount of water taken from the containment zone and associated rate of re-injection.

Heater System

Approximately 30 heater holes will be drilled in the interior of the containment zone, spaced approximately 25 feet apart, as shown on Exhibit L. A buffer zone of approximately 125 feet will be established between the freeze holes and the heater holes to minimize the potential for heating of the freeze wall. Electric heaters will be installed in each hole to uniformly heat the oil shale. The approximate surface area of the heated pattern is 130 feet by 100 feet. The heaters are in place and heat the resource target zone for approximately 2 years.

All the heaters will be installed and energized at about the same time. The heaters are operated to achieve heating rates that bring the average reservoir temperature to between 550 and 750°F in approximately two years. The requirements for high operating temperature and long heating duration have resulted in the development of heaters specially designed for the project.

Each heater has a controller and temperature indicator. Some heater holes will be monitored for changes in pressure. The temperature and pressure monitoring will provide operating information and data from this research project that will help in the design of future operations. The heaters are designed to operate for the entire period without requiring maintenance. If heaters fail in service, they may be replaced.

During heating, the heat is transferred in the rock formation by thermal conduction only – no steam or heat transfer fluids are injected into the oil shale. The superposition or overlapping of heat from the array of heaters causes the average resource target zone temperature to rise quite uniformly, except within a few feet of the heater holes. The kerogen closest to the heaters will be converted first with the conversion moving outward as the heating progresses.

Heating also results in expansion of the rock. The rocks have differing thermal conductivities, with the leaner oil shale having greater conductivity than the kerogen-rich oil shale. The design of the heated zone accounts for these conductivities to ensure a sufficient buffer distance to the freeze wall to prevent unacceptable input of heat to the freeze wall. This is a function of the amount of heat put into the system, the conductivity of the rock, the time that the heaters are energized and the distance between the heaters and the freeze wall.

Due to the heating associated with production, heave and subsidence can occur at the surface and compaction can occur within the reservoir. Based upon the small production footprint and the depth of heating, little surface expression of changes within the pyrolyzed zone is anticipated. The surface expressions of heave is expected to be approximately 1.0-1.5 inch and the surface expression of subsidence is expected to be approximately 0.5 – 1.0 inch.

Product Recovery

As heating occurs, the lighter and higher quality vaporized ICP products, plus steam and non-condensable gases, will flow to the producer holes. Because of the slow heating rate, and the close spacing between holes, the initial reservoir permeability required for fluid transport can be relatively low. There is no need to create permeability by hydraulic or explosive fracturing. The producer wells will collect the converted kerogen products (oil and gas mixed with some water) in the pyrolyzed zone and convey those products to the surface for transport to the processing facilities. Both traditional and experimental lift systems will be used in the producer holes to "lift" the product to the surface.

Ten producer wells will collect the gas and oil produced by the ICP. The locations of the producer wells are shown on Exhibit L. Initially the producer wells will be used to dewater the freeze wall containment area. Upon completion of dewatering, pumps are removed and the holes plugged to the top of the R-4. When production commences, these holes will be used as producer holes. The producer holes are completed to a depth of approximately 1,675 feet. Pumps will be installed in each hole to bring the product to the surface.

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Each producer hole will be equipped with instrumentation to monitor production and reservoir condition, performance, temperature, rates, and pressure as part of the ongoing research efforts at OST.

A pump with lift assist is used to bring the liquids to the surface. Such lift systems are used on conventional oil and gas production. Standard oil and gas production lift systems, as well as some experimental lift systems, will be used. This will enable operating personnel to determine the best system for use in future operations.

At the start of the heating cycle, cutter stock (purchased diesel or jet fuel) is injected into the inlet of the down-hole production pumps to prevent plugging from bitumen which is produced when the pyrolyzed zone is relatively cool. The cutter stock may also be circulated in the above ground field collection piping to prevent plugging. Both the cutter stock and the treated gas used in the chamber lift system will be recovered and treated in the processing system.

In general, the down hole heating process will be sufficient for release of the hydrocarbons from the kerogen, and movement toward the producer holes. At later stages of production, the hydrocarbons released from the kerogen may be removed with the assistance of water injection holes. These water injection holes will be located inside the freeze wall containment area, but outside the heated pattern. These holes will be used to inject water into the pyrolyzed zone. The intent is to assist in collecting and pumping fluid from the producer holes, while protecting the freeze wall. The recovered fluid (a mixture of water and hydrocarbons) will be collected for further processing.

The temperature of product from the producer holes will be approximately 400 °F. The product is quenched to cool the material for transport to the processing facility. Quench water brought to the well head is mixed with the heated product coming from the producer hole. This results in a mixture of water and hydrocarbon. The mixture is piped to the processing facility at about 250°F.

Oil and gas production is approximately 600 barrels of oil or 1,000 barrels of oil equivalent (oil and gas) per day at full production for the OST.

When production is completed, producer holes will revert back to water collection holes during the cooling and water reclamation phase of the project. The collection system will be used to capture and transport water to the water reclamation plant.

Field Collection Network

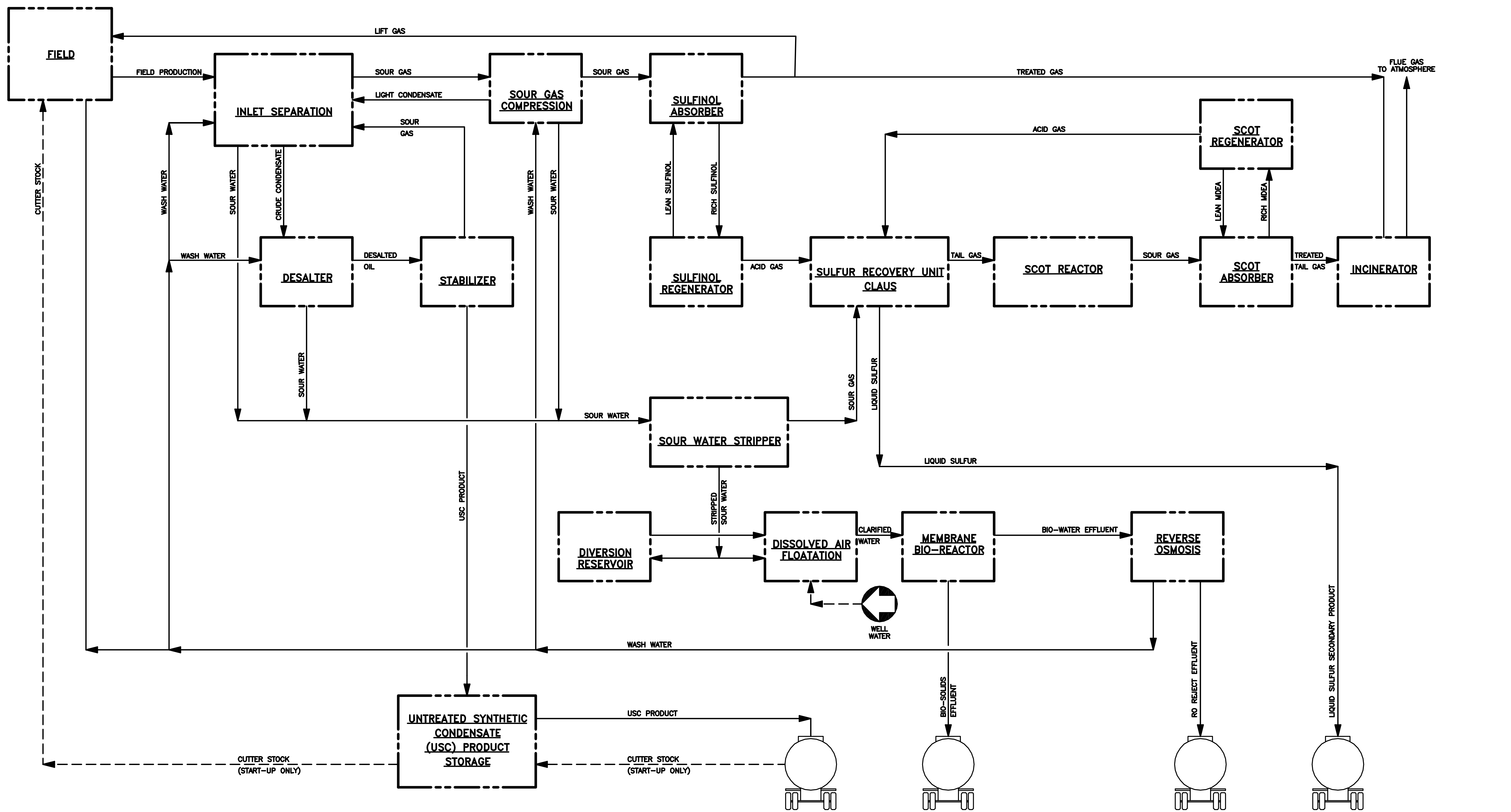
The field collection network will consist of headers and piping to collect oil and gas from the producer holes for transport to the processing facility. Figure 4.5 is a photograph of a typical production field piping network. The piping network at the OST site is expected to look similar to that shown in this photograph. Power is distributed throughout the surface of the production zone.

Figure 4.5 Photograph of Field Piping Network

The above ground collection system will operate under a nominal pressure of 60 psi. Pressure is monitored with instrumentation throughout the system, with readouts in the process control room. Visual inspections of the above ground piping network will be made on a regular basis. If there is a drop in pressure in the collection system indicative of a potential leak or break, that portion of the system can be shutoff until repairs are made. Surges in pressure will be relieved by a pressure release valve. Appropriate procedures for storage, handling and emergency response for the product recovery system will be included in Materials Handling and Waste Management Plan or the ERP to be developed for the site.

Processing System

The recovered product will include a mixture of liquid hydrocarbons, gas, and water that will be processed further to remove impurities and ready the products for transport off site or reuse in the recovery process. The recovery process is a typical process used in the oil and gas industry.
The processing system location is shown on Exhibit J with a more detailed, process block flow diagram shown on Figure 4.6.



Drawn By: KW | Date: 12/15/05 NW
Approved By: | Date:

FIGURE 4.6

PROCESSING BLOCK FLOW DIAGRAM OST

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The initial processing will separate the recovered product into three streams: liquid hydrocarbons, sour gas, and sour water. The term sour refers to the presence of sulfur compounds and carbon dioxide. Once the three streams have been separated, each stream is further processed to remove impurities. Except as noted in the following discussions, the waste streams generated during much of the processing are recycled back into the processing for further treating.

Liquid Hydrocarbons

The liquid hydrocarbons go through a two-step process to remove additional water and gas and create the liquid hydrocarbon product. The first step in the process involves removal of salt in the hydrocarbons through a desalting process. The hydrocarbon product is mixed with water and the salt is dissolved. The oil and water mixture is then separated using large electro-charged plates. The salty water is pulled to the bottom and the cleaned oil floats on top. The salty water is then sent for water treatment along with the sour water and the oil moves on to the next step.

The second step involves stabilizing the hydrocarbon product for transport through a distillation process. The distillation process separates the lighter gaseous and water fractions from the heavier liquid fractions and lowers the vapor pressure in the heavier fractions to that allowed for storage and transport. The liquid and gaseous streams are returned to the processing system for further processing.

The liquid hydrocarbon product is then sent to storage tanks. The product, known as Untreated Synthetic Condensate (USC) will be stored in two tanks located as shown on Exhibit J prior to transport off site. The facility is expected to produce approximately 600 barrels of oil per day at full production. The two USC tanks will each have a capacity of 139,000 gallons and will be designed with floating roofs. The tanks will be located within a containment area with curbing to contain any spills. Any spills will be collected and sent back to the processing system.

One or both USC tanks will initially be used to store cutter stock prior to product recovery and processing. Once the cutter stock has been introduced into the system, the tanks will be used for product storage. No clean-out will be required prior to the change in use.

Approximately five truckloads of USC will be shipped per day at full production. The tank loading area is a concrete area with curbed containment. Any spills will be collected and sent back to the processing system. The truck loading area will be equipped with heat sensors that control a foam system for fire suppression, if needed.

Gas Stream

The gas stream separated from the hydrocarbon product is treated through a multi-step process to remove sulfur and any remaining hydrocarbons and water. Hydrocarbons and water removed during the gas stream processing are returned to the hydrocarbon or sour water processing streams.

The gas is first compressed and cooled. Any condensed sour water and hydrocarbons are collected and sent back for further processing. The gas is then passed through columns and contacted with an amine-based solution that will absorb organic sulfur compounds, carbon dioxide, and acids. The treated gas collected after passing through the columns is then sent to the chamber lift system for use in product recovery, or used to supplement site fuel needs, or is incinerated. The solution is further processed to remove the high sulfur content gas and carbon dioxide and is then recycled back for reuse. The acid gas from the solution is sent to a conventional Claus sulfur recovery unit where it is converted to liquid sulfur. Gas which does not get converted to liquid sulfur in the sulfur recovery unit undergoes further treatment in a conventional SCOT (Shell Claus Offgas Treating) unit to remove the bulk of the remaining sulfur compounds. Methyl diethanolamine (MDEA) is used to strip the organic sulfur in this processing segment and then the MDEA is regenerated for reuse.

The sour gas processing employs the use of Sulfinol M, a proprietary solution containing MDEA, Sulfolane, and water. The MDEA and Sulfolane will be stored in tanks located within the processing system area (see Exhibit J for the processing area location). The Sulfolane and MDEA will be trucked to the site and unloaded into the tanks. Both the Sulfolane and MDEA are recycled for reuse in the process so large quantities are not required to be shipped to the site on a regular basis.

The gas processing results in products that include treated gas and liquid sulfur. The liquid sulfur will be stored in an enclosed concrete vault. The concrete vault will include steam coils in the bottom to maintain the sulfur as a liquid until shipped offsite. An estimated maximum of eight truckloads of liquid sulfur are shipped per month during the full production period. The tanker will be loaded in a curbed, concrete loadout area adjacent to the processing facility and concrete vault. Any spills will be collected and returned to the processing facility.

The treated gas will be incinerated on site, or used to supplement natural gas requirements used in processing. An incinerator was chosen to control the burn temperature to reduce the carbon monoxide and NO_x emissions. The incinerator operates at a temperature of approximately 1500° F. The exhaust gas from the incinerator is composed mainly of nitrogen, carbon dioxide, and water vapor. It also contains smaller amounts of nitrogen oxides, sulfur oxides, and carbon monoxide. A permit will be obtained from the Colorado Air Pollution Control Division for the incinerator exhaust gas.

As in other conventional treatment facilities for oil and gas, over pressure protection systems are provided as a safety feature. These safety systems provide pressure relief through a piping system that terminates at a lighted flare. The flare combusts any hydrocarbon in the relief stream to prevent the undesirable accumulation of combustible vapor. The flare location is shown on Exhibit J. The flare will not be routinely used, but is for emergency pressure release.

Water Stream

The sour water stream is run through a multi-step process to improve the water quality for reuse or discharge. The first step is a distillation process that removes ammonia, hydrogen sulfide gas, and light hydrocarbons. The vapor is sent for further treating in the gas stream segment of the processing system. The water is sent to a flotation cell and compressed air is used to generate gas bubbles that carry hydrocarbons and solids to the surface of the water in a froth layer that is then skimmed off. The froth layer is stored in a tank for eventual shipment from the site. The water continues to the next step of processing which is the membrane bio-reactor. The membrane bio-reactor uses bacteria, protozoa, and rotifers to remove organic material and convert this matter to biomass and other byproducts such as carbon dioxide, nitrogen gas and sulfates. Excess biosolids are collected and stored in a 214,000 gallon tank for shipment offsite. The water then goes through a reverse osmosis process to remove dissolved salts and other ions. Reject water from the reverse osmosis is directed into an 189,000 gallon tank for storage and transport offsite. Clean water is recycled back for use in the as quench water or in the processing facility.

The only additions for the water processing are compressed air and the bacteria, protozoa and rotifers. Tanks for storage of waste streams from the water treatment (air flotation solids, excess biosolids, and reject water from the reverse osmosis) will be located within concrete lined and curbed containment. The loadout area will be located north of the storm water pond as shown on Exhibit J and will also be a concrete lined and contained area. Any spilled materials will be sent back to one of these storage tanks.

The purified water stream is recycled for use as boiler feed water, washes for condenser units and as temperature regulating quench water. Any water not needed for the project will be discharged to the Yellow Creek drainage following treatment to the applicable standards. A Colorado Discharge Permit System permit will be obtained from the Colorado Water Quality Control Division for this discharge.

Processing System Pilot Scale Test Skids

Small "slipstream" volumes of gas, oil, and sour water will be processed in pilot scale test facilities located on skids to provide easy movement. These small plants will be used to conduct testing and collect data on USC processing methods. The pilot scale tests will be conducted within the process facilities area. Pilot scale testing will be used to evaluate the potential for additional processes to assist in further refining the products from the ICP process. Wastes from the pilot scale facilities will be handled in the process water treatment plant or the gas cleaning systems. Spills will be captured and treated in the process water treatment plant.

Process Water Pond

The Process Water Pond is a lined pond that is used as storage capacity for the stripped sour water from the Sour Water Stripper. This pond will be used to provide extra storage and in the event that the Dissolved Air Floatation, Membrane Bio-Reactor, or the Reverse Osmosis Units are off line for maintenance or repair or during periods when additional storage is needed. The stripped sour water can be diverted and stored in the Process Water Pond until the water treatment units are functional again. It is expected that the pond will be used for storage on a routine basis and will not remain empty for long periods of time.

The process water treatment pond has a capacity of approximately 10 acre-feet. Because the pond will hold process water that has not been fully treated to meet discharge standards, it is designed with a triple liner system composed of a soil liner overlain by two synthetic liners with a leak detection layer between. The soil liner is a geosynthetic clay liner (GCL) mat overlain on a six inch prepared subgrade. A 60-mil smooth HDPE liner will placed over the GCL. The primary liner is an 80-mil HDPE liner, textured on the side slopes and smooth on the bottom. Geo-net with a leachate collection and recovery system will be placed between the two liners. The pond does not have an outfall structure as it is a total containment pond.

The process water pond will be fenced with an eight-foot high chain link fence to prevent wildlife from entering the pond and causing liner damage.

4.4 Recovery Efficiency and Energy Balance

Although Shell's economic model contains many inputs, ICP economics depends heavily on the following three subsurface process performance metrics:

- Recovery Efficiency – the ratio of produced ICP oil to Fischer-assay oil in place
- Energy Balance – the ratio BTU's out as oil and gas to the BTU's input via electrical power
- Product Quality – the composition and properties of produced ICP fluids (e.g. API gravity) Product quality is addressed further in Section 4.7 below.

The high recovery efficiency of ICP (~100% of Fischer assay BOE, Barrel of Oil Equivalent) results from the slow, uniform heating process and also from the in situ vaporization of the hydrocarbons.

ICP makes more complete use of the oil shale resource. The entire oil shale column is pyrolized, including lower grade zones that could not be mined economically for surface retorting. ICP also can access deeper oil shale resources than are uneconomical to mine. Overall, much more oil and gas may be recovered from a given area utilizing the ICP process.

There are locations of thick resources in the Piceance Basin that could yield in excess of one million barrels of shale oil per acre.

ICP requires energy input for heating, freeze wall construction, processing, and maintenance but still generates three to four times as much net energy as it consumes. This energy ratio is very comparable to steam injection in heavy oil projects.

Support Facilities

Support facilities associated with the ICP and processing facilities include the building complex near the project entrance, the utility building and substations, a process control and locker/change house building, loading / unloading facilities, construction support, and driller support. Sanitary wastes from these facilities will be piped to the process water treatment building and treated in the Bio-Reactor. Solid waste (trash) will be disposed off site at an approved facility.

Security will be provided at the site. Trucks, visitors and employees will be required to enter through the security gate to access the work site. The maximum number of people employed at the site will occur during construction and drilling. An estimated maximum of approximately 720 individuals will be employed at the site during the construction and drilling period. Once construction is completed, the maximum expected employment at the site will be approximately 155. Shifts will typically be nine-hours per day, with some operators working twelve hour shifts.

Parking will be available in a parking lot just inside the main gate. An automated exit gate will be installed. Traffic will range from 300 to 650 vehicles per day, including personal automobiles and supply and product trucks.

Emergency Response personnel will be on site or on call. Written emergency procedures will be kept in manuals developed in accordance with Occupational Safety and Health Administration regulations prior to operation and in the Spill Prevention Control and Countermeasures (SPCC) and ERP. Copies of these manuals will be located in the control room and guard shack. Employee training will include safety, chemical handling, spill control and cleanup, and other emergency procedures.

Building Complex

The building complex includes a guard shack and gate, warehouse, shop building, laboratory building, and potable water tank and delivery system (see Exhibit J). The warehousing and maintenance shop will provide routine services for the operation.

Spill containment and cleanup procedures developed as part of the SPCC and the ERP will be implemented for any regulated chemicals used or stored in these facilities.

The laboratory will be used for process quality control testing, research testing and environmental monitoring. The building will be on a concrete foundation with a sump for spill containment. Chemicals will be stored in cabinets, appropriately segregated. Liquid waste from the laboratory will be treated at the process treatment plant or collected for off-site disposal in accordance with applicable regulations.

Potable water will be stored in a 12,500 gal tank at the building complex. Potable water will be brought from off site. The potable water system will service the lab, warehouse, shop, control room, and change house.

Utilities

Power is brought into the site from an electrical substation constructed, owned, and operated by White River Electric Association (WREA), just outside the permit boundary. Two substations on the project site will be maintained on site for power distribution to the project. It is anticipated that WREA will obtain the permits necessary for the substation and distribution line, an approximate location is shown on Exhibit C.

An electrical sub yard for heaters is located adjacent to the freeze wall containment area to support the heating process. An additional electrical sub yard is located just east of the WREA substation and services the rest of the facilities. Natural gas is brought on site via a pipeline from a commercial supplier located in proximity to the site and distributed to the processing facility. A stand-by diesel generator is located in the utility building. A small diesel storage tank will be located inside the curbed building to provide fuel for the stand-by generator.

The utility building area is also the location for the compressed air and nitrogen storage and distribution. Liquid nitrogen will be brought to the utility building in tank trucks. A paved unloading facility will be used. The liquid nitrogen is pumped into a 1,500-gallon nitrogen storage tank with a pressure release valve to atmosphere. The liquid nitrogen is vaporized for use in the process, including uses as blanket gas in process storage tanks and in the aqua ammonia expansion tanks. High pressure nitrogen is also brought to the site. The nitrogen will be brought to the site via a tube trailer and will be used to supply the refrigeration system with utility nitrogen, in the producer holes and gathering area as purge gas, and for instrument air.

Chemicals used in the processes are stored and handled within secondary containment and are subject to the ERP to be developed prior to initiation of refrigeration.

Process Control and Change House

The process control building and a change house are located near the utility building. The process control building will include data loggers from the many process sensors located throughout the project. The change house will be supplied with potable water. Sanitary waste from both buildings will be treated at the bioreactor at the process water treatment plant.

Drillers Support

Drilling of holes within the freeze wall containment area will last approximately one year. During that time, there will be a designated area for location of drilling support. Drilling support will include separate office, warehousing and operating equipment. Trailers for use as office and changing rooms will be located at the southwest end of the disturbed area as shown on Exhibit J. A material storage yard will be adjacent to the trailers. Diesel fuel, piping, and supplies will be located in the material storage yard.

Air compressors, mud traps and mud pumps will be located adjacent to the active drilling during the drilling program. Drill cuttings removed from the drilled holes will be dewatered so the water can be recycled back to the drill rigs. The dewatered cuttings will be placed into a cutting pit as shown on Exhibit J. This pit will be approximately 100 feet by 300 feet. The drill cuttings are not toxic or acid forming as shown by results of Meteoric Water Mobility Testing performed on cutting samples.

4.5 Water Management

Water requirements vary throughout the project life. Water uses include construction, potable water, dust control, drilling, processing, filling and cooling of the heated interval for reclamation, and rinsing of the zone inside the freeze wall.

Water Supply and Water Requirements

Water will be trucked to the site for construction and drilling activities. Potable water will be trucked to the site throughout the life of the facilities.

Onsite water will be used for most operational uses and will be supplied from water wells drilled for that purpose. A primary and a backup water supply well are planned. The well will supply water needed for processing and reclamation. Peak pumping demand from the well is estimated to be approximately 300 gpm and will occur during the fill and cool phase of the reclamation cycle (see Section 5.0). If the water well is available during construction and drilling, then this water will supplement or replace construction and drilling water trucked to the site.

Water needs for each phase of the operation are outlined below. The projected water needs are estimates and are subject to change as additional information becomes available and facility designs are finalized. Water rights required for the project will be acquired prior to startup of the operation.

Construction Water

Construction water will be trucked to the site as necessary for use in compaction, dust control and miscellaneous construction water needs. Construction water needs are estimated at approximately six gpm. Potable water needs during construction will be through provision of bottled water brought to the site.

Drilling Water

Water required for drilling will be trucked to the site until water from the on site water supply well is available to supplement or replace trucked water. Water needed for drilling operations is estimated at approximately five gpm.

Potable Water

Potable water will be delivered to the site by truck for use in the potable water system. The system will consist of a potable water tank and distribution lines to points of use. Potable water needs are estimated to be less than one gpm.

Operations and Reclamation Water

Water will be needed for various processing and operating needs. Water removed with the hydrocarbon products will be treated in the processing facilities and recycled or discharged. Figure 4.7 provides a general schematic of the process water management. It is currently anticipated that there will be excess water available during the initial processing period as a result of water within in the freeze wall containment area and that there will be no need for the water supply well to provide water for processing during this initial period. As processing progresses, there will be a need for up to approximately 11 gpm for water in processing.

Water is also needed to conduct reclamation filling and cooling of the heated interval within the freeze wall containment barrier as well as rinsing of the heated interval. This water will be a combination of recycle water and make up water from the water supply well as needed. During reclamation up to an approximately 300 gpm will be needed for initial stages of flushing and cooling. Figure 4.8 provides a general schematic of the reclamation water management.

