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

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1.0 INTRODUCTION AND BACKGROUND

This Plan of Operations (Plan) has been developed by Shell Frontier Oil and Gas Inc. (Shell) in order to develop a 160-acre parcel for the purpose of oil shale research and development (R&D). Shell is located at 4582 South Ulster Parkway, Suite 1340, Denver, Colorado 80237, (303) 305-4016. The Plan provides substantial background information generated by Shell over the past several years, and outlines how the R&D project will be organized and implemented. The Bureau of Land Management (BLM) owns both the mineral and surface land of the 160-acre R&D site. The operating company that would operate and manage on behalf of Shell would be Shell Exploration and Production Company. Shell Exploration and Production Company is located at 777 Walker St, Houston, Texas 77002. Through diligent development of the R&D technology, Shell anticipates acquiring a commercial scale lease from the BLM based on the success of its R&D project.

This project, called Shell E-ICP Test Project (E-ICP), is located on 160-acres located in Section 22, Township 1 South, Range 99 West, Rio Blanco County, Colorado. The general location of the R&D site is within the northern part of the Piceance Basin in Rio Blanco County (Exhibit A). The general area surrounding the R&D site 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 northern part of the structural basin has been eroded into a topographic basin by the drainage networks of the Piceance and Yellow Creeks that are tributary to the White River. Land surface altitudes range from about 5,500 feet in the White River valley to more than 8,000 feet on the Cathedral Bluffs west of the R&D site. The topography consists of ridges and valleys with local relief of 200 to 600 feet.

Since 1980 Shell has worked on developing and refining the In-situ Conversion Process (ICP) technique for oil shale development. The proprietary ICP uses subsurface heating to convert kerogen contained in oil shale into light hydrocarbons which can be readily processed into ultra-clean transportation fuels and gas. The ICP is more efficient and environmentally sensitive than conventional oil shale development.

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.

Shell has dedicated significant resources to determine the appropriate time, temperature, and pressure to convert kerogen into smaller hydrocarbon molecules that are extracted and upgraded by the process. Oil developed by the ICP process is higher quality than that derived from conventional surface retorting. Lighter and cleaner ICP products require less processing to become finished fuels.

2.0 PROJECT DESCRIPTION

2.1 Project Overview

The purpose of the R&D project is to demonstrate the feasibility of a commercial oil shale development to earn a 5,760-acre lease from the U.S. Government. The project site was selected based upon the following criteria:

- The oil shale resource should approximate what is currently considered to be a viable commercial oil shale resource target. Some of the key parameters include resource stratigraphic and structural continuity, resource grade, resource thickness, overburden and nahcolite content.
- The property is fully owned (minerals and surface) by the U. S. Government and managed by the BLM, White River Field Office in Meeker, Colorado.
- The surface water and associated tributary groundwater are fully contained in the Yellow Creek drainage sub-basin of the Piceance Creek Basin.

The proposed project site is a 160-acre federal tract of land in Section 22, Township 1 South, Range 99 West in Rio Blanco County, Colorado and is shown in Exhibit B. The site is located in the northern part of the Piceance Basin, approximately 18 aerial miles southeast of Rangely and 32 aerial miles west-southwest of Meeker. The majority of the surrounding area is owned by the BLM and the Colorado Department of Wildlife. Additionally several large parcels are owned and controlled by private entities. Land ownership and existing facilities adjacent to the R&D site are provided on Exhibit C. Existing facilities such as oil and gas wells and mines are also depicted on Exhibit C.

The project will be comprised of 4 major phases:

- Design and permitting
- Equipment fabrication and field construction
- On site heating, producing and operational testing
- Site reclamation.

Project development will follow after the issuance of all required permits and lease.

2.2 Operating Schedule

The following operating schedule is anticipated for field testing the two step ICP process

- Establishing the freeze wall is expected to take approximately one year
- ICP heating and resource recovery will require approximately 5-6 years to complete
- Ground water reclamation approximately 5 years
- Thawing of the freeze wall will take 1.5-3 years based upon the ground water reclamation program
- Decommissioning, abandonment, and land reclamation will require 12-18 months

Prior to initiation of any site disturbance, Shell will execute an acceptable financial assurance mechanism with the BLM. Financial assurances include, but are not limited to self bonding, third-party bonding, letter of credit, or cash escrow.

2.3 General Technology Description

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 develop oil from shale were expensive and had significant environmental impacts. Shell has been working since 1980 on an in-situ technique for developing such deposits that could significantly improve the product quality, recovery efficiency, energy balance and environmental impact of oil shale development.

Shell's proprietary ICP uses subsurface heating to convert kerogen contained in oil shale into ultra-clean transportation fuels and gas. Shell's process is more environmentally friendly and more efficient than previous oil shale efforts. It recovers the resource without conventional mining, uses less water, and does not generate large tailing piles. ICP has the potential to make much deeper, thicker, and richer resources available for development, without the complications of surface or subsurface mining.

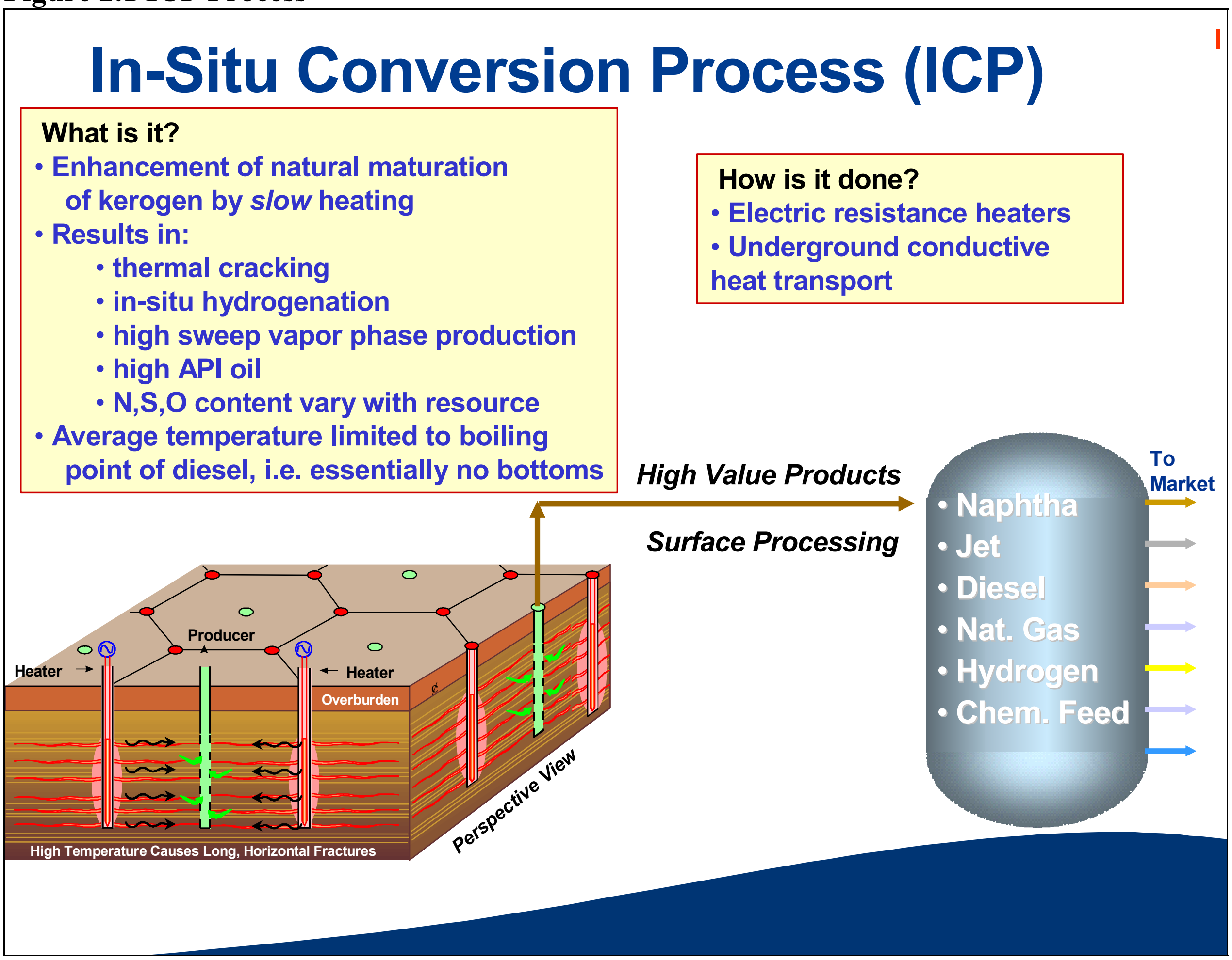
Extensive laboratory and field experiments by Shell have determined the optimum time, temperature, and pressure for improved product quality. The kerogen is thermally cracked into smaller hydrocarbon molecules that are slowly upgraded by in-situ hydrogenation. Since the average temperature is limited to the boiling point of diesel, the product is a light condensate with little bottoms.

The product quality of ICP shale oil is superior to that from surface retorting. ICP petroleum products are lighter and cleaner, requiring less processing to become finished transportation fuels like gasoline, jet and diesel.

In-situ Conversion Process

ICP's suitability to a particular resource is dependent on natural geologic conditions such as depth, thickness, and the presence of groundwater. Figure 2.1 shows a highly simplified diagram describing what ICP is, how it works, possible hydrocarbon resource targets, and principle products.

Figure 2.1 ICP Process



To prevent groundwater from flowing into the heated pattern and to contain the ICP products, a freeze wall is first installed. A series of holes are drilled outside the intended resource target and a chilled fluid (-45°F) is circulated inside a closed loop piping system. The cold fluid freezes the nearby rock and groundwater and in 6-12 months creates a wall of ice. The freeze wall is maintained during both the production and reclamation phases of the project.

After the freeze wall is established, producer holes are drilled and used to remove the groundwater trapped inside the wall as part of the dewatering effort. Heater holes are drilled and electric heaters are installed to uniformly heat, an otherwise undisturbed hydrocarbon-bearing target to between 550 and 750°F for a period of several years. Additional holes are used to monitor hydrology, geomechanics, temperatures, pressures, and water levels. These holes are placed in the heated pattern, inside the freeze wall, and outside the freeze wall.

The ICP uses self-contained heater wells. Heat transport from the heaters occurs by thermal conduction only.

Oil and gas comes to the surface via the previously installed producer holes and is collected for further processing using traditional processing techniques.

Shell's E-ICP Process is disclosed in patent application US 60/674081. Shell's Curie heaters for ICP are published in the following applications: U.S. 2004/0146288; U.S. 2004/0144540; PCT US 2005/013889; PCT US2005/013923; US 11/112863;US 11/112863; US 11/113342. In addition, Shell has been granted over 70 US patents covering many aspects of its ICP process. An additional 150 US patent applications have been filed. Internationally, patent applications have been filed in over 30 countries.

Over the past 60 years, a variety of technologies for recovering shale oil from oil shale have been tested, including mining with surface processing and other in-situ technologies.

Conventional surface processing mines the oil shale by surface mining or underground mining methods, transports the shale to the retort, collects the oil, cools down and finally disposes of the "spent" shale. The heating phase in a surface retort is very short and results in a quality of oil that needs significant processing.

In-situ retorting applies sustained heat to the kerogen while it is still embedded in its natural geological formation, and then recovers the hydrocarbon fluids using oil field production holes. Some in-situ processes rely on air or oxygen injection and require that relatively high permeability exist or be created through fracturing. The target deposit is fractured, air is injected, the deposit is ignited to heat the formation, and resulting shale oil is moved through natural or man-made fractures to production holes that transport it to the surface. This type of in-situ process suffers from difficulties in controlling the pyrolysis temperature and the flow of produced oil, resulting in poor oil and gas quality combined with low oil recovery efficiency because portions of the deposit are left unheated.

In contrast to technologies previously discussed, Shell's ICP has the potential to significantly reduce environmental impact. ICP involves no surface or underground mining, creates no leftover piles of spent shale, generates fewer other unwanted byproducts, and potentially requires less water usage.

3.0 GEOLOGY AND RESOURCE

3.1 Introduction

The proposed 160-acre R&D tract is located in the northern part of the Piceance Basin in northwestern Colorado (Exhibit A). This rugged and remote area of Colorado contains the world's richest deposits of oil shale. An estimated one trillion barrels of oil shale resource occurs within the Green River Formation in Colorado. The resource area covers 1,600 square-miles and is bounded by the Colorado River on the south, the White River on the north, the Douglas Creek Arch on the west, and the White River Uplift on the east (Exhibit D). The in-place oil shale resource lying beneath the 160-acre proposed R&D tract is estimated to be approximately 274 million barrels, a small fraction of the total basin resource.

3.2 Topography and Surface Drainage

The proposed 160-acre R&D tract is located within the Yellow Creek drainage subbasin of the Piceance Basin (Exhibits A and D). The tract lies along the northeast-trending Wolf Ridge at an elevation of 6,840 ft in Section 22, Township 1 South, Range 99 West, Rio Blanco County, Colorado (Exhibit E). The topographic relief surrounding the tract is as much as 200 feet. The tract terrain is mild, sloping eight percent northward.

3.3 Structure

The Piceance Basin is a structurally downwarped region of the Colorado Plateau Province. The basin is surrounded by several uplifts that emerged during the growth of the Rocky Mountains during the early Tertiary Period (Exhibit D). The Eocene Wasatch, Green River and Uinta Formations were deposited in a river-lake depositional system during basin development, coeval with this episode of mountain building. In the northern Piceance Basin, lying between the Colorado River and White River, the basin is asymmetric to the east and forms a plateau that is dissected by numerous ridges and valleys. The primary basin axis parallels the Grand Hogback-Axial Basin Arch structural front. This structural front is defined by large basement thrust faults and reverse faults that formed during basin development. Additionally, the basin contains several secondary northwesterly-oriented folds and faults that formed during post-Uinta Formation (late Eocene or later) time.

The trace of the Black Sulphur Creek Anticline, a secondary fold in the basin, and associated small normal faults, are exposed at the surface a few miles to the southwest of the proposed 160-acre R&D tract (Exhibit E). The anticline plunges gently to the southeast. The surface traces of the normal faults occur mainly on the eastern side of the fold axis and are sub-parallel to the trace of the fold axis. To the northeast of this area the strata dips gently to the northeast and is not known to be structurally disturbed (Exhibit G). Folds and faults are not evident within the proposed 160-acre R&D tract.

3.4 Stratigraphy

Overburden

The Uinta Formation and the underlying interfingering tongues of the Uinta and Green River formations are exposed over much of the northern Piceance Basin. These rocks overlie the organic-rich oil shale rocks in the Parachute Creek Member of the Green River Formation (Exhibit F). The Uinta Formation is composed predominantly of fluvial and lacustrine sandstones and siltstones. The Uinta tongues are of similar lithology but generally are finer-grained and more thinly bedded. The Green River tongues consist predominantly of interbedded marlstone and silty marlstone.

The Uinta Formation is exposed at the surface at the proposed R&D tract (Exhibit G). The projected thickness and depth of these units at the tract are illustrated on Exhibit H. The Uinta Formation is not known to contain acid-bearing minerals that can be readily leached by surface water. As a result, surface modification for facilities development should not result in acid-water issues.

Oil Shale and Marlstone

The Eocene Green River Formation conformably overlies the Wasatch Formation and it conformably underlies the Uinta Formation in the Piceance Basin (Exhibit F). 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. The lithology of the oil shale is distinguished from that of marlstone by its quantity of organic matter (kerogen). An oil shale contains greater than 10 gallons/ton oil yield from Fischer Assay analysis whereas a marlstone contains less than 10 gallons/ton. The two lithologies form an alternating stratigraphic succession of stacked organic-rich zones (R zones) composed primarily oil shale, and organic-lean zones (L zones) composed predominantly of marlstone (Exhibit F and H). 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 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 (naturally occurring sodium bicarbonate) 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 (Exhibit F). 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.

The proposed 160-acre R&D tract lies to the west-southwest of the limit of the Saline Zone (Exhibit E, G and H). All of the originally deposited nahcolite has been leached away by circulating groundwater beneath the tract. 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 its pore space and can be strong potential flow intervals. A geo-hydrologic model will be developed during the delineation phase on the 160-acre R&D tract.

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 the proposed 160-acre R&D tract 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. These concentrations are not considered economic for recovery and extraction of alumina from the dawsonite.

3.5 Oil Shale Resource

The R-7 through R-2 interval of the Parachute Creek Member of the Green River Formation is the resource interval of interest for oil shale development at the proposed R&D tract. The total oil-in-place resource is estimated to be approximately 274 million barrels beneath this tract (Exhibit G). The following table summarizes some important parameters of the resource target interval at the site.

Resource Interval	R-7 through R-2 interval, Parachute Creek Member
Surface Elevation	6,950 ft
Area	160 acres
Est. OIP Resource	274 million barrels; undiscounted for porosity
Average Overburden Depth	940 ft (depth to top of R-7 Zone)
Average Thickness	1,000 ft
Average Oil Grade	24.0 gallons/ton, Fischer Assay Oil Yield
Nahcolite Content	~0 %, visual estimate from core in offset core holes
Dawsonite Content	~4 %, estimate from XRD data in offset core holes
Est. Vugular Porosity	4% to 5%, visual estimate from core in offset core holes
Est. Fracture Porosity	<1%, visual estimate from core in offset core holes

3.6 Hydrologic Setting

Groundwater in the Piceance Creek/Yellow Creek Basin 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. It 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.

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 ibid)[2]. Spring discharge areas in the lower reaches of both Piceance and Yellow Creeks appear to be controlled by major fracture systems that allow hydraulic communication with deeper, more saline groundwater (Robson et al 1981)[1]. Groundwater discharge in the upper drainages occurs primarily from shallower bedrock (Uinta and upper Parachute Creek).

Historically, 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)[2], 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 used to describe local conditions of this Plan except for direct reference to historic USGS reports. This plan divides the section into several water bearing and confining intervals, for which chemical and potentiometric data blur the former upper and lower distinction. However, potentiometric data for smaller 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)[3] which are reproduced in Figures 3.1 and 3.2.

Modes of transmission of water vary with the unit. A- and B-groove units include both the silty lean zones, and fracture and vug permeability. In lower water bearing units, permeability is dominated by vugs interconnected by partings (where salt has been leached), tectonic fractures, and or fracturing and brecciation associated with dissolution collapse. Permeabilities of lower lean marlstones are not significantly higher than those of rich zones. Tables of hydraulic conductivity for water bearing units in this document are averaged over the unit interval, and do not attempt to partition the permeability between various intervals or modes of flow within each unit. Conductivity values should therefore not be used to gauge flow velocities.

West of the R&D project area, available potentiometric head and available water quality information from hydrostratigraphic intervals named for each included lean zone suggest that the conventional definition of Upper and Lower aquifer does not apply. The A-groove (L7), B-groove (L6), and L-5 water-bearing zones appear to have similar potentiometric heads, and the largest vertical potentiometric head difference actually occurs between the L-5 and L-4 water-bearing zones to the west of the project area. This is consistent with findings at the nearby C-a tract located to the west and east of the project site. At the C-a Tract references to the "Upper Aquifer" generally include both the A-groove and B-groove, with a lower limit as deep as the top of the L-5 zone. The "Lower Aquifer" lies between the top of the L-4 and the top of the Garden Gulch Member (L1) (*ibid*).

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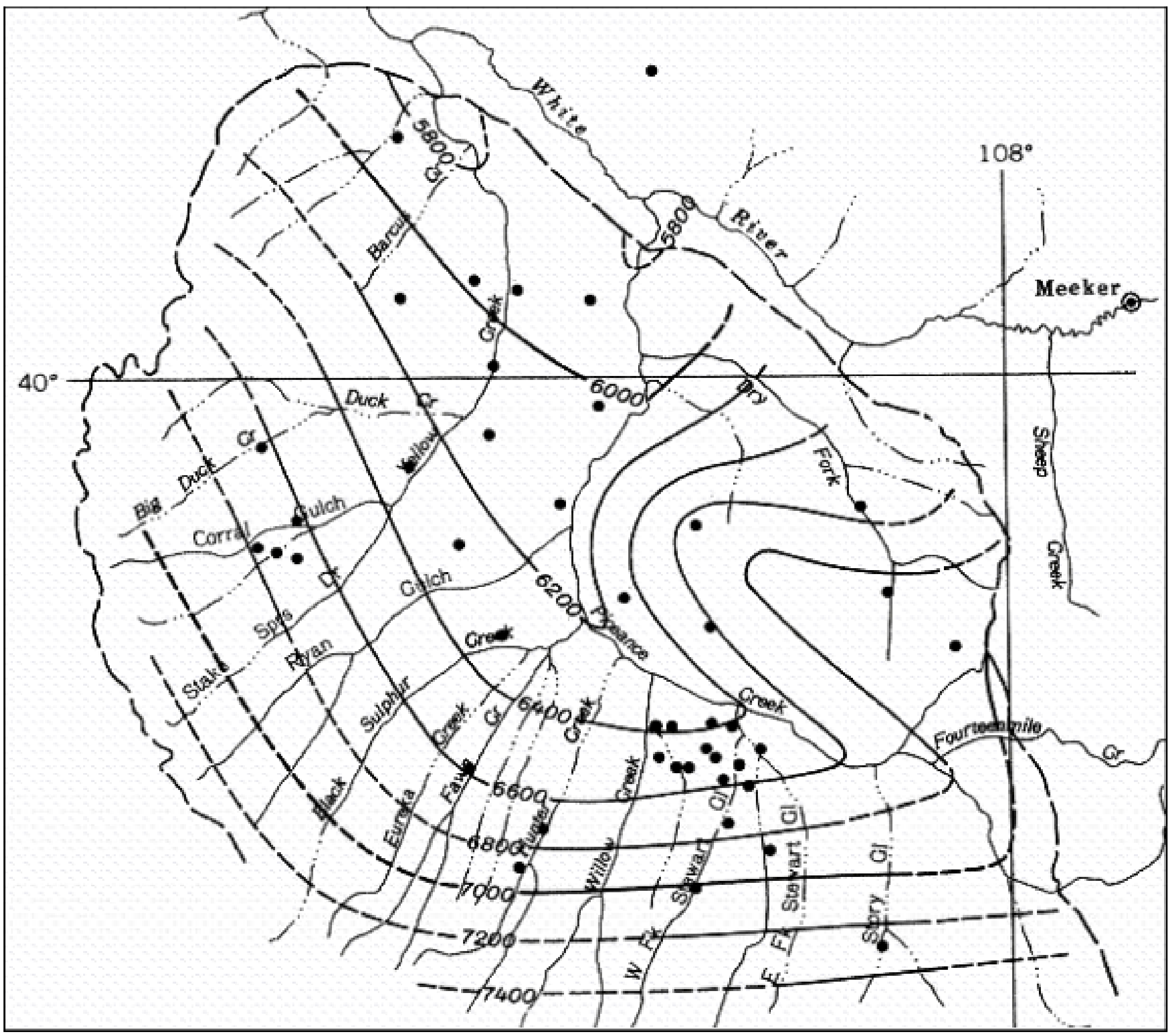
[1] Robson, S.G., G.J. Saulnier Jr., 1981. Hydrochemistry and simulated solute transport. Piceance basin, northwestern Colorado. U.S. Geological Society Professional Paper 1196, 65p.

[2].Coffin, D.L., F.A. Welder, R,K, Glanzman 1971. Geohydrology of the Piceance Creek structural basin between the White and Colorado Rivers, northwestern Colorado. U.S. Geological Survey Hydrologic Investigations Atlas HA-370.

The strata equivalent to the Garden Gulch and Douglas Creek members (Unnamed Member on Exhibit F) of the Green River Formation are characterized (Robert and Sauliner 1981)[3] as an impermeable base to the Parachute Creek Member groundwater system. Thus there is little suspected interaction between the Parachute Creek Formation and possible aquifers in the Wasatch Formation or deeper geologic units, though this is to be confirmed in future investigations

Figure 3.1 Potentiometric Surface for the "Upper Aquifer"



Dots indicate locations of wells providing information.

Groundwater flow in the Parachute Creek Member occurs through A- and B-groove silt zones, natural fractures, and parting-connected solution cavities or "vugs." Lean zones within the member tend to fracture more readily than do rich zones, and are generally more permeable and typically coincide with zones of relatively high water-production from boreholes. However, this is a very general relationship and does not hold everywhere because some of the layers of richer oil shale also are fractured, highly porous, and permeable. Several permeable zones occur within stratigraphically defined "rich" zones, and low permeability zones can exist within stratigraphic "lean" zones (Figure 3.3). In most cases where hydraulic testing has been conducted, it indicates that the rocks above and below the Parachute Creek Member have lower permeability. These are essentially aquicludes that prevent significant flow of groundwater outside the Parachute Creek Member.

Figure 3.2 Potentiometric Surface for the "Lower Aquifer"
Dots indicate locations of wells providing information.