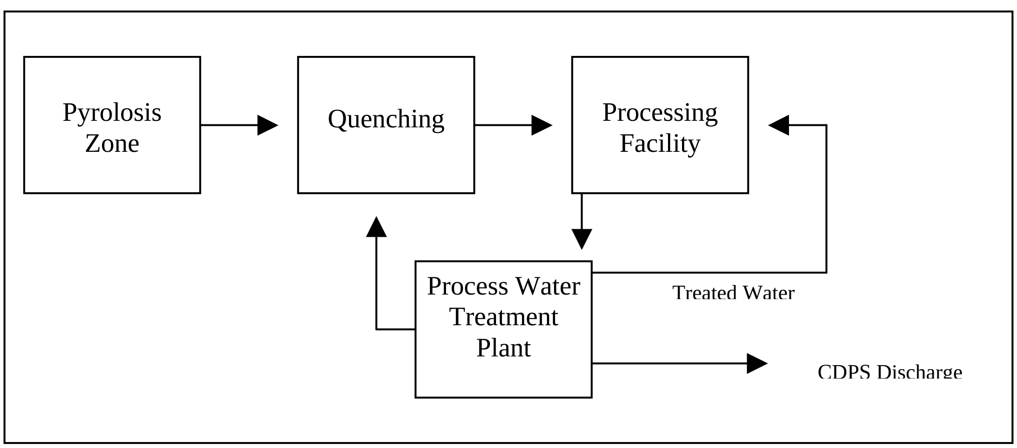


Figure 4.7 Processing Water Management

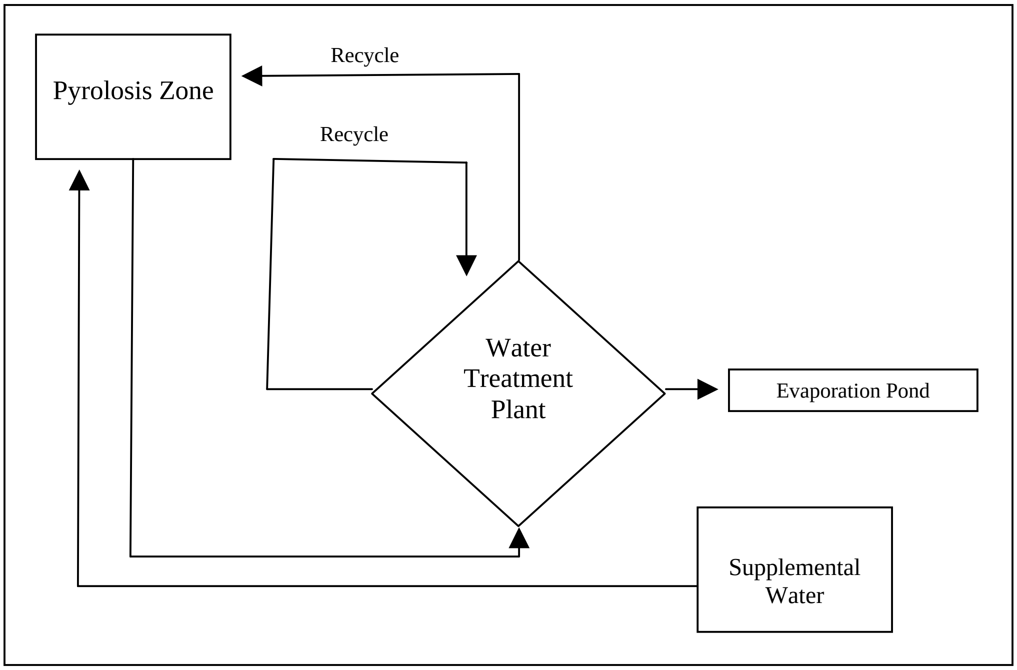


Figure 4.8 Reclamation Water

Water Discharge

Water that cannot be recycled or otherwise used will be treated to appropriate discharge standards in the process water treatment plant and released to a surface drainage under a Colorado Department of Public Health and Environment Colorado Discharge Permit.

Water Injection

Once the freeze wall is formed the containment area interior to the freeze wall will be dewatered by pumping. This intercepted natural ground water will be pumped from the freeze wall containment area and injected down gradient of the freeze wall through injection wells. The injection wells will be permitted with the EPA Underground Injection Control program for Class V injection wells authorized by rule. Water of appropriate quality will be injected into appropriate zones so that beneficial use classifications are maintained. Figure 4.9 shows a typical schematic for water management during dewatering and injection.

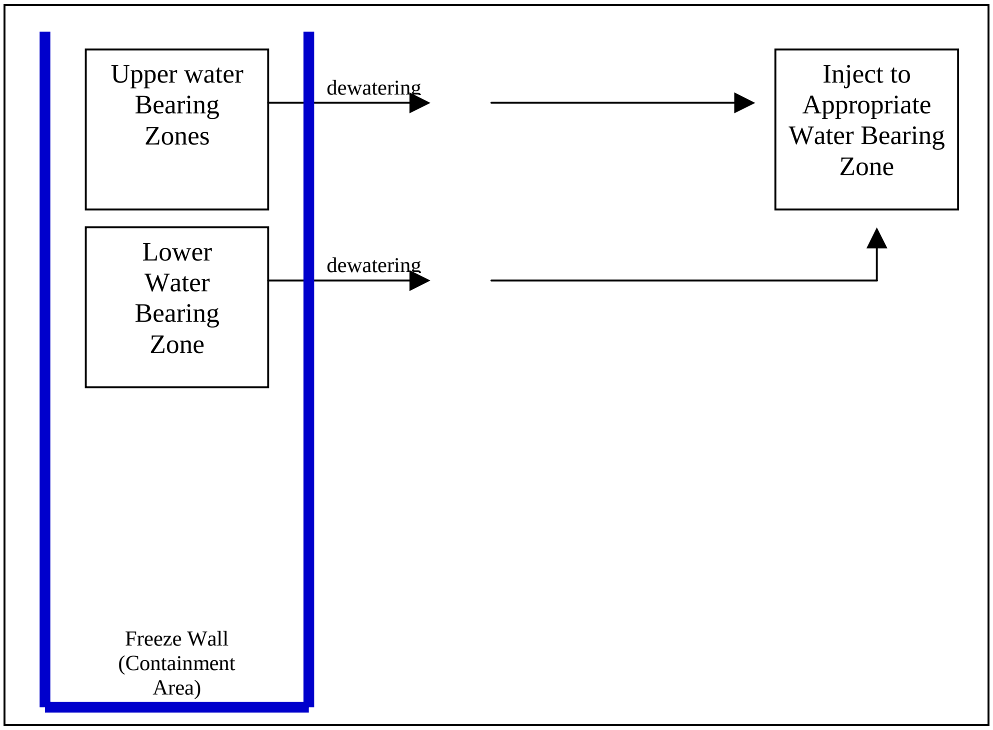


Figure 4.9 Dewatering and Injection Water Management

4.6 By-products and Wastes

During the course of the R&D project, construction and operation, a variety of by-products and waste materials will be generated. They include construction waste, drill hole cuttings, garbage and miscellaneous solid wastes and sanitary waste.

Surface construction operations will result in a variety of small waste products that could include paper, wood, scrap metal, refuse, garbage, etc. These materials will be collected in appropriate containers and recycled or disposed off site in accordance with applicable regulations

Approximately 200,000 cubic feet of earth and rock materials will be generated during drilling operations for the project. These non-toxic, non-acid forming drill cuttings will be separated from free water and will be buried below grade. Burial depth and soil coverage will be sufficient such that the materials will not impede revegetation.

During operation, garbage from the site will be collected in appropriate containers and disposed off site. Waste oils, reagents, lab chemicals that are not collected sumps and treated at the water treatment plants will be recycled or disposed off site in accordance with applicable regulations.

Sanitary Waste

A combination of sanitary waste handling methods will be employed. Some sanitary waste, such as that collected in temporary toilet facilities may be shipped to an approved facility for offsite treating and disposal. Any gray water or black water disposed onsite will be treated in an appropriate sewage processing unit or disposed according to standards via an approved septic system with clarifier and drain field.

4.7 Monitoring and Response

The OST project is a research, development, and demonstration program designed to demonstrate the ICP, gather additional operating data and information, and allow testing of components and systems. As a result, monitoring is inherent in the design of the project. ICP process monitoring will be designed to gather data on the functioning of the various system components. Shell will conduct extensive compliance monitoring as part of permit requirements e.g. air, water and mining permits. These will be defined as part of the permitting process.

Environmental monitoring that will be done to demonstrate other environmental protection measures for the site are described in this section.

Surface Water Monitoring

A proposed quarterly surface water sampling program will be performed on sampling sites identified in Table 4.3. The locations for these sites are shown in Exhibit O. The sampling parameters are detailed in Table 4.4. All monitoring records will be maintained at the project site.

Table 4.3 OST Surface Water Monitoring Locations

Stream Sites	Upstream	Corral Gulch	CR242
	Downstream	Corral Gulch	CR408
	Upstream	Stake Springs Draw	CR407
	Downstream	Stake Springs Draw	CR411
	Downstream	Yellow Creek	CR255

Table 4.4 Surface Water Sampling Parameters

Parameter	Unit	Parameter	Unit
Discharge	gpm	Boron, dissolved	mg/L
Field pH	SU	Cadmium, dissolved	mg/L
Field Conductivity	umhos/cm	Chromium dissolved	mg/L
Field Temperature	°C	Chromium, Trivalent Dissolved	mg/L
Field Dissolved Oxygen	mg/L	Chromium, Total	mg/L
Field Turbulence	ntu	Copper, dissolved	mg/L
Residue, Filterable (TDS)	mg/L	Iron, total recoverable	mg/L
Calcium, dissolved	mg/L	Lead, dissolved	mg/L
Magnesium, dissolved	mg/L	Manganese, dissolved	mg/L
Sodium, dissolved	mg/L	Mercury, total	mg/L
Hardness as $CaCO_3$	mg/L $CaCO_3$	Nickel, dissolved	mg/L
Bicarbonate as $CaCO_3$	mg/L	Selenium, dissolved	mg/L
Chloride	mg/L	Silver, dissolved	mg/L
Sulfate	mg/L	Zinc, dissolved	mg/L
Sulfide as S	mg/L	Benzene	ug/L
Nitrogen, Ammonia	mg/L	Toluene	ug/L
Nitrate/Nitrite as N	mg/L	Ethylbenzene	ug/L
Arsenic, dissolved	mg/L	Xylene	ug/L

Ground Water Monitoring

Ground water monitoring will be conducted outside of the freeze wall barrier to monitor ground water quality during operation and after reclamation.

Ground water monitoring will consist of monitoring of the water bearing units including the Uinta, A and B Groove, L5, L4 and L3. Compliance monitoring of these zones will occur using dedicated single completions in each zone.

Multiple zone completions are being tested for some wells interior to the freeze wall containment at FWT. Multiple completion wells are equipped with isolation packers to prevent crossflow between zones. Sample ports in the tubing string will allow for collection of pressure data and water samples. Should the information gained from the multiple zone completion wells demonstrate this type of completion is appropriate for ground water quality monitoring, then multiple zone completions could be proposed for ground water monitoring at a later date, subject to approval.

Planned ground water monitoring for the OST will include one upgradient completion in each unit and downgradient completions in each unit. Additional wells may be installed within the project area for early detection of potential problems.

Facilities Monitoring

Routine visual inspections and operational warning systems will facilitate monitoring of containment systems and features at the OST site. These will include the following:

- Piping systems will be pressured tested prior to use. The pipe systems will have pressure monitors to alert operators when a loss of pressure occurs that could be indicative of a potential problem.
- Sumps within concrete containment areas will be visually monitored on a daily basis and any liquids present in these sumps would be pumped to the process water treatment plant or sent off site for disposal at an appropriate facility.
- Storm water management systems would be inspected on a periodic basis as prescribed in the Storm Water Management Plan.
- A SPCC will be developed to address spill prevention and response for petroleum products at the site. The SPCC plan will prescribe inspection types and frequencies for petroleum related vessels and containments.

In addition, an ERP will be developed for responding to emergencies at the site while ensuring worker safety. The Plan will include designation of responsible personnel, an outline of procedures to be followed, a list of chemicals to be used or stored on site, a list of materials available to control spills or leaks, and notification requirements.

APPENDIX B

SELECTIONS FROM
PLAN OF OPERATION
FOR 2ND GENERATION ICP PROJECT

[[SELECTIONS FROM]]

Plan of Operations

Shell Frontier Oil and Gas Inc.

For 2nd Generation ICP Project

Oil Shale Research and Development Project

Prepared for:
Bureau of Land Management

February 15, 2006

4.0 OPERATING PLAN

4.1 General Project Overview and Summary

The 2nd Generation ICP Project is a research, development, and demonstration project designed to demonstrate the In Situ Conversion Process (ICP), gather additional operating data and information, and allow testing of components and systems to verify the feasibility of recovering hydrocarbons from oil shale for use in commercial operations. This plan details the construction, operation, and reclamation of the 2nd Generation ICP and the supporting facilities.

The 2nd Generation ICP anticipates resource recovery and oil production from both zones and is designed with facilities necessary to achieve that recovery. Those facilities and processes are the subject of this application. Installation of heaters in the lower oil shale resource from the top of R4 to the top of R2 and associated product recovery is dependent on results of ongoing research and development efforts.

The ICP is an in situ process using electric heaters to heat the oil shale in place. The heating process pyrolyzes the organic matter in the oil shale and converts this matter into oil and hydrocarbon gas. The oil and gas are then removed from the ground using conventional oil field pumping and extraction technology and processed using conventional oil and gas processing. The recovery is conducted within a contained area to allow recovery of the hydrocarbons while excluding ground water flow through the oil production area. Containment is provided in a freeze wall containment area consisting of a freeze wall system and low permeability barrier above and below the oil shale resource zone. These are described below.

Since the ICP for the 2nd Generation ICP is planned for use in areas below the ground water table, a freeze wall containment area is created to isolate the ICP from the surrounding ground water. Freezing of the in situ ground water and associated rock matrix creates a containment barrier that prevents migration of fluids into or out of the ICP area. The freeze wall is constructed by drilling closely spaced holes outside the intended oil shale resource target zone and circulating chilled refrigerant through closed loop piping in each freeze wall hole. Through heat exchange with the surrounding rock matrix, the refrigerant returns to the surface warmer than its inflow temperature and the surrounding rock and associated pore and fracture water is cooled and frozen. This frozen barrier is formed along the entire depth of the freeze hole and continues to grow and thicken until the area between freeze holes is frozen, forming a continuous frozen wall-like barrier that extends through the resource zone and into the impermeable layer at the bottom, thus forming a containment area that confines the ICP. The freeze wall containment area is maintained through heating and product recovery as well as during ground water reclamation.

Once the freeze wall is established, solution mining holes will be drilled in the interior of the freeze wall. Initially these holes will be used to remove nahcolite below the dissolution surface inside the freeze wall. After nahcolite is removed, these holes will be converted to dewatering holes and later be converted to producer holes that will remove the hydrocarbon products.

A series of heater holes are also drilled within the freeze wall containment area. Heaters are installed in these holes to allow heating of the resource interval. The heater holes are placed such that an unheated zone of approximately 125 feet is maintained between the freeze wall barrier and the heated zone so that the freeze wall is not impacted by heating. The heaters raise the temperature of the oil shale and initiate pyrolysis, releasing hydrocarbon products that are then removed using the production holes.

Products from the pyrolyzed zone are piped to an on-site processing facility, where processing separates the oil, gas, and water. Oil is processed to remove impurities, then shipped off site to existing refineries for refining. Gas from the production holes is also treated and used to supplement energy needs at the site or incinerated as quantities are not sufficient to justify facilities necessary for commercial transportation and sale. Sulfur, produced as a product during processing, is transported off-site as a marketable product. Figure 4.1 shows a simplified diagram describing the steps included in the 2nd Generation ICP.

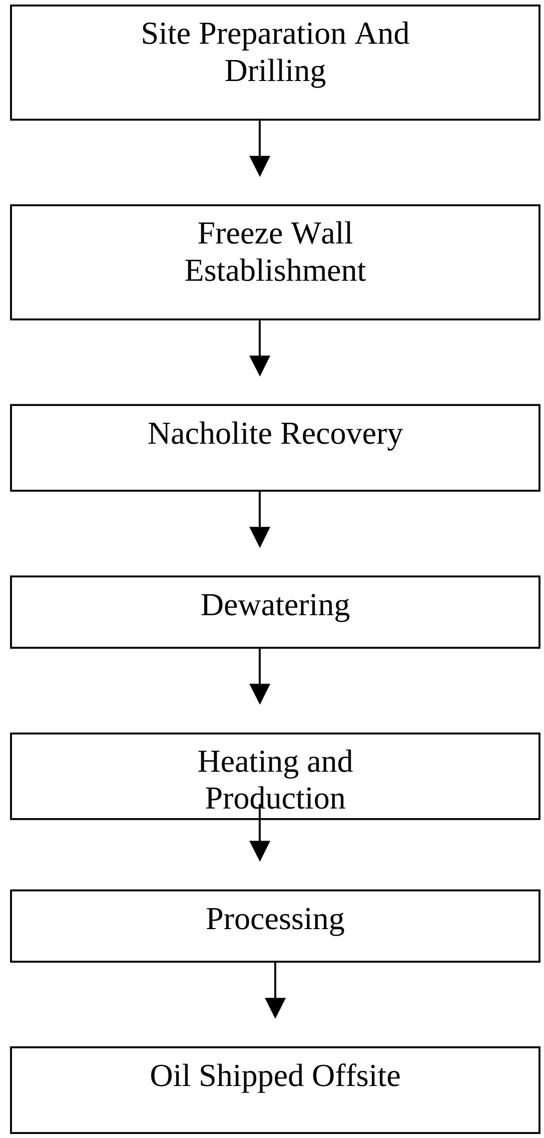


Figure 4.1 Diagram of 2nd Generation ICP

After removal of the recoverable product from the oil shale deposit, the area within the freeze wall containment area contains residual pyrolysis products. These are removed through rinsing prior to allowing the freeze wall barrier to thaw. The water used for rinsing is treated in an on-site ground water reclamation treatment plant, then recycled as rinse water. Waste from the ground water reclamation treatment plant is hauled off site. Reject brine solution from the ground water reclamation treatment plant is disposed in the evaporation pond. When the area is sufficiently rinsed and the collected rinse water meets appropriate quality, the freeze wall barrier is then allowed to thaw.

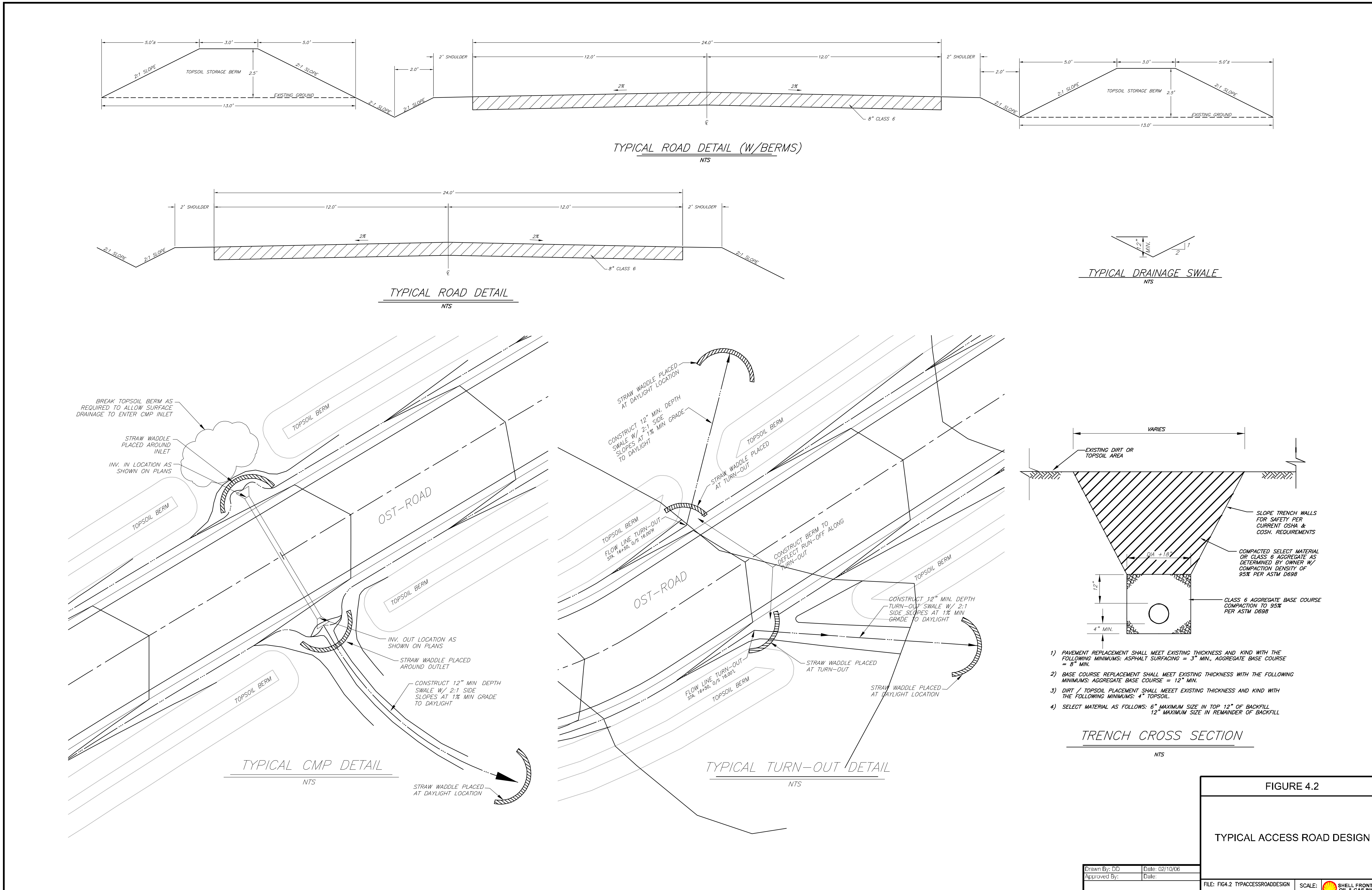
As a part of reclamation, the wells and holes not needed for monitoring are plugged and abandoned in accordance with requirements of the Colorado Office of the State Engineer. Facilities will be demolished and removed and the site will be regraded and revegetated. The paved access road will also be reclaimed, leaving a dirt road access route. The reclamation plan (Section 5) provides details on reclamation of the ICP and of the site disturbance.

Support facilities include a site access road; construction and drilling support consisting of lay down yards, storage units and office trailers; portable pilot test plants, process control building, change house, utilities, warehouse, shop/ maintenance facilities, laboratory, and other facilities necessary to support the 2nd Generation ICP Project. Potable water will be trucked to the site and stored for use in the on site potable water system. The following sections contain detailed information on the various process components associated with the 2nd Generation ICP facility.

4.2 General Site Development and Preparation

Initial construction activities include development of the site access road and fencing of the permit area. There are two proposed options for access roads into the site. One access is from County Road (CR) 5 to CR 24 which will enter the site from the Northeast. The other option is from CR 5 to CR 24 to CR 68 which will enter the site on the Southeast (see Exhibit C). This two-track road was originally constructed to access several ground water hydrology monitoring well sites. The access road will be extended to the 2nd Generation ICP site and expanded to a running width of approximately 24 feet to allow heavy equipment travel in two directions. The access road will be paved with asphalt for the 24-foot width and include appropriate ditches and culverts to maintain drainage control. Soils salvaged during the road construction will be stored in berms located on either side of the road. Figure 4.2 provides additional information on the design of the access road. Access to the 2nd Generation ICP site from the road will be restricted through an entry gate.

The 2nd Generation ICP project, excluding the access road, will be fenced with a combination barbed/smooth wire fence with the top wire being smooth. A 12-foot wide fire lane will be constructed along the permit boundary fence. Signs reading “Do Not Enter” will be posted at


TYPICAL ROAD DETAIL (W/BERMS)
NTS
TOPSOIL STORAGE BERM
EXISTING GROUND
2:1 SLOPE
2" SHOULDER
8" CLASS 6
TYPICAL ROAD DETAIL
NTS
TYPICAL DRAINAGE SWALE
NTS
12" MIN.
TYPICAL CMP DETAIL
NTS
BREAK TOPSOIL BERM AS REQUIRED TO ALLOW SURFACE DRAINAGE TO ENTER CMP INLET
STRAW WADDLE PLACED AROUND INLET
INV. IN LOCATION AS SHOWN ON PLANS
TOPSOIL BERM
OST-ROAD
INV. OUT LOCATION AS SHOWN ON PLANS
STRAW WADDLE PLACED AROUND OUTLET
CONSTRUCT 12" MIN DEPTH SWALE W/ 2:1 SIDE SLOPES AT 1% MIN GRADE TO DAYLIGHT
STRAW WADDLE PLACED AT DAYLIGHT LOCATION
TYPICAL TURN-OUT DETAIL
NTS
STRAW WADDLE PLACED AT DAYLIGHT LOCATION
CONSTRUCT 12" MIN. DEPTH SWALE W/ 2:1 SIDE SLOPES AT 1% MIN GRADE TO DAYLIGHT
STRAW WADDLE PLACED AT TURN-OUT
FLOW LINE TURN-OUT STA. 16+50, 0/S 16.00'R
CONSTRUCT BERM TO DEFLECT RUN-OFF ALONG TURN-OUT
CONSTRUCT 12" MIN. DEPTH TURN-OUT SWALE W/ 2:1 SIDE SLOPES AT 1% MIN GRADE TO DAYLIGHT
STRAW WADDLE PLACED AT TURN-OUT
FLOW LINE TURN-OUT STA. 16+50, 0/S 16.00'L
STRAW WADDLE PLACED AT DAYLIGHT LOCATION
TRENCH CROSS SECTION
NTS
VARIES
EXISTING DIRT OR TOPSOIL AREA
SLOPE TRENCH WALLS FOR SAFETY PER CURRENT OSHA & COSH. REQUIREMENTS
COMPACTED SELECT MATERIAL OR CLASS 6 AGGREGATE AS DETERMINED BY OWNER W/ COMPACTION DENSITY OF 95% PER ASTM D698
CLASS 6 AGGREGATE BASE COURSE COMPACTION TO 95% PER ASTM D698
DIA +18"
12"
4" MIN.
1) PAVEMENT REPLACEMENT SHALL MEET EXISTING THICKNESS AND KIND WITH THE FOLLOWING MINIMUMS: ASPHALT SURFACING = 3" MIN., AGGREGATE BASE COURSE = 8" MIN.
2) BASE COURSE REPLACEMENT SHALL MEET EXISTING THICKNESS WITH THE FOLLOWING MINIMUMS: AGGREGATE BASE COURSE = 12" MIN.
3) DIRT / TOPSOIL PLACEMENT SHALL MEEET EXISTING THICKNESS AND KIND WITH THE FOLLOWING MINIMUMS: 4" TOPSOIL.
4) SELECT MATERIAL AS FOLLOWS: 6" MAXIMUM SIZE IN TOP 12" OF BACKFILL 12" MAXIMUM SIZE IN REMAINDER OF BACKFILL
FIGURE 4.2
TYPICAL ACCESS ROAD DESIGN
Drawn By: DD
Date: 02/10/06
Approved By:
Date:
FILE: FIG4.2 TYPACCESSROADDESIGN
3235\Task 45\P00 5-2-05\FEB06
SCALE: NTS
SHELL FRONTIER OIL & GAS INC.

points of logical entrance to the facility, such as roads or trails, to redirect unauthorized personnel. Eight-foot high chain link fencing will be provided around lined ponds (storm water pond, process water pond, and evaporation pond) when these ponds are constructed.

Surface Drainage Controls

A surface water drainage collection and conveyance system will be established to manage drainage throughout the site. The surface drainage control system along with the site grading will route storm water flows from the disturbed areas into a storm water pond prior to discharge to the existing surface drainage system. The surface drainage system consists of ditches, storm sewers, culverts, curbs, and paving. Ditches will be lined with riprap or other material where necessary to assure stability. The pond will be designed to retain the runoff and sediment from a 50-year, 24-hour storm event (2.5 inches). Exhibit K shows the drainage control plan.

Construction storm water drainage will be managed through a construction Storm Water Management Plan and the use of accepted Best Management Practices (BMP), in accordance with a construction storm water permit. During construction and during operations areas of light disturbance that do not report to the storm water pond will be managed using BMPs. Erosion control measures will include stabilization of exposed soils and protection of steep slopes. Exposed soils will be stabilized by mulching, seeding, soil roughening, or chemical stabilization. Steep slopes will be protected by use of geotextiles, temporary slope drains, mulch, or seeding. Sediment controls may include sediment basins rock dams, sediment filters such as filter cloth, hay bales, erosion blankets, temporary seeding.

Site Preparation

A detailed site plan, including site grading, will be developed for the site during detailed design. The 2nd Generation ICP site will be graded to provide working levels for support facilities, production, processing, storage tanks, and shipping. Exhibit I is a preliminary plot plan that shows a general layout for all facilities at 2nd Generation ICP. A detailed design will optimize the layout.

Detailed engineering for the processing and water treatment systems is being conducted. It is anticipated that these facilities will be similar to what will be used at the OST research project for which more detailed design is complete. A partial list of equipment anticipated for the project is shown on Table 4.1.

Table 4.1 Equipment List

Air Blowers	Granular Activated Carbon Beds	Scrapers
Ammonia Circulation Pumps	H_2S Stripper	Separator
Ammonia Stripper Accumulator	H_2S Stripper Accumulator	Skimmings Concentrator
Ammonia Stripper Condensers	H_2S Stripper Condenser	Slop Oil Equalization Tank And Pumps
Ammonia Strippers	H_2S Stripper Inlet Preheat	Slops Pumps
Backhoes	High Pressure Nitrogen Storage Package	Solids Separation Clarifier
Backwash Water Pumps	Influent Transfer Pumps	Solvent Stripper
Bio-Solids Blower	Instrument Air Package	Sour Water Stripper Cooler
Bio-Solids Pump	Lean Sulfinol Heaters	Spent Carbon Feed Tanks
Biotreater Feed Cooler	Lo-Cat Absorber	SRC Pumps
Biotreater Pumps	Lo-Cat Oxidizer Vessel	Stabilizer Reboilers
Boiler Packages	Lo-Cat Slurry Centrifuge	Stand-By Generator
Bulldozers	Lo-Cat Solution Recirculation Tank	Stripper Effluent Coolers
Carbon Regeneration Furnace	MDEA Carbon Beds	Stripper Feed Pumps
Clarifier Sludge Transfer Pumps	MDEA Cooler	Sulfinol Pumps
Coalescing Filter	MDEA Exchangers	Sulfinol Reboilers
Combustion Products Accumulator	MDEA Pumps	Sulfur Pit
Combustion Products Condenser	Membrane Bio-Reactor Unit	Sulfur Product Tank
Concrete Trucks	Nitrogen Storage And Vaporizer	Sulfur Recovery Unit Reaction Furnace
Condensate Pots	NO_2 Gas Absorber	Sulfur Seal Pots
Condensate Pumps	NO_2 Gas Compressor	Sulfur Slurry Pumps
Converter Heaters	NO_2 Gas Condenser	Sump Pumps
Converters	NO_2 Gas Recycle Pumps	Supply Trucks
Deaerator Packages	Oil/Water Separators	SWS Overhead Accumulator
Deep Bed Nutshell Filters	Product Pumps	SWS Pumps
Discharge Coolers	Product Tanks	SWS Reboilers
Dissolved Air Flotation Unit	Quench Tank	SWS Strainers
Drills	Quench Water System	Thickener And Pumps
Equalization Tanks And Pumps	Recirculation Pumps	Utility Vehicles
Filter Press	Refrigeration Units	Vapor Catalytic Combustor
Flare Knock Out Pumps	Regenerated Carbon Storage Tanks	Virgin Carbon Make-Up Silo
Flare Package	Reverse Osmosis Unit	Water Heaters
Fuel Trucks	Sanitary Septic System	Water Pumps
Gas Burners	Scot Cargon Filters	Water Storage Tanks
Gas Compressors	Scot Pumps	Water Trucks
Gas Heaters	Scot Reflux Accumulator	Wet Well/Surge Tank

Pregnant Liquor Flash Tank	Crystallizers	Heat Exchangers
Boilers	Barren Liquor Heaters	Barren Liquor Injection Pumps
Carbon Dioxide Tank/Vaporizer	Centrifuge	Product Dryer
Heat Exchanger	Cooling Tower	Product Storage Bins
Glycol Chillers	Scot Regenerator	Product Loadout Facility

Prior to site preparation, the boundaries of the 160-acre site lease will be marked. The storm water pond will be constructed, clean water diversion ditches installed, and BMPs will be implemented. Larger trees will be cut and made available for firewood through a commercial operator. Stumps will be disposed of by burning on site (with the appropriate burn permits) or by hauling off site. Stumps may also be buried on site. Remaining vegetation will be cut and chipped with chips left on the ground to be incorporated into the salvaged soil. Approximately 12 inches of soil will be segregated, removed and deposited in three designated soil storage areas (Exhibit I). In areas where 12 inches of soil is not available for salvage, reasonable available soil material will be removed, with a targeted minimum of six inches removed in any location, where available. This material may not all be soil by strict definition, but will support vegetation and hence be suitable for plant growth medium. The soil stockpiles will be seeded with the BLM approved grass seed mix to minimize erosion and associated loss of soil. Soil stockpiles will also be covered with an erosion control netting to further minimize erosion and promote growth.

4.3 In-situ Conversion Process

Ground freezing as a means of containment was introduced in the 1800s to temporarily strengthen soils and serve as a barrier to ground water flow. Ground freezing continues to be applied in civil and geotechnical engineering to exclude water from areas being excavated; to seal tunnels, mine shafts, or other subsurface structures against flooding from ground water; and to enclose and/or consolidate hazardous or radioactive contaminants during remediation or reclamation operations. The containment system for the 2nd Generation ICP will consist of a series of drill holes in a close pattern (Exhibit J). Refrigerant will be circulated through the holes in a closed circuit to create a barrier of frozen water in a rock matrix.

The construction of the freeze wall containment area for the 2nd Generation ICP will allow heating of oil shale to recover products while preventing mixing of products with the ground water system. A freeze wall will be established for the depth of the freeze holes and will encircle the resource target zone creating an enclosed freeze wall containment area. The resource target zone is a carefully selected portion of the oil shale resource. The top and bottom of the resource target zone are low permeability layers that will prevent movement of converted hydrocarbons in a vertical direction. The freeze wall containment area provides lateral containment. The freeze wall will act to prevent liquid movement into or out of the containment area, separating the ground water system from the ICP products. The freeze wall containment area will be maintained and monitored throughout the heating, recovery, and the ground water reclamation phases of the operation. Since the freeze wall will take an extended period of time to thaw, the freeze wall refrigerant circulation may be stopped prior to final flushing if it can be demonstrated that the containment area is sufficiently rinsed and collected rinse water meets appropriate quality.

Freeze Wall Construction

Upon completion of site preparation, 150-200 freeze holes will be drilled approximately 8 feet apart. The freeze holes will be drilled to a depth of approximately 2,200 feet or the depth of the entire target interval. The configuration of a typical freeze hole is shown on Figure 4.3. Both air-mist fluid drilling and aerated fluid drilling methods are under consideration at this time. The air-mist method produces greater volumes of water compared to the aerated fluid method. Drilling methods will be selected based on field conditions and technology. Drilling fluids and additives that may be used are shown in Table 4.2.

Table 4.2 Inventory of Drilling Fluid Additives for use by Shell and its Contractors

Coring and Drilling Projects
Foamers
Baroid Quik-Foam
Bachman 485
Weatherford WFT FM A-100
Gels and Polymers
Baroid EZ-Mud - polymer
Halliburton Quik-Gel – bentonite gel
Halliburton Mud-Gel – bentonite gel
Baroid Quik-Trol and Quik-Trol LV - polymer
Benseal– for plugging back holes and hole abandonment
Baroid Holeplug – for plugging back holes and hole abandonment
Thread Compounds
Jet Lube Well Guard
MacDermid – Vinoleo thread compound for fiberglass casing
Best-O-Life Silicone GGT
Best-O-Life 72733 high temperature high pressure thread compound – not used in water wells or monitor holes.
Lub-O-Seal NM-91 anti-seize
Corrosion Inhibitors
Weatherford Corrfoam

Others
Rock Drill Oil R.D.O. ES
Sodium bicarbonate –pH neutralizer
Mazola Corn Oil – to free stuck pipe
Ventura Ultra-Fry (Canola Oil) – to free stuck pipe
Huskey LVI-50 Rod Grease – lubricate drill rods in dry hole

To complete the freeze hole and provide refrigeration for the length of the hole, an interior steel freeze tube will be installed to a depth of approximately 2,200 feet. The bottom of the steel tube will be sealed with an end cap. A smaller diameter high-density polyethylene (HDPE) inner freeze tube will be installed inside of the steel freeze tube. It is expected to take about six months to complete the drilling for the freeze wall pattern.

Once the drilling is completed, a chilled refrigerant, at an approximate temperature of -45º F is pumped through the holes. The interior HPDE tube will be used to convey the chilled aqua ammonia to the bottom of the hole and the outer steel pipe allows the solution to return to the surface for recycling back to the refrigeration system.

The area immediately surrounding the holes is frozen first. The frozen area continues to expand as refrigerant is re-circulated down each hole. Eventually the frozen "columns" expand to the point where the approximately concentric frozen "columns" are joined and a freeze wall barrier is created (Figure 4.4).

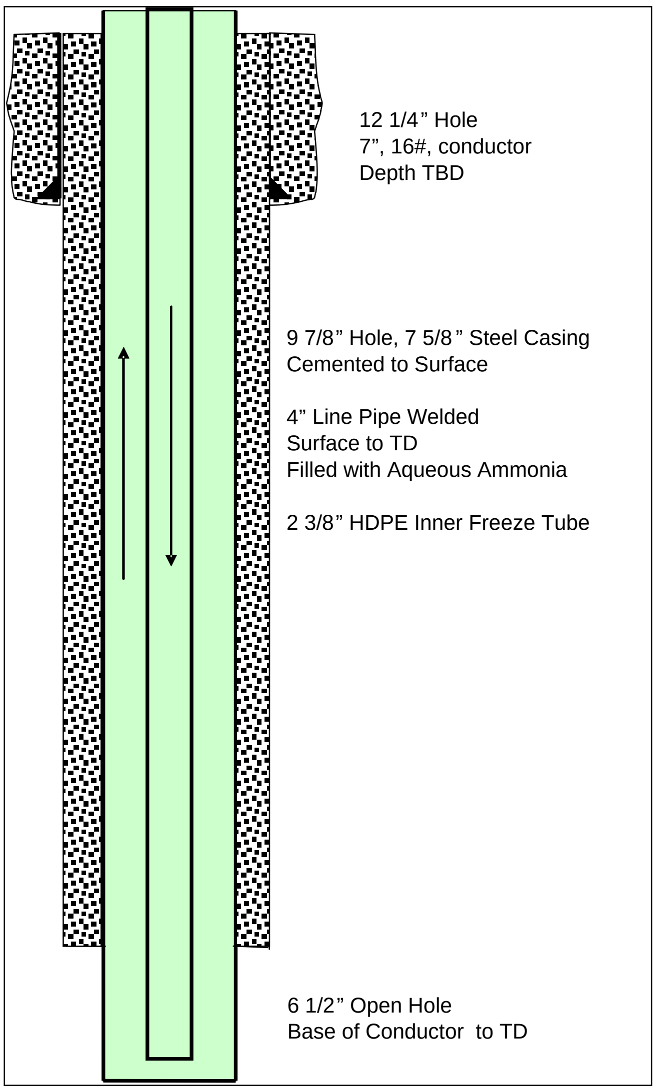


Figure 4.3 Typical Freeze Hole

It is anticipated to take approximately 18 months to establish a continuous freeze wall barrier.

As the circulation of refrigerant continues, the thickness of the freeze wall will continue to grow, although the rate of growth will slow as the wall thickens. Heating in the interior of the containment zone will inhibit inward growth of the freeze wall barrier.

Once the freeze wall is in place, there will be little change in the temperature of the wall throughout the thickness because of the insulating capacity of the rock matrix. In addition, the system can withstand power outages without damaging the integrity of the freeze wall due to the temperature and thickness.

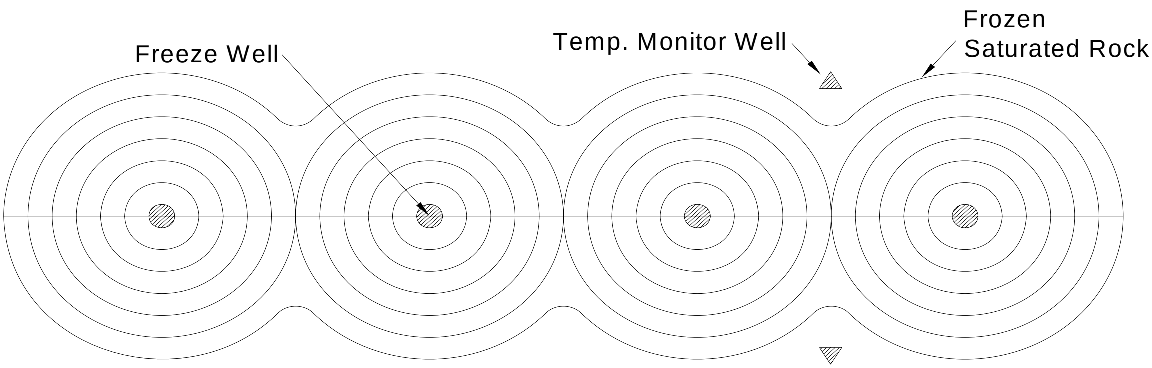


Figure 4.4 Freeze Wall

The freeze wall containment area will be maintained until it can be demonstrated that the containment system is sufficiently rinsed and collected rinse water meets appropriate quality. The period of time for operation of the freeze wall containment area is currently estimated to be approximately ten to eleven years.

Refrigeration System

As the freeze holes are being drilled and completed, the refrigeration system will be constructed. The refrigeration system will be installed before other process equipment due to the length of time required to establish the freeze wall containment barrier. The refrigeration system will be located on the processing level along with the processing facilities as shown on Exhibit I. The plant will contain several refrigeration units, which can each be operated separately.

Appropriate procedures for storage, handling and emergency response for ammonia chemicals used in the refrigeration system will be included in the Process Safety Management Manual to be developed in accordance with Occupational Safety and Health Administration regulations prior to operation. Emergency response procedures including procedures for clean-up of spills and notification requirements will be included in the Emergency Response Plan (ERP) to be developed prior to operations.

Nahcolite Recovery

Once the freeze wall has been established, drilling will occur inside the freeze wall. Within the freeze wall, vertical holes will be drilled on a triangular pattern with about a 100 ft. spacing. These holes will be drilled inside the freeze wall and will be used for solution mining, dewatering, and production. These holes will be completed within the production zone.

Solution mining is initiated using wells configured as in Figure 4.5. As shown in Beard et al, US Patent #3,779,602 assigned to Shell Oil Co., the solution mining wells are completed in a conventional manner with the casing through the top of the nahcolite zone sealed with low thermal conductivity cement.

A solution mining fluid injection tubing string and a solution mining fluid production tubing string are extended into the well. A packer is positioned in the casing above the lower end of the fluid injection tubing string. The lower end of the injection tubing string is positioned at the top of the nahcolite zone to be solution mined. The lower end of the production tubing string is positioned near the bottom of the nahcolite zone. This well completion injects the hot aqueous fluid at the top of the nahcolite zone and produces the denser nahcolite-bearing brine at the bottom. A pump may be positioned in the bottom of the production tubing string. Wells may be equipped for gas lift. All dissolution holes are installed and hot water is pumped through the circulating system at the same time. Pressure in the holes will be generated by the weight of the column of the mining solution and will vary depending upon the depth of the hole. Pressures will be above 700 psi.

The mining solution is pumped to a processing building where the mineral is removed. Detailed engineering has not been completed, but the process will remove the mineral from the water in a series of steps, dried, stored and loaded for market. Hot solution is cooled, the mineral is less soluble and crystallizes. Centrifuges drive off water to concentrate the crystallized material. The water is reheated and recycled as barren solution. CO2 is used to make a final product (sodium bicarbonate).

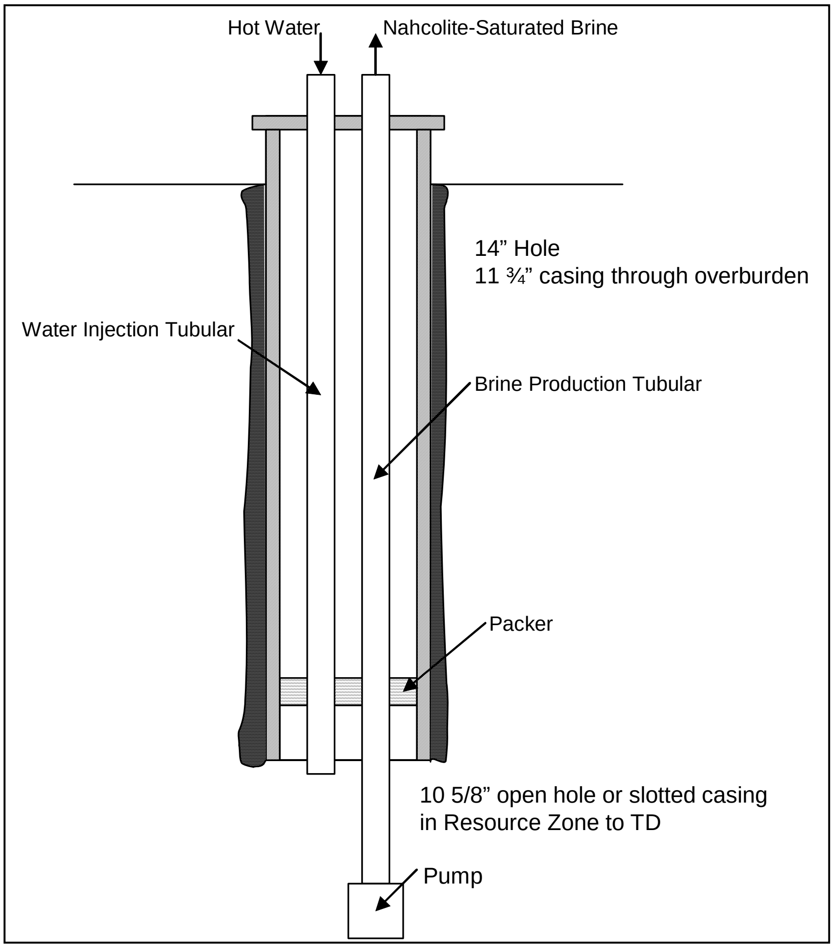


Figure 4.5 Typical Dissolution Well (Dewatering & Producer)

Detailed design of the processing facility has not been completed. It is anticipated that the nahcolite recovery system can be constructed, operated and decommissioned prior to beginning of groundwater reclamation. To minimize disturbance, the groundwater reclamation facilities are intended to be constructed at the same location as the nahcolite processing facility. Additional engineering evaluations will optimize the site arrangements for these facilities.

Dewatering Within the Freeze Wall Containment Area

Ground water will be removed from inside the freeze wall and will be injected into wells located down gradient, and outside the freeze wall. This will be accomplished through an above ground piping network that allows this water to be directed from dewatering holes to injection wells.

Two to four injection wells (Figure 4.6) will be installed outside of the freeze wall as shown on Exhibit J; one upper strata and one lower strata. Dewatering pumping rates will be adjusted to match with injection rates. During dewatering, the water being re-injected will be monitored periodically for water quality prior to re-injection to ensure that the water is being re-injected into the appropriate strata and that existing classified beneficial uses are not detrimentally impacted. Dewatering and re-injection flow rates will also be monitored to allow calculation of the amount of water taken from the containment zone and associated rate of re-injection.

Heater System

After the removal of the nahcolite and dewatering is completed, heaters will be installed in the resource zone. This may include approximately 100 vertical heaters spaced 20 ft to 30 ft apart on a triangular pattern. Heaters for the proposed location are about 2,200 feet long and are designed to concentrate most of their heat output in the bottom 1,100 feet (Figure 4.7). A buffer zone of approximately 125 feet will be established between the freeze holes and the heater holes to minimize the potential for heating of the freeze wall. Electric heaters will be installed in each hole to uniformly heat the oil shale. The heaters will heat the entire depth of the selected resource target zone. The heaters are in place and heat the resource target zone for approximately 2 years.

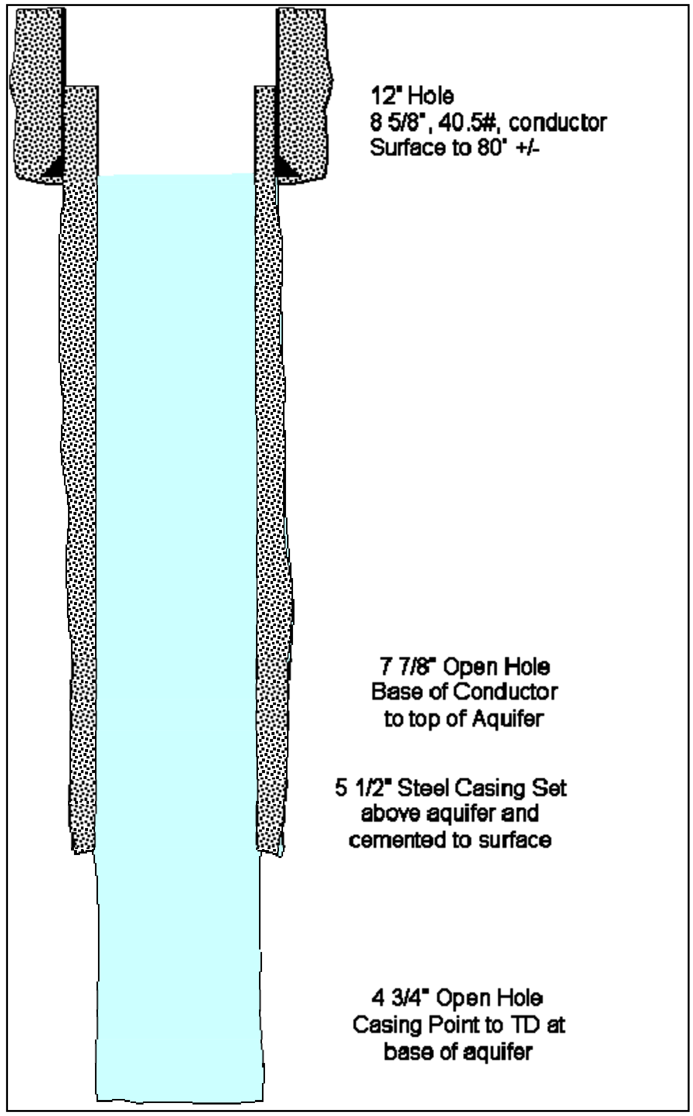
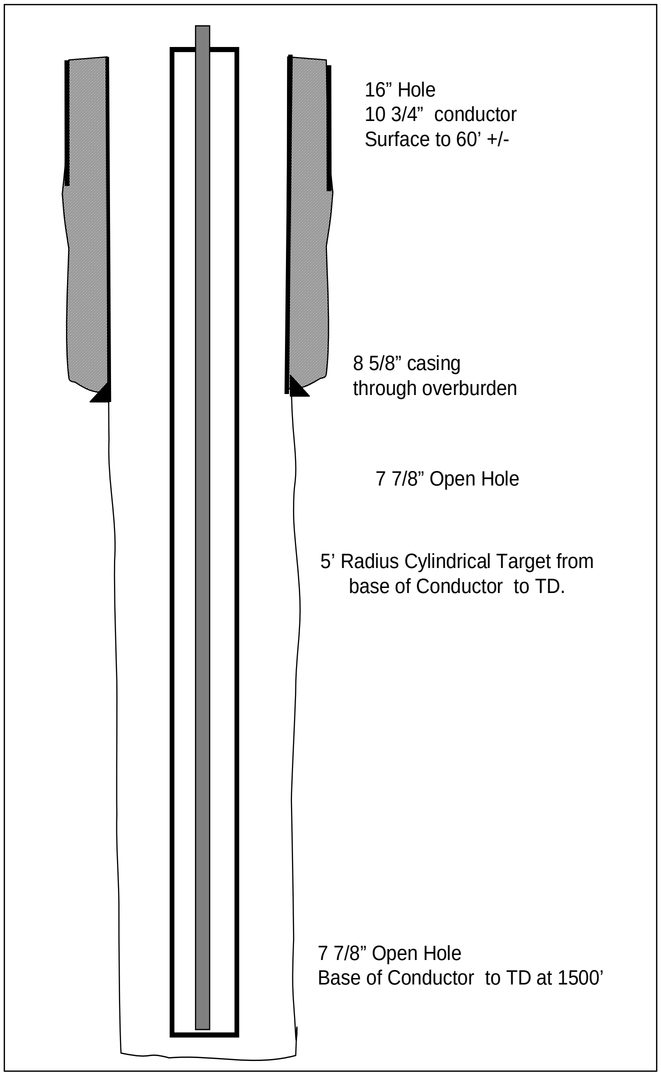


Figure 4.6 Typical Injection Well

All the heaters will be installed and energized at about the same time. The heaters are operated to achieve heating rates that bring the average reservoir temperature to between 550 and 750°F in approximately two years. The requirements for high operating temperature and long heating duration have resulted in the development of heaters specially designed for the project.

Each heater has a controller and temperature indicator. Some heater holes will be monitored for changes in pressure. The temperature and pressure monitoring will provide operating information and data from this research project that will help in the design of future operations. The heaters are designed to operate for the entire period without requiring maintenance. If heaters fail in service, they may be replaced.