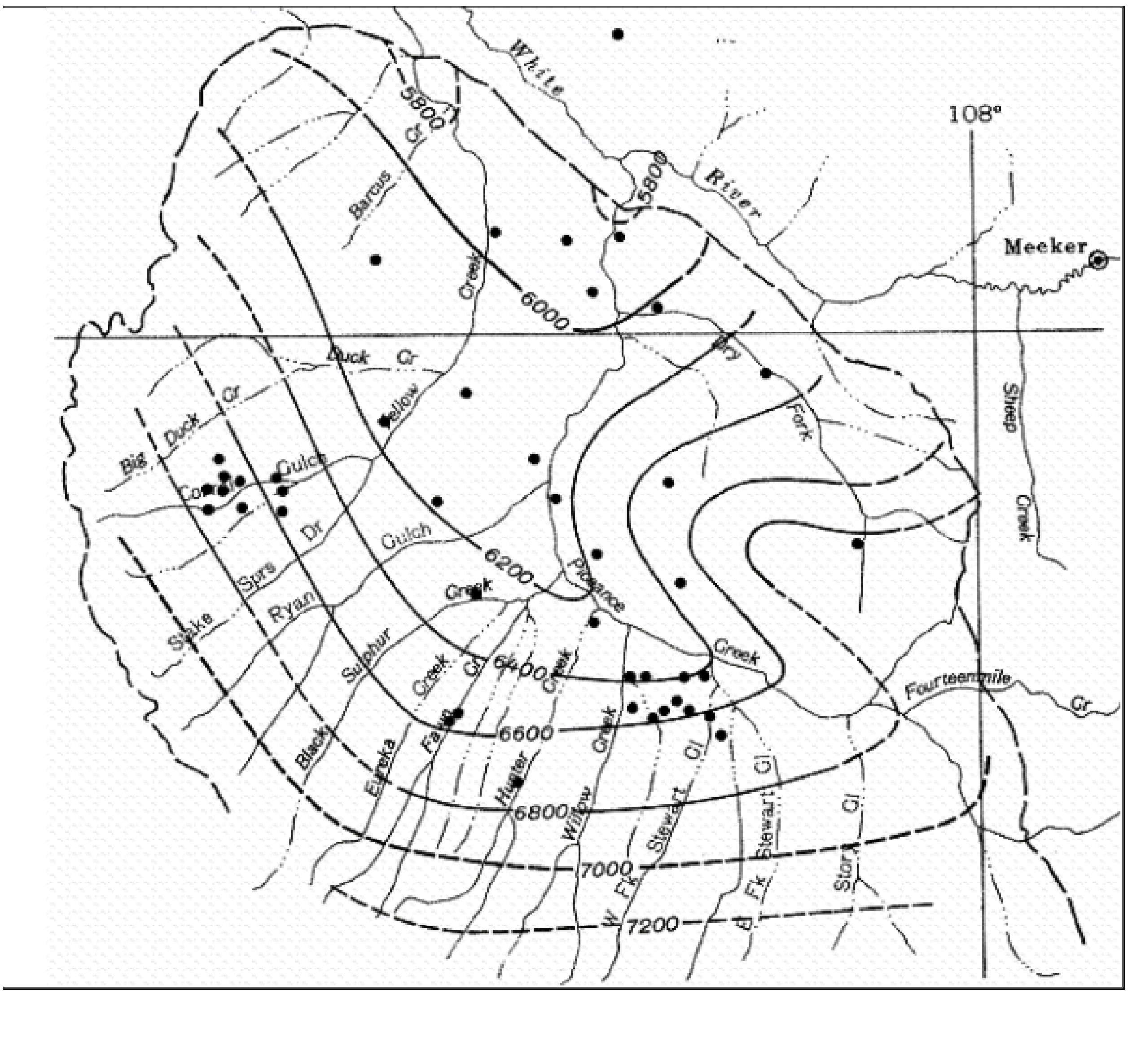
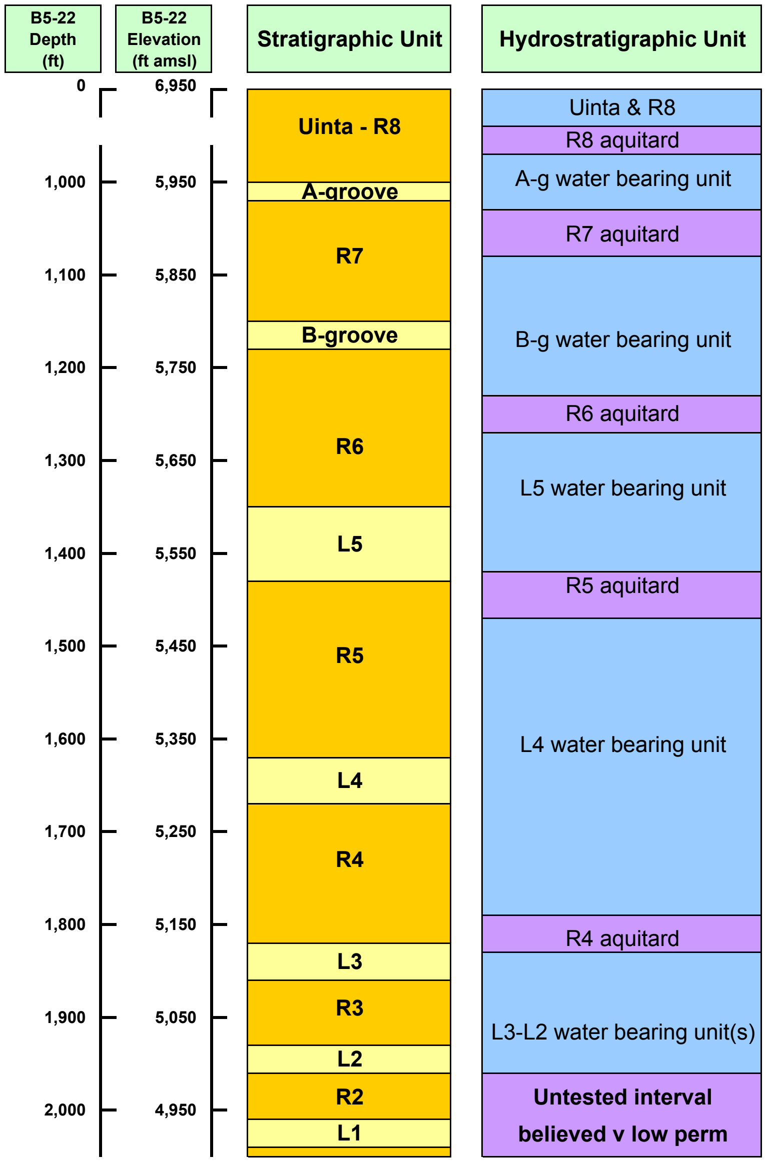


Figure 3.3 Hydrostratigraphic Units - E-ICP, Piceance Basin, Colorado



All water bearing units and aquitards drawn by analogy with other sites where packer testing has been performed throughout section

No saline zone in B5-22-L1

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.

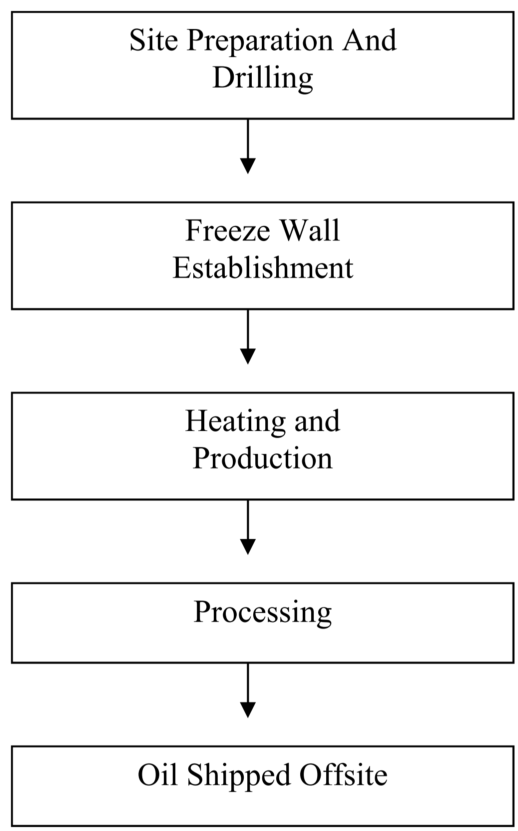


Figure 4.1 Diagram of E-ICP Project

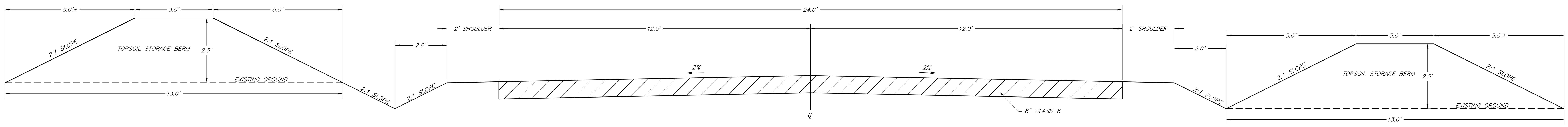
As a part of reclamation, the wells and holes not needed for monitoring are plugged and abandoned in accordance with requirements of the Colorado Office of the State Engineer. Facilities will be demolished and removed and the site will be regraded and revegetated. The paved access road will also be reclaimed, 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

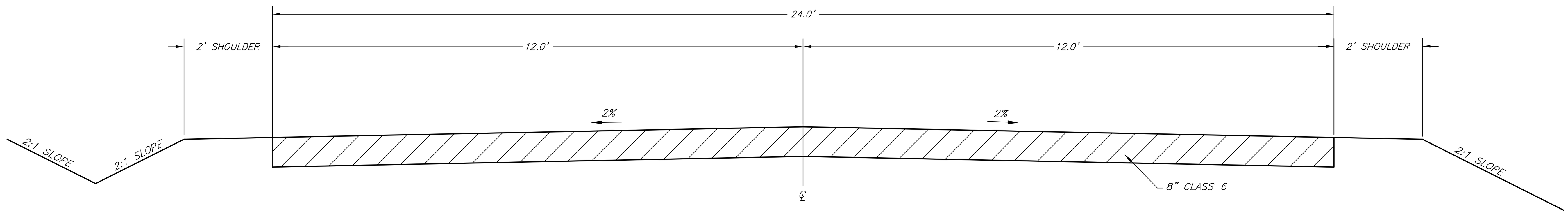
Initial construction activities include development of the site access road and fencing of the permit area. The present access to the E-ICP site is from County Road (CR) 5 to CR 24 to CR 24X (see Exhibit C). There are presently three proposed access roads to the site. Based upon input from BLM, one of 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.



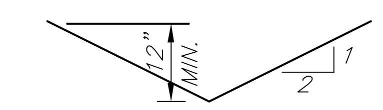
TYPICAL ROAD DETAIL (W/BERMS)

NTS



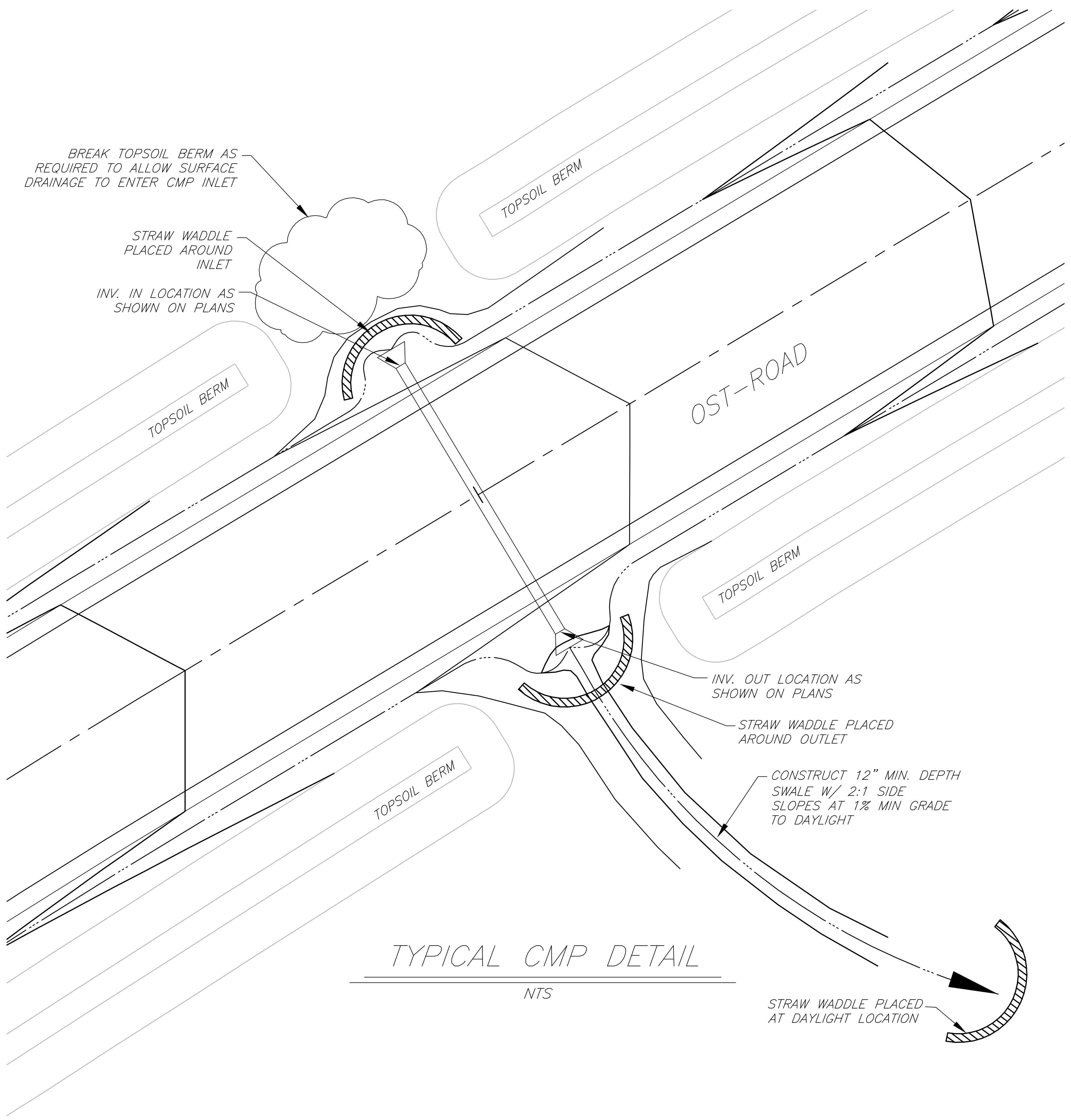
TYPICAL ROAD DETAIL

NTS



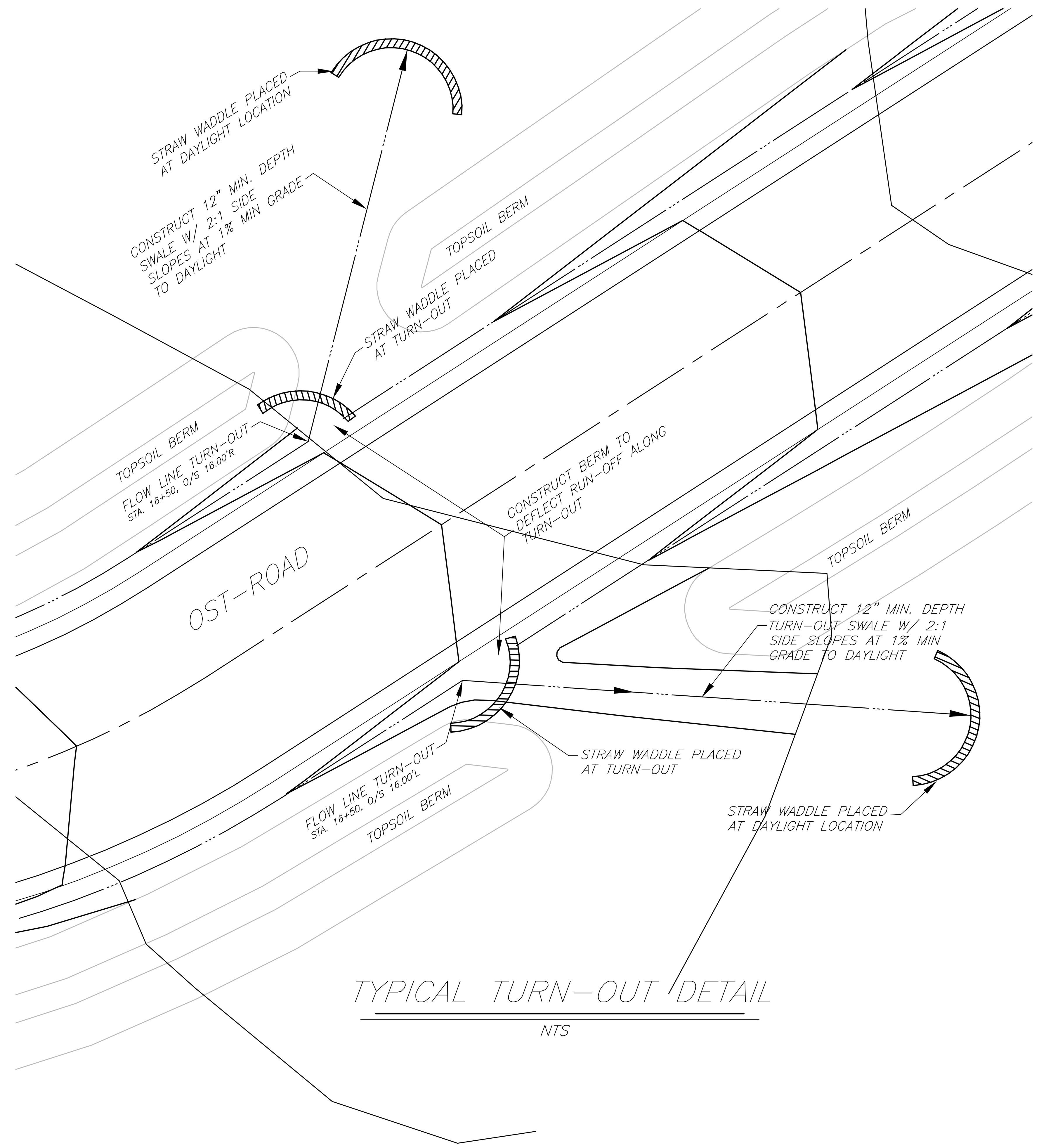
TYPICAL DRAINAGE SWALE

NTS



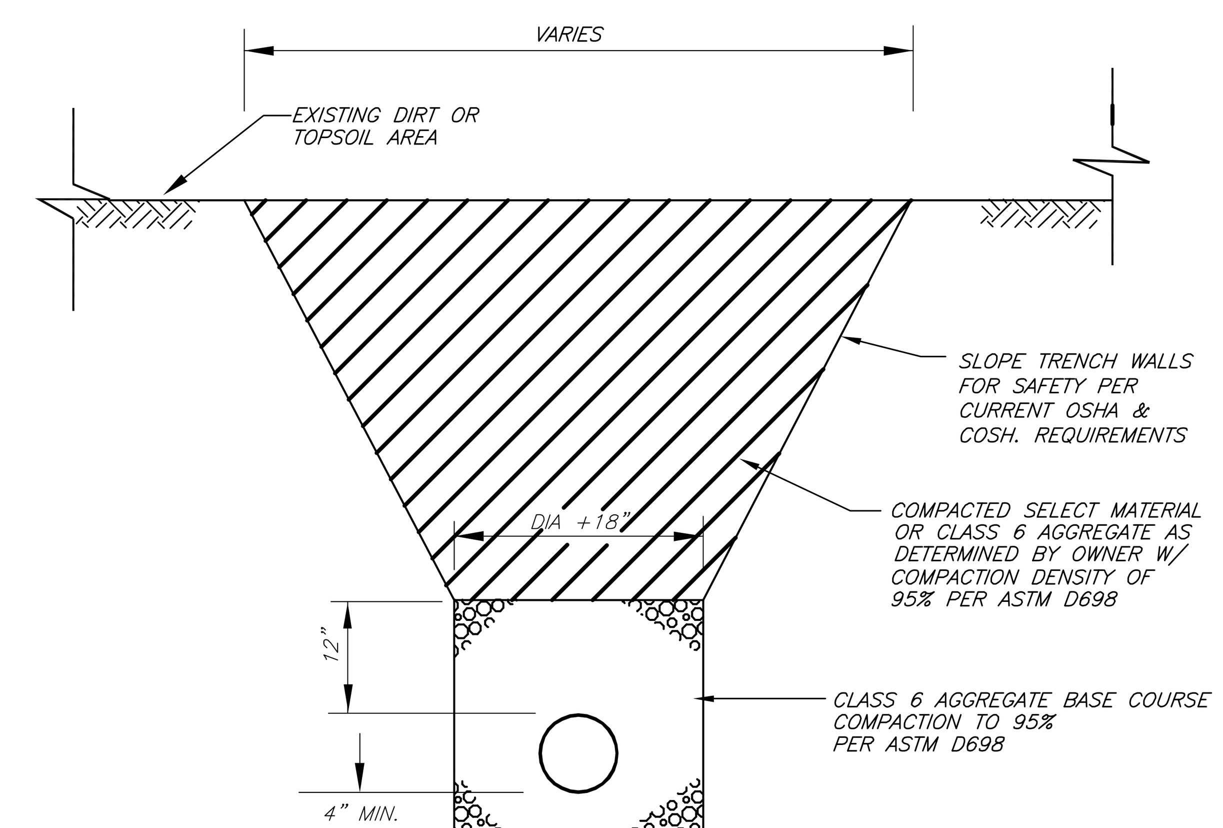
TYPICAL CMP DETAIL

NTS



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. 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.

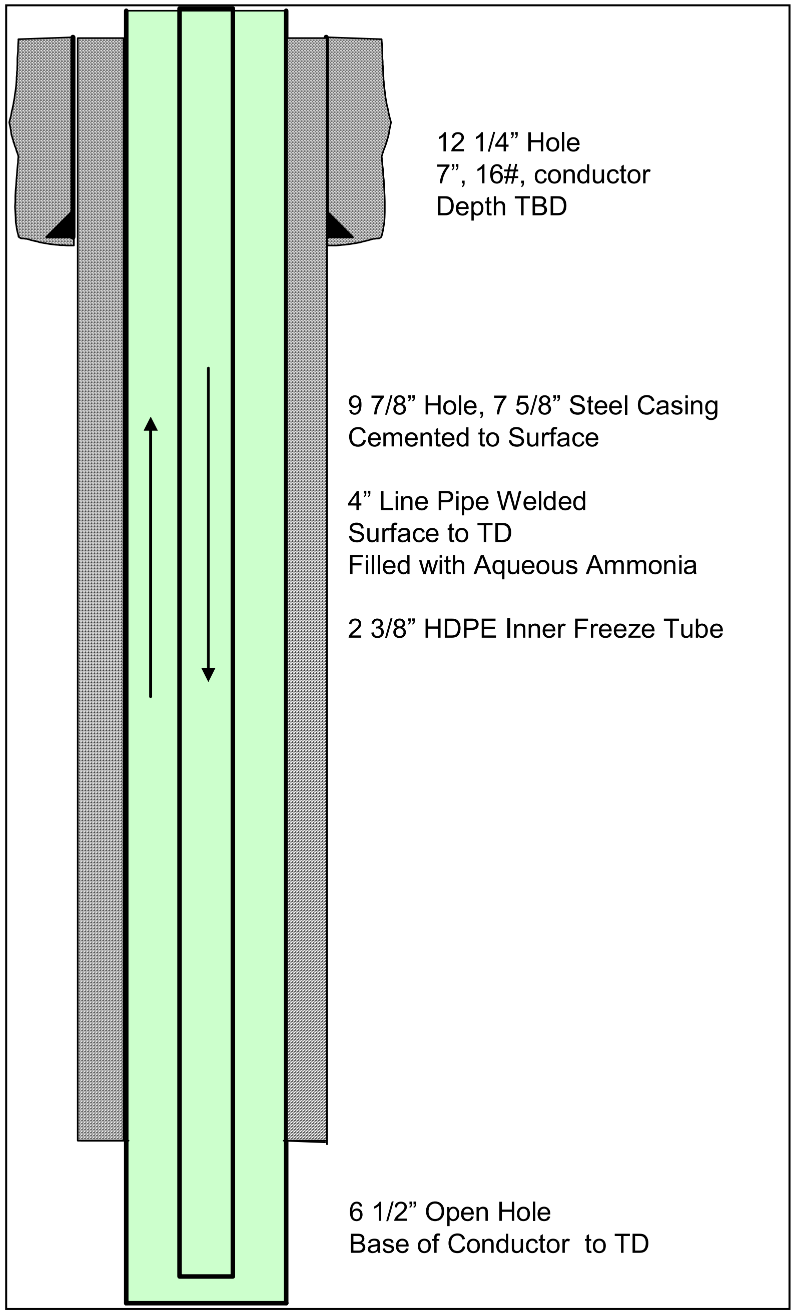


Figure 4.3 Typical Freeze Hole

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.

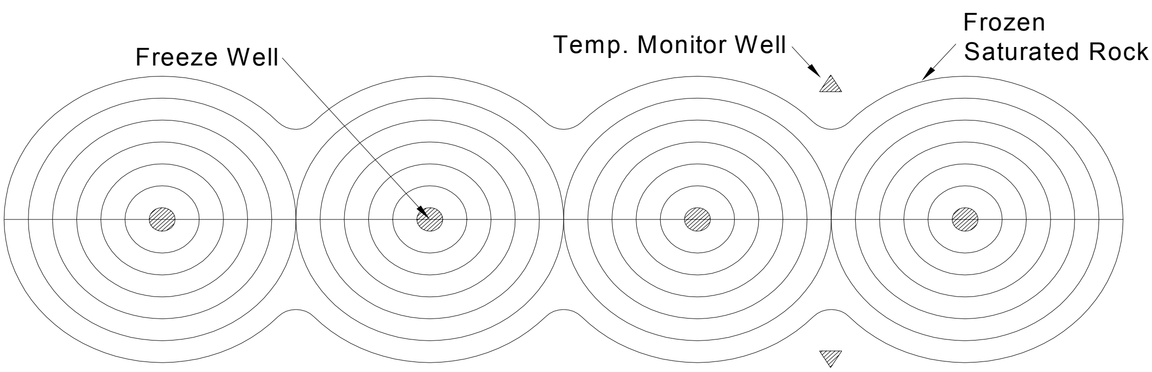


Figure 4.4 Freeze Well

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.

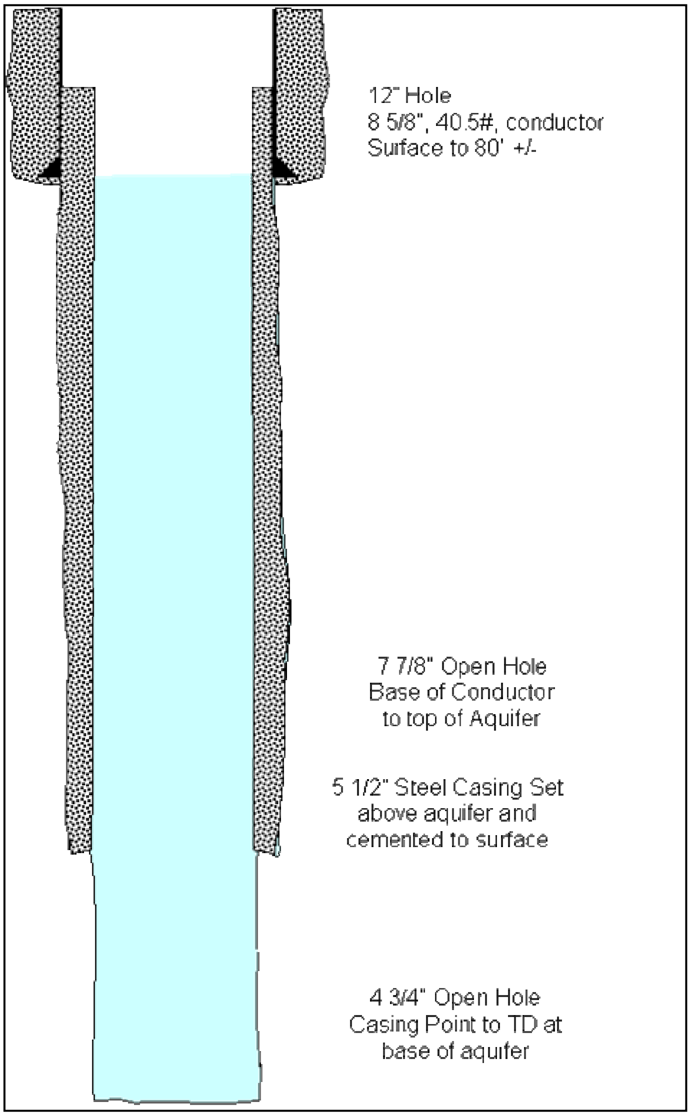


Figure 4.5 Typical Injection Well

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.

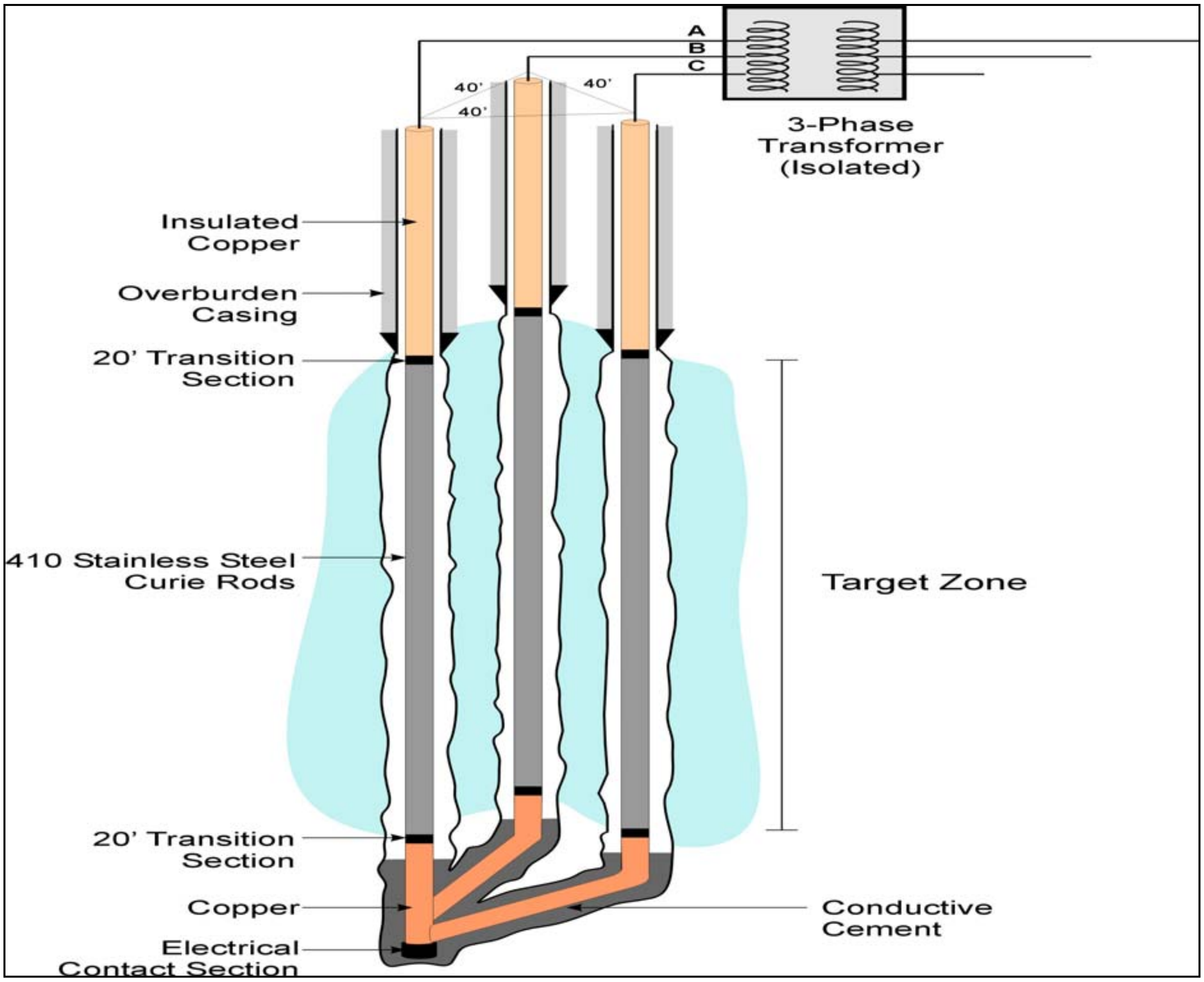


Figure 4.6 Typical Bare Electrode Heater Triad

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.