Figure 4.7 Typical Heater Hole



During heating, the heat is transferred in the rock formation by thermal conduction only – no steam or heat transfer fluids are injected into the oil shale. The superposition or overlapping of heat from the array of heaters causes the average resource target zone temperature to rise quite uniformly, except within a few feet of the heater holes. The kerogen closest to the heaters will be converted first with the conversion moving outward as the heating progresses.

Heating also results in expansion of the rock. The rocks have differing thermal conductivities, with the leaner oil shale having greater conductivity than the kerogen-rich oil shale. The design of the heated zone accounts for these conductivities to ensure a sufficient buffer distance to the freeze wall to prevent unacceptable input of heat to the freeze wall. This is a function of the amount of heat put into the system, the conductivity of the rock, the time that the heaters are energized and the distance between the heaters and the freeze wall.

Due to the heating associated with production, heave and subsidence can occur at the surface and compaction can occur within the reservoir. Based upon the small production footprint and the depth of heating, little surface expression of changes within the pyrolyzed zone is anticipated. The surface expressions of heave is expected to be approximately 1.0-1.5 inch and the surface expression of subsidence is expected to be approximately 0.5 – 1.0 inch.

Product Recovery

As heating occurs, the lighter and higher quality vaporized ICP products, plus steam and non-condensable gases, will flow to the producer holes. The producer holes are the same holes that were used for dissolution mining and dewatering (Figure 4.5). Each producer hole will be equipped with instrumentation to monitor production and reservoir condition, performance, temperature, rates, and pressure as part of the ongoing research efforts at 2nd Generation ICP.

Because of the slow heating rate, and the close spacing between holes, the initial reservoir permeability required for fluid transport can be relatively low. There is no need to create permeability by hydraulic or explosive fracturing. The producer wells will collect the converted kerogen products (oil and gas mixed with some water) in the pyrolyzed zone and convey those products to the surface for transport to the processing facilities. A pump with lift assist is used to bring the liquids to the surface. Such lift systems are used on conventional oil and gas production.

At the start of the heating cycle, cutter stock (purchased diesel or jet fuel) is injected into the inlet of the down-hole production pumps to prevent plugging from bitumen which is produced when the pyrolyzed zone is relatively cool. The cutter stock may also be circulated in the above ground field collection piping to prevent plugging. Both the cutter stock and the treated gas used in the chamber lift system will be recovered and treated in the processing system.

In general, the down hole heating process will be sufficient for release of the hydrocarbons from the kerogen, and movement toward the producer holes. At later stages of production, the hydrocarbons released from the kerogen may be removed with the assistance of water injection holes. These water injection holes will be located inside the freeze wall containment area, but outside the heated pattern. These holes will be used to inject water into the pyrolyzed zone. The intent is to assist in collecting and pumping fluid from the producer holes, while protecting the freeze wall. The recovered fluid (a mixture of water and hydrocarbons) will be collected for further processing.

The temperature of product from the producer holes will be approximately 400 °F. The product is quenched to cool the material for transport to the processing facility. Quench water brought to the well head is mixed with the heated product coming from the producer hole. This results in a mixture of water and hydrocarbon. The mixture is piped to the processing facility at about 250°F.

Oil and gas production is approximately 1,500 barrels of oil Untreated Synthetic Condensate (USC) per day at full production for the 2nd Generation ICP.

When production is completed, producer holes will revert back to water collection holes during the cooling and water reclamation phase of the project. The collection system will be used to capture and transport water to the water reclamation plant.

Field Collection Network

The field collection network will consist of headers and piping to collect oil and gas from the producer holes for transport to the processing facility. Figure 4.8 is a photograph of a typical production field piping network. The piping network at the 2nd Generation ICP site is expected to look similar to that shown in this photograph. Power is distributed throughout the surface of the production zone.

Figure 4.8 Photograph of Field Piping Network

The above ground collection system will operate under a nominal pressure of 60 psi. Pressure is monitored with instrumentation throughout the system, with readouts in the process control room. Visual inspections of the above ground piping network will be made on a regular basis. If there is a drop in pressure in the collection system indicative of a potential leak or break, that portion of the system can be shutoff until repairs are made. Surges in pressure will be relieved by a pressure release valve. Appropriate procedures for storage, handling and emergency response for the product recovery system will be included in Materials Handling and Waste Management Plan or the ERP to be developed for the site.

Processing System

The recovered product will include a mixture of liquid hydrocarbons, gas, and water that will be processed further to remove impurities and ready the products for transport off site or reuse in the recovery process. The recovery process is a typical process used in the oil and gas industry. The processing system location is shown on Exhibit I with a more detailed, process block flow diagram shown on Figure 4.9.

The initial processing will separate the recovered product into three streams: liquid hydrocarbons, sour gas, and sour water. The term sour refers to the presence of sulfur compounds and carbon dioxide. Once the three streams have been separated, each stream is further processed to remove impurities. Except as noted in the following discussions, the waste streams generated during much of the processing are recycled back into the processing for further treating.

Liquid Hydrocarbons

The liquid hydrocarbons go through a two-step process to remove additional water and gas and create the liquid hydrocarbon product. The first step in the process involves removal of salt in the hydrocarbons through a desalting process. The hydrocarbon product is mixed with water and the salt is dissolved. The oil and water mixture is then separated using large electro-charged plates. The salty water is pulled to the bottom and the cleaned oil floats on top. The salty water is then sent for water treatment along with the sour water and the oil moves on to the next step.

The second step involves stabilizing the hydrocarbon product for transport through a distillation process. The distillation process separates the lighter gaseous and water fractions from the heavier liquid fractions and lowers the vapor pressure in the heavier fractions to that allowed for storage and transport. The liquid and gaseous streams are returned to the processing system for further processing.

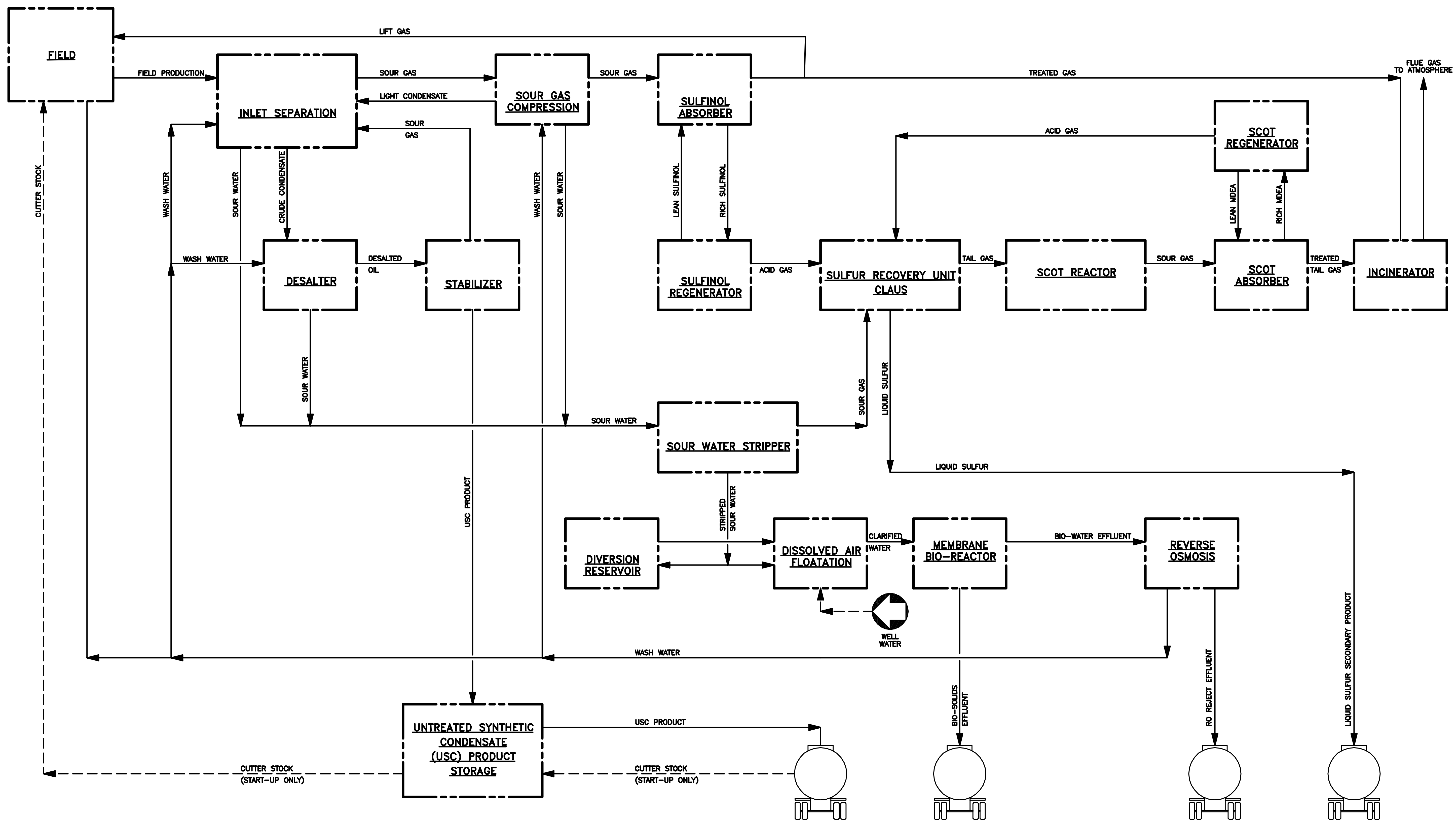


FIGURE 4.9

PROCESSING BLOCK FLOW DIAGRAM
2nd Generation ICP Project

Drawn By: KW	Date: 12/15/05 NW
Approved By:	Date:

FILE: Fig4.9 ProcessingBlockDiagram
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SHELL FRONTIER OIL & GAS INC.

The liquid hydrocarbon product is then sent to storage tanks. The product, known as USC will be stored in two tanks located as shown on Exhibit I prior to transport off site. The tanks will be located within a containment area with curbing to contain any spills. Any spills will be collected and sent back to the processing system.

Approximately five truckloads of USC will be shipped per day at full production. The tank loading area is a concrete area with curbed containment. Any spills will be collected and sent back to the processing system. The truck loading area will be equipped with heat sensors that control a foam system for fire suppression, if needed.

Gas Stream

The gas stream separated from the hydrocarbon product is treated through a multi-step process to remove sulfur and any remaining hydrocarbons and water. Hydrocarbons and water removed during the gas stream processing are returned to the hydrocarbon or sour water processing streams.

The gas is first compressed and cooled. Any condensed sour water and hydrocarbons are collected and sent back for further processing. The gas is then passed through columns and contacted with an amine-based solution that will absorb organic sulfur compounds, carbon dioxide, and acids. The treated gas collected after passing through the columns is then sent to the chamber lift system for use in product recovery, or used to supplement site fuel needs, or is incinerated. The solution is further processed to remove the high sulfur content gas and carbon dioxide and is then recycled back for reuse. The acid gas from the solution is sent to a conventional Claus sulfur recovery unit where it is converted to liquid sulfur. Gas which does not get converted to liquid sulfur in the sulfur recovery unit undergoes further treatment in a conventional SCOT (Shell Claus Offgas Treating) unit to remove the bulk of the remaining sulfur compounds. Methyl diethanolamine (MDEA) is used to strip the organic sulfur in this processing segment and then the MDEA is regenerated for reuse.

The sour gas processing employs the use of Sulfinol M, a proprietary solution containing MDEA, Sulfolane, and water. The MDEA and Sulfolane will be stored in tanks located within the processing system area (see Exhibit I for the processing area location). The Sulfolane and MDEA will be trucked to the site and unloaded into the tanks. Both the Sulfolane and MDEA are recycled for reuse in the process so large quantities are not required to be shipped to the site on a regular basis.

The gas processing results in products that include treated gas and liquid sulfur. The liquid sulfur will be stored in an enclosed concrete vault. The concrete vault will include steam coils in the bottom to maintain the sulfur as a liquid until shipped offsite. An estimated maximum of eight truckloads of liquid sulfur are shipped per month during the full production period. The tanker will be loaded in a curbed, concrete loadout area adjacent to the processing facility and concrete vault. Any spills will be collected and returned to the processing facility.

The treated gas will be incinerated on site, or used to supplement natural gas requirements used in processing. An incinerator was chosen to control the burn temperature to reduce the carbon monoxide and NO_x emissions. The incinerator operates at a temperature of approximately 1500° F. The exhaust gas from the incinerator is composed mainly of nitrogen, carbon dioxide, and water vapor. It also contains smaller amounts of nitrogen oxides, sulfur oxides, and carbon monoxide. A permit will be obtained from the Colorado Air Pollution Control Division for the incinerator exhaust gas.

As in other conventional treatment facilities for oil and gas, over pressure protection systems are provided as a safety feature. These safety systems provide pressure relief through a piping system that terminates at a lighted flare. The flare combusts any hydrocarbon in the relief stream to prevent the undesirable accumulation of combustible vapor. The flare location is shown on Exhibit I. The flare will not be routinely used, but is for emergency pressure release.

Water Stream

The sour water stream is run through a multi-step process to improve the water quality for reuse or discharge. The first step is a distillation process that removes ammonia, hydrogen sulfide gas, and light hydrocarbons. The vapor is sent for further treating in the gas stream segment of the processing system. The water is sent to a flotation cell and compressed air is used to generate gas bubbles that carry hydrocarbons and solids to the surface of the water in a froth layer that is then skimmed off. The froth layer is stored in a tank for eventual shipment from the site. The water continues to the next step of processing which is the membrane bio-reactor. The membrane bio-reactor uses bacteria, protozoa, and rotifers to remove organic material and convert this matter to biomass and other byproducts such as carbon dioxide, nitrogen gas and sulfates. Excess biosolids are collected and stored in a tank for shipment offsite. The water then goes through a reverse osmosis process to remove dissolved salts and other ions. Reject water from the reverse osmosis is directed into a tank for storage and transport offsite. Clean water is recycled back for use in the as quench water or in the processing facility.

The only additions for the water processing are compressed air and the bacteria, protozoa and rotifers. Tanks for storage of waste streams from the water treatment (air flotation solids, excess biosolids, and reject water from the reverse osmosis) will be located within concrete lined and curbed containment. The loadout area will be located north of the storm water pond as shown on Exhibit I and will also be a concrete lined and contained area. Any spilled materials will be sent back to one of these storage tanks.

The purified water stream is recycled for use as boiler feed water, washes for condenser units and as temperature regulating quench water. Any water not needed for the project will be discharged to the Yellow Creek drainage following treatment to the applicable standards. A Colorado Discharge Permit System permit will be obtained from the Colorado Water Quality Control Division for this discharge.

Processing System Pilot Scale Test Skids

Small “slipstream” volumes of gas, oil, and sour water will be processed in pilot scale test facilities located on skids to provide easy movement. These small plants will be used to conduct testing and collect data on USC processing methods. The pilot scale tests will be conducted within the process facilities area. Pilot scale testing will be used to evaluate the potential for additional processes to assist in further refining the products from the ICP process. Wastes from the pilot scale facilities will be handled in the process water treatment plant or the gas cleaning systems. Spills will be captured and treated in the process water treatment plant.

Process Water Pond

The Process Water Pond is a lined pond that is used as storage capacity for the stripped sour water from the Sour Water Stripper. This pond will be used to provide extra storage and in the event that the Dissolved Air Floatation, Membrane Bio-Reactor, or the Reverse Osmosis Units are off line for maintenance or repair or during periods when additional storage is needed. The stripped sour water can be diverted and stored in the Process Water Pond until the water treatment units are functional again. It is expected that the pond will be used for storage on a routine basis and will not remain empty for long periods of time.

The process water pond will be fenced with an eight-foot high chain link fence to prevent wildlife from entering the pond and causing liner damage.

4.4 Recovery Efficiency and Energy Balance

Although Shell’s economic model contains many inputs, ICP economics depends heavily on the following three subsurface process performance metrics:

- Recovery Efficiency – the ratio of produced ICP oil to Fischer-assay oil in place
- Energy Balance – the ratio BTU's out as oil and gas to the BTU's input via electrical power
- Product Quality – the composition and properties of produced ICP fluids (e.g. API gravity)

The high recovery efficiency of ICP (~100% of Fischer assay BOE, Barrel of Oil Equivalent) results from the slow, uniform heating process and also from the in situ vaporization of the hydrocarbons.

ICP makes more complete use of the oil shale resource. The entire oil shale column is pyrolized, including lower grade zones that could not be mined economically for surface retorting. ICP also can access deeper oil shale resources than are uneconomical to mine. Overall, much more oil and gas may be recovered from a given area utilizing the ICP process.

There are locations of thick resources in the Piceance Basin that could yield in excess of one million barrels of shale oil per acre.

ICP requires energy input for heating, freeze wall construction, processing, and maintenance but still generates three to four times as much net energy as it consumes. This energy ratio is very comparable to steam injection in heavy oil projects.

Support Facilities

Support facilities associated with the ICP and processing facilities include the building complex near the project entrance, the utility building and substations, a process control and locker/change house building, loading / unloading facilities, construction support, and driller support. Sanitary wastes from these facilities will be piped to the process water treatment building and treated in the Bio-Reactor. Solid waste (trash) will be disposed off site at an approved facility.

Security will be provided at the site. Trucks, visitors and employees will be required to enter through the security gate to access the work site. The maximum number of people employed at the site will occur during construction and drilling. An estimated maximum of approximately 720 individuals will be employed at the site during the construction and drilling period. Once construction is completed, the maximum expected employment at the site will be approximately 155. Shifts will typically be nine-hours per day, with some operators working twelve hour shifts.

Parking will be available in a parking lot just inside the main gate. An automated exit gate will be installed. Traffic will range from 300 to 650 vehicles per day, including personal automobiles and supply and product trucks.

Emergency Response personnel will be on site or on call. Written emergency procedures will be included in the Process Safety Management Manual to be developed in accordance with Occupational Safety and Health Administration regulations prior to operation and in the Spill Prevention Control and Countermeasures (SPCC) and ERP. Copies of this manual will be located in the control room and guard shack. Employee training will include safety, chemical handling, spill control and cleanup, and other emergency procedures.

Buildings

Buildings that are likely to be needed include a process control and change house, guard shack and gate, warehouse, shop building, laboratory building, and potable water tank and delivery system (see Exhibit I). The warehousing and maintenance shop will provide routine services for the operation. Trailers will be used for support of drilling activities e.g. warehousing, change house and offices.

Spill containment and cleanup procedures developed as part of the SPCC and the ERP will be implemented for any regulated chemicals used or stored in these facilities.

Utilities

Power is brought into the site from an electrical substation constructed, owned, and operated by White River Electric Association (WREA), just outside the permit boundary. Two substations on the project site will be maintained on site for power distribution to the project. It is anticipated that WREA will obtain the permits necessary for the substation and distribution line, an approximate location is shown on Exhibit I.

An electrical sub yard for heaters is located adjacent to the freeze wall containment area to support the heating process. An additional electrical sub yard is located just east of the WREA substation and services the rest of the facilities. Natural gas is brought on site via a pipeline from a commercial supplier located in proximity to the site and distributed to the processing facility. A stand-by diesel generator is located in the utility building. A small diesel storage tank will be located inside the curbed building to provide fuel for the stand-by generator.

4.5 Water Management

Water requirements vary throughout the project life. Water uses include construction, potable water, dust control, drilling, processing, filling and cooling of the heated interval for reclamation, and rinsing of the zone inside the freeze wall.

Water Supply and Water Requirements

Water will be trucked to the site for construction and drilling activities. Potable water will be trucked to the site throughout the life of the facilities.

Onsite water will be used for most operational uses and will be supplied from water wells drilled for that purpose. A primary and a backup water supply well are planned. The well will supply water needed for processing and reclamation. Peak pumping demand from the well is projected to be approximately 300 gpm and will occur during the fill and cool phase of the reclamation cycle (see Section 5.0). If the water well is available during construction and drilling, then this water will supplement or replace construction and drilling water trucked to the site.

Water needs for each phase of the operation are outlined below. The projected water needs are estimates and are subject to change as additional information becomes available and facility designs are finalized. Water rights required for the project will be acquired prior to the startup of the operation.

<u>Construction Water</u>

Construction water will be trucked to the site as necessary for use in compaction, dust control and miscellaneous construction water needs. Potable water needs during construction will be through provision of bottled water brought to the site. Water required for drilling will be trucked to the site until water from the on site water supply well is available to supplement or replace trucked water.

<u>Operations and Reclamation Water</u>

Water will be needed for various processing and operating needs. Water used in nahcolite recovery is recycled into the process. Makeup water will be required. Water removed with the hydrocarbon products will be treated in the processing facilities and recycled or discharged. Figure 4.10 provides a general schematic of the process water management. It is currently anticipated that there will be excess water available during the initial processing period as a result of water within in the freeze wall containment area and that there will be no need for the water supply well to provide water for processing during this initial period. As processing progresses, there will be a need for additional for water in processing.

Water is also needed to conduct reclamation filling and cooling of the heated interval within the freeze wall containment barrier as well as rinsing of the heated interval. This water will be a combination of recycle water and make up water from the water supply well as needed. During reclamation up to an approximately 300 gpm will be needed for initial stages of flushing and cooling. Figure 4.11 provides a general schematic of the reclamation water management.

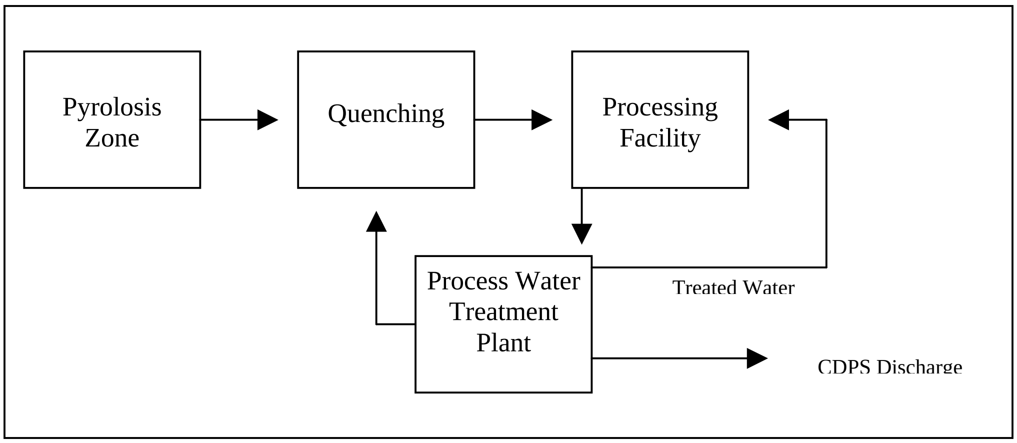

Figure 4.10 Processing Water Management

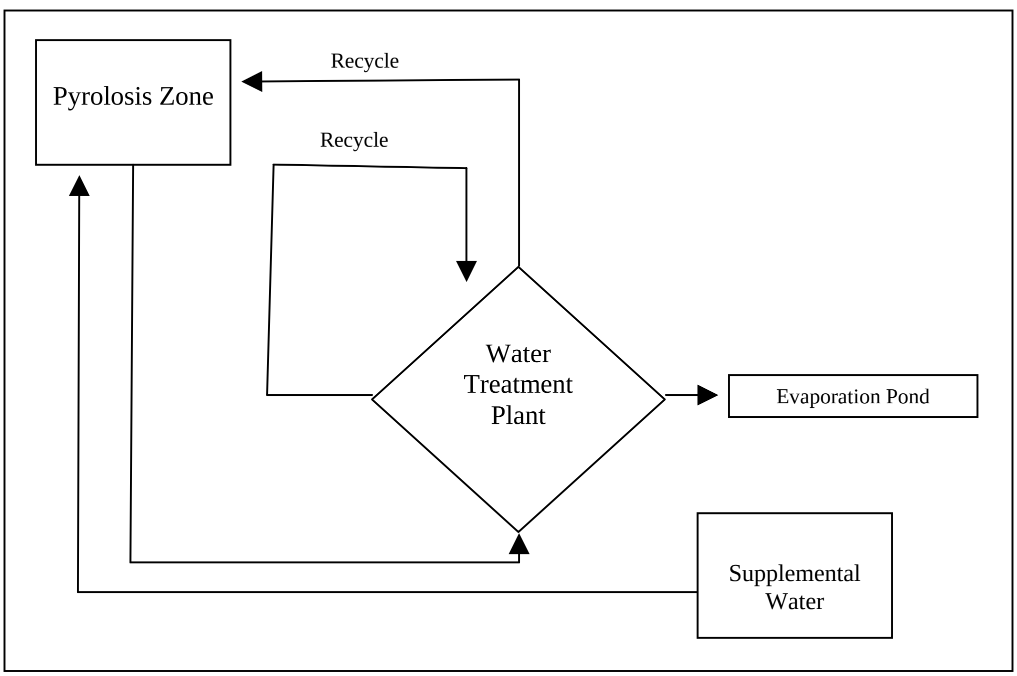

Figure 4.11 Reclamation Water

Water Discharge

Water that cannot be recycled or otherwise used will be treated to appropriate discharge standards in the process water treatment plant and released to a surface drainage under a Colorado Department of Public Health and Environment Colorado Discharge Permit.

Water Injection

Once the freeze wall is formed the containment area interior to the freeze wall will be dewatered by pumping. This intercepted natural ground water will be pumped from the freeze wall containment area and injected down gradient of the freeze wall through injection wells. The injection wells will be permitted with the EPA Underground Injection Control program for Class V injection wells authorized by rule. Water of appropriate quality will be injected into appropriate zones so that similar water quality is maintained. Figure 4.12 shows a typical schematic for water management during dewatering and injection.