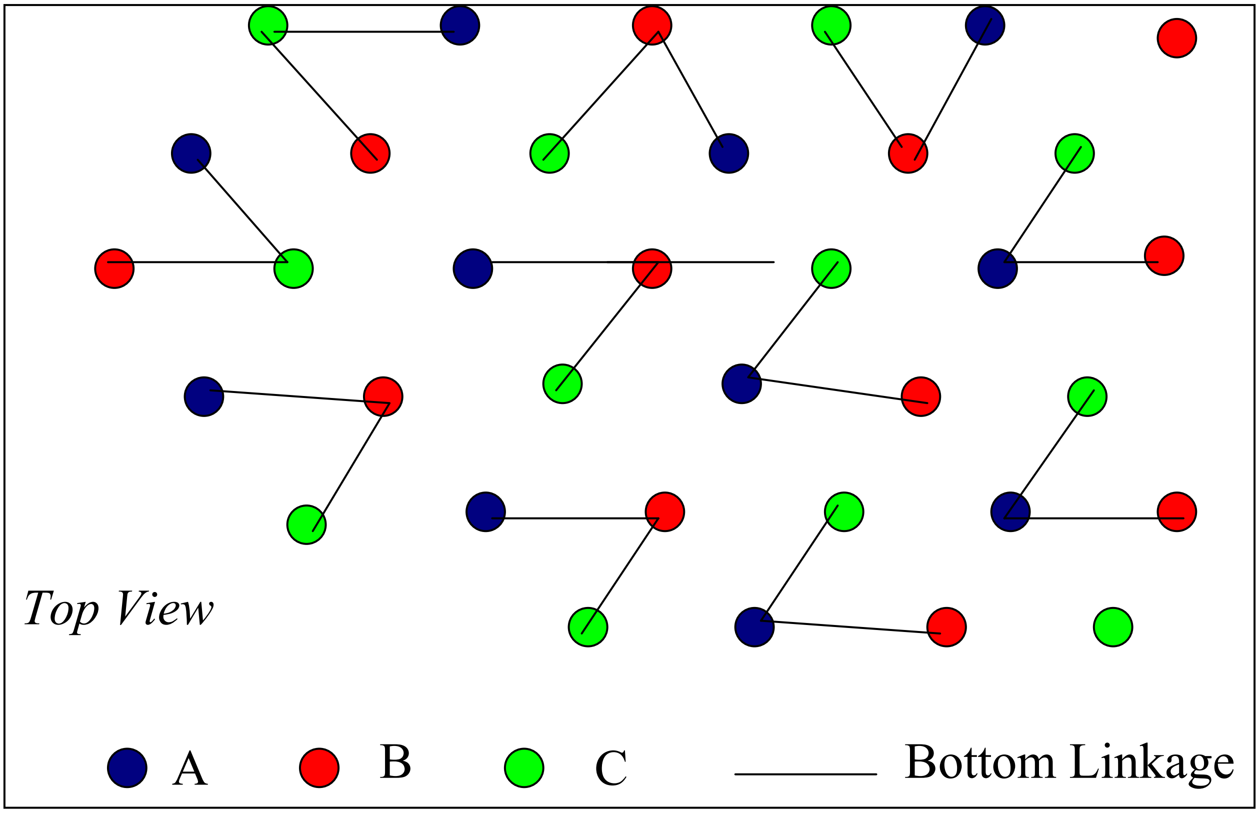


Figure 4.7 Areal Layout of Bare Electrode Heater Triads

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.

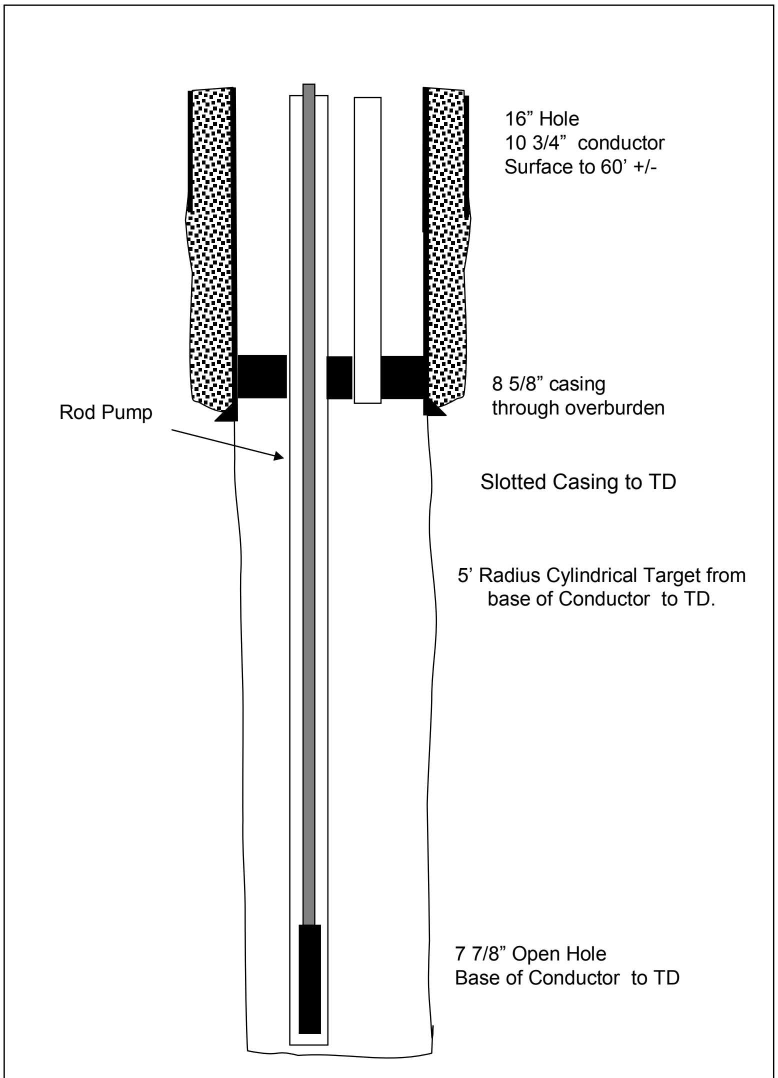


Figure 4.8 Typical Producer Hole

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.

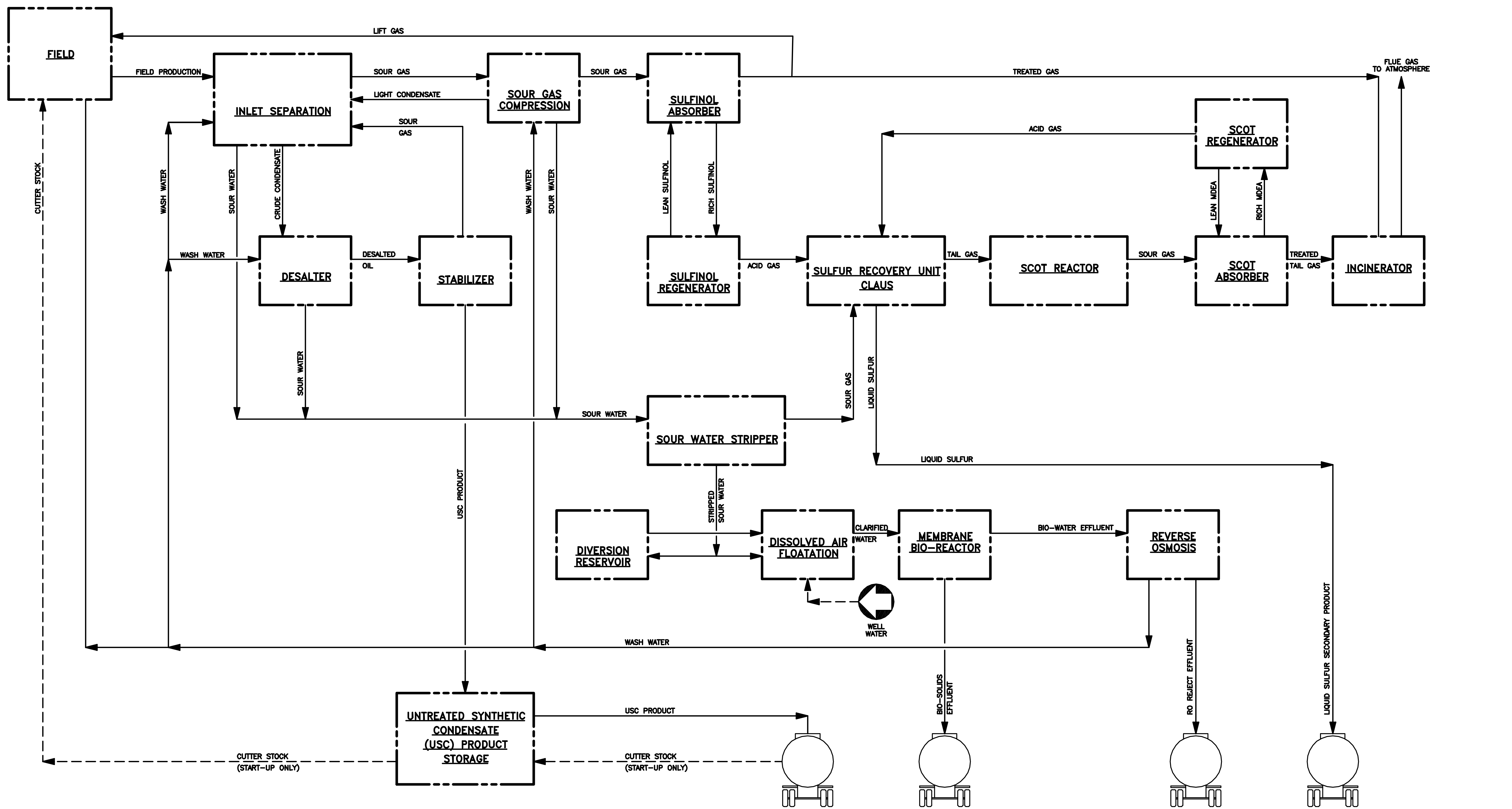
Figure 4.9 Photograph of Field Piping Network

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.

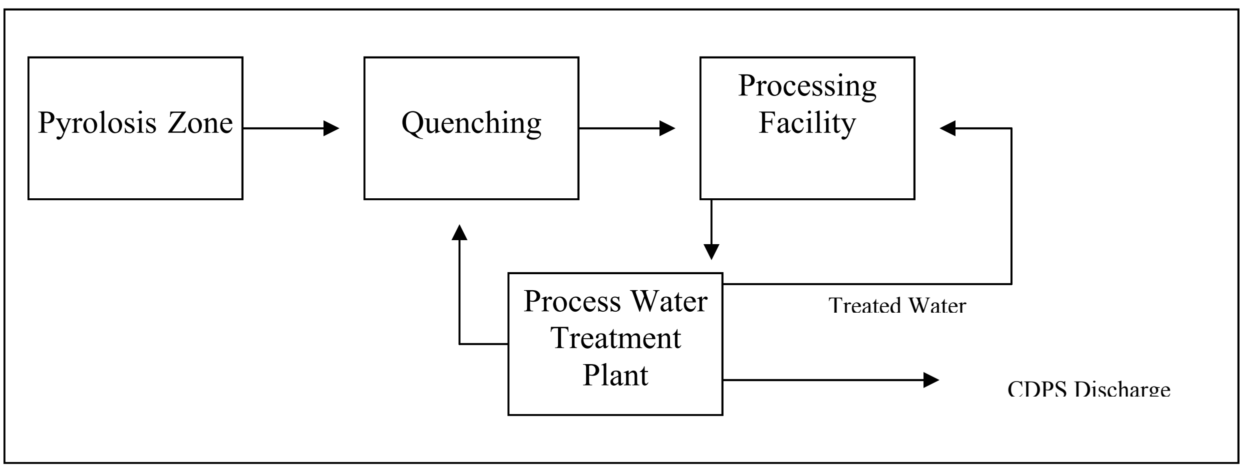


Figure 4.11 Processing Water Management

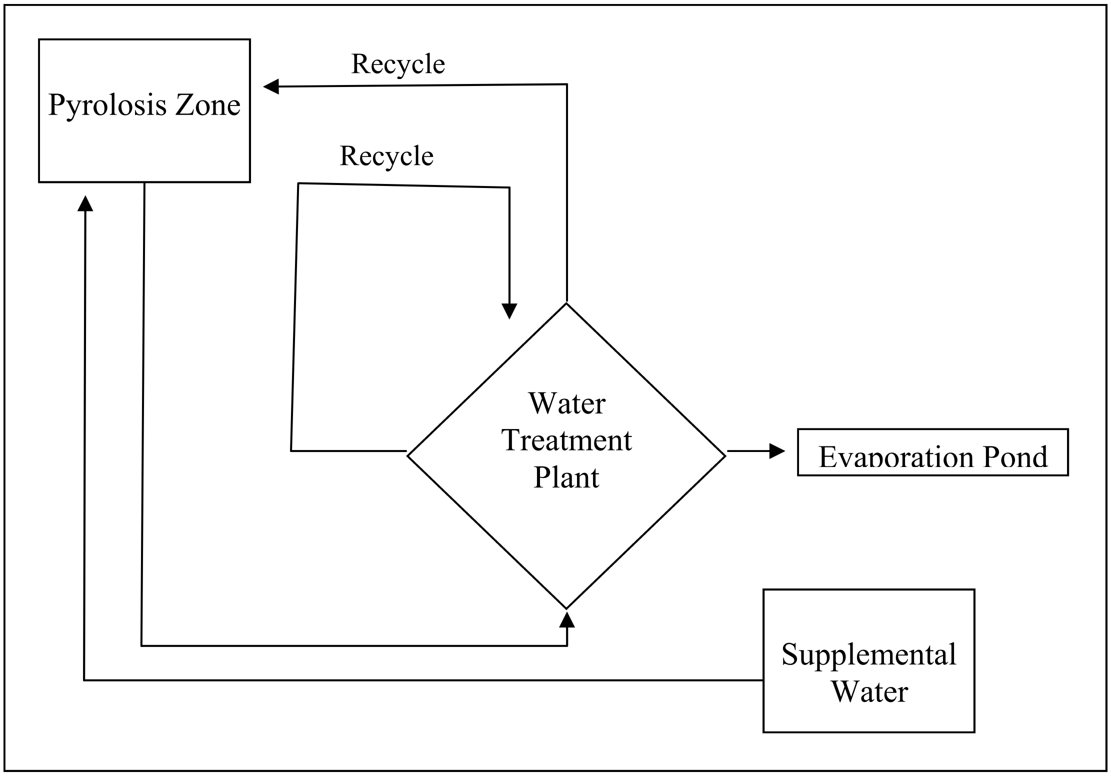


Figure 4.12 Reclamation Water

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.

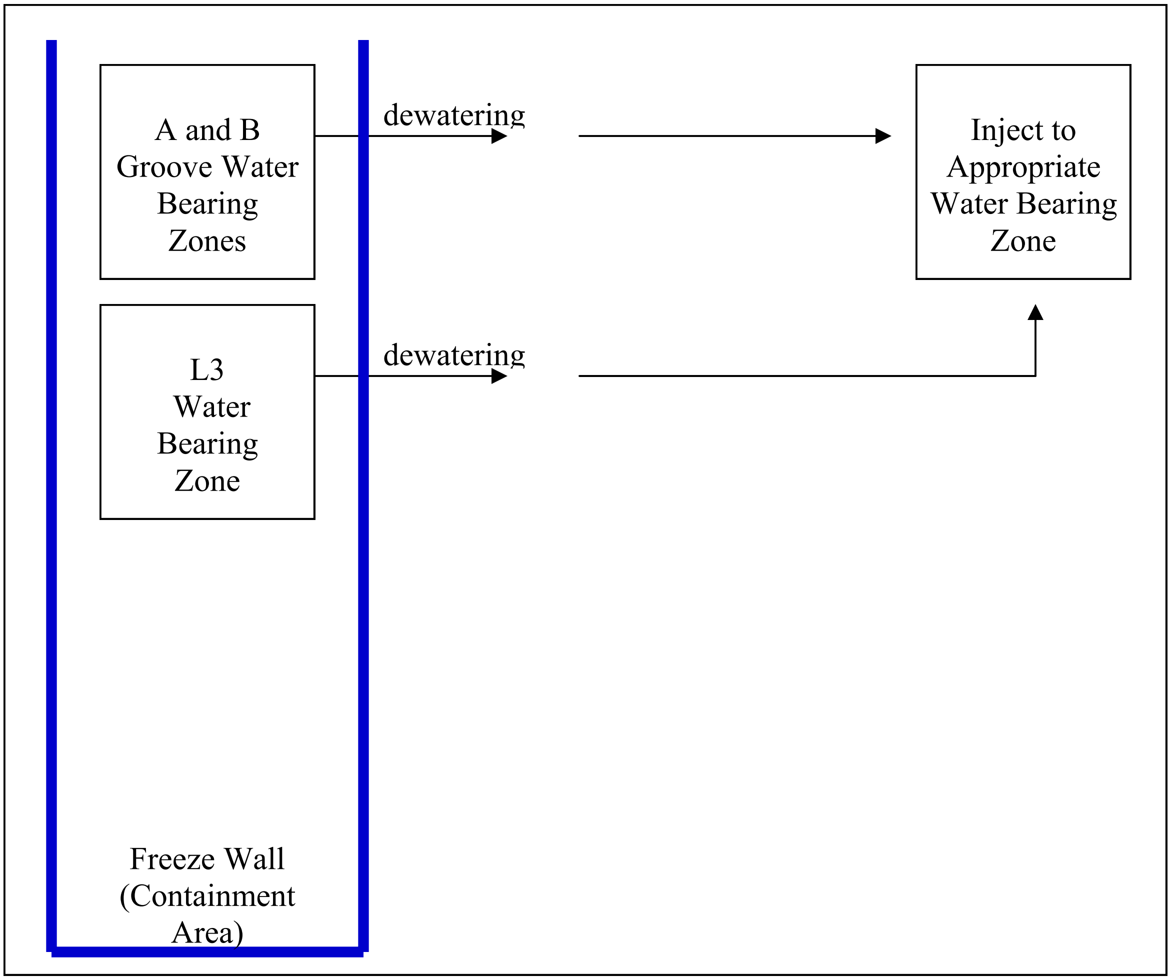


Figure 4.13 Dewatering and Injection Water Management

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.

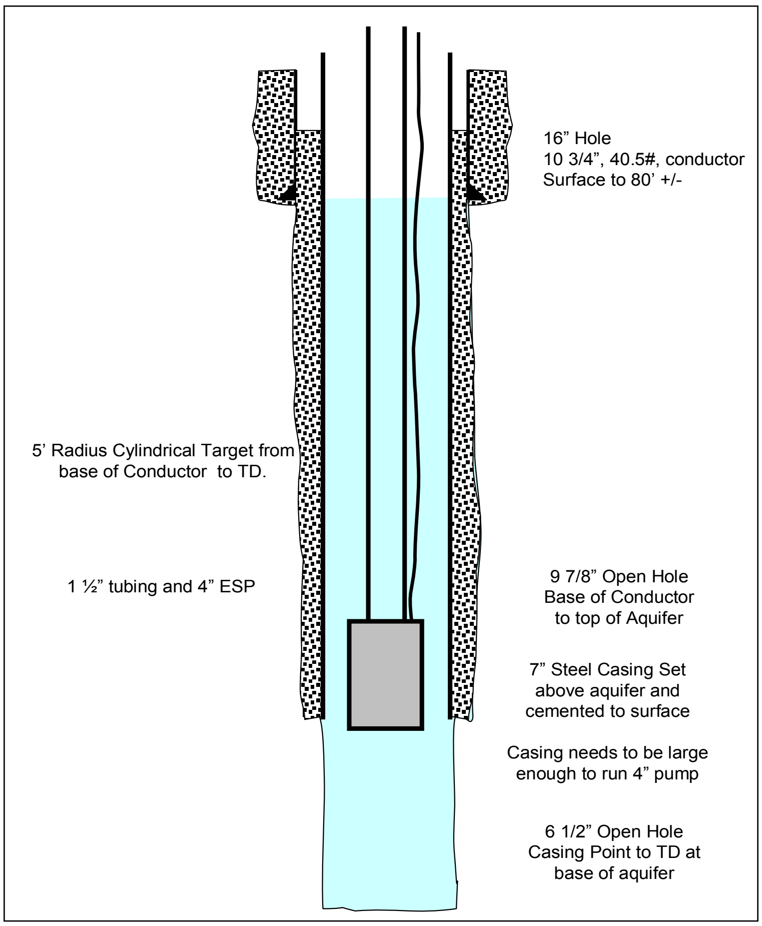


Figure 4.14 Typical Level Monitor Hole

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.

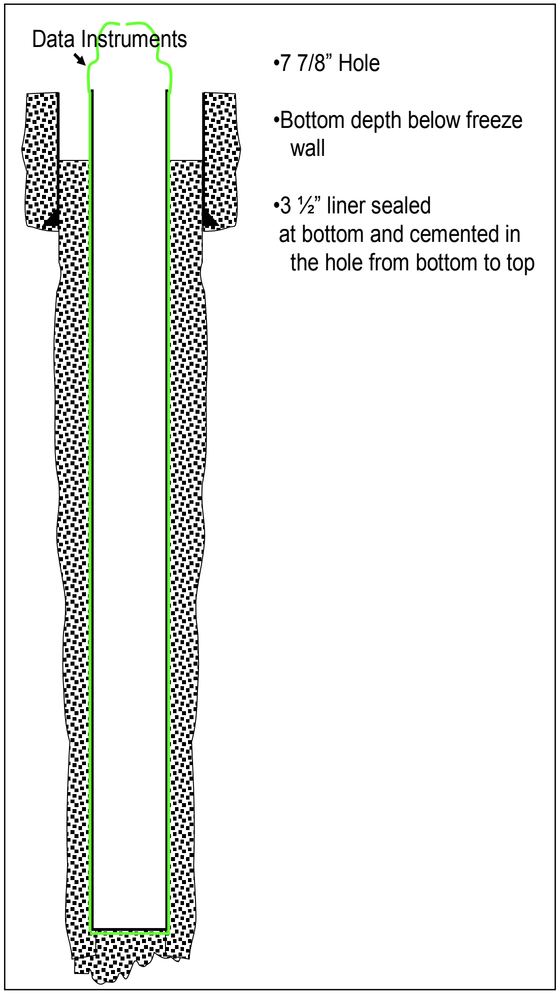


Figure 4.15 Typical Geomechanics Monitor

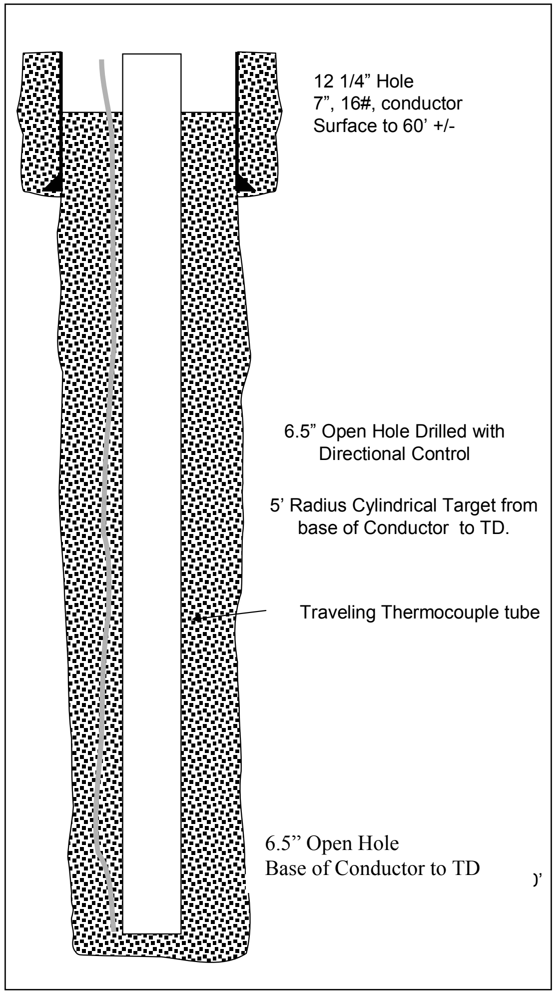


Figure 4.16 Typical Temperature Monitor

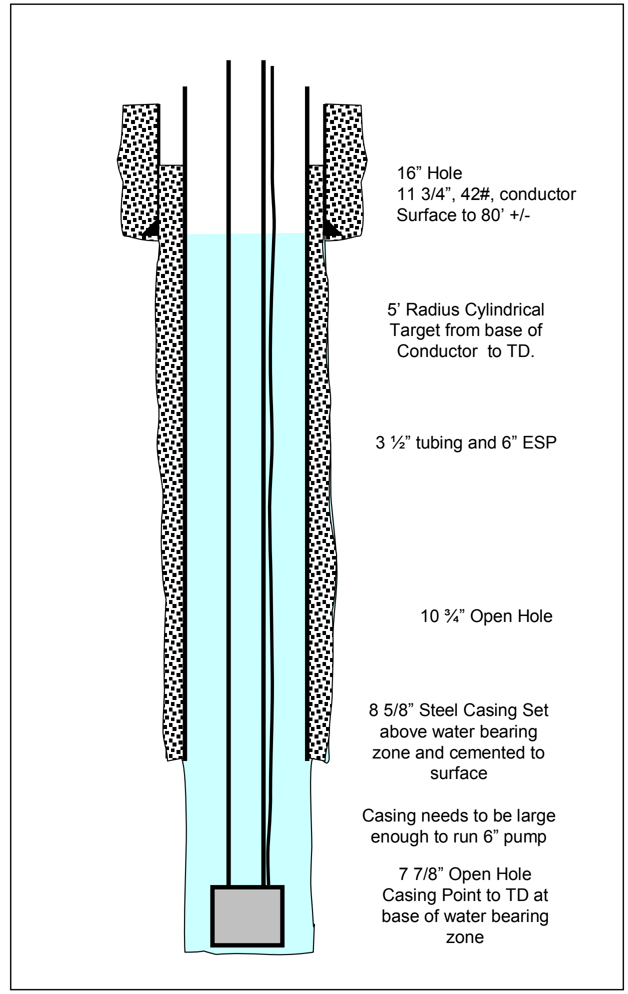


Figure 4.17 Typical Pumper Hole

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.