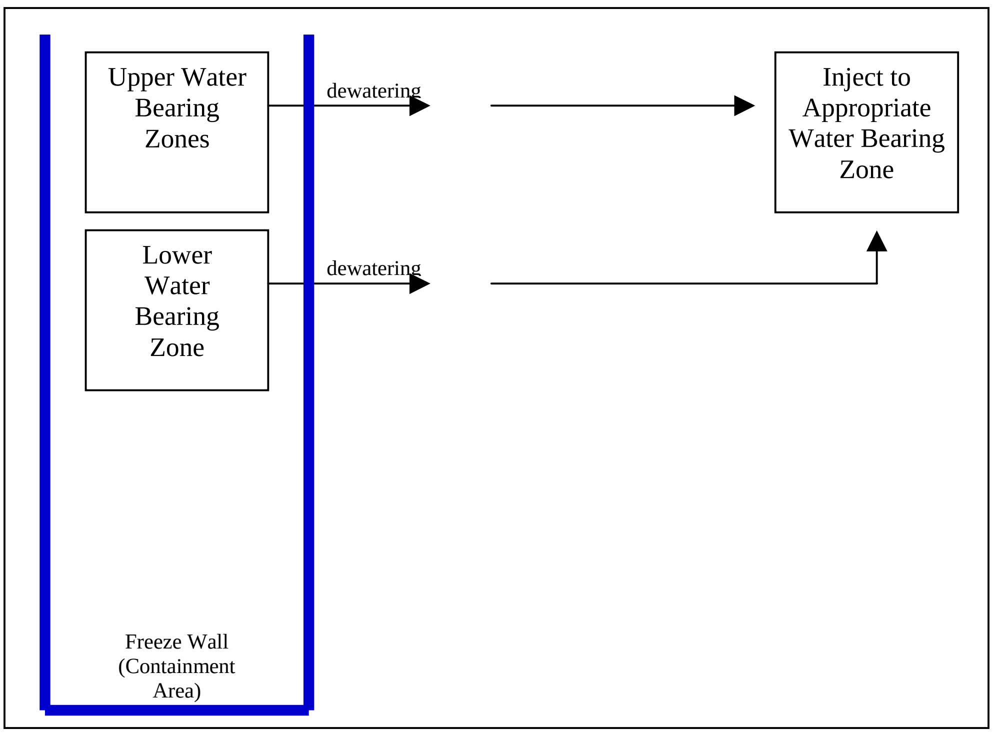

Figure 4.12 Dewatering and Injection Water Management

4.6 By-products and Wastes

During the course of the R&D project, construction and operation, a variety of by-products and waste materials will be generated. They include construction waste, drill hole cuttings, garbage and miscellaneous solid wastes and sanitary waste.

Surface construction operations will result in a variety of small waste products that could include paper, wood, scrap metal, refuse, garbage, etc. These materials will be collected in appropriate containers and recycled or disposed off site in accordance with applicable regulations

Approximately 200,000 cubic feet of earth and rock materials will be generated during drilling operations for the project. These non-toxic, non-acid forming drill cuttings will be separated from free water and will be buried below grade. Burial depth and soil coverage will be sufficient such that the materials will not impede revegetation.

During operation, garbage from the site will be collected in appropriate containers and disposed off site. Waste oils, reagents, lab chemicals that are not collected sumps and treated at the water treatment plants will be recycled or disposed off site in accordance with applicable regulations.

Sanitary Waste

A combination of sanitary waste handling methods will be employed. Some sanitary waste, such as that collected in temporary toilet facilities may be shipped to an approved facility for offsite treating and disposal. Any gray water or black water disposed onsite will be treated in an appropriate sewage processing unit or disposed according to standards via an approved septic system with clarifier and drain field.

4.7 Monitoring and Response

The 2nd Generation ICP project is a research, development, and demonstration program designed to demonstrate the ICP, gather additional operating data and information, and allow testing of components and systems. As a result, monitoring is inherent in the design of the project. ICP process monitoring will be designed to gather data on the functioning of the various system components. Shell will conduct extensive compliance monitoring as part of permit requirements e.g. air, water and mining permits. These will be defined as part of the permitting process.

Because this is an R&D project, extensive monitoring and instrumentation are provided for subsurface analysis. Temperatures, pressures, and levels are measured inside the heated patterns, inside the freeze wall and outside the freeze wall. Figures 4.13 - 4.15 show temperature, geomechanics, and level monitoring sketches.

Outside the freeze wall (Figure 4.16), pumper holes provide secondary containment in the unlikely event hydrocarbon escapes through the wall

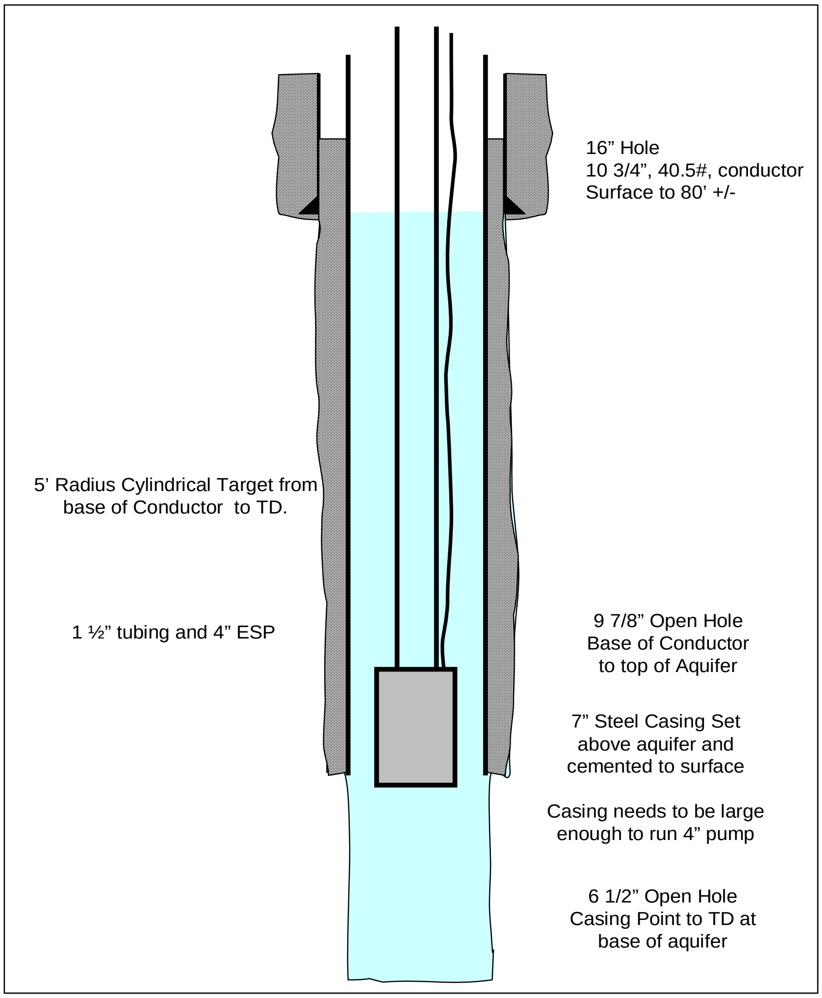

Figure 4.13 Typical Level Monitor Hole

Environmental monitoring that will be done to demonstrate other environmental protection measures for the site are described in this section.

Surface Water Monitoring

A proposed quarterly surface water sampling program will be performed on sampling sites identified in Table 4.3. The locations for these sites are shown in Exhibit L. The sampling parameters are detailed in Table 4.4. All monitoring records will be maintained at the project site.

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Table 4.3 2nd Generation ICP Surface Water Monitoring Locations

Stream Sites	Upstream	Corral Gulch	CR242
	Downstream	Corral Gulch	CR408
	Upstream	Stake Springs Draw	CR407
	Downstream	Stake Springs Draw	CR411
	Downstream	Yellow Creek	CR255

Table 4.4 Surface Water Sampling Parameters

Parameter	Unit	Parameter	Unit
Discharge	gpm	Boron, dissolved	mg/L
Field pH	SU	Cadmium, dissolved	mg/L
Field Conductivity	umhos/cm	Chromium dissolved	mg/L
Field Temperature	°C	Chromium, Trivalent Dissolved	mg/L
Field Dissolved Oxygen	mg/L	Chromium, Total	mg/L
Field Turbulence	ntu	Copper, dissolved	mg/L
Residue, Filterable (TDS)	mg/L	Iron, total recoverable	mg/L
Calcium, dissolved	mg/L	Lead, dissolved	mg/L
Magnesium, dissolved	mg/L	Manganese, dissolved	mg/L
Sodium, dissolved	mg/L	Mercury, total	mg/L
Hardness as $CaCO_3$	mg/L $CaCO_3$	Nickel, dissolved	mg/L
Bicarbonate as $CaCO_3$	mg/L	Selenium, dissolved	mg/L
Chloride	mg/L	Silver, dissolved	mg/L
Sulfate	mg/L	Zinc, dissolved	mg/L
Sulfide as S	mg/L	Benzene	ug/L
Nitrogen, Ammonia	mg/L	Toluene	ug/L
Nitrate/Nitrite as N	mg/L	Ethylbenzene	ug/L
Arsenic, dissolved	mg/L	Xylene	ug/L

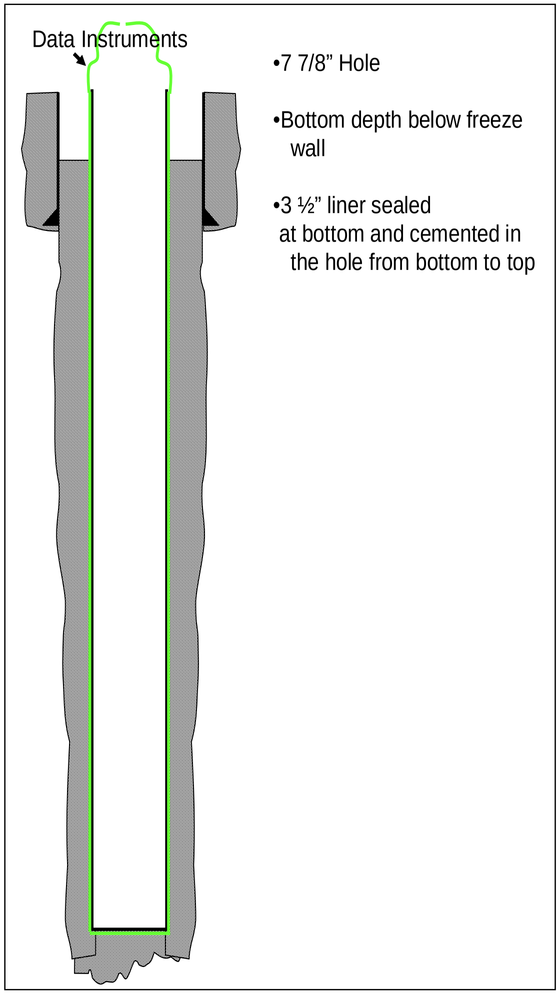


Figure 4.14 Typical Geomechanics Monitor

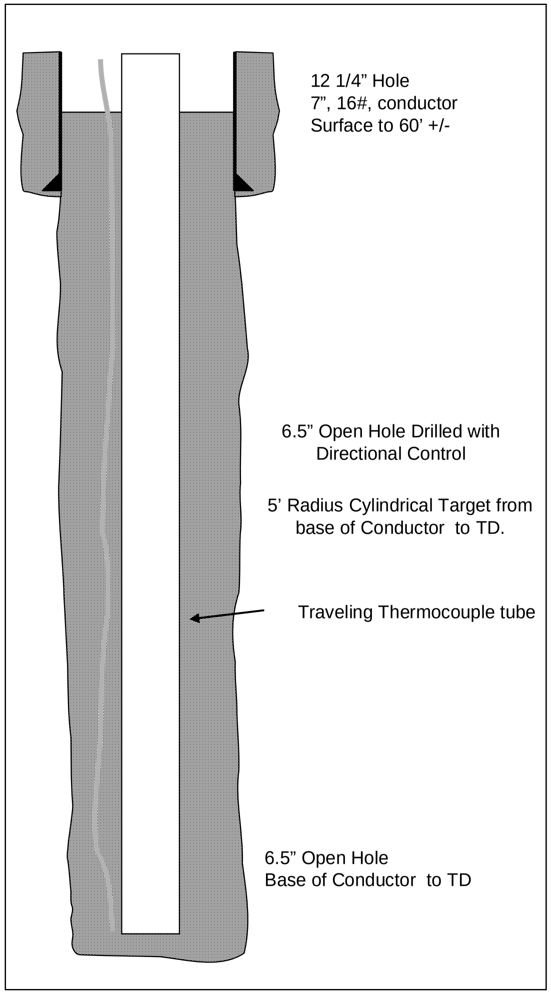


Figure 4.15 Typical Temperature Monitor

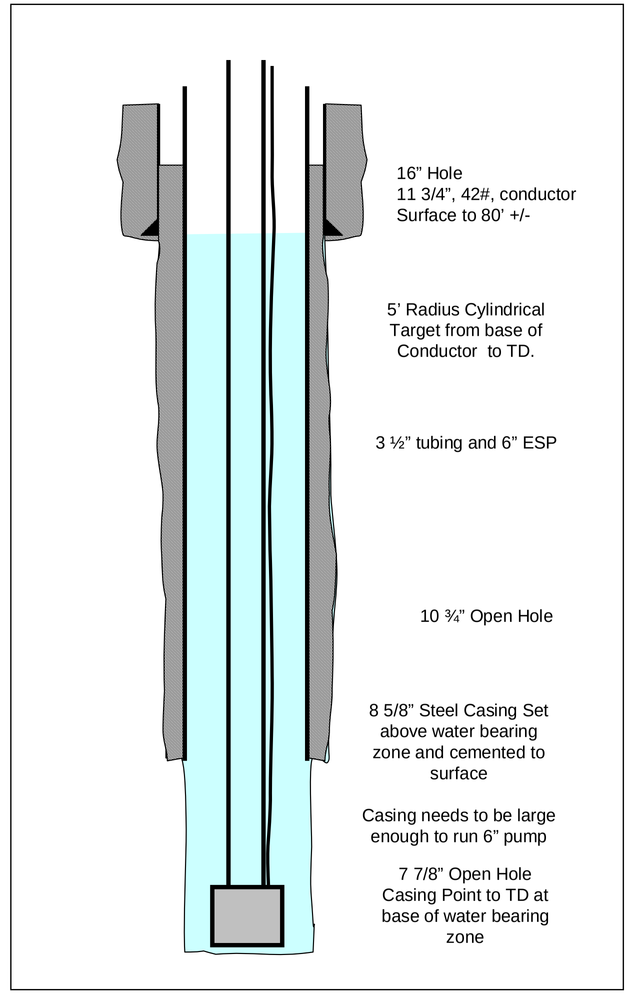


Figure 4.16 Typical Pumper Hole

Ground Water Monitoring

Ground water monitoring will be conducted outside of the freeze wall barrier to monitor ground water quality during operation and after reclamation.

Ground water monitoring will consist of monitoring of the water bearing units including the Uinta, A and B Groove, L5, L4 and L3. Compliance monitoring of these zones will occur using dedicated single completions in each zone unless multiple zone completion testing results discussed below provide the basis for using this technology.

Multiple zone completions are being tested for some wells interior to the freeze wall containment at FWT. Multiple completion wells are equipped with isolation packers to prevent crossflow between zones. Sample ports in the tubing string will allow for collection of pressure data and water samples. Should the information gained from the multiple zone completion wells demonstrate this type of completion is appropriate for ground water quality monitoring, then multiple zone completions could be proposed for ground water monitoring at a later date, subject to approval.

Planned ground water monitoring for the 2nd Generation ICP will include one upgradient completion in each unit and downgradient completions in each unit. Additional wells may be installed within the project area for early detection of potential problems.

Facilities Monitoring

Routine visual inspections and operational warning systems will facilitate monitoring of containment systems and features at the 2nd Generation ICP site. These will include the following:

- Piping systems will be pressured tested prior to use. The pipe systems will have pressure monitors to alert operators when a loss of pressure occurs that could be indicative of a potential problem.
- Sumps within concrete containment areas will be visually monitored on a daily basis and any liquids present in these sumps would be pumped to the process water treatment plant or sent off site for disposal at an appropriate facility.
- Storm water management systems would be inspected on a periodic basis as prescribed in the Storm Water Management Plan.
- A Spill Prevention Control and Countermeasure (SPCC) Plan will be developed to address spill prevention and response for petroleum products at the site. The SPCC plan will prescribe inspection types and frequencies for petroleum related vessels and containments.

In addition, an Emergency Response Plan (ERP) will be developed for responding to emergencies at the site while ensuring worker safety. The Plan will include designation of responsible personnel, an outline of procedures to be followed, a list of chemicals to be used or stored on site, a list of materials available to control spills or leaks, and notification requirements.

APPENDIX C

SELECTIONS FROM
PLAN OF OPERATION
E-ICP TEST PROJECT

[[SELECTIONS FROM]]

Plan of Operation

Shell Frontier Oil and Gas Inc.

E-ICP Test Project

Oil Shale Research and Development Project

Prepared for:
Bureau of Land Management

February 15, 2006

4.0 OPERATING PLAN

4.1 General Project Overview and Summary

The E-ICP Project is a research, development, and demonstration project designed to demonstrate the ICP, gather additional operating data and information, and allow testing of components and systems to verify the feasibility of recovering hydrocarbons from oil shale for use in commercial operations. This plan describes the construction, operation, and reclamation of the E-ICP and the supporting facilities. Exhibit I shows a preliminary plot plan.

The oil shale resource for the E-ICP extends from the R-7 through R-2 interval. The ICP is an in situ process using electric heaters to heat the oil shale in place. The heating process pyrolyzes the organic matter in the oil shale and converts this matter into oil and hydrocarbon gas. The oil and gas are then removed from the ground using conventional oil field pumping and extraction technology and processed using conventional oil and gas processing. The recovery is conducted within a contained area to allow recovery of the hydrocarbons while excluding ground water flow through the oil production area. Containment is provided in a freeze wall containment area consisting of a freeze wall system and low permeability barrier above and below the oil shale resource zone. These are described below.

Since the E-ICP project is planned for use in areas below the ground water table, a freeze wall containment area is created to isolate the heated zone from the surrounding ground water. Freezing of the in situ ground water and associated rock matrix creates a containment barrier that prevents migration of fluids into or out of the heated zone area. The freeze wall is constructed by drilling closely spaced holes outside the intended oil shale resource target zone and circulating chilled refrigerant through closed loop piping in each freeze wall hole. Through heat exchange with the surrounding rock matrix, the refrigerant returns to the surface warmer than its inflow temperature and the surrounding rock and associated pore and fracture water is cooled and frozen. This frozen barrier is formed along the entire depth of the freeze hole and continues to grow and thicken until the area between freeze holes is frozen, forming a continuous frozen wall-like barrier that extends through the resource zone and into the impermeable layer at the bottom, thus forming a containment area that confines the heated zone. The freeze wall containment area is maintained through heating and product recovery as well as during ground water reclamation.

Once the freeze wall is established, a series of dewatering holes are drilled to remove the ground water inside the freeze wall containment area prior to heating to allow recovery of the hydrocarbon products. The holes will later be converted to producer holes that will remove the hydrocarbon products. Water from dewatering the freeze wall containment area will be re-injected back into the ground water zones outside the freeze wall into the appropriate water-bearing zones so that classified beneficial uses are maintained. Dewatering and reinjection flow rates will be monitored to allow calculation of the amount of water taken from the freeze wall containment area. Removal of the ground water prior to heating will prevent mixing of the hydrocarbons and ground water. Dewatering will not result in removal of all of the ground water within the containment area as some pore water cannot be removed through pumping during dewatering.

A series of heater holes will also be drilled within the freeze wall containment area. Heaters are installed in these holes to allow heating of the resource interval. The heater holes are placed such that an unheated zone of approximately 125 feet is maintained between the freeze wall barrier and the heated zone so that the freeze wall is not impacted by heating. The heaters raise the temperature of the oil shale and initiate pyrolysis, releasing hydrocarbon products that are then removed using the production holes. A drilling hole schematic is included in Exhibit J.

Products from the pyrolyzed zone are piped to an on-site processing facility, where processing separates the oil, gas, and water. Oil is processed to remove impurities, then shipped off site to existing refineries for refining. Gas from the production holes is also treated and used to supplement energy needs at the site or incinerated as quantities are not sufficient to justify facilities necessary for commercial transportation and sale. Sulfur, produced as a product during processing, is transported off-site as a marketable product. Figure 4.1 shows a simplified diagram describing the steps included in the E-ICP.

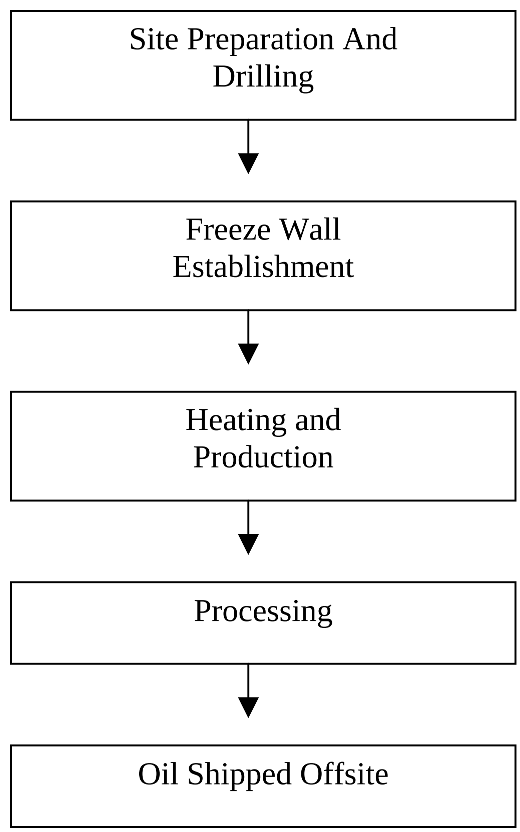


Figure 4.1 Diagram of E-ICP Project

As a part of reclamation, the wells and holes not needed for monitoring are plugged and abandoned in accordance with requirements of the Colorado Office of the State Engineer. Facilities will be demolished and removed and the site will be regraded and revegetated. The paved access road will also be reclaimed, leaving a dirt road access route. The reclamation plan (Section 5) provides details on reclamation of the heated zone and of the site disturbance.

Support facilities include a site access road; construction and drilling support consisting of lay down yards, storage units and office trailers; portable pilot test plants, process control building, change house, utilities, warehouse, shop/ maintenance facilities, laboratory, and other facilities necessary to support the E-ICP Project. Potable water will be trucked to the site and stored for use in the on site potable water system. The following sections contain detailed information on the various process components associated with the E-ICP facility.

4.2 General Site Development and Preparation

Initial construction activities include development of the site access road and fencing of the permit area. The present access to the E-ICP site is from County Road (CR) 5 to CR 24 to CR 24X (see Exhibit C). There are presently three proposed access roads to the site. Based upon input from BLM, one of these roads will be extended to the E-ICP site and expanded to a running width of approximately 24 feet to allow heavy equipment travel in two directions. The access road will be paved with asphalt for the 24-foot width and include appropriate ditches and culverts to maintain drainage control. Soils salvaged during the road construction will be stored in berms located on either side of the road. Figure 4.2 provides additional information on the design of the access road. Access to the E-ICP site from the road will be restricted through an entry gate.

The E-ICP project, excluding the access road, will be fenced with a combination barbed/smooth wire fence with the top wire being smooth. A 12-foot wide fire break will be constructed along the permit boundary fence. Signs reading “Do Not Enter” will be posted at points of logical entrance to the facility, such as roads or trails, to redirect unauthorized personnel. Eight-foot high chain link fencing will be provided around lined ponds (storm water pond, process water pond, and evaporation pond) when these ponds are constructed.

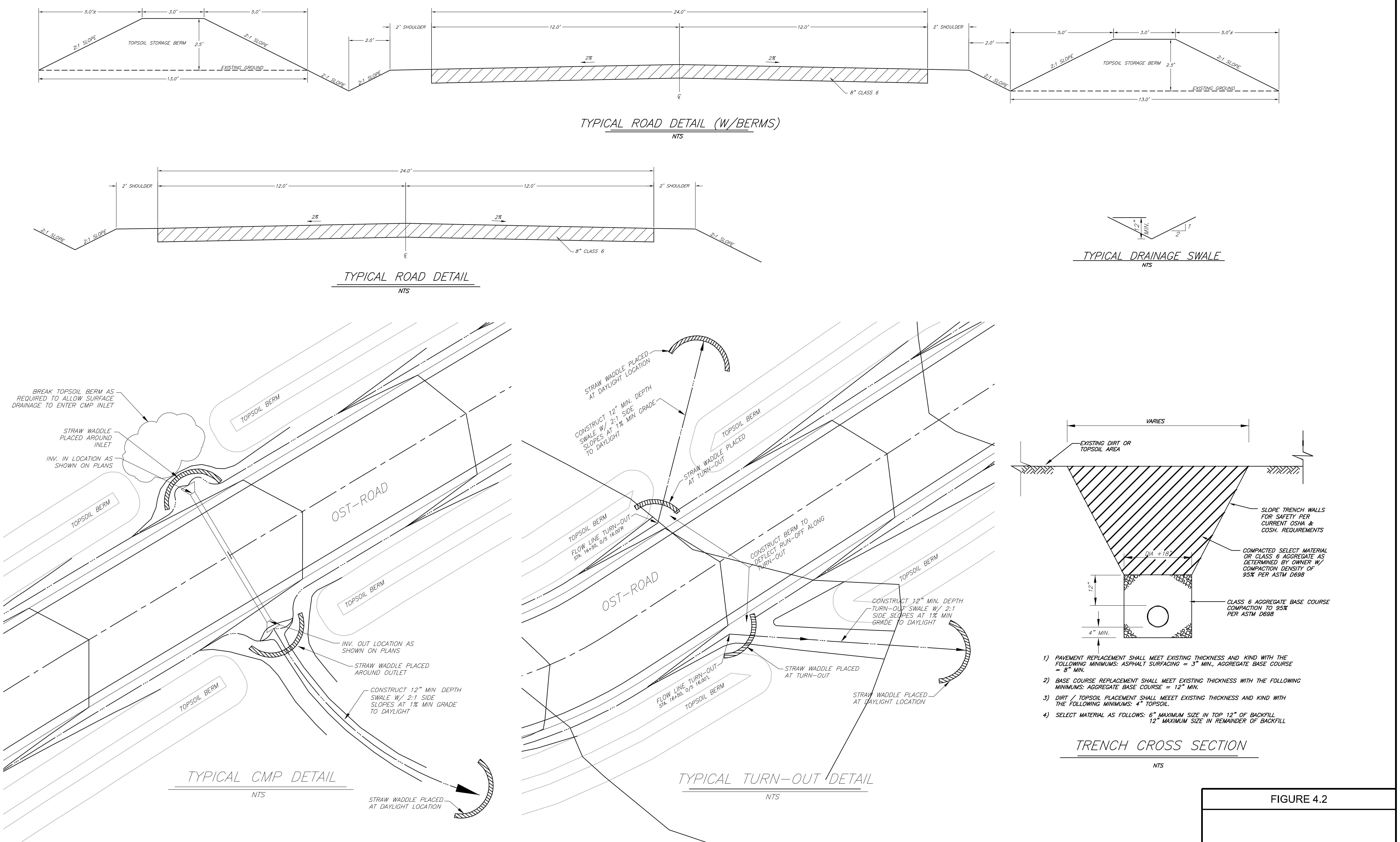


FIGURE 4.2

TYPICAL ACCESS ROAD DESIGN

Drawn By: DD	Date: 02/10/06	FILE: FIG4.2 TYPACCESSROADDESIGN 3235\Task 45\P00 5-2-05\FEB06	SCALE: NTS	SHELL FRONTIER OIL & GAS INC.
Approved By:	Date:			

Surface Drainage Controls

A surface water drainage collection and conveyance system will be established to manage drainage throughout the site. The surface drainage control system along with the site grading will route storm water flows from the disturbed areas into a storm water pond prior to discharge to the existing surface drainage system. The surface drainage system consists of ditches, storm sewers, culverts, curbs, and paving. Ditches will be lined with riprap or other material where necessary to assure stability. A storm water pond will be designed to retain the runoff and sediment from a 50-year, 24-hour storm event (2.5 inches). Exhibit K shows the preliminary drainage control plan.