5.0 RECLAMATION PLAN

Reclamation for the E-ICP Project will occur as operations at various project components are completed. The first step in reclamation of the E-ICP will be reclamation of the pyrolyzed zone inside the freeze wall containment area. Reclamation of the freeze wall containment area will involve flushing of the pyrolyzed zone with water to provide cooling after the heating phase and to flush potentially toxic-forming constituents from this zone. After flushing the freeze wall will be allowed to thaw. As such, the refrigeration plant will need to continue operation and the freeze wall will need to remain in place until the acceptable ground water quality is reached. Most of the on-site facilities would need to remain to support the flushing operations.

Once facilities are no longer needed, the equipment will be removed and the facilities demolished. Concrete foundations will be broken and buried at the site with a minimum of four feet of cover. The site will be regraded, soil will be replaced and the site will be revegetated.

The following sections provide information on the reclamation of the E-ICP Project. Section 2.2 shows the anticipated schedule for operation and reclamation of site facilities. Exhibit N shows the expected final topography and revegetation for the disturbed areas.

5.1 Reclamation of the ICP

Once pyrolysis and production are completed, the pyrolyzed oil shale within the freeze wall will be flushed with water for cooling and reclamation. After production has been completed, water will be injected into each water-bearing strata and allowed to remain in the pyrolyzed zone for a sufficient period of time to promote cooling. Temperatures in the pyrolyzed zone will be monitored during the period to evaluate the cooling process. The initial injected water is converted to steam, and some remaining hydrocarbons are removed by steam distillation. The steam generated by the initial cooling is collected in the gathering system and routed to the ground water reclamation treatment plant.

After the cooling period, reclamation of the pyrolyzed zone will be performed by injecting ambient ground water into each water-bearing strata to mobilize (“flush”) residual hydrocarbons, while the freeze wall containment barrier remains in place. Injected water will be passed through the pore spaces, pumped to the surface, treated in the ground water reclamation treatment plant to remove potential ground water contaminants, and then recirculated to repeat the flushing process. The injection, flushing, pumping, treatment, and reinjection procedure will be continued until concentrations are sufficiently low so as to meet applicable water quality targets.

The ground water reclamation treatment plant is designed to remove hydrocarbons and some other trace elements and compounds. The treatment plant will be comprised of a number of unit processes that separate the residual oil, water, and gas phases; capture, convert, and treat gases; and provide additional treatment of the water with refined separation, selective sorption, and filtration as necessary.

Flushing will be accomplished through the use of the ground water monitoring wells completed in the interior to the freeze wall containment. Water will be circulated from the ground water reclamation treatment plant down the hole to the water-bearing zone being flushed. Flushed water is recovered through the producer holes and circulated back to the treatment plant for treatment. This cycle continues until the water quality meets acceptable standards.

Prior to the completion of recovery operations, the ground water reclamation treatment plant and associated evaporation pond will be constructed in the locations shown on Exhibit I. The primary purpose of the treatment plant is to provide water treatment for the water used and recovered during flushing of the pyrolyzed zone. The producer holes will be used for circulation of the flush water along with the existing piping system. The treatment plant will provide treatment for removal of hydrogen sulfide, ammonia, volatile and semi-volatile organic compounds as well as removal of metals and selenium.

The treatment system will include pretreatment and polishing steps to optimize the water treatment. The first step is to remove remaining hydrocarbons through an oil / water separation stage. This stage uses flotation methodology to capture the oil in air bubbles, which float to the top of the water and can be skimmed off the surface. Depending on the concentration of hydrocarbons in the skimmed portion removed, the removed hydrocarbons will either be processed through the processing facility or hauled from the site for appropriate disposal.

The water will then move to a filtration unit to remove remaining solids and hydrocarbons prior to the steam stripper. The filtration unit will be periodically backwashed to clean out filtered substances and allow for continued optimal treatment. This backwash will be sent to an equalization tank for further processing to recover oil and collect waste sludge that will be ultimately hauled off site for proper disposal.

The removal of solids and hydrocarbons is important prior to the next stage to prevent short circulating of the steam stripping process. The purpose of the steam strippers is to concentrate contaminants into a vapor stream and recover the water portion of the steam separately from the other vapor products produced. The steam stripper operates in two stages; the first stage focuses on removal of hydrogen sulfide, while the second stage focuses on removal of ammonia and volatile and semi-volatile organic compounds. In the first stage, hydrogen sulfide would be converted to elemental sulfur which will be collected and hauled off site. Volatile and semi-volatile organic compounds are sent on to the second stage stripper. In the second stage stripper, these gases are collected and sent to a catalytic oxidizer along with ammonia. The ammonia in the off gas is combusted to nitrogen oxide and water. The nitrogen oxide is then converted, through compression and diffusion in a NO_x absorber to nitric acid. Nitric acid and water used to clean out the absorber is sent to the evaporation pond along with any residual solids. Sodium hydroxide is used to neutralize the nitric acid prior to discharge to the evaporation pond. Volatile and semi-volatile organic compounds are combusted.

Following steam stripping, the water is sent to an equalization tank. The equalization tank also collects supernatant from the sludge thickener and filtrate from sludge filter press. Suspended solids would be deposited as sludge in the bottom of the equalization tank. The waste sludge would be contract hauled at least once per year. The solids are primarily of an inert chemical nature and the sludge should not be biologically or chemically active.

The effluent is then sent to coolers to decrease the temperature prior to being passed through granular activated carbon for removal of any remaining volatile and semi-volatile organic compounds. Two carbon trains will be used and each carbon train will have two beds operating in series. Each bed in the train can operate independently and during maximum loading in the early stages of treatment, one bed will be regenerated while the other is being used. The carbon will be regenerated on site. Water released during regeneration goes to equalization tank. Off gases, which will be mainly carbon dioxide and water vapor with some metal oxides and oxidized sulfur compounds, will be sent to the NO_x absorber.

Following the carbon filtration, selenium, mercury, molybdenum, and vanadium will be removed by the selenium and metals removal treatment. Metals treatment includes hydrogen peroxide addition and ferric iron co-precipitation. Sludge produced during the metals treatment will go through a thickener before being hauled off-site for proper disposal. The sludge is expected to test as non-hazardous under Toxicity Characteristics Leaching Procedure standards.

Treated effluent goes re-injection to the pyrolyzed zone or for use as fresh water in the ground water reclamation treatment plant.

An evaporation pond is designed as a triple-lined containment area to hold certain wastes streams from the ground water reclamation treatment plant and allow water to evaporate. The evaporation pond will receive solids from boiler water treatment reverse osmosis, and blow downs from the boilers, and the NO_x absorber. Concentrated brine, remaining after this period, will be excavated and hauled to an appropriate off-site disposal facility. The evaporation pond will be fenced with an eight-foot chain link fence to prevent wildlife ingress to the lined pond area.

Thawing of the Freeze Wall

When the flush water meets acceptable water quality targets, the refrigerant will cease to be circulated in the freeze holes and the freeze wall containment barrier will be allowed to thaw. The freeze wall is expected to take some time to completely thaw. Previous testing as well as modeling indicates that the freeze wall containment will thaw slowly and the barrier will continue to be in place for some period of time following the cessation of refrigerant flow into the freeze holes. Monitoring of down hole freeze hole temperatures will continue through thawing. Monitoring in temperature monitoring holes will also continue to provide information on the duration of thawing.

Plugging and Abandonment of Drill Holes

Once the flushing is completed and the freeze wall is allowed to thaw, drill holes associated with the E-ICP can be plugged and abandoned. Plugging and abandonment will occur over a period of time, as certain holes will 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 will be plugged and abandoned consistent with applicable state rules and regulations. Most of the holes will have surface casing cemented through alluvium. This casing will be left in place, but will be cut-off five feet below final grade. The uppermost five feet of the hole will be filled with a material less permeable than the surrounding soils and will be adequately compacted to prevent settling and a cap will be welded at the top of the hole with proper identification information. Cement plugs will also be placed where the surface casing is cut off, five feet below the surface and where required to isolate water-bearing zones. Sealing is important to prevent mixing of different quality ground water. Coated bentonite pellets, cement grout, abandonment fluid or comparable alternative will be used as fill between required cement plugs.

Decommissioning of Facilities

When it has been determined that the flushing is completed and the freeze wall is allowed to thaw, the refrigeration system and processing facilities will be decommissioned. All chemicals will be removed from the site and properly disposed. Any remaining product and wastes will be removed as well; wastes will be disposed off-site and product will be shipped for additional treatment. Storage tanks for waste and product will be triple rinsed prior to removal with the rinse water directed to the ground water reclamation treatment plant. Plant equipment will be removed for disposal or reuse.

If there is any sludge in the bottom of the process water treatment pond, such sludge will be tested to determine appropriate disposal. Results of the testing will determine if the sludge can be buried in place or must be removed from the pond prior to pond reclamation. If test results indicate that the pond sludge meets applicable leaching standards, the sludge will be left in place, otherwise the sludge will be removed for appropriate disposal off-site. The process water treatment pond liners will then be punctured and folded inward. The pond will be backfilled and graded in preparation for soil placement and revegetation.

Upon completion of the ground water flushing and associated water treatment, the ground water reclamation treatment plant will be reclaimed. Any remaining unused chemicals or wastes will be removed from the site for off-site disposal. Storage tanks for waste and product will be triple rinsed prior to removal with the rinse water directed to the evaporation pond. Plant equipment will be removed for disposal or re-use. The plant building will be demolished and the site regraded in preparation for soil placement and revegetation.

The evaporation pond would not be reclaimed for approximately 3 years following completion of ground water treatment and flushing. During that period of time, the brine in the pond will be allowed to concentrate. The concentrated brine that remains in the bottom of the pond at the end of the three-year period will require removal and appropriate disposal off-site. Once the brine solution has been removed from the pond, piping and pumping would be removed and the evaporation pond liners will be punctured and folded inward. The pond area will be backfilled and the surface area regraded prior to soil replacement and revegetation.

Other facilities associated with the E-ICP operations will be removed when no longer needed to support the reclamation efforts. Small quantities of chemicals and waste stored in the laboratory and at other locations will be collected and shipped off site for re-use or disposal. The buildings will be demolished and foundations broken and buried on site. The building locations will be graded in anticipation of soil replacement and revegetation.

When no longer needed to collect storm water runoff from the site, the storm water pond will be reclaimed. It is currently anticipated that this pond will be reclaimed along with removal of the storm sewer drainage system and grading of disturbed areas. Any sediment in the bottom of the storm water pond will be tested to determine appropriate disposal. If test results indicate that the sediment is not acid- or toxic-forming, the sediment will be left in place, otherwise the sediment will be removed for appropriate disposal off-site. The piping and pump systems will be removed and the pond liners will then be punctured and folded inward. The pond will be backfilled and graded in preparation for soil placement and revegetation.

Final Site Regrading and Revegetation

The site access road will be reclaimed to a dirt road at the completion of project activities. Asphalt paving will be removed and the road will be regraded to an approximate 12- foot wide compacted dirt travel surface. Soil stockpiled on either side of the road will be replaced on the regraded areas and the areas will be revegetated.

Following completion of demolition of the facilities, land reclamation will begin. Soils in the vicinity of aboveground petroleum product storage tanks will be tested for petroleum contamination prior to recontouring the area. Existing sediment control structures will control erosion and contain runoff and sediment within the project area during reclamation. Using typical earth moving equipment, the disturbed area will be recontoured to a final topography that blends with existing undisturbed growth. Earthmoving should be limited based upon the cut/fill work used to establish the benched layout of the facilities to centralize drainage control. The regraded material will be scarified prior to planting to prepare a seed bed.

Salvaged and stockpiled soils will be redistributed over the recontoured area. Topsoil will be redistributed to a minimum depth of six inches over disturbed areas. Redistributed soil will then be tested to determine if amendments are necessary to promote plant establishment. Fertilizer and other appropriate amendments, if needed, will be applied after soil placement. The area will then be seeded with seed mixes recommended in the BLM Resource Management Plan modified based upon site specific data obtained during the baseline vegetation survey. Seed will be drilled or broadcasted. Straw will be crimped over the seed or mulch will be added using a hydromulcher. Seeding will occur in the fall with the early spring serving as an alternative should fall seeding not be completed.

Three types of vegetative habitats are planned for reclamation of the E-ICP to allow final land uses of rangeland and wildlife habitat. The three vegetative habitat types consist of a pinyon pine/ Utah juniper mixture located on the ridgelines, a more mesic mix for the mid-slope position of the regraded topography and a third mix for reclaiming upland drainages.

The main species in each of the mixes will not vary significantly as the two dominant plant communities in the area are sagebrush grassland and pinyon/juniper. However, the percentages by species will be adjusted slightly for the various topographic positions. The pinyon/juniper type will be augmented with seedling plantings in the area. Additionally, smaller "islands" of the pinyon pine/Utah juniper seedlings will be interspersed within the mid-slope areas to serve as a seed source and cover areas for wildlife species. Pinyon/juniper at the edge of disturbance will also provide a natural source of seed for the revegetated area. Exhibit N provides mapping of the expected areas for seeding by each type.

Pinyon/Juniper Ridge Top Community Seed Mix

Species of plant	**Variety**	**Pure Live Seed (lbs/acre)**
Western wheatgrass*	Rosanna	2
Bluebunch wheatgrass*	Secar	2
Thickspike wheatgrass*	Critana	2
Indian ricegrass*	Nezpar	1
Fourwing saltbush*	Wytana	1
Utah sweetvetch*		1
Junegrass		1
Hood's Phlox		1
Antelope Bitterbrush		1
Broom Snakeweed		1
Wyoming Big Sagebrush		2

Alternates: Needle and thread, globemallow

Pinyon Pine and Utah juniper seedlings will be planted, with an assumed mortality rate of 30 percent, based on the on average number of trees per acre in the pinyon/juniper ridge top communities surveyed at the site, in order to achieve pre disturbance tree and shrub counts.

Mid slope Community Seed Mix

Species of plant	**Variety**	**Pure Live Seed (lbs/acre)**
Western wheatgrass*	Rosanna	2
Indian ricegrass*	Nezpar	1
Bluebunch wheatgrass*	Whitmar	2
Thickspike wheatgrass*	Critana	2
Green needlegrass*	Lodorm	1

Globemallow*		0.5
Junegrass		1
Hood's Phlox		1
Fremont's Penstemon		1
Wyoming Big Sagebrush		2
Broom Snakeweed		1
Rubber Rabbitbrush		1

Alternates: Fourwing saltbush, Utah sweetvetch, balsamroot

Upland Drainage community Seed Mix

Species of plant	Variety	Pure Live Seed (lbs/acre)
Western wheatgrass*	Rosanna	2
Needle and thread*		2
Thickspike wheatgrass*	Critana	2
Indian ricegrass*	Nezpar	2
Sand dropseed*		1
Slender Wheatgrass		1
Basin Wildrye		1
Basin Big Sagebrush		2
Rubber Rabbitbrush		1
Greasewood		1

Following reclamation, vehicle traffic will be restricted over the area. Some limited travel will be required to conduct post reclamation monitoring of vegetation, potential subsidence and water monitoring holes. The revegetated areas will be monitored for the first two years to evaluate the need for supplemental seeding and noxious weed control. Recontouring, reseeding, or other appropriate measures will address areas of erosion in the revegetated areas. Noxious weed control will occur through the use of BLM recommended procedures based on the amount and type of noxious weed present. Erosion control measures will not be removed until vegetation is established.

Although subsidence of the disturbed area is not anticipated, periodic monitoring will be conducted in order to detect any significant deformation in the area.

6.0 ENVIRONMENTAL SETTING AND BASELINE STUDIES

The project site is located on federal lands managed by the BLM. The land is not wilderness, wilderness study areas or adjacent to a wild and scenic river. Shell has completed preliminary baseline surveys on several large parcels which include the 160-acre R&D site (Exhibit O). Baseline information has been forwarded to the BLM field office; it is summarized here.

6.1 Vegetation

The R&D site area is dominated by pinyon-juniper and sagebrush communities. In and near the bottoms of drainages, basin big sagebrush dominates the bottomland areas. There are several areas where vegetation transitional between sagebrush and pinyon-juniper woodland is prevalent. Based on studies completed to date of the R&D site and surrounding areas (approximately 3,800 acres) no federally threatened and endangered (T&E) species or BLM sensitive species were located.

6.2 Soils

Predominant soils types 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. Primarily they are well drained and the permeability is moderately rapid with a very low available water capacity. Surface layers (soils and soil parent materials) in the study area are derived primarily from the Uinta Formation, with exposures of the Green River Formation along valley slopes.

The elevation range of the R&D site is between 6,900 to 7,000 ft. The bottoms of larger upland drainages generally have shallower soils supporting pinyon and juniper. Lower slopes of these upland drainages usually have deeper soils which generally support a Wyoming sagebrush/grass plant community.

6.3 Wildlife

Based on studies completed to date of the R&D site and surrounding areas (approximately 3,800 acres) no federally-or State-listed T&E species breed on or frequent the R&D site. A few species of concern could occur on the site.

A red-tailed hawk in a large juniper was found in 2001 within the R&D site which fledged two young. Shell will work with the BLM to mitigate impacts to the nest.

No nesting habitat for American peregrine falcons or bald eagles exists on the R&D site, but these wide-ranging raptors might occasionally hunt or fly over the site. Although greater sage-grouse historically bred in upland sage habitat nearby, the site is not currently considered within sage-grouse range by Colorado Division of Wildlife.

The entire R&D parcel is mapped by CDOW as both summer and winter elk and mule deer range. No severe winter range exists on the site. However, summer range is considered critical habitat in this region, because of the limited extent of summer range for the elk that inhabit the Piceance and Douglas Creek Basins.

6.4 Cultural and Paleontology Resources

The cultural resource survey investigated prehistoric occupation and use of the drainage-bottom/ridge-top, pinyon/juniper habitat of the Piceance Basin region described above. The inventory results were forwarded to the BLM as part of previous exploration program. During the inventory, the newly and previously recorded resources indicate that this area was intensively occupied during the Prehistoric Era. Additional inventories in the immediate vicinity support this assumption. One cultural site was found within the R&D site. It was determined that the site needs further testing in order to determine eligibility into the National Register of Historic Places. Shell will fence off the site during site construction and will completely avoid the site throughout the life of the project.

A survey was conducted on R&D site and surrounding areas to determine the potential for scientifically significant paleontological resources. The R&D 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.

The unnamed tongue of the Uinta Formation is exposed in incised drainages on the R&D site. A number of paleo-botanical sites were recorded during the survey. 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 the R&D site represent both a chronologically younger assemblage and a depositional change (fluvial rather than lacusrtrine) than the better understood Parachute Creek Member of the Green River Formation. Therefore, these sites are significant paleontological scientific resources.

6.5 Climate

Climate of the R&D site is similar to a semi-arid steppe region. High mountains surrounding the northwest Colorado region deflect many migratory low-pressure systems around the region. Stationary high-pressure cells often persist for days, their passage blocked by the Continental Divide to the east. As a result there is a high frequency of clear sunny days with light winds and large diurnal temperature changes. Gradient winds are generally westerly, existing throughout the year, except when interrupted by the passage of frontal systems. Surface winds tend to be from the southwest, following the axis of the ridges and gulches.

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. The dry air and lack of activity in the area provide excellent visibility in general.

Lightning during summer thunderstorms is a significant problem due to the high elevation and exposure on the mountain ridges. Wildfires (grass fires) do occur during the dry season.

Ambient temperatures have been recorded as low as –20 °F in winter. Summer temperatures rarely exceed 85 °F. A diurnal change of 30 – 40 °F is common.

6.6 Visual

The project area includes areas that viewers may travel through or recreate in. The project area is, according to the White River Resource Management Plan, within a Class III Visual Resource Management (VRM) area. These areas are intended to partially retain the existing character of the landscape. The temporary 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 (BLM 1986)[3]. Prior to project start-up Shell will consult with the BLM regarding additional work on visual assessment.

6.7 Hydrology

The regional studies completed in the area associated with the project assessed tributaries to Yellow Creek and Piceance Creek, which are the two streams flowing within the topographic

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[3] BLM. 1986. Visual Resource Inventory. BLM Manual – Handbook 8410-1.

basin to the White River. The White River is a tributary of the Green River, which is a tributary to the Lower Colorado River Surface hydrology studies for the R&D facility area to date have been conducted on Big Duck Creek, and Corral Gulch, which flow to Yellow Creek. The R&D site is located in on an unnamed tributary of Big Duck Creek (to the north) and Corral Gulch which bounds the property to the south. Big Duck Creek has two sample sites, 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 Exhibit L.

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 (Table 6.1). Corral Gulch is intermittent among many of its reaches. Yellow Creek is perennial to the north near site CR255.

Table 6.1 Stream lows Near E-ICP R&D Project (cfs)

Drainage	New Sitename	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

All of the springs and seeps near the project 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, Flows have been monitored in springs in Big Duck Creek, Duck Creek, Corral Gulch and Yellow Creek, and flows are summarized in Table 6.2.

This suggests that groundwaters discharging from springs in the channel bottoms in the major drainages are likely from alluvial groundwater systems. The alluvial groundwater systems in the major drainages do not appear to receive appreciable recharge from bedrock groundwater systems adjacent to the major drainages in the area. 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. Alluvial groundwater systems in the major drainages, which are underlain by very low-permeability bedrock, likely act as conveyance mechanisms for water from recharge areas to the west to discharge areas in lower-elevation regions to the northeast.

Table 6.2 Spring Flows near E-ICP R&D Project (gpm)						
Drainage	**New Sitename**	**Count**	**Min**	**Max**	**Mean**	**Median**
Big Duck Creek	SP118	7	11.00	21.00	15.70	15.00
Duck Creek	SP124	10	166.00	405.00	291.50	279.00
Corral Gulch	SP105	9	0.00	0.28	0.03	0.00
Corral Gulch	SP106	9	0.00	1.51	0.59	0.14
Corral Gulch	SP107	9	0.00	1.59	0.77	1.00
Corral Gulch	SP159	5	0.00	110.00	41.60	32.00
Yellow Creek	SP129	13	0.00	520.00	178.18	156.00
Yellow Creek	SP130	4	1.13	5.00	3.17	3.28
Yellow Creek	SP162	4	0.00	0.00	0.00	0.00
Yellow Creek	SP163	5	0.00	0.00	0.00	0.00

The water quality of the surface waters is typically a magnesium sulfate, with moderate salinity levels and high hardness. Periodically, elevated levels of iron, selenium, chromium, nitrate and sulfide are observed. Sampling at springs identified reduced dissolved oxygen levels that would compromise aquatic life. As water flowed downstream, however, normal oxygenation from turbulence increased dissolved oxygen to acceptable concentrations. The mainstem of Yellow Creek, including all tributaries, from the source to the confluence with the White River have stream standards and are classified as usable for recreation (Class 2), agriculture, and Class 2 aquatic life warm. Representative standards for the reach are identified for pH, dissolved oxygen, fecal coliform, as well as some anion inorganics and metals. Existing water quality is the standard until the next triennial review (February 28, 2009).

Groundwater

To date most groundwater monitoring has been conducted up-gradient from the R&D site. Since 2002, eight wells have been drilled to monitor water levels and quality (Exhibit M). These sites were originally associated with a previous research site. SEPCo is in the process of expanding the groundwater monitoring program to include the R&D site which should begin this summer.

Water is principally a sodium-rich bicarbonate type where increases in TDS are the result, principally, 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 zone.

In general, the regional ground water quality of the Uinta and Parachute Creek and Garden Gulch Members of the Green River strata is of moderately poor quality, using “common” water quality parameters such as total dissolved solids. 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 total dissolved solids, arsenic, barium, boron, cadmium, chloride, iron, fluoride, 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).

Seasonal variations were not expected and were not found in these confined aquifers. The variability of the ground water 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 and Parachute Creek and Garden Gulch Members of the Green River formations.

The water quality assessment does confirm a vertical variation that is quasi-predictable; that of increasing total dissolved solids with depth of the permeable strata.

7.0 ENVIRONMENTAL PROTECTION PLAN

7.1 Surface Water Management Plan

Surface water drainage has been described in Section 4.2. Waters discharged into surface waters will be treated to meet specifications of permits. Surface water monitoring will verify environmental protection measures.

7.2 Groundwater Protection

Extensive groundwater protection measures are built into the E-ICP process. One of the primary purposes of the freeze wall is to segregate the processing zone from groundwater. Water management and treatment is an integral part of the operation. Ground water monitoring will verify environmental protection measures.

7.3 Air Quality

Facilities Emission by Permit

The processing system will have emissions to the air. The process equipment is designed to substantially control these emissions. The facility emissions will be evaluated to procure all permits, with associated compliance demonstration requirements prior to construction of the R&D project. The demonstration requirements may include assurance during the application process through atmospheric dispersion modeling that ambient air impacts around the project will meet National Ambient Air Quality Standards (NAAQS).

Fugitive Dust Control

A Fugitive Dust Control Plan will be created for the site in order to control fugitive dust. All access roads will maintain a good drivable surface and speed will be controlled as necessary. Where needed, water will be used to suppress dust on roads and disturbed areas.

Control of Wild Fires and Resource Fires

Contingent with BLM guidelines, a fire break will be constructed around the site. Should a wild fire occur within or adjacent to the R&D site, Shell will notify the appropriate agencies and will provide assistance where feasible for containing and extinguishing the fire.

7.4 Fish and Wildlife

There will be a temporary interruption to fish, wildlife, soils and vegetation within the R&D site. Impacts to fish and wildlife will be protected by maintaining water quality with the use of conveyance and containment structures to detain water until its acceptable for release. Wildlife habitat will be restored through the reclamation plan which includes planting grasses, forbs, shrubs and trees. Planting patterns will utilize small clusters of trees and shrubs to serve as seed sources for adjacent sagebrush/grass lands. These measures are more formerly described in the reclamation plan.

7.5 Soil and Vegetation

Prior to salvaging topsoil, sediment control measures will be constructed and all suitable soil materials salvaged and stockpiled to minimize erosion. Stockpiles will be seeded with fast growing seeds to minimize disturbance. Following recontouring, salvaged soil will be redistributed and seeded with BLM approved seed mixes as part of the reclamation plan.

7.6 Health and Safety

Shell will control access to the R&D site. Access points will have signs and markers to alert the general public. In an emergency Shell will notify local emergency planning coordinators as directed under SARA as well as any other applicable local agencies.

Shell will have a quality HSE Management System (HSEMS) to ensure this operation protects the people and the environment. Some elements of that HSE will include a Spill Prevention Control & Countermeasures (SPCC), Risk Management Planning (RMP), Process Safety Management (PSM), and an Emergency Response Plan (ERP).

The ERP is designed to train employees and contractors to handle a potential emergency situation effectively. Shell will maintain the ERP in several key locations as required by applicable regulations. An “emergency” would be defined as a serious incident that is not part of the normal operation of the project. The ERP provides an orderly and systematic approach to manage a crisis.

The ERP will include appropriate notification to all regulatory agencies. Any releases which exceed the reportable quantity (RQ) of hazardous substances as defined by CERCLA will be reported to the National Response Center and applicable state and local agencies within 24 hours. The facility will appoint an emergency response coordinator.

Any releases of extremely hazardous substances which exceed the reportable quantity, as defined by SARA, and which leave the site boundary will be reported to state and local emergency response coordinators. The site SPCC Plan will provide a list of these regulated substances and appropriate contact information.

8.0 EXHIBITS

A – Regional Location Map
B – General Location Plan
C – Surface Ownership and Existing Facilities
D – Regional Geology Map
E – R&D Tract Base Map
F – Stratigraphic Column
G – Geology Map
H – Structural Cross Section A-A'
I – Preliminary Plot Plan
J – Drill Hole Schematic
K – Drainage Control Plan
L – Surface Water Hydrology Map
M – Groundwater Hydrology Map
N – Reclamation Plan
O – Environmental Study Area