Construction storm water drainage will be managed through a construction Storm Water Management Plan and the use of accepted Best Management Practices (BMP), in accordance with a construction storm water permit. During construction and operations areas of light disturbance that do not report to the storm water pond will be managed using BMPs. Erosion control measures will include stabilization of exposed soils and protection of steep slopes. Exposed soils will be stabilized by mulching, seeding, soil roughening, or chemical stabilization. Steep slopes will be protected by use of geotextiles, temporary slope drains, mulch, or seeding. Sediment controls may include sediment basins, rock dams, sediment filters such as filter cloth, hay bales, erosion blankets, and/or temporary seeding.

Site Preparation

A detailed site plan, including site grading, will be developed for the site during detailed design. The E-ICP site will be graded to provide working levels for support facilities, production, processing, storage tanks, and shipping. Exhibit I is a preliminary plot plan that shows a general layout for all facilities at E-ICP. A detailed design will optimize the layout.

Engineering for the processing and water treatment systems is being conducted. It is anticipated that these facilities will be similar to what will be used at the OST research project, another Shell R&D project, for which more detailed design is complete. A partial list of equipment anticipated for the site is shown on Table 4.1.

Table 4.1 Equipment List

Air Blowers	Granular Activated Carbon Beds	Scrapers
Ammonia Circulation Pumps	H_2S Stripper	Separator
Ammonia Stripper Accumulator	H_2S Stripper Accumulator	Skimmings Concentrator
Ammonia Stripper Condensers	H_2S Stripper Condenser	Slop Oil Equalization Tank And Pumps
Ammonia Strippers	H_2S Stripper Inlet Preheat	Slops Pumps
Backhoes	High Pressure Nitrogen Storage Package	Solids Separation Clarifier
Backwash Water Pumps	Influent Transfer Pumps	Solvent Stripper
Bio-Solids Blower	Instrument Air Package	Sour Water Stripper Cooler
Bio-Solids Pump	Lean Sulfinol Heaters	Spent Carbon Feed Tanks
Biotreater Feed Cooler	Lo-Cat Absorber	SRC Pumps
Biotreater Pumps	Lo-Cat Oxidizer Vessel	Stabilizer Reboilers
Boiler Packages	Lo-Cat Slurry Centrifuge	Stand-By Generator
Bulldozers	Lo-Cat Solution Recirculation Tank	Stripper Effluent Coolers
Carbon Regeneration Furnace	MDEA Carbon Beds	Stripper Feed Pumps
Clarifier Sludge Transfer Pumps	MDEA Cooler	Sulfinol Pumps
Coalescing Filter	MDEA Exchangers	Sulfinol Reboilers
Combustion Products Accumulator	MDEA Pumps	Sulfur Pit
Combustion Products Condenser	Membrane Bio-Reactor Unit	Sulfur Product Tank
Concrete Trucks	Nitrogen Storage And Vaporizer	Sulfur Recovery Unit Reaction Furnace
Condensate Pots	NO2 Gas Absorber	Sulfur Seal Pots
Condensate Pumps	NO2 Gas Compressor	Sulfur Slurry Pumps
Converter Heaters	NO2 Gas Condenser	Sump Pumps
Converters	NO2 Gas Recycle Pumps	Supply Trucks
Deaerator Packages	Oil/Water Separators	SWS Overhead Accumulator
Deep Bed Nutshell Filters	Product Pumps	SWS Pumps
Discharge Coolers	Product Tanks	SWS Reboilers
Dissolved Air Flotation Unit	Quench Tank	SWS Strainers
Drills	Quench Water System	Thickener And Pumps
Equalization Tanks And Pumps	Recirculation Pumps	Utility Vehicles
Filter Press	Refrigeration Units	Vapor Catalytic Combustor
Flare Knock Out Pumps	Regenerated Carbon Storage Tanks	Virgin Carbon Make-Up Silo
Flare Package	Reverse Osmosis Unit	Water Heaters
Fuel Trucks	Sanitary Septic System	Water Pumps
Gas Burners	Scot Cargon Filters	Water Storage Tanks
Gas Compresors	Scot Pumps	Water Trucks

Gas Heaters	Scot Reflux Accumulator	Wet Well/Surge Tank
Glycol Chillers	Scot Regenerator	

Prior to site preparation, the boundaries of the 160-acre site lease will be marked. The storm water pond will be constructed, clean water diversion ditches installed, and BMPs will be implemented. Larger trees will be cut and made available for firewood through a commercial operator. Stumps will be disposed of by burning on site (with the appropriate burn permits) or by hauling off site. Stumps may also be buried on site. Remaining vegetation will be cut and chipped with chips left on the ground to be incorporated into the salvaged soil. Approximately 12 inches of soil will be segregated, removed and deposited in soil storage areas. In areas where 12 inches of soil is not available for salvage, reasonable available soil material will be removed, with a targeted minimum of six inches removed in any location, where available. This material may not all be soil by strict definition, but will support vegetation and hence be suitable for plant growth medium. The soil stockpiles will be seeded with the BLM approved grass seed mix to minimize erosion and associated loss of soil (Section 5.0). Soil stockpiles will also be covered with an erosion control netting to further minimize erosion and promote growth.

4.3 In-situ Conversion Process

Ground freezing as a means of containment was introduced in the 1800s to temporarily strengthen soils and serve as a barrier to ground water flow. Ground freezing continues to be applied in civil and geotechnical engineering to exclude water from areas being excavated; to seal tunnels, mine shafts, or other subsurface structures against flooding from ground water; and to enclose and/or consolidate hazardous or radioactive contaminants during remediation or reclamation operations. The containment system for the E-ICP will consist of a series of drill holes in a close pattern (Exhibit J). Refrigerant will be circulated through the holes in a closed circuit to create a barrier of frozen water in a rock matrix.

The construction of the freeze wall containment area for the E-ICP will allow heating of oil shale to recover products while preventing mixing of products with the ground water system. A freeze wall will be established for the depth of the freeze holes and will encircle the resource target zone creating an enclosed freeze wall containment area. The resource target zone is a carefully selected portion of the oil shale resource. The top and bottom of the resource target zone are low permeability layers that will prevent movement of converted hydrocarbons in a vertical direction. The freeze wall containment area provides lateral containment. The freeze wall will act to prevent liquid movement into or out of the containment area, separating the ground water system from the ICP products. The freeze wall containment area will be maintained and monitored throughout the heating, recovery, and the ground water reclamation phases of the operation. Since the freeze wall will take an extended period of time to thaw, the freeze wall refrigerant circulation may be stopped prior to final flushing if it can be demonstrated that the containment area is sufficiently rinsed and collected rinse water meets appropriate quality.

Freeze Wall Construction

Upon completion of site preparation, about 150-200 freeze holes will be drilled approximately 8 feet apart. These freeze holes will be drilled to a depth of approximately 2,000 feet or the depth of the entire target interval. The configuration of a typical freeze hole is shown on Figure 4.3. Both air-mist fluid drilling and aerated fluid drilling methods are under consideration and are being tested at this time. The air-mist method produces greater volumes of water compared to the aerated fluid method. Drilling methods will be selected based on field conditions and technology. Drilling fluids and additives that may be used are shown in Table 4.2.

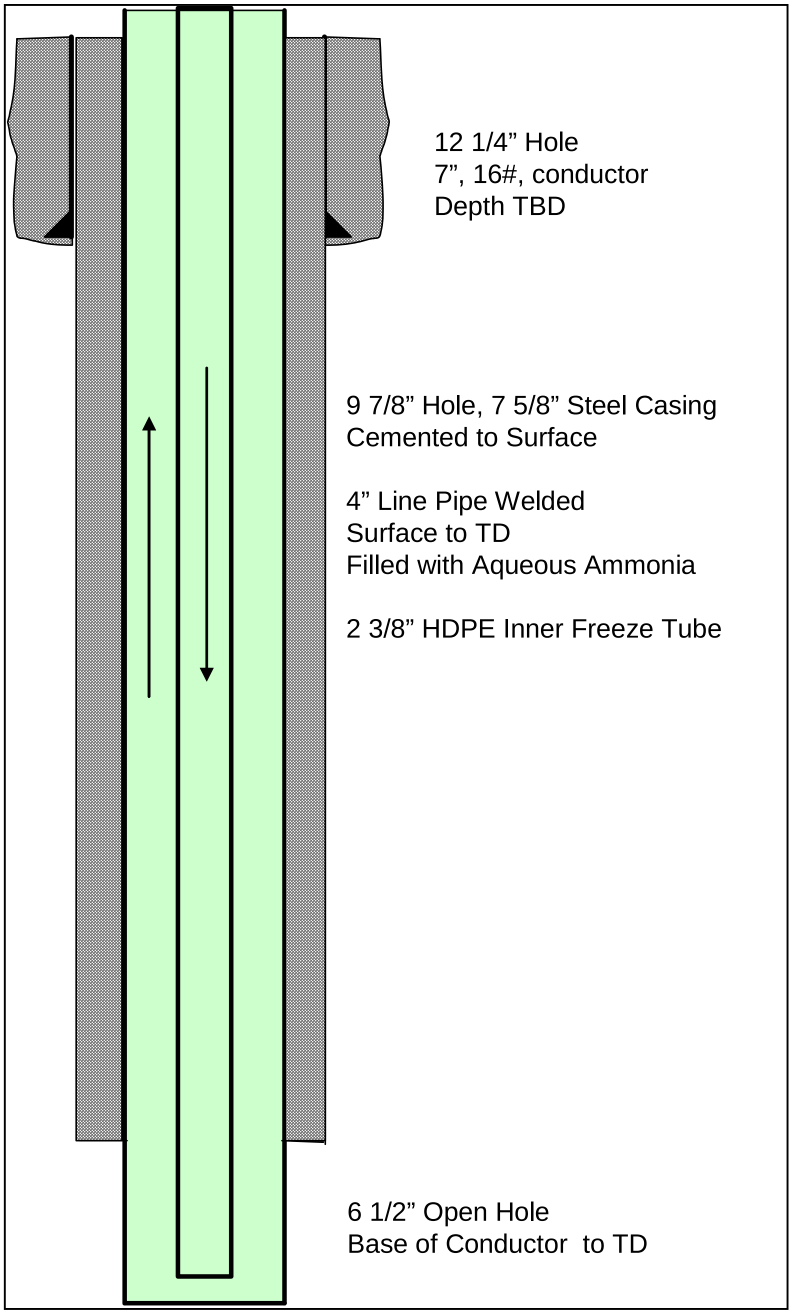


Figure 4.3 Typical Freeze Hole

Table 4.2 Inventory of Drilling Fluid Additives for Use by Shell and its Contractors

Coring and Drilling Projects
Foamers
Baroid Quik-Foam
Bachman 485
Weatherford WFT FM A-100
Gels and Polymers
Baroid EZ-Mud - polymer
Halliburton Quik-Gel – bentonite gel
Halliburton Mud-Gel – bentonite gel
Baroid Quik-Trol and Quik-Trol LV - polymer
Benseal– for plugging back holes and hole abandonment
Baroid Holeplug – for plugging back holes and hole abandonment
Thread Compounds
Jet Lube Well Guard
MacDermid – Vinoleo thread compound for fiberglass casing
Best-O-Life Silicone GGT
Best-O-Life 72733 high temperature high pressure thread compound – not used in water wells or monitor holes.
Lub-O-Seal NM-91 anti-seize
Corrosion Inhibitors
Weatherford Corrfoam
Others
Rock Drill Oil R.D.O. ES
Sodium bicarbonate –pH neutralizer
Mazola Corn Oil – to free stuck pipe
Ventura Ultra-Fry (Canola Oil) – to free stuck pipe
Huskey LVI-50 Rod Grease – lubricate drill rods in dry hole

To complete the freeze hole and provide refrigeration for the length of the hole, an interior steel freeze tube will be installed. The bottom of the steel tube will be sealed with an end cap. A smaller diameter high-density polyethylene (HDPE) inner freeze tube will be installed inside of the steel freeze tube. It is expected to take about six months to complete the drilling for the freeze wall pattern.

Once the drilling is completed, refrigerant at an approximate temperature of -45º F is pumped through the holes. The interior HPDE tube will be used to convey the chilled aqua ammonia to the bottom of the hole and the outer steel pipe allows the solution to return to the surface for recycling back to the refrigeration system (Figure 4.3).

The area immediately surrounding the holes is frozen first. The frozen area continues to expand as refrigerant is re-circulated down each hole. Eventually the frozen "columns" expand to the point where the approximately concentric frozen "columns" are joined and a freeze wall barrier is created as shown in Figure 4.4.

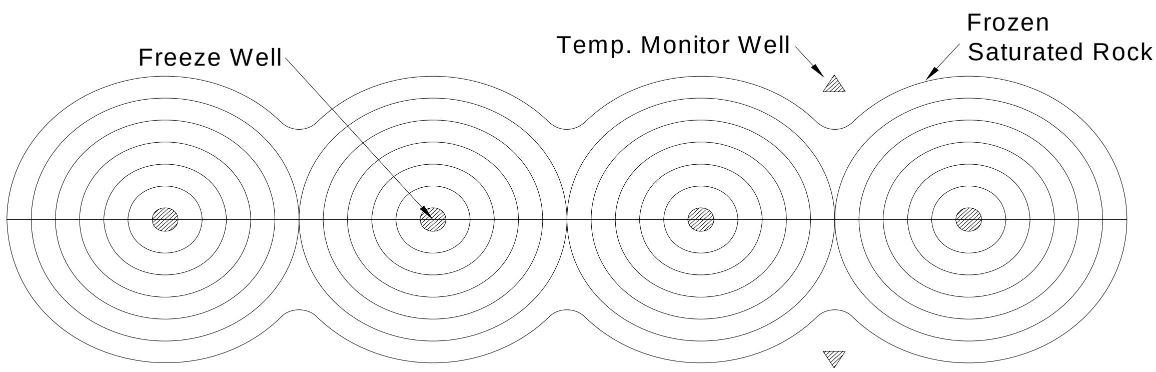


Figure 4.4 Freeze Well

It is anticipated to take approximately 12 to 18 months to establish a continuous freeze wall barrier.

As the circulation of refrigerant continues, the thickness of the freeze wall will continue to grow, although the rate of growth will slow as the wall thickens. Heating in the interior of the containment zone will inhibit inward growth of the freeze wall barrier.

Once the freeze wall is in place, there will be little change in the temperature of the wall throughout the thickness because of the insulating capacity of the rock matrix. In addition, the system can withstand power outages without damaging the integrity of the freeze wall due to the temperature and thickness.

Between the freeze wall and the heated area is a buffer zone about 125 ft wide that prevents the freezing and heating form interfering with each other. The exact width of the buffer depends on the thermal conductivity of the rock and the time required to heat the patterns. The oil shale has a fairly low thermal conductivity, which keeps the buffer to a manageable size and contributes to uniform, steady heating.

The freeze wall containment area will be maintained until it can be demonstrated that the containment system is sufficiently rinsed and collected rinse water meets appropriate quality. The period of time for operation of the freeze wall containment area is currently estimated to be approximately ten to eleven years.

Refrigeration System

As the freeze holes are being drilled and completed, the refrigeration system will be constructed. The refrigeration system will be installed before other process equipment due to the length of time required to establish the freeze wall containment barrier. The plant will contain several refrigeration units, which can each be operated separately.

Appropriate procedures for storage, handling and emergency response for ammonia chemicals used in the refrigeration system will be included in the Process Safety Management Manual to be developed in accordance with Occupational Safety and Health Administration regulations prior to operation. Emergency response procedures including procedures for clean-up of spills and notification requirements will be included in the Emergency Response Plan (ERP) to be developed prior to operations.

Dewatering Within the Freeze Wall Containment Area

Once the freeze wall has been established, drilling will occur inside the freeze wall containment area for both producer wells and heater holes. The functions of these are discussed in later sections of this Operating Plan. Some of the producer holes will initially serve as ground water dewatering holes and their function as dewatering holes is discussed in this section.

There will be several producer holes used for dewatering inside the freeze wall containment area. Figure 4.8 shows the configuration of these holes. A submersible pump is used for dewatering.

Ground water removed from inside the freeze wall containment area prior to heating will be injected into wells located down gradient, and outside the freeze wall or used in the process. This will be accomplished through an above ground piping network that allows this water to be directed from dewatering holes to injection wells. Figure 4.5 shows a typical injection well.

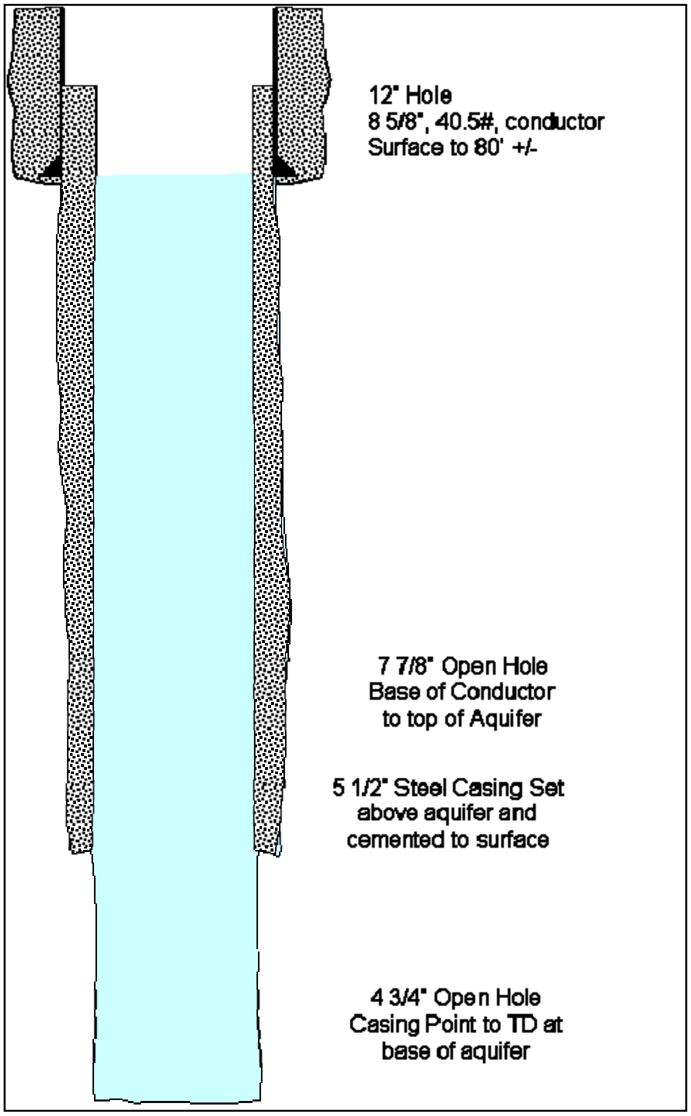


Figure 4.5 Typical Injection Well

Two to four injection wells will be installed outside of the freeze wall as shown on Exhibit J; one upper strata and one lower strata. The dewatering phase is expected to last approximately 4 months, but actual time will be determined by dewatering efficiency.

Once the ability to pump water slows to the point that dewatering is no longer economical or feasible, dewatering operations will cease. During dewatering, the water being re-injected will be monitored periodically for water quality prior to re-injection to ensure that the water is being re-injected into the appropriate strata and that existing classified beneficial uses are not diminished. Dewatering and re-injection flow rates will also be monitored to allow calculation of the amount of water taken from the containment zone and associated rate of re-injection.

Heater System

The R&D project will include about 70 to 100 vertical heaters spaced 20 ft to 40 ft apart. The bare electrode heaters for the proposed location are about 1,950 ft long and are designed to concentrate most of their heat output in the bottom 1,000 ft.

Figure 4.6 shows the cross sectional view of the bare electrode heaters used in E-ICP. The bare electrode heaters will be located in three adjacent wells spaced about 20 - 40 ft apart in the target zone and electrically connected together at the bottom below the target zone. The three electrode wells are electrically configured as a three-phase Wye circuit, with the neutral connection at the bottom connection end. This forms a three-electrode “triad”.

The E-ICP bare electrode heater has three sections: an overburden section, a target zone, and a contact section.

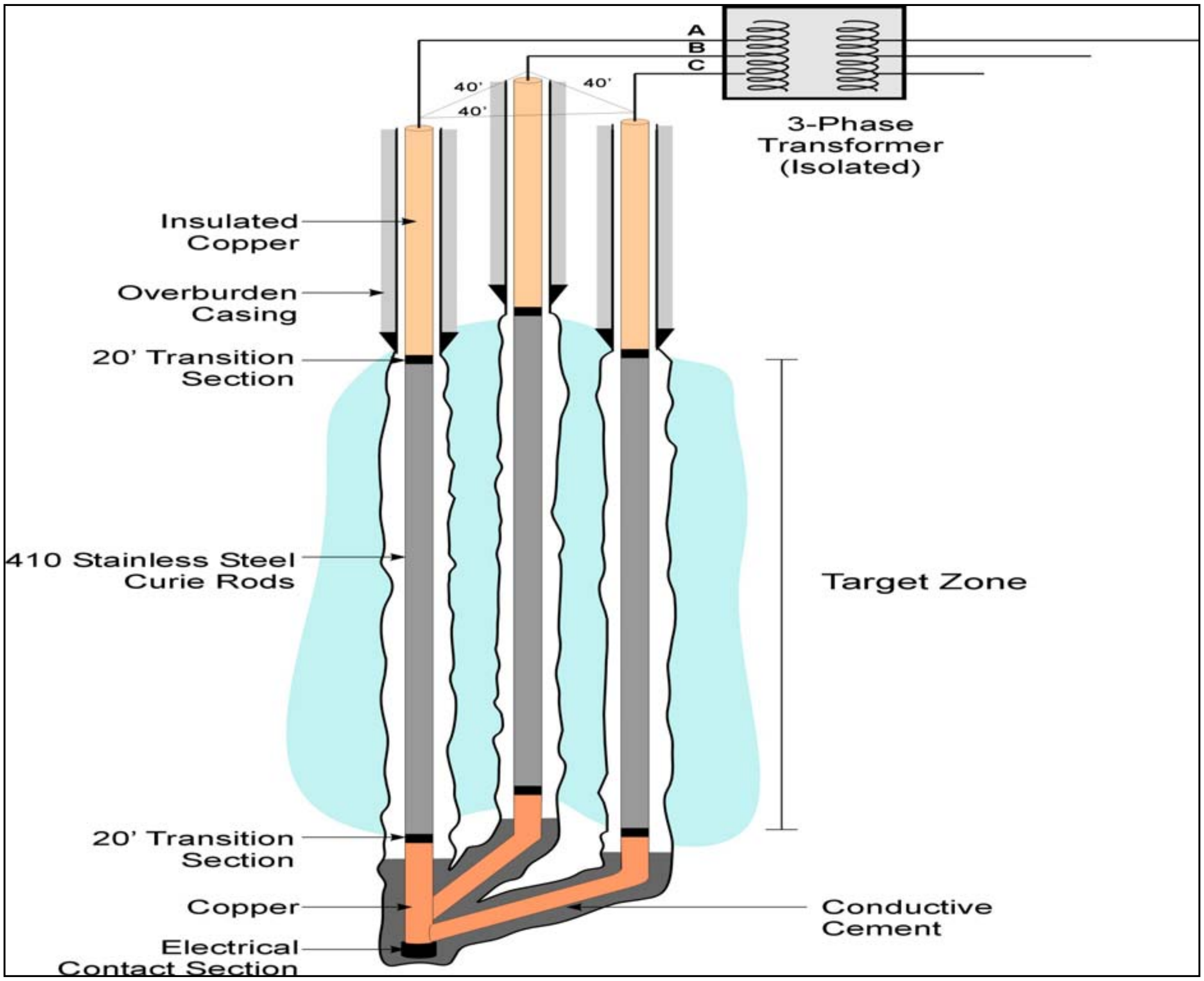


Figure 4.6 Typical Bare Electrode Heater Triad

The well is cased and cemented conventionally in the overburden. The electrode is insulated in the overburden section and consists of a copper rod with polymer insulation to prevent shorting to the casing.

A 6.5 inch hole is drilled in the target section. In the target zone, R-7 through R-2, the bare electrode heater will consist of a 410 SS rod of 1.5 inch diameter. The 410 SS alloy is preferred because of its high Curie temperature (1340 °F), low cost (12% Cr, 0% Ni), resistance to high temperature sulfidation (~20 mils/yr at 1300 °F), low galvanic corrosion, and high temperature creep strength.

At the top and bottom of the heated section are short thermal transition sections (~20 ft) of 347H SS clad copper. These transition sections provide the separation between the high temperature section and the upper and lower copper sections.

The lower intercept section is made from copper rod. The contactor section at the bottom is constructed from copper clad steel.

The three electrode wells in a triad are directionally drilled vertically until the bottom of the target zone. The first well is drilled straight and vertical. The two other wells are directionally drilled straight and parallel to the first well through the target section at a 20 ft to 40 ft separation. Below the target section the second and third wells are deviated by directional drilling to intercept the first well at the bottom.

Figure 4.7 is a sketch of the areal layout of the three (A, B, and C) electrical phases. At the surface, each triad of heaters is connected to an isolated three-phase transformer. Each triad has its own isolated three-phase transformer so there are no conductive paths between the isolated circuits and the rest of the triads or the electrical grid – therefore it is physically impossible for currents to flow to distant electrical sinks. This electrical configuration alone is a substantial cost savings relative to the isolated single phase transformers used for pipe in pepe heaters in conventional ICP (savings of approximately one billion dollars in upfront capital).

In E-ICP, the oil shale behaves as an ohmic resistive element until the formation water has been evaporated. Ohmic heating occurs in the volume between the electrode heater wells and is in addition to thermal conduction heating from the electrode heater wells themselves. Once the water in the oil shale is evaporated, the oil shale becomes highly electrically insulating and the electrical heating is then confined to the wellbore. The bare electrode heater then behaves as a simple thermal conduction heater as in conventional ICP.

E-ICP is not practical unless the bare electrode heater has self-regulating Curie properties that prevent overheating near the top of the target zone, where the voltage is the highest and maximum current leakage occurs. The Curie effect also prevents overheating opposite the rich oil shale layers that have the lowest thermal conductivities. Self-regulation can be achieved by using 410 SS for the bare electrode heater. Because of its ferromagnetic properties, 410 SS behaves as a self-regulating Curie heater (T Curie = 1330 $^{\circ}$F) when energized with alternating current. Other Curie metals and Curie metal composites are possible, but 410 SS is preferred because it meets all the constraints (Curie temperature, corrosion resistance, creep strength) at the minimum cost.

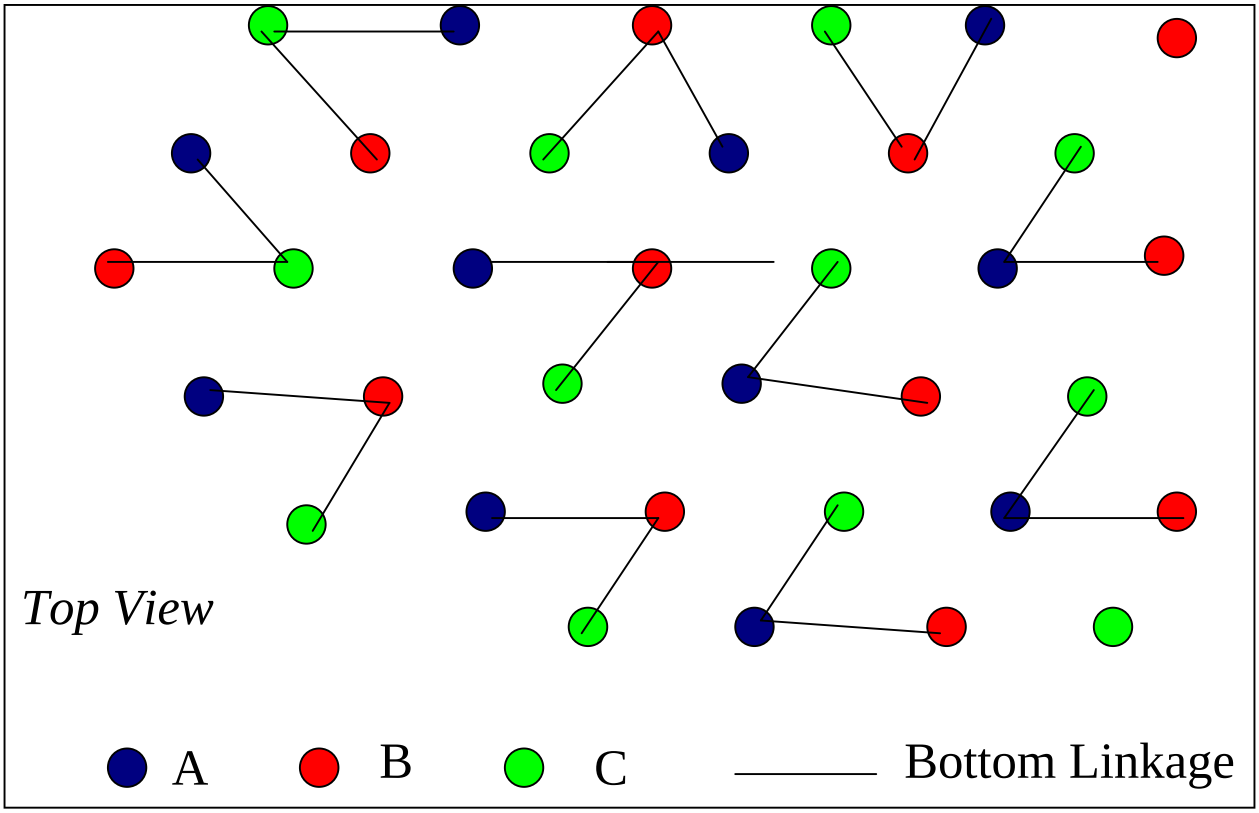


Figure 4.7 Areal Layout of Bare Electrode Heater Triads

The dramatic cost savings of E-ICP is achieved because the bare electrode heater is a simple rod of 410 SS that costs considerably less than a Curie PIP heater. This results in a significant capital savings over the 35-year ICP project lifetime. The E-ICP potentially lowers the heater well capital costs. It therefore may enable economical recovery of hydrocarbons in lower richness oil shale, thus greatly increasing the US oil shale target resource by making much more of the Piceance basin commercially attractive. Shell cost estimates suggest an additional 175 billion barrels of oil shale with richness down to 20 gal/ton would become economically attractive at $25-$30/bbl if E-ICP were successful. This 2nd-generation E-ICP heater technology has never been deployed in oil shale, but laboratory data and numerical simulations suggest it has a good probability of being successful.

All the heaters will be installed and energized at about the same time. Heat is injected by thermal conduction only – no steam or heat transfer fluids are injected into the oil shale. The superposition of heat from the array of heaters causes the average reservoir temperature to rise quite uniformly, except within a few feet of the heater holes. Because the process relies on relatively slow thermal conduction, and because the thermal conductivity of oil shale varies by only about a factor of two to three from the richest to the leanest layers, ICP uniformly distributes heat in the target deposit. This results in uniform pyrolysis and high thermal sweep efficiency.

The heaters have to operate between a certain temperature range to achieve heating rates that bring the average reservoir temperature to approximately 600 ºF in approximately four years. The high operating temperature, formation stresses, corrosive gas environment, and long heating duration are severe requirements that have resulted in the development of a new effective heater. Shell continues to work on and improve heater design.

Shell's numerical simulations show that E-ICP will proceed very similarly to the ICP process with self-contained heater wells. At the start, ohmic heating occurs in the oil shale before the free water is vaporized. Water boils first in the near-electrode region and proceeds from the top downwards. After water vaporizes throughout the near-electrode region, electric current flow is confined to the near wellbore and the bare electrode heaters then behave as thermal conduction heaters until pyrolization occurs. The top section of the electrode heater reaches Curie self-regulating temperatures first because of the lower porosities and the absence of dawsonite in the top section. The Curie properties of the electrode heater prevent overheating in the upper section of the formation.

Heating results in expansion of the rock. The rocks have differing thermal conductivities, with the leaner oil shale having greater conductivity than the kerogen-rich oil shale. The design of the heated zone accounts for these conductivities to ensure a sufficient buffer distance to the freeze wall to prevent unacceptable input of heat to the freeze wall. This is a function of the amount of heat put into the system, the conductivity of the rock, the time that the heaters are energized and the distance between the heaters and the freeze wall.

Due to the heating associated with production, heave and subsidence can occur at the surface and compaction can occur within the reservoir. Based upon the small production footprint and the depth of heating, little surface expression of changes within the pyrolyzed zone is anticipated. The surface expressions of heave is expected to be approximately 1.0-1.5 inch and the surface expression of subsidence is expected to be approximately 0.5 – 1.0 inch.

Product Recovery

Upon completion of dewatering, pumps are removed from the dewatering holes and they are converted to producer wells. As heating occurs, the lighter and higher quality vaporized hydrocarbon products, plus steam and non-condensable gases, will flow to the producer holes. Because of the slow heating rate, and the close spacing between holes, the initial reservoir permeability required for fluid transport can be relatively low. There is no need to create permeability by hydraulic or explosive fracturing. The producer wells will collect the converted kerogen products (oil and gas mixed with some water) in the pyrolyzed zone and convey those products to the surface for transport to the processing facilities.

Producer wells will collect the gas and oil produced by the ICP. Initially the producer wells will be used to dewater the freeze wall containment area.

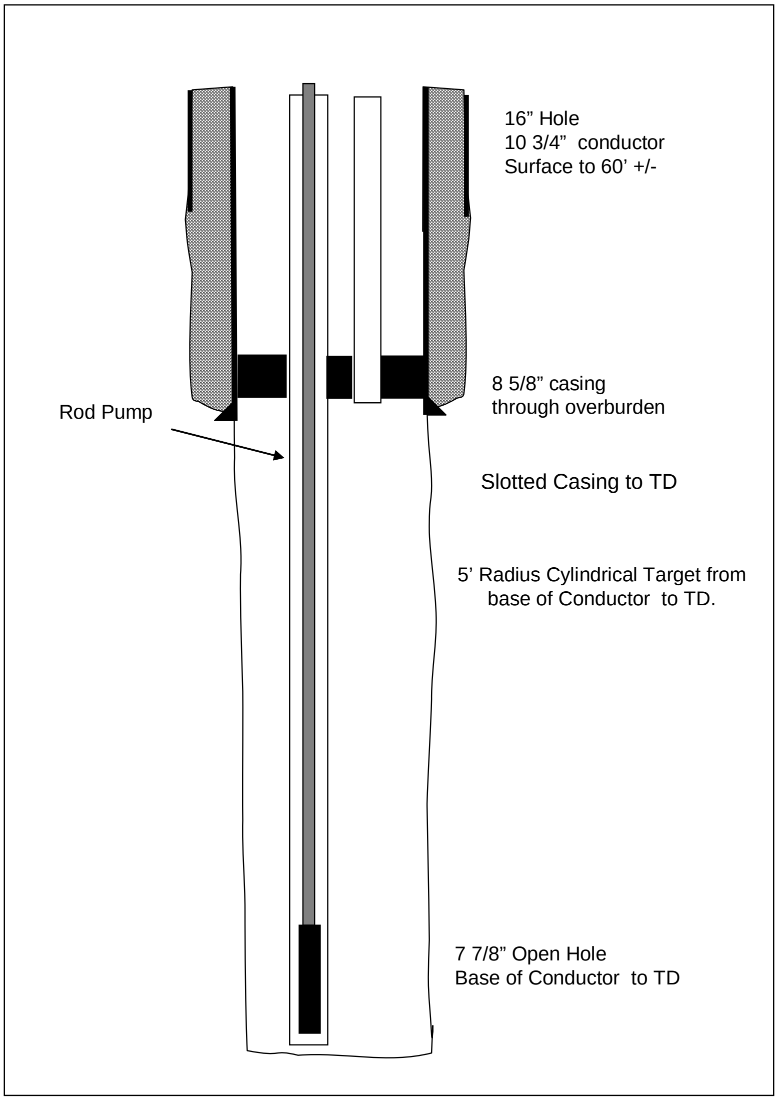


Figure 4.8 Typical Producer Hole

Producer holes are similar in design to traditional oil field wells. They have a perforated liner that allows liquids and gases to flow from the nearby rock into the holes. From there the fluids are pumped to the surface and gathered. Producer holes are installed among the heaters on a ratio of about 5-7 heaters per producer. This R&D project has about 20 producers, which are approximately 1,950 ft deep (Figure 4.8).

A pump with lift assist is used to bring the liquids to the surface. Such lift systems are used on conventional oil and gas production. Standard oil and gas production lift systems, as well as some experimental lift systems, will be used. This will enable operating personnel to determine the best system for use in future operations.

At the start of the heating cycle, cutter stock (purchased diesel or jet fuel) is injected into the inlet of the down-hole production pumps to prevent plugging from bitumen which is produced when the pyrolyzed zone is relatively cool. The cutter stock may also be circulated in the above ground field collection piping to prevent plugging. Both the cutter stock and the treated gas used in the chamber lift system will be recovered and treated in the processing system.

In general, the down hole heating process will be sufficient for release of the hydrocarbons from the kerogen, and movement toward the producer holes. At later stages of production, the hydrocarbons released from the kerogen may be removed with the assistance of water injection holes. These water injection holes will be located inside the freeze wall containment area, but outside the heated pattern. These holes will be used to inject water into the pyrolyzed zone. The intent is to assist in collecting and pumping fluid from the producer holes, while protecting the freeze wall. The recovered fluid (a mixture of water and hydrocarbons) will be collected for further processing.

The temperature of product from the producer holes will be approximately 400 °F. The product is quenched to cool the material for transport to the processing facility. Quench water brought to the well head is mixed with the heated product coming from the producer hole. This results in a mixture of water and hydrocarbon. The mixture is piped to the processing facility at about 250°F.

Oil and gas production is approximately 600 barrels of oil or 1,500 barrels of oil equivalent (oil and gas) per day at full production for the E-ICP.

When production is completed, producer holes will revert back to water collection holes during the cooling and water reclamation phase of the project. The collection system will be used to capture and transport water to the water reclamation plant.

Field Collection Network

The field collection network will consist of headers and piping to collect oil and gas from the producer holes for transport to the processing facility. Figure 4.9 is a photograph of a typical production field piping network. The piping network at the E-ICP site is expected to look similar to that shown in this photograph. Power is distributed throughout the surface of the production zone.

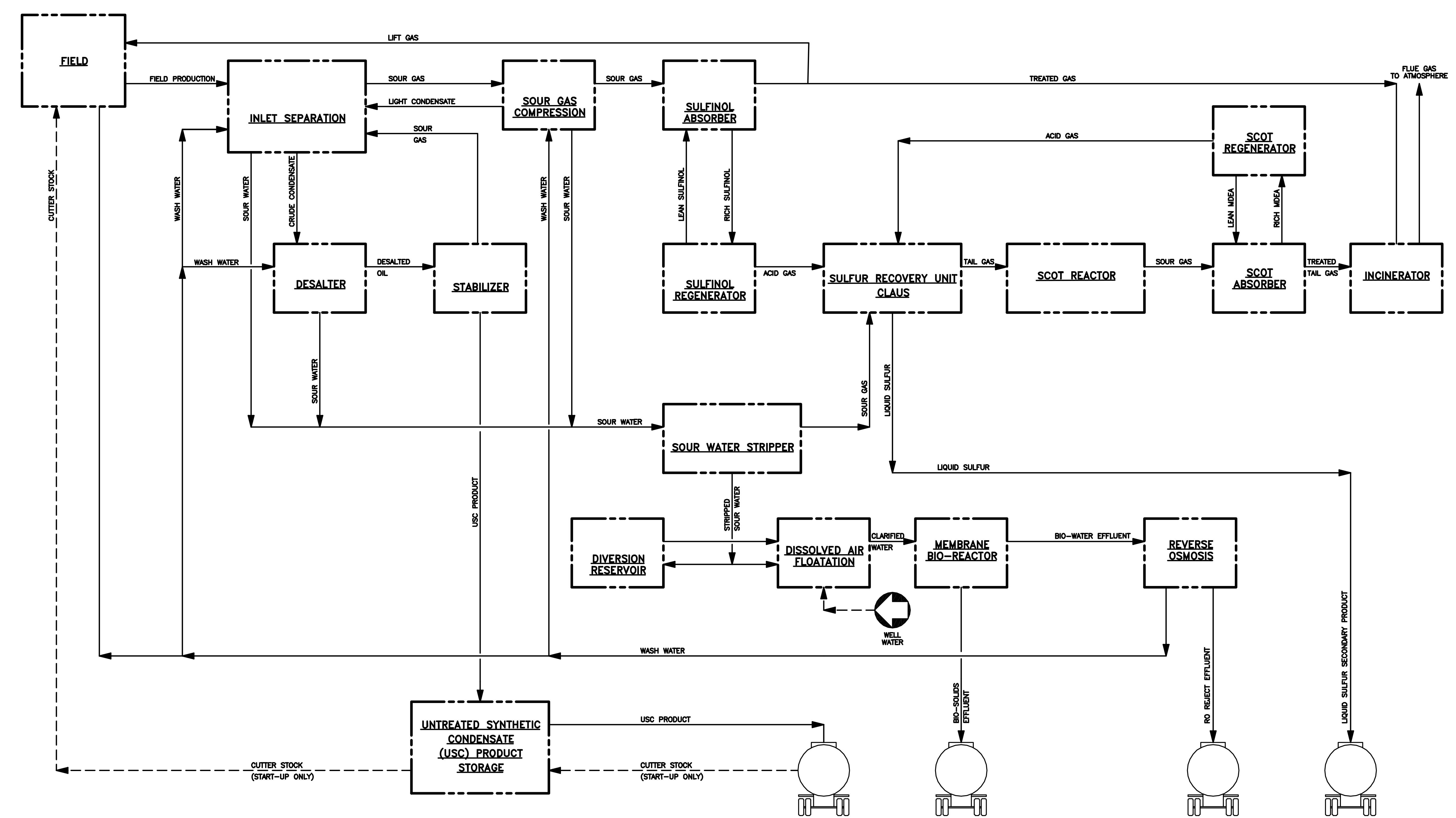
Figure 4.9 Photograph of Field Piping Network

The above ground collection system will operate under a nominal pressure of 60 psi. Pressure is monitored with instrumentation throughout the system, with readouts in the process control room. Visual inspections of the above ground piping network will be made on a regular basis. If there is a drop in pressure in the collection system indicative of a potential leak or break, that portion of the system can be shutoff until repairs are made. Surges in pressure will be relieved by a pressure release valve. Appropriate procedures for storage, handling and emergency response for the product recovery system will be included in Materials Handling and Waste Management Plan or the ERP to be developed for the site.

Processing System

The recovered product will include a mixture of liquid hydrocarbons, gas, and water that will be processed further to remove impurities and ready the products for transport off site or reuse in the recovery process. The recovery process is a typical process used in the oil and gas industry. The processing system location is shown on Exhibit I with a more detailed, process block flow diagram shown on Figure 4.10.

The initial processing will separate the recovered product into three streams: liquid hydrocarbons, sour gas, and sour water. The term sour refers to the presence of sulfur compounds and carbon dioxide. Once the three streams have been separated, each stream is further processed to remove impurities. Except as noted in the following discussions, the waste streams generated during much of the processing are recycled back into the processing for further treating.



Drawn By: KW	Date: 12/15/05 NW
Approved By:	Date:

FIGURE 4.10

PROCESSING BLOCK FLOW DIAGRAM
E-ICP Project

FILE: Fig4.10 ProcessingBlockDiagram
3235\Task 45\112(d)\OST OP\Final Figures

SHELL FRONTIER OIL & GAS INC.

Liquid Hydrocarbons

The liquid hydrocarbons go through a two-step process to remove additional water and gas and create the liquid hydrocarbon product. The first step in the process will involve removal of salt in the hydrocarbons through a desalting process. The hydrocarbon product is mixed with water and the salt is dissolved. The oil and water mixture is then separated using large electro-charged plates. The salty water is pulled to the bottom and the cleaned oil floats on top. The salty water is then sent for water treatment along with the sour water and the oil moves on to the next step.

The second step involves stabilizing the hydrocarbon product for transport through a distillation process. The distillation process separates the lighter gaseous and water fractions from the heavier liquid fractions and lowers the vapor pressure in the heavier fractions to that allowed for storage and transport. The liquid and gaseous streams are returned to the processing system for further processing.

The liquid hydrocarbon product is then sent to storage tanks. The product, known as Untreated Synthetic Condensate (USC) will be stored in tanks located as shown on Exhibit I prior to transport off site. The tanks will be located within a containment area with curbing to contain any spills. Any spills will be collected and sent back to the processing system.

USC will be shipped off site for further processing. The tank loading area is a concrete area with curbed containment. Any spills will be collected and sent back to the processing system. The truck loading area will be equipped with heat sensors that control a foam system for fire suppression, if needed.

Gas Stream

The gas stream separated from the hydrocarbon product is treated through a multi-step process to remove sulfur and any remaining hydrocarbons and water. Hydrocarbons and water removed during the gas stream processing are returned to the hydrocarbon or sour water processing streams.

The gas is first compressed and cooled. Any condensed sour water and hydrocarbons are collected and sent back for further processing. The gas is then passed through columns and contacted with an amine-based solution that will absorb organic sulfur compounds, carbon dioxide, and acids. The treated gas collected after passing through the columns is then sent to the chamber lift system for use in product recovery, or used to supplement site fuel needs, or is incinerated. The solution is further processed to remove the high sulfur content gas and carbon dioxide and is then recycled back for reuse. The acid gas from the solution is sent to a conventional Claus sulfur recovery unit where it is converted to liquid sulfur. Gas which does not get converted to liquid sulfur in the sulfur recovery unit undergoes further treatment in a conventional SCOT (Shell Claus Offgas Treating) unit to remove the bulk of the remaining sulfur compounds. Methyl diethanolamine (MDEA) is used to strip the organic sulfur in this processing segment and then the MDEA is regenerated for reuse.

The sour gas processing employs the use of Sulfinol M, a proprietary solution containing MDEA, Sulfolane, and water. The MDEA and Sulfolane will be stored in tanks located within the processing system area (see Exhibit I for the processing area location). The Sulfolane and MDEA will be trucked to the site and unloaded into the tanks. Both the Sulfolane and MDEA are recycled for reuse in the process so large quantities are not required to be shipped to the site on a regular basis.

The gas processing results in products that include treated gas and liquid sulfur. The liquid sulfur will be stored in an enclosed concrete vault. The concrete vault will include steam coils in the bottom to maintain the sulfur as a liquid until shipped offsite. The tanker will be loaded in a curbed, concrete loadout area adjacent to the processing facility and concrete vault. Any spills will be collected and returned to the processing facility.

The treated gas will be incinerated on site, or used to supplement natural gas requirements used in processing. An incinerator was chosen to control the burn temperature to reduce the carbon monoxide and NO_x emissions. The incinerator operates at a temperature of approximately 1500° F. The exhaust gas from the incinerator is composed mainly of nitrogen, carbon dioxide, and water vapor. It also contains smaller amounts of nitrogen oxides, sulfur oxides, and carbon monoxide. A permit will be obtained from the Colorado Air Pollution Control Division for the incinerator exhaust gas.

As in other conventional treatment facilities for oil and gas, over pressure protection systems are provided as a safety feature. These safety systems provide pressure relief through a piping system that terminates at a lighted flare. The flare combusts any hydrocarbon in the relief stream to prevent the undesirable accumulation of combustible vapor. The flare location is shown on Exhibit I. The flare will not be routinely used, but is for emergency pressure release.

<u>Water Stream</u>

The sour water stream is run through a multi-step process to improve the water quality for reuse or discharge. The first step is a distillation process that removes ammonia, hydrogen sulfide gas, and light hydrocarbons. The vapor is sent for further treating in the gas stream segment of the processing system. The water is sent to a flotation cell and compressed air is used to generate gas bubbles that carry hydrocarbons and solids to the surface of the water in a froth layer that is then skimmed off. The froth layer is stored in a tank for eventual shipment from the site. The water continues to the next step of processing which is the membrane bio-reactor. The membrane bio-reactor uses bacteria, protozoa, and rotifers to remove organic material and convert this matter to biomass and other byproducts such as carbon dioxide, nitrogen gas and sulfates. Excess biosolids are collected and stored in a 214,000 gallon tank for shipment offsite. The water then goes through a reverse osmosis process to remove dissolved salts and other ions. Reject water from the reverse osmosis is directed into a tank for storage and transport offsite. Clean water is recycled back for use in the as quench water or in the processing facility.

The only additions for the water processing are compressed air and the bacteria, protozoa and rotifers. Tanks for storage of waste streams from the water treatment (air flotation solids, excess biosolids, and reject water from the reverse osmosis) will be located within concrete lined and curbed containment. The loadout area will be located north of the storm water pond as shown on Exhibit I and will also be a concrete lined and contained area. Any spilled materials will be sent back to one of these storage tanks.

The purified water stream is recycled for use as boiler feed water, washes for condenser units and as temperature regulating quench water. Any water not needed for the project will be discharged to the Yellow Creek drainage following treatment to the applicable standards. A Colorado Discharge Permit System permit will be obtained from the Colorado Water Quality Control Division for this discharge.

Processing System Pilot Scale Test Skids

Small “slipstream” volumes of gas, oil, and sour water will be processed in pilot scale test facilities located on skids to provide easy movement. These small plants will be used to conduct testing and collect data on USC processing methods. The pilot scale tests will be conducted within the process facilities area. Pilot scale testing will be used to evaluate the potential for additional processes to assist in further refining the products from the ICP process. Wastes from the pilot scale facilities will be handled in the process water treatment plant or the gas cleaning systems. Spills will be captured and treated in the process water treatment plant.

Process Water Pond

The Process Water Pond is a lined pond that is used as storage capacity for the stripped sour water from the Sour Water Stripper. This pond will be used to provide extra storage and in the event that the Dissolved Air Floatation, Membrane Bio-Reactor, or the Reverse Osmosis Units are off line for maintenance or repair or during periods when additional storage is needed. The stripped sour water can be diverted and stored in the Process Water Pond until the water treatment units are functional again. It is expected that the pond will be used for storage on a routine basis and will not remain empty for long periods of time. Pond sizing and design will be defined by further engineering studies.

The process water pond will be fenced with an eight-foot high chain link fence to prevent wildlife from entering the pond and causing liner damage.

4.4 Recovery Efficiency and Energy Balance

Although Shell's economic model contains many inputs, ICP economics depends heavily on the following three subsurface process performance metrics:

- Recovery Efficiency – the ratio of produced ICP oil to Fischer-assay oil in place
- Energy Balance – the ratio BTU's out as oil and gas to the BTU's input via electrical power
- Product Quality – the composition and properties of produced ICP fluids (e.g. API gravity)

The high recovery efficiency of ICP (~100% of Fischer assay BOE, Barrel of Oil Equivalent) results from the slow, uniform heating process and also from the in situ vaporization of the hydrocarbons.

ICP makes more complete use of the oil shale resource. The entire oil shale column is pyrolized, including lower grade zones that could not be mined economically for surface retorting. ICP also can access deeper oil shale resources than are uneconomical to mine. Overall, much more oil and gas may be recovered from a given area utilizing the ICP process.

There are locations of thick resources in the Piceance Basin that could yield in excess of one million barrels of shale oil per acre. The economics of the ICP process could be improved dramatically if bare electrode heaters were installed that combined both thermal conduction heating with some ohmic heating of the oil shale formation. The bare electrode ICP process is called E-ICP and is a patented 2nd-generation in-situ heating technology. By dramatically lowering the heater well capital costs, E-ICP may economically recover hydrocarbons in lower richness oil shale, thus greatly increasing the US oil shale target resource by making much more of the Piceance basin commercially attractive.

ICP requires energy input for heating, freeze wall construction, processing, and maintenance but still generates three to four times as much net energy as it consumes. This energy ratio is very comparable to steam injection in heavy oil projects.

Support Facilities

Support facilities associated with the E-ICP and processing facilities include the building complex near the project entrance, the utility building and substations, a process control and locker/change house building, loading / unloading facilities, construction support, and driller support. Sanitary wastes from these facilities will be piped to the process water treatment building and treated in the Bio-Reactor. Solid waste (trash) will be disposed off site at an approved facility.

Security will be provided at the site. Trucks, visitors and employees will be required to enter through the security gate to access the work site.

The maximum number of people employed at the site will occur during construction and drilling. An estimated maximum of approximately 700 individuals will be employed at the site during the construction and drilling period. Once construction is completed, the maximum expected employment at the site will be approximately 150. Shifts will typically be nine-hours per day, with some operators working twelve hour shifts. Parking will be available in a parking lot just inside the main gate. An automated exit gate will be installed. Traffic will range from 300 to 650 vehicles per day, including personal automobiles and supply and product trucks.

Emergency Response personnel will be on site or on call. Written emergency procedures will be included in the Process Safety Management Manual to be developed in accordance with Occupational Safety and Health Administration regulations prior to operation and in the Spill Prevention Control and Countermeasures (SPCC) and Emergency Response Plan (ERP). Copies of this manual will be located in the control room and guard shack. Employee training will include safety, chemical handling, spill control and cleanup, and other emergency procedures.

Buildings

Buildings that are likely to be needed include a process control and change house, guard shack and gate, warehouse, shop building, laboratory building, and potable water tank and delivery system (see Exhibit I). The warehousing and maintenance shop will provide routine services for the operation. Trailers will be used for support of drilling activities e.g. warehousing, change house and offices.

Spill containment and cleanup procedures developed as part of the SPCC and the ERP will be implemented for any regulated chemicals used or stored in these facilities.

Utilities

Power is brought into the site from an electrical substation constructed, owned, and operated by White River Electric Association (WREA), just outside the permit boundary. Substations on the project site will be maintained on site for power distribution to the project. It is anticipated that WREA will obtain the permits necessary for the substation and distribution line. An approximate location is shown on Exhibit I. An electrical sub yard for heaters is located adjacent to the freeze wall containment area to support the heating process. An additional electrical sub yard is located just east of the WREA substation and services the rest of the facilities.

Natural gas is brought on site via a pipeline from a commercial supplier located in proximity to the site and distributed to the processing facility. A stand-by diesel generator is located in the utility building. Arguments of power and gas lines have not been finalized. A small diesel storage tank will be located inside the curbed building to provide fuel for the stand-by generator.

4.5 Water Management

Water requirements vary throughout the project life. Water uses include construction, potable water, dust control, drilling, processing, filling and cooling of the heated interval for reclamation, and rinsing of the zone inside the freeze wall.

Water Supply and Water Requirements

Water will be trucked to the site for construction and drilling activities. Potable water will be trucked to the site throughout the life of the facilities.

Onsite water will be used for most operational uses and will be supplied from water wells drilled for that purpose. A primary and a backup water supply well are planned. The well will supply water needed for processing and reclamation. Peak pumping demand will occur during the fill and cool phase of the reclamation cycle (see Section 5.0). If the water well is available during construction and drilling, then this water will supplement or replace construction and drilling water trucked to the site.

Water needs for each phase of the operation are outlined below. The projected water needs are estimates and are subject to change as additional information becomes available and facility designs are finalized. Water rights required for the project will be acquired prior to the startup of the operation.

Construction Water

Construction water will be trucked to the site as necessary for use in compaction, dust control and miscellaneous construction water needs. Potable water needs during construction will be brought to the site. Water required for drilling will be trucked to the site until water from the on site water supply well is available to supplement or replace trucked water.

Operations and Reclamation Water

Water will be needed for various processing and operating needs. Water removed with the hydrocarbon products will be treated in the processing facilities and recycled or discharged. Figure 4.11 provides a general schematic of the process water management. It is currently anticipated that there will be excess water available during the initial processing period as a result of water within in the freeze wall containment area and that there will be no need for the water supply well to provide water for processing during this initial period. As processing progresses, there will be a need for additional water in processing.

Water is also needed to conduct reclamation filling and cooling of the heated interval within the freeze wall containment barrier as well as rinsing of the heated interval. This water will be a combination of recycle water and make up water from the water supply well as needed. During reclamation a water supply will be needed for initial stages of flushing and cooling. Figure 4.12 provides a general schematic of the reclamation water management.

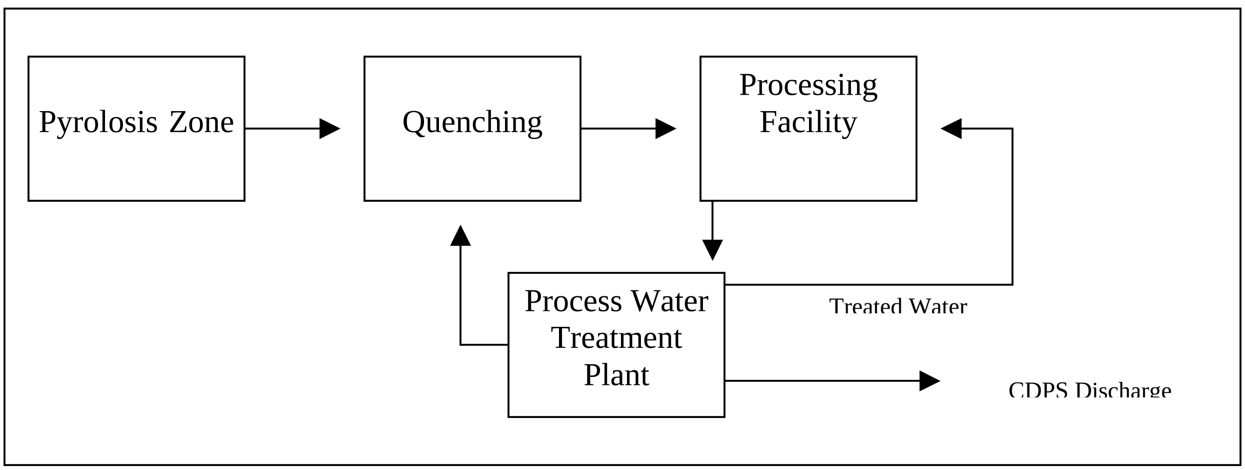


Figure 4.11 Processing Water Management

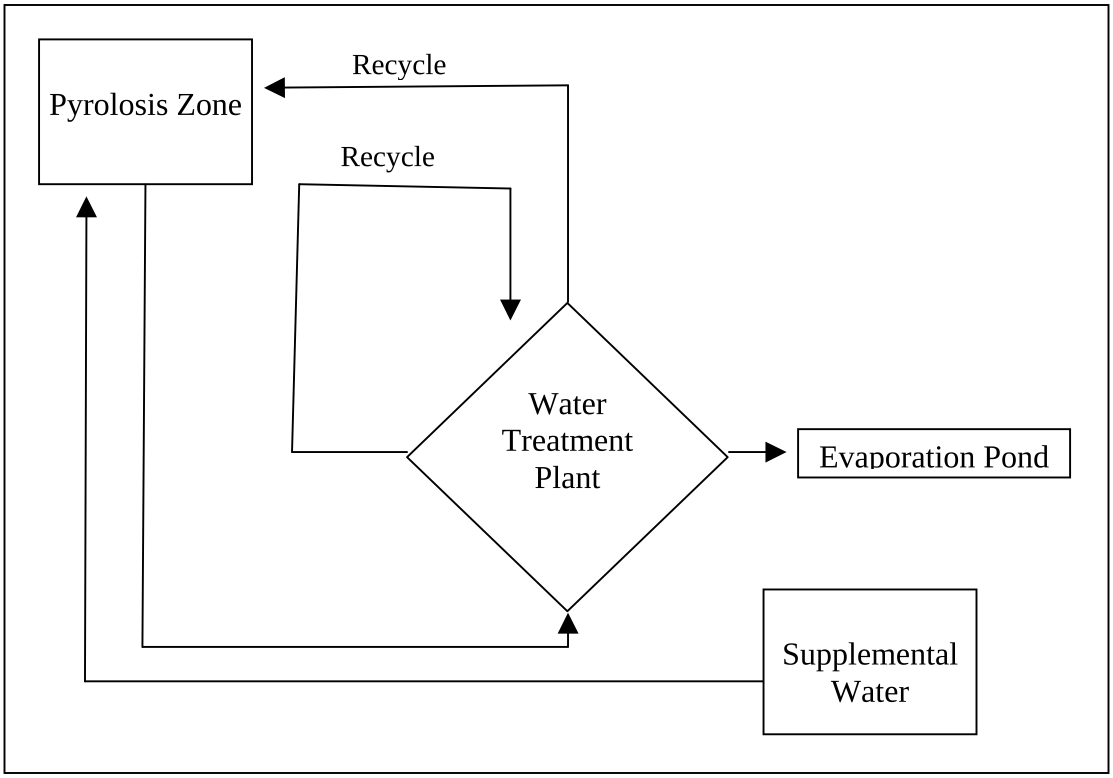


Figure 4.12 Reclamation Water

Water Discharge

Water that cannot be recycled or otherwise used will be treated to appropriate discharge standards in the process water treatment plant and released to a surface drainage under a Colorado Department of Public Health and Environment Colorado Discharge Permit.

Water Injection

Once the freeze wall is formed the containment area will be dewatered by pumping. This intercepted natural ground water will be pumped from the freeze wall containment area and injected down gradient of the freeze wall through injection wells. The injection wells will be permitted with the EPA Underground Injection Control program for Class V injection wells authorized by rule. Water of appropriate quality will be injected into appropriate zones so that similar water quality is maintained. Figure 4.13 shows a typical schematic for water management during dewatering and injection.

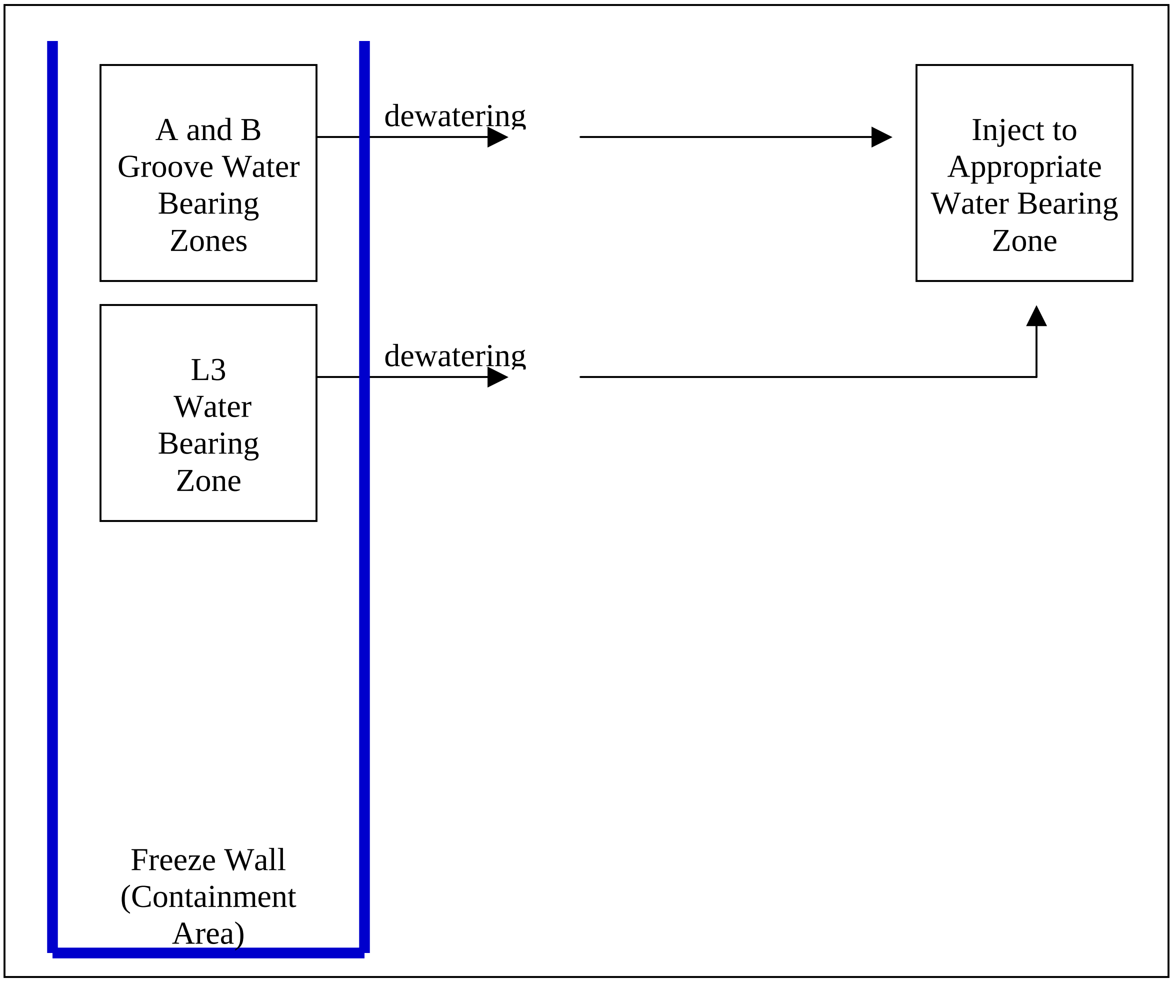


Figure 4.13 Dewatering and Injection Water Management

4.6 By-products and Wastes

During the course of the R&D project, construction and operation, a variety of by-products and waste materials will be generated. They include construction waste, drill hole cuttings, garbage and miscellaneous solid and sanitary wastes.

Surface construction operations will result in a variety of small waste products that could include paper, wood, scrap metal, refuse, garbage, etc. These materials will be collected in appropriate containers and recycled or disposed off site in accordance with applicable regulations

Approximately 200,000 cubic feet of earth and rock materials will be generated during drilling operations for the project. Drill cuttings removed from the drilled holes will be dewatered so the water can be recycled back to the drill rigs. The dewatered cuttings will be placed into a cutting pit as shown on Exhibit I. These non-toxic, non-acid forming drill cuttings will be separated from free water and will be buried below grade. Burial depth and soil coverage will be sufficient such that the materials will not impede revegetation.

During operation, garbage from the site will be collected in appropriate containers and disposed off site. Waste oils, reagents, lab chemicals that are not collected sumps and treated at the water treatment plants will be recycled or disposed off site in accordance with applicable regulations.

Sanitary Waste

A combination of sanitary waste handling methods will be employed. Some sanitary waste, such as that collected in temporary toilet facilities may be shipped to an approved facility for offsite treating and disposal. Any gray water or black water disposed onsite will be treated in an appropriate sewage processing unit or disposed according to standards via an approved septic system with clarifier and drain field.

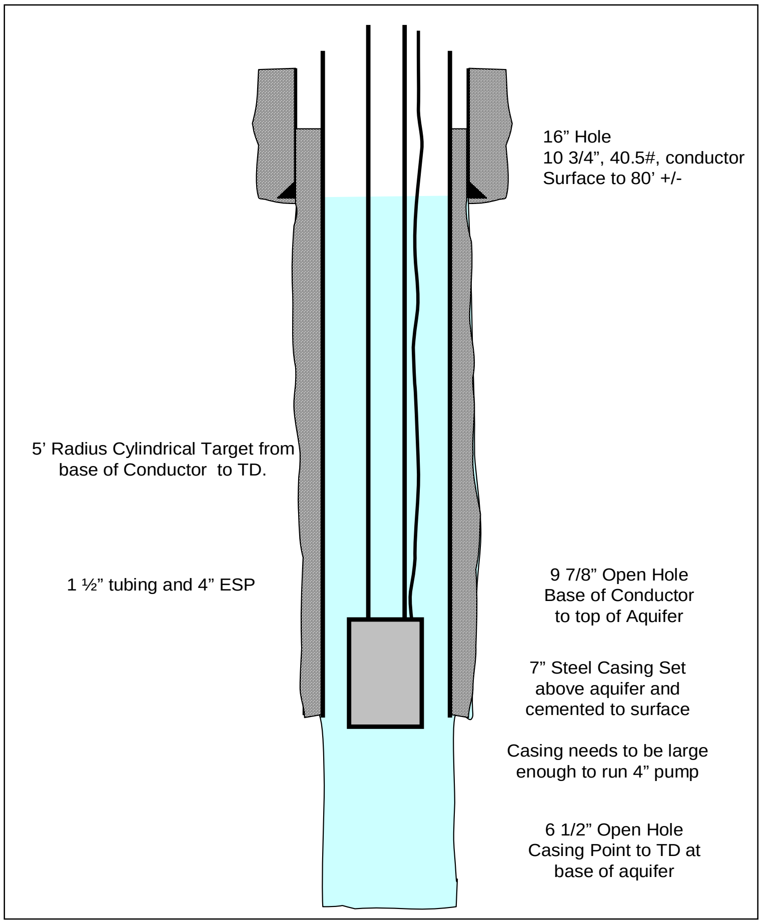


Figure 4.14 Typical Level Monitor Hole

4.7 Monitoring and Response

The E-ICP project is a research, development, and demonstration program designed to demonstrate the ICP, gather additional operating data and information, and allow testing of components and systems. As a result, monitoring is inherent in the design of the project. ICP process monitoring will be designed to gather data on the functioning of the various system components. Shell will conduct extensive compliance monitoring as part of permit requirements, e.g. air, water and mining permits. These will be defined as part of the permitting process.

Because this is an R&D project, extensive monitoring and instrumentation are provided for subsurface analysis. Temperatures, pressures, and levels are measured inside the heated patterns, inside the freeze wall and outside the freeze wall. Figures 4.14 - 4.15 show temperature, geomechanics, and level monitoring sketches.

Outside the freeze wall (Figure 4.17), pumper holes provide secondary containment in the unlikely event hydrocarbon escapes through the wall.

Environmental monitoring that will be done to demonstrate other environmental protection measures for the site are described in this section.

Surface Water Monitoring

A proposed quarterly surface water sampling program will be performed on sampling sites identified in Table 4.3. The locations for these sites are shown in Exhibit L. The sampling parameters are detailed in Table 4.4. All monitoring records will be maintained at the project site.

Table 4.3 E-ICP Surface Water Monitoring Locations

Stream Sites	Upstream	Corral Gulch	CR242
	Downstream	Corral Gulch	CR408
	Upstream	Stake Springs Draw	CR407
	Downstream	Stake Springs Draw	CR411
	Downstream	Yellow Creek	CR255

Table 4.4 Surface Water Sampling Parameters

Parameter	Unit	Parameter	Unit
Discharge	gpm	Boron, dissolved	mg/L
Field pH	SU	Cadmium, dissolved	mg/L
Field Conductivity	umhos/cm	Chromium dissolved	mg/L
Field Temperature	°C	Chromium, Trivalent Dissolved	mg/L
Field Dissolved Oxygen	mg/L	Chromium, Total	mg/L
Field Turbulence	ntu	Copper, dissolved	mg/L
Residue, Filterable (TDS)	mg/L	Iron, total recoverable	mg/L

Table 4.4 Surface Water Sampling Parameters

Parameter	Unit	Parameter	Unit
Calcium, dissolved	mg/L	Lead, dissolved	mg/L
Magnesium, dissolved	mg/L	Manganese, dissolved	mg/L
Sodium, dissolved	mg/L	Mercury, total	mg/L
Hardness as $CaCO_3$	mg/L $CaCO_3$	Nickel, dissolved	mg/L
Bicarbonate as $CaCO_3$	mg/L	Selenium, dissolved	mg/L
Chloride	mg/L	Silver, dissolved	mg/L
Sulfate	mg/L	Zinc, dissolved	mg/L
Sulfide as S	mg/L	Benzene	ug/L
Nitrogen, Ammonia	mg/L	Toluene	ug/L
Nitrate/Nitrite as N	mg/L	Ethylbenzene	ug/L
Arsenic, dissolved	mg/L	Xylene	ug/L

Ground Water Monitoring

Ground water monitoring will be conducted outside of the freeze wall barrier to monitor ground water quality during operation and after reclamation.

Ground water monitoring will consist of monitoring of the water bearing units including the Uinta, A and B Groove, L5, L4 and L3 contingent upon multiple zone completion as discussed below.

Multiple zone completions are being tested for some wells interior to the freeze wall containment at FWT, another Shell R&D Project. Multiple completion wells are equipped with isolation packers to prevent crossflow between zones. Sample ports in the tubing string will allow for collection of pressure data and water samples. Should the information gained from the multiple zone completion wells demonstrate this type of completion is appropriate for ground water quality monitoring, then multiple zone completions could be proposed for ground water monitoring at a later date, subject to approval. Compliance monitoring of these zones will occur using dedicated single completions in each zone.

Planned ground water monitoring for the E-ICP will include one upgradient completion in each unit and downgradient completions in each unit. Additional wells may be installed within the project area for early detection of potential problems.

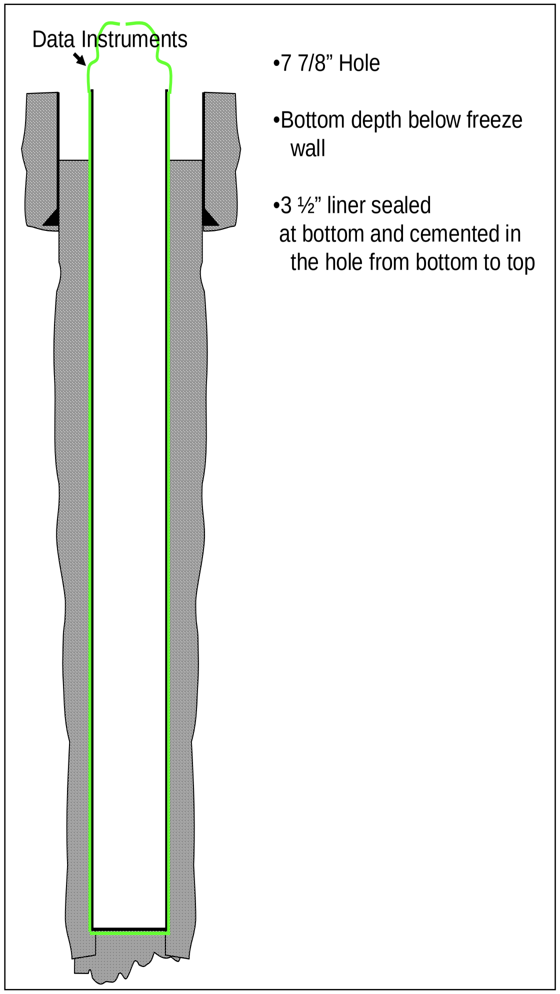


Figure 4.15 Typical Geomechanics Monitor

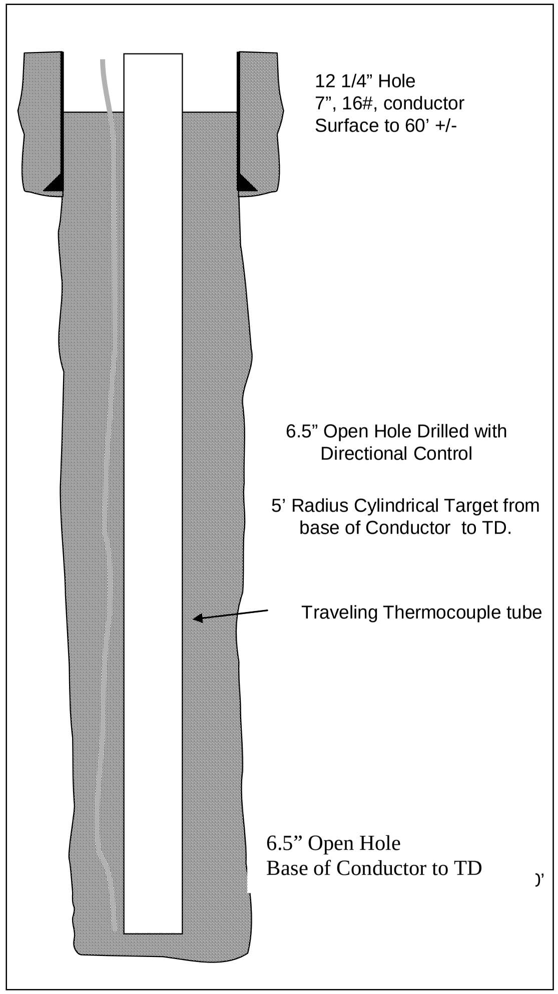


Figure 4.16 Typical Temperature Monitor

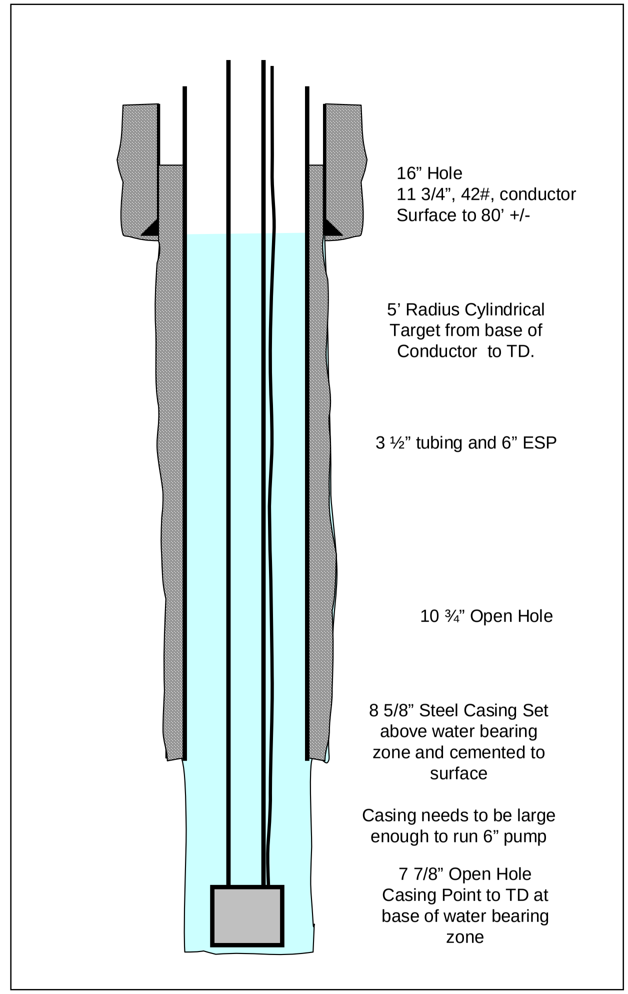


Figure 4.17 Typical Pumper Hole

Facilities Monitoring

Routine visual inspections and operational warning systems will facilitate monitoring of containment systems and features at the E-ICP site. These will include the following:

- Piping systems will be pressured tested prior to use. The pipe systems will have pressure monitors to alert operators when a loss of pressure occurs that could be indicative of a potential problem.
- Sumps within concrete containment areas will be visually monitored on a daily basis and any liquids present in these sumps would be pumped to the process water treatment plant or sent off site for disposal at an appropriate facility.
- Storm water management systems would be inspected on a periodic basis as prescribed in the Storm Water Management Plan.
- A SPCC will be developed to address spill prevention and response for petroleum products at the site. The SPCC plan will prescribe inspection types and frequencies for petroleum related vessels and containments.

In addition, an ERP will be developed for responding to emergencies at the site while ensuring worker safety. The Plan will include designation of responsible personnel, an outline of procedures to be followed, a list of chemicals to be used or stored on site, a list of materials available to control spills or leaks, and notification requirements.